CALIFORNIA HATCHERY REVIEW REPORT

A review of anadromous fish hatchery programs in California was funded by the U.S. Congress to evaluate how the programs could be operated to meet harvest goals and achieve contemporary species conservation goals for steelhead and Chinook and coho salmon. Eleven scientists, known as the California Hatchery Scientific Review Group (California HSRG), were appointed to evaluate the anadromous fish hatcheries of California's Central Valley and the Klamath and Trinity rivers.

The goal of the hatchery program review initiative was to ensure that anadromous hatchery programs in California are managed and operated to meet one or both of the primary purposes for hatcheries:

- Helping recover and conserve naturally spawning salmon and steelhead populations, and
- Supporting sustainable fisheries with little or no deleterious consequence to natural populations.

Weighing available scientific information, the California HSRG produced consensus recommendations for changes in hatchery practices that should provide guidance to policy makers who will be responsible for implementing changes to California hatchery programs.

A brief summary of the report was included in the news release announcing the report (Agenda Item E.1.a, Attachment 1). The final report of the California HSRG was released August 7, 2012, and is available electronically in the briefing book (Agenda Item E.1.b, CHSRG Report) or online at: http://cahatcheryreview.com/. The recommendations section of the report is excerpted as Attachment 2.

Council Action:

1. Receive information, provide guidance as appropriate.

Reference Materials:

1. Agenda Item E.1.a, Attachment 1: News Release.
2. Agenda Item E.1.a, Attachment 2: CHSRG Report Excerpt - Recommendations.
3. Agenda Item E.1.b, CHSRG Report: California Hatchery Review Report (electronic/on line only).

Agenda Order:

a. Agenda Item Overview — Chuck Tracy
b. Reports and Comments of Advisory Bodies and Management Entities
c. Public Comment
d. Council Discussion and Guidance

PFMC
08/21/12

Agenda Item E.1.a
Attachment 1
September 2012

Conservation Agencies and Tribes Complete Scientific Review of California's Salmon and Steelhead Hatcheries

Aug 07, 2012

August 7, 2012
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Conservation Agencies and Tribes Complete Scientific Review of California's Salmon and Steelhead Hatcheries

Sacramento - The U.S. Fish and Wildlife Service (Service) today released the findings of a comprehensive scientific review of 19 salmon and steelhead hatchery programs currently operating in the Central Valley of California and on the Klamath and Trinity Rivers. The findings were announced during a briefing at the State-operated Nimbus Fish Hatchery in Gold River, Calif., and involved leaders from the Service, National Marine Fisheries Service (NMFS), California Department of Fish and Game (CDFG) and Hoopa Valley Tribe.

The review was administered through the Pacific States Marine Fisheries Commission in Portland, Oregon. The Service, NMFS, CDFG, Hoopa Valley Tribe, and Yurok Tribe oversaw the review process and production of the final report. The goals of the California Scientific Hatchery Review Project were to provide recommendations to:

- Improve the hatchery operations
- Reduce the impact of hatchery operations on natural salmon and steelhead populations
- Support sustainable commercial, tribal, and recreational fisheries

A panel of 11 fishery scientists and biologists, appointed as the California Hatchery Scientific Review Group (California HSRG), conducted the review, which was directed by Congress in 2010 and funded by the Service. The California HSRG used available scientific information to produce consensus recommendations for changes in hatchery practices. The recommendations include: 1) improving management of broodstock to ensure production of genetically diverse fish appropriate to the program's basin; 2) re-evaluating the size and release strategy of hatchery programs to prevent inappropriately high levels of hatchery returns and to reduce rates of straying; 3) improving incubation, rearing and fish health procedures to increase hatchery survival and reduce the risk of fish disease; 4) increasing monitoring and evaluation of hatchery programs to assess impacts of hatchery programs on natural stocks and determine if programs are meeting their goals; 5) reducing the direct effect of hatchery operations on habitats and organisms within their watersheds.

"These recommendations provide useful guidance to state and federal policy makers, and will inform how salmon and steelhead hatcheries in California are operated," said Dan Castleberry, Assistant Regional Director for Fisheries with Service's Pacific Southwest Region.

California HSRG recommendations address a range of factors, from operating hatcheries themselves to the number of hatchery fish released and monitoring them in the natural environment. Policy makers from agencies and Tribes will use the recommendations to work with the entities that operate hatcheries to implement changes. More information, including the California HSRG's report and recommendations, can be found online at *www.CAhatcheryreview.com*.

With numerous fish species listed as threatened or endangered under the Endangered Species Act, Congress has identified salmon conservation as a high priority. Hatchery program reviews were first completed in Puget Sound and coastal Washington (2004). In 2005, Congress directed NOAA Fisheries to replicate the process in the Columbia River Basin in Oregon, Washington and Idaho.

Salmon and steelhead hatcheries in California include*:*

Coleman National Fish Hatchery – USFWS
Livingston Stone National Fish Hatchery – USFWS
Feather River Hatchery – CDFG
Iron Gate Hatchery – CDFG
Merced River Hatchery – CDFG
Mokelumne River Hatchery – CDFG
Nimbus Fish Hatchery – CDFG
Trinity River Hatchery – CDFG

Agency leaders participating in today's event included Michael Orcutt, Fisheries Department Director, Hoopa Valley Tribe; Charlton H. Bonham, Director, California Department of Fish and Game; Rodney R. McInnis, Regional Administrator, National Marine Fisheries Service, Southwest Region and Ren Lohoefener, Regional Director, U.S. Fish and Wildlife Service, Pacific Southwest Region.

Guideline 5.2.4. Fish ladders used to circumvent barrier weirs or impoundment structures or that provide access to hatchery adult holding ponds should allow adequate capture of appropriate numbers of target species over the full spectrum of the run and limit passage delay and injury to target species and also to non-target organisms as required by in-river fishery management.

Guideline 5.2.5. Limit reach specific impacts of hatchery water diversions, such as diminishment of in-stream flows between diversion and discharge return points.

Guideline 5.2.6. All general facility construction and operations should limit effects on the riparian corridor and be consistent with fluvial geomorphology principles (i.e., avoid bank erosion or undesired channel modification).

- **Standard 5.3: Effluent treatment facilities are secure and operated to meet NPDES requirements.**

- **Standard 5.4: Current facility infrastructure and construction of new facilities avoid creating an unsafe environment for the visiting public and staff and provide adequate precautions (e.g., fencing and signage) where unsafe conditions are noted.**

5. Summary of Hatchery Program Recommendations

Major hatchery program recommendations are highlighted in this section which is organized by hatchery, beginning with facilities in the Klamath-Trinity Basin and proceeding to the Central Valley of California. For each hatchery, we provide facility and program overviews, followed by the California HSRG's major recommendations for each program operated at the hatchery. These recommendations were collaboratively developed by the California HSRG, reflecting facility or operational modifications that we view as necessary to protect and sustain California's salmon and steelhead resources. Appendix VIII includes a full suite of standards for each program along with guidelines that suggest implementation strategies to meet each standard. We note that among situations where program size is reduced or programs eliminated, in no case should such change result in relinquishment of mitigation responsibility.

5.1 Iron Gate Hatchery

Iron Gate Hatchery (IGH) was established in the late 1960s to mitigate for construction of Iron Gate Dam and the anadromous fish habitat lost between Iron Gate and Copco dams. For many years, fish were reared at both the Fall Creek and IGH facilities; however, current production is limited to IGH. IGH is located approximately eight miles east of Hornbrook, California; the primary spawning facility is at the base of Iron Gate Dam at RM 190. Hatchery operation and monitoring is fully funded by PacifiCorp.

Three programs are conducted at IGH, producing coho, fall Chinook and steelhead. Each program is briefly summarized below, followed by sections highlighting the California HSRG's major recommendations for all Iron Gate programs and then program-specific recommendations.

The Southern Oregon / Northern California Coasts coho salmon ESU was classified under the ESA as threatened in 1997. The ESU includes all naturally spawned populations of coho salmon in coastal streams between Cape Blanco, Oregon, and Punta Gorda, California, and the Iron Gate Hatchery, Trinity River Hatchery, and Cole River Hatchery coho programs.

Iron Gate Hatchery Coho Program

The integrated coho program goal is to produce 75,000 smolts at 15 fish per pound (fpp) for release between March 15 and May 1. All juvenile IGH-produced coho salmon are marked with a left maxillary fin clip and released at the hatchery.

Historically, IGH was operated to mitigate for blocked fish habitat; however, recently a conservation focus for the coho program has been deemed necessary to protect the remaining genetic resources of the Upper Klamath River coho population unit (CDFG 2011). Adult coho salmon returns to this population (and to the entire Klamath River) have been declining to the point where less than 60 adult fish returned to the hatchery and Bogus Creek, the largest tributary in this population unit (in terms of measured production) in 2009 (CDFG 2011).

According to the 2011 Draft HGMP, the coho salmon program is operated to protect and conserve the genetic resources of the Upper Klamath River coho population unit. As natural coho salmon production increases over time with implementation of habitat and other recovery actions, it is expected that the program will be operated as an integrated program.

Iron Gate Hatchery Fall Chinook Program

This integrated program at IGH has a goal to produce six million juvenile fall Chinook salmon annually. The production goal is to release 5.1 million subyearlings ("fingerlings", at 90 fpp) between May 1 and June 15 and 900,000 subyearlings ("yearlings", at 10 fpp) between October 15 and November 20. Fall Chinook are marked at a rate of 25 percent (constant fractional marking) with an adipose fin-clip and coded wire-tag, and released at the hatchery site.

Iron Gate Hatchery Steelhead Program

Broodstock for the Iron Gate steelhead program is collected from fish that volitionally enter the fish trap located at the base of the dam and currently includes fish that demonstrate either an anadromous or resident life history. The goal of this integrated program is to produce 200,000 steelhead smolts at 10 fpp for release between March 15 and May 1. All steelhead are released at the hatchery site and all are marked with an adipose fin clip.

During the past decade, the IGH steelhead program has failed to meet mitigation goals. Historically, thousands of steelhead migrated into the upper Klamath River and as late as 1982, juveniles released from IGH comprised up to seven percent of the half-pounder steelhead captured by seining in the lower Klamath River (CDFG unpublished data). Prior to the last decade, several thousand adult steelhead were trapped annually at IGH.

Steelhead production has varied substantially over the years, with a high of approximately 643,000 yearlings released in 1970 to a low of about 11,000 yearlings released in 1997. The 200,000 yearling production goal was met in most years prior to 1991; however, the production goal has not been achieved since that time.

5.1.1 Recommendations for All Iron Gate Hatchery Programs

- Clear goals should be established for the program. Program production goals should be expressed in terms of the number of age-3 ocean recruits just prior to harvest (Chinook), age-3 adults returning to freshwater (coho), and the number of adults and half-pounders returning to freshwater (steelhead).

- Adult holding facilities in hatcheries should be upgraded/expanded to provide adequate space, water flows and temperature regimes to hold the number of adults required for broodstock at high rates of survival (greater than 90 percent). Facilities need to be adequate to hold the expected number of unripe adults for extended periods with minimal hatchery-caused mortality.

- The adult spawning facility is inadequate to meet current needs for fish sorting, spawning and monitoring and should be upgraded.

- All outdoor raceways should be protected from predators with bird netting or similar protection to reduce predation rates on juvenile fish.

- Managers should investigate the feasibility of collecting natural-origin adult fish at alternate locations. The existing trapping location is very limited in its ability to capture fish representing the entire spectrum of life history diversity. Only fish that migrate to the furthest upstream reaches are susceptible to capture.

- Performance standards for each phase of the fish culture process should be established and tracked annually. Summaries of data collected with comparisons to established targets must be included in annual hatchery reports.

- CDFG should develop and promulgate a formal, written fish health policy for operation of its anadromous hatcheries through the Fish and Game Commission policy review process. Hatchery compliance with this policy should be documented annually as part of a Fish Health Management Plan. The current CDFG fish health policy is inadequate to protect native stocks.

- CDFG should develop an updated Hatchery Procedure Manual which includes performance criteria and culture techniques presented in IHOT (1995), Fish Hatchery Management (Wedemeyer 2001) or comparable publications. The fish culture manual (Leitritz and Lewis 1976) is outdated and does not reflect current research and advancements in fish culture.

- A Monitoring and Evaluation Program should be developed and implemented and a Hatchery Coordination Team formed for the program. Implementation of these processes will inform hatchery decisions and document compliance with best management practices defined in this report.

5.1.2 Iron Gate Coho -Major Program Recommendations

The major recommendations of interest to resource managers for the Iron Gate coho salmon hatchery program are provided below. Those selected for presentation may represent major changes in operations, changes in approach or outcomes towards achieving harvest or conservation goals, or will require substantial investment of resources. The California HSRG's evaluation of program compliance with standards and guidelines and the group's comments about this program are presented in their entirety in Appendix VIII.

- The draft HGMP for the IGH coho program should be approved and implemented.

- Mating protocols should be reviewed for consistency with California HSRG recommendations for splitting egg lots.

- Water quality for egg incubation should be improved to remove organic debris and siltation that is likely affecting egg survival. If the air incubation solution tried in 2011 is ineffective, hatchery and fish health staff should continue studies to determine the cause of low egg survival rates.

5.1.3 Iron Gate Fall Chinook- Major Program Recommendations

The major recommendations of interest to resource managers for the Iron Gate fall Chinook salmon hatchery program are provided below. Those selected for presentation may represent major changes in operations, changes in approach or outcomes towards achieving harvest or conservation goals, or will require substantial investment of resource. The California HSRG's evaluation of program compliance with standards and guidelines and the group's comments about this program are presented in their entirety in Appendix VIII.

- Managers should consider changes in the program, including reducing the size of the program, to mitigate disease issues. Large numbers of naturally spawning fish may increase the incidence of *C. shasta* disease through the release of myxospores from carcasses, which in turn increases the probability of perpetuating myxozoan infections in juvenile Chinook and coho salmon in the following spring and summer. We note that in any situation where program size is reduced or programs eliminated, in no case should such change result in relinquishment of mitigation responsibility.

- Natural-origin fish should be incorporated into broodstock at a minimum rate of 10 percent to prevent divergence of the hatchery and natural components of the integrated population. This may require auxiliary adult collection facilities (e.g., Bogus Creek) or alternative collection methods (e.g., seining or trapping).

- Jacks should be incorporated into the broodstock at a rate that does not exceed 50 percent of the total number of jacks encountered during spawning operations and in no case more than 5 percent of the total males spawned.

- Program fish should be 100 percent coded-wire tagged and 25 percent adipose fin-clipped. "Yearling" releases should receive an additional distinguishing external mark or tag (e.g., a ventral fin clip) allowing real-time discrimination from fingerling releases at the adult stage.

- Returning yearling-origin adults should not be used as broodstock. If eggs are collected from or fertilized by such fish, they should be culled soon after spawning. Adequate numbers of fingerlings should be released each year to meet numerical goals for broodstock. When adult returns from fingerling releases are inadequate to satisfy hatchery egg take needs, yearling returns may be used to reduce the deficit.

- CWT releases and recoveries of fall Chinook should be reported annually to RMIS in a timely manner.

- Water quality for egg incubation should be improved to remove organic debris and siltation that is likely affecting egg survival. If the air incubation solution tried in 2011 is ineffective, hatchery and fish health staff should continue studies to determine the cause of low egg survival rates.

5.1.4 Iron Gate Steelhead –Major Program Recommendations

The major recommendations of interest to resource managers for the Iron Gate Hatchery steelhead program are provided below. Those selected for presentation may represent major changes in operations, changes in approach or outcomes towards achieving harvest or conservation goals, or will require substantial investment of resources. The California HSRG's evaluation of program compliance with standards and guidelines and the group's comments about this program are presented in their entirety in Appendix VIII.

- This program should terminate use of the current broodstock and be reestablished with broodstock collected from an off-site location. The program has not consistently produced adequate numbers of anadromous steelhead returning to the hatchery and few adults in the broodstock show evidence of anadromy. The program currently provides little in the way of conservation benefits to the species or harvest benefits to the public.

- Non-anadromous fish typically should not be used as steelhead broodstock.

- The minimum release size for juvenile fish should be at least 8 fpp and a size at release study conducted to refine the release size target. Variability of fish size at release should be reduced.

- Hatchery-origin adult steelhead returns to the hatchery should be treated as follows: (1) unspawned males should be extended reconditioned and released; (2) unspawned females should be stripped of eggs, extended reconditioned and released; and (3) spawned fish should be removed from the system.

- Natural-origin adult steelhead returns to the hatchery, whether spawned or unspawned, should be released. Fish may be reconditioned prior to release.

5.2 Trinity River Hatchery

The Trinity River Division of the Central Valley Project in California included construction of Trinity and Lewiston dams that divert a substantial portion of the river's flow to the Central Valley for agricultural, municipal and industrial uses. Lewiston Dam, completed in 1963, is the upstream limit of anadromy, blocking access to 109 miles of salmon and trout spawning and rearing habitat. Trinity River Hatchery (TRH) was constructed at river mile 110 at the base of Lewiston Dam to mitigate for the loss of this anadromous fish habitat. The Bureau of Reclamation funds operation and maintenance of the TRH, which is operated and managed by the CDFG.

Four anadromous programs are conducted here, producing coho salmon, fall Chinook salmon, spring Chinook salmon and steelhead. Each program is briefly summarized below, followed by sections highlighting the major recommendations for all Trinity River Hatchery programs and then program-specific recommendations.

Mitigation goals for lost adult production were determined from pre-project studies of anadromous fish populations in the basin. The USFWS and CDFG (1956) estimated that 5,000 coho; 3,000 spring Chinook, 8,000 summer Chinook and 24,000 fall Chinook; and 10,000 steelhead (no run timing was designated) passed above the Lewiston Dam site prior to its construction. Total annual adult production goals (catch plus escapement) for TRH were further defined in 1980 to be 7,500 coho, 6,000 spring Chinook, 70,000 fall Chinook and 22,000 steelhead (Frederickson et al. 1980). Escapement goals to the hatchery were further defined in 1983 as 2,100 coho, 3,000 spring Chinook, 9,000 fall Chinook and 10,000 steelhead (USFWS 1983).

The Southern Oregon / Northern California Coasts coho salmon ESU was classified under the ESA as threatened in 1997. The ESU includes all naturally spawned populations of coho salmon in coastal streams between Cape Blanco, Oregon, and Punta Gorda, California, and the Iron Gate Hatchery, Trinity River Hatchery, and Cole River Hatchery coho programs.

Trinity River Hatchery Coho Program

TRH coho salmon broodstock originated from an in-river weir, with some augmentation from out-of-basin sources to boost production. Only endemic Trinity River broodstock have been used at TRH since 1970 (CDFG 2004). Currently, this integrated coho program releases approximately 500,000 yearlings annually at 10 to 20 fpp from March 15 to May 15. All coho are released at the hatchery site and all are marked with a right maxillary fin clip.

Trinity River Hatchery Fall Chinook Program

TRH fall Chinook salmon broodstock originated from an in-river weir when hatchery operations began in 1964. No eggs or fish from outside the basin have been used to supplement this program in at least the last 10 years. This integrated fall Chinook program has a goal to release 2 million subyearlings (“fingerlings”, at 90 fpp) in June and 900,000 subyearlings (“yearlings”, at 10 fpp) in October. Fall Chinook are marked at a rate of 25 percent (constant fractional marking) with an adipose fin-clip and coded wire tag, and released at the hatchery site.

Trinity River Hatchery Spring Chinook Program

As with the fall Chinook program, TRH spring Chinook salmon broodstock originally were collected from an in-river weir in 1964. In the last ten years, no out-of-basin eggs or broodstock have been used to supplement the program. The goal of this integrated program is to release 1 million subyearlings (“fingerlings”, at 90 fpp) in June and 400,000 subyearlings (“yearlings”, at 10 fpp) in October. Spring Chinook are marked at a rate of 25 percent (constant fractional marking) with an adipose fin-clip and coded wire tag, and released at the hatchery site.

Trinity River Hatchery Steelhead Program

Broodstock used in the TRH steelhead program originated from the Trinity River watershed. From 1974 until at least 1994, some eggs were imported from Iron Gate Hatchery; however, no eggs or fish from outside the Trinity River watershed have been used to supplement this program in the last 10 years. This integrated program has a goal to release 800,000 six-inch-long steelhead smolts from March 15 to May 1. All steelhead are marked with an adipose fin clip and released at the hatchery site.

5.2.1 Recommendations for All Trinity River Hatchery Programs

- Natural-origin fish should be incorporated into broodstock at a minimum rate of 10 percent to prevent divergence of the hatchery and natural components of the integrated population. This may require auxiliary adult collection facilities or alternative collection methods (e.g., seining or trapping).

- Adult holding facilities in hatcheries should be upgraded/expanded to provide adequate space, water flows and temperature regimes to hold the number of adults required for broodstock at high rates of survival (more than 90 percent). Facilities need to be adequate to hold the expected number of unripe adults for extended periods with minimal hatchery-caused mortality.

- The adult spawning facility is inadequate to meet current needs for fish sorting, spawning and monitoring and should be upgraded.

- Managers should investigate the feasibility of collecting natural-origin adult fish at alternate locations. The existing trapping location is very limited in its ability to capture fish representing the entire spectrum of life history diversity. Only fish that migrate to the furthest upstream reaches are susceptible to capture.

- Performance standards for each phase of the fish culture process should be established and tracked annually. Summaries of data collected with comparisons to established targets must be included in annual hatchery reports.

- A Monitoring and Evaluation Program should be developed and implemented and a Hatchery Coordination Team formed for the program. Implementation of these processes will inform hatchery decisions and document compliance with best management practices defined in this report.

- Co-managers should develop and promulgate a formal, written fish health policy for the operation of the hatchery. Hatchery compliance with this policy should be documented annually as part of a Fish Health Management Plan. The current fish health policy is inadequate to protect native stocks.

- Co-managers should develop an updated Hatchery Procedure Manual which includes performance criteria and culture techniques presented in IHOT (1995), Fish Hatchery Management (Wedemeyer 2001) or comparable publications. The fish culture manual (Leitritz and Lewis 1976) is outdated and does not reflect current research and advancements in fish culture.

5.2.2 Trinity River Coho- Major Program Recommendations

The major recommendations of interest to resource managers for the Trinity River Hatchery coho program are provided below. Those selected for presentation may represent major changes in operations, changes in approach or outcomes towards achieving harvest or conservation goals, or will require substantial investment of resources. The California HSRG's evaluation of program compliance with standards and guidelines and the group's comments about this program are presented in their entirety in Appendix VIII.

- Co-managers should identify the purposes and goals of this program and determine appropriate program size given existing hatchery escapement goals for hatchery coho salmon, the ESA-listed status of the population, and the tribal trust issues raised by construction of Lewiston and Trinity dams. Adult returns to the hatchery have averaged over 7,000 adults, more than three times the hatchery escapement goal of 2,100 fish.

- Jacks should be incorporated into the broodstock at a rate that does not exceed 50 percent of the total number of jacks encountered during spawning operations and in no case more than 10 percent of the total males spawned.

5.2.3 Trinity River Fall Chinook- Major Program Recommendations

The major recommendations of interest to fisheries managers for the Trinity River fall Chinook salmon hatchery program are provided below. Those selected for presentation may represent major changes in operations, changes in approach or outcomes towards achieving harvest or conservation goals, or will require substantial investment of resources. The California HSRG's evaluation of program compliance with standards and guidelines and the group's comments about this program are presented in their entirety in Appendix VIII.

- Adult collection facilities should be operated throughout the entire temporal migration period of the run and should not exclude fish with particular life history characteristics, except when non-representative broodstock collection is necessary to achieve program goals. Currently, the trap is shut down for a period of approximately two weeks to minimize hybridization between separate spring and fall Chinook. Fish collected during this period should be euthanized without spawning.

- Tag analysis should be used to determine the number of fall and spring Chinook spawned during the suspected period of run overlap (e.g., fish spawned in the last two weeks of spring Chinook spawning and the first two weeks of fall Chinook spawning). Tags should be read and egg lots tracked and eliminated from production as appropriate to reduce introgression of the two runs. Incubation techniques should therefore allow for separation of eggs from individual parents/families (no more than two families per tray).

- Program fish should be 100 percent coded-wire tagged and 25 percent adipose fin-clipped. "Yearling" releases should receive an additional distinguishing external mark or tag (e.g., a ventral fin clip) allowing real-time discrimination from fingerling releases at the adult stage.

- Returning yearling-origin adults should not be used as broodstock. If eggs are collected from or fertilized by such fish, they should be culled soon after spawning. Adequate numbers of fingerlings should be released each year to meet numerical goals for broodstock. When adult returns from fingerling releases are inadequate to satisfy hatchery egg take needs, yearling returns may be used to reduce the deficit.

- CWT releases and recoveries of fall Chinook should be reported annually to RMIS in a timely manner.

- Jacks should be incorporated into the broodstock at a rate that does not exceed 50 percent of the total number of jacks encountered during spawning operations and in no case more than 5 percent of the total males spawned.

- Fish growth trajectories need to be monitored more closely to achieve the identified release target of 90 fpp for fingerlings and 10 fpp for yearlings. Data supplied by the hatchery indicate that average release size for the two respective groups has been 108 fpp and 15.4 fpp from 2000-2010.

5.2.4 Trinity River Spring Chinook- Major Program Recommendations

The major recommendations of interest to resource managers for the Trinity River spring Chinook salmon hatchery program are provided below. Those selected for presentation may represent major changes in operations, changes in approach or outcomes towards achieving harvest or conservation goals, or will require substantial investment of resources. The California HSRG's evaluation of program

compliance with standards and guidelines and the group's comments about this program are presented in their entirety in Appendix VIII.

- Adult collection facilities should be operated throughout the entire temporal migration period of the run and should not exclude fish with particular life history characteristics, except when non-representative broodstock collection is necessary to achieve program goals. Currently, the trap is shut down for a period of approximately two weeks to minimize hybridization between separate spring and fall Chinook. Fish collected during this period should be euthanized without spawning.

- Tag analysis should be used to determine the number of fall and spring Chinook spawned during the suspected period of run overlap (e.g., fish spawned in the last two weeks of spring Chinook spawning and the first two weeks of fall Chinook spawning). Tags should be read and egg lots tracked and eliminated from production as appropriate to reduce introgression of the two runs. Incubation techniques should therefore allow for separation of eggs from individual parents/families (no more than two families per tray).

- Program fish should be 100 percent coded wire tagged and 25 percent adipose fin-clipped. "Yearling" releases should receive an additional distinguishing external mark or tag (e.g., a ventral fin clip) allowing real-time discrimination from fingerling releases at the adult stage.

- Returning yearling-origin adults should not be used as broodstock. If eggs are collected from or fertilized by such fish, they should be culled soon after spawning. Adequate numbers of fingerlings should be released each year to meet numerical goals for broodstock. When adult returns from fingerling releases are inadequate to satisfy hatchery egg take needs, yearling returns may be used to reduce the deficit.

- CWT releases and recoveries of fall Chinook should be reported annually to RMIS in a timely manner.

- Jacks should be incorporated into the broodstock at a rate that does not exceed 50 percent of the total number of jacks encountered during spawning operations and in no case more than 5 percent of the total males spawned.

- Fish growth trajectories need to be monitored more closely to achieve identified release size targets.

5.2.5 Trinity River Steelhead- Major Program Recommendations

The major recommendations of interest to resource managers for the Trinity River Hatchery steelhead program are provided below. Those selected for presentation may represent major changes in operations, changes in approach or outcomes towards achieving harvest or conservation goals, or will require substantial investment of resources. The California HSRG's evaluation of program compliance with standards and guidelines and the group's comments about this program are presented in their entirety in Appendix VIII.

- Program goals should be measured as the number of anadromous hatchery-origin steelhead adults and half-pounders returning to freshwater each year. Adult steelhead mitigation goals for the program are described in various historical non-hatchery related documents. It does not appear that the program is operated to achieve these goals or adjusted if goals are not achieved.

- Hatchery-origin adult steelhead returns to the hatchery should be treated as follows: (1) unspawned males should be extended reconditioned and released; (2) unspawned females should be stripped of eggs, extended reconditioned and released; and (3) spawned fish should be removed from the system.

- Natural-origin adult steelhead returns to the hatchery, whether spawned or unspawned, should be released. Fish may be reconditioned prior to release.

5.3 Nimbus Fish Hatchery

Nimbus Fish Hatchery (NFH) was constructed in 1955 at RM 22 of the American River, approximately 0.25 mile downstream of Nimbus Dam. Hatchery operation helps fulfill mitigation requirements for construction of Nimbus Dam as described in the "Contract between the United States and the State of California for the Operation of the Nimbus Fish Hatchery" (Reclamation 1956). Mitigation is provided for the American River reach between Nimbus and Folsom dams; it does not address lost habitat upstream from Folsom Dam. The CDFG operates a fall Chinook salmon and a steelhead program here. Each program is briefly summarized below, followed by sections highlighting the California HSRG's major recommendations for all Nimbus programs and then the program-specific recommendations.

The Central Valley fall/late fall-run Chinook salmon ESU was classified as a federal Species of Concern in 2004. The ESU includes all naturally spawned populations of fall-run Chinook salmon in the Sacramento and San Joaquin rivers and their tributaries, east of the Carquinez Strait.

The Central Valley steelhead DPS was classified under the ESA as threatened in 1998. The DPS includes all naturally spawned anadromous steelhead populations below natural and manmade impassable barriers in the Sacramento and San Joaquin rivers and their tributaries, east of the Carquinez Strait, and the Feather River Hatchery and Coleman National Fish Hatchery steelhead programs.

Nimbus Fall Chinook Program

The goal of the integrated fall Chinook program at NFH is to release four million smolts that average 60 fpp or larger. These fish are marked at a rate of 25 percent (constant fractional marking) with an adipose fin-clip and coded wire tag and then all are released in San Pablo Bay between mid-May and mid-June.

Nimbus Steelhead Program

The NFH segregated winter steelhead program traps and artificially spawns adult steelhead marked with an adipose fin clip. Unmarked fish are not included in the broodstock and are released back to the river. Broodstock has been derived from a number of different populations and presently appears to cluster genetically most closely with Eel River steelhead. Nielson et al. (2005) reported that juvenile fish from the lower American River and NFH were genetically similar in microsatellite allelic frequencies. Garza and Pearse (2008) reported similar results for fish sampled from the lower American River and NFH.

The program has a juvenile release goal of 430,000 yearling steelhead (at 4 fpp). All NFH steelhead are marked with an adipose fin clip. Fish are released from January through February approximately one mile above the confluence of the American and Sacramento rivers (at Jibboom Street) to reduce predation on natural-origin Chinook fry.

5.3.1 Recommendations for All Nimbus Hatchery Programs

- Clear goals should be established for the program. Program production goals should be expressed in terms of the number of age-3 ocean recruits just prior to harvest (Chinook salmon), and the number of adults returning to freshwater (steelhead).

- Managers should investigate the feasibility of collecting natural-origin adult fish at alternate locations. The existing trapping location is very limited in its ability to capture fish representing the entire spectrum of life history diversity. Only fish that migrate to the furthest upstream reaches are susceptible to capture.

- Adult holding facilities should be upgraded and/or expanded to provide adequate space, water flows and temperature regimes to hold the number of adults required for broodstock at high rates of survival (greater than 90 percent).

- Transporting and releasing juveniles to areas outside of the American River or to the lower American River should be discontinued. Juvenile fish should be released at the hatchery, or if not possible, as far upstream in the American River from the confluence of the Sacramento River as possible to reduce adult straying and increase the number of adults returning to the hatchery. Consider necessary facility modifications or equipment purchases that will facilitate on-site releases. Release locations for steelhead may take into consideration ecological and predation effects on other fish populations but should not compromise homing of adults to the hatchery.

- Performance standards for each phase of the fish culture process should be established and tracked annually. Summaries of data collected with comparisons to established targets must be included in annual hatchery reports.

- A Monitoring and Evaluation Program should be developed and implemented and a Hatchery Coordination Team formed for the program. Implementation of these processes will inform hatchery decisions and document compliance with best management practices defined in this report.

- CDFG should develop and promulgate a formal, written fish health policy for operation of its anadromous hatcheries through the Fish and Game Commission policy review process. Hatchery compliance with this policy should be documented annually as part of a Fish Health Management Plan. The current CDFG fish health policy is inadequate to protect native stocks.

- CDFG should develop an updated Hatchery Procedure Manual which includes performance criteria and culture techniques presented in IHOT (1995), Fish Hatchery Management (Wedemeyer 2001) or comparable publications. The fish culture manual (Leitritz and Lewis 1976) is outdated and does not reflect current research and advancements in fish culture.

5.3.2 Nimbus Fall Chinook- Major Program Recommendations

The major recommendations of interest to resource managers for the NFH fall Chinook salmon program are provided below. Those selected for presentation may represent major changes in operations, changes in approach or outcomes towards achieving harvest or conservation objectives, or will require substantial investment of resources. The California HSRG's evaluation of program compliance with standards and guidelines and the group's comments about this program are presented in their entirety in Appendix VIII.

- Natural-origin fish should be incorporated into broodstock at a minimum rate of 10 percent to prevent divergence of the hatchery and natural components of the integrated population. This may require auxiliary adult collection facilities or alternative collection methods (e.g., seining or trapping).

- Until all off-site releases of Chinook salmon are eliminated in the entire Central Valley, coded-wire tag analysis should be used to identify stray hatchery-origin fish among those fish selected for broodstock. Strays from other hatchery programs should not be used as broodstock, or if eggs are collected from or fertilized by such fish, they should be culled soon after spawning.

- Program fish should be 100 percent coded wire-tagged and 25 percent adipose fin-clipped.

- The cause of the low egg-to-juvenile release survival rate (43.6 percent) should be determined.

5.3.3 Nimbus Steelhead Program- Major Recommendations

The major recommendations of interest to resource managers for the NFH steelhead program are provided below. Those selected for presentation may represent major changes in operations, changes in approach or outcomes towards achieving harvest or conservation objectives, or will require substantial investment of resources. The California HSRG's evaluation of program compliance with standards and guidelines and the group's comments about this program are presented in their entirety in Appendix VIII.

- The current broodstock for this program should be replaced with an alternative broodstock that is appropriate for the American River.

- Non-anadromous (resident) or unmarked fish should not be used as broodstock and the current 16-inch minimum length for broodstock should be continued. This recommendation to not use unmarked fish will no longer apply once the current broodstock is replaced.

- Because Nimbus steelhead currently are not part of the Central Valley steelhead Distinct Population Segment, all juvenile fish released should receive an adipose fin-clip plus an additional distinguishing external mark (non-adipose fin clip) or CWT, until a native broodstock is established. This additional distinguishing mark or tag will ensure that if these fish return to another hatchery, they can be excluded from its broodstock.

- With the current broodstock, all hatchery-origin adult steelhead returns to the hatchery, whether spawned or unspawned, should be removed from the system. With a native broodstock, hatchery-origin adult steelhead returns to the hatchery should be treated as follows: (1) unspawned males should be extended reconditioned and released; (2) unspawned females should be stripped of eggs, extended reconditioned and released; and (3) spawned fish should be removed from the system, or extended reconditioned and released.

- Natural-origin adult steelhead returns to the hatchery, whether spawned or unspawned, should be released. Fish may be reconditioned prior to release.

- An alternative cold-water source should be developed to reduce summer rearing water temperatures.

- The cause of the low egg-to-juvenile release survival rate (24.5 percent) should be determined. It is suspected that the low value is a result of egg-culling practices; however, this cannot be confirmed because of the way data are collected and reported.

5.4 Mokelumne River Hatchery

The Mokelumne River Fish Hatchery (MRFH) is located on the lower Mokelumne River just downstream of Camanche Dam. Funding for hatchery operations is provided by the East Bay Municipal Utility District (EBMUD) while the hatchery is operated and managed by the CDFG. The fall Chinook and steelhead hatchery programs were originally designed to comply with the 1961 requirements of the California State Water Resources Control Board. The 1961 agreement and related amendments directed the construction of a hatchery to rear 100,000 juvenile salmon and spawning channels with a capacity for up to 15 million Chinook salmon eggs.

In March 1998, EBMUD, CDFG and the USFWS entered into an agreement to resolve various FERC relicensing and state water right issues. EBMUD agreed to fund an expansion and upgrade of the MRFH as an integral part of a strategy to supplement the natural production and to meet the mitigation requirement for anadromous fish in the lower Mokelumne River. Hatchery reconstruction was completed in 2002. The fall Chinook salmon and steelhead programs are briefly summarized below, followed by sections highlighting the California HSRG's major recommendations for both Mokelumne programs and then the program-specific recommendations.

The Central Valley fall/late fall-run Chinook salmon ESU was classified as a federal Species of Concern in 2004. The ESU includes all naturally spawned populations of fall-run Chinook salmon in the Sacramento and San Joaquin rivers and their tributaries, east of the Carquinez Strait.

The Central Valley steelhead DPS was classified under the ESA as threatened in 1998. The DPS includes all naturally spawned anadromous steelhead populations below natural and manmade impassable barriers in the Sacramento and San Joaquin rivers and their tributaries, east of the Carquinez Strait, and the Feather River Hatchery and Coleman National Fish Hatchery steelhead programs.

Mokelumne Fall Chinook Program

The integrated fall Chinook program at MRFH has a goal to release up to five million fall-run Chinook salmon smolts that average 60 fpp or larger for harvest purposes. Approximately two million additional Chinook are raised to post-smolt size (45 fpp) each year for an ocean enhancement program. All of the enhancement salmon production is released into San Pablo Bay or reared in net pens on the coast. Remaining Mokelumne-origin salmon smolts are released below Woodbridge Dam, about 10 miles downstream of the hatchery. Juvenile fall Chinook are released between March and June and all fish are marked at a rate of 25 percent (constant fractional marking) with an adipose fin-clip and coded wire tag.

Mokelumne Steelhead Program

The integrated steelhead program at Mokelumne has a goal to release 250,000 yearling steelhead at 4 fpp. The program has been experimenting with small releases (less than 2,000 fish) of two-year-old steelhead juveniles using a "natures" rearing strategy (i.e., presence of structure, low rearing density, shallow pond depth, cover and colored raceways). All steelhead are released from February through March and are marked with an adipose fin clip. Steelhead are released at New Hope Landing, approximately 10.5 miles downstream from the confluence of the Mokelumne and Consumes rivers.

5.4.1 Recommendations for All Mokelumne River Hatchery Programs

- Clear goals should be established for the program. Program production goals should be expressed in terms of the number of age-3 ocean recruits just prior to harvest (Chinook salmon), and the number of adults returning to freshwater (steelhead).

- Broodstock for the program should only come from native, locally adapted stocks. Out-of-subbasin importation of eggs, juveniles or adults should not occur, even if it means juvenile production targets will not be achieved in some years. Work with water managers to improve conditions for migrating juveniles and adults.

- Transporting and releasing juveniles to areas outside of the Mokelumne River should be discontinued. Juvenile fish should be released at the hatchery, or if not possible, as far upstream in the Mokelumne River from the confluence of the Sacramento River as possible to reduce adult straying and increase the number of adult fish returning to the hatchery. Consider necessary facility modifications or equipment purchases that will facilitate on-site releases. Release locations for steelhead may take into consideration ecological and predation effects on other fish populations but should not compromise homing of adults to the hatchery.

- Performance standards for each phase of the fish culture process should be established and tracked annually. Summaries of data collected with comparisons to established targets must be included in annual hatchery reports.

- Managers should investigate the feasibility of collecting natural-origin adult fish at alternate locations. The existing trapping location is very limited in its ability to capture fish representing the entire spectrum of life history diversity. Only fish that migrate to the furthest upstream reaches are susceptible to capture.

- A Monitoring and Evaluation Program should be developed and implemented and a Hatchery Coordination Team formed for the program. Implementation of these processes will inform hatchery decisions and document compliance with best management practices defined in this report.

- CDFG should develop and promulgate a formal, written fish health policy for operation of its anadromous hatcheries through the Fish and Game Commission policy review process. Hatchery compliance with this policy should be documented annually as part of a Fish Health Management Plan. The current CDFG fish health policy is inadequate to protect native stocks.

- CDFG should develop an updated Hatchery Procedure Manual which includes performance criteria and culture techniques presented in IHOT (1995), Fish Hatchery Management (Wedemeyer 2001) or comparable publications. The fish culture manual (Leitritz and Lewis 1976) is outdated and does not reflect current research and advancements in fish culture.

5.4.2 Mokelumne River Fall Chinook- Major Program Recommendations

The major recommendations of interest to resource managers for the Mokelumne fall Chinook salmon hatchery program are provided below. Those selected for presentation may represent major changes in operations, changes in approach or outcomes towards achieving harvest or conservation objectives, or will require substantial investment of resources. The California HSRG's evaluation of program

compliance with standards and guidelines and the group's comments about this program are presented in their entirety in Appendix VIII.

- Natural-origin fish should be incorporated into broodstock at a minimum rate of 10 percent to prevent divergence of the hatchery and natural components of the integrated population. This may require auxiliary adult collection facilities or alternative collection methods (e.g., seining or trapping).

- Until all off-site releases of Chinook salmon are eliminated in the entire Central Valley, coded-wire tag analysis should be used to identify stray hatchery-origin fish among those fish selected for broodstock. Strays from other hatchery programs should not be used as broodstock, or if eggs are collected from or fertilized by such fish, they should be culled soon after spawning.

- Program fish should be 100 percent coded wire-tagged and 25 percent adipose fin-clipped. "Yearling" releases should receive an additional distinguishing external mark or tag (e.g., a ventral fin clip) allowing real-time discrimination from fingerling releases at the adult stage.

- Returning yearling-origin adults should not be used as broodstock. If eggs are collected from or fertilized by such fish, they should be culled soon after spawning. Adequate numbers of fingerlings should be released each year to meet numerical goals for broodstock. When adult returns from fingerling releases are inadequate to satisfy hatchery egg take needs, yearling returns may be used to reduce the deficit.

5.4.3 Mokelumne River Steelhead- Major Program Recommendations

The major recommendations of interest to resource managers for the Mokelumne steelhead hatchery program are provided below. Those selected for presentation may represent major changes in operations, changes in approach or outcomes toward achieving harvest or conservation goals, or will require substantial investment of resources. The California HSRG's evaluation of program compliance with standards and guidelines and the group's comments about this program are presented in their entirety in Appendix VIII.

- Non-anadromous (resident) or unmarked fish typically should not be used as broodstock and the current 16-inch minimum length for broodstock should be continued.

- Hatchery-origin adult steelhead returns to the hatchery should be treated as follows: (1) unspawned males should be extended reconditioned and released; (2) unspawned females should be stripped of eggs, extended reconditioned and released; and (3) spawned fish should be removed from the system, or extended reconditioned and released.

- Natural-origin adult steelhead returns to the hatchery, whether spawned or unspawned, should be released. Fish may be reconditioned prior to release.

5.5 Merced River Hatchery

Merced River Hatchery (MRH) is located just below Crocker-Huffman Dam (the terminus of anadromy), north of Fresno. The original fish facility, completed in 1970 by the Merced Irrigation District (MID), was a Chinook salmon spawning channel designed to enhance salmon runs. To increase production, the facility was converted into a spawning and rearing hatchery during the 1980s and 1990s. Operational funding is provided by the CDFG and the MID; CDFG operates and maintains the hatchery. Fall Chinook salmon are the only species reared at Merced Hatchery.

The fall Chinook salmon program at MRH is considered an experimental program to test juvenile to adult survival rates for various release sites in the basin. The original purpose of the program was to mitigate for lost habitat from the construction of the Crocker-Huffman, Merced Falls, and Exchequer dams. This was to be achieved by producing 960,000 fall Chinook smolts and 330,000 yearlings. The yearling program was discontinued due to high fish losses from proliferative kidney disease (PKD), caused by *Tetracapsuloides bryosalmonae*, an endemic myxozoan parasite in the Merced River.

Current production goals for the integrated fall Chinook program are to take two million fall Chinook eggs and release one million smolts at 60 fpp (80 mm fork length) between late April and mid-May. Most releases of Merced River fall Chinook salmon are for experimental purposes. These fish have been marked (adipose fin-clipped, panjet marked) and coded wire tagged, and the remaining fish are currently marked at a 25 percent constant fractional marking rate with an adipose fin-clip and coded wire tag. Fall Chinook are released at the hatchery, at lower Merced River locations, and at various locations in the San Joaquin River and further downstream.

The Central Valley fall/late fall-run Chinook salmon ESU was classified as a federal Species of Concern in 2004. The ESU includes all naturally spawned populations of fall-run Chinook salmon in the Sacramento and San Joaquin rivers and their tributaries, east of the Carquinez Strait.

5.5.1 Merced River Fall Chinook- Major Program Recommendations

The major recommendations of interest to resource managers for the Merced fall Chinook salmon hatchery program are provided below. Those selected for presentation may represent major changes in operations, changes in approach or outcomes towards achieving harvest or conservation objectives, or will require substantial investment of resources. The California HSRG's evaluation of program compliance with standards and guidelines and the group's comments about this program are presented in their entirety in Appendix VIII.

A clear purpose and goal should be established for the program that appears to be dual purpose: experimentation and mitigation. If managers determine that the facility is to be operated for experimental purposes, operational guidelines should be developed consistent with the experiments being undertaken. If managers determine that the hatchery will be operated as a production hatchery to meet mitigation objectives identified in the program description, applicable hatchery standards and guidelines developed by the California HSRG, including the following recommendations should be implemented:

- Transporting and releasing juveniles to areas outside of the Merced River should be discontinued. Juvenile fish should be released at the hatchery, or if not possible, as far upstream in the Merced River from the confluence of the San Joaquin River as possible to reduce adult straying and increase the number of adult fish returning to the hatchery. Consider necessary facility modifications or equipment purchases that will facilitate on-site releases. Release locations for steelhead may take into consideration ecological and predation effects on other fish populations but should not compromise homing of adults to the hatchery.

- Performance standards for each phase of the fish culture process should be established and tracked annually. Summaries of data collected with comparisons to established targets must be included in annual hatchery reports.

- Broodstock for the program should only come from native, locally adapted stocks. Out-of-subbasin importation of eggs, juveniles or adults should not occur, even if it means juvenile production targets will not be achieved in some years.

- Natural-origin fish should be incorporated into broodstock at a minimum rate of 10 percent to prevent divergence of the hatchery and natural components of the integrated population. This may require auxiliary adult collection facilities or alternative collection methods (e.g., seining or trapping).

- Until all off-site releases of Chinook salmon are eliminated in the entire Central Valley, coded wire tag analysis should be used to identify stray hatchery-origin fish among those fish selected for broodstock. Strays from other hatchery programs should not be used as broodstock, or if eggs are collected from or fertilized by such fish, they should be culled soon after spawning.

- Program fish should be 100 percent coded wire-tagged and 25 percent adipose fin-clipped.

- Managers should investigate the feasibility of collecting natural-origin adult fish at alternate locations. The existing trapping location is very limited in its ability to capture fish representing the entire spectrum of life history diversity. Only fish that migrate to the furthest upstream reaches are susceptible to capture.

- A Monitoring and Evaluation Program should be developed and implemented and a Hatchery Coordination Team formed for the program. Implementation of these processes will inform hatchery decisions and document compliance with best management practices defined in this report.

- CDFG should develop and promulgate a formal, written fish health policy for operation of its anadromous hatcheries through the Fish and Game Commission policy review process. Hatchery compliance with this policy should be documented annually as part of a Fish Health Management Plan. The current CDFG fish health policy is inadequate to protect native stocks.

- CDFG should develop an updated Hatchery Procedure Manual which includes performance criteria and culture techniques presented in IHOT (1995), Fish Hatchery Management (Wedemeyer 2001) or comparable publications. The fish culture manual (Leitritz and Lewis 1976) is outdated and does not reflect current research and advancements in fish culture.

5.6 Feather River Hatchery

In 1960, California voters authorized the Department of Water Resources (DWR) to construct and operate the State Water Project. Oroville Dam and Reservoir on the Feather River were completed in 1968 and are essential components of this development, providing water storage, hydroelectric power, flood control, and recreational benefits. The dam is five miles east of the City of Oroville. Feather River Hatchery (FRH) is a component of the Oroville Project that was constructed in the mid-1960s to mitigate for blocked Chinook salmon and steelhead spawning habitat. FRH is located downstream of Oroville

Dam and about 66 miles upstream from the confluence of the Feather and Sacramento rivers. An additional facility, the FRH Annex, is located 11 miles downstream adjacent to the Thermalito Afterbay.

The CDFG operates and maintains FRH under contract with the DWR. Although there are no other agencies, tribes, or cooperators directly involved in operating FRH, one advisory group, the Feather River Technical Team, advises FRH personnel on the integration of hatchery operations with management of the salmonid fisheries below Oroville Dam. Three programs are conducted here, producing fall Chinook, spring Chinook and steelhead. Each program is briefly summarized below, followed by sections highlighting the California HSRG's major recommendations for all Nimbus programs and then the program-specific recommendations.

The Central Valley fall/late fall-run Chinook salmon ESU was classified as a federal Species of Concern in 2004. The ESU includes all naturally spawned populations of fall-run Chinook salmon in the Sacramento and San Joaquin rivers and their tributaries, east of the Carquinez Strait.

The Central Valley spring-run Chinook salmon ESU was classified under the ESA as threatened in 1999. The ESU includes all naturally spawned populations of spring-run Chinook salmon in the Sacramento River and its tributaries, and the FRH spring-run Chinook salmon program.

The Central Valley steelhead DPS was classified under the ESA as threatened in 1998. The DPS includes all naturally spawned anadromous steelhead populations below natural and manmade impassable barriers in the Sacramento and San Joaquin rivers and their tributaries, east of the Carquinez Strait, and the Feather River Hatchery and Coleman National Fish Hatchery steelhead programs.

Feather River Hatchery Fall Chinook

This integrated program traps and spawns fall-run Chinook salmon from the Feather River for rearing and release as juveniles. There are no specific goals for the number of adult Chinook salmon annually trapped or artificially spawned; however, the production goal is to release six million fall-run Chinook salmon smolts that are 60 fpp or larger. Up to two million additional fish may be reared as part of a separate ocean enhancement program. The size at release goal for enhancement program fish is 30 fpp or larger. With the exception of some small on-site experimental releases, Chinook smolts are all released into the Carquinez Straits between April and June. Feather River fall Chinook are currently marked at a 25 percent rate (constant fractional marking) with an adipose fin-clip and a coded wire-tag.

Feather River Hatchery Spring Chinook

The spring Chinook salmon program at Feather River has two components with different purposes: (1) an integrated harvest program to mitigate for lost habitat and juvenile fish production in the Feather River; and (2) an integrated conservation program to aid in the recovery and conservation of spring Chinook salmon from Deer, Mill and Butte creeks. Adult hatchery-produced spring Chinook are intended to spawn naturally or to be genetically integrated with the natural population through artificial propagation. There are no specific goals for the number of adult spring Chinook produced by this program; however, the juvenile production goal is to release two million smolts sized at 60 fpp during April or May. Juvenile hatchery-produced spring Chinook are currently 100 percent marked with an adipose fin-clip and a coded wire-tag. These fish are all released into the Feather River south of Yuba City at the Boyd's Pump Boat Launch (44 miles downstream of the hatchery).

Feather River Hatchery Steelhead

The FRH steelhead program is an integrated harvest program that traps and artificially spawns both marked hatchery-origin and unmarked natural-origin steelhead. Only a few unmarked fish are trapped annually. FRH steelhead are intended to migrate to the ocean and return to provide recreational fishing opportunities and hatchery broodstock as mitigation for lost habitat and juvenile fish production capacity resulting from construction of Oroville Dam. From 1968 through 1987, steelhead eggs from Nimbus, Iron Gate and Skamania hatcheries were transferred to FRH and the juvenile fish reared and released. Since then, only fish returning to the Feather River Basin have been used for broodstock.

There are no specific goals for the number of adult steelhead produced by this program; however, the juvenile production goal is to release 450,000 yearling steelhead annually at three fpp during late January or February. Excluding the past three seasons, hatchery personnel have taken approximately 1.5 million eggs to produce 450,000 juveniles. During the past three seasons, the number of adults trapped and eggs taken have decreased dramatically to less than 615,000 eggs with a commensurate decrease in the number of fish released.

All FRH steelhead are marked with an adipose fin-clip prior to release. These fish are all released into the Feather River south of Yuba City at the Boyd's Pump Boat Launch (44 miles downstream of the hatchery) or at the confluence of the Feather and Sacramento rivers (Verona Marina).

5.6.1 Recommendations for All Feather River Hatchery Programs

- Clear goals should be established for the program. Program production goals should be expressed in terms of the number of age-3 ocean recruits just prior to harvest (Chinook salmon), and the number of adults returning to freshwater (steelhead).

- Transporting and releasing juveniles to areas outside of the Feather River and near or downstream of the confluence of the Yuba River should be discontinued. Juvenile fish should be released at the hatchery, or if not possible, as far upstream in the Feather River from the confluence of the Yuba River as possible to reduce adult straying and increase the number of adult fish returning to the hatchery. Consider necessary facility modifications or equipment purchases that will facilitate on-site releases. Release locations for steelhead may take into consideration ecological and predation effects on other fish populations but should not compromise homing of adults to the hatchery.

- Managers should investigate the feasibility of collecting natural-origin adult fish at alternate locations. The existing trapping location is very limited in its ability to capture fish representing the entire spectrum of life history diversity. Only fish that migrate to the furthest upstream reaches are susceptible to capture.

- Adult holding facilities should be upgraded and/or expanded to provide adequate space, water flows and temperature regimes to hold the number of adults required for broodstock at high rates of survival (greater than 90 percent). In addition, because of a lack of adult holding space, fall Chinook are returned to the river to make room for late arriving spring Chinook. Evaluate the prospects of using the Thermalito Annex Facility for the long-term holding of spring Chinook broodstock. While the Annex water temperature is relatively high, a pilot study could be used to determine whether any associated increased holding mortality was sufficiently offset by the Annex's otherwise excellent water quality.

- Natural-origin fish should be incorporated into broodstock at a minimum rate of 10 percent to prevent divergence of the hatchery and natural components of the integrated population. This may require auxiliary adult collection facilities or alternative collection methods (e.g., seining or trapping).

- A Monitoring and Evaluation Program should be developed and implemented and a Hatchery Coordination Team formed for the program. Implementation of these processes will inform hatchery decisions and document compliance with best management practices defined in this report.

- Performance standards for each phase of the fish culture process should be established and tracked annually. Summaries of data collected with comparisons to established targets must be included in annual hatchery reports.

- CDFG should develop and promulgate a formal, written fish health policy for operation of its anadromous hatcheries through the Fish and Game Commission policy review process. Hatchery compliance with this policy should be documented annually as part of a Fish Health Management Plan. The current CDFG fish health policy is inadequate to protect native stocks.

- CDFG should develop an updated Hatchery Procedure Manual which includes performance criteria and culture techniques presented in IHOT (1995), Fish Hatchery Management (Wedemeyer 2001) or comparable publications. The fish culture manual (Leitritz and Lewis 1976) is outdated and does not reflect current research and advancements in fish culture.

5.6.2 Feather River Fall Chinook- Major Program Recommendations

The major recommendations of interest to resource managers for the Feather River fall Chinook salmon hatchery program are provided below. Those selected for presentation may represent major changes in operations, changes in approach or outcomes towards achieving harvest or conservation objectives, or will require substantial investment of resources. The California HSRG's evaluation of program compliance with standards and guidelines and the group's comments about this program are presented in their entirety in Appendix VIII.

- Use of the Feather River Annex for rearing should be discontinued unless juveniles are released in the vicinity of the Annex and an adult collection facility is installed in the downstream outlet of the Thermalito Afterbay.

- The program should limit the number of eggs taken to the number necessary to meet production goals (which would include a reasonable overage to account for egg loss and culling of spring x fall crosses). On average, the program takes about 20 million eggs to produce 6 million juveniles.

- Tag analysis should be used to determine the fall and spring hatchery-origin Chinook spawned during the suspected period of run overlap (e.g., fish spawned in the last two weeks of spring Chinook spawning and the first two weeks of fall Chinook spawning). Tags should be read and egg lots tracked and eliminated from production as appropriate to reduce introgression of the two runs. Incubation techniques should therefore allow for separation of eggs from individual parents/families (no more than two families per tray).

- Only unmarked fish should be spawned in the fall brood (FRH spring Chinook are 100 percent adipose fin-clipped, FRH fall Chinook are 25 percent adipose fin-clipped) to reduce the need for culling. Any spring x fall Chinook crosses of hatchery-origin fish (e.g., due to marking or mark detection errors) should be identified by coded wire-tag analysis and eggs should be culled soon after spawning.

- Until all off-site releases of Chinook salmon are eliminated in the entire Central Valley, coded wire tag analysis should be used to identify stray hatchery-origin fish among those fish selected for broodstock. Strays from other hatchery programs should not be used as broodstock, or if eggs are collected from or fertilized by such fish, they should be culled soon after spawning.

- Program fish should be 100 percent coded wire-tagged and 25 percent adipose fin-clipped.

5.6.3 Feather River Spring Chinook- Major Program Recommendations

The major recommendations of interest to resource managers for the Feather spring Chinook salmon hatchery program are provided below. Those selected for presentation may represent major changes in operations, changes in approach or outcomes towards achieving harvest or conservation goals, or will require substantial investment of resources. The California HSRG's evaluation of program compliance with standards and guidelines and the group's comments about this program are presented in their entirety in Appendix VIII.

- Tag analysis should be used to determine the number of fall and spring Chinook spawned during the suspected period of run overlap (e.g., fish spawned in the last two weeks of spring Chinook spawning and the first two weeks of fall Chinook spawning). Tags should be read and egg lots tracked and eliminated from production as appropriate to reduce introgression of the two runs. Incubation techniques should therefore allow for separation of eggs from individual parents/families (no more than two families per tray).

- Until all off-site releases of Chinook salmon are eliminated in the entire Central Valley, coded wire tag analysis should be used to identify stray hatchery-origin fish among those fish selected for broodstock. Strays from other hatchery programs should not be used as broodstock, or if eggs are collected from or fertilized by such fish, they should be culled soon after spawning.

5.6.4 Feather River Steelhead- Major Program Recommendations

The major recommendations of interest to resource managers for the Feather River steelhead hatchery program are provided below. Those selected for presentation may represent major changes in operations, changes in approach or outcomes towards achieving harvest or conservation goals, or will require substantial investment of resources. The California HSRG's evaluation of program compliance with standards and guidelines and the group's comments about this program are presented in their entirety in Appendix VIII.

- A Hatchery Coordination Team should be established to review the status of the FRH steelhead program.

- The number of eggs taken annually should be reduced to a level appropriate to produce 450,000 juveniles and the transfer of eggs to other programs terminated. Collection of excess eggs is permissible to increase effective population size as long as culling is done representatively.

- Broodstock for the program should only come from native, locally adapted stocks. Out-of-subbasin importation of eggs, juveniles or adults should not occur, even if it means juvenile production targets will not be achieved in some years.

- Non-anadromous (resident) fish should not be used as broodstock and the current 16-inch minimum length for broodstock should be continued.

- Hatchery-origin adult steelhead returns to the hatchery should be treated as follows: (1) unspawned males should be extended reconditioned and released; (2) unspawned females should be stripped of eggs, extended reconditioned and released; and (3) spawned fish should be removed from the system, or extended reconditioned and released.

- Natural-origin adult steelhead returns to the hatchery, whether spawned or unspawned, should be released. Fish may be reconditioned prior to release.

5.7 Coleman National Fish Hatchery

Coleman National Fish Hatchery (NFH) was completed by the USBR in 1943 to partially mitigate for habitat and fish losses caused by construction of two Central Valley Project features, Shasta and Keswick dams. The hatchery is funded by the USBR and operated by the USFWS. Coleman NFH occupies 75 acres adjacent to Battle Creek, a tributary to the Sacramento River, about 20 miles southeast of Redding.

Shasta Dam blocks 187 miles of salmonid spawning and rearing habitat. Fall Chinook, late-fall Chinook and steelhead are produced to mitigate for this habitat loss, to contribute to ocean and river harvest, and to provide adequate escapement to the hatchery for broodstock. These three programs are summarized below, followed by the California HSRG's major recommendations that apply to all Coleman programs and then sections presenting program-specific recommendations.

The Central Valley fall/late fall-run Chinook salmon ESU was classified as a federal Species of Concern in 2004. This ESU includes all naturally spawned populations of fall-run Chinook salmon in the Sacramento and San Joaquin rivers and their tributaries, east of the Carquinez Strait.

The Central Valley steelhead DPS was classified under the ESA as threatened in 1998. The DPS includes all naturally spawned anadromous steelhead populations below natural and manmade impassable barriers in the Sacramento and San Joaquin rivers and their tributaries, east of the Carquinez Strait, and the Feather River Hatchery and Coleman National Fish Hatchery steelhead programs.

Coleman NFH Fall Chinook Program

The fall Chinook salmon program is integrated with the natural spawning populations in Battle Creek and the Sacramento River. Program broodstock include returning hatchery-origin fish collected from the hatchery fish ladders, and natural-origin fish collected at the Battle Creek weir. Managers also use the barrier weir to block the movement of hatchery-origin fall Chinook into upper Battle Creek in order to protect the ESA-listed spring Chinook salmon spawning in that area, although the weir is ineffective during high flow events.

The program annually releases 12 million fall Chinook in April at a size of 90 fpp, which are expected to contribute a total of 120,000 fish to harvest and escapement over the life of the brood (60-75 percent for harvest). Released fish are constant fractionally marked at a rate of 25 percent (adipose fin-clipped and coded wire-tagged). Ninety percent of program fish are released at or near the hatchery in Battle Creek; ten percent are released into San Pablo Bay.

Coleman NFH Late-Fall Chinook Program

Late-fall Chinook salmon have been managed distinctly from fall Chinook salmon at Coleman since 1973. The late-fall Chinook salmon program is integrated with the natural spawning populations in Battle Creek and the Sacramento River. Program broodstock include returning hatchery-origin fish collected from the hatchery fish ladders and Battle Creek weir, and natural-origin fish collected at the Keswick Dam fish trap. Managers also use the barrier weir to block the movement of hatchery-origin late-fall Chinook into upper Battle Creek in order to protect the ESA-listed spring Chinook salmon spawning in that area, although the weir is ineffective during high flow events.

The program annually releases 1 million late-fall Chinook in December at a size of 13 fpp, which are expected to contribute a total of 10,000 fish to harvest and escapement over the life of the brood (50 percent to harvest). All released fish are adipose fin-clipped and coded wire-tagged, and released at or near the hatchery in Battle Creek.

Coleman NFH Steelhead Program

Until recently, the steelhead program was operated in an integrated fashion, incorporating into the broodstock natural-origin Sacramento River fish from 1947–1986, and natural-origin Battle Creek fish from 1952–2009. The use of natural-origin fish in the program was discontinued in 2009 due to the low abundance of Battle Creek natural-origin fish. If the abundance of the Battle Creek population recovers to sufficient levels in the future, the program will be re-integrated with this population.

The program annually releases 600,000 steelhead in January at a size of 4 fpp, which are expected to contribute a total of 3,000 fish to harvest and escapement over the life of the brood (33 percent for harvest). All released fish are adipose fin-clipped, and released into the Sacramento River at Bend Bridge (about 15 miles downstream of the Battle Creek confluence) to reduce predation on newly emerging Chinook in the upper Sacramento River and Battle Creek. Managers use the Battle Creek barrier weir to block the movement of hatchery-origin steelhead into upper Battle Creek, although the weir is ineffective during high flow events.

The adult return goal to the hatchery has been met in 7 of the last 11 years. Creel survey data indicate that approximately 500 steelhead are harvested annually in the upper Sacramento River, and that the majority of these fish were likely Coleman NFH steelhead since only adipose fin-clipped steelhead can be retained as harvest.

5.7.1 Recommendations for All Coleman Hatchery Programs

- Transporting and releasing juveniles to areas outside of Battle Creek should be discontinued. Juvenile fish should be released at the hatchery to reduce adult straying and increase the number of adult fish returning to the hatchery. Consider necessary facility modifications or equipment purchases that will facilitate on-site releases. Release locations for steelhead may take into consideration ecological and predation effects on other fish populations but should not compromise homing of adults to the hatchery.

- Performance standards for each phase of the fish culture process should be established and tracked annually. Summaries of data collected with comparisons to established targets must be included in annual hatchery reports.

- The emergency backup water intake (#2) should be screened to prevent fish entrainment.

- The USFWS should develop a Hatchery Procedure Manual for each program at Coleman NFH that includes performance criteria and culture techniques presented in IHOT (1995), Fish Hatchery Management (Wedemeyer 2001) or comparable publications.

5.7.2 Coleman Fall Chinook- Major Program Recommendations

The major recommendations of interest to resource managers for the Coleman NFH fall Chinook salmon program are provided below. Those selected for presentation may represent major changes in operations, changes in approach or outcomes towards achieving harvest or conservation goals, or will require substantial investment of resources. The California HSRG's evaluation of program compliance with standards and guidelines and the group's comments about this program are presented in their entirety in Appendix VIII.

- Program fish should be 100 percent coded wire-tagged and 25 percent adipose fin-clipped.

5.7.3 Coleman NFH Late-Fall Chinook – Major Program Recommendations

The major recommendations of interest to resource managers for the Coleman late-fall Chinook salmon hatchery program are provided below. Those selected for presentation may represent major changes in operations, changes in approach or outcomes towards achieving harvest or conservation goals, or will require substantial investment of resources. The California HSRG's evaluation of program compliance with standards and guidelines and the group's comments about this program are presented in their entirety in Appendix VIII.

- It is recommended that managers investigate the feasibility of collecting natural-origin adult fish at alternate locations, including collecting and retaining fish from Battle Creek.

5.7.4 Coleman NFH Steelhead- Major Program Recommendations

The major recommendations of interest to resource managers for the Coleman steelhead hatchery program are provided below. Those selected for presentation may represent major changes in operations, changes in approach or outcomes towards achieving harvest or conservation goals, or will require substantial investment of resources. The California HSRG's evaluation of program compliance with standards and guidelines and the group's comments about this program are presented in their entirety in Appendix VIII.

- Adult steelhead holding facilities should be upgraded and/or expanded to provide adequate space, water flows and temperature regimes to hold the number of adults required for broodstock at high rates of survival (greater than 90 percent).

- This program should be converted back into an integrated program with a minimum pNOB of 10 percent which thus requires 40-50 natural-origin adults. In recent years, due to the current low abundance of Battle Creek natural-origin steelhead and the concern that collecting these fish for natural-origin broodstock is likely to negatively affect population viability (Standard 1.13), no natural-origin fish have been incorporated into the spawning matrix. It is recommended that managers investigate the feasibility of collecting natural-origin adult fish at alternate locations (e.g., Keswick Dam fish trap) until the abundance of natural-origin steelhead returning to Battle Creek has sufficiently increased to resume their incorporation into the program.

- Current efforts should be expanded to determine the cause of low smolt-to-adult returns for this program. Possible residualization, high in-river mortality, high mortality in the delta/estuary or the ocean, straying as adults, and under-reported catch may be factors.

- Hatchery-origin adult steelhead returns to the hatchery should be treated as follows: (1) unspawned males should be extended reconditioned and released; (2) unspawned females should be stripped of eggs, extended reconditioned and released; and (3) spawned fish should be removed from the system, or extended reconditioned and released.

- Natural-origin adult steelhead returns to the hatchery, whether spawned or unspawned, should be released. Fish may be reconditioned prior to release.

5.8 Livingston Stone National Fish Hatchery

Livingston Stone National Fish Hatchery (NFH), a substation of Coleman NFH, was constructed by the Bureau of Reclamation in late 1997 to produce ESA-listed winter-run Chinook salmon to assist in population recovery. The hatchery is located at the base of Shasta Dam on the Sacramento River (above the terminus of anadromy).

The Sacramento River winter-run Chinook salmon ESU was classified under the ESA as endangered in 1994. The ESU includes all naturally spawned populations of winter-run Chinook salmon in the Sacramento River and its tributaries, the Livingston Stone NFH winter-run Chinook program, and the University of California Bodega Marine Laboratory winter-run Chinook captive broodstock program.

Artificial propagation of winter-run Chinook salmon at Livingston Stone NFH is intended to be a temporary measure that will cease when the naturally spawning population is recovered. A captive broodstock component of the winter-run Chinook salmon program operated from 1991 to 2007, after which it was discontinued because the abundance of natural-origin adults increased. If the abundance level again falls to critically low levels, the captive broodstock element of this program could be reconsidered (USFWS 2011). The Livingston Stone winter-run Chinook salmon program is supported in the NMFS draft Recovery Plan for winter-run Chinook salmon (NMFS 2009; USFWS 2011). No other salmon species are reared here, although the hatchery also rears ESA-listed Delta smelt.

The Livingston Stone NFH program is a conservation-oriented program integrated with the natural population of winter-run Chinook salmon in the upper Sacramento River to provide a demographic boost to aid in population recovery (USFWS 2011). Hatchery-origin winter-run Chinook salmon are intended to return as adults to the upper Sacramento River, spawn in the wild, and become reproductively and genetically assimilated into the natural population. Although there is no adult production goal, Livingston Stone NFH releases up to 250,000 winter-run Chinook salmon at 60 fpp (or a minimum size of 80 fpp) each year in late January or early February. Winter-run Chinook salmon are released at the pre-smolt stage and are intended to rear in the freshwater environment prior to smoltification. All juvenile winter-run Chinook salmon produced at Livingston Stone NFH are adipose fin-clipped and coded wire-tagged. They are released into the Sacramento River at Caldwell Park in Redding (RM 299), about 10 miles downstream of the hatchery.

5.8.1 Livingston Stone Winter Chinook – Major Program Recommendations

The major recommendations of interest to resource managers for the Livingston Stone winter-run Chinook salmon hatchery program are provided below. Those selected for presentation may represent major changes in operations, changes in approach or outcomes towards achieving harvest or conservation goals, or will require substantial investment of resources. The California HSRG's evaluation of program compliance with standards and guidelines and the group's comments about this program are presented in their entirety in Appendix VIII.

- Program production goals should be expressed in terms of the number of adult recruits just prior to harvest (age-3 ocean recruits for Chinook).

- It is recommended that managers investigate the feasibility of collecting natural-origin adult fish at the fish ladder at Anderson-Cottonwood Irrigation District (ACID) Dam near Caldwell Park in Redding. The existing trapping location (Keswick Dam) is very limited in its ability to capture fish representing the entire spectrum of winter-run Chinook salmon life history diversity. Only fish that migrate to the furthest upstream reaches are susceptible to capture. Habitat conditions in the uppermost reaches where the trap is located are substantially different from the primary winter-run Chinook salmon spawning area.

- A biosecurity plan (see Standard 3.9) that protects individual programs (winter-run Chinook salmon and Delta smelt) should be prepared and implemented.

- The USFWS should develop a Hatchery Procedure Manual for the program at Livingston Stone NFH, which includes performance criteria and culture techniques presented in IHOT (1995), Fish Hatchery Management (Wedemeyer 2001) or comparable publications.

6. Implementation and Research

Hatchery management and related activities change due to new regulatory mandates and funding opportunities. Management goals and objectives are often inconsistent due to multiple political and regulatory jurisdictions. If hatchery benefits and risks are scientifically assessed, a common language and framework is needed to ensure critical work is effectively developed, efficiently implemented, and reported in a timely manner. The framework consists of a set of premises (Section 1.2) that are the foundation of the statewide issues and recommended standards and guidelines for operating hatchery programs (Chapter 4). The California HSRG strongly urges fishery and hatchery managers to implement the specific standards and guidelines and the resulting program-specific recommendations for hatchery operations. We believe that institutionalization of this implementation framework is critical to achieve meaningful and sustained improvements in hatchery operations, and optimize long-term management of California's anadromous fishery resources.

In the process of this review, the California HSRG was made aware of several internal California State issues that we think limit the ability of state-operated hatcheries to meet program goals. We strongly recommend that the State of California address these specific issues to improve and properly evaluate program performance:

- The California HSRG repeatedly heard that recent State contract issues have prevented hatcheries from using optimum feed. It is essential that all hatcheries have access to the most appropriate feed to ensure meeting readiness-to-smolt and growth trajectory goals.

- Research on a variety of hatchery-related topics (see below) is essential to identify and implement effective hatchery management goals and actions. We recommend that the CDFG develop streamlined and centralized protocols for review, coordination, and timely approval of appropriate or necessary research at all of the hatcheries it operates.

- The CDFG should develop a means to consistently apply best management practices and conservation principles at all of its hatcheries.

- Many of the specific recommendations in this report depend on the collection of biological data both within and outside of hatcheries. We suggest that the State of California provide sufficient, appropriately trained staff at each hatchery to collect this information.

6.1 Implementation Recommendations

Implementation of the Standards and Guidelines and program-specific recommendations will have implications to resource managers (including fishery, hatchery, tribal, and perhaps habitat managers); funding authorities such as utilities, and state and federal agencies; and regulators such as the NMFS. All of these entities will have a role in the implementation of these new recommendations for hatchery operations. In some instance, the California HSRG's recommendations address both in-hatchery reform and out-of-hatchery issues including additional monitoring and research needs.

The California HSRG's review can add significant value to current hatchery practices and the sustainability of existing natural anadromous fish populations only if the principles and recommendations are integrated into the appropriate aspects of hatchery and resource management.

To this end, the following recommendations for implementation are provided:

- Successful implementation of the California HSRG's recommendations will require regular programmatic performance reviews of hatchery programs. While Hatchery Coordination Teams should review programs annually, the California HSRG recommends periodic regional performance reviews of hatchery programs that assess program performance against resource management agencies' goals. These reviews could be undertaken at the regional level and scheduled so that hatchery programs in each region are publicly evaluated no less frequently than every 10 years. The reviews could accomplish necessary oversight for a number of processes, including funding, ESA regulation, independent scientific oversight, and public accountability. As part of the scientific oversight, each hatchery program should be rated on its conservation and harvest performance objectives and the degree to which California HSRG recommendations have been implemented.

- The California HSRG recognizes that Hatchery and Genetic Management Plans (HGMPs) coupled with timely and complete annual fish hatchery reports, are required for effective program management and evaluation. Responsible agencies and the NMFS should apply California HSRG recommendations in the preparation and review of HGMPs (Section 4.4, HGMPs). Resource management agencies should review these recommendations and make reasonable efforts to incorporate them into their management programs. Additionally, the California HSRG recommends that responsible agencies place a high priority on providing the resources for and commit to providing needed monitoring and evaluation information and data as a requirement and integral component of hatchery programs.

- The California HSRG encourages the regional hatchery funding entities (utilities, California Department of Water Resources, US Bureau of Reclamation, USFWS, and the State of California) to adopt the California HSRG's standards and guidelines as a basis for future funding and accountability of their respective hatchery mitigation or enhancement programs.

- Staff with specific highly technical expertise (e.g., fish health specialists) should be tasked with addressing specific highly technical problems in the California hatcheries. Recent consolidation of state classifications (e.g., all "Biologist" classifications subsumed under an "Environmental Scientist" designation) may make it difficult to identify staff with this specific technical expertise.

- Detailed, standardized protocols for monitoring of hatchery programs are currently lacking in the anadromous salmonid hatcheries of California. Section 4.4, Monitoring and Evaluation, lists attributes that need to be monitored and specifies approximate sample sizes that seem appropriate, but standardized protocols for many of these attributes remain to be developed. The same protocols should be adopted at all hatcheries so that data can be directly compared across facilities.

- We recommend that a similar review process be undertaken for the programs in the two state-operated hatcheries in coastal basins, Warm Springs (Russian River) and Mad River hatcheries. Since these programs were not formally part of the purview of the California HSRG, we are not familiar with all aspects of them, but we note that the two steelhead programs at these facilities share many similarities with the programs that were reviewed, and that many of the recommendations in this report are therefore relevant to the operation of these steelhead programs. We recommend that, in the interim period, resource management agencies implement the standards and guidelines specified in this report when they are clearly applicable to these programs.

- Finally, the publicly-accessible website housing the California HSRG's reports will require a permanent host and long-term funding. As of this publication date, the Pacific States Marine Fisheries Commission has indicated a willingness to permanently house and manage this data and information.

6.2 Areas of Needed Research

Deliberations and observations by the California HSRG, while developing recommendations for the 19 anadromous salmonid hatchery programs under review, led to the recognition of areas in particular need of scientific research to guide future management of these and other hatchery programs. In this section we outline these topics, recognizing that there are many more areas in need of information. These topics are all considered to be high priority and are not listed in order of importance.

Identify Populations and Delineate Population Boundaries with which Hatcheries Should be Integrated

For ESA listed stocks, populations and population boundaries have already been established and should be used to determine the appropriate populations and boundaries over which hatchery programs should be integrated. However, many salmonids in California are not ESA-listed and do not have explicitly defined populations and population boundaries. For example, explicit definitions of populations and population boundaries are not available for economically important fall run Chinook salmon in both the Klamath-Trinity basin and the Central Valley. Research is needed to delineate boundaries for all populations that may be affected by a given integrated hatchery program. This should include estimation of rates of straying and genetic migration of hatchery-origin fish released on-site into natural populations and the geographic distribution of such migration.

Determine Relative Reproductive Success of Hatchery- and Natural-origin Salmonids Spawning Naturally

Studies have shown loss of fitness for natural spawning and rearing in hatchery steelhead, coho salmon, and yearling outmigrant populations of Chinook salmon, and the magnitude of this loss appears to vary among species and populations. No such studies have been done for subyearling Chinook salmon released as “fingerlings”, where the hatchery fish spend only a few months in the hatchery and their subsequent life history closely matches that of the natural-origin fish, and limited work has directly compared the relative reproductive success of hatchery and natural-origin salmonids in California, with the exception of the steelhead study conducted by USFWS in Battle Creek. Research is needed to evaluate relative reproductive success for hatchery and natural-origin fish spawning naturally and to determine the importance of genetics (domestication) versus developmental history in causing any differences in reproductive success. Since subyearling Chinook salmon released at the fingerling stage have less opportunity for domestication selection, the reduction in reproductive success for such fish may be less than for other hatchery salmonids in California. Therefore, studies of the relative reproductive success of subyearling hatchery Chinook salmon released as fingerlings and natural-origin fish should be a top priority.

Assess Ecological Effects of Hatchery-origin Fish on Naturally Spawning Populations

Research is needed to evaluate whether or where hatchery programs have negative effects on natural populations through competition (in river, estuary, or nearshore ocean), predation (direct or through attracting predator aggregations), behavior effects (e.g., premature emigration of natural-origin fish), or disease and other effects.

Development of Anadromy in Landlocked O. mykiss

While it is clear that life history variation in *O. mykiss* has a heritable component, little is known about the genetic basis of anadromy versus resident behavior, or perhaps more importantly, the potential for induction of genetic changes leading to heritable anadromous behavior in landlocked populations. In many cases, particularly in the Central Valley, resident *O. mykiss* above existing barriers to migration may be more genetically similar to ancestral anadromous *O. mykiss* than contemporary *O. mykiss* found below these barriers. The California HSRG recommends that appropriate agencies implement studies to address this issue.

Potential Uses and Limitations of Parentage Based Tagging

Parentage Based Tagging (PBT) has emerged as a new technology to enhance our understanding of the life histories of hatchery salmon and steelhead through the use of molecular genetic tags to follow the passage of genes over multiple generations. However, the prospects and limits of this technique are not yet well understood. For example, theoretical studies are needed to evaluate how PBT could be used to: 1) improve understanding of survival, maturation schedule and other attributes of hatchery steelhead on a brood year-specific basis, 2) determine the survival of reconditioned kelts, 3) determine the rates of inbreeding (and fitness consequences) for salmon and steelhead hatchery programs, and 4) improve understanding of trait variation in hatchery stocks. Studies are also needed to determine if Chinook salmon hatchery spawning and rearing practices, coastwide sampling programs in fisheries and on spawning grounds, and recovered tag decoding programs could be practically and cost-effectively implemented to completely fulfill the California HSRG Chinook salmon monitoring and evaluation standards.

Assess Long-term Changes in Productivity of Naturally Spawning Populations of Anadromous Salmonids Under Continuing Hatchery Supplementation

Even under situations where hatcheries are operated as integrated programs and PNI exceeds 0.5, as we recommend, the California HSRG remains concerned that the productivity of naturally spawning fish under continuing "supplementation" by hatchery fish may continuously decline in a manner that it not sustainable in the long term. It is therefore recommended that high priority be given to long-term studies of productivity (e.g., smolts produced per spawner) that would be carried out in a stream or streams where, ideally, habitat conditions for spawning and rearing are excellent, but where a substantial fraction (say greater than 20 percent) of spawners are of hatchery origin. Such a study would likely require use of modern genetic methods which could establish the identity of downstream migrants with respect to their parentage (NOxNO, NOxHO, HOxHO). It is important that the habitat conditions in selected streams are unlikely to experience dramatic changes so that any observed changes in productivity could be attributed to the long-term consequences of continuous infusion of hatchery spawners rather than changes in habitat conditions that might otherwise cause productivity to change through time.

Investigate Causes of Decline in Returns of Anadromous Fish in Steelhead Programs

Most of the steelhead programs in California have generally low smolt to adult return ratios. Adult returns to two steelhead hatchery programs (Iron Gate and Mokelumne River hatcheries) have been so low in recent years that it has led to functional failure of these programs. The specific causes of these declines are not well understood. However, several fish culture issues may contribute to the low ratios; IHOT (1995) guidelines recommend release times for juvenile steelhead that are much later than currently practiced at most California hatcheries. Early release may lead to residualism and cause generally low survival rates of released fish. Research should be initiated to elucidate the causes of low adult returns and inform changes in hatchery protocols and procedures to avoid future failure to meet program goals.

Investigate Hatchery Domestication Selection and Development of Mitigation Strategies

The loss in fitness of both hatchery-origin fish and the natural populations with which they are integrated is perhaps the most important negative effect of salmonid hatchery programs. The primary mechanism for such loss of fitness is believed to be domestication selection, which is a general term to describe a variety of selective processes due to hatchery operations or ancestry that typically cause loss of fitness of hatchery-origin fish in natural spawning areas. However, the exact mechanisms that cause this domestication and loss of fitness are poorly understood. Careful research and monitoring should be undertaken to understand domestication selection and propose mitigation measures.

Develop Adaptive Framework for Habitat Carrying Capacity and Production Goals

Diminished carrying capacity of freshwater or ocean habitats can lead to adverse effects on natural populations and/or reduction in societal benefits. Research is needed to evaluate the ability of available freshwater and saltwater habitat to support salmonids at different life history stages and use this information to assist in setting hatchery production goals to avoid adverse effects. Ideally, such a framework would incorporate information on inter-annual and decadal scale variability to adaptively manage hatchery program operations.

Determine the Effects of Hatchery Spawning and Mating Protocols on Age Distribution

The use of age-based selection of fish as broodstock and the subsequent selection of mating partners is likely to have substantial effects on the age distribution of maturing adult salmon and steelhead. For example, two-year-old male salmon (jacks) typically have lower reproductive success than older males in natural spawning areas (although this has not been demonstrated in California), but the magnitude of the difference is not clear. Hatchery spawning protocols most likely fail to replicate the relative reproductive success of different age classes. Age of maturity in salmonids has a heritable component and over- or under-representation of different age classes in hatchery production may cause a selective shift in the age distribution of both the hatchery stock and the natural population with which it is integrated. A mating strategy has been suggested for Chinook salmon (Section 4.1.1) whereby no female is ever mated with a smaller male (except when the male is a jack). The California HSRG is intrigued by this concept but did not fully endorse it, instead preferring to experimentally evaluate the protocol in a selected stock (late-fall Chinook salmon at Coleman NFH). Research is needed on the effects of using different protocols for incorporation of two year old fish into broodstock on the age distributions of the associated hatchery and natural populations, as well as on the effects of using size-based protocols to choose mating partners, and how both of these interact with known effects of hatchery growth rates and harvest on age distribution.

Agenda Item E.1.b
CHSRG Report
September 2012

California Hatchery Review Report

California Hatchery Scientific Review Group

June 2012

California Hatchery Review Report

Prepared by the
California Hatchery Scientific Review Group

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California Hatchery Review Report

1. Purpose and Scope of the Review

In 2000, the U.S. Congress established and funded a hatchery review process because it recognized that, while hatcheries have a necessary role to play in meeting harvest and conservation goals for Pacific salmonids, the hatchery systems were in need of comprehensive reform. Most hatcheries were producing fish for harvest primarily to mitigate for past habitat loss (rather than for conservation of at-risk populations) and were not taking into account the effects of their programs on naturally spawning populations. With numerous species listed as threatened or endangered under the Endangered Species Act, Congress identified salmon conservation as a high priority. Genetic resources in the region were at risk and many hatchery programs were contributing to those risks. Congress intended that the reviews be scientifically founded and evaluated; that independent scientists would interact with agency and tribal scientists to provide direction and operational guidelines; and that hatchery systems as a whole would be evaluated for compliance with science-based recommendations.

Hatchery program reviews were completed in Puget Sound and coastal Washington (2004) and then in 2005, Congress directed NOAA Fisheries to replicate the process in the Columbia River Basin. The scope of that review broadened and evaluation tools were refined. Implementation successes led Congress to further expand the geographic scope in 2010 and funds were appropriated to conduct a scientific review of hatchery programs in California, hereafter referred to as the California Hatchery Scientific Review Project. An appropriation for this purpose was provided to the US Fish and Wildlife Service and was administered through the Pacific States Marine Fisheries Commission. Due to limitations in time and other resources, the review was subsequently limited to hatchery programs in the Klamath/Trinity and Central Valley basins, with the programs at the two agency-operated hatcheries in coastal basins (Warm Springs Hatchery and Mad River Hatchery) to be reviewed at a later time.

The goal of this hatchery program review initiative is to ensure that hatchery programs are managed and operated to meet one or both of the primary purposes for hatcheries:

- Helping recover and conserve naturally spawning salmon and steelhead populations, and
- Supporting sustainable fisheries with little or no deleterious consequence to natural populations.

As for the previous hatchery program reviews, appointments of qualified fishery scientists and biologists were made to a California Hatchery Scientific Review Group (California HSRG). The California HSRG was assisted in their deliberations by consultants affiliated with DJ Warren and Associates (hereafter the Consultants). The primary role of the Consultants was to assemble and organize existing data concerning operation and performance of the majority of California's salmon and steelhead hatcheries and to identify current scientific literature that seemed most pertinent to operation and management of these hatcheries. The role of the California HSRG was to weigh available scientific information so as to produce consensus recommendations for changes in hatchery practices which should provide guidance to policy makers who will be responsible for implementing changes in how California hatcheries are operated.

1.1 Organization and Implementation of the Hatchery Review

The California HSRG and the Consultants together engaged in five distinct activities: (1) scientific review and policy development (the responsibility of the California HSRG), (2) technical support and facilitation (the responsibility of the consultants), (3) preliminary report development (shared by the California HSRG and the consultants), (4) policy coordination, and (5) final statewide report approval (the responsibility of the California HSRG). The scientific review, including development of Statewide and program-specific recommendations, was based in part on information compiled by the technical contractors who gathered and analyzed information relevant to the evaluation of hatchery programs in the Klamath / Trinity and Central Valley regions. Facility site visits and group discussions occurred over the 16 month review period. The facilitation team was responsible for project management, budgets, contracting, collection or existing data, meeting organization and coordination of draft work products. Policy Committee support provided a communications link between the California HSRG and the federal, state and tribal fishery agencies at the policy level.

1.1.1 California Hatchery Scientific Review Group

The California HSRG was composed of 11 members, six of whom were affiliated with agencies in California and five of whom were previously affiliated with resource agencies or who are university faculty. Affiliated members did not represent their respective agencies, but were instead expected to bring their individual scientific expertise to the table and act independently. The intent of this structure and approach was to ensure that the California HSRG maintained independence and impartiality, while at the same time assuring that it contained thorough knowledge of salmonid populations and hatchery programs in the Klamath / Trinity and Central Valley regions.

Members of the California HSRG were selected from a pool of candidates nominated by the American Fisheries Society and confirmed by the Policy Committee. Two additional members (one affiliated and one non-affiliated) were subsequently recommended to the Policy Committee and confirmed based on expertise with hatcheries in general and California programs in particular. The California HSRG operated without a chairperson or other officers.

Table 1-1 lists the California HSRG members and their associated organizations; brief professional biographies of the members are presented in Appendix II.

Table 1-1. Members of the California Hatchery Scientific Review Group

Name	Organization
Agency Affiliated Members	
Dr. John Carlos Garza	NOAA Fisheries
Scott Hamelberg	US Fish and Wildlife Service
Michael Lacy	California Department of Fish and Game
Michael Mohr	NOAA Fisheries
Kevin Niemela	US Fish and Wildlife Service
Kimberly True	US Fish and Wildlife Service
Unaffiliated Members	
Dr. David Hankin	Humboldt State University
Dennis Lee	Independent Consultant

Name	Organization
Dr. Bernie May	UC Davis
George Nandor	Pacific States Marine Fisheries Commission
Dr. Reg Reisenbichler	Independent Consultant

1.1.2 Technical Support, Facilitation and Policy Components

Technical support and facilitation of the California hatchery reviews was conducted by D.J. Warren and Associates, Inc. in association with Malone Environmental Consulting, Meridian Environmental, Inc. and ICF.

The Policy Committee tracked the progress of the review and convened periodic meetings to review progress and status of products, as well as draft recommendations for changes to hatchery programs. Policy Committee members identified agency and tribal resource specialists that provided program-specific information used in the review. Members of the Committee are identified in Table 1-2. Dr. Bernie May, a member of the California HSRG, acted as a liaison and provided direct communication to the Policy Committee as did Dr. Doug DeHart, a member of the facilitation team.

Table 1-2. Members of the Policy Committee

Name	Organization
Robert Clarke	US Fish and Wildlife Service
Randy Fisher	Pacific States Marine Fisheries Commission
Dave Hillemeier	Yurok Tribe
Mike Orcutt	Hoopa Valley Tribe
George Kautsky	Hoopa Valley Tribe
Kevin Shaffer	California Department of Fish and Game
Diane Windham	NOAA Fisheries

1.1.3 Work Sessions and Regional Review Process

The review evaluated all salmon and steelhead hatchery programs in the Klamath / Trinity and Central Valley regions. For logistical purposes, the two regions were split into three geographic areas: (1) Klamath / Trinity, (2) Central Valley South, and (3) Central Valley North. Figures 1-1 through 1-3 show the prominent features and hatchery facilities in each of the regional review areas. Programs reviewed within each region are as follows:

- **Klamath-Trinity Region** - February-March 2011
  - Iron Gate Coho Program
  - Iron Gate Fall Chinook Program
  - Iron Gate Steelhead Program
  - Trinity Coho Program

    - Trinity Fall Chinook Program
    - Trinity Spring Chinook Program
    - Trinity Steelhead Program
- **Central Valley South Region** – April –May 2011
    - Nimbus Fall Chinook Program
    - Nimbus Steelhead Program
    - Mokelumne Fall Chinook Program
    - Mokelumne Steelhead Program
    - Merced Fall Chinook Program
- **Central Valley North Region** – June-July 2011
    - Feather Fall Chinook Program
    - Feather Spring Chinook Program
    - Feather Steelhead Program
    - Coleman Fall Chinook Program
    - Coleman Late-Fall Chinook Program
    - Coleman Steelhead Program
    - Livingston Stone Winter Chinook Program

The review was conducted over a 16-month period from November 2010 to March 2012. Initial California HSRG meetings (1) developed definitions and an understanding of operational and programmatic data needed for the review and (2) defined and finalized the approach for presenting operational and programmatic information for evaluations of the hatchery programs. An overview of the project tasks, work sessions and schedule is provided as Table 1-3.

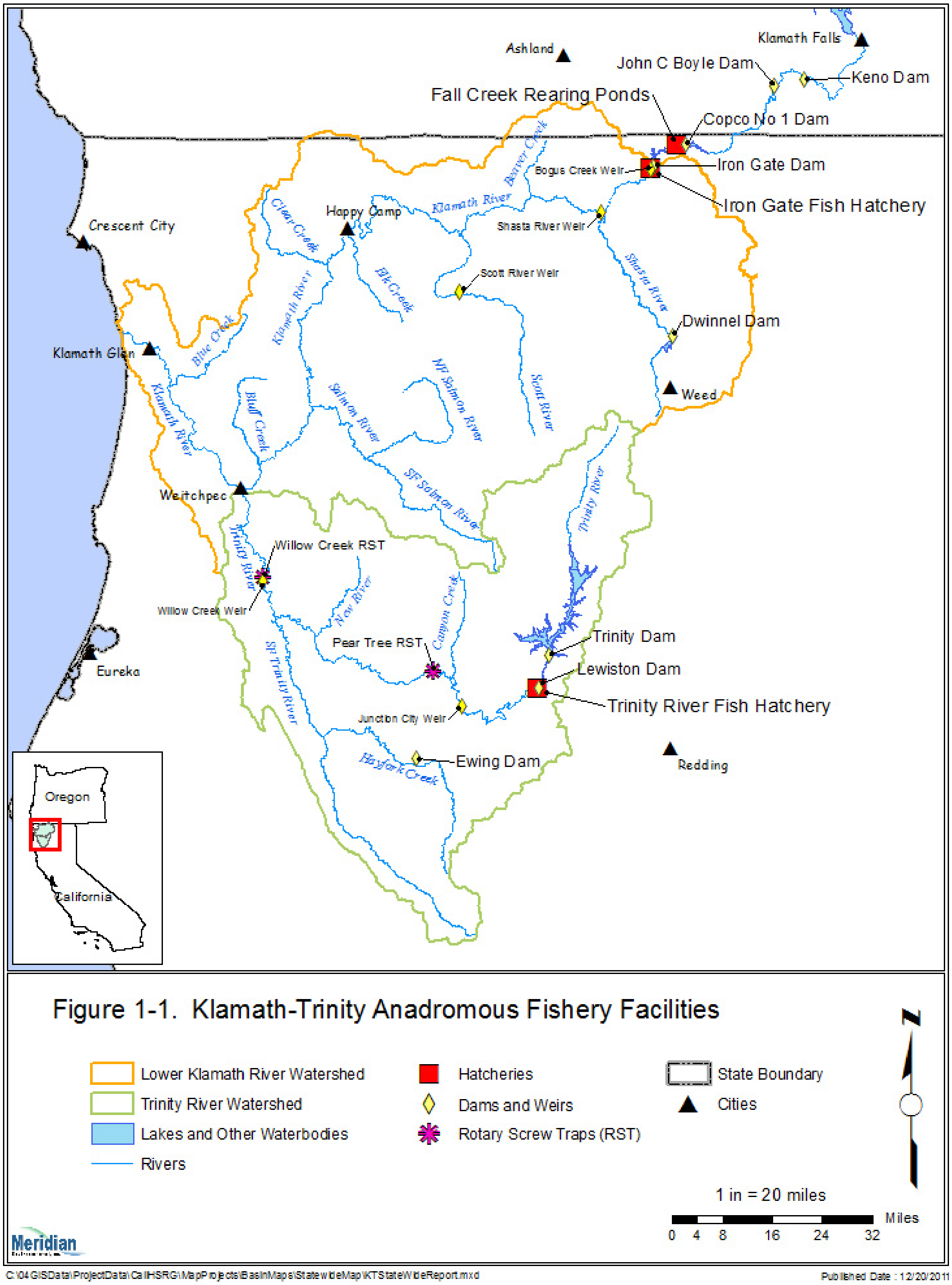

Figure 1-1. Klamath / Trinity Region

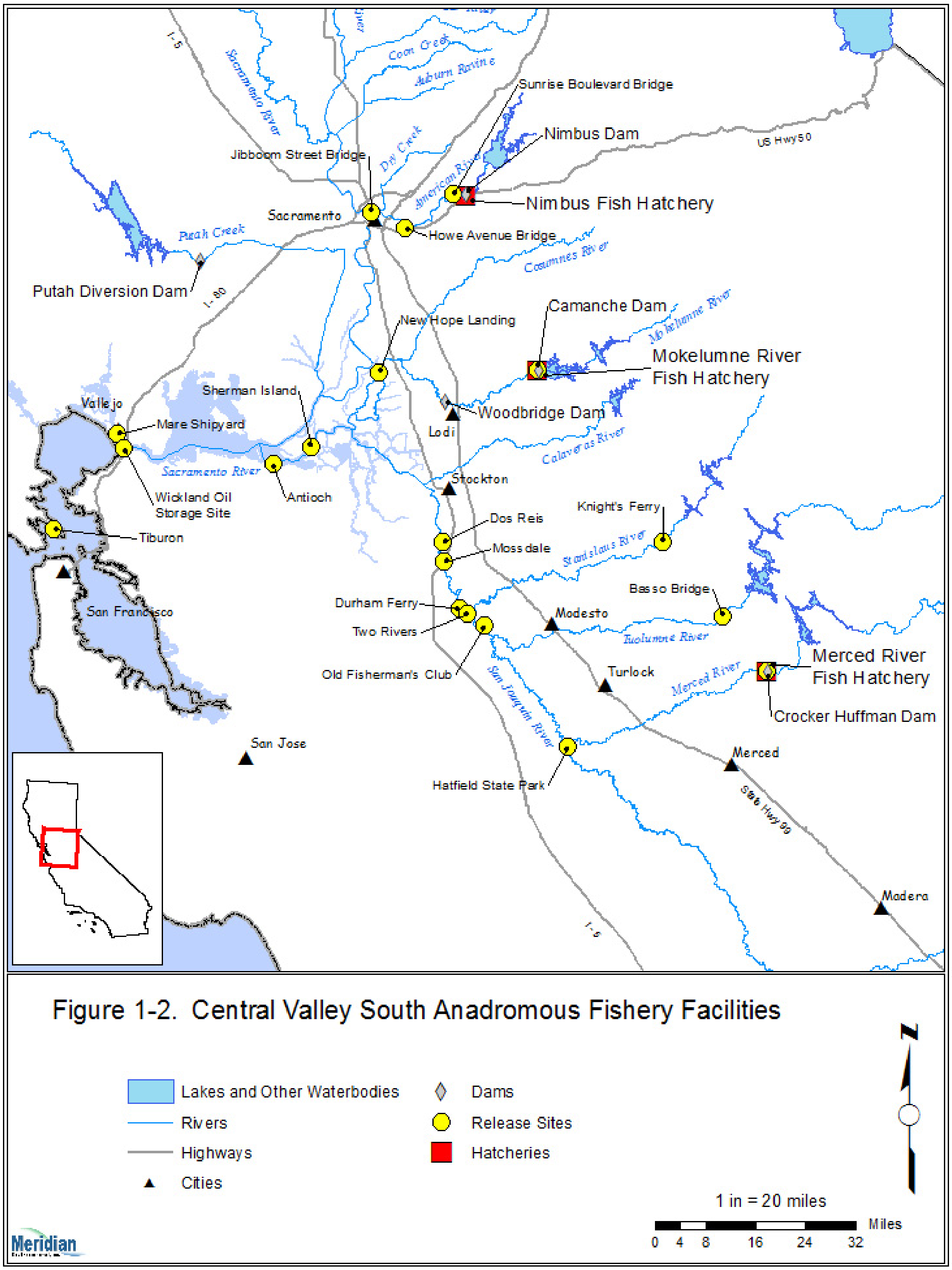

Figure 1-2. **Central Valley South Region**

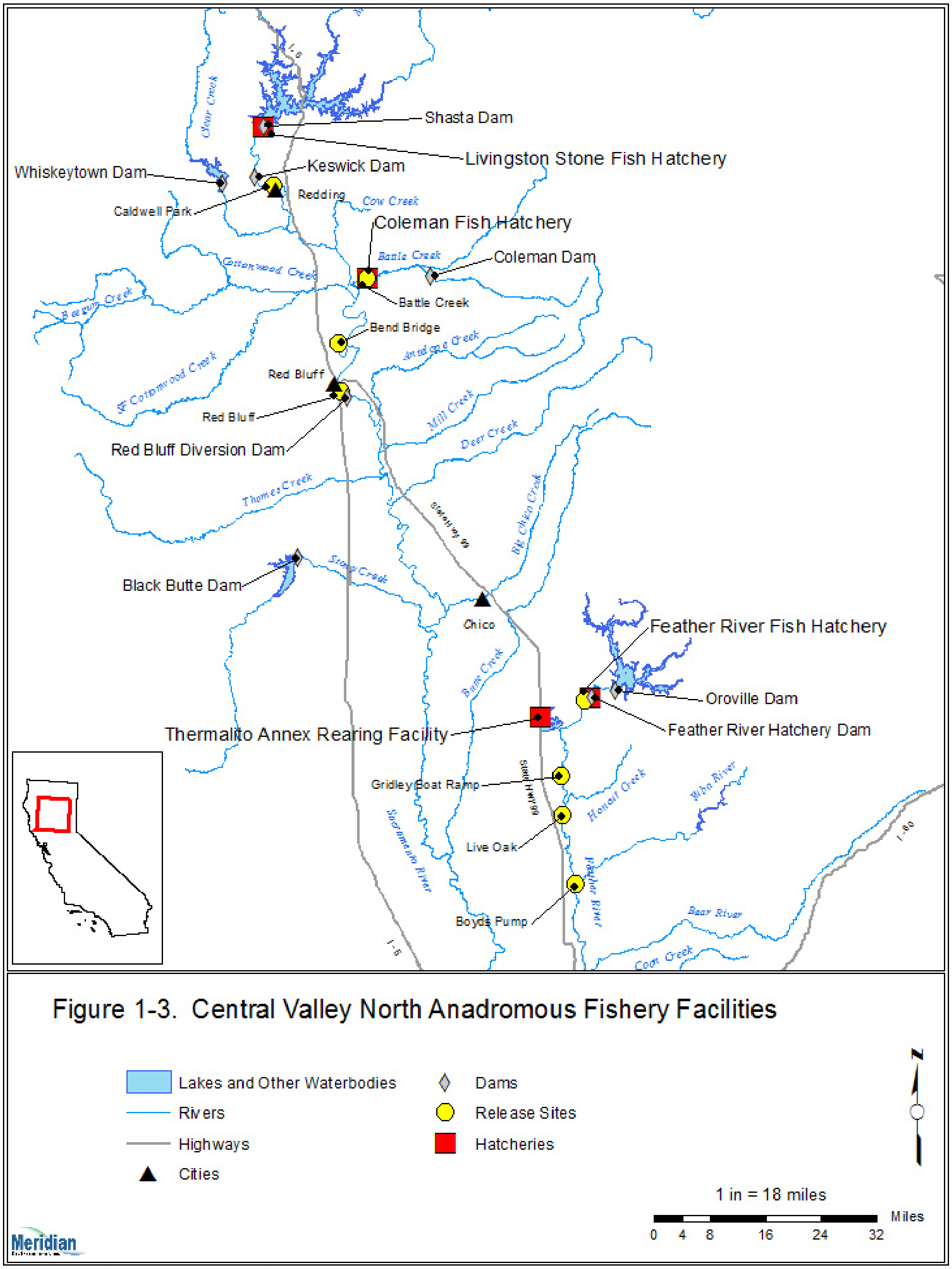

Figure 1-3. Central Valley North Region

Table 1-3. California Hatchery Review Regional Process

Task Description	Work Session Date	Specific Objectives
Work Session, Sacramento, CA	November 2010	Define review and participants (CA HSRG and Contractors)
Conference call	December 2010	Define review, schedule and components (CA HSRG and Contractors)
Planning Session / Sacramento, CA	January 4, 5 2011	Define review, schedule and components (CA HSRG and Contractors)
Klamath/ Trinity / data and information collection	February, 2011	Conduct hatchery and biological / programmatic data and information workshops and develop draft reports (Contractors)
Klamath/ Trinity tour and workshop / Redding, CA	March, 2011	Regional review of Iron Gate and Trinity hatchery programs (Contractors and CA HSRG)
Central Valley, South / data and information collection	April, 2011	Conduct hatchery and biological / programmatic data and information workshops and develop draft reports (Contractors)
Central Valley, South / tour and workshop, Sacramento, CA	May, 2011	Regional review of Nimbus, Mokelumne and Merced hatchery programs. Refined framework for review (Contractors and CA HSRG)
Central Valley, South / data and information collection	June, 2011	Conduct hatchery and biological / programmatic data and information workshops and develop draft reports (Contractors)
Central Valley, North / tour and workshop, Redding, CA	July, 2011	Regional review of Feather, Livingston Stone and Coleman hatchery programs. Refined framework for review (Contractors and CA HSRG)
Work session on review products, Sacramento, CA	September, 2011	Develop premise for standards and guidelines, refinement of statewide issues and observations, development of recommended standards and guidelines for operating hatchery programs (Contractors and CA HSRG)
Work session on review products and recommendations, Sacramento, CA	November 2011	Application of recommended standards and guidelines, develop recommendations for specific hatchery programs of final (Contractors and CA HSRG)
Work on draft final report for California HSRG	November, December 2011	Prepare draft of final report for California HSRG Review (Contractors and CA HSRG)
Work session on final report, Sacramento, CA	January, 2012	Finalize draft report and incorporate comments (CA HSRG and Contractors)
Telephone work sessions on final report	February, 2012	Four conference calls to complete report review (CA HSRG and Contractors)
Final report complete	March, 2012	Contractors and CA HSRG
Policy Committee comments on Final Report	April, 2012	Contractors consolidate and provide as Appendix VII
Report submitted to PSMFC	June, 2012	Project complete

Data and information collection and the review process in each region included the following steps:

(1) The contractors requested, collected and consolidated available information on hatchery programs in a region. This included data and information about direct hatchery program operations and biological and programmatic issues for each specific region (see Appendix III).

(2) Work sessions were then conducted to solicit information about specific hatchery program operations. These sessions, conducted at each hatchery (and for each program) in a region, generally involved hatchery operations staff and other key regional hatchery staff. The method for the sessions was an interview format using a standardized set of approximately 90 questions (see Appendix A-1 of each program report presented in Appendix VIII).

(3) Work sessions were then conducted with regional and other biologists to identify biological/programmatic issues. These work sessions included consolidation of data and information on:

- Population structure of Chinook, coho and steelhead;
- Life history characteristics of Chinook, coho and steelhead by population;
- Ocean and in-river catch and harvest rates on Chinook, coho and steelhead;
- Spawner abundance estimates for Chinook, coho and steelhead; and
- Composition of spawners (hatchery and wild) by population or population component.

(4) Contractors compiled both operational and biological information in the draft Hatchery Program Reports (Appendix VIII). Draft reports were then sent back to hatchery staff and biologists to confirm data accuracy. The reports were provided to the California HSRG in advance of each regional review.

(5) Regional work sessions attended by both contractors and the California HSRG were then conducted. These sessions generally involved a one- to two-day tour of the watershed and hatcheries followed by a two- to three-day work session to review programs and develop the framework for program recommendations

Additional work sessions and conference calls were conducted in August, September, and November 2011 and January and February 2012. These four to five day sessions generally focused on a premise for development of standards and guidelines and development of recommended standards and guidelines for operating hatchery programs (Chapter 4).

1.2 Analytical Approach

This review of the California hatchery programs is based on criteria that derive from three fundamental principles:

(1) Well-defined Goals

Goals for salmon and steelhead resource management should be quantified, where possible, and expressed in terms of values to the community (e.g., conservation, restoration, adult production, harvest and harvest opportunity, research or education). Hatchery juvenile production may be a means to contribute to harvest, conservation goals, or other values, but it is not an endpoint. When population goals are clearly defined in terms of these community values, hatcheries can be managed as tools to help meet those goals. Explicitly defined goals, performance standards, and success criteria should be established for all hatchery programs.

To be successful, hatcheries should be used as part of a comprehensive strategy where habitat, hatchery management and harvest are coordinated to best meet resource management goals that are defined for each population in the watershed or larger affected area. Hatcheries are by their very nature a compromise—a trade-off among benefits and risks to the target population, other populations, and the natural and human environment affected by the hatchery program.

(2) Scientific Defensibility

The operation and management, as well as the purpose of each hatchery program, must be scientifically defensible. Once a set of well-defined goals has been identified, the scientific rationale for a hatchery program must be formulated in terms of benefits and risks, explaining how the program expects to contribute to the goals. The benefits of a well-designed and properly operated hatchery program significantly outweigh the risks. The operational strategy of the hatchery program, as a part of an integrated or segregated strategy, must be explicitly stated. The chosen strategies for operation and management must be consistent with current scientific knowledge. Where there is uncertainty, hypotheses and assumptions should be articulated. This structured approach needs to be applied to current program operations, when formulating modifications to existing programs, and when developing new hatchery programs.

This approach ensures a scientific foundation for hatchery programs, a means for addressing uncertainty, and a method for demonstrating accountability. Documentation for each program should include a description of analytical methods and should be accompanied with citations from the scientific literature.

In Chapter 4, the state-wide recommendations of the California HSRG for operating California hatchery programs are presented in the form of Standards and Guidelines that are consistent with current science. These sets of standards are then applied to each of the 19 programs that were part of this review (Appendix VIII), along with recommended implementation guidelines specific to each program.

(3) Informed Decision-Making and Adaptive Management

Decisions about resource goals and defensible scientific rationales should be informed and modified by continuous evaluation of success at meeting hatchery program goals, changing circumstances, and new scientific information. Systems affecting and affected by hatchery programs are dynamic and complex; therefore, uncertainty is unavoidable and surprises should be anticipated. Managing hatchery programs is an ongoing and dynamic process that requires flexibility in programs, facilities, management, and expectations.

Managers must monitor the results of their programs and identify when environmental conditions or scientific knowledge has changed. Climate change and human population growth are examples of factors that must be taken into consideration in the future. New data will change our understanding of the ecological and genetic impacts of hatchery programs. Recognizing these changes and new information should lead directly to changes in hatchery operations.

This adaptive management approach will require a substantial increase in scientific oversight of hatchery operations, particularly in the areas of genetic, population, and ecological monitoring. Hatchery programs and associated monitoring should be structured to encourage directed research, innovation and experimentation so that hatchery programs may be effectively modified to better contribute to new goals and incorporate new concepts in fish culture practices.

1.3 Report Organization

The findings and recommendations of the California Hatchery Review Group for the 19 salmon and steelhead hatchery programs currently operating in the Klamath-Trinity Basin and the Central Valley are compiled in this report, as are a suite of proposed statewide hatchery standards. The following summary is provided to guide reviewers through the components of this report.

- Chapter 1 introduces the hatchery review project, specifically the purpose of the review and the analytical approach taken.
- Chapter 2 provides an overview of the unique California context within which the California Hatchery Scientific Review Project was conducted. Included in this section are overviews of habitat loss and hatchery development, integrated and segregated program distinctions, harvest management issues, marking and tagging strategies and anadromous fish population structure.
- Chapter 3 describes 14 major issues that the California HSRG judged of greatest importance for management of California's salmon and steelhead hatcheries.
- Chapter 4 presents the California HSRG standards and guidelines for hatchery operations. These are organized into five key topic areas: broodstock management; program size and release strategies; incubation, rearing and fish health management; monitoring and evaluation; and direct effects of hatchery operation on local habitat and aquatic or terrestrial organisms.
- Chapter 5 is a summary of the 19 program reviews, identifying key aspects of the current program and the major program-specific recommendations of the California HSRG.
- Chapter 6 is a suggested framework for implementing hatchery reforms and outlines a number of key research topics identified by the California HSRG as a result of this review.
- Chapter 7 lists citations referenced in the body of this report.
- Appendix I is a glossary defining technical terms and acronyms used throughout this report.
- Appendix II briefly summarizes the credentials of California HSRG members.
- Appendix III describes the data collection methods and sources interviewed for preparation of the 19 program reports.
- Appendix IV provides a list of required and recommended data collection and reporting.
- Appendix V presents information on two key fish health topics, BKD management and Iodophor disinfection.
- Appendix VI provides electronic links to the extensive resource library compiled as part of this review.
- Appendix VII presents comments from the Policy Committee based on their review of a draft of this report.
- Appendix VIII presents full reports, prepared by the Contractor team, about each of the 19 programs reviewed by the California HSRG. These reflect up-to-date program information obtained from published reports and interviews with program and regional managers and biologists. Each report contains program-specific standards and guidelines that were selected by the California HSRG from the complete list of standards and guidelines presented in Chapter 4. Appended to each program report is a set of tables with key hatchery data.

2. Context of the California Hatchery Scientific Review

This section provides an overview of the unique California context within which the California Hatchery Scientific Review Project was conducted. Although California's Central Valley is near the southern limits of the distribution of Chinook (*Oncorhynchus tshawytscha*) and coho salmon (*Oncorhynchus kisutch*), historic runs of Chinook salmon in the Sacramento-San Joaquin system were once among the largest in North America. California is the largest state in the lower 48, with the largest population, and with enormous competing demands for water, from the agriculture industry and from the human population. California's anadromous salmonids must compete with these other water users in a highly modified landscape.

The hatcheries that were the focus of the California HSRG's attentions are found in two large river systems that are quite different in many respects. The Klamath-Trinity system, near the California/Oregon border, has terminal hatcheries (Iron Gate and Trinity River) located immediately below dams that limit further upstream migration of anadromous fish. Although this river system has very clearly been affected by construction of dams, the watershed is sparsely populated, much of the landscape is dominated by National Forest land, and the Hoopa and Yurok tribes have large reservations along the Trinity and lower Klamath rivers, respectively. The Hoopa and Yurok tribes have a recognized legal right to 50 percent of the harvestable surplus of Klamath-Trinity fall Chinook salmon (Parravano vs. Babbitt 1995) and substantial tribal terminal fisheries have been in place since the mid-1990s. As a consequence, ocean fisheries for Klamath-Trinity-origin fall Chinook salmon have been reduced so as to allow appropriate numbers of fish to escape to freshwater. Well-coordinated multi-agency sampling programs have operated since about 1978 and there is excellent information on the dynamics of fall Chinook salmon in this system. Both spring and fall run Chinook are propagated at Klamath-Trinity hatcheries and neither run is listed under the Endangered Species Act (ESA). Threatened coho salmon are present in this system and are the focus of conservation efforts at both Iron Gate and Trinity River hatcheries. Information on abundance and distribution of coho is poor compared to that for fall Chinook salmon. Renowned steelhead runs enter the Klamath-Trinity system, including substantial returns of a distinctive "half-pounder" life history type. Half-pounders are immature steelhead that return to freshwater after just a few months at sea, at a size of about 12-18 inches. They feed in the winter while in freshwater, return to the ocean and then subsequently return to freshwater as adults to spawn. Both Iron Gate and Trinity River hatcheries propagate steelhead. Steelhead are not listed under the ESA in the Klamath-Trinity system. Information on abundance of steelhead populations is relatively limited, especially in the Klamath River.

Spring, fall, late-fall, and winter runs of Chinook salmon are recognized in the Sacramento/San Joaquin River system. Spring and winter run have been listed under the ESA; although the fall run is a stock of concern, it has not been listed. Fall Chinook are propagated at five hatcheries (Coleman, Feather River, Nimbus, Mokelumne and Merced); spring Chinook are propagated at Feather River Hatchery; late-fall Chinook are propagated at Coleman; and winter run Chinook are propagated at the Livingston Stone conservation hatchery. Naturally-produced and hatchery-produced fall Chinook salmon from the Central Valley are the primary contributors to ocean fisheries off central California. Because there are no established Native American fishing rights in the Central Valley and freshwater recreational harvest of Chinook is modest, ocean fishery harvest rates are much higher off central California where Sacramento fall Chinook dominate, than off northern California, where Klamath-Trinity Chinook are present in large numbers. Although ocean fishery harvest information is excellent for Central Valley salmon fisheries, historic data on freshwater returns, particularly information on freshwater age-specific harvests and escapements to natural spawning areas, is poor when compared to the Klamath-Trinity system. No coho salmon are propagated in Central Valley hatcheries, but steelhead are raised at Coleman, Feather River, Nimbus and Mokelumne hatcheries. Steelhead are listed as threatened in the Central Valley. Information on abundance and harvest from steelhead populations is quite limited and of questionable accuracy.

In the sections that follow, we present brief overviews of the following topics:

- How habitat loss and dam construction have altered abundance and distribution of steelhead and salmon in the Klamath-Trinity and Sacramento-San Joaquin river systems, and how hatcheries have been developed in response to these habitat alterations;

- The concept of segregated and integrated hatchery programs, as defined by HSRG (2004) and considered by the California HSRG;

- The role that hatcheries have played in supplementing fishery harvests and how harvest regulations differ between the two river systems;

- Current and proposed marking and tagging strategies and background relevant to the marking and tagging programs that are recommended by the California HSRG;

- A review of the current state of knowledge concerning population structure of anadromous salmonids in the Klamath/Trinity and Sacramento/San Joaquin river systems.

Together, these sections are intended to provide the reader with the background context that is needed to appreciate the major issues that the California HSRG has recognized as of greatest importance for future management of steelhead and salmon hatcheries in these two large river systems**.**

2.1 Habitat Loss and Hatchery Development in the Sacramento-San Joaquin and Klamath-Trinity River Basins

2.1.1 Historical Salmon and Steelhead Abundance

The Central Valley of California consists of the Sacramento River Basin in the north and San Joaquin River Basin in the south and historically has been one of the most productive systems for Chinook salmon on the west coast of the United States. Chinook salmon were once widely distributed and highly abundant in virtually all the major Central Valley tributaries, with some salmon swimming 400 miles upstream to adult holding and spawning areas (Moyle 2002, Yoshiyama et al. 2001). The historical high abundance of salmon in the Central Valley is documented by fishery records dating back to the 1850s. The Central Valley is unique in that it is the only system supporting four temporal runs of Chinook salmon. Before extensive habitat modification of the 19th and 20th centuries, maximum historical abundance (harvest plus escapement) of all four runs were estimated by Fisher (1994) at 2 million (100,000 late-fall, 200,000 winter, 700,000 spring and 900,000 fall). Steelhead (*Oncorhynchus mykiss*) were also broadly distributed throughout the system, with an historical run size that may have approached 1 to 2 million adults annually (McEwan 2001).

The Klamath River watershed once produced large runs of Chinook salmon, steelhead and coho salmon, and also supported significant runs of other anadromous fish, that contributed to substantial commercial, recreational, subsistence, and Tribal harvests. The historical range of salmon abundance for the Klamath-Trinity River has been estimated at 650,000–1 million fish (*see* Hamilton et al. 2005).

2.1.2 Abundance Decline of Salmon and Steelhead Associated with Reduction of Habitat Quantity and Quality

Abundance of all Chinook salmon runs and steelhead in the Central Valley and Chinook salmon, coho salmon and steelhead in the Klamath-Trinity Basin has declined substantially. For example, Central Valley spring-run and Sacramento River winter-run Chinook salmon are now listed as threatened and endangered, respectively, under the ESA, and fall Chinook abundance fell to about 50,000 adults system-wide in 2009. By the early 1960s, Central Valley steelhead declined to about 40,000 adults (McEwan 2001) and are now listed as threatened under the ESA.

Many factors including overfishing, pollution, and introduction of invasive species have contributed to the decline of salmon and steelhead in California; however, habitat loss, degradation, and modification associated with the construction of dams and water diversion on all major rivers seems to be the single greatest cause of population abundance decline in the Central Valley (Moyle 2002, Yoshiyama et al. 2000). Historical records document that in several major Central Valley streams and rivers, large salmon runs were severely reduced or extirpated in the 1870s and 1880s by hydraulic gold mining and blockage by dams (Clark 1929, Yoshiyama et al. 1998). Construction of permanent dams and corresponding loss of salmon habitat peaked during the 1890s to 1920s and continued into the 1970s (Yoshiyama et al. 1998). The amount of Chinook salmon spawning and holding habitat lost in the Central Valley probably exceeds 72%, and may be as high as 95%, as most of the prime spawning and adult holding habitat is in upstream reaches now inaccessible for salmon and steelhead (Yoshiyama et al. 2001, Reynolds et al. 1993, Moyle 2002). The direct loss of steelhead habitat is likely greater than for salmon because steelhead were able to access headwater habitat areas due to their greater athleticism and higher flows during their migration. Downstream consequences of dam construction include water temperature changes, flow modification/disruption /diversion, and diminished spawning gravel recruitment, which in combination have affected productivity of natural populations in their remaining accessible habitat. In fact, effects of water management and water diversion have rendered some tributaries largely incapable of supporting natural production and/or no longer favoring an anadromous life history for steelhead. There also appears to be inadequate nursery habitat in the American, Feather and Mokelumne rivers to support natural steelhead populations. Periodic natural events (drought and poor ocean conditions) have also severely affected the remaining natural populations. For example, the droughts in the mid/late 1970s and late 1980s to early 1990s, had major effects on natural populations (most notably winter-run Chinook) and poor prevailing ocean conditions resulted in the most recent (~2007-2010) fall Chinook salmon abundance collapse (Lindley et al. 2009).

Habitat loss due to dam construction is also substantial in the Klamath-Trinity system. In the Klamath River, Iron Gate Dam now limits access to about 190 miles of habitat. In the Trinity River Basin, 50% of the spawning habitat was lost following the construction of Lewiston Dam (Moffett and Smith 1950). In addition to habitat blockages, major factors affecting the habitat in the Klamath-Trinity system include hydropower development and the associated water management (NMFS 1996). Resource managers should consider how removal of the Klamath River dams may alter the need and purpose for the future program.

2.1.3 Hatchery Development and Roles

Fish hatcheries in the Central Valley and in the Klamath-Trinity Basin were constructed to mitigate for the habitat loss associated with a number of the major dams. In recognition of the importance of preserving significant runs of Chinook and coho salmon and steelhead, seven hatcheries were constructed (five in the Central Valley[1] and in two in the Klamath/Trinity system) between the early 1940s and 1970. For example, the U.S. Fish and Wildlife Service's (USFWS) Coleman National Fish Hatchery was constructed to partially mitigate for the permanent loss of almost 200 miles of habitat following construction of Shasta and Keswick dams. We note that additional downstream consequences of dam construction and water management (i.e., water temperature changes, flow modification/disruption, diminished spawning gravel recruitment) resulted in further serious impacts to natural production, effects that were not considered in assigning the mitigation responsibilities for the hatcheries in the Central Valley or in the Klamath-Trinity systems.

Presently, hatchery-origin Chinook salmon make-up a substantial percentage of Central Valley salmon runs (Yoshiyama et al. 2000). Hatcheries will continue to provide opportunity for egg fertilization and incubation and early life history protection, and hatcheries and hatchery programs appear to be capable of maintaining salmon/steelhead runs even in areas where habitats have been significantly modified or degraded. Even this scenario, however, requires a functional migration corridor for both juvenile and adult fish. Spawning escapement to some major streams is now dominated by hatchery-origin fish. Because salmon and steelhead tend to home to their natal stream, it is not unexpected that thousands of returning adults may be found a short distance below hatchery sites, especially when the hatchery is at the terminus of anadromous fish migration. As abundance of natural-origin fish continues to decline, hatchery production has become increasingly important to support important ocean commercial and recreational, and in-river fisheries for fall- and spring-run Chinook salmon, and the in-river catch of steelhead. The largest combined hatchery program in the Central Valley is for fall-run Chinook salmon and the California ocean and in-river fisheries depend heavily on this stock.

2.1.4 Challenges to Face

While harvest opportunities are an important societal benefit, hatchery operations and programs also have effects on natural salmon and steelhead productivity. The California HSRG identified areas where hatchery facilities and programs can and should be modified to control undesirable impacts. However, it is important to emphasize that the hatcheries under review were constructed as a result of substantial habitat loss, and natural populations have been displaced to areas that are often subject to additional habitat modifications. Hatchery reform alone will not reverse the effects from accumulated degradation of salmonid habitats nor is it reasonable to assume that it can restore historic levels of naturally produced Chinook salmon and steelhead in the Central Valley or the Klamath-Trinity system.

Although most anadromous fish hatchery programs in California are operated to mitigate for lost habitat and decreased production capacity caused by dam construction, these hatcheries must have a larger role than simply producing and releasing defined numbers of juvenile fishes, and mitigators have a greater responsibility to help maintain, and in some cases rebuild, healthy naturally producing populations of anadromous fish. To accomplish this, the California HSRG believes that hatcheries in California should be operated not as isolated entities, but as components within the broader context of habitat restoration and protection, water management and harvest (see section below), that affect both natural and hatchery fish populations. The California HSRG recommends not only to limit the hatchery impacts, but also to restore habitat quantity and quality to increase opportunity for natural production.

[1] An additional facility, Livingstone Stone National Fish Hatchery, was constructed 1997 at the base of Shasta Dam to assist in the recovery of endangered winter Chinook salmon. The Livingston Stone NFH is part of the Coleman NFH Complex.

Therefore, in conjunction with this Hatchery Scientific Review and expected subsequent implementation of its recommendations, major efforts to restore and/or protect habitat in California's Central Valley and Klamath/Trinity river systems (including migration corridors) must occur and/or continue. A sincere commitment to preserve and protect salmon and steelhead in California will require difficult decisions that will likely require societal compromises. Lackey (2000) pessimistically noted that …"it is likely that society is chasing the illusion that wild salmon runs can be restored to the Pacific Northwest without massive changes in the number and lifestyle of its human occupants, changes that society shows little willingness to seriously consider, much less implement." California is the most populous state in the nation, growing from less than 100,000 people in 1850, to over 37 million today[2] . By 2025, the state's population is expected to increase to between 44 million and 48 million[3] , and reach approximately 60 million by 2050[4]. Continued population growth, coupled with climate change, will impart tremendous pressures on the state's natural resources, especially water development and water management.

Protecting and increasing the quality and quantity of habitat (including stream flows) and the biotic community in holding, spawning, and rearing areas and throughout migration corridors must be a priority if natural reproduction of salmon and steelhead populations is desired and the abundance of natural-origin fish expected to increase. The likelihood of collapse of salmon or steelhead runs and of further listings under ESA will be reduced if the abundance of the natural populations increases. Impacts of hatcheries are also reduced when the health and size of natural populations is improved. Prominent among the requirements for such increases will be maintaining high quality water flows to support all life history stages and behaviors inherent in each of the runs, thus allowing full opportunity for evolutionary adaptation. As stated by Neff et al. (2011), maintaining healthy habitats and ecological processes is the only effective approach to ensure the persistence of wild populations, and the rehabilitation and maintenance of healthy habitat and ecological function should be the first choice to preserve existing populations in their native habitat and avoid the potential loss of local adaptations.

2.2 California HSRG Position Concerning Integrated and Segregated Hatchery Programs

According to HSRG (2009), hatchery programs should be managed as either genetically integrated with, or segregated from, the natural populations they most directly influence:

> "A fundamental purpose of an i*ntegrated* hatchery program is to increase abundance, while minimizing the genetic divergence of a hatchery broodstock from a naturally spawning population. An integrated program is intended to maintain the genetic characteristics of a local, natural population among hatchery-origin fish by minimizing the genetic effects of domestication. This is expected to reduce the genetic risks that hatchery-origin fish may pose to the naturally spawning population.
>
> "The intent of a *segregated* hatchery program is to maintain a genetically distinct hatchery population. The only way to reduce risk (genetic and ecological) to natural populations from segregated programs is to minimize the contribution of hatchery fish to natural spawning."

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[2] http://geography.about.com/od/obtainpopulationdata/a/californiapopulation.htm.

[3] www.ca2025.org

[4] http://www.dof.ca.gov/research/demographic/reports/projections/p-1/

The California HSRG believes that for a program to be truly segregated, returning hatchery-origin adults must not breed in naturally-spawning populations, and thus must be completely isolated reproductively from these populations. In a truly segregated program, neither domestication selection nor phenotypic divergence of a hatchery population from a natural population would pose any risk to natural populations through interbreeding, although ecological and disease risks from the hatchery program might still exist. We emphasize that for a program to be truly segregated, the proportion of hatchery-origin spawners on a natural spawning ground, pHOS, must be equal to zero. To meet this criterion, hatchery fish must, at a minimum, be released at a location and in such a way as to foster reliable homing, although this tactic will not result in 100% fidelity to the release site (a low stray rate is expected and is "natural"). Thus, when hatchery fish return to spawn, (a) it must be to locations that are free of naturally-spawning fish or (b) they must be behaviorally and/or physiologically isolated reproductively from naturally-spawning fish. It is theoretically possible that returning hatchery-origin adults could be entirely removed from natural spawning grounds through the use of mechanical methods (e.g., segregation weirs). In practice this mechanism is not always an option and, when an option, is never completely efficient. We note that numerous Columbia River hatchery programs have been designated as segregated, but have not achieved the criterion of pHOS equal to zero. In addition, when hatchery-origin fish from highly segregated programs breed in natural populations, the potential reduction in fitness of the natural population is greater than that from hatchery-origin fish from an integrated program. Therefore, the California HSRG asserts that a truly segregated anadromous fish hatchery program is not possible in California, and we are therefore generally unsupportive of the concept.

For integrated hatchery programs, some returning hatchery-origin fish are expected to breed in naturally-spawning populations and natural-origin fish must be incorporated into the hatchery broodstock. When hatchery-origin fish spawn in natural areas, domestication and other effects will generally reduce the mean level of fitness of the naturally-spawning population; recruits per spawner will be less than if the naturally-spawning population included no hatchery-origin fish. The magnitude of this effect can be highly variable, depending upon the differences in fitness and phenotype between the hatchery- and natural-origin fish. Regular incorporation of natural-origin fish into hatchery broodstock should significantly reduce the intensity of domestication and other effects that can cause reduced fitness in natural areas.

The first Hatchery Scientific Review Group (HSRG 2004) followed Ford (2002) and adopted general guidelines for pHOS and pNOB (the proportion of natural-origin fish used as broodstock in a hatchery program) for integrated hatchery programs that are intended to guarantee that the "Proportionate Natural Influence" (PNI = pNOB/(pNOB+pHOS)) of the entire (hatchery + natural) integrated population exceeds some specified value when the natural population is judged to be of substantial importance. However, these guidelines implicitly assume that the geographic boundaries of the natural portion of an integrated population either can be or have been clearly identified. Previous efforts of Technical Recovery Teams (Williams et al. 2006; Lindley et al. 2004) have identified populations and population boundaries for listed ESUs of salmon and steelhead in California (coho salmon in the Klamath-Trinity system; spring-run and winter-run Chinook salmon and steelhead in the Central Valley), but similar populations and population boundaries have not yet been established for fall-run Chinook in the Central Valley or for fall-run and spring-run Chinook or steelhead in the Klamath-Trinity system.

The California HSRG believes that in successful integrated hatchery programs, the natural environment is the primary factor that determines adaptation and fitness of the integrated (hatchery- and naturally-spawned) population. This will help to minimize differences in fitness between hatchery- and natural-origin fish and reduce the potential detrimental effects of hatchery-origin fish spawning in natural areas. To accomplish this, PNI should exceed 0.5 in most cases.

The California HSRG considered two difficult questions related to hatchery fish spawning in natural areas: (1) What should be the geographic extent of the population with which a hatchery is integrated, and (2) Should we adopt explicit guidelines for pHOS, pNOB, and PNI, as was done by the Columbia River HSRG?

The California HSRG believes that the geographic boundaries of the population with which a hatchery is considered integrated should adhere to the following guidelines.

- Where independent populations and associated boundaries have been identified for listed species, these same populations and boundaries should be used to define the geographic boundaries of the population with which a hatchery should be integrated.

- For non-listed species for which neither independent populations nor population boundaries have thus far been established, boundaries for related species could be used, on an interim basis, while work is done to better define population boundaries for these non-listed species. Thus, for example, defined populations and boundaries for coho salmon in the Klamath-Trinity system (Williams et al. 2006) could be used, provisionally, for fall and spring Chinook salmon, to the extent that they are applicable.

The California HSRG makes the following explicit recommendations for pHOS, pNOB and PNI:

- An "overall" pHOS should be calculated over the entire spawning population with which a hatchery is determined to be integrated.

- It would be imprudent to adopt a single numerical guideline for pHOS in all natural spawning areas integrated with hatcheries, because optimal pHOS will depend upon multiple factors. Among these factors are the amount of spawning by natural-origin fish in areas integrated with the hatchery, the value of pNOB, the importance of the integrated population to the larger stock, the fitness differences between hatchery- and natural-origin fish, and societal values, such as angling opportunity. pHOS can also vary considerably from year to year, as it depends on the year-class strength of the contributing natural- and hatchery-origin cohorts, and controlling it to specific values would require intensive management, even in years when pHOS thresholds would not be exceeded. Therefore, the California HSRG recommends that program-specific management plans be developed for the natural spawning areas integrated with hatcheries that reflect these different factors, and with corresponding population-specific targets and thresholds for pHOS, pNOB, and PNI. When insufficient information or tools are available to designate such targets, average levels of pNOB and pHOS should be manipulated so that PNI at least exceeds 0.5 while further research can determine the importance of shifting PNI toward higher values.

- The California HSRG further recommends that pHOS be monitored in natural spawning areas not considered integrated with hatchery programs and that target and threshold pHOS values be established for each such spawning population, taking into account the same factors used for designating pHOS guidelines for integrated spawning areas. We recommend pHOS less than 0.05 as a provisional rule for populations not integrated with the program. When pHOS thresholds are consistently exceeded, consideration should be given to reducing program size or to reducing the straying of hatchery fish into spawning populations not integrated with the program.

- For conservation-oriented programs that are involved in reintroduction or supplementation efforts, acceptable pHOS may be much higher than 5 percent and could actually approach 100 percent in some generations.

2.3 Hatcheries and Harvest

A primary goal of the California Hatchery Scientific Review Project was to develop recommendations that, when implemented, would result in a more holistic management approach for salmonids, including hatcheries along with other factors that affect natural populations of salmon and steelhead. To accomplish this, the California HSRG believes that hatcheries in California should be operated not as isolated entities, with goals only of achieving specified release targets, but rather, within the broader context that includes habitat quantity and quality and harvest management, which collectively affect the abundance and sustainability of natural salmonid populations. Only by considering management of hatcheries, habitat, and harvest together can we maximize the efficiencies and benefits of hatchery production programs while, at the same time, providing the level of protections necessary for the conservation of natural salmonid populations.

2.3.1 Hatchery Goals

Currently, goals for most anadromous fish hatchery facilities in California are described as 'mitigation', and measured only in terms of numbers of juvenile fish to be produced and released annually. Annual production from salmon and steelhead hatcheries in California approaches 50 million juveniles, with fall-run Chinook being the predominant stock in terms of overall production. In most years, over 32 million fall-run Chinook salmon are produced at five hatcheries in California's Central Valley and nearly 9 million are produced at two hatcheries in the Klamath-Trinity Basin. Hatchery production, particularly of Sacramento River Fall Chinook (SRFC), contributes to major recreational and commercial fisheries in ocean and inland areas.

While supporting fisheries is a primary goal of hatcheries and an important goal for state and federal resource management agencies, efforts to augment harvest must also be balanced against the impacts of fisheries on natural salmon and steelhead populations. Substantial research has shown that fish produced in hatcheries can have detrimental genetic and ecological effects on natural salmonid populations (Kostow 2009; Araki et al. 2008). Indeed, Standard and Guidelines put forth in this document are intended to limit the potential for these types of effects. Fishery harvests that are sustained at high levels by targeting abundant hatchery-origin fish may over-exploit naturally reproducing salmonids and may also induce selection on maturation schedule and other traits. Effects of exploitation on naturally producing salmon were not directly addressed by the California HSRG and are not addressed in the Standards and Guidelines of this document; however, fishery exploitation rates must be in alignment with the productivity of naturally reproducing salmon stocks for the recommendations in this report to be successful at conserving natural salmonid populations.

2.3.2 Harvest Management Setting

The ocean salmon fisheries off the coast of Washington, Oregon, and California are managed under authority of the Magnuson-Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act or MSA). The Pacific Fishery Management Council (PFMC) manages these fisheries under the terms of the Pacific Coast Salmon Plan (FMP), which specifies stock management objectives, exploitation rate control rules, status determination criteria, user-group allocation agreements, etc., consistent with the provisions of the MSA. Annual fishery management measures are developed by the PFMC under the terms of the FMP, and recommended to the Secretary of the U.S. Department of Commerce for implementation.

The California Fish and Game Commission is responsible for managing California's river recreational fisheries, and the Yurok and Hoopa tribes are responsible for managing their tribal fisheries on the Klamath River, and do so consistent with the terms of the FMP and the PFMC annual fishery management measures. For ESA-listed stocks, the National Marine Fisheries Service (NMFS) specifies take limits (typically in the form of exploitation rate limits) through its Biological Opinions and consultation standards which are adhered to by the PFMC and the other management entities.

The FMP requires that annual fishery management measures be crafted to achieve, in expectation, the management objectives for all stocks each year. When coupled with the ESA consultation standards for listed stocks, this results in a given year's fisheries effectively being constrained by those stocks whose abundance in that year dictates the allowable level of exploitation. This is commonly referred to as "weak-stock management". One property of weak-stock management is that the harvest of some stocks may be less in a given year than would otherwise be allowed under that stock's management objective in that year. Moreover, although the ocean distributions of California's Chinook stocks overlap considerably, there are differences in the relative distributions of these stocks, both temporally and spatially, as indicated through analysis of coded-wire tag recoveries. Therefore, in any given year, the PFMC crafts management measures using a combination of time and area closures (and infrequently quotas) of California fisheries that attempt to maximize the opportunity to harvest the more abundant stocks, while also meeting the management objectives and consultation standards of the weakest stocks. In general, Sacramento River fall Chinook Salmon (SRFC) is the dominant stock available to ocean fisheries off California and Oregon.

2.3.3 Sacramento River Fall Chinook Management Objective

The SRFC management objective contrasts with the management objectives for other California Chinook salmon stocks. In particular, the PFMC manages fall Chinook salmon from the Klamath River system to achieve an overall brood harvest rate of 68 percent, subject to a minimum natural area spawning escapement target of 40,700 adults. These reference points are based on a stock-recruitment analysis of recruits produced by fish spawning in natural areas (which are a mixture of natural and hatchery-origin adults). The Klamath River management regime is thus based directly on the observed productivity of fish spawning in natural areas. In contrast, SRFC historically has been managed to achieve a total aggregate spawning escapement (returns of adults to hatcheries and natural spawning areas) of 122,000-180,000 adults. This value is viewed by the PFMC as approximately representing the level of spawning escapement at maximum sustainable yield (MSY), but this management strategy is not based directly on the capacity and productivity of SRFC spawning in natural areas. From 1988 through 1997, SRFC was not a constraining stock for fishery management and there were few ESA-listed stocks to constrain harvests: overall brood harvest rates averaged 79 percent and were as high as 87 percent. The California HSRG believes that these overall brood harvest rates likely exceeded MSY harvest rates for SRFC natural area production. From 1998 through 2007, SRFC were not a constraining stock, but other stocks were: overall brood harvest rates averaged 58 percent and, with the exception of 2004 (75 percent), were below 70 percent. It is unclear whether or not these more recent harvest rates exceeded the MSY harvest rate for SRFC natural area production. Salmon fisheries that impact SRFC were largely closed during 2008 and 2009, and highly constrained during 2010, due to low aggregate abundance of SRFC in those years. As of 2012, SRFC will be managed for an aggregate spawning escapement of

122,000 adults, but with an overall brood harvest rate capped at 70 percent. The overall brood harvest rate previously has not been capped for this stock.

2.3.4 Concerns and Recommendations

The California HSRG is concerned that an overall brood harvest rate of 70 percent may be too high considering the productivity of naturally spawning fish under current habitat conditions (see habitat discussion, Section 2.1). While this harvest rate is similar to that estimated as optimal for natural area spawning fall Chinook salmon in the Klamath Basin, the Sacramento Basin habitat (particularly the conditions for downstream migration) for fall Chinook is more highly degraded and SRFC natural spawning areas are probably less productive. The California HSRG also believes that an aggregate escapement target for this stock that includes returns to hatcheries lacks biological support. The target could theoretically be met if all fish returned to hatcheries and none returned to natural spawning areas, or if all fish in natural spawning areas were of hatchery origin. Both of these outcomes would clearly be at odds with a desire to foster sustainable natural production of fall Chinook salmon in the Sacramento River system. Therefore, we recommend that the SRFC management objective be reviewed by the appropriate state and federal fishery management entities in reference to these concerns, and revised to explicitly account for the status and productivity of SRFC spawning in natural areas.

Even if harvest management of Sacramento River fall Chinook salmon were revised to be more consistent with the current productivity of this stock as we recommend above, and even if California hatcheries were operated in the future as integrated programs with PNI greater than 0.5, as we also recommend above, the California HSRG remains concerned about possible long-term declines in the productivity of Chinook in natural spawning areas. To assist identification of potential causes of productivity decline (i.e., continued degradation of habitat conditions or impacts from hatchery-origin adults spawning in natural areas), we recommend (in Section 6.2) that high priority be given to long-term studies of productivity (e.g., smolts produced per spawner) that would be carried out in a stream or streams where habitat conditions for spawning and rearing are excellent, but where a substantial fraction of the spawners are of hatchery origin (e.g., pHOS greater than 20%). Only through such studies will it be possible to determine if the new concepts of integrated hatchery programs can truly lead to long-term sustainable coexistence of salmon and steelhead hatcheries and the naturally spawning populations with which they are associated.

2.4 Current and Proposed Marking and Tagging Strategies

Throughout this report, marking and tagging programs are described and recommended as means to distinguish between hatchery- and natural-origin fish, a purpose stressed by HSRG (2004), but also for many other purposes related to successful operation and evaluation of hatchery programs. For example, we recommend marking by adipose fin-clipping and tagging by insertion of coded wire-tags (CWT) for many Chinook salmon programs for identification of hatchery- and natural-origin fish, but also for identification of stock-of-origin to maintain the distinctness of runs reared in a single hatchery, and to exclude stray hatchery-origin fish from program broodstock where that is a problem. Maxillary fin clipping is currently used with coho salmon in the Klamath/Trinity basin to distinguish them from natural-origin fish, from northern hatchery-origin stocks that are all adipose fin-clipped, and to distinguish Iron Gate Hatchery fish (left maxillary fin clip) from Trinity River Hatchery fish (right maxillary fin clip). The California HSRG recommends an adipose fin clip plus an additional distinguishing external mark or CWT for the Nimbus steelhead program so that these fish (of out-of-basin ancestry) can be excluded from steelhead broodstock at other Central Valley hatcheries, until a native broodstock is established at Nimbus Hatchery. We also recommend an additional distinguishing external mark or tag (e.g., a ventral fin clip) for "yearling" releases of Chinook salmon (Iron Gate Hatchery, Trinity River Hatchery, and Mokelumne River Hatchery) to allow for the exclusion of adults released as yearlings from the broodstock to reduce the degree of domestication in these programs. We anticipate that future technological developments (e.g., RFID tags suitable for implantation in juvenile salmonids, or real-time identification using genetic tags) may permit these important objectives to be achieved in a more efficient or cost-effective manner.

2.4.1 Coded Wire-Tagging and Constant Fractional Marking

Current tagging programs for most Chinook salmon hatcheries in California consist of "constant fractional marking" (CFM) programs in which a fixed proportion (25 percent) of all hatchery fish are externally marked by an adipose fin clip and internally tagged with a CWT. CWTs provide a batch tag whereby fish released from a particular hatchery can subsequently be identified as belonging to a particular release group (brood year and release location) and hatchery of origin. Remaining fish are released unmarked and untagged. CFM marking programs were introduced at Trinity River Hatchery system beginning with the 2000 brood year; at all Central Valley hatcheries beginning with the 2006 brood year; and at Iron Gate Hatchery beginning with the 2008 brood year. Adoption of CFM marking/tagging programs was specifically designed to allow unbiased estimation of the proportion of hatchery fish in freshwater catches, natural spawning escapements (pHOS), and among hatchery returns, while at the same time delivering the typical estimates of fishery and life history parameters that are required by salmon fishery managers. Historically, a very low percentage of hatchery Chinook salmon were marked and tagged, particularly in the Central Valley, tagging programs were not coordinated across hatcheries, and as a consequence, it was very difficult to determine the contribution of hatcheries to escapement or to determine the proportion of hatchery fish on spawning grounds.

The CWT technology was very quickly adopted by many agencies following its introduction in the early 1970s and a collaborative coast-wide (California, Oregon, Washington, British Columbia and Alaska) tag recovery system and database management system (RMIS, managed by the Pacific States Marine Fisheries Commission [PSMFC]) was also developed rapidly (see Hankin et al. 2005 for a detailed review). Initially, the adipose fin clip was "sequestered" as a fin mark that could be used only if it were directly associated with an internal CWT, so that ocean and freshwater samplers could visually identify fish that were tagged. Quantitative fisheries scientists soon realized that cohort reconstruction methods could be used to estimate important ocean and freshwater fishery parameters (e.g., age-specific exploitation rates), overall survival of individual CWT release groups, and important life history parameters (e.g., age-specific maturation probabilities). With the emergence of harvest rate-based theories of harvest management, target and estimated ocean fishery exploitation rates assumed a dominant role in stock assessment and the development of annual fishery management measures by the PFMC. Prior to the advent of mark-selective ocean and/or freshwater fisheries, the exploitation history of a hatchery indicator stock was assumed to be the same as that of its unmarked natural stock counterpart. Thus, the estimated exploitation rates associated with tagged hatchery indicator stocks provided information on the likely fishery impacts on natural populations. If exploitation rates were judged too high for natural populations of concern, fishery managers revised fishery regulations so as to reduce exploitation rates to levels appropriate for natural populations.

2.4.2 Mark-Selective Fisheries

Mark-selective fisheries for marked hatchery steelhead were introduced throughout the Northwest beginning about 1965, and recreational fishery regulations were often changed to allow harvest of adipose-fin clipped steelhead, a species where all hatchery fish are typically marked. Thereafter, fisheries on natural steelhead populations were usually of a catch-and-release nature, or bag limits for unmarked steelhead were considerably less than for marked steelhead, theoretically generating relatively low fishery mortality rates on unmarked steelhead of natural origin. Mark-selective ocean fisheries for coho salmon were first adopted in Oregon coastal fisheries in 1998; mark-selective ocean coho fisheries were subsequently introduced in Washington and British Columbia, but not in California waters. Mark-selective ocean fisheries for Chinook salmon were first adopted in 2010 in Washington waters remain of fairly limited extent, and similarly have not been introduced in California waters.

Mark-selective fisheries for coho and Chinook salmon also rely on angler identification of hatchery-origin fish via absence of an adipose fin. Millions of hatchery coho and Chinook salmon released from hatcheries are currently "mass marked" (100 percent marked with adipose fin-clip) in Oregon, Washington and British Columbia. In mass marking programs, however, many fish are released with an adipose fin-clip but without an associated CWT. Thus, a consequence of the introduction of mass marking without a commensurate 100 percent tagging rate was a de facto "de-sequestration" of the adipose fin-clip as a mark reserved for fish with CWTs. Also, because fish with an adipose fin-clip could be retained in mark-selective fisheries, but unmarked fish could not, exploitation history of an adipose fin-clipped hatchery stock could no longer be assumed to be the same as that of their unmarked natural-origin counterpart. Whether or not unmarked fish subjected to mark-selective fisheries actually experience reduced exploitation rates compared to marked fish is a complex subject that involves consideration of the proportion of available fish that are marked and various assumptions concerning non-catch mortality rates, independence of fishery encounters and other variables (see, e.g., Lawson and Sampson 1996).

Mark-selective ocean or freshwater salmon fisheries have not been introduced in California waters and whether or not such fisheries should be introduced remains a complex and controversial subject (see, e.g., lists of presentations given at a 2009 CAL-NEVA sponsored symposium - available at http://marking.fishsciences.net/afs_forum.php). Within the California HSRG there was substantial divergence of opinion regarding the wisdom of mark-selective fisheries in California. Because CDFG has not indicated an intention or desire to introduce mark-selective fisheries for salmon, and because there is no consensus among California HSRG members concerning the desirability of such fisheries, we recommend marking and tagging programs for Chinook salmon that will be highly effective in achieving the large number of objectives (specified under Standards for Monitoring and Evaluation, Chapter 4.4 of this report) that are needed for effective management of our salmon hatchery programs and associated fisheries, while not unintentionally facilitating mark-selective fisheries.

2.4.3 Parentage-Based Tagging

We recommend use of parentage-based tagging (PBT) of steelhead in California, in addition to marking with adipose fin-clips. PBT relies on genotyping with molecular markers of the hatchery broodstock for tag issuance and genotyping fish from the next generation with the same molecular markers, followed by large scale parentage analysis to identify the parent pairs in the previous generation (Hankin et al. 2005; Anderson and Garza 2006; Garza and Anderson 2007). Use of the PBT approach is already underway in the Central Valley. Unlike CWTs, these genetic tags can be recovered non-lethally, which is an important consideration for this iteroparous species, many distinct population segments of which are ESA-listed. Genetic tags identify stock of origin and this information will provide estimates of straying and broodstock incorporation rates between hatcheries within the Central Valley and Klamath/Trinity basins. The PBT programs will also provide broodstock age distribution information and allow estimation of genetic effective size and trends in inbreeding by age of parents, as well as many other parameters. Moreover, several of the molecular markers currently used for PBT in California have been shown to be strongly associated with resident/anadromous life history strategy (Limborg et al. 2012; Miller et al. 2012) and may therefore have some predictive power for assessing whether particular fish chosen as broodstock are likely to produce anadromous progeny. However, more research and evaluation of this topic is needed (see Section 6.2).

2.5 Population Structure of Anadromous Salmonids in the Klamath-Trinity and Sacramento-San Joaquin Systems

Another application of genetic data with relevance to hatchery management is the elucidation of population structure of salmon and steelhead. Such population structure information helps to inform hatchery management in several ways, including identifying the extent of differentiation between local populations and the related issue of gene flow between them, and providing a better understanding of the effects of hatchery programs on naturally spawning populations. Evaluations of genetic population structure have been undertaken for all of the stocks of relevance to the California HSRG.

For steelhead, several studies of population structure have been undertaken in the Central Valley. Nielsen et al. (2005) and Garza et al. (2008) both found significant structure of *O. mykiss* populations in the Central Valley, although it was largely not geographically consistent. Both of these studies found that populations of fish above dams were generally more closely related to each other than to populations of fish below dams in the same basin. Garza and Pearse (2008) used data from steelhead populations in coastal California to infer that this pattern is due to primarily native ancestry in the fish populations above dams, with below dam populations affected by the presence of and introgression by fish with non-native ancestry. At least some part of this pattern was due to the long-standing use of broodstock derived from out-of-basin sources in the Nimbus Hatchery steelhead program, although it was unclear the extent to which this stock affected populations beyond the central portion of the Central Valley Basin. Evaluations of steelhead/*O. mykiss* population structure in the Klamath/Trinity Basin found somewhat different patterns, with genetic differentiation strongly dependent upon geographic distance, and the presence of subbasin specific genetic groups (Pearse et al. 2007; M. Peterson et al. unpublished data). These patterns indicated that most of the tributary populations of steelhead in the Klamath/Trinity Basin, aside from those in the Shasta and Scott rivers, are largely unaffected by gene flow from hatchery programs.

Population structure of coho salmon in the Klamath/Trinity Basin has also been evaluated (Garza et al. unpublished data), although with insufficient sampling in the Trinity River subbasin. This evaluation has shown that coho salmon in the Klamath River and the Trinity River are substantially differentiated, in spite of the fact that spawning of fish from the Trinity River Hatchery has been documented in the Iron Gate Hatchery program. Genetic examination of eight years of Iron Gate Hatchery coho salmon broodstock found that a policy of not spawning two-year-old fish had induced differentiation between the three brood cycles spawned at the hatchery and that this structure was greater than that between naturally spawning populations in different upper Klamath tributaries. Substantial gene flow of hatchery-origin fish into the Shasta River population was also evident.

Detailed studies of Chinook salmon population structure are available for both the Central Valley and the Klamath/Trinity Basin. In the Central Valley, the four long-recognized temporal runs – winter, spring, late-fall and fall – are arranged into four primary genetic groups, but those groups are not coincident with run identity (Banks et al. 2000; Garza and Pearce 2008). Winter-run are highly differentiated from all other salmon, at least partly due to documented bottlenecks in abundance, and form one group. Naturally spawning spring-run Chinook salmon form two differentiated groups, those from Butte Creek and those from Mill and Deer creeks. The smaller populations in other streams, such as Clear Creek, are comprised of migrants from both of these groups, as well as from the Feather River Hatchery program (Smith and Garza unpublished data). Feather River Hatchery spring-run Chinook salmon have been introgressed by fish from the fall-run program (Garza and Pearse 2008) and cluster more closely with the fourth genetic group- fall-/late fall-run Chinook salmon. Fall-run and late fall-run salmon at Coleman National Fish Hatchery and in natural areas are extremely similar genetically and cannot be reliably distinguished with genetic stock identification methods. Within the fall-run, there is little or no significant population structure present in the Central Valley (Williamson and May 2005; Garza et al. 2008). This has been attributed to the off-site release of fall-run Chinook salmon in the Central Valley and the consequent elevation of straying rates. One of the goals of the California HSRG is to reestablish conditions for local adaptation to reemerge. As a first step toward reestablishing adaptive genetic differentiation among Central Valley fall Chinook salmon populations, all releases should be made on-site (at or in the near vicinity of the hatchery of origin).

In the Klamath/Trinity Basin, both spring-run and fall-run Chinook salmon are present. The Trinity River Hatchery produces spring-run salmon, and spring-run salmon are found primarily in the Trinity River subbasin, although a small population of spring-run salmon is also present in the Salmon River tributary of the Klamath River subbasin. Genetic analysis has shown that these two populations of spring run are not each other's closest relatives (i.e., are not monophyletic) and that spring-run and fall-run Chinook salmon at the Trinity River Hatchery are only marginally differentiated (Kinziger et al. 2008; Kinziger et al. *in prep*). In contrast, substantial structure exists within the Klamath/Trinity Basin fall-run. Genetic evaluation of both the Iron Gate and Trinity River hatchery stocks, as well as most of the large naturally spawning populations in the basin, found substantial differentiation between Klamath and Trinity stocks, as well as a gradient of gene flow from the hatchery stocks into downstream natural populations, with the amount of hatchery ancestry commensurate with distance from the hatchery.

The contrast between the geographically consistent population structure of fall-run Chinook salmon in the Klamath/Trinity Basin, some of which is likely associated with local adaptation, the substantial structure found in other large basins (e.g., Columbia and Fraser rivers) and the near complete lack of genetic structure of fall-run salmon in the Central Valley highlights the effects of off-site release programs on population structure and associated local adaptation.

3. Issues of Greatest Importance for Management of California's Salmon and Steelhead Hatcheries

In this section, 14 major issues were identified as having paramount importance by the California HSRG during its review of salmon and steelhead hatcheries in the Klamath-Trinity and Sacramento-San Joaquin systems. Because it is difficult to fully appreciate the significance of these specific issues without context, Chapter 2 provides critical background material that we highly recommend be read before proceeding to the 14 major issues discussed in this chapter.

It has not escaped the California HSRG's attention that many reviews of individual hatcheries or groups of hatcheries have been done in the past, including a relatively recent inter-agency review of Central Valley salmon and steelhead hatcheries (CDFG/NMFS 2001). The recommendations that have been presented in these reviews have often been only partially implemented. It is our hope that the relevant agencies and stakeholder groups will use this document as leverage to initiate needed changes in the operation of California hatcheries and that their attention will be focused especially on the major issues that we identify below. We suggest this document is the only the first step in essentially an adaptive management approach to continued evolution in the operation of California's anadromous salmonid hatcheries.

3.1 Serious Loss and Degradation of Habitat Limits Natural Production of Salmon and Steelhead in California

A substantial amount of historic habitat for anadromous salmonids has been lost in the Klamath/Trinity and Sacramento/San Joaquin river systems due to the construction of large impassable dams. Associated downstream water management and other land-use practices have resulted in additional habitat modifications further impacting productivity of anadromous species. The California HSRG has identified areas where hatchery facilities and programs can and should control undesirable hatchery impacts. The California HSRG notes, however, that hatcheries and hatchery reform alone will not recoup historic adult holding, spawning, and nursery habitats or likely influence water or land-use management. Protecting the remaining available habitats and restoring former habitats must be a priority if viable natural populations of salmon and steelhead are desired and the abundance of natural-origin fish is expected to increase. Therefore, in conjunction with this Hatchery Scientific Review and expected subsequent implementation of changes in hatchery practices, major efforts to protect and restore habitat quality and quantity in California's Central Valley and in the Klamath/Trinity river system (including migration corridors) must continue or expand.

3.2 Hatchery Program Goals have been Consistently Expressed in Terms of Juvenile Production Rather than Adult Production

Because survival from release to adult varies substantially across hatcheries and programs, as well as across years, juvenile production is not an adequate or sufficient measure of program goals. Instead, the California HSRG recommends that program goals should be expressed in terms of expected (average) adult production which has direct relevance for fishery harvests and spawning escapements. For Chinook salmon, adult production should be measured by age 3 pre-fishery ocean recruits. For coho salmon (currently not subjected to ocean harvest in California) and steelhead (also not subjected to significant ocean harvest), adult production goals should be expressed as adult freshwater returns.

3.3 Program Purposes Have Not Been Clearly Defined

Most hatchery programs in California do not have clearly defined purposes other than juvenile production targets and, sometimes, undefined contribution to harvest. Providing fish for harvest, population supplementation or prevention of extinction are potential purposes. Lack of clearly defined program purposes hinder success in meeting program goals and has likely led to negative impacts on natural spawning populations. We recommend that hatchery program purposes be clearly defined and used to guide management decisions. Also, an emerging conservation focus for many of the State's steelhead, Chinook and coho programs needs to be recognized, and appropriate operational procedures adopted.

3.4 Hatchery Monitoring and Evaluation Programs and Hatchery Coordination Teams Are Needed

Monitoring and evaluation (M&E) programs perform a critical role in assessing whether hatcheries are achieving their goals of providing societal benefits (e.g., harvest opportunity) and assisting in the conservation of depressed populations. M&E programs also are critical to assess the level of impact hatchery programs may have on natural populations. Effective monitoring and evaluation provides accurate, timely, and objective information collected within a sound scientific framework. Despite the importance of hatchery M&E programs, they have generally received insufficient emphasis at California's anadromous fish hatcheries. The California HSRG recommends that every anadromous fish hatchery program in California have a dedicated M&E program and that Hatchery Coordination Teams be formed to bring together the knowledge and expertise of hatchery managers, biologists and fish culturists, M&E biologists, fish health specialists, regional fish biologists, fishery managers, and other representatives from management or funding agencies. Implementation of these M&E programs and associated review processes will inform hatchery decisions and document compliance with best management practices. Furthermore, we urge periodic interaction among the Hatchery Coordination Teams from different facilities to share scientific approaches and practices.

3.5 Program Size (as Measured by Juvenile Production) has been Set Independent of any Consideration of Potential Impacts of Hatchery Fish on Affected Natural Populations

There are a large number of possible negative impacts that release of millions of hatchery fish may have on natural populations, including direct competition or predation among hatchery- and natural-origin juveniles, transmission or promotion of disease from hatchery to natural populations, competition between hatchery- and naturally-produced adults for spawning habitat, and reduction in fitness due to interbreeding of hatchery and naturally-produced adults on spawning grounds. We recommend that studies be carried out to assess these interactions and their effects on naturally spawning populations of salmon and steelhead. Where substantial negative effects occur, hatchery programs should be modified to ameliorate those effects. In cases where hatchery operational strategies cannot be modified to satisfactorily reduce negative impacts on natural salmonid populations, program size should be reduced. Among situations where program size is reduced or programs eliminated, in no case should such change result in relinquishment of mitigation responsibility.

3.6 Off-site Releases Promote Unacceptable Levels of Straying Among Populations

All releases of Chinook salmon and steelhead in the Klamath-Trinity system have been made on-site at the hatcheries where fish were spawned and reared, with a few exceptions in the mid-1980s. As a consequence, the majority of adult hatchery fish return to spawn either at the hatchery or in natural areas in the immediate vicinity of the hatchery. In the Central Valley, however, because of the degraded conditions of downstream migration corridors, most Chinook salmon hatchery production has been routinely released off-site, significantly downstream of the hatchery or in the estuary. Although this off-site release practice has improved survival rates and resulted in increased ocean harvest of hatchery fish, it has also led to widespread straying of hatchery fish throughout the Sacramento-San Joaquin system. For example, in fall 2010, about 70 percent of fall Chinook salmon spawning in the Yuba River were of hatchery origin, mostly from the Feather River Hatchery. Genetic evidence suggests that the long-term use of off-site release locations has substantially contributed to the lack of genetic differentiation among Central Valley fall Chinook salmon (Williamson and May 2005), whereas, in the smaller Klamath-Trinity system, where on-site release has been the predominant policy, substantial genetic differentiation continues to exist among fall Chinook salmon populations. One of the goals of the California HSRG is to reestablish conditions for local adaptation to reemerge. As a first step toward reestablishing adaptive genetic differentiation among Central Valley fall Chinook salmon populations, all releases should be made on-site (at or in the near vicinity of the hatchery of origin). Until all off-site releases of Chinook salmon are eliminated in the entire Central Valley, coded wire tag analysis should be used at Feather, Nimbus, Mokelumne, and Merced hatcheries to identify stray hatchery-origin fish among those fish selected for broodstock. Strays from other hatchery programs should not be used as broodstock, or if eggs are collected from or fertilized by such fish, they should be culled soon after spawning. We note that this interim action will not, however, address straying of out-of-subbasin hatchery-origin fish into natural spawning areas, and is therefore an insufficient solution to the problem of off-site releases.

3.7 Marking/Tagging Programs are Needed for Real-time Identification of all Hatchery Chinook Salmon

Current marking programs for Chinook salmon in the Klamath-Trinity system and, for the most part, in the Central Valley system, consist of a constant fractional marking program in which 25 percent of fish produced are released with adipose fin-clip and coded-wire tag (CWT). This marking program is adequate to allow reasonably accurate statistical estimation of the proportion of hatchery fish on natural spawning grounds and in hatchery returns, and does a good job of supporting needs of fishery managers, but it does not allow real-time identification of all hatchery fish as being of hatchery origin. For the immediate future, we recommend generally that all Chinook salmon (100 percent) should be tagged with CWT and that 25 percent should be adipose fin-clipped to allow real-time identification of hatchery-origin fish (using electronic CWT detection devices). This is essential for the following purposes: to enable improved monitoring of hatchery and natural interactions throughout the entire life cycle; to enable culling of undesirable hatchery matings between out-of-subbasin and local stocks or between spring and fall Chinook stocks from the same basin (through CWT reading), to enable improved management of hatchery broodstock (incorporation of known numbers of natural fish), and to monitor and potentially control spawner composition in natural spawning areas. While 100 percent adipose fin-clipping would also allow real-time identification of all hatchery-origin fish, it is a crude mark which doesn't provide the hatchery of origin or run-type.

3.8 Standards for Fish Culture, Fish Health Management and Associated Reporting are Inadequate and Need to be Improved

Fish culture techniques and fish health management are intrinsically intertwined; each discipline requires attention to detail, prompt remediation of adverse conditions and a coordinated effort to promote optimum fish health and survival. Clearly defined goals, roles and standards for fish culture and fish health management, promulgated in official policy, foster optimum health of hatchery fish while preventing the importation, dissemination, and amplification of pathogens and diseases known to adversely affect both hatchery and natural fish populations. The California HSRG observed large variation in hatchery operations relevant to fish health, including fish culture techniques, the level of fish health support requested or provided, and the data collected during each production cycle (adult collection to juvenile release) that affect fish health and survival, and provide inadequate protection for both hatchery and natural fish populations from disease impacts. The California HSRG also noted that the current fish culture protocols (Leitritz and Lewis 1976) are now outdated and that infrastructure needs and inadequate fish pathology staff compromise efficient and cost-effective operation of some hatchery facilities.

The California HSRG recommends adopting the standards of the Integrated Hatchery Operations Team (IHOT, IHOT 1995) for California anadromous fish hatchery programs. These policies and procedures were developed in the Columbia Basin anadromous salmonid hatcheries and include comprehensive standards for fish culture techniques, fish health management and reduction of negative ecological interactions with natural populations. In addition to the IHOT standards, the California HSRG recommends that a comprehensive fish health policy, fish health management plans for ESA species, and an updated fish culture operational manual be developed for state-operated anadromous fish hatchery programs.

3.9 Populations and Population Boundaries have not been Established for Non-listed Species and are Needed for Effective Development of Integrated Hatchery Programs

Previous HSRG efforts in Puget Sound and the Columbia River (HSRG 2004, 2009) primarily reviewed hatchery programs that affected species of anadromous fish whose associated Evolutionarily Significant Unit (ESU) or Distinct Population Segment (DPS) had been previously listed as Endangered or Threatened under the Endangered Species Act. Because of this, ESU/DPS population boundaries were established by Technical Recovery Teams and population importance was established in associated Recovery Plans. In contrast, the majority of the populations with which California hatcheries are associated, including all fall Chinook programs, belong to ESUs/DPSs that have not been listed under the ESA, and as such, the component populations have not been explicitly delineated. Therefore, in many cases, it is not a straightforward matter to identify the geographic boundaries of the population with which a hatchery is intended to be integrated. For example, what is the lower population boundary of fall Chinook salmon spawning in the mainstem Trinity River with which the Trinity River Hatchery program is integrated? Challenges such as these are further complicated by genetic homogenization of Central Valley fall Chinook salmon (Williamson and May 2005).

The California HSRG recommends that the geographic boundaries for naturally spawning populations to be integrated with hatchery programs should adhere to the following guidelines for ESA-listed species.

- Where independent populations and associated population boundaries have been identified for listed species, these same populations and boundaries should be used to define the geographic boundaries of the population with which a hatchery should be integrated.

The California HSRG recommends that provisional identities and boundaries for non-ESA listed species should be established in one of the following ways:

- Where judged appropriate, boundaries for related species could be used, on an interim basis, while work is done to better define and motivate population boundaries for these non-listed species. Thus, for example, defined populations and boundaries for coho salmon in the Klamath-Trinity system (Williams et al. 2006) could be used, provisionally, for fall Chinook salmon.

- In the Central Valley, populations and population boundaries as defined in the Anadromous Fish Restoration Program (AFRP) under the Central Valley Project Improvement Act may be used to define populations and their boundaries.

The California HSRG also makes two important observations. First, designation of population boundaries can have an important influence on the proportion of hatchery-origin spawners (pHOS) in natural areas and on the associated proportion of natural-origin broodstock (pNOB) that would be required to achieve a particular proportionate natural influence (PNI) value for an integrated hatchery program. Second, population boundaries are important so that managers can assess the prevalence of stray hatchery fish (pHOS) in natural populations that are not integrated with hatchery programs.

3.10 Harvest Management of Sacramento River Fall Chinook Should Account for the Productivity of Naturally-Spawning Adults

The Pacific Fishery Management Council (PFMC) and California Fish and Game Commission manage the ocean and river fisheries that impact Sacramento River fall Chinook salmon. As of 2012, the total overall brood harvest rate for this stock is capped at 70 percent with a minimum aggregate spawning escapement (returns to hatcheries and natural areas) target of 122,000 adults. In contrast, the total overall brood harvest rate for Klamath-Trinity fall Chinook salmon is capped at 68 percent with a minimum natural area spawning escapement target of 40,700 adults. The allowable harvest rate for Klamath-Trinity fall Chinook salmon is based on a stock-recruitment analysis of natural area spawning fall Chinook salmon and is therefore consistent with the productivity of naturally spawning fish in this system. The California HSRG is concerned that an overall brood harvest rate of 70 percent for Sacramento River fall Chinook salmon may be too high for naturally-spawning fish given the degraded conditions for downstream migration that are experienced throughout this basin. We also believe that an aggregate escapement target for this stock that includes returns to hatcheries lacks biological support. The target could theoretically be met if all fish returned to hatcheries and none returned to natural spawning areas, or if all fish in natural spawning areas were of hatchery origin. Both of these outcomes would clearly be at odds with a desire to foster sustainable natural production of fall Chinook salmon in the Sacramento River system. We therefore recommend that the current approach used to manage the harvest rate on Sacramento River fall Chinook salmon be reviewed by the fishery management entities, and revised to explicitly account for the status and productivity of Sacramento River fall Chinook spawning in natural areas.

3.11 Several Steelhead Programs Have Seriously Underperformed

Several steelhead programs reviewed by the California HSRG were observed to be underperforming or potentially detrimental to native steelhead populations. The winter steelhead program at Nimbus Fish Hatchery uses broodstock derived from fish imported from the Eel and Mad rivers and there is evidence that these fish have introgressed native steelhead populations in the Central Valley. We recommend that this broodstock be replaced with an appropriate native broodstock. Several steelhead programs experience very low adult return rates and appear to use resident fish as broodstock. At Iron Gate and Mokelumne River hatcheries, adult return rates are so low in comparison to historical returns, that the California HSRG recommends managers review the existing programs and develop alternative broodstock collection and rearing strategies so as to meet program goals and objectives. Finally, runs of both natural- and hatchery-origin steelhead in the Central Valley are at record lows when compared to historical numbers both before and after construction of numerous water projects. The California HSRG believes that the recommendations for steelhead hatchery programs in this report should be assigned a high priority for implementation, and that continuing improvements in monitoring freshwater returns, including creel surveys, also have high priority.

3.12 Adults Returning from "Yearling" Releases of Hatchery Chinook Salmon Should be Excluded from Broodstock

Chinook salmon are reared and released as subyearlings during their first spring or fall at Iron Gate Hatchery, Trinity River Hatchery, and Mokelumne River Hatchery. "Fingerlings" are released in early June at about 90-100 fish/pound, and "yearlings" are released in early October at about 10 fish/pound. Yearlings typically have greater survival rates to adult than fingerlings. Also, release of smolts in fall, after naturally-produced juvenile salmon have left the river for the ocean, probably reduces competition with natural Chinook during the juvenile phase. The longer duration of rearing in the hatchery, however, almost certainly increases the potential for domestication of yearlings as compared to fingerlings and likely causes greater detrimental effects to natural populations when these fish spawn in natural areas. To reduce the degree of domestication in these programs, we recommend that all yearlings receive an additional distinguishing external mark or tag (e.g., a ventral fin clip), and be completely excluded from hatchery broodstock upon return. Adequate numbers of fingerlings should be released each year to meet numerical goals for broodstock. When adult returns from fingerling releases are inadequate to satisfy hatchery egg take needs, then yearling returns may be used to reduce the deficit.

3.13 True "1:1 Matings" and Associated Incubation Protocols Need to be Adopted by California Steelhead and Salmon Hatcheries

Most of the production (non-conservation) programs reviewed by the California HSRG used mating practices whereby eggs from multiple females (e.g., 5) and sperm from multiple males (e.g., 5) were placed, sequentially, in the same tub. Eggs from such matings are then distributed across a number of incubators based on the total volume of eggs fertilized in any given set of females. Such procedures do not constitute "1: 1 matings" as we define them, and, in many cases, the contributing males may have widely different levels of egg fertilization success (see Campton 2004), due to differences in sperm motility and fertilization success among males. This unequal male contribution reduces the genetic effective size of a population.

For programs that spawn more than 250 females, the California HSRG instead recommends that they routinely adopt true 1:1 mating protocols in which eggs from only one female are fertilized by sperm from only one male in a separate pan. Coleman National Fish Hatchery currently employs a very efficient 1:1 spawning protocol for all Chinook salmon (more than 4,000 males and 4,000 females are spawned in most years). For smaller programs, we further recommend eggs from each female be split into two or more lots and that each lot be fertilized by sperm from a different male in a separate pan, and also that eggs from no more than two females be incubated in a single incubator tray, ideally with a divider to separate the two families, so that eggs from undesired matings (e.g., in-subbasin and out-of-subbasin stocks) can be readily culled. These same incubation protocols should also be considered for adoption in large-scale hatchery programs, especially when large numbers of out-of-subbasin broodstock have been unintentionally incorporated into the broodstock historically. Efficient systems to track eggs from the spawning area to the incubation area likely will also need to be developed.

3.14 Effective Methods are Needed to Ensure Maintenance of Distinct Runs of Chinook Salmon Reared at the Same Facility

Three facilities in California produce multiple runs of Chinook salmon: Coleman National Fish Hatchery (late fall- and fall-run), Feather River (spring- and fall-run), and Trinity River (spring- and fall-run) hatcheries. Different methods are used at the three facilities for separating the broodstock for the two Chinook programs and they have different effectiveness. The late fall- and fall-run separation at Coleman Hatchery is achieved through periodic trap operation, differential mark rate application and subsequent identification and phenotypic discrimination. Fish collected between the fall and late-fall spawning seasons are euthanized and excluded from the broodstock. Coded wire-tag analysis has shown this to be highly effective at maintaining separation of these two stocks. At Feather River Hatchery, spring-run broodstock are identified using a phenotypically-based method (Hallprint dart-type tag) and appears to be effective at limiting gene flow from the fall- to spring-run. In contrast, fall-run identification at Feather River Hatchery is not effective and the California HSRG recommends coded-wire tag analysis during the first few weeks of fall-run broodstock collection to identify and remove spring-run fish. (We note that this will not, however, allow identification of natural-origin spring-run fish in the broodstock.) At Trinity River Hatchery, some degree of separation between spring- and fall-run is achieved through a two week trap closure, but separation does not appear to be sufficient to isolate spring from fall runs. We recommend that the fish trap remain open during the period between spring- and fall-run broodstock collection but that fish collected during this period be euthanized. We further recommend coded-wire tag analysis of broodstock in the last two weeks of the spring-run and the first two weeks of the fall-run spawning seasons to establish run-type of spawners. Eggs identified from matings of spring- and fall-run fish should be culled. We further recommend that facilities be constructed to allow early-returning spring-run fish to be held at the Trinity River Hatchery for up to several months prior to spawning.

4. California Statewide Issues and Recommended Statewide Standards and Guidelines for Operating Hatchery Programs

For each of the 19 anadromous hatchery programs evaluated during this review, contractors initially compiled both operational and biological information as draft program reports. These draft reports were provided to the California HSRG in advance of each regional review. Regional work sessions attended by both contractors and the California HSRG were then conducted (see Table 1-3). These sessions generally involved a one-day tour of the watershed and hatcheries and discussions with hatchery personnel and regional biologists. These information gathering reviews were followed by a two- or three-day work session of the California HSRG. Additional multi-day work sessions and conference calls were conducted by the California HSRG as well. During these reviews and work sessions, the California HSRG deliberated at length on the challenges facing all 19 of the programs.

Based on our review, the California HSRG identified a suite of issues that were applicable to hatchery programs statewide. These common issues were organized under five key hatchery topics (1) broodstock management; (2) program size and release strategies; (3) incubation, rearing and fish health management; (4) monitoring and evaluation; and (5) direct effects of hatchery operation on local habitat and aquatic or terrestrial organisms. The California HSRG then developed standards and guidelines for each topic along with the scientific rationale for the standards and guidelines. Each of the 19 hatchery programs was then reviewed for compliance with the standards; non-compliance was noted along with relevant guidelines. In many cases, comments were supplied as well. These program-specific compliance/non-compliance determinations, by topic, are recorded in the 19 individual Program Reports (Appendix VIII). Major program specific recommendations are highlighted in Chapter 5. Below we present the complete set of standards and guidelines that we recommend for use at all anadromous salmonid hatcheries in California.

4.1 Broodstock Management

Maturing adult fish are available for use as broodstock in hatchery operations when they return to the hatchery or are trapped at an auxiliary facility. The way in which fish are chosen for use as broodstock and their subsequent handling are critically important issues for performance of hatchery programs. The California HSRG identified several areas of broodstock management where standards and guidelines are necessary: the source and life history attributes of fish used; the collection and subsequent holding of fish until spawning and, with steelhead, until release; the selection of fish for spawning from among all fish trapped; the selection of mating partners for spawning; and the effects of broodstock collection on the naturally-spawning populations of the same species.

In California, almost all of the salmon and steelhead hatchery programs have been using broodstock that originated from the natural population in the immediate vicinity of the hatchery for at least several decades. The one exception is the Nimbus steelhead program, which uses broodstock derived from out-of-basin sources, including California's Eel and Mad rivers. Many other hatchery programs historically imported some broodstock or eggs, but it is now widely accepted that such out-of-basin broodstock typically performs poorly, and such introductions generally fail to produce consistent adult returns. In addition, fish from out-of-subbasin, not locally adapted to be basin of interest, are expected to have greater negative consequences on naturally spawning populations of fish native to the basin where the hatchery is located. For these reasons, the California HSRG recommends that broodstock be taken from fish native to the hatchery location or thereabouts and with life history attributes appropriate to program goals. When native fish of multiple life history types, such as temporal runs of salmon or resident and anadromous *O. mykiss*, occur within the basin where the hatchery is located, particular care must be taken in collection of broodstock for use in the hatchery.

Incorporating natural-origin fish into hatchery broodstock is complicated by the fact that natural-origin fish do not enter most primary hatchery trapping facilities in sufficient numbers to meet either current program goals or those recommended by the California HSRG. Existing broodstock collection facilities for most of the hatchery programs are located at the hatchery site, which is typically the terminus of the migratory pathway. These facilities are often extremely limited in their ability to capture a representative sample of the naturally-spawned population with which the hatchery stock is associated. Additional broodstock trapping facilities and protocols are needed to collect adequate numbers of natural-origin fish displaying the full range of phenotypic variation in the stock to meet program goals. The California HSRG notes that one goal of all of the steelhead programs is to produce anadromous fish and that this is best accomplished by using anadromous adults as broodstock.

In addition, many fish collected for broodstock are not spawned immediately or at all. Steelhead may be held at the hatchery following spawning for reconditioning and eventual release. Adequate facilities are necessary to hold fish in the hatchery until spawning and/or release in the numbers that they are typically encountered and without substantial hatchery-related mortality (e.g., disease and predation). Since steelhead are iteroparous and can perform more than one anadromous migration, some fish used as broodstock should be reconditioned prior to release; adequate facilities for such reconditioning are required.

Protocols must be in place for selecting fish for broodstock because more fish are generally brought into the hatchery than are needed to meet program goals. These protocols must specify how different size and age groups are used in spawning, how different life-history types are identified and selected, and how natural- and hatchery-origin fish will be incorporated into the program's broodstock. Several salient issues identified by the California HSRG are that smaller adults are generally believed to have lower reproductive success than larger fish in natural spawning, and 2-year-old fish (i.e., jacks for salmon), which are most frequently males, may have much lower reproductive success in naturally-spawning populations. As such, they should be incorporated into broodstock at rates that are lower than their abundance and, ideally, commensurate with their reproductive contribution in the naturally spawning population, to avoid possible hatchery selection on age distribution. For the coho salmon programs in California, it is of particular importance to incorporate 2-year-old fish (i.e., jacks and jills) into broodstock. Most fish in these stocks mature as 3-year-olds and all fish mature as either 2- or 3-year-olds so that excluding jacks will reduce effective population size and induce divergence among the three brood cycles.

The California HSRG also recognized that total isolation of the hatchery stock from the naturally-spawning populations in the same basin is impossible. Since the negative consequences of hatchery fish breeding in natural populations are generally greater the more divergent the fish are, some level of integration between hatchery and natural populations is desirable. Incorporating natural-origin fish into the hatchery broodstock decreases divergence between hatchery and natural populations (Reisenbichler and McIntyre 1986, Lichatowich and McIntyre 1987, Cuenco et al. 1993). Natural-origin fish should be incorporated into broodstock in the highest proportion possible (Harada et al. 1998), and a minimum proportion of 10 percent natural-origin fish as broodstock (pNOB) is a widely employed general guideline to reduce divergence of the hatchery- and natural-origin components of integrated populations. However, use of natural-origin fish as broodstock must be achieved without decreasing the viability of the natural population due to the demographic effects of removing mature fish.

Once fish have been selected for broodstock, mating partners must be chosen. As a general rule, care must be taken not to induce selection by using phenotypic characters to select fish to mate (Neff et al. 2011). The California HSRG recommends that once fish have been identified as belonging to the stock being produced (i.e., the intended temporal run or life history type), mating partners should not be chosen on the basis of any phenotypic traits, such as size or color (except where size is used to identify jacks or anadromous steelhead). However, in natural populations, larger salmonids generally garner higher reproductive success. As noted above, Chinook salmon jacks (age-2) should be incorporated into broodstock at a rate that is lower than their abundance and, ideally, commensurate with their reproductive contribution in the naturally spawning population. Similarly, larger females typically have greater fecundity (i.e., more eggs). Moreover, size is strongly correlated with age, although the size distributions of different age fish from the same cohort generally overlap and the size distributions of different age fish can vary considerably between cohorts. Because age at reproductive maturity has a considerable heritable component (Hankin et al. 1993), choosing mating partners without regard to size may induce unintentional selection for early age at maturity in Chinook (Hankin et al. 2009). An alternative, and relatively simple, mating strategy has been suggested for Chinook salmon to mitigate this concern, whereby no female is mated with a smaller male (except when the male is a jack). The California HSRG is intrigued by this concept but did not fully endorse it, instead preferring to recommend experimentally evaluating the protocol in a selected stock (late-fall Chinook salmon at Coleman NFH). Such a protocol would have to include a provision for incorporation of some jacks so as to avoid inducing selection on age distribution of the stock.

In addition, mating protocols must not substantially contribute to inbreeding in the stock. Inbreeding occurs when related individuals mate and produce offspring, with many of their gene copies then identical by descent. Inbreeding leads to the expression of deleterious recessive traits, reduces genetic diversity and has been shown to decrease fitness in salmonids dramatically. To address inbreeding concerns, the California HSRG considered the widely adopted breakpoints for effective population size (N_e>50 to avoid inbreeding depression, N_e>500 to maintain additive genetic variation, N_e>5,000 to allow for mutation and to maintain genetic variation at quasi-neutral loci; Frankel and Soule 1981, Lande 1995) to evaluate the adequacy of the numbers of spawners used or to help develop guidelines for when to consider factorial mating designs. In such natural populations, fish can choose mates with the appropriate level of relatedness and avoid severe inbreeding. Even so, some inbreeding in natural populations (e.g., that between non-sibling relatives) is not only unavoidable, but may serve a beneficial role. In hatcheries, natural mate choice does not operate, and higher rates of inbreeding can occur as a result. In large hatchery programs integrated with large natural populations, the proportion of inbred matings that occurs during hatchery spawning is relatively minor and controlling it is impractical. However, in smaller programs, or those integrated with a small natural population, it can be a substantial problem. For such programs, protocols must be in place to avoid inbreeding and reduce loss of genetic diversity due to inbreeding and genetic drift. Such techniques include multifactorial mating (i.e., splitting egg lots) and molecular genetic specification of mating partners, so-called genetic broodstock management. For salmon and steelhead propagation programs of all sizes, it is also important to ensure that male gametes are not mixed prior to or at the time of fertilization, as sperm competition can reduce the effective number of broodstock by skewing contribution of different males.

The potentially iteroparous nature of steelhead raises a unique set of issues regarding the disposition of fish trapped as part of broodstock collection efforts, since these fish may potentially return to spawn in subsequent years whether they are used as broodstock or not. There are two main issues to consider in an adult steelhead disposition plan: 1) reducing reproductive contributions of hatchery-origin fish in natural populations, and 2) avoiding selection against iteroparity in the hatchery stock and, therefore, the integrated population. The ESA-listed status of some of the hatchery stocks is also an important consideration in such a plan.

With all of this in mind, the California HSRG provides recommendations for the disposition of trapped steelhead for the six hatchery programs we reviewed. Note that the current Nimbus broodstock and a potential native Nimbus broodstock, to be used in the future per our other recommendations below, are treated separately in the plan and have different disposition recommendations.

The California HSRG steelhead disposition plan recommends that all natural-origin steelhead, male and female, spawned and unspawned, are released. Hatcheries should undertake extended reconditioning of spawned fish prior to release. Extended reconditioning means that fish are held until after the spawning season. A summary of the plan, with associated rationale, follows.

For the Klamath/Trinity programs, unspawned hatchery-origin fish should be released when it is determined that they will not spawn in natural areas that year, which requires extended reconditioning for males and stripping eggs followed by extended reconditioning for females. Preventing spawning of hatchery-origin fish in that year will reduce pHOS, whereas releasing them to potentially return in subsequent years will not result in selection against iteroparity. Spawned fish should be removed. This will prevent their subsequent reproduction in natural areas either that year (males) or in following years (both males and females). Since these fish are reproducing and broodstock will include a mix of fish that would have returned to spawn and those that would not, it should result in little selection against iteroparity. Fish that are iteroparous may have greater lifetime reproductive success than non-iteroparous fish, which would favor iteroparity, but any under-representation of these fish will be largely compensated for by only allowing iteroparous fish to spawn in the non-broodstock component of the trapped fish.

For the Central Valley programs, we recommend removal of all fish, spawned or unspawned, from the current Nimbus program. It is important to limit reproduction of this non-native stock in natural areas as much as possible and we are not concerned about selection against iteroparity in this stock. For the rest of the programs, including a future Nimbus program with a native broodstock, the recommendation for unspawned fish is the same as for the Klamath/Trinity programs: release steelhead after ensuring that they do not spawn in that season.

For spawned fish, however, there is the option to either remove or recondition them. The option to recondition steelhead is important because Coleman and Feather River stocks are ESA-listed and it may be problematic to remove them. If steelhead are released, extended reconditioning is necessary to prevent them from engaging in spawning activities again that year in either natural areas or the hatchery. The Mokelumne River stock is not ESA-listed, but a recent genetic analysis (Garza and Pearse unpublished data) shows that it is genetically derived from the Feather River Hatchery stock or otherwise very similar to it, and it should therefore be treated similarly to the ESA-listed stocks. Any future Nimbus stock should be of native origin and be treated similarly.

The California HSRG also recognizes that small hatchery programs and/or those that are integrated with small or ESA-listed populations must adopt best management practices that are essentially those of designated conservation programs; the California HSRG therefore employs the term conservation-oriented programs to refer to all such hatchery programs.

The specific standards that broodstock management must achieve are listed below.

Broodstock Source

- **Standard 1.1**: **Broodstock is appropriate to the basin and the program goals and should encourage local adaptation.**

  Guideline 1.1.1. Broodstock should be chosen from locally adapted stocks native to the basin and with life history characteristics appropriate for the program goals.

  Guideline 1.1.2. Broodstock should be representative of the natural population with which the hatchery program is integrated. Spatial distribution of the integrated population should not be based on straying associated with off-site releases.

Broodstock Collection

- **Standard 1.2**: **Trapping is done in such a way as to minimize physical harm to both broodstock and non-broodstock fish.**

- **Standard 1.3**: **Collection methods are appropriate for the program goals.**

  Guideline 1.3.1. Trapping locations should include mechanisms for collecting sufficient numbers and diversity of both hatchery- and natural-origin fish to meet program goals. If inadequate numbers of natural-origin fish are available with current collection methods, then additional collection methods are required.

- **Standard 1.4: Trapping is designed to collect sufficient fish as potential broodstock to be representative of the entire run timing and life history distribution of the population or population component with which it is integrated.**

  Guideline 1.4.1. Fish traps should be operated for at least the entire temporal period of the run and should not exclude fish with any particular life history characteristics. An exception to this guideline is allowable when non-representative broodstock collection is necessary to achieve program goals, such as separating broodstock of differing eco-types.

- **Standard 1.5**: **Hatcheries have effective facilities for the extended holding of unripe fish and males that will be used for multiple spawning.**

Guideline 1.5.1. Holding facilities in hatcheries should provide adequate space, water flows and temperature requirements to hold the expected number of unripe adult fish for extended periods of time with minimal hatchery-caused mortality (refer to Senn et al. 1984 for specific water quality, flow and temperature parameters).

Guideline 1.5.2. Holding facilities in hatcheries should permit appropriate antibiotic and/or chemical treatments when deemed necessary to control adult mortality or prevent vertical transmission of diseases to progeny.

Broodstock Composition

- **Standard 1.6**: **Broodstock is primarily comprised of fish native to the hatchery location, with incorporation of fish from other locations not exceeding the rate of straying of natural-origin fish.**

Guideline 1.6.1. Broodstock should originate in the subbasin in which the hatchery is located, except when estimates of natural straying from proximate locations are known, in which case, incorporation of returning adults from those locations should not exceed this natural stray rate.

Guideline 1.6.2. Until all off-site releases of Chinook salmon are eliminated in the entire Central Valley, coded wire tag analysis should be used at Feather River, Nimbus, Mokelumne and Merced hatcheries to identify stray hatchery-origin fish among those fish selected for broodstock. Strays from other hatchery programs should not be used as broodstock, or if eggs are collected from or fertilized by suck fish, they should be culled soon after spawning.

- **Standard 1.7: The levels of natural-origin broodstock are appropriate for program goals.**

Guideline 1.7.1. For conservation-oriented programs, the proportion of natural-origin broodstock proportions should be approaching 100 percent.

Guideline 1.7.2. For integrated programs, pNOB should be at least 10 percent to avoid run divergence. Higher pNOB may be applied to avoid/minimize domestication but should not be large enough to pose a demographic hazard to the natural population(s).

Guideline 1.7.3. For segregated programs where some natural-origin fish from original sources may be incorporated to maintain the genetic health of the hatchery stock, the number of natural-origin fish incorporated should not increase adverse effects on natural populations.

- **Standard 1.8: Fish from different runs are not crossed**.

Guideline 1.8.1. Hatcheries should employ effective methods to identify fish from different runs and avoid crossing them. Eggs produced by unintentionally crossing types should be culled.

- **Standard 1.9**: **Steelhead broodstock collection focuses on the anadromous life history. Integrated steelhead programs incorporate non-anadromous fish in a proportion not greater**

than their natural (pre-disturbance) abundance in the local population and commensurate with their reproductive contribution in the naturally spawning population when known. For segregated programs, only anadromous broodstock are used.

Guideline 1.9.1. Programs should incorporate an effective mechanism to identify non-anadromous (resident) individuals so as to control their rate of incorporation.

Guideline 1.9.2. Non-anadromous fish should only be incorporated in conjunction with a management plan that specifies maintenance or manipulation of life history diversity.

Guideline 1.9.3. Steelhead programs should retain a 16-inch cutoff to identify non-anadromous fish unless population-specific data are available.

- **Standard 1.10: For Chinook and coho salmon, fish from all age classes and sizes are incorporated into broodstock at rates that are commensurate with their relative reproductive success in natural areas, when known.**

Guideline 1.10.1. For Chinook salmon, the number of jacks to be incorporated into broodstock should not exceed the lesser of: 1) 50 percent of the total number of jacks encountered at the hatchery, and 2) 5 percent of the total males used for spawning.

Guideline 1.10.2. For Chinook and coho salmon, when the number of males available as broodstock is less than or equal to 50, or when less than or equal to 50 broodstock are used to accomplish specific program objectives, the acceptable number of two-year-olds is unlimited.

Guideline 1.10.3. For coho salmon, the number of jacks to be incorporated into broodstock should not exceed the lesser of: 1) 50 percent of the total number of jacks encountered at the hatchery, and 2) 10 percent of the total males used for spawning.

Guideline 1.10.4. For all programs, broodstock should be selected so as to not induce changes in the maturation schedule of the natural population with which the hatchery population is integrated.

Mating Protocols

- **Standard 1.11**: **The program uses genetically conscious mating protocols to control or reduce inbreeding and genetic drift (random loss of alleles), to retain existing genetic variability and avoid domestication, while promoting local adaptation for integrated stocks.**

Guideline 1.11.1. For broodstock numbers greater than or equal to 250 females, matings should be 1 male x 1 female, with each 1:1 spawn in a single spawning pan. Limit the reuse of males to unavoidable situations (e.g., where loss of eggs might result if males are not reused and loss of eggs threatens program goals).

Guideline 1.11.2. For broodstock number between 50 and 250 females, female's eggs should be split into 2 egg lots and each lot should be fertilized with a different male in a separate pan. Limit the reuse of males to two egg lots (or the equivalent of one female), except for unavoidable situations (e.g., where loss of eggs might result if males are not reused and loss of eggs threatens program goals).

Guideline 1.11.3. For broodstock numbers less than 50 females, egg lots should be split into greater than 2 with each lot fertilized by a different male in a separate pan. Limit the reuse of males to no more than 4 egg lots, but ideally males will not be reused.

Guideline 1.11.4. For steelhead, if both non-anadromous and anadromous parents are spawned as broodstock, a non-anadromous fish should never be mated with another non-anadromous fish.

Guideline 1.11.5. For integrated programs including conservation programs:

- Maximize incorporation of natural-origin fish into broodstock to the extent that the number of natural-origin broodstock used in the hatchery program does not substantially reduce the population viability of the donor stock.
- Hatchery-origin fish should be preferentially mated with natural-origin fish. Hatchery origin x hatchery origin matings should be considered least desirable.
- In conservation-oriented programs, relatedness between mated pairs may be more important than hatchery vs. natural origin.

➢ **Standard 1.12**: **Inbreeding is avoided.**

Guideline 1.12.1. For conservation-oriented programs, populations that have experienced known bottlenecks, populations that exhibit evidence of inbreeding depression, and programs where broodstock numbers are regularly less than or equal to 50 individuals, zero matings should be between fish related at the half-sibling level or higher.

Guideline 1.12.2. For conservation-oriented programs, genetic broodstock management techniques (e.g., genetically-based spawner candidate lists, individual spawner marking and holding) should be used to reduce mating of related individuals.

Guideline 1.12.3. For conservation-oriented programs that cannot institute genetic broodstock management but where inbreeding is of concern, or as a transition protocol prior to eventual genetic broodstock management, mate hatchery-origin x natural-origin fish as frequently as possible to reduce inbreeding potential. When possible and appropriate, mate individuals from different cohorts.

Guideline 1.12.4. Census size of small natural populations should be increased in order to reduce the probability of inbreeding.

Guideline 1.12.5. Assume that inbreeding is an issue, especially for small populations or small numbers of broodstock, to avoid unintentional diversity loss (Hedrick and Kalinowski 2000).

- **Standard 1.13**: **The proportion of natural-origin fish used as broodstock does not negatively affect the long-term viability of the donor population. For conservation-oriented programs, extinction risk of the ESU may take precedence.**

  Guideline 1.13.1. For integrated programs, the number of natural-origin broodstock should not substantially decrease the viability of the donor stock.

  Guideline 1.13.2. For conservation-oriented programs, maximize incorporation of natural-origin fish into broodstock. Generally, the number of natural-origin broodstock should not decrease viability of the donor stock. However, some conservation-oriented programs may need to take the entire run into the hatchery to protect existing diversity of very small, very threatened, high value (e.g., unique diversity element) stocks.

  Guideline 1.13.3. For segregated programs, only hatchery-origin fish should be used and indigenous natural-origin fish should not be used as broodstock.

Steelhead Spawner Disposition

- **Standard 1.14**: **For steelhead hatchery programs, the post-spawning disposition of mature fish that are collected as potential broodstock are appropriate to program goals**.

  Guideline 1.14.1. Natural-origin fish from integrated programs will be reconditioned and released if spawned.

  Guideline 1.14.2. Hatchery-origin fish will be disposed of in a manner consistent with identified program goals and using methods that result in no or minimal effects to natural-origin fish.

4.2 Program Size and Release Strategies

Most salmon and steelhead programs in California's Central Valley and Klamath/Trinity River Basin were established as "mitigation" programs to replace anadromous fish production lost due to construction of dams that block upstream migration. Production goals for these and other programs (e.g., harvest augmentation and conservation) typically have been expressed in terms of numbers of juveniles released without specifying whether or how this hatchery production contributes to adult recruits, harvest, conservation, or other purposes. Such juvenile production goals alone are not acceptable. Although releasing juveniles is the means of producing adult fish that contribute to harvest, conservation, and other values, juveniles released is not a suitable endpoint in itself. Instead, hatchery goals must be expressed as adult production goals. In California, these are best expressed as age-3 pre-fishery ocean recruitment (Chinook salmon) or adult freshwater returns (coho salmon, steelhead). Additional, qualitative goals for integrated or conservation-oriented programs should include perpetuation of attributes such as size and age composition and run timing for the integrated or target natural populations.

Program size and release strategy can have important conservation effects on ecological (competition, direct or indirect predation, behavior or disease) or genetic interactions between hatchery-and natural-origin fish. Ecological interactions can be positive or negative; however, the standards and guidelines focus on the latter because negative effects are more prevalent and compromise conservation efforts. Potential examples of positive ecological effects of hatchery-origin fish are nutrient enrichment in low-productivity streams, and decreased predation rates on natural-origin fish when predators are swamped or satiated with hatchery-origin fish. Carcasses of hatchery-origin adults can increase nutrient levels in the stream (whether from fish that die in the stream or from fish that return to the hatchery, are killed, and are then distributed to the stream). Such nutrient enhancement has been shown to benefit natural-origin salmonids in low-productivity streams in the Pacific Northwest. The practice may warrant evaluation in California streams; however, productivity in many streams may already be high and care should be taken to avoid over-enrichment or exacerbation of disease problems (HSRG 2009, Appendix A). Another potential beneficial effect, depensatory predation, has long been prominent in theoretical considerations. However, the California HSRG is not aware that it has been documented for salmon or steelhead. Indeed, empirical data seem to show increased predation rates due to predator attraction rather than reduced predation rates (e.g., Nickelson 2003; Kostow 2009). Excessive aggregations of predators more likely call for reduced program size or altered time, date or location of release rather than expanded program size (Nickelson 2003; Chilcote et al. 2011). Any efforts to reduce predation rates by releasing more hatchery fish must be rigorously evaluated before implementation and are not recommended by the California HSRG at this time.

Survival of juvenile fish, economic efficiency for integrated hatchery programs, and production and viability for affected natural-origin populations all decline as numbers of fish approach or exceed carrying capacity of the river, estuary, or marine rearing areas. The California HSRG recommends that hatchery programs be sized so that overall populations of natural- and hatchery-origin fish remain within the carrying capacity of the available habitat. Although mitigation programs may simply replace natural-origin fish that were eliminated by dam construction and formerly fell within a system's carrying capacity, these programs might exceed present-day carrying capacities, which often are diminished by reduced flows, other habitat degradation or loss, or climate change. The California HSRG encourages all efforts to improve carrying capacity of these systems. Furthermore, the number or biomass of hatchery fish (smolts) required to produce a given number of adults seems to be several times greater than for comparable natural-origin fish. Although limitations in knowledge of carrying capacities are problematic, the issue should be revisited regularly as new knowledge is developed. During the interim, models and procedures are available for exploring the issue (e.g., Mobrand et al. 1997; Weber and Fausch 2005; Scheuerell et al. 2006; Beauchamp et al. 2007; Duffy 2009; HSRG 2009, Appendix C; Liermann et al. 2010).

Annual and decadal-scale variation in freshwater and ocean conditions often prevent programs from achieving their targets. Managers should not respond to a period of decreasing marine survival by releasing increased numbers of hatchery fish without considering the expected increase of hatchery-origin adults in natural spawning areas and whether freshwater carrying capacities may have concomitantly declined and deleterious ecological interactions intensified (Beamish and Bouillon 1993).

Program goals and objectives may create detrimental conditions for natural fish populations when the genetic effects of interbreeding between hatchery- and natural-origin fish are not recognized (Reisenbichler et al. 2003; Araki et al. 2008; HSRG 2009). Fishery and hatchery managers need to recognize and provide a balance between mitigation responsibilities and the number of hatchery-origin fish returning to spawn in natural areas. Program sizes and release strategies that result in inappropriately high levels of pHOS are undesirable.

Release strategy also can be problematic when hatchery fish are released at sizes and dates that differ markedly from those of natural-origin fish. Extended rearing and fall ("yearling") release of subyearling Chinook salmon is such a strategy, because almost all naturally spawned fall Chinook juveniles in

California emigrate in their first spring at much smaller sizes. Fall releases are expected to lead to increased domestication due to the more extended duration of rearing in the hatchery and because juvenile fish emigrating in the fall experience different developmental and environmental conditions than do those emigrating in the spring. Yearling releases have also been shown to change the size and age at maturity of adults (Hankin 1990, Hankin and Logan 2010). The practice has been favored because it greatly increases smolt-to-adult survival and eliminates most competitive and behavioral interactions with juvenile natural-origin Chinook salmon, as most of these natural-origin fish have emigrated months before yearlings are released. Managers who elect to release a portion of their juveniles in the fall should distinctively mark all of these fish so that they can be readily identified as adults. Such fall released fish should be removed to the extent possible and excluded from the hatchery broodstock. Unfortunately, the distinctive mark will not totally eliminate some of the yearling-released fish from spawning in natural areas.

Release strategy can also affect homing and straying. Throughout this report, straying of hatchery fish is defined as failure of hatchery-origin fish to return to the hatchery from which they originated or to the watershed in the immediate vicinity of the hatchery. When hatchery fish are released on-site (at or near the hatchery of origin), most fish will effectively home back to this local area. When fish are released off-site, often at distances far from hatcheries of origin, many of these fish enter spawning streams or hatcheries other than where they were reared (Hallock and Reisenbichler 1979; Quinn 1993; Chapman et al. 1997). In such cases, straying of hatchery-origin fish, with consequent interbreeding with natural-origin fish, may constrain genetic divergence among populations and compromise local adaptation. Hatchery-origin fish may also have reduced reproductive performance (compared to natural fish) when they interbreed with one another or with natural-origin fish on spawning grounds.

When hatchery-origin fish that have been released on-site return to the watershed in the vicinity of the hatchery but do not enter the hatchery of origin, they may generate high pHOS in the population with which they are integrated, even though straying rates are very low. Since excessive pHOS can conflict with program goals, it is therefore important that hatchery ladders and other attraction devices are operated so as to encourage the highest possible percentage of returning hatchery-origin adults to enter hatchery facilities. If pHOS in this area consistently exceeds management targets and/or thresholds, consideration should be given to reducing program size. Among situations where program size is reduced or a program is eliminated, in no case should such change result in relinquishment of mitigation responsibility. If changes in hatchery program operations do not achieve pHOS goals, additional harvest or manual removal of hatchery-origin fish may also be a means to control pHOS.

The specific standards that program size and release strategies must achieve are listed below.

Program Size

- **Standard 2.1: Program size is established by a number of factors including mitigation responsibilities, societal benefits, and effects on natural fish populations.**

  Guideline 2.1.1. Program purpose should be identified and expressed in terms of measurable values such as harvest, conservation, hatchery broodstock, education, or research.

- **Standard 2.2: Program size is measured as adult production.**

  Guideline 2.2.1. Production goals (program size) should be expressed in terms of number of adult recruits just prior to harvest (age-3 ocean recruits for Chinook salmon in California) or at freshwater entry (age-3 adults returning to freshwater for coho; anadromous adults returning to freshwater for steelhead).

- **Standard 2.3: Annual assessments are made to determine if adult production goals are being met.**

  Guideline 2.3.1. Consider variation in environmental conditions when evaluating the performance of a hatchery program, recognizing that poor environmental conditions in one or more years can temporarily preclude attainment of production goals in the best of hatchery programs and do not necessarily call for modification of the hatchery program size or release strategies.

  Guideline 2.3.2. A program that consistently fails to achieve its adult production goals by a substantial margin, especially if it fails to meet broodstock needs, should be judged a failure and remedial action should be taken. Naturally spawning populations should not be depleted to maintain such failed programs.

  Guideline 2.3.3. A program that consistently exceeds its adult production goals by a substantial margin should be reduced in size.

- **Standard 2.4: Program size is based on consideration of ecological and genetic effects on naturally spawning populations, in addition to harvest goals or other community values.**

  Guideline 2.4.1. If deleterious ecological or genetic effects result in substantial reduction of productivity for high-priority naturally spawning populations, and these effects cannot be alleviated by other changes, program size should be reduced. Under certain circumstances, conservation-oriented programs might increase program size to eliminate deleterious effects, for example to reduce inbreeding.

  Guideline 2.4.2. Managers should consider program changes, including reducing program size, to mitigate disease issues. Large numbers of naturally spawning fish may increase the incidence of *C. shasta* disease through the release of myxospores from carcasses, which in turn increases the probability of severe juvenile infection rates the following spring and summer.

- **Standard 2.5: Natural spawning populations not integrated with a hatchery program should have less than five percent total hatchery-origin spawners (i.e., pHOS less than five percent). Spawners from segregated hatchery programs should be absent from all natural spawning populations (i.e., pHOS from segregated programs should be zero).**

Release Strategy

- **Standard 2.6: Size, age, and date at release for hatchery-origin fish produce adult returns that mimic adult attributes (size at age and age composition) of the natural population from which the hatchery broodstock originated (integrated program) or achieve some other desired size or condition at adult return (segregated programs).**

  Guideline 2.6.1. Size and date at release should generally mimic size and period of emigration of naturally migrating smolts in the river system on which a hatchery is located. Deviations from this guideline require substantial justification that addresses both the ecological and genetic consequences of such a strategy, particularly when extended rearing is proposed. Consider retaining some flexibility in release date to take advantage of beneficial flow, turbidity, or temperature conditions without increasing deleterious ecological effects on natural populations.

Guideline 2.6.2. Size and date at release should ensure physiological readiness to migrate rapidly to the sea (to limit predation on or competition with natural-origin fish).

Guideline 2.6.3. When hatchery fish are released at sizes and dates that substantially differ from those of the natural-origin population with which they are integrated, they should all be distinctively marked so that they can be recognized as adults and excluded from hatchery broodstock and spawning in natural areas.

Guideline 2.6.4. For steelhead, size (mean and frequency distribution) and date at release should be managed to limit residualization or extended rearing near the release site prior to emigration.

- **Standard 2.7: Juveniles are released at or in the near vicinity of the hatchery.**

4.3 Incubation, Rearing and Fish Health Management

State-operated anadromous fish hatcheries in California are managed under the statutes and policies of the Fish and Game Code and the Fish and Game Commission. Consistent with these policies and procedures, anadromous fish hatcheries use a goals and constraints document for each facility that provides general directions for the production of fish. Typically, the goals and constraints provide broad guidance and include topics such as broodstock selection, mating and spawning protocols, and disposition of excess fish and eggs (CDFG/NMFS 2001). A “working” fish health policy is provided in the California Department of Fish and Game Operations Manual; however, specific standards and actions have not been prepared or adopted.

The Bonneville Power Administration developed regional policies and procedures for operation of anadromous fish hatcheries in the Columbia River Basin. This document, *Integrated Hatchery Operations Team 1995 Policies and Procedures for Columbia Basin Anadromous Salmonid Hatcheries* (IHOT 1995), includes comprehensive policy guidance and standards for regional coordination, performance, fish health, genetics, and ecological interactions for hatchery programs. The California HSRG reviewed the report and concurred that the fish health and culture standards established by the IHOT are generally applicable to anadromous fish hatcheries in California.

The California HSRG recommends adopting the IHOT standards with minor modifications that address the current and unique conditions of California’s anadromous fish hatchery programs. The California HSRG recommends that the State of California develop a comprehensive Fish Health Policy and Biosecurity Plan for all anadromous fish hatchery programs. Additionally, a Fish Health Management Plan (FHMP) should be developed for ESA-listed species or where fish disease poses a risk to hatchery or natural fish populations. Suggested protocols to control BKD and for iodophor disinfection of eggs are presented in Appendix V.

There are two federally operated anadromous fish hatcheries in California, Coleman National Fish Hatchery and its satellite facility, Livingston Stone National Fish Hatchery. These facilities are operated under the USFWS Aquatic Animal Health Policy (USFWS 2004), as well as all applicable federal and state laws pertaining to hatchery operations. The USFWS Aquatic Animal Health Policy includes a chapter from the American Fisheries Society's "Fish Health Blue Book", entitled *Standard Procedures for Aquatic Animal Health Hatchery Inspections*. This widely accepted "Hatchery Inspection Manual" describes procedures and protocols for conducting fish health inspections at anadromous fish hatcheries.

Written fish rearing protocols provide a training tool for employees, and provide standardization between hatchery programs or facilities that ensure they are operated in a cost-effective and efficient manner. *Trout and Salmon Culture (Hatchery Methods) - Fish Bulletin 164* (Leitritz and Lewis 1976) provides information related to anadromous fish culture and is used by personnel at the State of California operated fish hatcheries. New techniques and procedures related to fish rearing have been developed since its publication and the California HSRG recommends updating the information in Fish Bulletin 164 with more current protocols or adopting an alternative updated manual.

The California HSRG believes that biologists and hatchery managers should use Best Management Practices that help ensure the conservation of both natural and hatchery produced fish through the responsible operation of hatcheries. The rationale, benefits, risks, and expected outcomes of any deviations from established best management practices for fish culture and fish health management should be clearly articulated in a Hatchery Genetic and Management Plan, Fish Health Management Plan, or a similar plan.

The standards and guidelines presented in this section are intended to outline processes for hatchery operations once broodstock have been collected and artificially spawned, and production numbers have been established. The California HSRG believes that maintaining and restoring anadromous fishery resources, including both hatchery- and natural-origin populations, requires the protection of existing and future fish stocks from the importation, dissemination, and amplification of pathogens and diseases. To help achieve this goal, the California HSRG believes that a formal Fish Health Policy that describes prescriptions for monitoring, therapeutic treatments, and a definite course of action when disease epizootics occur is needed to help managers and fish health specialists make decisions.

The specific standards that incubation, rearing and fish health management must achieve are listed below.

Fish Health Policy

- **Standard 3.1: Fishery resources are protected, including hatchery and natural fish populations, from the importation, dissemination, and amplification of fish pathogens and disease conditions by a statewide fish health policy. The fish health policy clearly defines roles and responsibilities, and what actions are required of fish health specialists, hatchery managers, and fish culture personnel to promote and maintain optimum health and survival of fishery resources under their care. The Fish Health Policy includes the California HSRG's Bacterial Kidney Disease (BKD) management strategy (see Appendix V)**

    Guideline 3.1.1. Develop and promulgate a formal, written fish health policy for operation of DFG anadromous fish hatcheries through the Fish and Game Commission policy review process. Such a policy may be formally identified in regulatory code, Fish and Game Commission policy, or in the Department of Fish and Game Operations Manual.

Hatchery Monitoring by Fish Health Specialists

- **Standard 3.2: Fish health inspections are conducted annually on all broodstocks to prevent the transmission, dissemination or amplification of fish pathogens in the hatchery facility and the natural environment, as follows:**

  a) Inspections are conducted by or under the supervision of an AFS certified fish health specialist or qualified equivalent. For state-operated anadromous fishery programs, specific standards and qualifications are to be defined during development of a fish health policy.

  b) Annual inspections follow AFS 'Fish Health Bluebook' guidelines for hatchery inspections.

  c) Broodstocks are examined annually for the presence of BKD and where the causative bacterium *Renibacterium salmoninarum* recurs, the California HSRG's control strategy will be implemented.

  Guideline 3.2.1. Number of individuals examined per stock may vary according to management objectives, but the minimum number should be at the 5 percent Assumed Pathogen Prevalence Levels (APPL), generally 60 fish.

  Guideline 3.2.2. Methodology and effort should meet or exceed AFS "Fish Health Blue Book" procedures.

  Guideline 3.2.3. Develop a fish health management plan to address BKD when present (see California HSRG BKD protocols – Appendix V).

- **Standard 3.3: Frequent routine fish health monitoring is performed to provide early detection of fish culture, nutrition, or environmental problems, and diagnosis of fish pathogens, as follows:**

  a) Monitoring is conducted by or under the supervision of an AFS certified fish health specialist or qualified equivalent.

  b) Monitoring is conducted on a monthly, or at least bi-monthly basis, for all anadromous species at each hatchery facility.

  c) A representative sample of healthy and moribund fish from each lot is examined. Results of fish necropsies and laboratory findings are reported on a standard fish health monitoring form.

  Guideline 3.3.1. The frequency of monitoring should depend on the disease history of the facility, the importance of the species being reared, and the variable environmental conditions that occur in a particular rearing cycle (e.g., elevated water temperatures in spring and summer months).

  Guideline 3.3.2. Review fish culture practices with manager including nutrition, water flow and chemistry, loading and density indices, handling methods, disinfection procedures, and preventative treatments.

  Guideline 3.3.3. The number of fish examined is at the discretion of the fish health specialist.

- **Standard 3.4: All antibiotic or other treatments are pre-approved by the appropriate fish health specialist for each facility. If antibiotic therapy is advised, fish health personnel will culture bacterial pathogens to verify drug sensitivity. Post-treatment examinations of treated units are conducted to evaluate and document efficacy of antibiotic or chemical treatments.**

  Guideline 3.4.1. Re-occurring mortality, or repeated use of antibiotics or chemicals to control mortality, generally indicates that underlying fish culture, nutritional or environmental problems are not being fully remediated and should be further investigated.

- **Standard 3.5: Examinations of fish are conducted prior to release or transfer to ensure fish are in optimum health condition, can tolerate the stress associated with handling and hauling during release, and can be expected to perform well in the natural environment after release.**

  Guideline 3.5.1. Review transportation protocols with appropriate hatchery staff to ensure fish are handled and hauled in a manner that minimizes stress and provides the best opportunity for survival.

- **Standard 3.6: Annual reporting standards and guidelines will be followed for fish health reports, including results of adult inspections, juvenile monitoring and treatments administered, and pre-liberation examinations for each hatchery program. A cumulative five year disease history will be maintained for each program and reported in annual or other appropriate facility reports.**

  Guideline 3.6.1. Include an annual fish disease assessment for each program in the hatchery annual report (see Standard 3.14).

- **Standard 3.7: Fish health status of stock is summarized prior to release or transfer to another facility.**

  Guideline 3.7.1. Written reports should include findings of monitoring and laboratory results. For fish transfers, feeding regime and current growth rate, and any other information necessary to assist fish culturists at the receiving station, should be provided.

Facility Requirements

- **Standard 3.8: Physical facilities and equipment are adequate, and operated in a manner that promotes quality fish production and optimum survival throughout the rearing period. If facilities are determined to be inadequate to meet all program needs, and improvements are not feasible, then the hatchery program(s) must be re-evaluated within the context of what the facility can support without compromising fish culture and/or fish health, or causing adverse interactions between hatchery and natural fish populations.**

  Guideline 3.8.1. Facilities and equipment should allow: effective capture and holding of adults, appropriate incubation and rearing units with adequate capacity to meet program size, equipment and/or methods for effective predator control, and release of fish without undue stress or harm (see Section 4.1.1, Broodstock Management for additional adult holding requirements).

Guideline 3.8.2. Hatchery managers, fish health specialists, biologists and fish culturists should identify facility/equipment deficiencies that constrain hatchery operations and/or prevent the facility from meeting program goals. Such facility deficiencies or constraints should be communicated to resource managers for remedy or redress.

Guideline 3.8.3. When physical facility and/or equipment needs exist, resource managers and appropriate funding source(s) should actively pursue facility maintenance, upgrades or equipment needs through a prioritized budget process. In the interim, modifications should be made to program goals to minimize adverse impacts to fish culture and/or fish health.

- **Standard 3.9: Distinct separation of spawning operations, egg incubation, and rearing facilities is maintained through appropriate sanitation procedures and biosecurity measures at critical control points to prevent potential pathogen introduction and disease transmission to hatchery or natural fish populations, as follows:**

a) Disinfect/water harden eggs in iodophor prior to entering "clean" incubation areas. In high risk situations, disinfect eggs again after shocking and picking, or movement to another area of the hatchery.

b) Foot baths containing appropriate disinfectant will be maintained at the incubation facility's entrance and exit. Foot baths will be properly maintained (disinfectant concentration and volume) to ensure continual effectiveness.

c) Sanitize equipment and rain gear utilized in broodstock handling or spawning after leaving adult area.

d) Sanitize all rearing vessels after eggs or fish are removed and prior to introducing a new group.

e) Disinfect equipment, including vehicles used to transfer eggs or fish between facilities, prior to use with any other fish lot or at any other location. Disinfecting water should be disposed of in properly designated areas.

f) Sanitize equipment used to collect dead fish prior to use in another pond and/or fish lot.

g) Properly dispose of dead adult or juvenile fish, ensuring carcasses do not come in contact with water supplies or pose a risk to hatchery or natural populations.

Guideline 3.9.1. Use dedicated equipment and rain gear that is not moved between adult spawning, incubation and rearing areas of the hatchery; otherwise, thoroughly scrub and disinfect gear when moving between these areas.

Guideline 3.9.2. A critical control point is defined as the physical location where pathogen containment occurs from a "dirty" to a "clean" area (i.e., between functional areas such as spawning and incubation). In addition to egg disinfection, ensure that spawning buckets/trays are surface-disinfected before entering incubation area.

- **Standard 3.10: All hatchery water intake systems follow federal and state fish screening policies.**

  Guideline 3.10.1. Follow existing statutes, including NEPA, CEQA, ESA, CESA, and current court decisions.

Fish Health Management Plans

- **Standard 3.11: Fish Health Management Plans (FHMP) similar to or incorporated within an HGMP have been developed. The FHMP will:**

  a) Describe the disease problem in adequate detail, including assumptions and areas of uncertainty about contributing risk factors.

  b) Provide detailed remedial steps, or alternative approaches and expected outcomes.

  c) Define performance criteria to assess if remediation steps are successful and to quantify results when possible.

  d) Include scientific rationale, study design, and statistical analysis for proposed studies aimed at addressing disease problems or areas of uncertainty pertaining to disease risks.

  Guideline 3.11.1. Compliance with the FHMP should be reviewed annually, through the hatchery coordination team, and include any new data or information that may inform actions or decisions to address disease concerns.

Water Quality

- **Standard 3.12: Water chemistry and characteristics at any new hatchery site meet the water quality required by salmonids, as identified in Hatchery Performance Standards (IHOT 1995) or a comparable reference such as Fish Hatchery Management (Wedemeyer 2001).**

- **Standard 3.13: Existing facilities strive for suggested water chemistry and characteristics (IHOT 1995, Wedemeyer 2001) which may require water filtration and disinfection, additional heating or cooling, degassing and/or aeration, or other modifications to the quantity and quality of an existing water supply, as follows:**

  a) Pathogen-free water supplies will be explored for each facility, particularly for egg incubation and early rearing.

  b) Water supplies must provide acceptable temperature regimes for egg incubation, juvenile rearing and adult holding.

  c) Water supplies will have appropriate water chemistry profiles, including dissolved gases: near saturation for oxygen, and less than saturation for nitrogen.

  d) Water supplies for egg incubation must not contain excessive organic debris, unsettleable solids or other characteristics that negatively affect egg quality and survival.

  Guideline 3.13.1. When surface water is used, a biosecurity evaluation should be performed, and water supplies protected to the extent feasible, to avoid direct contamination of hatchery water supply by potential disease vectors (i.e. live fish, amphibians, birds, or mammals).

Guideline 3.13.2. Cooling and/or heating of water supplies may be necessary to meet water quality standards and program goals, for example, when egg incubation and early rearing water temperatures are too low in fall and winter months to consistently achieve desired fish size-at-release.

Guideline 3.13.3. Degassing columns or aeration devices may be necessary to meet water quality standards throughout the rearing cycle.

Guideline 3.13.4. If unable to remediate siltation problems for egg incubation, alternative incubation sites, water supplies, or incubation methods should be considered.

Best Management Practices

- **Standard 3.14: The rationale, benefits, risks, and expected outcomes of any deviations from established best management practices[5] for fish culture and fish health management are clearly articulated in the hatchery operational plan (including specific fish culture procedures), Hatchery and Genetic Management Plan (HGMP), Fish Health Management Plan, the hatchery coordination team process, and/or in annual written reports.**

  Guideline 3.14.1. Develop required plans.

- **Standard 3.15: Information on hatchery operations is collected, reviewed, and reported in a timely, consistent and scientifically rigorous manner (see requirements and list of reporting parameters in Section 4.4, Monitoring and Evaluation (M&E)).**

  Guideline 3.15.1. An annual report containing monitoring and evaluation information (see M&E standards), including pathogen prevalence, fish disease prevalence, and treatment efficacies, should be produced in a time such that the information can be used to inform hatchery actions during the following brood cycle.

- **Standard 3.16: Eggs are incubated using best management practices and in a manner that ensures the highest survival rate and genetic contribution to the hatchery population, as follows:**

a) Eggs are incubated at established temperatures, egg densities, and water flows for specific species. Appropriate egg incubation parameters are identified in Hatchery Performance Standards (IHOT 1995, Chapter 4) or Fish Hatchery Management (Wedemeyer 2001).

b) Incubation techniques should allow for discrimination of individual parents/families where required for program goals (e.g., for conservation-oriented programs and steelhead programs, or to exclude families for genetic (hybridization) or disease culling purposes).

c) Eggs in excess of program needs are discarded in a manner that is consistent with agency policies and does not pose disease risks to hatchery or natural populations.

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[5] Best management practices are procedures for operating hatchery programs in a defensible scientific manner to: 1) utilize well established and accepted fish culture techniques and fish health methodologies to ensure hatchery populations have the greatest potential to achieve program goals and, 2) minimize adverse ecological interactions between hatchery and natural-origin fish.

Guideline 3.16.1. Culling should be done to minimize unintentional selection.

Guideline 3.16.2. Excess eggs are culled in a manner that does not eliminate representative families or any temporal segment of the run; and culled in portions that are representative of the entire run. Culling may be done to change the variance in family size.

Guideline 3.16.3. Non-representative culling may occur to achieve specific program goals, but must be justified based on genetic considerations of maintaining or rebuilding desired characteristics of the spawning stock.

Guideline 3.16.4. Eggs, fry, or juvenile fish in excess of production needs are disposed of in a manner that is consistent with agency policies on egg culling and fish disposal and will not be released, and should have no effects on natural populations.

Guideline 3.16.5. For conservation-oriented programs, individual reproductive output should be as close to equivalent as possible, while avoiding selection for egg size and age at maturity, and not unduly reducing overall production. These stipulations generally require that families are kept separate until staff can move eyed eggs for separate rearing for specific program types. Avoid loss of within-population diversity resulting from reduced effective population size in the hatchery stock.

- **Standard 3.17: Fish are reared using best management practices and in a manner that promotes optimum fish health to ensure a high survival rate to the time of release, and provides a level of survival after-release appropriate to achieve program goals, while minimizing adverse impacts to natural fish populations, as follows:**

a) Fish performance standards (i.e., species-specific metrics for size, weight, condition factor, and health status) will be established for all life stages (fry, fingerling, and yearling) at each facility.

b) Fish nutrition and growth rates are maintained through the proper storage and use of high quality feeds. Appropriate feeding rates will be closely monitored and adjusted as needed to accommodate fish growth/biomass in rearing units.

c) Juvenile fish will be reared at density and flow indices and temperature that promote optimum health. Appropriate density and flow requirements for anadromous fish are identified in Hatchery Performance Standards Policy (IHOT 1995, Chapter 4) or in a comparable reference such as Fish Hatchery Management (Wedemeyer 2001).

d) Appropriate growth strategies will be developed, with particular attention to photoperiod, temperature units and feeding rates to optimize parr-to-smolt transformation, to ensure juvenile fish reach target size-at-release and are physiologically ready to out-migrate and survive salt-water entry.

Guideline 3.17.1. Feeding practices should supply feed at a rate that is quickly consumed by juvenile fish, and does not permit excess feed to accumulate in rearing units. Excess or uneaten food has a high potential to increase organic loads in the rearing unit that can lead to fish pathogen amplification and disease outbreaks.

Guideline 3.17.2. Fish Health specialists should be promptly contacted when fish feeding behavior appears abnormal or when fish stop feeding.

Guideline 3.17.3. Stress-induced infections or diseases, related to crowding or high rearing densities, should be minimized to promote optimal growth, and to avoid excessive use of therapeutics (antibiotic medicated feed or chemical treatments).

Guideline 3.17.4. Rearing strategies will optimize the physical layout and use of rearing units at the facility to minimize handling of juvenile fish for inventory, transfer between rearing units, or tagging purposes. Preferably, fish are placed in units that allow adequate space and flows to permit extended periods of growth with no handling.

Guideline 3.17.5. Steelhead size at release should follow guidelines established in IHOT 1995 (Table 16, Chapter 4-Hatchery Performance Standards Policy), or guidelines established through program-specific experimental management strategies, but should not substantially alter the natural maturation schedule of the population from which broodstock originate.

4.4 Monitoring and Evaluation

Monitoring and evaluation must be recognized as an essential component of all anadromous fish hatchery programs in California. Monitoring and evaluation are necessary to determine the quality of fish stocks, to assess impacts of hatchery programs on natural populations, and to determine how well hatcheries achieve their specified goals and objectives. Effective monitoring and evaluation provides accurate, timely, and objective information collected within a sound scientific framework. Despite the importance of hatchery monitoring and evaluation, it has generally received insufficient emphasis at California's anadromous fish hatcheries.

In this section, we focus on eight central topics: (1) the need to prepare a Hatchery and Genetic Management Plan (i.e., a detailed operational plan) or similar document for each hatchery program; (2) the need to form, for each hatchery program, an active and independent Monitoring and Evaluation Program to assess hatchery performance and impacts; (3) the need to develop Hatchery Coordination Teams to bring together specialized expertise from a broad diversity of disciplines to enable more informed decisions and better coordinated hatchery management; (4) in-hatchery monitoring, data collection, and reporting associated with fish propagation and culture; (5) monitoring, data collection, and reporting associated with hatchery juvenile post-release emigration; (6) marking and tagging programs designed to achieve various species-specific standards to evaluate the performance and impacts of hatchery fish; (7) monitoring, data collection, and reporting associated with adult fishery contributions and escapement; and (8) evaluation standards that allow assessment of hatchery program performance with respect to operational goals (e.g., adult recruitment) and societal benefits.

Hatchery and Genetic Management Plans

Hatchery and Genetic Management Plans (HGMPs) are described in the final salmon and steelhead 4(d) rule (July 10, 2000; 65 FR 42422) and are used as a mechanism to address the take of listed species that may occur as a result of artificial propagation activities. The NMFS uses the information provided by HGMPs to evaluate the impacts on anadromous salmon and steelhead listed under the ESA and, in certain situations, the HGMPs will apply to the evaluation and issuance of ESA Section 10 take permits. Completed HGMPs may also be used for regional fish production and management planning by federal, state, and tribal resource managers. The primary goal of the HGMP is to devise biologically based artificial propagation management strategies that ensure the conservation and recovery of listed ESUs. The HSRG believes HGMPs should be prepared for all hatchery programs.

HGMPs include a description of hatchery facilities, operational protocols and the benefits derived from each hatchery propagation program, as well as assessments of the effects of the program on naturally produced fish. An addendum to the HGMP template may be used, when appropriate, to describe impacts of salmonid propagation programs on other aquatic and terrestrial organisms. The detailed descriptions and operational protocols provided in HGMPs also help to guide adaptive management decisions made at the hatchery level and provide accountability for deviations from established operational protocols.

- **Standard 4.1: Each hatchery program is thoroughly described in a detailed operational plan such as an HGMP or Biological Assessment**. **Operational plans are regularly updated to reflect updated data, changes to goals and objectives, infrastructure modifications, and changing operational strategies.**

    Guideline 4.1.1. Funding entities should provide the necessary resources to prepare and implement HGMPs for all California anadromous fish hatchery programs.

Hatchery Evaluation Programs

Every anadromous fish hatchery in the State of California should have a dedicated Monitoring and Evaluation (M&E) program. M&E programs perform a critical role in assessing whether hatcheries are achieving their goals and whether these goals are achieved with a minimum of negative impacts on natural populations of anadromous fish. Improving our knowledge of natural population responses to hatchery activities is essential and, when appropriate, may lead to recommended changes in hatchery operations that would reduce negative effects and possibly also increase benefits. M&E programs provide an important information feedback loop that promotes hatchery operation on the basis of scientific management principles and practices. M&E programs can also be used to develop and implement processes for hatcheries to respond to requests for experimental fishes, samples, and data.

- **Standard 4.2: For each hatchery, a Monitoring and Evaluation program dedicated to reviewing the hatchery's achievement of program goals and assessing impacts to naturally produced fishes must be established. Each M&E program will describe and implement a transparent, efficient, and timely process to respond to requests for experimental fishes, samples, and data.**

    Guideline 4.2.1. Hatchery Monitoring and Evaluation programs should be outside the direct hatchery line-of-command so they have a large degree of independence and autonomy from decisions made at the hatchery level. Program member expertise should include fish biology, population ecology, genetics, field sampling methods, experimental design and survey sampling strategies, database creation and management, and statistical analysis. Descriptions of specific monitoring and evaluation programs may be included as part of HGMPs.

Hatchery Coordination Teams

The effects of anadromous fish hatcheries are far reaching and overlap with several areas of science and resource management. The complexity and scope of issues affecting and affected by anadromous fish hatcheries is too broad to be effectively managed at the level of the hatchery alone. Complex decisions related to the management of fish hatcheries should draw upon information generated by a variety of specialized experts.

Hatchery Coordination Teams should be formed to bring together the knowledge and expertise of hatchery managers, biologists and fish culturists, M&E biologists, fish health specialists, regional fish biologists, fishery managers, and other representatives from management or funding agencies. Representatives from the hatchery's funding agency must be informed of critical operational, maintenance, and infrastructure needs. Hatchery Coordination Teams provide a forum to bring together a broad diversity of specialized technical expertise, providing more comprehensive, better informed, and more coordinated operation of hatcheries.

- **Standard 4.3. A Hatchery Coordination Team has been created for each hatchery.**

  Guideline 4.3.1. Hatchery Coordination Teams should be comprised of hatchery managers, hatchery biologists/fish culturists, monitoring and evaluation biologists, fish health specialists, regional fish biologists, and fishery managers.

In-Hatchery Monitoring and Record Keeping

A comprehensive system of in-hatchery monitoring and record keeping is an integral part of effective and efficient hatchery management. In-hatchery monitoring and record keeping provides the means to evaluate hatchery facilities and operations and assess the performance of hatchery-produced fish.

- **Standard 4.4: The monitoring and record keeping responsibilities listed below are carried out on an annual basis in-hatchery for each anadromous salmonid program. Summaries of data collected, with comparisons to established targets, are included in annual hatchery program reports, and individual measurements (unless otherwise indicated) are stored in electronic data files. Sample sizes indicated are provisional pending further consideration (see Section 6.2). A complete list of required and recommended data collection and reporting is provided in Appendix IV.**

  a) Record date, number, size, age (if available), gender, and origin (natural or hatchery; hatchery- and basin-specific when available) of (a) all hatchery returns and (b) fish actually used in spawning. (Summaries in annual reports; individual measurements in electronic files.)

  b) Record age composition of hatchery returns, as determined by reading scales and/or tags, from a systematic sample of the hatchery returns (n>550, or all returns for programs with less than 550 returns).

  c) Record sex-specific age composition of the fish spawned, as determined by reading scales and/or tags, from a systematic sample of the fish spawned (n>550, or all spawned fish for programs with less than 550 spawned fish).

  d) Describe in detail the spawning protocols used for each program (by family group for conservation-oriented programs), including the number of times individual males were used.

  e) Describe in detail the culling protocols used for each program, including purpose.

  f) Calculate and record effective population size (in conservation-oriented programs).

g) Measure and record mean egg size, fecundity, and fish length for each individual in a systematic sample of spawned females (n>50), to establish and monitor the relation between fecundity, egg size, and length in the broodstock. (Include a table of all measurements in annual report.)

h) Record survival through the following life stages: green egg to eyed egg, eyed egg to hatch, hatch to ponding, ponding to marking/tagging, and marking/tagging to release.

i) Record mean, standard deviation, and frequency distribution based on n>100 measurements of fish length, by raceway, at periodic intervals (no less than monthly) prior to release and at time of release for all release types, to assess trends and variability in size throughout the rearing process. (Report means and standard deviations in annual reports; individual measurements and frequency distributions in electronic files.)

j) Maintain records of disease incidence and treatment, including monitoring of treatment efficacy.

k) Report CWT releases and recoveries to relevant databases (i.e., RMIS) on a timely annual basis.

Marking and Tagging Programs

The specific information needs to be addressed by marking and tagging programs differ by species, but broadly these programs must allow for (1) estimation of fishery impacts, (2) estimation of natural area and hatchery escapement, (3) estimation of the proportion of hatchery-origin adult fish in natural spawning areas and hatchery broodstock, (4) real-time identification of hatchery-origin juveniles and adults, and (5) identification of stock of origin for hatchery-origin fish.

Chinook salmon. The typical mass marking strategy for Chinook salmon currently used in the Pacific Northwest consists of 100 percent adipose fin-clip plus some generally unspecified level of tagging with CWTs. This strategy was designed primarily to support mark-selective fisheries on hatchery-origin fish, which, via this strategy, are all identifiable in real-time due to the absence of an adipose fin. Although this strategy does support mark-selective fisheries, it does not allow identification of most hatchery-origin fish to stock of origin (only those that receive a CWT can be so identified), and it imposes new sampling requirements for fisheries, hatcheries, and spawning escapement surveys. The mass marking strategy “desequestered” the adipose fin clip as a mark associated only with coded wire tagged fish. Therefore, all adipose fin-clipped fish must be scanned electronically to determine presence or absence of CWT before heads are taken by samplers for CWT extraction. Further, if double index tagged (DIT) groups of hatchery fish are used to attempt to assess fishery impacts on unmarked natural populations of Chinook salmon, then all fish encountered (adipose fin-clipped or not) during ocean and freshwater surveys must be electronically scanned for the presence of CWTs (see Hankin et al. 2005).

For Chinook salmon mitigation/harvest programs, the California HSRG recommends tagging 100 percent of hatchery-released fish with CWT plus marking 25 percent of hatchery-released fish by adipose fin-clip. The recommended strategy of inserting a CWT into 100 percent of hatchery-released fish means that all hatchery-origin fish can be identified as such in real-time at weirs, in samples, or at hatcheries using electronic detection devices, and that stock of origin can be determined (by CWT extraction) whenever necessary or desired. Using 100 percent CWT tagging therefore serves one of the important purposes of the 100 percent adipose fin-clip programs adopted elsewhere: all hatchery-origin fish can be unambiguously identified while in hand as being of hatchery origin. However, because all adipose fin-clipped fish possess a CWT with this marking and tagging strategy, there is no requirement to use electronic detection devices on adipose fin-clipped fish encountered in fishery or escapement surveys. Thus existing CWT recovery programs are unaffected by adoption of this new marking/tagging strategy. Whenever identification of stock of origin for particular hatchery-origin fish is needed (e.g., to eliminate crosses between different runs or populations at hatcheries, or to improve accuracy of estimation of stock-specific proportions of hatchery-origin fish present in natural spawning areas), CWTs can be recovered and read. Elimination of crosses between different runs or populations at hatcheries may necessitate infrastructure modifications in hatchery spawning buildings and additional staff and equipment for electronic detection and recovery of CWTs from all hatchery-origin fish used as broodstock.

The proposed marking and tagging strategy for Chinook salmon is not designed to promote mark-selective fisheries. As noted previously, the California HSRG makes no recommendation regarding the implementation of mark-selective fisheries, and was careful to avoid making recommendations that might unintentionally facilitate mark-selective fisheries in the absence of expressed agency intentions to implement such fisheries in California.

For Chinook salmon mitigation/harvest programs that produce both fingerling and yearling release types (Iron Gate Hatchery, Trinity River Hatchery, and Mokelumne River Hatchery), the California HSRG specifies that 100 percent of yearling releases receive an additional distinguishing external mark or tag (e.g., a ventral fin clip) to allow for real-time discrimination from fingerling releases at the adult stage. This will readily enable the exclusion of yearling-origin adult fish from the program broodstock to reduce the degree of domestication in these programs.

For Chinook salmon conservation-oriented programs (winter run Chinook salmon produced at Livingston Stone Hatchery), the California HSRG recommends 100 percent CWT plus 100 percent adipose fin-clip marking and tagging. While 100 percent CWT tagging will fulfill the same needs identified above for mitigation/harvest programs, the 100 percent adipose fin-clipping will amplify (by a factor of four) the number of CWT recoveries from these programs in fishery and escapement surveys, and thus increase the precision (by a factor of four) of the quantities being estimated therein. This is necessary given the relatively small number of fish released by conservation-oriented programs.

Coho salmon. For the coho salmon programs (Iron Gate Hatchery and Trinity River Hatchery), the California HSRG recommends that a hatchery-specific external mark (not an adipose fin clip) be applied to 100 percent of the program fish. This will enable real-time differentiation of Iron Gate and Trinity River hatchery-origin fish from each other, from natural-origin fish, and from northern hatchery-origin stocks which are 100 percent adipose fin-clipped to support mark-selective fisheries. Because a mark-selective ocean fishery for coho salmon is often conducted off the coast of Oregon for adipose fin-clipped fish, it is necessary that this external mark be something other than an adipose fin-clip in order to exclude them from being harvested in these fisheries. Presently maxillary fin clipping is used for these purposes (Iron Gate Hatchery – left maxillary fin clip, Trinity River Hatchery – right maxillary fin clip).

Steelhead. For steelhead programs, the California HSRG recommends parentage-based tagging plus 100 percent adipose fin-clip marking of program fish. This will enable mark-selective river fisheries, real-time identification of hatchery-origin fish in fishery and escapement surveys, identification of stock of origin, and evaluation of several genetics-related quantities (see Section 2.4.3).

Because the present Nimbus Hatchery steelhead stock is derived from out-of-basin sources, fish from this program should not be used as broodstock in any other Central Valley hatchery steelhead program. To enable real-time differentiation of Nimbus Hatchery fish from other Central Valley steelhead for broodstock exclusion purposes, we recommend that 100 percent of the Nimbus Hatchery program fish receive an additional distinguishing external mark (non-adipose fin clip) or CWT, until a native broodstock has been established for this program.

The specific standards that marking and tagging programs must achieve are listed below, by species. This is followed by guidelines for marking and tagging strategies as described above that rely on currently available technologies (primarily coded wire tagging and fin clipping) that are known to achieve these standards. We anticipate that future technological developments (e.g., RFID tags suitable for implantation in juvenile salmonids, or real-time identification using genetic tags) may permit these same standards to be achieved in a more efficient or cost-effective manner.

- **Standard 4.5: Chinook salmon marking and tagging programs allow for:**

  a) Estimation of ocean and freshwater fishery impacts, and natural area and hatchery escapement at the age-, stock- and release group-specific levels,

  b) Estimation of the proportion of hatchery-origin fish in natural spawning areas,

  c) Estimation of the proportion of natural-origin fish in hatchery broodstock,

  d) Real-time identification of hatchery-origin juveniles and adults (i.e., hatchery vs. non-hatchery origin),

  e) Identification of stock of origin for hatchery-origin fish,

  f) Real-time identification of yearling vs. fingerling release-type fish at the adult stage

  Guideline 4.5.1. For mitigation/harvest programs (fall-, late fall-, and spring-run), all releases should be 100 percent CWT and 25 percent adipose fin-clipped. Yearling releases should receive an additional distinguishing external mark or tag (e.g., a ventral fin clip) allowing real-time discrimination from fingerling releases at the adult stage. Deviation from this guideline must be rigorously justified, and in no circumstance can marking and tagging programs fail to meet Standard ((a) through (f) above).

  Guideline 4.5.2. For conservation-oriented programs (winter-run), all releases should be 100 percent CWT and 100 percent adipose fin-clipped.

- **Standard 4.6: Coho salmon marking and tagging programs allow for:**

  a) Estimation of natural area and hatchery escapement,

  b) Estimation of the proportion of hatchery-origin fish in natural spawning areas,

  c) Real-time identification of hatchery-origin juveniles and adults (i.e., hatchery vs. non-hatchery origin),

d) Identification of stock of origin for hatchery-origin fish,

e) Non-retention in mark-selective fisheries targeting adipose fin-clipped fish.

Guideline 4.6.1. All fish released should receive a hatchery-specific (Iron Gate Hatchery vs. Trinity River Hatchery) external mark (not an adipose fin-clip).

- **Standard 4.7: Steelhead marking and tagging programs allow for:**

a) Estimation of freshwater fishery impacts and natural area and hatchery escapements,

b) Estimation of the proportion of hatchery-origin fish in natural spawning areas,

c) Real-time visual identification of hatchery-origin juveniles and adults (i.e., hatchery vs. non-hatchery origin),

d) Real-time identification of Nimbus hatchery-origin adults from other hatchery-origin steelhead as long as broodstock derived from out-of-basin sources is used,

e) Identification of stock of origin for hatchery fish.

Guideline 4.7.1. All broodstock should be genotyped as part of a parentage-based tagging (PBT) program.

Guideline 4.7.2. All juvenile fish released should be adipose fin-clipped.

Guideline 4.7.3. All Nimbus Hatchery juvenile fish released should receive an additional distinguishing external mark (non-adipose fin clip) or CWT, until a native broodstock is established.

Post-Release Emigration Monitoring

Monitoring hatchery fish following their release in freshwater is necessary to evaluate effects on naturally produced juveniles and to provide insights about possible causes for failure to achieve program goals. Large-scale releases of hatchery-origin salmon and steelhead may (1) create competition for food and rearing space with naturally produced juvenile salmonids; (2) cause loss of natural-origin fish through predation by larger hatchery-origin fish or by attracting aggregations of piscivorous birds, fish, or mammals; or (3) cause premature emigration of natural-origin fish. Competition or predation can be especially important with steelhead, as some fish may rear in freshwater for extended periods following release and others may entirely fail to adopt an anadromous life history strategy (residualize). Monitoring should assess the likelihood of substantial deleterious effects by measuring degree of spatial and temporal overlap and size differences between hatchery- and natural-origin juveniles. High likelihood of spatial and temporal overlap should motivate additional work to verify a problem or assess its magnitude. Detecting and assessing the effect of predator aggregations requires directed studies considered beyond the scope of standard monitoring and evaluation programs.

- **Standard 4.8: The quantities listed below are monitored in the freshwater environment following release of juvenile Chinook and coho. Summaries of collected data and associated estimates, along with comparisons to established targets, are included in annual or periodic (every 5 to 10 years) reports produced by the monitoring agencies/entities.**

  a) Annual: Document length (mean, standard deviation, and frequency distribution) of hatchery fish at release as compared to naturally produced smolts.

  b) Periodic: Document the number of days (mean, standard deviation, and frequency distribution) from release of hatchery fish to passage at a location near entry to salt water (e.g., using PIT tags/detectors or acoustic tags/arrays) and the degree of overlap with natural-origin fish.

  c) Periodic: Estimate the percent hatchery-origin fish among outmigrating juveniles and, where feasible, estimate total juvenile production.

- **Standard 4.9: The quantities listed below are monitored in the freshwater environment following release of juvenile steelhead. Summaries of collected data and associated estimates, along with comparisons to established targets, are included in periodic (every 5 to 10 years) reports produced by the monitoring agencies/entities.**

  a) Assess residualization (permanent freshwater residence).

  b) Assess extended rearing (following release) prior to ocean entrance.

Adult Monitoring Programs

The specific information needs for and feasibility of monitoring programs differ substantially by species, but broadly these programs must allow for estimation of (1) fishery impacts, (2) hatchery returns, (3) within basin tributary spawning escapements, and (4) the proportion of hatchery-origin fish among natural area spawners.

Chinook salmon. Because Chinook salmon are subject to substantial recreational and commercial fisheries, monitoring programs for this species need to generate accurate and timely information concerning contributions of hatchery-origin fish to fisheries. Cohort analysis of CWT recoveries from releases of marked and tagged hatchery fish is typically used to estimate fishery impacts on marked and tagged fish. From estimated landings of fish with adipose fin-clip and CWT, expansions can assess total fishery contributions (marked plus unmarked) of hatchery fish based on the program mark-rate. Cohort analyses require estimates of recoveries of marked and tagged hatchery fish for each of the possible fates that a marked and tagged hatchery fish can encounter from ages two through five: (1) landed or non-landed mortality in ocean recreational or commercial fisheries, (2) capture in freshwater fisheries, (3) return to hatchery, or (4) return to (and possibly spawn in) natural area. Assessing numbers of marked and tagged fish that spawn naturally generally requires spawning escapement estimation programs in all of the major streams to which hatchery-origin fish may stray. Within each such stream, the fraction of escapement that originates from a particular marked and tagged group must be estimated. Spawning escapements (hatchery- plus natural-origin fish) should be evaluated as to whether spawner densities exceed the carrying capacity of natural spawning areas, thereby reducing reproductive success through competition and perhaps through displacement of natural-origin spawners to inferior spawning areas.

Coho salmon. Because coho salmon lacking an adipose fin-clip are not currently subject to directed harvest in ocean fisheries off the coasts of Oregon and California, and the species is ESA-listed as threatened in the Southern Oregon/Northern California Coasts ESU, monitoring programs should emphasize the demographic and genetic status of hatchery populations, and contributions to naturally spawning populations, rather than fishery contributions.

Steelhead. Monitoring programs for steelhead are necessarily more limited than for Chinook or coho salmon because steelhead spawning typically takes place during high flows and low visibilities, not all steelhead die after spawning (i.e., are iteroparous), and hatcheries use non-lethal spawning methods for steelhead. Spawning escapements (hatchery- plus natural-origin fish) should be evaluated to determine whether spawner densities exceed the carrying capacity of natural spawning areas, thereby reducing reproductive success through competition and perhaps through displacement of natural-origin spawners to inferior spawning areas.

The specific standards that adult monitoring programs must achieve are listed below, by species.

Chinook Salmon

- **Standard 4.10: Monitoring programs for Chinook salmon allow for estimation of the following on an annual basis.**

  a) Total recreational and commercial ocean harvest, and harvest of hatchery-origin fish at the age-, stock-, and release group-specific (CWT) level,

  b) Total freshwater harvest, and harvest of hatchery-origin fish at the age-, stock-, and release group-specific (CWT) level,

  c) Total returns (hatchery -and natural-origin) to hatchery, and returns at the age-, stock-, and release group-specific (CWT) level,

  d) Age composition of hatchery returns,

  e) Total escapement by tributary and by species/run,

  f) Proportion of hatchery-origin fish among natural area spawners (pHOS) by tributary and at age-, stock-, and release group-specific (CWT) level,

  g) Age composition of individual tributaries important for natural production.

Coho Salmon

- **Standard 4.11: Monitoring programs for coho salmon allow estimation of the following on an annual basis:**

  a) Probable fishery impacts in ocean and freshwater (recreational and tribal),

  b) Hatchery returns of hatchery- and natural-origin fish by age, stock and release type,

  c) Total escapement to individual tributaries important for natural production,

d) Proportion of hatchery-origin fish among natural area spawners (pHOS) in individual tributaries important for natural production.

Steelhead

- **Standard 4.12: Monitoring programs for steelhead allow estimation of the following on an annual or periodic (every 5 to 10 years) basis:**

  a) Annual: Freshwater recreational and tribal catch, ideally by hatchery and brood year,

  b) Annual: Hatchery returns by age and stock,

  c) Annual: Total escapement to individual tributaries important for natural production,

  d) Annual: Proportion of hatchery-origin fish among natural area spawners (pHOS), at the stock-specific level, in individual tributaries important for natural production,

  e) Periodic: Proportion of adult hatchery returns that have exhibited an anadromous life history.

Evaluation Programs

Monitoring programs primarily collect data needed to evaluate the performance of hatcheries with respect to their operational goals, to assess their impacts on natural fish populations, and to determine societal benefits realized from the production of hatchery fish. Mere collection of these data is not sufficient for program evaluation; therefore, fundamental standards for evaluation and analysis of data collected in monitoring programs are provided. These evaluation standards allow managers to assess whether or not hatchery programs are meeting their program goals and provide substantial insight into factors that may be responsible for failure to achieve program goals.

The specific needs and feasibility of evaluation differ substantially by species. For Chinook salmon, explicit guidelines for program evaluation are provided that rely on application of run reconstruction analyses based on CWT recovery data. Because similar data are not available for coho salmon and steelhead, prescriptive guidelines for those species are not presented.

- **Standard 4.13: Evaluation programs for Chinook salmon assess the following fundamental issues on a brood-specific basis:**

  a) Survival from release to pre-fishery recruitment,

  b) Age-specific maturation schedules,

  c) Straying (here defined as failure of hatchery-origin fish to return to the hatchery from which they originated or to the watershed in the immediate vicinity of the hatchery),

  d) Age-specific fishery contribution rates,

  e) Pre-fishery age-3 ocean recruitment.

Evaluation programs for Chinook salmon assess the following fundamental issues on a periodic basis (e.g., every 5 to 10 years):

f) The relationship of hatchery fish survival rates and maturation schedules to size and/or date of release;

g) Long-term trends in phenotypic traits (age, maturity, fecundity at size, run/spawn timing, size distribution) and genetic traits (divergence among year classes, effective population size, divergence from natural populations) of hatchery populations;

h) Spatial and temporal overlap and relative sizes of emigrating juvenile hatchery- and natural-origin fish and total (hatchery- plus natural-origin) spawner distribution and densities to assess the likelihood or magnitude of deleterious effects of hatchery-origin fish on naturally spawning fish due to competition, predation, or behavioral effects .

Guideline 4.13.1. Use tag recovery data and cohort reconstruction (cohort analysis) methods to estimate the following quantities. In the future, alternative technologies or analytical methods may generate other data suitable for estimating these quantities.

- Brood survival from release to ocean age-2 at the release group-specific (CWT) level,
- Brood maturation schedule (age-specific conditional maturation probabilities) at the release group-specific (CWT) level,
- Straying and geographic distribution of stray hatchery-origin fish at the release group-specific (CWT) level,
- Age-specific ocean and freshwater fishery contributions and exploitation rates at the release group-specific (CWT) level,
- Pre-fishery ocean recruitment of hatchery-origin fish at age-3 at the release group-specific (CWT) and program level.

➢ **Standard 4.14: Evaluation programs for coho salmon estimate the following attributes on a brood-specific basis:**

a) Age-3 recruitment (tributary escapements plus hatchery returns). If non-selective ocean fisheries for coho salmon are resumed, age-3 recruitment would include ocean catches at age-3.

b) Survival from release to age-3 recruitment.

Evaluation programs for coho salmon evaluate the following fundamental issues on a periodic basis (e.g., every 5 to 10 years):

c) Long-term trends in phenotypic traits (age, maturity, fecundity at size, run/spawn timing, size distribution) and genetic traits (divergence among year classes, effective size, divergence from natural populations) of hatchery populations.

d) Spatial and temporal overlap and relative sizes of emigrating juvenile hatchery- and natural-origin fish and total (hatchery- plus natural-origin) spawner distribution and densities to assess the likelihood or magnitude of deleterious effects of hatchery-origin fish on naturally spawning fish due to competition, predation, or behavioral effects.

- **Standard 4.15: Evaluation programs for steelhead estimate the following attributes on an annual basis:**

a) Age-specific freshwater adult returns (and half-pounders in the Klamath/Trinity Basin), in order of the following preference:

  - River catch and catch-and-release adult mortality plus tributary returns of adults plus hatchery returns of adults,
  - Tributary returns of adults plus hatchery returns of adults,
  - River catch and catch-and-release adult mortality plus hatchery returns of adults,
  - Hatchery returns of adults.

b) At facilities where kelts are reconditioned and released, determine the survival (return for subsequent spawning) of reconditioned and released kelts.

Evaluation programs for steelhead assess the following fundamental issues on a periodic basis (i.e., every 5 to 10 years):

c) The relationship of life history patterns (age at return, tendency to exhibit half-pounder life history pattern in the Klamath/Trinity Basin, residualization) to hatchery rearing and release practices with a focus on size and age at release.

d) Long-term trends in phenotypic traits (age, maturity, fecundity at size, run/spawn timing, size distribution) and genetic traits (divergence among year classes, effective population size, divergence from natural populations) of hatchery populations.

e) Spatial and temporal overlap and relative sizes of emigrating juvenile hatchery- and natural-origin fish (including juvenile salmon) and total (hatchery- plus natural-origin) spawner distribution and densities to assess the likelihood or magnitude of deleterious effects of hatchery-origin fish on naturally spawning fish due to competition, predation, or behavioral effects.

4.5 Direct Effects of Hatchery Operations on Local Habitats, Aquatic or Terrestrial Organisms

Operation of hatchery facilities can have adverse effects on local environments, thus affecting salmonid populations and other aquatic species. Hatchery facilities include adult collection, spawning, incubation, rearing and release facilities as well as structures to remove and discharge water. Intake structures, fish ladders, and weirs are typically located in riparian areas or within creek/river channels and can affect habitat quality and quantity. Hatchery structures can create obstacles to migration for juvenile and adult fish, change instream flow, alter riparian habitat and diminish water quality through hatchery discharges. Water for hatchery use is often drawn from nearby sources via pumps or gravity. Improperly designed and maintained water intakes can entrain migrant or resident juveniles on hatchery screens or cause fish to be trapped in hatchery facilities. Structures such as adult weirs and water intake dams can also block natural passage of salmonids to spawning or rearing areas. Water diverted from adjacent streams for fish culture purposes is often returned further downstream, reducing the amount of flow for juvenile rearing and upstream adult migration in the reach between the intake and discharge. Hatchery discharge can also diminish water quality below the point of discharge through changes in temperature, settleable and suspended solids, chemical composition, and presence of therapeutic drugs. If hatchery facilities and operations are not managed to mitigate these effects, additional loss of natural production can result, diminishing the net benefit of the hatchery program.

Throughout California, major watershed restoration actions and efforts are underway to benefit both listed and non-listed anadromous salmonids. These habitat restoration programs are often complex collaborative efforts between public and private organizations (e.g., state and federal agencies and local watershed groups). While hatcheries are not charged with habitat enhancement, the agencies responsible for their operation are often charged with habitat enhancement and protection. Therefore, where feasible, hatchery staff should be aware of and participate in habitat restoration planning processes and implementation. Such participation will inform them of efforts underway and assist them in determining how hatchery infrastructure or operations may need modification/alteration to appropriately integrate with local restoration actions and programs.

- **Standard 5.1: Hatchery operations/infrastructure is integrated into local watershed restoration efforts to support local habitat restoration activities.**

  Guideline 5.1.1. Hatchery staff should participate in local habitat restoration planning efforts to help assess the effects of current hatchery operations on future habitat enhancement or vice versa and to plan for operational changes that may become necessary.

- **Standard 5.2: Hatchery infrastructure is operated in a manner that facilitates program needs while reducing impacts to aquatic species, particularly listed anadromous salmonids.**

  Guideline 5.2.1. Water supply intake structures located in anadromous waters should conform with NMFS and CDFG fish screen criteria or other appropriate criteria that matches screen size and approach and sweeping velocity to the target organism requiring protection. Design and operation of facility water diversion/supply structures also should provide operational flexibility to avoid catastrophic facility water loss due to debris loading or other failure.

  Guideline 5.2.2. Consider screening needs of facility water supply intakes in non-anadromous waters to protect other ESA or CESA listed organisms. Design and operation of facility water diversion/supply structures also needs to consider operational flexibility to avoid catastrophic facility water loss due to debris loading or other failure.

  Guideline 5.2.3. Barrier weirs should effectively block adult passage either for broodstock congregation/collection or as required for in-river fishery management.

Guideline 5.2.4. Fish ladders used to circumvent barrier weirs or impoundment structures or that provide access to hatchery adult holding ponds should allow adequate capture of appropriate numbers of target species over the full spectrum of the run and limit passage delay and injury to target species and also to non-target organisms as required by in-river fishery management.

Guideline 5.2.5. Limit reach specific impacts of hatchery water diversions, such as diminishment of in-stream flows between diversion and discharge return points.

Guideline 5.2.6. All general facility construction and operations should limit effects on the riparian corridor and be consistent with fluvial geomorphology principles (i.e., avoid bank erosion or undesired channel modification).

- **Standard 5.3: Effluent treatment facilities are secure and operated to meet NPDES requirements.**

- **Standard 5.4: Current facility infrastructure and construction of new facilities avoid creating an unsafe environment for the visiting public and staff and provide adequate precautions (e.g., fencing and signage) where unsafe conditions are noted.**

5. Summary of Hatchery Program Recommendations

Major hatchery program recommendations are highlighted in this section which is organized by hatchery, beginning with facilities in the Klamath-Trinity Basin and proceeding to the Central Valley of California. For each hatchery, we provide facility and program overviews, followed by the California HSRG's major recommendations for each program operated at the hatchery. These recommendations were collaboratively developed by the California HSRG, reflecting facility or operational modifications that we view as necessary to protect and sustain California's salmon and steelhead resources. Appendix VIII includes a full suite of standards for each program along with guidelines that suggest implementation strategies to meet each standard. We note that among situations where program size is reduced or programs eliminated, in no case should such change result in relinquishment of mitigation responsibility.

5.1 Iron Gate Hatchery

Iron Gate Hatchery (IGH) was established in the late 1960s to mitigate for construction of Iron Gate Dam and the anadromous fish habitat lost between Iron Gate and Copco dams. For many years, fish were reared at both the Fall Creek and IGH facilities; however, current production is limited to IGH. IGH is located approximately eight miles east of Hornbrook, California; the primary spawning facility is at the base of Iron Gate Dam at RM 190. Hatchery operation and monitoring is fully funded by PacifiCorp.

Three programs are conducted at IGH, producing coho, fall Chinook and steelhead. Each program is briefly summarized below, followed by sections highlighting the California HSRG's major recommendations for all Iron Gate programs and then program-specific recommendations.

The Southern Oregon / Northern California Coasts coho salmon ESU was classified under the ESA as threatened in 1997. The ESU includes all naturally spawned populations of coho salmon in coastal streams between Cape Blanco, Oregon, and Punta Gorda, California, and the Iron Gate Hatchery, Trinity River Hatchery, and Cole River Hatchery coho programs.

Iron Gate Hatchery Coho Program

The integrated coho program goal is to produce 75,000 smolts at 15 fish per pound (fpp) for release between March 15 and May 1. All juvenile IGH-produced coho salmon are marked with a left maxillary fin clip and released at the hatchery.

Historically, IGH was operated to mitigate for blocked fish habitat; however, recently a conservation focus for the coho program has been deemed necessary to protect the remaining genetic resources of the Upper Klamath River coho population unit (CDFG 2011). Adult coho salmon returns to this population (and to the entire Klamath River) have been declining to the point where less than 60 adult fish returned to the hatchery and Bogus Creek, the largest tributary in this population unit (in terms of measured production) in 2009 (CDFG 2011).

According to the 2011 Draft HGMP, the coho salmon program is operated to protect and conserve the genetic resources of the Upper Klamath River coho population unit. As natural coho salmon production increases over time with implementation of habitat and other recovery actions, it is expected that the program will be operated as an integrated program.

Iron Gate Hatchery Fall Chinook Program

This integrated program at IGH has a goal to produce six million juvenile fall Chinook salmon annually. The production goal is to release 5.1 million subyearlings ("fingerlings", at 90 fpp) between May 1 and June 15 and 900,000 subyearlings ("yearlings", at 10 fpp) between October 15 and November 20. Fall Chinook are marked at a rate of 25 percent (constant fractional marking) with an adipose fin-clip and coded wire-tag, and released at the hatchery site.

Iron Gate Hatchery Steelhead Program

Broodstock for the Iron Gate steelhead program is collected from fish that volitionally enter the fish trap located at the base of the dam and currently includes fish that demonstrate either an anadromous or resident life history. The goal of this integrated program is to produce 200,000 steelhead smolts at 10 fpp for release between March 15 and May 1. All steelhead are released at the hatchery site and all are marked with an adipose fin clip.

During the past decade, the IGH steelhead program has failed to meet mitigation goals. Historically, thousands of steelhead migrated into the upper Klamath River and as late as 1982, juveniles released from IGH comprised up to seven percent of the half-pounder steelhead captured by seining in the lower Klamath River (CDFG unpublished data). Prior to the last decade, several thousand adult steelhead were trapped annually at IGH.

Steelhead production has varied substantially over the years, with a high of approximately 643,000 yearlings released in 1970 to a low of about 11,000 yearlings released in 1997. The 200,000 yearling production goal was met in most years prior to 1991; however, the production goal has not been achieved since that time.

5.1.1 Recommendations for All Iron Gate Hatchery Programs

- Clear goals should be established for the program. Program production goals should be expressed in terms of the number of age-3 ocean recruits just prior to harvest (Chinook), age-3 adults returning to freshwater (coho), and the number of adults and half-pounders returning to freshwater (steelhead).

- Adult holding facilities in hatcheries should be upgraded/expanded to provide adequate space, water flows and temperature regimes to hold the number of adults required for broodstock at high rates of survival (greater than 90 percent). Facilities need to be adequate to hold the expected number of unripe adults for extended periods with minimal hatchery-caused mortality.

- The adult spawning facility is inadequate to meet current needs for fish sorting, spawning and monitoring and should be upgraded.

- All outdoor raceways should be protected from predators with bird netting or similar protection to reduce predation rates on juvenile fish.

- Managers should investigate the feasibility of collecting natural-origin adult fish at alternate locations. The existing trapping location is very limited in its ability to capture fish representing the entire spectrum of life history diversity. Only fish that migrate to the furthest upstream reaches are susceptible to capture.

- Performance standards for each phase of the fish culture process should be established and tracked annually. Summaries of data collected with comparisons to established targets must be included in annual hatchery reports.

- CDFG should develop and promulgate a formal, written fish health policy for operation of its anadromous hatcheries through the Fish and Game Commission policy review process. Hatchery compliance with this policy should be documented annually as part of a Fish Health Management Plan. The current CDFG fish health policy is inadequate to protect native stocks.

- CDFG should develop an updated Hatchery Procedure Manual which includes performance criteria and culture techniques presented in IHOT (1995), Fish Hatchery Management (Wedemeyer 2001) or comparable publications. The fish culture manual (Leitritz and Lewis 1976) is outdated and does not reflect current research and advancements in fish culture.

- A Monitoring and Evaluation Program should be developed and implemented and a Hatchery Coordination Team formed for the program. Implementation of these processes will inform hatchery decisions and document compliance with best management practices defined in this report.

5.1.2 Iron Gate Coho -Major Program Recommendations

The major recommendations of interest to resource managers for the Iron Gate coho salmon hatchery program are provided below. Those selected for presentation may represent major changes in operations, changes in approach or outcomes towards achieving harvest or conservation goals, or will require substantial investment of resources. The California HSRG's evaluation of program compliance with standards and guidelines and the group's comments about this program are presented in their entirety in Appendix VIII.

- The draft HGMP for the IGH coho program should be approved and implemented.

- Mating protocols should be reviewed for consistency with California HSRG recommendations for splitting egg lots.

- Water quality for egg incubation should be improved to remove organic debris and siltation that is likely affecting egg survival. If the air incubation solution tried in 2011 is ineffective, hatchery and fish health staff should continue studies to determine the cause of low egg survival rates.

5.1.3 Iron Gate Fall Chinook- Major Program Recommendations

The major recommendations of interest to resource managers for the Iron Gate fall Chinook salmon hatchery program are provided below. Those selected for presentation may represent major changes in operations, changes in approach or outcomes towards achieving harvest or conservation goals, or will require substantial investment of resource. The California HSRG's evaluation of program compliance with standards and guidelines and the group's comments about this program are presented in their entirety in Appendix VIII.

- Managers should consider changes in the program, including reducing the size of the program, to mitigate disease issues. Large numbers of naturally spawning fish may increase the incidence of *C. shasta* disease through the release of myxospores from carcasses, which in turn increases the probability of perpetuating myxozoan infections in juvenile Chinook and coho salmon in the following spring and summer. We note that in any situation where program size is reduced or programs eliminated, in no case should such change result in relinquishment of mitigation responsibility.

- Natural-origin fish should be incorporated into broodstock at a minimum rate of 10 percent to prevent divergence of the hatchery and natural components of the integrated population. This may require auxiliary adult collection facilities (e.g., Bogus Creek) or alternative collection methods (e.g., seining or trapping).

- Jacks should be incorporated into the broodstock at a rate that does not exceed 50 percent of the total number of jacks encountered during spawning operations and in no case more than 5 percent of the total males spawned.

- Program fish should be 100 percent coded-wire tagged and 25 percent adipose fin-clipped. "Yearling" releases should receive an additional distinguishing external mark or tag (e.g., a ventral fin clip) allowing real-time discrimination from fingerling releases at the adult stage.

- Returning yearling-origin adults should not be used as broodstock. If eggs are collected from or fertilized by such fish, they should be culled soon after spawning. Adequate numbers of fingerlings should be released each year to meet numerical goals for broodstock. When adult returns from fingerling releases are inadequate to satisfy hatchery egg take needs, yearling returns may be used to reduce the deficit.

- CWT releases and recoveries of fall Chinook should be reported annually to RMIS in a timely manner.

- Water quality for egg incubation should be improved to remove organic debris and siltation that is likely affecting egg survival. If the air incubation solution tried in 2011 is ineffective, hatchery and fish health staff should continue studies to determine the cause of low egg survival rates.

5.1.4 Iron Gate Steelhead –Major Program Recommendations

The major recommendations of interest to resource managers for the Iron Gate Hatchery steelhead program are provided below. Those selected for presentation may represent major changes in operations, changes in approach or outcomes towards achieving harvest or conservation goals, or will require substantial investment of resources. The California HSRG's evaluation of program compliance with standards and guidelines and the group's comments about this program are presented in their entirety in Appendix VIII.

- This program should terminate use of the current broodstock and be reestablished with broodstock collected from an off-site location. The program has not consistently produced adequate numbers of anadromous steelhead returning to the hatchery and few adults in the broodstock show evidence of anadromy. The program currently provides little in the way of conservation benefits to the species or harvest benefits to the public.

- Non-anadromous fish typically should not be used as steelhead broodstock.

- The minimum release size for juvenile fish should be at least 8 fpp and a size at release study conducted to refine the release size target. Variability of fish size at release should be reduced.

- Hatchery-origin adult steelhead returns to the hatchery should be treated as follows: (1) unspawned males should be extended reconditioned and released; (2) unspawned females should be stripped of eggs, extended reconditioned and released; and (3) spawned fish should be removed from the system.

- Natural-origin adult steelhead returns to the hatchery, whether spawned or unspawned, should be released. Fish may be reconditioned prior to release.

5.2 Trinity River Hatchery

The Trinity River Division of the Central Valley Project in California included construction of Trinity and Lewiston dams that divert a substantial portion of the river's flow to the Central Valley for agricultural, municipal and industrial uses. Lewiston Dam, completed in 1963, is the upstream limit of anadromy, blocking access to 109 miles of salmon and trout spawning and rearing habitat. Trinity River Hatchery (TRH) was constructed at river mile 110 at the base of Lewiston Dam to mitigate for the loss of this anadromous fish habitat. The Bureau of Reclamation funds operation and maintenance of the TRH, which is operated and managed by the CDFG.

Four anadromous programs are conducted here, producing coho salmon, fall Chinook salmon, spring Chinook salmon and steelhead. Each program is briefly summarized below, followed by sections highlighting the major recommendations for all Trinity River Hatchery programs and then program-specific recommendations.

Mitigation goals for lost adult production were determined from pre-project studies of anadromous fish populations in the basin. The USFWS and CDFG (1956) estimated that 5,000 coho; 3,000 spring Chinook, 8,000 summer Chinook and 24,000 fall Chinook; and 10,000 steelhead (no run timing was designated) passed above the Lewiston Dam site prior to its construction. Total annual adult production goals (catch plus escapement) for TRH were further defined in 1980 to be 7,500 coho, 6,000 spring Chinook, 70,000 fall Chinook and 22,000 steelhead (Frederickson et al. 1980). Escapement goals to the hatchery were further defined in 1983 as 2,100 coho, 3,000 spring Chinook, 9,000 fall Chinook and 10,000 steelhead (USFWS 1983).

The Southern Oregon / Northern California Coasts coho salmon ESU was classified under the ESA as threatened in 1997. The ESU includes all naturally spawned populations of coho salmon in coastal streams between Cape Blanco, Oregon, and Punta Gorda, California, and the Iron Gate Hatchery, Trinity River Hatchery, and Cole River Hatchery coho programs.

Trinity River Hatchery Coho Program

TRH coho salmon broodstock originated from an in-river weir, with some augmentation from out-of-basin sources to boost production. Only endemic Trinity River broodstock have been used at TRH since 1970 (CDFG 2004). Currently, this integrated coho program releases approximately 500,000 yearlings annually at 10 to 20 fpp from March 15 to May 15. All coho are released at the hatchery site and all are marked with a right maxillary fin clip.

Trinity River Hatchery Fall Chinook Program

TRH fall Chinook salmon broodstock originated from an in-river weir when hatchery operations began in 1964. No eggs or fish from outside the basin have been used to supplement this program in at least the last 10 years. This integrated fall Chinook program has a goal to release 2 million subyearlings (“fingerlings”, at 90 fpp) in June and 900,000 subyearlings (“yearlings”, at 10 fpp) in October. Fall Chinook are marked at a rate of 25 percent (constant fractional marking) with an adipose fin-clip and coded wire tag, and released at the hatchery site.

Trinity River Hatchery Spring Chinook Program

As with the fall Chinook program, TRH spring Chinook salmon broodstock originally were collected from an in-river weir in 1964. In the last ten years, no out-of-basin eggs or broodstock have been used to supplement the program. The goal of this integrated program is to release 1 million subyearlings (“fingerlings”, at 90 fpp) in June and 400,000 subyearlings (“yearlings”, at 10 fpp) in October. Spring Chinook are marked at a rate of 25 percent (constant fractional marking) with an adipose fin-clip and coded wire tag, and released at the hatchery site.

Trinity River Hatchery Steelhead Program

Broodstock used in the TRH steelhead program originated from the Trinity River watershed. From 1974 until at least 1994, some eggs were imported from Iron Gate Hatchery; however, no eggs or fish from outside the Trinity River watershed have been used to supplement this program in the last 10 years. This integrated program has a goal to release 800,000 six-inch-long steelhead smolts from March 15 to May 1. All steelhead are marked with an adipose fin clip and released at the hatchery site.

5.2.1 Recommendations for All Trinity River Hatchery Programs

- Natural-origin fish should be incorporated into broodstock at a minimum rate of 10 percent to prevent divergence of the hatchery and natural components of the integrated population. This may require auxiliary adult collection facilities or alternative collection methods (e.g., seining or trapping).

- Adult holding facilities in hatcheries should be upgraded/expanded to provide adequate space, water flows and temperature regimes to hold the number of adults required for broodstock at high rates of survival (more than 90 percent). Facilities need to be adequate to hold the expected number of unripe adults for extended periods with minimal hatchery-caused mortality.

- The adult spawning facility is inadequate to meet current needs for fish sorting, spawning and monitoring and should be upgraded.

- Managers should investigate the feasibility of collecting natural-origin adult fish at alternate locations. The existing trapping location is very limited in its ability to capture fish representing the entire spectrum of life history diversity. Only fish that migrate to the furthest upstream reaches are susceptible to capture.

- Performance standards for each phase of the fish culture process should be established and tracked annually. Summaries of data collected with comparisons to established targets must be included in annual hatchery reports.

- A Monitoring and Evaluation Program should be developed and implemented and a Hatchery Coordination Team formed for the program. Implementation of these processes will inform hatchery decisions and document compliance with best management practices defined in this report.

- Co-managers should develop and promulgate a formal, written fish health policy for the operation of the hatchery. Hatchery compliance with this policy should be documented annually as part of a Fish Health Management Plan. The current fish health policy is inadequate to protect native stocks.

- Co-managers should develop an updated Hatchery Procedure Manual which includes performance criteria and culture techniques presented in IHOT (1995), Fish Hatchery Management (Wedemeyer 2001) or comparable publications. The fish culture manual (Leitritz and Lewis 1976) is outdated and does not reflect current research and advancements in fish culture.

5.2.2 Trinity River Coho- Major Program Recommendations

The major recommendations of interest to resource managers for the Trinity River Hatchery coho program are provided below. Those selected for presentation may represent major changes in operations, changes in approach or outcomes towards achieving harvest or conservation goals, or will require substantial investment of resources. The California HSRG's evaluation of program compliance with standards and guidelines and the group's comments about this program are presented in their entirety in Appendix VIII.

- Co-managers should identify the purposes and goals of this program and determine appropriate program size given existing hatchery escapement goals for hatchery coho salmon, the ESA-listed status of the population, and the tribal trust issues raised by construction of Lewiston and Trinity dams. Adult returns to the hatchery have averaged over 7,000 adults, more than three times the hatchery escapement goal of 2,100 fish.

- Jacks should be incorporated into the broodstock at a rate that does not exceed 50 percent of the total number of jacks encountered during spawning operations and in no case more than 10 percent of the total males spawned.

5.2.3 Trinity River Fall Chinook- Major Program Recommendations

The major recommendations of interest to fisheries managers for the Trinity River fall Chinook salmon hatchery program are provided below. Those selected for presentation may represent major changes in operations, changes in approach or outcomes towards achieving harvest or conservation goals, or will require substantial investment of resources. The California HSRG's evaluation of program compliance with standards and guidelines and the group's comments about this program are presented in their entirety in Appendix VIII.

- Adult collection facilities should be operated throughout the entire temporal migration period of the run and should not exclude fish with particular life history characteristics, except when non-representative broodstock collection is necessary to achieve program goals. Currently, the trap is shut down for a period of approximately two weeks to minimize hybridization between separate spring and fall Chinook. Fish collected during this period should be euthanized without spawning.

- Tag analysis should be used to determine the number of fall and spring Chinook spawned during the suspected period of run overlap (e.g., fish spawned in the last two weeks of spring Chinook spawning and the first two weeks of fall Chinook spawning). Tags should be read and egg lots tracked and eliminated from production as appropriate to reduce introgression of the two runs. Incubation techniques should therefore allow for separation of eggs from individual parents/families (no more than two families per tray).

- Program fish should be 100 percent coded-wire tagged and 25 percent adipose fin-clipped. "Yearling" releases should receive an additional distinguishing external mark or tag (e.g., a ventral fin clip) allowing real-time discrimination from fingerling releases at the adult stage.

- Returning yearling-origin adults should not be used as broodstock. If eggs are collected from or fertilized by such fish, they should be culled soon after spawning. Adequate numbers of fingerlings should be released each year to meet numerical goals for broodstock. When adult returns from fingerling releases are inadequate to satisfy hatchery egg take needs, yearling returns may be used to reduce the deficit.

- CWT releases and recoveries of fall Chinook should be reported annually to RMIS in a timely manner.

- Jacks should be incorporated into the broodstock at a rate that does not exceed 50 percent of the total number of jacks encountered during spawning operations and in no case more than 5 percent of the total males spawned.

- Fish growth trajectories need to be monitored more closely to achieve the identified release target of 90 fpp for fingerlings and 10 fpp for yearlings. Data supplied by the hatchery indicate that average release size for the two respective groups has been 108 fpp and 15.4 fpp from 2000-2010.

5.2.4 Trinity River Spring Chinook- Major Program Recommendations

The major recommendations of interest to resource managers for the Trinity River spring Chinook salmon hatchery program are provided below. Those selected for presentation may represent major changes in operations, changes in approach or outcomes towards achieving harvest or conservation goals, or will require substantial investment of resources. The California HSRG's evaluation of program

compliance with standards and guidelines and the group's comments about this program are presented in their entirety in Appendix VIII.

- Adult collection facilities should be operated throughout the entire temporal migration period of the run and should not exclude fish with particular life history characteristics, except when non-representative broodstock collection is necessary to achieve program goals. Currently, the trap is shut down for a period of approximately two weeks to minimize hybridization between separate spring and fall Chinook. Fish collected during this period should be euthanized without spawning.

- Tag analysis should be used to determine the number of fall and spring Chinook spawned during the suspected period of run overlap (e.g., fish spawned in the last two weeks of spring Chinook spawning and the first two weeks of fall Chinook spawning). Tags should be read and egg lots tracked and eliminated from production as appropriate to reduce introgression of the two runs. Incubation techniques should therefore allow for separation of eggs from individual parents/families (no more than two families per tray).

- Program fish should be 100 percent coded wire tagged and 25 percent adipose fin-clipped. "Yearling" releases should receive an additional distinguishing external mark or tag (e.g., a ventral fin clip) allowing real-time discrimination from fingerling releases at the adult stage.

- Returning yearling-origin adults should not be used as broodstock. If eggs are collected from or fertilized by such fish, they should be culled soon after spawning. Adequate numbers of fingerlings should be released each year to meet numerical goals for broodstock. When adult returns from fingerling releases are inadequate to satisfy hatchery egg take needs, yearling returns may be used to reduce the deficit.

- CWT releases and recoveries of fall Chinook should be reported annually to RMIS in a timely manner.

- Jacks should be incorporated into the broodstock at a rate that does not exceed 50 percent of the total number of jacks encountered during spawning operations and in no case more than 5 percent of the total males spawned.

- Fish growth trajectories need to be monitored more closely to achieve identified release size targets.

5.2.5 Trinity River Steelhead- Major Program Recommendations

The major recommendations of interest to resource managers for the Trinity River Hatchery steelhead program are provided below. Those selected for presentation may represent major changes in operations, changes in approach or outcomes towards achieving harvest or conservation goals, or will require substantial investment of resources. The California HSRG's evaluation of program compliance with standards and guidelines and the group's comments about this program are presented in their entirety in Appendix VIII.

- Program goals should be measured as the number of anadromous hatchery-origin steelhead adults and half-pounders returning to freshwater each year. Adult steelhead mitigation goals for the program are described in various historical non-hatchery related documents. It does not appear that the program is operated to achieve these goals or adjusted if goals are not achieved.

- Hatchery-origin adult steelhead returns to the hatchery should be treated as follows: (1) unspawned males should be extended reconditioned and released; (2) unspawned females should be stripped of eggs, extended reconditioned and released; and (3) spawned fish should be removed from the system.

- Natural-origin adult steelhead returns to the hatchery, whether spawned or unspawned, should be released. Fish may be reconditioned prior to release.

5.3 Nimbus Fish Hatchery

Nimbus Fish Hatchery (NFH) was constructed in 1955 at RM 22 of the American River, approximately 0.25 mile downstream of Nimbus Dam. Hatchery operation helps fulfill mitigation requirements for construction of Nimbus Dam as described in the "Contract between the United States and the State of California for the Operation of the Nimbus Fish Hatchery" (Reclamation 1956). Mitigation is provided for the American River reach between Nimbus and Folsom dams; it does not address lost habitat upstream from Folsom Dam. The CDFG operates a fall Chinook salmon and a steelhead program here. Each program is briefly summarized below, followed by sections highlighting the California HSRG's major recommendations for all Nimbus programs and then the program-specific recommendations.

The Central Valley fall/late fall-run Chinook salmon ESU was classified as a federal Species of Concern in 2004. The ESU includes all naturally spawned populations of fall-run Chinook salmon in the Sacramento and San Joaquin rivers and their tributaries, east of the Carquinez Strait.

The Central Valley steelhead DPS was classified under the ESA as threatened in 1998. The DPS includes all naturally spawned anadromous steelhead populations below natural and manmade impassable barriers in the Sacramento and San Joaquin rivers and their tributaries, east of the Carquinez Strait, and the Feather River Hatchery and Coleman National Fish Hatchery steelhead programs.

Nimbus Fall Chinook Program

The goal of the integrated fall Chinook program at NFH is to release four million smolts that average 60 fpp or larger. These fish are marked at a rate of 25 percent (constant fractional marking) with an adipose fin-clip and coded wire tag and then all are released in San Pablo Bay between mid-May and mid-June.

Nimbus Steelhead Program

The NFH segregated winter steelhead program traps and artificially spawns adult steelhead marked with an adipose fin clip. Unmarked fish are not included in the broodstock and are released back to the river. Broodstock has been derived from a number of different populations and presently appears to cluster genetically most closely with Eel River steelhead. Nielson et al. (2005) reported that juvenile fish from the lower American River and NFH were genetically similar in microsatellite allelic frequencies. Garza and Pearse (2008) reported similar results for fish sampled from the lower American River and NFH.

The program has a juvenile release goal of 430,000 yearling steelhead (at 4 fpp). All NFH steelhead are marked with an adipose fin clip. Fish are released from January through February approximately one mile above the confluence of the American and Sacramento rivers (at Jibboom Street) to reduce predation on natural-origin Chinook fry.

5.3.1 Recommendations for All Nimbus Hatchery Programs

- Clear goals should be established for the program. Program production goals should be expressed in terms of the number of age-3 ocean recruits just prior to harvest (Chinook salmon), and the number of adults returning to freshwater (steelhead).

- Managers should investigate the feasibility of collecting natural-origin adult fish at alternate locations. The existing trapping location is very limited in its ability to capture fish representing the entire spectrum of life history diversity. Only fish that migrate to the furthest upstream reaches are susceptible to capture.

- Adult holding facilities should be upgraded and/or expanded to provide adequate space, water flows and temperature regimes to hold the number of adults required for broodstock at high rates of survival (greater than 90 percent).

- Transporting and releasing juveniles to areas outside of the American River or to the lower American River should be discontinued. Juvenile fish should be released at the hatchery, or if not possible, as far upstream in the American River from the confluence of the Sacramento River as possible to reduce adult straying and increase the number of adults returning to the hatchery. Consider necessary facility modifications or equipment purchases that will facilitate on-site releases. Release locations for steelhead may take into consideration ecological and predation effects on other fish populations but should not compromise homing of adults to the hatchery.

- Performance standards for each phase of the fish culture process should be established and tracked annually. Summaries of data collected with comparisons to established targets must be included in annual hatchery reports.

- A Monitoring and Evaluation Program should be developed and implemented and a Hatchery Coordination Team formed for the program. Implementation of these processes will inform hatchery decisions and document compliance with best management practices defined in this report.

- CDFG should develop and promulgate a formal, written fish health policy for operation of its anadromous hatcheries through the Fish and Game Commission policy review process. Hatchery compliance with this policy should be documented annually as part of a Fish Health Management Plan. The current CDFG fish health policy is inadequate to protect native stocks.

- CDFG should develop an updated Hatchery Procedure Manual which includes performance criteria and culture techniques presented in IHOT (1995), Fish Hatchery Management (Wedemeyer 2001) or comparable publications. The fish culture manual (Leitritz and Lewis 1976) is outdated and does not reflect current research and advancements in fish culture.

5.3.2 Nimbus Fall Chinook- Major Program Recommendations

The major recommendations of interest to resource managers for the NFH fall Chinook salmon program are provided below. Those selected for presentation may represent major changes in operations, changes in approach or outcomes towards achieving harvest or conservation objectives, or will require substantial investment of resources. The California HSRG's evaluation of program compliance with standards and guidelines and the group's comments about this program are presented in their entirety in Appendix VIII.

- Natural-origin fish should be incorporated into broodstock at a minimum rate of 10 percent to prevent divergence of the hatchery and natural components of the integrated population. This may require auxiliary adult collection facilities or alternative collection methods (e.g., seining or trapping).

- Until all off-site releases of Chinook salmon are eliminated in the entire Central Valley, coded-wire tag analysis should be used to identify stray hatchery-origin fish among those fish selected for broodstock. Strays from other hatchery programs should not be used as broodstock, or if eggs are collected from or fertilized by such fish, they should be culled soon after spawning.

- Program fish should be 100 percent coded wire-tagged and 25 percent adipose fin-clipped.

- The cause of the low egg-to-juvenile release survival rate (43.6 percent) should be determined.

5.3.3 Nimbus Steelhead Program- Major Recommendations

The major recommendations of interest to resource managers for the NFH steelhead program are provided below. Those selected for presentation may represent major changes in operations, changes in approach or outcomes towards achieving harvest or conservation objectives, or will require substantial investment of resources. The California HSRG's evaluation of program compliance with standards and guidelines and the group's comments about this program are presented in their entirety in Appendix VIII.

- The current broodstock for this program should be replaced with an alternative broodstock that is appropriate for the American River.

- Non-anadromous (resident) or unmarked fish should not be used as broodstock and the current 16-inch minimum length for broodstock should be continued. This recommendation to not use unmarked fish will no longer apply once the current broodstock is replaced.

- Because Nimbus steelhead currently are not part of the Central Valley steelhead Distinct Population Segment, all juvenile fish released should receive an adipose fin-clip plus an additional distinguishing external mark (non-adipose fin clip) or CWT, until a native broodstock is established. This additional distinguishing mark or tag will ensure that if these fish return to another hatchery, they can be excluded from its broodstock.

- With the current broodstock, all hatchery-origin adult steelhead returns to the hatchery, whether spawned or unspawned, should be removed from the system. With a native broodstock, hatchery-origin adult steelhead returns to the hatchery should be treated as follows: (1) unspawned males should be extended reconditioned and released; (2) unspawned females should be stripped of eggs, extended reconditioned and released; and (3) spawned fish should be removed from the system, or extended reconditioned and released.

- Natural-origin adult steelhead returns to the hatchery, whether spawned or unspawned, should be released. Fish may be reconditioned prior to release.

- An alternative cold-water source should be developed to reduce summer rearing water temperatures.

- The cause of the low egg-to-juvenile release survival rate (24.5 percent) should be determined. It is suspected that the low value is a result of egg-culling practices; however, this cannot be confirmed because of the way data are collected and reported.

5.4 Mokelumne River Hatchery

The Mokelumne River Fish Hatchery (MRFH) is located on the lower Mokelumne River just downstream of Camanche Dam. Funding for hatchery operations is provided by the East Bay Municipal Utility District (EBMUD) while the hatchery is operated and managed by the CDFG. The fall Chinook and steelhead hatchery programs were originally designed to comply with the 1961 requirements of the California State Water Resources Control Board. The 1961 agreement and related amendments directed the construction of a hatchery to rear 100,000 juvenile salmon and spawning channels with a capacity for up to 15 million Chinook salmon eggs.

In March 1998, EBMUD, CDFG and the USFWS entered into an agreement to resolve various FERC relicensing and state water right issues. EBMUD agreed to fund an expansion and upgrade of the MRFH as an integral part of a strategy to supplement the natural production and to meet the mitigation requirement for anadromous fish in the lower Mokelumne River. Hatchery reconstruction was completed in 2002. The fall Chinook salmon and steelhead programs are briefly summarized below, followed by sections highlighting the California HSRG's major recommendations for both Mokelumne programs and then the program-specific recommendations.

The Central Valley fall/late fall-run Chinook salmon ESU was classified as a federal Species of Concern in 2004. The ESU includes all naturally spawned populations of fall-run Chinook salmon in the Sacramento and San Joaquin rivers and their tributaries, east of the Carquinez Strait.

The Central Valley steelhead DPS was classified under the ESA as threatened in 1998. The DPS includes all naturally spawned anadromous steelhead populations below natural and manmade impassable barriers in the Sacramento and San Joaquin rivers and their tributaries, east of the Carquinez Strait, and the Feather River Hatchery and Coleman National Fish Hatchery steelhead programs.

Mokelumne Fall Chinook Program

The integrated fall Chinook program at MRFH has a goal to release up to five million fall-run Chinook salmon smolts that average 60 fpp or larger for harvest purposes. Approximately two million additional Chinook are raised to post-smolt size (45 fpp) each year for an ocean enhancement program. All of the enhancement salmon production is released into San Pablo Bay or reared in net pens on the coast. Remaining Mokelumne-origin salmon smolts are released below Woodbridge Dam, about 10 miles downstream of the hatchery. Juvenile fall Chinook are released between March and June and all fish are marked at a rate of 25 percent (constant fractional marking) with an adipose fin-clip and coded wire tag.

Mokelumne Steelhead Program

The integrated steelhead program at Mokelumne has a goal to release 250,000 yearling steelhead at 4 fpp. The program has been experimenting with small releases (less than 2,000 fish) of two-year-old steelhead juveniles using a "natures" rearing strategy (i.e., presence of structure, low rearing density, shallow pond depth, cover and colored raceways). All steelhead are released from February through March and are marked with an adipose fin clip. Steelhead are released at New Hope Landing, approximately 10.5 miles downstream from the confluence of the Mokelumne and Consumes rivers.

5.4.1 Recommendations for All Mokelumne River Hatchery Programs

- Clear goals should be established for the program. Program production goals should be expressed in terms of the number of age-3 ocean recruits just prior to harvest (Chinook salmon), and the number of adults returning to freshwater (steelhead).

- Broodstock for the program should only come from native, locally adapted stocks. Out-of-subbasin importation of eggs, juveniles or adults should not occur, even if it means juvenile production targets will not be achieved in some years. Work with water managers to improve conditions for migrating juveniles and adults.

- Transporting and releasing juveniles to areas outside of the Mokelumne River should be discontinued. Juvenile fish should be released at the hatchery, or if not possible, as far upstream in the Mokelumne River from the confluence of the Sacramento River as possible to reduce adult straying and increase the number of adult fish returning to the hatchery. Consider necessary facility modifications or equipment purchases that will facilitate on-site releases. Release locations for steelhead may take into consideration ecological and predation effects on other fish populations but should not compromise homing of adults to the hatchery.

- Performance standards for each phase of the fish culture process should be established and tracked annually. Summaries of data collected with comparisons to established targets must be included in annual hatchery reports.

- Managers should investigate the feasibility of collecting natural-origin adult fish at alternate locations. The existing trapping location is very limited in its ability to capture fish representing the entire spectrum of life history diversity. Only fish that migrate to the furthest upstream reaches are susceptible to capture.

- A Monitoring and Evaluation Program should be developed and implemented and a Hatchery Coordination Team formed for the program. Implementation of these processes will inform hatchery decisions and document compliance with best management practices defined in this report.

- CDFG should develop and promulgate a formal, written fish health policy for operation of its anadromous hatcheries through the Fish and Game Commission policy review process. Hatchery compliance with this policy should be documented annually as part of a Fish Health Management Plan. The current CDFG fish health policy is inadequate to protect native stocks.

- CDFG should develop an updated Hatchery Procedure Manual which includes performance criteria and culture techniques presented in IHOT (1995), Fish Hatchery Management (Wedemeyer 2001) or comparable publications. The fish culture manual (Leitritz and Lewis 1976) is outdated and does not reflect current research and advancements in fish culture.

5.4.2 Mokelumne River Fall Chinook- Major Program Recommendations

The major recommendations of interest to resource managers for the Mokelumne fall Chinook salmon hatchery program are provided below. Those selected for presentation may represent major changes in operations, changes in approach or outcomes towards achieving harvest or conservation objectives, or will require substantial investment of resources. The California HSRG's evaluation of program

compliance with standards and guidelines and the group's comments about this program are presented in their entirety in Appendix VIII.

- Natural-origin fish should be incorporated into broodstock at a minimum rate of 10 percent to prevent divergence of the hatchery and natural components of the integrated population. This may require auxiliary adult collection facilities or alternative collection methods (e.g., seining or trapping).

- Until all off-site releases of Chinook salmon are eliminated in the entire Central Valley, coded-wire tag analysis should be used to identify stray hatchery-origin fish among those fish selected for broodstock. Strays from other hatchery programs should not be used as broodstock, or if eggs are collected from or fertilized by such fish, they should be culled soon after spawning.

- Program fish should be 100 percent coded wire-tagged and 25 percent adipose fin-clipped. "Yearling" releases should receive an additional distinguishing external mark or tag (e.g., a ventral fin clip) allowing real-time discrimination from fingerling releases at the adult stage.

- Returning yearling-origin adults should not be used as broodstock. If eggs are collected from or fertilized by such fish, they should be culled soon after spawning. Adequate numbers of fingerlings should be released each year to meet numerical goals for broodstock. When adult returns from fingerling releases are inadequate to satisfy hatchery egg take needs, yearling returns may be used to reduce the deficit.

5.4.3 Mokelumne River Steelhead- Major Program Recommendations

The major recommendations of interest to resource managers for the Mokelumne steelhead hatchery program are provided below. Those selected for presentation may represent major changes in operations, changes in approach or outcomes toward achieving harvest or conservation goals, or will require substantial investment of resources. The California HSRG's evaluation of program compliance with standards and guidelines and the group's comments about this program are presented in their entirety in Appendix VIII.

- Non-anadromous (resident) or unmarked fish typically should not be used as broodstock and the current 16-inch minimum length for broodstock should be continued.

- Hatchery-origin adult steelhead returns to the hatchery should be treated as follows: (1) unspawned males should be extended reconditioned and released; (2) unspawned females should be stripped of eggs, extended reconditioned and released; and (3) spawned fish should be removed from the system, or extended reconditioned and released.

- Natural-origin adult steelhead returns to the hatchery, whether spawned or unspawned, should be released. Fish may be reconditioned prior to release.

5.5 Merced River Hatchery

Merced River Hatchery (MRH) is located just below Crocker-Huffman Dam (the terminus of anadromy), north of Fresno. The original fish facility, completed in 1970 by the Merced Irrigation District (MID), was a Chinook salmon spawning channel designed to enhance salmon runs. To increase production, the facility was converted into a spawning and rearing hatchery during the 1980s and 1990s. Operational funding is provided by the CDFG and the MID; CDFG operates and maintains the hatchery. Fall Chinook salmon are the only species reared at Merced Hatchery.

The fall Chinook salmon program at MRH is considered an experimental program to test juvenile to adult survival rates for various release sites in the basin. The original purpose of the program was to mitigate for lost habitat from the construction of the Crocker-Huffman, Merced Falls, and Exchequer dams. This was to be achieved by producing 960,000 fall Chinook smolts and 330,000 yearlings. The yearling program was discontinued due to high fish losses from proliferative kidney disease (PKD), caused by *Tetracapsuloides bryosalmonae*, an endemic myxozoan parasite in the Merced River.

Current production goals for the integrated fall Chinook program are to take two million fall Chinook eggs and release one million smolts at 60 fpp (80 mm fork length) between late April and mid-May. Most releases of Merced River fall Chinook salmon are for experimental purposes. These fish have been marked (adipose fin-clipped, panjet marked) and coded wire tagged, and the remaining fish are currently marked at a 25 percent constant fractional marking rate with an adipose fin-clip and coded wire tag. Fall Chinook are released at the hatchery, at lower Merced River locations, and at various locations in the San Joaquin River and further downstream.

The Central Valley fall/late fall-run Chinook salmon ESU was classified as a federal Species of Concern in 2004. The ESU includes all naturally spawned populations of fall-run Chinook salmon in the Sacramento and San Joaquin rivers and their tributaries, east of the Carquinez Strait.

5.5.1 Merced River Fall Chinook- Major Program Recommendations

The major recommendations of interest to resource managers for the Merced fall Chinook salmon hatchery program are provided below. Those selected for presentation may represent major changes in operations, changes in approach or outcomes towards achieving harvest or conservation objectives, or will require substantial investment of resources. The California HSRG's evaluation of program compliance with standards and guidelines and the group's comments about this program are presented in their entirety in Appendix VIII.

A clear purpose and goal should be established for the program that appears to be dual purpose: experimentation and mitigation. If managers determine that the facility is to be operated for experimental purposes, operational guidelines should be developed consistent with the experiments being undertaken. If managers determine that the hatchery will be operated as a production hatchery to meet mitigation objectives identified in the program description, applicable hatchery standards and guidelines developed by the California HSRG, including the following recommendations should be implemented:

- Transporting and releasing juveniles to areas outside of the Merced River should be discontinued. Juvenile fish should be released at the hatchery, or if not possible, as far upstream in the Merced River from the confluence of the San Joaquin River as possible to reduce adult straying and increase the number of adult fish returning to the hatchery. Consider necessary facility modifications or equipment purchases that will facilitate on-site releases. Release locations for steelhead may take into consideration ecological and predation effects on other fish populations but should not compromise homing of adults to the hatchery.

- Performance standards for each phase of the fish culture process should be established and tracked annually. Summaries of data collected with comparisons to established targets must be included in annual hatchery reports.

- Broodstock for the program should only come from native, locally adapted stocks. Out-of-subbasin importation of eggs, juveniles or adults should not occur, even if it means juvenile production targets will not be achieved in some years.

- Natural-origin fish should be incorporated into broodstock at a minimum rate of 10 percent to prevent divergence of the hatchery and natural components of the integrated population. This may require auxiliary adult collection facilities or alternative collection methods (e.g., seining or trapping).

- Until all off-site releases of Chinook salmon are eliminated in the entire Central Valley, coded wire tag analysis should be used to identify stray hatchery-origin fish among those fish selected for broodstock. Strays from other hatchery programs should not be used as broodstock, or if eggs are collected from or fertilized by such fish, they should be culled soon after spawning.

- Program fish should be 100 percent coded wire-tagged and 25 percent adipose fin-clipped.

- Managers should investigate the feasibility of collecting natural-origin adult fish at alternate locations. The existing trapping location is very limited in its ability to capture fish representing the entire spectrum of life history diversity. Only fish that migrate to the furthest upstream reaches are susceptible to capture.

- A Monitoring and Evaluation Program should be developed and implemented and a Hatchery Coordination Team formed for the program. Implementation of these processes will inform hatchery decisions and document compliance with best management practices defined in this report.

- CDFG should develop and promulgate a formal, written fish health policy for operation of its anadromous hatcheries through the Fish and Game Commission policy review process. Hatchery compliance with this policy should be documented annually as part of a Fish Health Management Plan. The current CDFG fish health policy is inadequate to protect native stocks.

- CDFG should develop an updated Hatchery Procedure Manual which includes performance criteria and culture techniques presented in IHOT (1995), Fish Hatchery Management (Wedemeyer 2001) or comparable publications. The fish culture manual (Leitritz and Lewis 1976) is outdated and does not reflect current research and advancements in fish culture.

5.6 Feather River Hatchery

In 1960, California voters authorized the Department of Water Resources (DWR) to construct and operate the State Water Project. Oroville Dam and Reservoir on the Feather River were completed in 1968 and are essential components of this development, providing water storage, hydroelectric power, flood control, and recreational benefits. The dam is five miles east of the City of Oroville. Feather River Hatchery (FRH) is a component of the Oroville Project that was constructed in the mid-1960s to mitigate for blocked Chinook salmon and steelhead spawning habitat. FRH is located downstream of Oroville

Dam and about 66 miles upstream from the confluence of the Feather and Sacramento rivers. An additional facility, the FRH Annex, is located 11 miles downstream adjacent to the Thermalito Afterbay.

The CDFG operates and maintains FRH under contract with the DWR. Although there are no other agencies, tribes, or cooperators directly involved in operating FRH, one advisory group, the Feather River Technical Team, advises FRH personnel on the integration of hatchery operations with management of the salmonid fisheries below Oroville Dam. Three programs are conducted here, producing fall Chinook, spring Chinook and steelhead. Each program is briefly summarized below, followed by sections highlighting the California HSRG's major recommendations for all Nimbus programs and then the program-specific recommendations.

The Central Valley fall/late fall-run Chinook salmon ESU was classified as a federal Species of Concern in 2004. The ESU includes all naturally spawned populations of fall-run Chinook salmon in the Sacramento and San Joaquin rivers and their tributaries, east of the Carquinez Strait.

The Central Valley spring-run Chinook salmon ESU was classified under the ESA as threatened in 1999. The ESU includes all naturally spawned populations of spring-run Chinook salmon in the Sacramento River and its tributaries, and the FRH spring-run Chinook salmon program.

The Central Valley steelhead DPS was classified under the ESA as threatened in 1998. The DPS includes all naturally spawned anadromous steelhead populations below natural and manmade impassable barriers in the Sacramento and San Joaquin rivers and their tributaries, east of the Carquinez Strait, and the Feather River Hatchery and Coleman National Fish Hatchery steelhead programs.

Feather River Hatchery Fall Chinook

This integrated program traps and spawns fall-run Chinook salmon from the Feather River for rearing and release as juveniles. There are no specific goals for the number of adult Chinook salmon annually trapped or artificially spawned; however, the production goal is to release six million fall-run Chinook salmon smolts that are 60 fpp or larger. Up to two million additional fish may be reared as part of a separate ocean enhancement program. The size at release goal for enhancement program fish is 30 fpp or larger. With the exception of some small on-site experimental releases, Chinook smolts are all released into the Carquinez Straits between April and June. Feather River fall Chinook are currently marked at a 25 percent rate (constant fractional marking) with an adipose fin-clip and a coded wire-tag.

Feather River Hatchery Spring Chinook

The spring Chinook salmon program at Feather River has two components with different purposes: (1) an integrated harvest program to mitigate for lost habitat and juvenile fish production in the Feather River; and (2) an integrated conservation program to aid in the recovery and conservation of spring Chinook salmon from Deer, Mill and Butte creeks. Adult hatchery-produced spring Chinook are intended to spawn naturally or to be genetically integrated with the natural population through artificial propagation. There are no specific goals for the number of adult spring Chinook produced by this program; however, the juvenile production goal is to release two million smolts sized at 60 fpp during April or May. Juvenile hatchery-produced spring Chinook are currently 100 percent marked with an adipose fin-clip and a coded wire-tag. These fish are all released into the Feather River south of Yuba City at the Boyd's Pump Boat Launch (44 miles downstream of the hatchery).

Feather River Hatchery Steelhead

The FRH steelhead program is an integrated harvest program that traps and artificially spawns both marked hatchery-origin and unmarked natural-origin steelhead. Only a few unmarked fish are trapped annually. FRH steelhead are intended to migrate to the ocean and return to provide recreational fishing opportunities and hatchery broodstock as mitigation for lost habitat and juvenile fish production capacity resulting from construction of Oroville Dam. From 1968 through 1987, steelhead eggs from Nimbus, Iron Gate and Skamania hatcheries were transferred to FRH and the juvenile fish reared and released. Since then, only fish returning to the Feather River Basin have been used for broodstock.

There are no specific goals for the number of adult steelhead produced by this program; however, the juvenile production goal is to release 450,000 yearling steelhead annually at three fpp during late January or February. Excluding the past three seasons, hatchery personnel have taken approximately 1.5 million eggs to produce 450,000 juveniles. During the past three seasons, the number of adults trapped and eggs taken have decreased dramatically to less than 615,000 eggs with a commensurate decrease in the number of fish released.

All FRH steelhead are marked with an adipose fin-clip prior to release. These fish are all released into the Feather River south of Yuba City at the Boyd's Pump Boat Launch (44 miles downstream of the hatchery) or at the confluence of the Feather and Sacramento rivers (Verona Marina).

5.6.1 Recommendations for All Feather River Hatchery Programs

- Clear goals should be established for the program. Program production goals should be expressed in terms of the number of age-3 ocean recruits just prior to harvest (Chinook salmon), and the number of adults returning to freshwater (steelhead).

- Transporting and releasing juveniles to areas outside of the Feather River and near or downstream of the confluence of the Yuba River should be discontinued. Juvenile fish should be released at the hatchery, or if not possible, as far upstream in the Feather River from the confluence of the Yuba River as possible to reduce adult straying and increase the number of adult fish returning to the hatchery. Consider necessary facility modifications or equipment purchases that will facilitate on-site releases. Release locations for steelhead may take into consideration ecological and predation effects on other fish populations but should not compromise homing of adults to the hatchery.

- Managers should investigate the feasibility of collecting natural-origin adult fish at alternate locations. The existing trapping location is very limited in its ability to capture fish representing the entire spectrum of life history diversity. Only fish that migrate to the furthest upstream reaches are susceptible to capture.

- Adult holding facilities should be upgraded and/or expanded to provide adequate space, water flows and temperature regimes to hold the number of adults required for broodstock at high rates of survival (greater than 90 percent). In addition, because of a lack of adult holding space, fall Chinook are returned to the river to make room for late arriving spring Chinook. Evaluate the prospects of using the Thermalito Annex Facility for the long-term holding of spring Chinook broodstock. While the Annex water temperature is relatively high, a pilot study could be used to determine whether any associated increased holding mortality was sufficiently offset by the Annex's otherwise excellent water quality.

- Natural-origin fish should be incorporated into broodstock at a minimum rate of 10 percent to prevent divergence of the hatchery and natural components of the integrated population. This may require auxiliary adult collection facilities or alternative collection methods (e.g., seining or trapping).

- A Monitoring and Evaluation Program should be developed and implemented and a Hatchery Coordination Team formed for the program. Implementation of these processes will inform hatchery decisions and document compliance with best management practices defined in this report.

- Performance standards for each phase of the fish culture process should be established and tracked annually. Summaries of data collected with comparisons to established targets must be included in annual hatchery reports.

- CDFG should develop and promulgate a formal, written fish health policy for operation of its anadromous hatcheries through the Fish and Game Commission policy review process. Hatchery compliance with this policy should be documented annually as part of a Fish Health Management Plan. The current CDFG fish health policy is inadequate to protect native stocks.

- CDFG should develop an updated Hatchery Procedure Manual which includes performance criteria and culture techniques presented in IHOT (1995), Fish Hatchery Management (Wedemeyer 2001) or comparable publications. The fish culture manual (Leitritz and Lewis 1976) is outdated and does not reflect current research and advancements in fish culture.

5.6.2 Feather River Fall Chinook- Major Program Recommendations

The major recommendations of interest to resource managers for the Feather River fall Chinook salmon hatchery program are provided below. Those selected for presentation may represent major changes in operations, changes in approach or outcomes towards achieving harvest or conservation objectives, or will require substantial investment of resources. The California HSRG's evaluation of program compliance with standards and guidelines and the group's comments about this program are presented in their entirety in Appendix VIII.

- Use of the Feather River Annex for rearing should be discontinued unless juveniles are released in the vicinity of the Annex and an adult collection facility is installed in the downstream outlet of the Thermalito Afterbay.

- The program should limit the number of eggs taken to the number necessary to meet production goals (which would include a reasonable overage to account for egg loss and culling of spring x fall crosses). On average, the program takes about 20 million eggs to produce 6 million juveniles.

- Tag analysis should be used to determine the fall and spring hatchery-origin Chinook spawned during the suspected period of run overlap (e.g., fish spawned in the last two weeks of spring Chinook spawning and the first two weeks of fall Chinook spawning). Tags should be read and egg lots tracked and eliminated from production as appropriate to reduce introgression of the two runs. Incubation techniques should therefore allow for separation of eggs from individual parents/families (no more than two families per tray).

- Only unmarked fish should be spawned in the fall brood (FRH spring Chinook are 100 percent adipose fin-clipped, FRH fall Chinook are 25 percent adipose fin-clipped) to reduce the need for culling. Any spring x fall Chinook crosses of hatchery-origin fish (e.g., due to marking or mark detection errors) should be identified by coded wire-tag analysis and eggs should be culled soon after spawning.

- Until all off-site releases of Chinook salmon are eliminated in the entire Central Valley, coded wire tag analysis should be used to identify stray hatchery-origin fish among those fish selected for broodstock. Strays from other hatchery programs should not be used as broodstock, or if eggs are collected from or fertilized by such fish, they should be culled soon after spawning.

- Program fish should be 100 percent coded wire-tagged and 25 percent adipose fin-clipped.

5.6.3 Feather River Spring Chinook- Major Program Recommendations

The major recommendations of interest to resource managers for the Feather spring Chinook salmon hatchery program are provided below. Those selected for presentation may represent major changes in operations, changes in approach or outcomes towards achieving harvest or conservation goals, or will require substantial investment of resources. The California HSRG's evaluation of program compliance with standards and guidelines and the group's comments about this program are presented in their entirety in Appendix VIII.

- Tag analysis should be used to determine the number of fall and spring Chinook spawned during the suspected period of run overlap (e.g., fish spawned in the last two weeks of spring Chinook spawning and the first two weeks of fall Chinook spawning). Tags should be read and egg lots tracked and eliminated from production as appropriate to reduce introgression of the two runs. Incubation techniques should therefore allow for separation of eggs from individual parents/families (no more than two families per tray).

- Until all off-site releases of Chinook salmon are eliminated in the entire Central Valley, coded wire tag analysis should be used to identify stray hatchery-origin fish among those fish selected for broodstock. Strays from other hatchery programs should not be used as broodstock, or if eggs are collected from or fertilized by such fish, they should be culled soon after spawning.

5.6.4 Feather River Steelhead- Major Program Recommendations

The major recommendations of interest to resource managers for the Feather River steelhead hatchery program are provided below. Those selected for presentation may represent major changes in operations, changes in approach or outcomes towards achieving harvest or conservation goals, or will require substantial investment of resources. The California HSRG's evaluation of program compliance with standards and guidelines and the group's comments about this program are presented in their entirety in Appendix VIII.

- A Hatchery Coordination Team should be established to review the status of the FRH steelhead program.

- The number of eggs taken annually should be reduced to a level appropriate to produce 450,000 juveniles and the transfer of eggs to other programs terminated. Collection of excess eggs is permissible to increase effective population size as long as culling is done representatively.

- Broodstock for the program should only come from native, locally adapted stocks. Out-of-subbasin importation of eggs, juveniles or adults should not occur, even if it means juvenile production targets will not be achieved in some years.

- Non-anadromous (resident) fish should not be used as broodstock and the current 16-inch minimum length for broodstock should be continued.

- Hatchery-origin adult steelhead returns to the hatchery should be treated as follows: (1) unspawned males should be extended reconditioned and released; (2) unspawned females should be stripped of eggs, extended reconditioned and released; and (3) spawned fish should be removed from the system, or extended reconditioned and released.

- Natural-origin adult steelhead returns to the hatchery, whether spawned or unspawned, should be released. Fish may be reconditioned prior to release.

5.7 Coleman National Fish Hatchery

Coleman National Fish Hatchery (NFH) was completed by the USBR in 1943 to partially mitigate for habitat and fish losses caused by construction of two Central Valley Project features, Shasta and Keswick dams. The hatchery is funded by the USBR and operated by the USFWS. Coleman NFH occupies 75 acres adjacent to Battle Creek, a tributary to the Sacramento River, about 20 miles southeast of Redding.

Shasta Dam blocks 187 miles of salmonid spawning and rearing habitat. Fall Chinook, late-fall Chinook and steelhead are produced to mitigate for this habitat loss, to contribute to ocean and river harvest, and to provide adequate escapement to the hatchery for broodstock. These three programs are summarized below, followed by the California HSRG's major recommendations that apply to all Coleman programs and then sections presenting program-specific recommendations.

The Central Valley fall/late fall-run Chinook salmon ESU was classified as a federal Species of Concern in 2004. This ESU includes all naturally spawned populations of fall-run Chinook salmon in the Sacramento and San Joaquin rivers and their tributaries, east of the Carquinez Strait.

The Central Valley steelhead DPS was classified under the ESA as threatened in 1998. The DPS includes all naturally spawned anadromous steelhead populations below natural and manmade impassable barriers in the Sacramento and San Joaquin rivers and their tributaries, east of the Carquinez Strait, and the Feather River Hatchery and Coleman National Fish Hatchery steelhead programs.

Coleman NFH Fall Chinook Program

The fall Chinook salmon program is integrated with the natural spawning populations in Battle Creek and the Sacramento River. Program broodstock include returning hatchery-origin fish collected from the hatchery fish ladders, and natural-origin fish collected at the Battle Creek weir. Managers also use the barrier weir to block the movement of hatchery-origin fall Chinook into upper Battle Creek in order to protect the ESA-listed spring Chinook salmon spawning in that area, although the weir is ineffective during high flow events.

The program annually releases 12 million fall Chinook in April at a size of 90 fpp, which are expected to contribute a total of 120,000 fish to harvest and escapement over the life of the brood (60-75 percent for harvest). Released fish are constant fractionally marked at a rate of 25 percent (adipose fin-clipped and coded wire-tagged). Ninety percent of program fish are released at or near the hatchery in Battle Creek; ten percent are released into San Pablo Bay.

Coleman NFH Late-Fall Chinook Program

Late-fall Chinook salmon have been managed distinctly from fall Chinook salmon at Coleman since 1973. The late-fall Chinook salmon program is integrated with the natural spawning populations in Battle Creek and the Sacramento River. Program broodstock include returning hatchery-origin fish collected from the hatchery fish ladders and Battle Creek weir, and natural-origin fish collected at the Keswick Dam fish trap. Managers also use the barrier weir to block the movement of hatchery-origin late-fall Chinook into upper Battle Creek in order to protect the ESA-listed spring Chinook salmon spawning in that area, although the weir is ineffective during high flow events.

The program annually releases 1 million late-fall Chinook in December at a size of 13 fpp, which are expected to contribute a total of 10,000 fish to harvest and escapement over the life of the brood (50 percent to harvest). All released fish are adipose fin-clipped and coded wire-tagged, and released at or near the hatchery in Battle Creek.

Coleman NFH Steelhead Program

Until recently, the steelhead program was operated in an integrated fashion, incorporating into the broodstock natural-origin Sacramento River fish from 1947–1986, and natural-origin Battle Creek fish from 1952–2009. The use of natural-origin fish in the program was discontinued in 2009 due to the low abundance of Battle Creek natural-origin fish. If the abundance of the Battle Creek population recovers to sufficient levels in the future, the program will be re-integrated with this population.

The program annually releases 600,000 steelhead in January at a size of 4 fpp, which are expected to contribute a total of 3,000 fish to harvest and escapement over the life of the brood (33 percent for harvest). All released fish are adipose fin-clipped, and released into the Sacramento River at Bend Bridge (about 15 miles downstream of the Battle Creek confluence) to reduce predation on newly emerging Chinook in the upper Sacramento River and Battle Creek. Managers use the Battle Creek barrier weir to block the movement of hatchery-origin steelhead into upper Battle Creek, although the weir is ineffective during high flow events.

The adult return goal to the hatchery has been met in 7 of the last 11 years. Creel survey data indicate that approximately 500 steelhead are harvested annually in the upper Sacramento River, and that the majority of these fish were likely Coleman NFH steelhead since only adipose fin-clipped steelhead can be retained as harvest.

5.7.1 Recommendations for All Coleman Hatchery Programs

- Transporting and releasing juveniles to areas outside of Battle Creek should be discontinued. Juvenile fish should be released at the hatchery to reduce adult straying and increase the number of adult fish returning to the hatchery. Consider necessary facility modifications or equipment purchases that will facilitate on-site releases. Release locations for steelhead may take into consideration ecological and predation effects on other fish populations but should not compromise homing of adults to the hatchery.

- Performance standards for each phase of the fish culture process should be established and tracked annually. Summaries of data collected with comparisons to established targets must be included in annual hatchery reports.

- The emergency backup water intake (#2) should be screened to prevent fish entrainment.

- The USFWS should develop a Hatchery Procedure Manual for each program at Coleman NFH that includes performance criteria and culture techniques presented in IHOT (1995), Fish Hatchery Management (Wedemeyer 2001) or comparable publications.

5.7.2 Coleman Fall Chinook- Major Program Recommendations

The major recommendations of interest to resource managers for the Coleman NFH fall Chinook salmon program are provided below. Those selected for presentation may represent major changes in operations, changes in approach or outcomes towards achieving harvest or conservation goals, or will require substantial investment of resources. The California HSRG's evaluation of program compliance with standards and guidelines and the group's comments about this program are presented in their entirety in Appendix VIII.

- Program fish should be 100 percent coded wire-tagged and 25 percent adipose fin-clipped.

5.7.3 Coleman NFH Late-Fall Chinook – Major Program Recommendations

The major recommendations of interest to resource managers for the Coleman late-fall Chinook salmon hatchery program are provided below. Those selected for presentation may represent major changes in operations, changes in approach or outcomes towards achieving harvest or conservation goals, or will require substantial investment of resources. The California HSRG's evaluation of program compliance with standards and guidelines and the group's comments about this program are presented in their entirety in Appendix VIII.

- It is recommended that managers investigate the feasibility of collecting natural-origin adult fish at alternate locations, including collecting and retaining fish from Battle Creek.

5.7.4 Coleman NFH Steelhead- Major Program Recommendations

The major recommendations of interest to resource managers for the Coleman steelhead hatchery program are provided below. Those selected for presentation may represent major changes in operations, changes in approach or outcomes towards achieving harvest or conservation goals, or will require substantial investment of resources. The California HSRG's evaluation of program compliance with standards and guidelines and the group's comments about this program are presented in their entirety in Appendix VIII.

- Adult steelhead holding facilities should be upgraded and/or expanded to provide adequate space, water flows and temperature regimes to hold the number of adults required for broodstock at high rates of survival (greater than 90 percent).

- This program should be converted back into an integrated program with a minimum pNOB of 10 percent which thus requires 40-50 natural-origin adults. In recent years, due to the current low abundance of Battle Creek natural-origin steelhead and the concern that collecting these fish for natural-origin broodstock is likely to negatively affect population viability (Standard 1.13), no natural-origin fish have been incorporated into the spawning matrix. It is recommended that managers investigate the feasibility of collecting natural-origin adult fish at alternate locations (e.g., Keswick Dam fish trap) until the abundance of natural-origin steelhead returning to Battle Creek has sufficiently increased to resume their incorporation into the program.

- Current efforts should be expanded to determine the cause of low smolt-to-adult returns for this program. Possible residualization, high in-river mortality, high mortality in the delta/estuary or the ocean, straying as adults, and under-reported catch may be factors.

- Hatchery-origin adult steelhead returns to the hatchery should be treated as follows: (1) unspawned males should be extended reconditioned and released; (2) unspawned females should be stripped of eggs, extended reconditioned and released; and (3) spawned fish should be removed from the system, or extended reconditioned and released.

- Natural-origin adult steelhead returns to the hatchery, whether spawned or unspawned, should be released. Fish may be reconditioned prior to release.

5.8 Livingston Stone National Fish Hatchery

Livingston Stone National Fish Hatchery (NFH), a substation of Coleman NFH, was constructed by the Bureau of Reclamation in late 1997 to produce ESA-listed winter-run Chinook salmon to assist in population recovery. The hatchery is located at the base of Shasta Dam on the Sacramento River (above the terminus of anadromy).

The Sacramento River winter-run Chinook salmon ESU was classified under the ESA as endangered in 1994. The ESU includes all naturally spawned populations of winter-run Chinook salmon in the Sacramento River and its tributaries, the Livingston Stone NFH winter-run Chinook program, and the University of California Bodega Marine Laboratory winter-run Chinook captive broodstock program.

Artificial propagation of winter-run Chinook salmon at Livingston Stone NFH is intended to be a temporary measure that will cease when the naturally spawning population is recovered. A captive broodstock component of the winter-run Chinook salmon program operated from 1991 to 2007, after which it was discontinued because the abundance of natural-origin adults increased. If the abundance level again falls to critically low levels, the captive broodstock element of this program could be reconsidered (USFWS 2011). The Livingston Stone winter-run Chinook salmon program is supported in the NMFS draft Recovery Plan for winter-run Chinook salmon (NMFS 2009; USFWS 2011). No other salmon species are reared here, although the hatchery also rears ESA-listed Delta smelt.

The Livingston Stone NFH program is a conservation-oriented program integrated with the natural population of winter-run Chinook salmon in the upper Sacramento River to provide a demographic boost to aid in population recovery (USFWS 2011). Hatchery-origin winter-run Chinook salmon are intended to return as adults to the upper Sacramento River, spawn in the wild, and become reproductively and genetically assimilated into the natural population. Although there is no adult production goal, Livingston Stone NFH releases up to 250,000 winter-run Chinook salmon at 60 fpp (or a minimum size of 80 fpp) each year in late January or early February. Winter-run Chinook salmon are released at the pre-smolt stage and are intended to rear in the freshwater environment prior to smoltification. All juvenile winter-run Chinook salmon produced at Livingston Stone NFH are adipose fin-clipped and coded wire-tagged. They are released into the Sacramento River at Caldwell Park in Redding (RM 299), about 10 miles downstream of the hatchery.

5.8.1 Livingston Stone Winter Chinook – Major Program Recommendations

The major recommendations of interest to resource managers for the Livingston Stone winter-run Chinook salmon hatchery program are provided below. Those selected for presentation may represent major changes in operations, changes in approach or outcomes towards achieving harvest or conservation goals, or will require substantial investment of resources. The California HSRG's evaluation of program compliance with standards and guidelines and the group's comments about this program are presented in their entirety in Appendix VIII.

- Program production goals should be expressed in terms of the number of adult recruits just prior to harvest (age-3 ocean recruits for Chinook).

- It is recommended that managers investigate the feasibility of collecting natural-origin adult fish at the fish ladder at Anderson-Cottonwood Irrigation District (ACID) Dam near Caldwell Park in Redding. The existing trapping location (Keswick Dam) is very limited in its ability to capture fish representing the entire spectrum of winter-run Chinook salmon life history diversity. Only fish that migrate to the furthest upstream reaches are susceptible to capture. Habitat conditions in the uppermost reaches where the trap is located are substantially different from the primary winter-run Chinook salmon spawning area.

- A biosecurity plan (see Standard 3.9) that protects individual programs (winter-run Chinook salmon and Delta smelt) should be prepared and implemented.

- The USFWS should develop a Hatchery Procedure Manual for the program at Livingston Stone NFH, which includes performance criteria and culture techniques presented in IHOT (1995), Fish Hatchery Management (Wedemeyer 2001) or comparable publications.

6. Implementation and Research

Hatchery management and related activities change due to new regulatory mandates and funding opportunities. Management goals and objectives are often inconsistent due to multiple political and regulatory jurisdictions. If hatchery benefits and risks are scientifically assessed, a common language and framework is needed to ensure critical work is effectively developed, efficiently implemented, and reported in a timely manner. The framework consists of a set of premises (Section 1.2) that are the foundation of the statewide issues and recommended standards and guidelines for operating hatchery programs (Chapter 4). The California HSRG strongly urges fishery and hatchery managers to implement the specific standards and guidelines and the resulting program-specific recommendations for hatchery operations. We believe that institutionalization of this implementation framework is critical to achieve meaningful and sustained improvements in hatchery operations, and optimize long-term management of California's anadromous fishery resources.

In the process of this review, the California HSRG was made aware of several internal California State issues that we think limit the ability of state-operated hatcheries to meet program goals. We strongly recommend that the State of California address these specific issues to improve and properly evaluate program performance:

- The California HSRG repeatedly heard that recent State contract issues have prevented hatcheries from using optimum feed. It is essential that all hatcheries have access to the most appropriate feed to ensure meeting readiness-to-smolt and growth trajectory goals.

- Research on a variety of hatchery-related topics (see below) is essential to identify and implement effective hatchery management goals and actions. We recommend that the CDFG develop streamlined and centralized protocols for review, coordination, and timely approval of appropriate or necessary research at all of the hatcheries it operates.

- The CDFG should develop a means to consistently apply best management practices and conservation principles at all of its hatcheries.

- Many of the specific recommendations in this report depend on the collection of biological data both within and outside of hatcheries. We suggest that the State of California provide sufficient, appropriately trained staff at each hatchery to collect this information.

6.1 Implementation Recommendations

Implementation of the Standards and Guidelines and program-specific recommendations will have implications to resource managers (including fishery, hatchery, tribal, and perhaps habitat managers); funding authorities such as utilities, and state and federal agencies; and regulators such as the NMFS. All of these entities will have a role in the implementation of these new recommendations for hatchery operations. In some instance, the California HSRG's recommendations address both in-hatchery reform and out-of-hatchery issues including additional monitoring and research needs.

The California HSRG's review can add significant value to current hatchery practices and the sustainability of existing natural anadromous fish populations only if the principles and recommendations are integrated into the appropriate aspects of hatchery and resource management.

To this end, the following recommendations for implementation are provided:

- Successful implementation of the California HSRG's recommendations will require regular programmatic performance reviews of hatchery programs. While Hatchery Coordination Teams should review programs annually, the California HSRG recommends periodic regional performance reviews of hatchery programs that assess program performance against resource management agencies' goals. These reviews could be undertaken at the regional level and scheduled so that hatchery programs in each region are publicly evaluated no less frequently than every 10 years. The reviews could accomplish necessary oversight for a number of processes, including funding, ESA regulation, independent scientific oversight, and public accountability. As part of the scientific oversight, each hatchery program should be rated on its conservation and harvest performance objectives and the degree to which California HSRG recommendations have been implemented.

- The California HSRG recognizes that Hatchery and Genetic Management Plans (HGMPs) coupled with timely and complete annual fish hatchery reports, are required for effective program management and evaluation. Responsible agencies and the NMFS should apply California HSRG recommendations in the preparation and review of HGMPs (Section 4.4, HGMPs). Resource management agencies should review these recommendations and make reasonable efforts to incorporate them into their management programs. Additionally, the California HSRG recommends that responsible agencies place a high priority on providing the resources for and commit to providing needed monitoring and evaluation information and data as a requirement and integral component of hatchery programs.

- The California HSRG encourages the regional hatchery funding entities (utilities, California Department of Water Resources, US Bureau of Reclamation, USFWS, and the State of California) to adopt the California HSRG's standards and guidelines as a basis for future funding and accountability of their respective hatchery mitigation or enhancement programs.

- Staff with specific highly technical expertise (e.g., fish health specialists) should be tasked with addressing specific highly technical problems in the California hatcheries. Recent consolidation of state classifications (e.g., all "Biologist" classifications subsumed under an "Environmental Scientist" designation) may make it difficult to identify staff with this specific technical expertise.

- Detailed, standardized protocols for monitoring of hatchery programs are currently lacking in the anadromous salmonid hatcheries of California. Section 4.4, Monitoring and Evaluation, lists attributes that need to be monitored and specifies approximate sample sizes that seem appropriate, but standardized protocols for many of these attributes remain to be developed. The same protocols should be adopted at all hatcheries so that data can be directly compared across facilities.

- We recommend that a similar review process be undertaken for the programs in the two state-operated hatcheries in coastal basins, Warm Springs (Russian River) and Mad River hatcheries. Since these programs were not formally part of the purview of the California HSRG, we are not familiar with all aspects of them, but we note that the two steelhead programs at these facilities share many similarities with the programs that were reviewed, and that many of the recommendations in this report are therefore relevant to the operation of these steelhead programs. We recommend that, in the interim period, resource management agencies implement the standards and guidelines specified in this report when they are clearly applicable to these programs.

- Finally, the publicly-accessible website housing the California HSRG's reports will require a permanent host and long-term funding. As of this publication date, the Pacific States Marine Fisheries Commission has indicated a willingness to permanently house and manage this data and information.

6.2 Areas of Needed Research

Deliberations and observations by the California HSRG, while developing recommendations for the 19 anadromous salmonid hatchery programs under review, led to the recognition of areas in particular need of scientific research to guide future management of these and other hatchery programs. In this section we outline these topics, recognizing that there are many more areas in need of information. These topics are all considered to be high priority and are not listed in order of importance.

Identify Populations and Delineate Population Boundaries with which Hatcheries Should be Integrated

For ESA listed stocks, populations and population boundaries have already been established and should be used to determine the appropriate populations and boundaries over which hatchery programs should be integrated. However, many salmonids in California are not ESA-listed and do not have explicitly defined populations and population boundaries. For example, explicit definitions of populations and population boundaries are not available for economically important fall run Chinook salmon in both the Klamath-Trinity basin and the Central Valley. Research is needed to delineate boundaries for all populations that may be affected by a given integrated hatchery program. This should include estimation of rates of straying and genetic migration of hatchery-origin fish released on-site into natural populations and the geographic distribution of such migration.

Determine Relative Reproductive Success of Hatchery- and Natural-origin Salmonids Spawning Naturally

Studies have shown loss of fitness for natural spawning and rearing in hatchery steelhead, coho salmon, and yearling outmigrant populations of Chinook salmon, and the magnitude of this loss appears to vary among species and populations. No such studies have been done for subyearling Chinook salmon released as "fingerlings", where the hatchery fish spend only a few months in the hatchery and their subsequent life history closely matches that of the natural-origin fish, and limited work has directly compared the relative reproductive success of hatchery and natural-origin salmonids in California, with the exception of the steelhead study conducted by USFWS in Battle Creek. Research is needed to evaluate relative reproductive success for hatchery and natural-origin fish spawning naturally and to determine the importance of genetics (domestication) versus developmental history in causing any differences in reproductive success. Since subyearling Chinook salmon released at the fingerling stage have less opportunity for domestication selection, the reduction in reproductive success for such fish may be less than for other hatchery salmonids in California. Therefore, studies of the relative reproductive success of subyearling hatchery Chinook salmon released as fingerlings and natural-origin fish should be a top priority.

Assess Ecological Effects of Hatchery-origin Fish on Naturally Spawning Populations

Research is needed to evaluate whether or where hatchery programs have negative effects on natural populations through competition (in river, estuary, or nearshore ocean), predation (direct or through attracting predator aggregations), behavior effects (e.g., premature emigration of natural-origin fish), or disease and other effects.

Development of Anadromy in Landlocked O. mykiss

While it is clear that life history variation in *O. mykiss* has a heritable component, little is known about the genetic basis of anadromy versus resident behavior, or perhaps more importantly, the potential for induction of genetic changes leading to heritable anadromous behavior in landlocked populations. In many cases, particularly in the Central Valley, resident *O. mykiss* above existing barriers to migration may be more genetically similar to ancestral anadromous *O. mykiss* than contemporary *O. mykiss* found below these barriers. The California HSRG recommends that appropriate agencies implement studies to address this issue.

Potential Uses and Limitations of Parentage Based Tagging

Parentage Based Tagging (PBT) has emerged as a new technology to enhance our understanding of the life histories of hatchery salmon and steelhead through the use of molecular genetic tags to follow the passage of genes over multiple generations. However, the prospects and limits of this technique are not yet well understood. For example, theoretical studies are needed to evaluate how PBT could be used to: 1) improve understanding of survival, maturation schedule and other attributes of hatchery steelhead on a brood year-specific basis, 2) determine the survival of reconditioned kelts, 3) determine the rates of inbreeding (and fitness consequences) for salmon and steelhead hatchery programs, and 4) improve understanding of trait variation in hatchery stocks. Studies are also needed to determine if Chinook salmon hatchery spawning and rearing practices, coastwide sampling programs in fisheries and on spawning grounds, and recovered tag decoding programs could be practically and cost-effectively implemented to completely fulfill the California HSRG Chinook salmon monitoring and evaluation standards.

Assess Long-term Changes in Productivity of Naturally Spawning Populations of Anadromous Salmonids Under Continuing Hatchery Supplementation

Even under situations where hatcheries are operated as integrated programs and PNI exceeds 0.5, as we recommend, the California HSRG remains concerned that the productivity of naturally spawning fish under continuing "supplementation" by hatchery fish may continuously decline in a manner that it not sustainable in the long term. It is therefore recommended that high priority be given to long-term studies of productivity (e.g., smolts produced per spawner) that would be carried out in a stream or streams where, ideally, habitat conditions for spawning and rearing are excellent, but where a substantial fraction (say greater than 20 percent) of spawners are of hatchery origin. Such a study would likely require use of modern genetic methods which could establish the identity of downstream migrants with respect to their parentage (NOxNO, NOxHO, HOxHO). It is important that the habitat conditions in selected streams are unlikely to experience dramatic changes so that any observed changes in productivity could be attributed to the long-term consequences of continuous infusion of hatchery spawners rather than changes in habitat conditions that might otherwise cause productivity to change through time.

Investigate Causes of Decline in Returns of Anadromous Fish in Steelhead Programs

Most of the steelhead programs in California have generally low smolt to adult return ratios. Adult returns to two steelhead hatchery programs (Iron Gate and Mokelumne River hatcheries) have been so low in recent years that it has led to functional failure of these programs. The specific causes of these declines are not well understood. However, several fish culture issues may contribute to the low ratios; IHOT (1995) guidelines recommend release times for juvenile steelhead that are much later than currently practiced at most California hatcheries. Early release may lead to residualism and cause generally low survival rates of released fish. Research should be initiated to elucidate the causes of low adult returns and inform changes in hatchery protocols and procedures to avoid future failure to meet program goals.

Investigate Hatchery Domestication Selection and Development of Mitigation Strategies

The loss in fitness of both hatchery-origin fish and the natural populations with which they are integrated is perhaps the most important negative effect of salmonid hatchery programs. The primary mechanism for such loss of fitness is believed to be domestication selection, which is a general term to describe a variety of selective processes due to hatchery operations or ancestry that typically cause loss of fitness of hatchery-origin fish in natural spawning areas. However, the exact mechanisms that cause this domestication and loss of fitness are poorly understood. Careful research and monitoring should be undertaken to understand domestication selection and propose mitigation measures.

Develop Adaptive Framework for Habitat Carrying Capacity and Production Goals

Diminished carrying capacity of freshwater or ocean habitats can lead to adverse effects on natural populations and/or reduction in societal benefits. Research is needed to evaluate the ability of available freshwater and saltwater habitat to support salmonids at different life history stages and use this information to assist in setting hatchery production goals to avoid adverse effects. Ideally, such a framework would incorporate information on inter-annual and decadal scale variability to adaptively manage hatchery program operations.

Determine the Effects of Hatchery Spawning and Mating Protocols on Age Distribution

The use of age-based selection of fish as broodstock and the subsequent selection of mating partners is likely to have substantial effects on the age distribution of maturing adult salmon and steelhead. For example, two-year-old male salmon (jacks) typically have lower reproductive success than older males in natural spawning areas (although this has not been demonstrated in California), but the magnitude of the difference is not clear. Hatchery spawning protocols most likely fail to replicate the relative reproductive success of different age classes. Age of maturity in salmonids has a heritable component and over- or under-representation of different age classes in hatchery production may cause a selective shift in the age distribution of both the hatchery stock and the natural population with which it is integrated. A mating strategy has been suggested for Chinook salmon (Section 4.1.1) whereby no female is ever mated with a smaller male (except when the male is a jack). The California HSRG is intrigued by this concept but did not fully endorse it, instead preferring to experimentally evaluate the protocol in a selected stock (late-fall Chinook salmon at Coleman NFH). Research is needed on the effects of using different protocols for incorporation of two year old fish into broodstock on the age distributions of the associated hatchery and natural populations, as well as on the effects of using size-based protocols to choose mating partners, and how both of these interact with known effects of hatchery growth rates and harvest on age distribution.

7. Literature Cited

Anderson, E.C. and J.C. Garza. 2006. The power of single-nucleotide polymorphisms for large-scale parentage inference. Genetics 172:2567 – 2582.

Araki, H., B.A. Berejikian, M.J. Ford, and M.S. Blouin. 2008. Fitness of hatchery-reared salmonids in the wild. Evolutionary Applications 1: 342-355.

Atkinson, S.D., and J.L. Bartholomew. 2010. Spatial, temporal and host factors structure the *Ceratomyxa shasta* (Myxozoa) population in the Klamath River basin. Infection, Genetics and Evolution Volume 10(7): 1019-1026.

Banks, M.A., V.K. Rashbrook, M.J. Calavetta, C.A. Dean, and D. Hedgecock. 2000. Analysis of microsatellite DNA resolves genetic structure and diversity of Chinook salmon (*Oncorhynchus tshawytscha*) in California's Central Valley. Canadian Journal of Fisheries and Aquatic Sciences 57:915-927.

Beamish, R.J., and D.R. Bouillon. 1993. Pacific salmon production trends in relation to climate. Canadian Journal of Fisheries and Aquatic Sciences 50(5): 1002-1016.

Beauchamp, D.A., A.D. Cross, J.L. Armstrong, K.W. Myers, J.H. Moss, J.L. Boldt, and L.J. Haldorson. 2007. Bioenergetic responses by Pacific salmon to climate and ecosystem variation. N. Pac. Anadr. Fish Comm. Bull. 4: 257–269.

Campton, D. 2004. Sperm competition in salmon hatcheries: The need to institutionalize genetically benign spawning protocols. Transactions of the American Fisheries Society 133:1277-1289.

CDFG (California Department of Fish and Game). 2004. Recovery strategy for California coho. Report to the Fish and Game Commission. 594 pp.

CDFG (California Department of Fish and Game). 2011. Hatchery and genetic management plan for Iron Gate Hatchery. Prepared by the California Department of Fish and Game (Northern Region) for submittal to NOAA Fisheries. February 2011.

CDFG/NMFS (California Department of Fish and Game/National Marine Fisheries Service Southwest Region Joint Hatchery Review Committee). 2001. Final report on anadromous salmonid fish hatcheries in California. December 2001.

Chapman, D., C. Carlson, D. Weitkamp, G. Matthews, J. Stevenson, and M. Miller. 1997. Homing in sockeye and Chinook salmon transported around part of their smolt migration route in the Columbia River. North American Journal of Fisheries Management 17:101-113.

Chilcote, M.W., K.W. Goodson, and M.R. Falcy. 2011. Reduced recruitment performance in natural populations of anadromous salmonids associated with hatchery-reared fish. Can. J. Fish. Aquat. Sci. 68: 511-522.

Clark, G. H. 1929. Division of Fish and Game of California. Fish Bulletin No. 17. Sacramento-San Joaquin salmon (*Oncorhynchus tshawytscha*) fishery of California. 73 pp., 32 figs.

Cuenco, M.S., T.W.H. Backman and P.R. Munday. 1993. The use of supplementation to aid natural stock restoration. Pages 269-293 *in* J. G. Cloud and G.H. Thorgard (eds), Genetic conservation of salmonid fishes. Plenum Publishing Co., New York, New York.

Duffy, E.J. 2009. Factors during early marine life that affect smolt-to-adult survival of ocean-type Puget Sound Chinook salmon (*Oncorhynchus tshawytscha*). Ph.D. dissertation, University of Washington, Seattle.

Fisher, F.W. 1994. Past and present status of Central Valley Chinook salmon. Conservation Biology Volume 8: 870-873.

Ford, M.J. 2002. Selection in captivity during supportive breeding may reduce fitness in the wild. Conservation Biology. 16: 815-825.

Frankel, O.H., and M.E. Soule. 1981. Conservation and evolution. Cambridge University Press, Cambridge, UK.

Frederikson, Kamine and Associates. 1980. Proposed Trinity River basin fish and wildlife management program. Prepared for USDOI Water and Power Resources Service. Contract # 8-07-02-V0035.

Garza, J.C. and E. Anderson. 2007. Large scale parentage inference as an alternative to coded wire-tags for salmon fishery management. *In*: PSC genetic stock identification workshop (May and September 2007): Logistics workgroup final report and recommendations. p.48-55. Pacific Salmon Commission, British Columbia, Canada.

Garza, J.C. and D.E. Pearse 2008. Population genetic structure of *Oncorhynchus mykiss* in the California Central Valley. Final report for the California Department of Fish and Game. Contract No. PO485303 with University of California, Santa Cruz and NOAA Southwest Fisheries Science Center. 54 p.

Hallock, R.J., and R.R. Reisenbichler. 1979. Evaluation of returns from Chinook salmon, *Oncorhynchus tshawytscha*, released as fingerlings at Coleman and Nimbus hatcheries and in the Sacramento River estuary. California Dept. of Fish and Game. Anadromous Fisheries Branch office report. 10 p.

Hamilton J.B., G.L. Curtis, S.M. Snedaker, and D.K. White. 2005. Distribution of anadromous fishes in the upper Klamath River watershed prior to hydropower dams—A synthesis of the historical evidence. Fisheries Vol. 30, No. 4.

Hankin, D. G. 1990. Effects of month of release of hatchery- reared Chinook salmon on size at age, maturation schedule and fishery contribution. Oregon Dept. of Fish and Wildlife. Information Report 90-4. 37 pp.

Hankin, D., and J.E. Logan. 2010. A preliminary analysis of Chinook salmon coded-wire tag recovery data from Iron Gate, Trinity River and Cole Rivers hatcheries, brood years 1978-2004. Contract report prepared for Hoopa Tribal Council, Bureau of Reclamation. 65 pp.

Hankin, D.G., J.H. Clark, R.B. Deriso, J.C. Garza, G.S. Morishima, B.F. Riddell, and C. Schwarz. 2005. Report of the expert panel on the future of the coded wire tag recovery program for Pacific salmon. Pacific Salmon Commission Technical Report No. 18. 230 pp.

Hankin, D.G., J.W. Nicholas, and T.W. Downey. 1993. Evidence for inheritance of age of maturity in Chinook salmon, *Oncorhynchus tshawytscha*. Can. J. Fish. Aquat. Sci. 50: 347-358.

Hankin, D.G., J. Fitzgibbons, and Y. Chen. 2009. Unnatural random mating policies select for younger age at maturity in hatchery Chinook salmon populations. Can. J. Fish. Aquat. Sci. 66: 1505-1521.

Harada, Y., M. Yokota, and M. Iizuka. 1998. Genetic risk of domestication in artificial fish stocking and its possible reduction. Research Population Ecology 40(3):311-324.

Hedrick, P.W. and S.T. Kalinowski. 2000. Inbreeding depression in conservation biology. Annual Review of Ecology and Systematics 31:139-162.

Horner, R.W., and R. L. Eshenrodr [EDS]. 1993. Protocol to minimize the risk of introducing emergency disease agents with importation of salmonid fishes from enzootic areas. Great Lakes Fish. Comm. Spec. Pub 93-1: 39-54.

HSRG (Hatchery Scientific Review Group). 2004. Assessing the potential for predation on wild salmonid fry by hatchery-reared salmonids in Washington. Appendix B. p. B-51 – B-67 *in* Hatchery reform: Principles and recommendations of the HSRG. Long Live the Kings, 1305 Fourth Avenue, Suite 810, Seattle, WA 98101 (available from www.hatcheryreform.org).

HSRG (Hatchery Scientific Review Group). 2009. Columbia River hatchery reform system-wide report. Bonneville Power Administration and NOAA Fisheries. February 2009 http://hatcheryreform.us/hrp/uploads/C1EKAOMVHURK/01_HSRG%20Final%20Systemwide%20Report.pdf

IHOT (Integrated Hatchery Operations Team) 1995. Policies and procedures for Columbia Basin anadromous salmonid hatcheries. Annual Report, 1994. Report to Bonneville Power Administration, Contract No. 1992B160629; BPA Report DOE/BP-60629. http://www.hatcheryreform.us/hrp/uploads/VAGREAJSVIM5/IHOT%20STANDARDS.pdf.

Johnson, S.L., M.F. Solazzi, and T.E. Nickelson. 1990. Effects on survival and homing of trucking hatchery yearling coho salmon to release sites. North American Journal of Fisheries Management Volume 10(4): 427-433.

Keeley, E.R., and J.W.A. Grant. 2001. Prey size of salmonid fishes in streams, lakes, and oceans. Can. J. Fish. Aquat. Sci. 58: 1122-1132.

Kinziger, A.P., E. J. Loudenslager, D.G. Hankin, E.C. Anderson, and J.C. Garza. 2008. Hybridization between spring-run and fall-run Chinook salmon returning to Trinity River, California. N. Am. J. Fish. Manage. 28: 1426-1438.

Kinziger, A.P., M. Hellmair, D.G. Hankin, and J.C. Garza. *in prep*. Retention of genetic structure in Klamath Basin Chinook salmon (*Oncorhynchus tshawytscha*) despite extensive within-basin transplantation.

Kostow, K. 2009. Factors that contribute to the ecological risks of salmon and steelhead hatchery programs and some mitigating strategies. Rev. Fish. Biol. Fisheries. 19:9-31.

Lackey, Robert T. 2000. Restoring wild salmon to the Pacific Northwest: chasing an illusion? *In*: What We Don't Know about Pacific Northwest Fish Runs - An Inquiry into Decision-Making. Patricia Koss and Mike Katz, Editors, Portland State University, Portland, Oregon, pp. 91 - 143.

Lande, R. 1995. Mutation and conservation. Conservation Biology 9(4):782-791.

Lawson, P. and D. Sampson. 1996. Gear-related mortality in selective fisheries for ocean salmon. North American Journal of Fisheries Management 16: 512-520.

Leitritz, E. and E. Lewis 1976. Trout and salmon culture (hatchery methods). California Department of Fish and Game, Fish Bulletin 164.

Lichatowich, J.A. and J.D. McIntyre. 1987. Use of hatcheries in the management of Pacific anadromous salmonids. American Fisheries Society Symposium 1:131-136.

Liermann, M.C., R. Sharma, and C.K. Parken. 2010. Using accessible watershed size to predict management parameters for Chinook salmon, *Oncorhynchus tshawytscha*, populations with little or no spawner-recruit data: a Bayesian hierarchical modeling approach. Fisheries Management and Ecology 17(1): 40–51.

Limborg,M.T., S.M. Blankenship, S.F. Young, F.M. Utter, L.W Seeb, M.H.H Hansen, and J.E. Seeb. 2012. Signatures of natural selection among lineages and habitats in *Oncorhynchus mykiss*. Ecology and Evolution 2:1-18.

Lindley, S.T., R. Schick, B.P. May, J.J. Anderson, S. Greene, C. Hanson, A. Low, D. McEwan, R.B. MacFarlane, C. Swanson, and J.G. Williams. 2004. Population structure of threatened and endangered Chinook salmon ESUs in California's Central Valley basin. NOAA Technical Memorandum NMFS-SWFSC-360.

Lindley, S.T., C.B. Grimes, M.S. Mohr, W. Peterson, J. Stein, J.T. Anderson, L.W. Botsford, , D.L. Bottom, C.A. Busack, T.K. Collier, J. Ferguson, J.C. Garza, A.M. Grover, D.G. Hankin, R.G. Kope, P.W. Lawson, A. Low, R.B. MacFarlane, K. Moore, M. Palmer-Zwahlen, F.B. Schwing, J. Smith, C. Tracy, R. Webb, B.K. Wells, and T.H. Williams. 2009. What caused the Sacramento River fall Chinook stock collapse? Pre-publication report to the Pacific Fishery Management Council. March 18, 2009.

McEwan, D.R. 2001. Central Valley Steelhead. *in* Contributions to the biology of Central Valley salmonids, R. L. Brown, editor. California Department of Fish and Game Fish Bulletin 179. Pg 1-44.

Miller,M.R., J. P. Brunelli, P.A. Wheeler, S. Liu, C.E Rexroad III, Y. Palti, C.Q. Doe, G. H Thorgaard. 2012. A conserved haplotype controls parallel adaptation in geographically distant salmonid populations. Molecular Ecology 21:237-249.

Mobrand, L. E., J. A. Lichatowich, L. C. Lestelle, and T. S. Vogel. 1997. An approach to describing ecosystem performance "through the eyes of salmon". Canadian Journal of Fisheries and Aquatic Sciences 54:2964-2973.

Moffett, J.W., and S.H. Smith. 1950. Biological investigations of the fishery resources of Trinity River, California. U.S. Fish and Wildlife Service. Spec. Sci. Rep. Fish. 12, 71 p.

Moyle, P. B. 2002. Inland Fishes of California, Revised Edition. University of California Press, Berkeley.

Neff, B.D., S.R. Garner, and T.E. Pitcher. 2011. Conservation and enhancement of wild fish. Can. J. Fish. Aquat. Sci. 68:1139-1154.

Nickelson, T. 2003. The influence of hatchery coho salmon (*Oncorhynchus kisutch*) on the productivity of wild coho salmon populations in Oregon coastal basins. Can. J. Fish. Aquat. Sci. 60(9): 1050-1056.

Nielson, J.L., S.A. Pavey, T. Wiacek, and I. Williams. 2005. Genetics of Central Valley *O. mykiss* populations: drainage and watershed scale analyses. San Francisco Estuary and Watershed Science. 3(2).

NMFS (National Marine Fisheries Service). 1996. Factors for decline: A supplement to the notice of determination for west coast steelhead under the Endangered Species Act. NMFS Protected Species Branch, Portland, OR, 82 p. + app.

NMFS (National Marine Fisheries Service). 2009. Public draft recovery plan for the evolutionarily significant units of Sacramento River winter-run Chinook salmon and Central Valley spring-run Chinook salmon and the distinct population segment of Central Valley steelhead. Sacramento Protected Resources Division. October 2009.

Parravano vs. Babbit. 1995. 70 F.3d 539, 544 (9th Circuit)

Pearse, D.E., C.J. Donohoe, and J.C. Garza. 2007. Population genetics of steelhead (*Oncorhynchus mykiss*) in the Klamath River. Environmental Biology of Fishes 80(4):377-387.

Quinn, T.P. 1993. A review of homing and straying of wild and hatchery-produced salmon. Fisheries Research 18(1-2): 29-44.

Reclamation (U.S. Bureau of Reclamation). 1956. Contract between the United States and the State of California for the operation of Nimbus Fish Hatchery. Central Valley Project. 3 pages.

Reisenbichler, R.R. and McIntyre. 1986. Requirements for integrating natural and artificial production of anadromous salmonids in the Pacific Northwest. *In* R.H. Stroud [ed.] Fish culture in fisheries management. American Fisheries Society. Bethesda, MD. p. 365-374.

Reisenbichler, R.R., F.M. Utter, and C.C. Krueger. 2003. Genetic concepts and uncertainties in restoring fish populations and species. Pages 149-183 in R.C. Wissmar and P.A. Bisson [editors]. Strategies for restoring river ecosystems – sources of variability and uncertainty in natural and managed systems. American Fisheries Society, Bethesda, MD.

Reynolds, F.L., T.J. Mills, R. Benthin and A. Low. 1993. Restoring Central Valley streams: A plan for action. California Department of Fish and Game, Sacramento, CA. 129pp.

Scheuerell, M.D., R. Hilborn, M.H. Ruckelshaus, K.K. Bartz, K.M. Lagueux, A.D. Hass, K. Rawson. 2006. The Shiraz model: a tool for incorporating anthropogenic effects and fish-habitat relationships in conservation planning. Can. J. Fish. Aquat. Sci. 63:1596-1607.

Senn, H., J. Mack, and L. Rothfus. 1984. Compendium of low-cost Pacific salmon and steelhead trout production facilities and practices in the Pacific Northwest. Fish Management Consultants.

Stocking R.J., and Bartholomew J.L. 2007. Distribution and habitat characteristics on *Manayunkia speciosa* and infection prevalence with the parasite *Ceratomyxa shasta* in the Klamath River, Oregon-California. J. Parasitology 93(1):78-88.

USFWS (US Fish and Wildlife Service). 1983. Trinity River basin fish and wildlife management program. Final Environmental Impact Report.

USFWS (US Fish and Wildlife Service). 1995. Working paper on restoration needs: Habitat restoration actions to double natural production of anadromous fish in the Central Valley of California. Volume 2. May 9, 1995. Anadromous Fish Restoration Program Core Group. Stockton, CA.

USFWS (US Fish and Wildlife Service). 2004. Aquatic animal health policy (713 FW 2). http://www.fws.gov/policy/e1713fw2.html

USFWS (US Fish and Wildlife Service). 2011. Biological assessment of artificial propagation at Coleman National Fish Hatchery and Livingston Stone National Fish Hatchery: Program description and incidental take of Chinook salmon and steelhead. Coleman National Fish Hatchery Complex, Anderson, CA. July 2011.

USFWS and CDFG (US Fish and Wildlife Service and California Department of Fish and Game). 1956. A plan for the protection and maintenance of fish and wildlife resources affected by the Trinity River Division, Central Valley Project. November 1956.

Weber, E.D. and K.D. Fausch. 2003. Interactions between hatchery and wild salmonids in streams: differences in biology and evidence for competition. Canadian Journal of Fisheries and Aquatic Sciences. 60(8):1018-1036.

Weber, E.D., and K.D. Fausch. 2005. Competition between hatchery-reared and wild juvenile Chinook salmon in enclosures in the Sacramento River, California. Trans. Am. Fish. Soc. 134: 44-58.

Wedemeyer, Gary A. [Ed] 2001. Fish hatchery management, second edition. American Fisheries Society, Bethesda MD, 733 pp.

Williams, J.C. 2006. Central Valley salmon: a perspective on Chinook and steelhead in the Central Valley of California. San Francisco Estuary and Watershed Science. 4(3). 416 p.

Williams, T.H., E.P. Bjorkstedt, W.G. Duffy, D. Hillemeier, G. Kautsky, T.E. Lisle, M. McCain, M. Rode, R.G. Szerlong, R.S. Schick, M.N. Goslin, and A. Agrawal. 2006. Historical population structure of coho salmon in the Southern Oregon/Northern California coasts evolutionarily significant unit. NOAA Technical Memorandum NMFS-SWFSC-390. 71 p.

Williamson, K. and B. May. 2005. Homogenization of fall-run Chinook salmon gene pools in the Central Valley of California. North American Journal of Fisheries Management 25: 993-1009.

Williamson, K. E., A. R. Murdoch, T. N. Pearsons, E. J. Ward, and M. J. Ford. 2010. Factors influencing the relative fitness of hatchery and wild spring Chinook salmon (*Oncorhynchus tshawytscha*) in the Wenatchee River, Washington, USA. Can. J. Fish Aquat. Sci. 67: 1840-1851.

Winton, J.R. 2001. Fish health management. Pages 569-639 *in* G. Wedemeyer (Editor) Fish hatchery management, second edition. American Fisheries Society, Bethesda MD.

Yoshiyama, R.M., F.W. Fisher, and P.B. Moyle. 1998. Historical abundance and decline of Chinook salmon in the Central Valley region in California. North American Journal of Fisheries Management 18: 487–521.

Yoshiyama, Ronald M., Eric R. Gerstung, Frank W. Fisher, and Peter B. Moyle. 2000. Chinook salmon in the California Central Valley: an assessment. Fisheries. 25(2): 6-20.

Yoshiyama, R. M., E. R. Gerstung, F. W. Fisher, and P. B. Moyle. 2001. Historical and present distribution of Chinook salmon in the Central Valley drainage of California. Pages 71-176 *in* Contributions to the biology of Central Valley salmonids, R. L. Brown, editor. California Department of Fish and Game, Fish Bulletin 179.

California Hatchery Review Report

California Hatchery Scientific Review Group

June 2012

Prepared for:

Cover photos by Mary Edwards Photography, Joseph, Oregon

Agenda Item E.1.b
Supplemental CHSRG PPT
September 2012

California Hatchery Review Project

Recovering, Conserving & Sustaining California's Salmon & Steelhead Fisheries

Who called for California hatcheries to be reviewed?

- In 2010, Congress provided the U.S. Fish and Wildlife Service funds to review California's salmon and steelhead hatcheries
- This review followed similar reviews completed by other agencies in Puget Sound and coastal Washington (2004), and in the Columbia River Basin (2005).

Who conducted the California hatchery review?

- The hatchery review was completed by the California Hatchery Scientific Review Group (CA HSRG)
- California HSRG was composed of 11 members, six of whom were affiliated with agencies in California and five of whom were previously affiliated with resource agencies or who are university faculty. They were assisted by independent contractors that assembled data and facilitated California HSRG meetings and field trips

Members of the California Hatchery Scientific Review Group

Name	Organization
Agency Affiliated Members	
Dr. John Carlos Garza	NOAA Fisheries
Scott Hamelberg	US Fish and Wildlife Service
Michael Lacy	California Department of Fish and Game
Michael Mohr	NOAA Fisheries
Kevin Niemela	US Fish and Wildlife Service
Kimberly True	US Fish and Wildlife Service
Unaffiliated Members	
Dr. David Hankin	Humboldt State University
Dennis Lee	Independent Consultant
Dr. Bernie May	UC Davis
George Nandor	Pacific States Marine Fisheries Commission
Dr. Reg Reisenbichler	Independent Consultant

What was the purpose of the California Hatchery Review?

Make Recommendations to:

- Improve hatchery efficiency
- Support commercial, tribal, and recreational fisheries
- Reduce the impact of hatchery operations on natural populations

Which hatcheries did the CA HSRG review?

- The CA HSRG reviewed the following anadromous fish hatchery programs located in the Klamath River Basin and the Central Valley:
  - Iron Gate Hatchery: Coho, Fall Chinook and Steelhead (Klamath River)
  - Trinity River Hatchery: Coho, Fall Chinook, Spring Chinook and Steelhead (Trinity River)
  - Nimbus Hatchery: Fall Chinook and Steelhead (American River)
  - Mokelumne Hatchery: Fall Chinook and Steelhead (Mokelumne River)
  - Merced Hatchery: Fall Chinook (Merced River)
  - Feather River Hatchery: Fall Chinook, Spring Chinook and Steelhead (Feather River)
  - Coleman National Fish Hatchery: Fall Chinook, Late-fall Chinook and Steelhead (Battle Creek)
  - Livingston Stone National Fish Hatchery Winter Chinook (Sacramento River)

What is in the Final Report?

Purpose and Scope

Context

Issues of Greatest Importance

Statewide Recommendations and Standards

Program Recommendations

Implementation and Research

Context

Two large river systems – KT and CV

Both have listed and non-listed stocks

Both have degraded habitat and large dams

Both have large mitigation hatcheries

Both have commercial and recreational fisheries

KT has terminal tribal fisheries, CV does not

Context

Literal view of segregation re: programs

70 percent brood harvest rate may be too high for naturally spawning fish in CV

No mark-selective salmon fisheries in CA

What major hatchery problems or issues were identified by the CA HSRG?

- The CA HSRG identified 14 major problems/issues:
  1. **Serious loss and degradation of habitat limits natural production of salmon and steelhead in California.**
  2. Hatchery program goals have been consistently expressed in terms of juvenile production rather than adult production.
  3. Program purposes have not been clearly defined.
  4. Hatchery monitoring and evaluation programs and Hatchery Coordination Teams are needed.
  5. Program size has been set independent of any consideration of potential impacts of hatchery fish on affected natural populations.
  6. Off-site releases promote unacceptable levels of straying.
  7. Marking/tagging programs are needed for real-time identification of all hatchery-origin Chinook salmon returning to hatchery facilities.

What major hatchery problems or issues were identified by the CA HSRG?

8. Standards for fish culture, fish health management and associated reporting are inadequate and need to be improved.
9. Populations and population boundaries have not been established for non-listed species and are needed for effective integrated hatchery programs.
10. **Harvest management of Sacramento River Fall Chinook should account for the productivity of naturally-spawning adults.**
11. Several steelhead programs have seriously underperformed.
12. Adults returning from "yearling" releases of hatchery fall Chinook salmon should be excluded from broodstock.
13. True "1:1 matings" and associated incubation protocols need to be adopted.
14. Effective methods are needed to ensure maintenance of distinct runs of Chinook salmon reared at the same facility.

Statewide Recommendations
standards and guidelines

Broodstock Management

Program Size and Release

Incubation Rearing and Fish Health

Monitoring and Evaluation

Effects on Habitats and Organisms

Hatchery Program Recommendations

Information gathered through site visits and Hatchery Program Viewer (HPV)

120 Recommendations for 19 Programs

Implementation

- Regular Performance Reviews by Hatchery Coordination Teams – both Programmatic and Regional every 10 yrs
- Complete HGMPs
- Staff with Expertise should address Technical problems
- Detailed Standardized Monitoring

Implementation

- Review Coastal Hatcheries
- Find Permanent Host for Publicly Accessible Website

Research

Population Identification and Delineation

Relative Reproductive Success

Effects of Hatchery Fish on Natural Populations

Development of Anadromy in *O. mykiss*

Parentage Based Tagging

Research

Long-term Changes to Natural Population Productivity

Decline in Steelhead Program Anadromy

Domestication of Natural and Hatchery Pops

Carrying Capacity and Production Goals

Effects of Mating Protocols on Age Distribution

www.CAhatcheryreview.com

HABITAT COMMITTEE REPORT ON CALIFORNIA HATCHERY REVIEW REPORT

The Habitat Committee (HC) received a presentation from Jim Smith, Project Leader from the US Fish and Wildlife Service Red Bluff Office, regarding the recently released Scientific Review of California's Salmon and Steelhead Hatcheries.

The Hatchery Review Group (HSRG) report identifies 14 issues of primary importance and makes specific recommendations for each hatchery reviewed. The HC notes that a primary issue identified by the HSRG was that substantial amount of historic habitat has been lost in both the Klamath/Trinity and Central Valley systems due to the construction of large, impassable dams. Furthermore, downstream water management and other land-use practices have reduced salmonid productivity in both of these systems. The report notes the importance of protecting the remaining available habitats and restoring former habitats if the abundance of natural-origin fish is expected to increase.

Many of the HSRG's recommendations focused on minimizing negative interactions between hatchery and natural populations. The HSRG identified 14 important issues that overlap all hatchery programs. Those that are habitat-specific are listed below.

- Serious loss and degradation of habitat limits natural production of salmon and steelhead in California.
- Program size has been set independent of any consideration of potential impacts of hatchery fish on affected natural populations.
- Off-site releases promote unacceptable levels of straying among populations.
- Marking/tagging programs are needed for real-time identification of all hatchery-origin Chinook salmon returning to hatchery facilities. 100 percent tagging allows scientists to distinguish fish habitat relationships for hatchery and naturally-produced fish.
- Populations and population boundaries have not been established for non-listed species, and are needed for effective development of integrated hatchery programs.

The HC offers the following observations and comments:

- In response to the unprecedented collapse of Central Valley fall Chinook from 2006-2009, the Council requested that National Marine Fisheries Service (April 4, 2008 letter) conduct an investigation into the factors that caused the collapse of the 2004 and 2005 broods. The resultant investigation (Lindley et al, 2009) concluded that, among other factors, hatchery operations in the Central Valley have led to a genetically homogenous population of natural and hatchery fish with little life history diversity to buffer against environmental variation. The implementation of many of the recommendations in the HSRG report would help restore life history diversity of fish populations in the Central Valley, as well within the Klamath Basin.
- Strategies used to enhance smolt-to-adult return ratios of hatchery fish, such as trucking and net pen transportation of the smolts to the estuary, can have a negative impact on

essential fish habitat (EFH). Smolt transport programs have been shown to increase stray rates for returning adults, thereby increasing competition for habitat and affecting the genetic structure of naturally-produced salmonids.

- Transportation strategies that remove fish from their habitats can divert attention from habitat deficiencies and become a disincentive to correct degraded habitat. A strategy that leaves some releases in the river spreads the risk, has the potential to reduce stray rates, and keeps an important focus on habitat.
- There is a nexus between hatchery program protocols and required EFH consultation where hatchery practices adversely affect EFH. Modifications to hatchery practices may trigger EFH consultation for which the Council may be required to comment, so we recommend the Council stay abreast of new hatchery practices.
- To facilitate implementation of the recommendations included in the report, the HC recommends the Council support the formation of Hatchery Coordination Teams and the participation of responsible agencies in those groups.
- Overall, the HC agrees with recommendations presented in the HSRG report, as they would reduce negative interactions between hatchery and natural fish populations.

PFMC
09/14/12

Agenda Item E.1.b
Supplemental SAS Report
September 2012

SALMON ADVISORY SUBPANEL REPORT ON CALIFORNIA HATCHERY REVIEW REPORT

The Salmon Advisory Subpanel (SAS) is concerned with the recommendation to discontinue the off-site releases of juvenile Chinook salmon. The SAS is interested in knowing what the stray rate of natural fish is today in the Central Valley system.

The SAS recommends the fish production for mitigation achieve the levels in the mitigation agreements, but at a minimum, maintain the current level in the Central Valley.

The SAS encourages state, Federal, and tribal co-managers to develop a management structure that evaluates the recommendations recommended in the California Hatchery Scientific Review Group (HRSG) final report in order to determine appropriate implementation measures. More importantly, the SAS suggests that a long-term governance structure be developed to evaluate future management actions at California hatcheries, which should include public involvement through their respective governments. Further, the SAS request that the review and potential implementation of the HSRG final report recommendations be evaluated based upon scientific merit prior to determining the cost of implementation. Implementation cost could be integrated into hatcheries' annual operational budgets. Agencies and non-governmental organizations responsible for mitigation funding to operate California hatcheries should develop appropriate mechanisms that require beneficiaries of water exports (for example, agricultural and hydropower interest) to pay an expected increase in hatchery operation costs.

PFMC
09/14/12

SALMON TECHNICAL TEAM REPORT ON CALIFORNIA HATCHERY REVIEW REPORT

The California Hatchery Scientific Review Group conducted a very careful analysis and review of most California anadromous hatchery programs. Given the diverse criteria addressed by the California Hatchery Scientific Review Group for hatchery operations, the Salmon Technical Team agrees with the recommendations stated in the report.

PFMC
09/14/12

From: **Don Heichel** <kiheidon@sbcglobal.net>
Date: Fri, Aug 31, 2012 at 12:58 PM
Subject: Fw: PFMC: Salmon Model Evaluation Workgroup to Hold Work Session
To: mike.burner@noaa.gov

Hi Mike,

We spoke on the phone yesterday...

Reducing hatchery stocks to preserve purity of E.S.U.'s in California when the NMFS admits 70-90% of all original California Salmon spawning habitat is gone is making me wonder who is in charge.

Hatcheries stated, original purpose is to replace Salmon lost to us by the damning of Rivers & other irrigation projects, no way can those numbers be maintained with only 10-30% of habitat existing.

What purity? New Zealand Chinooks were introduced to the Sacramento River in the 1920's & hatcheries have been making up for lost habitat since the 1880's Hydraulic Mining silted their spawning grounds with minimal records. We have no idea what their original DNA was after all this fiddling for 130 years.

You regulators allowed the Winter Run Sacramento River Chinooks' population to fall to less than 200 fish in 1992, some replacement job you did, NOT!

Reducing Hatchery Salmon is backward; we need their numbers now!

Rather than reducing populations, up the barge system funding to take the Smolts through the Delta safely while maintaining their origin water imprint, clearly the current trucking of the Smolts around the Delta is the reason for Salmon numbers rebound (need the YouTube link?).

Ask Govn'r Moonbeam what will happen when the scented, imprint water is routed through his twin (Peripheral canal) tunnels & NEVER reaches the Delta.

Create a long term plan to replace all dams with off-river water storage & flood control; restore confiscated Salmon spawning habitat with wild rivers.

Only then may you reduce Hatchery Salmon Stocks, they are meeting their purpose NOW to replace what has been LOST (euphemism for Salmon habitat confiscated by Gov't water projects!)!!!

Don Heichel
Soquel, Ca.

2012 SALMON METHODOLOGY REVIEW

Each year, the Scientific and Statistical Committee (SSC) and Salmon technical Team (STT) complete a methodology review to help assure new or significantly modified methodologies employed to estimate impacts of the Council's salmon management use the best available science. This review is preparatory to the Council's adoption, at the November meeting, of all proposed changes to be implemented in the coming season, or, in certain limited cases, providing directions for handling any unresolved methodology problems prior to the formulation of salmon management options the following March. Because there is insufficient time to review new or modified methods at the March meeting, the Council may reject their use if they have not been approved the preceding November.

The Methodology Review is also used as a forum to review updated stock conservation objective proposals, which allows the Council to approve updates at the November meeting and allows adequate time for planning fisheries in the subsequent year. The Salmon Fishery Management Plan (FMP) allows conservation objectives to be updated without a formal FMP amendment, provided a comprehensive technical review of the best scientific information available provides conclusive evidence that, in the view of the STT, SSC, and the Council, justifies a modification.

At its April 2012 meeting, the Council adopted the following priority candidate items that the SSC and STT may consider for the 2012 Salmon Methodology Review. Source entities to deliver detailed reports for SSC review are included in brackets with each candidate item.

- Implementation and assessment of proposed bias-corrections methods for mark-selective fisheries into the Coho Fishery Regulation Assessment Model (FRAM). [Model Evaluation Workgroup; (MEW)]
- Review of modifications to Chinook FRAM size limit algorithms implemented to allow evaluation of changes to size-limits. [MEW]
- Review of alternative forecast methodologies for the Sacramento Fall Chinook index. [STT]
- A multi-year review and evaluation of preseason forecasts and postseason estimates for mark-selective coho fisheries both north and south of Cape Falcon. [STT]
- Preliminary assessment of the feasibility of abundance-based management for California Coastal Chinook. [NMFS Southwest Region]
- A user's manual for the Visual Studio version of FRAM. [MEW]
- Investigate Chinook FRAM's sensitivity to age composition forecasts. [MEW]
- Evaluate the feasibility of incorporating bias-correction methods for mark-selective fisheries into Chinook FRAM. [MEW]
- Develop recommendations on management methodologies for Sacramento River Winter Chinook that better achieve Council's objective, particularly at low abundance. [STT]

These subjects and the responsible agencies were identified in a reminder email dated June 19, 2012, which requested agencies prepare to speak to the status of the subjects in terms of completeness and priority (Agenda Item E.2.a, Attachment 1).

Other review topics or conservation objective updates may be considered for review at this meeting, provided responsible agencies or individuals are prepared to justify their inclusion. All materials for review are to be received at the Council office at least two weeks prior to the review meeting of the SSC Salmon Subcommittee and STT, which is scheduled for October 10-11, 2012.

Council Action:

1. **Determine if topics identified for review will be ready for the joint SSC Salmon Subcommittee - STT meeting in October.**
2. **Set priorities for review of methodologies and/or conservation objective update proposals**.

Reference Materials:

1. Agenda Item E.2.a, Attachment 1: Email to the agencies from Chuck Tracy dated June 19, 2012.

Agenda Order:

a. Agenda Item Overview — Chuck Tracy
b. Reports and Comments of Advisory Bodies and Management Entities
c. Public Comment
d. **Council Action**: Adopt Final Review Priorities

PFMC
08/17/12

Agenda Item E.2.a
Attachment 1
September 2012

Chuck Tracy <chuck.tracy@noaa.gov>

Salmon Methodology Review Dates

1 message

Chuck Tracy <chuck.tracy@noaa.gov> Tue, Jun 19, 2012 at 9:57 AM
To: Craig Foster <Craig.A.Foster@state.or.us>, Doug Milward <MILWADAM@dfw.wa.gov>, Eric Schindler <Eric.D.Schindler@state.or.us>, Henry Yuen <Henry_Yuen@fws.gov>, Jennifer Simon <jsimon@dfg.ca.gov>, Keith Lutz <lutz@nwifc.org>, Larrie LaVoy <Larrie.LaVoy@noaa.gov>, Mike O'Farrell <michael.ofarrell@noaa.gov>, Robert Kope <Robert.Kope@noaa.gov>, Sandy Zeiner <szeiner@nwifc.org>, Wendy Beeghley <BeeghWLB@dfw.wa.gov>, Bob Conrad <bconrad@nwifc.org>, Carlos Garza <Carlos.Garza@noaa.gov>, Charlie Petrosky <cpetrosky@idfg.idaho.gov>, Loo Botsford <lwbotsford@ucdavis.edu>, Meisha Key <Mkey@dfg.ca.gov>, Owen Hamel <owen.hamel@noaa.gov>, Pete Lawson <Peter.W.Lawson@noaa.gov>, Andy Rankis <ARankis@nwifc.org>, Angelika Hagen-breaux <hagenafh@dfw.wa.gov>, Ethan Clemons <Ethan.R.Clemons@state.or.us>, Jim Packer <PackeJFP@dfw.wa.gov>
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Hi All:

Just to let you know, the salmon methodology review has been tentatively set for October 10 and 11 here in Portland.

The Council adopted the following topics for potential review in the annual salmon methodology review process (parties responsible for analysis in bold and brackets):

1) Implementation and assessment of proposed bias-corrections methods for mark-selective fisheries into the Coho FRAM. [**MEW]**

2) Review of modifications to Chinook FRAM size limit algorithms implemented to allow evaluation of changes to size-limits. [**MEW]**

3) Review of alternative forecast methodologies for the Sacramento Fall Chinook index. [**STT]**

4) A multi-year review and evaluation of preseason forecasts and postseason estimates for mark-selective coho fisheries both north and south of Cape Falcon. **[STT]**

5) Preliminary assessment of the feasibility of abundance-based management for California Coastal Chinook. **[NMFS Southwest Region]**

6) A user's manual for the Visual Studio version of FRAM. **[MEW]**

7) Investigate Chinook FRAM's sensitivity to age composition forecasts. **[MEW]**

8) Evaluate the feasibility of incorporating bias-correction methods for mark-selective fisheries into Chinook FRAM. **[MEW]**

9) Develop recommendations on management methodologies for Sacramento River Winter Chinook that better achieve Council's objective, particularly at low abundance. **[STT]**

The Council will make a final list at the September meeting in Boise; additional topics may be considered at that time (please let me and Mike Burner know in advance). Responsible parties should be prepared to report at that time if sufficient progress has been made to review the topic at the October meeting. Recall that materials should be available 2 weeks prior to the October meeting date.

Thanks everybody.

--

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MODEL EVALUATION WORKGROUP REPORT ON 2012 SALMON METHODOLOGY REVIEW

There are two changes to the Fishery Regulation Assessment Model (FRAM) that the Model Evaluation Workgroup (MEW) has reviewed and recommends as topics at the October Methodology Review Meeting.

1) The implementation and assessment of proposed bias-corrections methods for mark-selective fisheries into the Coho FRAM.

2) Review of modifications to Chinook FRAM size limit algorithms implemented to allow evaluation of changes to size-limits.

There were three other topics identified as MEW responsibilities, topic:

3) A FRAM User Manual, updated for the FRAM Visual Studio version, is still a work in-progress.

4) Chinook FRAM's sensitivity to the age composition of forecasts: The MEW has not yet addressed this topic, but some work has begun and the MEW is discussing potential future work on this topic.

5) Feasibility of incorporating bias-correction methods for mark-selective fisheries into Chinook FRAM: The MEW has not yet addressed this topic but will discuss it prior to the October Methodology Meeting and would like to have another discussion with the Salmon Technical Team and the Scientific and Statistical Committee Salmon Subcommittee at the October methodology review meeting.

PFMC
09/12/12

Northwest Indian Fisheries Commission
6730 Martin Way E., Olympia, Washington 98516-5540
Phone (360) 438-1180 www.nwifc.org FAX # 753-8659

Mr. Dan Wolford
Pacific Fisheries Management Council
7700 NE Ambassador Place, Suite 101
Portland, Oregon 97220-1384

Dear Chairman Wolford,

The Northwest Indian Fisheries Commission (NWIFC) would like the attached report prepared by Robert Conrad, biometrician for the NWIFC, to be considered by the Council as a Salmon Methodology Review topic for the review meeting scheduled for October, 2012. This report compares the current method for estimating release mortalities by the ocean coho fisheries under the Council's jurisdiction to an alternative method that we consider an improvement based on its analytical framework and specified assumptions.

The Council will be recommending Salmon Methodology Review topics at its September meeting in Boise, and we would like this item to be included on the list of items recommended.

Thank you for your consideration of this important item.

Sincerely,

Michael Grayum
Executive Director, NWIFC

Comparison of Two Methods for Estimating Coho Salmon Encounters and Release Mortalities in the Ocean Mark-selective Fishery

Robert H. Conrad
Northwest Indian Fisheries Commission
6730 Martin Way East
Olympia, WA 98516

September 17, 2012

Pacific Fishery Management Council
Salmon Methodology Review
October 10-11, 2012

INTRODUCTION

This report compares two methods for estimating the total number of encounters with coho salmon and the number of release mortalities in the mark-selective fisheries for coho conducted annually off the Washington coast (WDFW Marine Catch Areas 1, 2, 3, and 4). The starting points for both methods are estimates of the numbers of marked and unmarked legal-size coho landed (brought to the dock) in each marine catch area during each month of the fishery. The methods used to estimate landed catch and its variance are described in Lai et al. (1991). Currently, estimates of landed catch by the two components of the recreational fishing fleet (charter boats and private boats) are combined and used to estimate total encounters (and total release mortalities) for marked and unmarked coho salmon.

Three potential problems with the current estimation methods are:

- the estimate of marked coho release mortalities is not a function of marked coho encounters but is a constant fraction of the total landed catch of marked coho salmon,
- the estimate of total encounters with legal-size coho salmon is based on the assumption that there is no release of legal-size marked coho by either component of the recreational fleet,
- the estimate of total legal-size coho salmon encounters is made using the combined landed catch of the fleets, and
- the proportion of all legal-size coho salmon encounters that are marked ($\hat{P}_M$), that is a component of the total encounters estimate, is estimated using sample data from each fleet that is simply combined and does not consider the proportion of total encounters occurring in each fleet.

This report describes an alternate method which estimates total encounters of legal-size coho salmon by the charter boat and private boat fleets separately and, therefore, estimates $\hat{P}_M$ (and other encounter proportions) separately for each fleet. It also incorporates fleet-specific estimates of the proportion of legal-size marked coho that are caught and released into the estimate of total encounters. The estimates of total legal-size coho salmon encounters and total release mortalities for marked and unmarked legal-size coho by each method are then compared for the three most recent ocean fishing seasons (2009, 2010, and 2011).

METHODS

Current Method

For simplification, the methods used to estimate coho salmon encounters and release mortalities for a single month and area will be described and corresponding subscripts for month and area omitted from the notation. This method begins with the estimate of total landed catch (marked and unmarked coho combined) for a month and catch area (see Table 1 for definitions of the notation used). Total landed catch (C_T) is estimated as the sum of the estimates of landed marked and unmarked coho by each fleet:

$$\hat{C}_T = \left(\hat{C}_M^C + \hat{C}_U^C\right) + \left(\hat{C}_M^P + \hat{C}_U^P\right) \quad [1]$$

with variance,

$$\hat{V}\left(\hat{C}_T\right) = \hat{V}\left(\hat{C}_M^C\right) + \hat{V}\left(\hat{C}_U^C\right) + \hat{V}\left(\hat{C}_M^P\right) + \hat{V}\left(\hat{C}_U^P\right). \quad [2]$$

Currently the number of marked coho salmon released is estimated as 6% of the marked coho landed catch. The number of marked coho mortalities due to release (R_M) is estimated by applying the PFMC recommended mortality rate of 14% for coho salmon released by ocean recreational fisheries off the coast of Washington (PFMC 2000) to this estimated number released:

$$\hat{R}_M = \left(\hat{C}_M^C + \hat{C}_M^P\right) x \ 0.06 \ x \ 0.14 \quad [3]$$

with variance,

$$\hat{V}\left(\hat{R}_M\right) = [0.06 \ x \ 0.14]^2 \ x \ \left[\hat{V}\left(\hat{C}_M^C\right) + \hat{V}\left(\hat{C}_M^P\right)\right]. \quad [4]$$

Currently, the estimated number of unmarked coho mortalities due to release is based on an estimate of the total encounters of legal-size coho salmon (E_T) by the fishery:

$$\hat{E}_T = \frac{\hat{C}_T}{\hat{P}_M} \quad [5]$$

where $\hat{P}_M$ is an estimate of the proportion of all legal-size coho salmon encounters[1] in the fishery that are marked based on data collected by onboard observers for the charter boat fleet and by voluntary trip reports (VTRs) for the private boat fleet. The reasoning behind using total catch in this calculation instead of total marked catch is unclear other than it will provide a somewhat larger estimate of total encounters.

Table 1. Definitions of the notation used.

Notation		Definition
$\hat{C}_j^i$	=	the estimated landed catch of legal-size marked (*j* = *M*) or unmarked (*j* = *U*) coho by either the charter boat (*i* = *C*) or private boat (*i* = *P*) fleets. Subscript *T* indicates the estimated total landed catch of marked and unmarked coho.
$\hat{E}_T^i$	=	the estimated total number of encounters with legal-size coho salmon by anglers in fleet *i*.
P_M^i	=	the estimated proportion of all legal-size coho salmon encounters by anglers in fleet *i* that were marked.
$\hat{R}_j^i$	=	the estimated number of mortalities of legal-size coho salmon of mark status *j* due to their release by anglers in fleet *i*.
$\hat{\Phi}_M^i$	=	the estimated proportion of all legal-size encounters of marked coho salmon that were kept by anglers in fleet *i*.
$\hat{\Omega}_M^i$	=	the estimated proportion of all legal-size coho salmon encounters (both marked and unmarked) that were both marked and kept by anglers in fleet *i*.
$\hat{\theta}_j^i$	=	the estimated proportion of all legal-size coho salmon encounters that were mark status *j* and released by anglers in fleet *i*.

[1] The definition of an encounter as used for management of these fisheries is a coho salmon that is brought to the boat by the angler, identified as a marked or unmarked fish, and then typically kept if a marked fish and released if an unmarked fish. Drop-offs (fish that are hooked but free themselves before being brought to the boat) are accounted for separately.

Assuming the covariance between $\hat{C}_T$ and $\hat{P}_M$ is 0, the variance of the total encounter estimate can be approximated using the delta method (Seber 1982) as:

$$\hat{V}(\hat{E}_T) \approx \frac{\hat{V}(\hat{C}_T)}{[\hat{P}_M]^2} + \frac{\hat{V}(\hat{P}_M)\ x\ \hat{C}_T^2}{[\hat{P}_M]^4}\,. \qquad [6]$$

The variance of $\hat{P}_M$ is estimated using the formula for the variance of a binomial proportion (Cochran 1977). Let N_T = the number of legal-size coho salmon recorded as brought to the boat by both charter boat observers and on VTRs and N_M = the number of those coho that were marked (missing an adipose fin). Then $\hat{P}_M$ = N_M / N_T with variance:

$$\hat{V}(\hat{P}_M) = \frac{\hat{P}_M\ x\ [1-\hat{P}_M]}{N_T-1}\,. \qquad [7]$$

Currently, the number of unmarked coho salmon mortalities due to release is estimated as:

$$\hat{R}_U = (\hat{E}_T - \hat{C}_T)\ x\ 0.14$$

which is equivalent to:

$$\hat{R}_U = \hat{C}_T\ x\ \left(\frac{1}{\hat{P}_M} - 1\right)\ x\ 0.14. \qquad [8]$$

The variance of $\hat{R}_U$ can be estimated using Goodman's (1960) formula for the variance of the product of two independent random variables,

$$\hat{V}(\hat{R}_U) = 0.14^2\ x\ \left\{\left[\left(\frac{1}{\hat{P}_M}\right)^2\ x\ \hat{V}(\hat{C}_T)\right] + \left[(\hat{C}_T)^2\ x\ \hat{V}(\tfrac{1}{\hat{P}_M})\right] - \left[\hat{V}(\hat{C}_T)\ x\ \hat{V}(\tfrac{1}{\hat{P}_M})\right]\right\}. \qquad [9]$$

The variance of $1/\hat{P}_M$ can be approximated using the delta method as:

$$\hat{V}\left(\frac{1}{\hat{P}_M}\right) \approx \frac{\hat{V}(\hat{P}_M)}{[\hat{P}_M]^4}\,. \qquad [10]$$

While the release mortality rate (0.14) is acknowledged to be an estimate there is no measure of uncertainty (variance) currently associated with it. Therefore, it is treated as a known constant.

Proposed Alternate Method

The alternate method begins with an estimate of total encounters of legal-size coho by each fleet, $\hat{E}_T^i$, (where *i* is either the charter boat or private boat fleet) and is generated differently than the previous method in that it is based on the estimated total landed catch of only marked coho salmon expanded to account for the release of any legal-size marked coho by each recreational fleet:

$$\hat{E}_T^i = \frac{\hat{C}_M^i}{\hat{\Phi}_M^i}\ /\hat{P}_M^i \qquad [11]$$

where $\hat{P}_M^i$ is defined as for the previous method except now it is estimated separately for each fleet and $\hat{\Phi}_M^i$ is an estimate of the proportion of legal-size marked coho salmon that are brought to the boat and kept. Therefore, 1 - $\hat{\Phi}_M^i$ is an estimate of the proportion of legal-size marked coho salmon that are encountered but intentionally released by each fleet. This method is more intuitive than the previous method as it is based on the landed catch of only legal-size marked coho salmon and expands that catch to account for legal-size marked coho that were caught but released by the angler. Therefore, when expanded by $\hat{P}_M^i$ it provides an unbiased estimate of the total encounters of legal-size coho salmon by each fleet.

Equation 11 can be re-expressed as:

$$\hat{E}_T^i = \frac{\hat{C}_M^i}{(\hat{\Phi}_M^i \ x \ \hat{P}_M^i)} \quad [12]$$

and the product in the denominator is equivalent to the estimated proportion of all legal-size coho salmon encountered that are both marked and kept by the angler based on either charter boat observer or VTR data (depending upon the fleet being analyzed - see Appendix A).

Letting $\hat{\Omega}_M^i$ represent the estimated proportion of all legal-size coho salmon encountered by anglers in a fleet that are marked coho which are kept, the variance of this total encounter estimate can be approximated using the delta method as:

$$\hat{V}(\hat{E}_T^i) \approx \frac{\hat{V}(\hat{C}_M^i)}{[\hat{\Omega}_M^i]^2} + \frac{\hat{V}(\hat{\Omega}_M^i)\, x\, [\hat{C}_M^i]^2}{[\hat{\Omega}_M^i]^4} . \quad [13]$$

This assumes that the estimates of $\hat{C}_T^i$ and $\hat{\Omega}_M^i$ are independent. The variance of $\hat{\Omega}_M^i$ can be estimated as the variance of a binomial proportion similarly to the variance of $\hat{P}_M$ (see Appendix A).

Letting $\hat{\theta}_M^i$ equal the estimated proportion of all legal-size coho salmon encountered by anglers from a fleet that are marked coho which are released (see Appendix A), the number of marked coho mortalities due to release by fleet *i* can then be estimated as:

$$\hat{R}_M^i = [\hat{E}_T^i \, x \, \hat{\theta}_M^i] \; x \;\; 0.14 \quad [14]$$

with variance estimated using Goodman's (1960) formula,

$$\hat{V}(\hat{R}_M^i) = 0.14^2 \; x$$
$$\left\{\left[(\hat{\theta}_M^i)^2 \; x \;\; \hat{V}(\hat{E}_T^i)\right] \; + \; \left[(\hat{E}_T^i)^2 x \;\; \hat{V}(\hat{\theta}_M^i)\right] - \left[\hat{V}(\hat{E}_T^i) \; x \; \hat{V}(\hat{\theta}_M^i)\right]\right\}. \quad [15]$$

The number of unmarked coho mortalities due to release can be estimated as:

$$\hat{R}_U^i = \left[\hat{E}_T^i \; x \; \hat{\theta}_U^i\right] \; x \;\; 0.14 \quad [16]$$

with variance,

$$\hat{V}(\hat{R}_U^i) = 0.14^2 \; x$$
$$\left\{\left[(\hat{\theta}_U^i)^2 \; x \;\; \hat{V}(\hat{E}_T^i)\right] \; + \; \left[(\hat{E}_T^i)^2 x \;\; \hat{V}(\hat{\theta}_U^i)\right] - \left[\hat{V}(\hat{E}_T^i) \; x \; \hat{V}(\hat{\theta}_U^i)\right]\right\} \quad [17]$$

where $\hat{\theta}_U^i$ is the estimated proportion of all legal-size coho salmon encountered by anglers from a fleet that are unmarked coho which are released (see Appendix A).

Fleet-specific Estimates of $\hat{\Omega}_M^i$

An estimate of $\hat{\Omega}_M^i$ is required for the proposed alternate method of estimating total encounters of legal-size coho salmon. If $\hat{\Omega}_M^i$ is the same for each fleet then the total number of legal-size coho salmon encounters can be estimated using a combined estimate (charter and private boat fleet) of the landed catch of legal-size marked coho and an estimate of the overall $\hat{\Omega}_M$. Data to estimate $\hat{\Omega}_M^i$ come from the onboard observer program for the charter boat fleet and the voluntary trip reporting program for the private boat fleet. If there is a difference in $\hat{\Omega}_M^i$ between the charter and private boat fleets then an estimate of the total encounters by each fleet is more appropriate.

As demonstrated in Appendix A, $\hat{\Omega}_M^i$ can be expressed as the product of the proportion of all encounters that are marked ($\hat{P}_M^i$) and the proportion of marked coho encountered that are kept ($\hat{\Phi}_M^i$). There are reasons to expect that these parameters may be different between the charter and private boat fleets because:

- charter boat anglers are routinely discouraged from releasing legal-size marked coho that are caught while private boat anglers are not, and
- the private boat fleet tends to be more dispersed than the charter boat fleet and fishes in some areas not heavily fished by the charter boat fleet, therefore, it may encounter a different segment of the coho salmon population at large in the ocean than the charter boat fleet.

Comparison of $\hat{\Omega}_M^i$ for charter boat and private boat fleets

Estimates of $\hat{\Omega}_M^i$ from charter boat observers were compared to private boat VTRs for the same area and month strata where available. The three most recent years of data were analyzed (2009, 2010, and 2011). Fisher's exact test (Conover 1980) was used to test whether the estimates of $\hat{\Omega}_M^i$ for the two fleets were statistically different for month-area combinations (hereafter referred to as cells) with 10 or more total encounters with legal-size coho salmon by each sample program. We also tested whether the two fleets had similar estimates of $\hat{\Omega}_M^i$ across the entire three-year data set using ordinary least squares regression analysis to compare a line defined by the estimates to a line with a slope of 1.00 (i.e., the line of equality). Finally, the nonparametric Wilcoxon signed ranks test (Conover 1980) was used to compare the estimates across all areas and years by treating the estimates from the two data sources for a specific month-area cell as a matched pair of observations of the same parameter. The Wilcoxon test is based on the signed ranks of the differences between the paired observations and tests whether the differences between the two data sources have a median = 0 which, if accepted, indicates they are not significantly different from one another.

Estimates of $\hat{\Omega}_M^i$ from dockside interview data from charter boats were compared to dockside interview data from private anglers, also. Dockside interview data are complete-trip interview data. The sample unit for dockside interviews is a boat; therefore, the data is commonly for multiple anglers in the boat. The data collected include:

- number of coho retained regardless of mark status,
- number of marked coho retained,
- number of coho released regardless of mark status, and
- number of marked coho released.

Three major differences between the dockside interview data and the sampling program data (onboard observer and VTRs) are: (1) the unit of data collection is the boat for the dockside data compared to the encounter for the sampling program data; (2) there is no differentiation between legal and sublegal coho salmon released for the dockside data compared to a separate accounting of legal-size and sublegal-size coho for the sampling programs; and (3) the charter onboard observer and VTR data do not rely on recall (the data for an encounter is recorded shortly after it occurs) while the dockside data relies on angler recall of the number of coho salmon released and their mark-status. Therefore, the release data from dockside interviews includes a small proportion of sublegal-size coho salmon and is not directly comparable to the sampling program data. For the above reasons, the dockside data were not appropriate for a chi-square test. However, we examined the dockside release data to see if trends similar to those observed in the onboard observer and VTR sampling program data comparison were present in the dockside data using plots of the data, regression analysis, and the Wilcoxon test.

Evaluation of proxy estimates of $\hat{\Omega}_M^i$ when direct sampling data are lacking or insufficient

In order to estimate total encounters by fleet, an estimate of $\hat{\Omega}_M^i$ is needed for each fleet for each month-area combination[2]. Often onboard observer data for the charter boats is lacking for areas 3 and 4 (and occasionally for areas 1 and 2 in September). Similarly, VTR data for the private fleet is occasionally lacking or has a very small sample size (less than 10 total encounters with legal-size coho salmon). Fortunately, only a small portion of the total coho salmon catch occurs in these month-area strata with missing or insufficient data. For the three years examined, 5.7%, 3.4%, and 2.2% of the total landed catch of legal-size coho salmon occurred in these type of strata in 2009, 2010, and 2011, respectively.

Therefore, alternate methods of estimating $\hat{\Omega}_M^i$ were sometimes needed to produce fleet-specific estimates of encounters (and subsequent release mortalities). We considered three methods of estimating $\hat{\Omega}_M^i$ when these data were missing for a month-area. They were:

1. estimate $\hat{\Omega}_M^i$ for either the charter boat or private boat fleet using the corresponding dockside interview data,
2. estimate $\hat{\Omega}_M^i$ using sample data for the same fleet from a neighboring area and/or month cell, and
3. estimate $\hat{\Omega}_M^i$ for the charter boat fleet using VTR data from the corresponding month-area cell.

Methods similar to those described in the previous section were used to compare data from different sources. For these analyses, data from either charter boat onboard observers or private boat VTRs were considered to provide the "best" estimate of the composition of legal-size coho salmon encounters. Analyses were conducted to determine if the alternative being evaluated provided a reasonable proxy for the missing data. We considered a straight substitution of estimates, an estimate based on a ratio of means (ROM) estimator, and a regression estimate using the linear relationship between the two data sources for these analyses.

[2] Similarly, estimates of $\hat{\theta}_j^i$ for each fleet by area-month are needed to estimate release mortalities.

RESULTS

Analyses of $\hat{\Omega}_M^i$

The results from the comparison of $\hat{\Omega}_M^i$ between fleets are presented first since this will determine whether total encounters need to be estimated separately for each fleet. This is followed by an evaluation of proxies.

Comparison of $\hat{\Omega}_M^i$ for charter boat and private boat fleets

For the three years of data examined, there were 17 month-area cells that had data from both the charter boat observer and VTR data collection programs[3]. Table 2 summarizes the data collected by each program and the results of Fisher's exact test comparing $\hat{\Omega}_M$ for each fleet. There was one significant difference between the $\hat{\Omega}_M$ estimates for the fleets in each year; all three significant tests occurred in Area 2.

It can be seen from Table 2 that private boat anglers generally have a lower proportion of legal-size marked coho retained than the charter boat fleet (i.e., private boat anglers tend to release a higher proportion of legal-size marked coho salmon than charter boat anglers). The Wilcoxon signed rank test rejected the hypothesis that the median difference between the ranks of the paired estimates was 0 (P = 0.009) further indicating that the estimates of $\hat{\Omega}_M$ from the two fleets were significantly different from one another.

A scatter plot of the estimates (Figure 1) shows that the majority of the points (11 of 17) lie above the line of equality (where the two estimates are equal). The ordinary least squares regression of these data results in significant regression coefficients (P = 0.003 for both the slope and intercept) and a slope with a 95% confidence interval that does not include 1.00 (slope = 0.570 with a 95% confidence interval of 0.231 to 0.908). This again indicates that estimates are different from one another in a consistent manner.

Appendix Table B compares the results of the dockside interview data to the sampling program data. The general trend shown by the dockside data is for retained legal-size marked coho to be a higher proportion of all coho salmon encounters by the charter fleet compared to the private fleet. If we assume equal dockside reporting accuracy as to the number of coho released by mark status for charter and private anglers and similar encounter rates of sublegal size coho then, on average, about 7% more of the total coho encounters result in a marked coho being kept by the charter fleet compared to the private fleet. This compares favorably with the results of the observer and VTR data comparison where for the same month-area cells, on average about 6% more of the total legal-size coho salmon encounters by the charter fleet consisted of legal-size coho that were retained compared to the private fleet. Note that the dockside encounter data include encounters with sublegal coho.

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[3] Only month-area combinations with 10 or more observations (total encounters of legal-size coho salmon recorded) for each fleet were included in this analysis.

Table 2. Summary of data and Fisher's exact test results comparing the percentage of legal-size marked coho salmon kept from all legal-size coho encounters for the charter boat observer and private boat voluntary trip report data, by month-area cell for the years 2009-2011.

			Charter Fleet Onboard Observer Data					Private Fleet Voluntary Trip Report (VTR) Data					Fisher's Exact Test (1 df)[a]	
Year	Month	Area	Marked Kept	Marked Released	Unmarked Kept	Unmarked Released	Marked Kept %	Marked Kept	Marked Released	Unmarked Kept	Unmarked Released	Marked Kept %	χ^2 Statistic	*P*
2009	July	1	247	9	0	151	60.7%	62	1	0	40	60.2%	0.008	1.000
2009	August	1	184	7	0	125	58.2%	28	1	0	26	50.9%	1.025	0.376
2009	July	2	286	4	0	236	54.4%	53	7	0	62	43.4%	**4.742**	**0.034**
2009	August	2	257	4	0	209	54.7%	111	3	1	109	49.6%	1.601	0.223
2010	July	1	112	1	0	111	50.0%	56	6	0	54	48.3%	0.091	0.819
2010	August	1	121	1	1	121	49.6%	126	6	0	163	42.7%	2.545	0.118
2010	July	2	67	2	0	78	45.6%	13	3	0	35	25.5%	**6.345**	**0.013**
2010	August	2	53	1	0	41	55.8%	13	3	0	9	52.0%	0.115	0.823
2010	Sept.	2	56	0	0	54	50.9%	4	0	0	6	40.0%	0.436	0.743
2010	July	4	17	1	0	34	32.7%	33	6	0	65	31.7%	0.015	1.000
2011	June	1	15	0	0	12	55.6%	19	0	0	12	61.3%	0.196	0.790
2011	July	1	152	4	0	124	54.3%	100	2	0	77	55.9%	0.110	0.773
2011	August	1	94	5	2	114	43.7%	133	5	0	141	47.7%	0.763	0.413
2011	Sept.	1	25	1	0	15	61.0%	18	0	0	22	45.0%	2.075	0.184
2011	July	2	29	0	0	56	34.1%	28	4	0	47	35.4%	0.032	0.871
2011	August	2	99	1	1	128	43.2%	41	5	0	94	29.3%	**7.176**	**0.008**
2011	Sept.	2	12	0	0	8	60.0%	11	0	0	14	44.0%	1.138	0.373

[a] Significant exact test results ($P \leq 0.05$) are in **bold**.

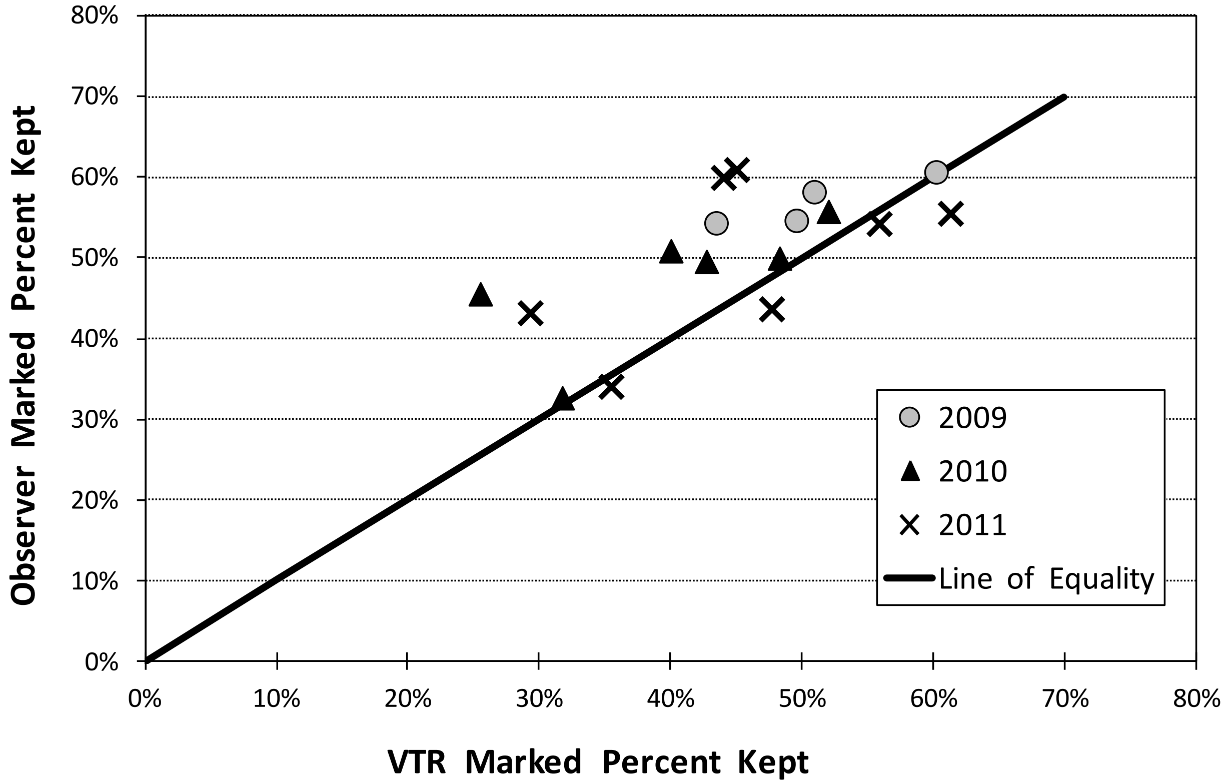

Figure 1. Comparison of estimated percentage of all legal-size coho salmon encounters which were both marked coho and retained (kept) for VTR and onboard observer data, by month-area cell.

When the dockside estimates of $\hat{\Omega}_M$ from charter boats are compared to those from private boat anglers across the 41 month-area cells sampled during the years 2009-2011, the private boat estimate of $\hat{\Omega}_M$ was less than the charter boat estimate for 76% of the comparisons (31 out of 41). The Wilcoxon signed rank test rejected the hypothesis that the median difference between the ranks of the paired estimates was 0 ($P < 0.001$) indicating that the estimates from the two data sources were significantly different from one another.

Given the above results, which consistently indicate that a higher proportion of the legal-size coho salmon encountered by the charter boat fleet are marked coho which are kept relative to the private boat fleet, it is recommend that separate estimates of total encounters are made for the charter and private boat fleets in each month-area cell.

Evaluation of proxy estimates for $\hat{\Omega}_M^i$ when direct sampling data were lacking or insufficient

The preferred method of estimating $\hat{\Omega}_M^i$ when direct sampling data were lacking or insufficient was to use dockside sampling data because:

- corresponding dockside sampling data are almost always available for a month-area cell while corresponding VTR data are more frequently not available for missing or insufficient charter boat observer data,

- corresponding charter boat observer data are rarely available to replace missing or insufficient VTR data, and
- between-area and between-month similarities in $\hat{\Omega}_M^i$ are inconsistent.

There was not a significant linear relationship between the dockside interview and onboard charter boat observer estimates of $\hat{\Omega}_M^C$ (regression R^2 = 0.070 and *P* for slope = 0.248). Therefore, the ratio of means estimator was selected as appropriate for estimating $\hat{\Omega}_M^C$ when onboard observer data were not available. Figure 2A compares the line defined by the ratio estimator (ROM = 1.0798) with the line of equality.

The linear relationship between the dockside interview and VTR estimates of $\hat{\Omega}_M^P$ was significant (regression R^2 = 0.484 and *P* for slope < 0.001). However, the Y-intercept for this relationship was not significant (*P* = 0.090) indicating a line through the origin was appropriate. Since the appropriate regression line passes through the origin, for simplicity and consistency with the charter boat estimator the ROM estimator was used to estimate $\hat{\Omega}_M^P$ when VTR data were not available for the private boat fleet. Figure 2B compares the line defined by the ratio estimator (ROM = 1.1093) with the line of equality.

In order to estimate total release mortalities, estimates of the proportions of all legal-size coho salmon encounters that were marked coho that were released ($\hat{\theta}_M^i$) and unmarked coho that were released ($\hat{\theta}_U^i$) are required for each month-area cell by fleet. A ROM estimator was used to estimate these parameters when appropriate observer or VTR data were not available (see Appendix C for further ROM analysis details).

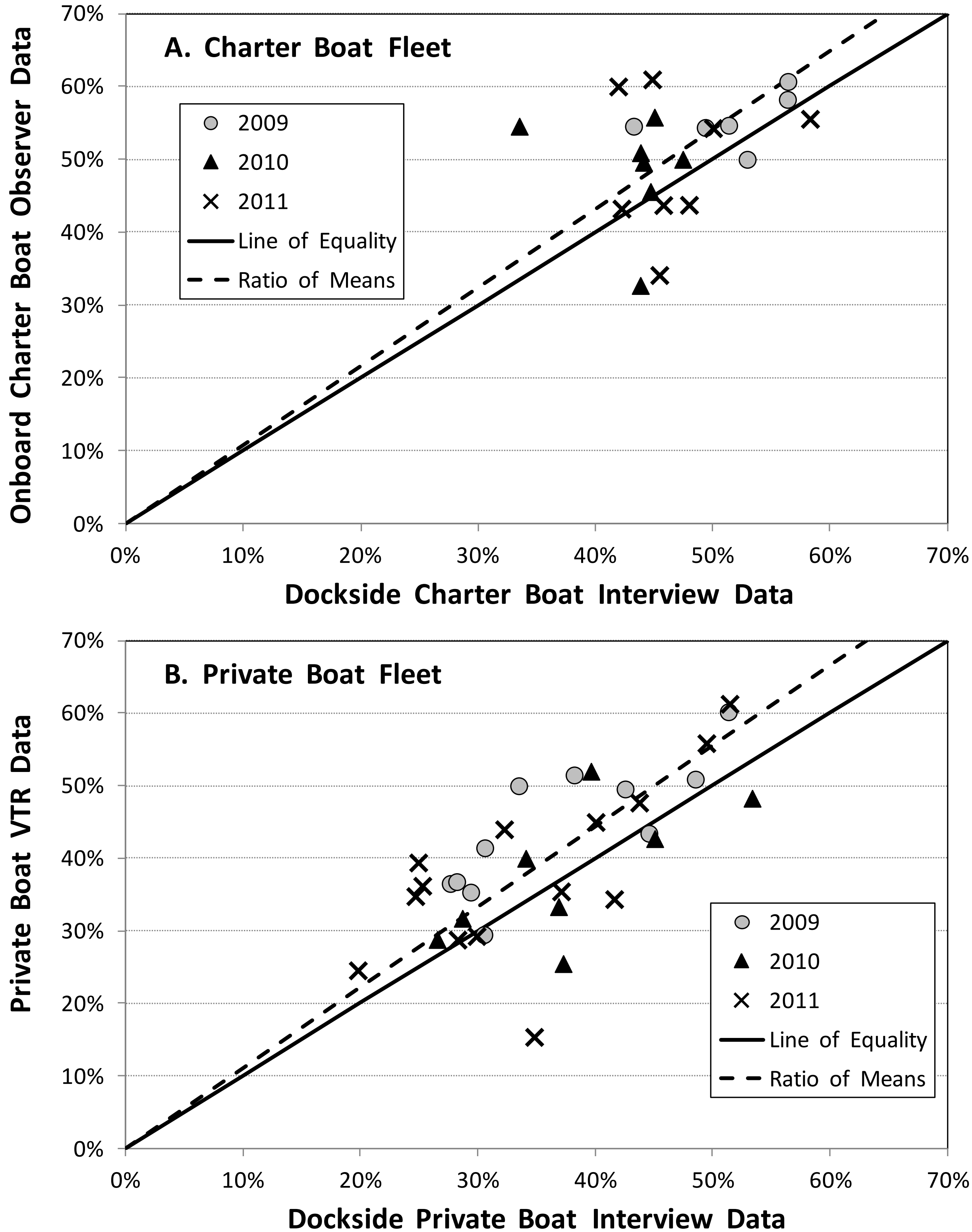

Figure 2. Comparison of dockside interview data to (A) onboard charter boat observer data and (B) private boat voluntary trip report (VTR) data for the percent of all legal-size coho encounters that were both marked coho and kept by the angler.

Comparison of Estimates of Total Encounters and Release Mortalities by the Two Methods

The procedures described for the two estimation methods (current and proposed) were applied to the 2009-2011 ocean sampling program data. Separate estimates of encounters and release mortalities were made for the charter boat and private boat fleets.

The proposed estimation method resulted in an increase in the estimates of total legal-size coho salmon encounters and unmarked coho release mortalities for all month-area cells during the three years of data examined (Figure 3). However, the differences between methods for the estimated number of release mortalities for marked coho were both positive and negative.

The percent differences in the estimates of total legal-size coho salmon encounters for a catch area during a year relative to the current method ranged from +3.4% to +16.4%. For the annual totals, the proposed method estimated +8.1%, +9.0%, and +7.5% more encounters compared to the current method for the years 2009, 2010, and 2011, respectively (Appendix Table D1). The relative precision of the estimates as measured by the coefficient of variation was similar for the two methods.

The percent differences in the estimates of total release mortalities for unmarked coho salmon in a catch area during a year relative to the current method ranged from 0.7% to 25.8%. For the annual totals, the proposed method estimated +14.4%, +11.6%, and +9.4% more unmarked release mortalities compared to the current method for the years 2009, 2010, and 2011, respectively (Appendix Table D2). The relative precision of the estimates as measured by the coefficient of variation was similar for the two methods.

The percent differences in the estimates of total release mortalities for marked coho salmon in a catch area during a year relative to the current method ranged from -53% to +175%. For the annual totals, the proposed method estimated -42.0%, -1.6%, and -5.7% fewer marked release mortalities compared to the current method for the years 2009, 2010, and 2011, respectively (Appendix Table D3). On a catch area by year level, the current method estimated fewer marked coho release mortalities half the time. The relative precision for the estimates of marked coho salmon release mortalities for the proposed method was considerably worse than for the current method. This is a result of the estimate for the current method being based on a constant fraction (with no associated variance) of the landed marked catch instead of using sample data from the onboard observer or VTR programs.

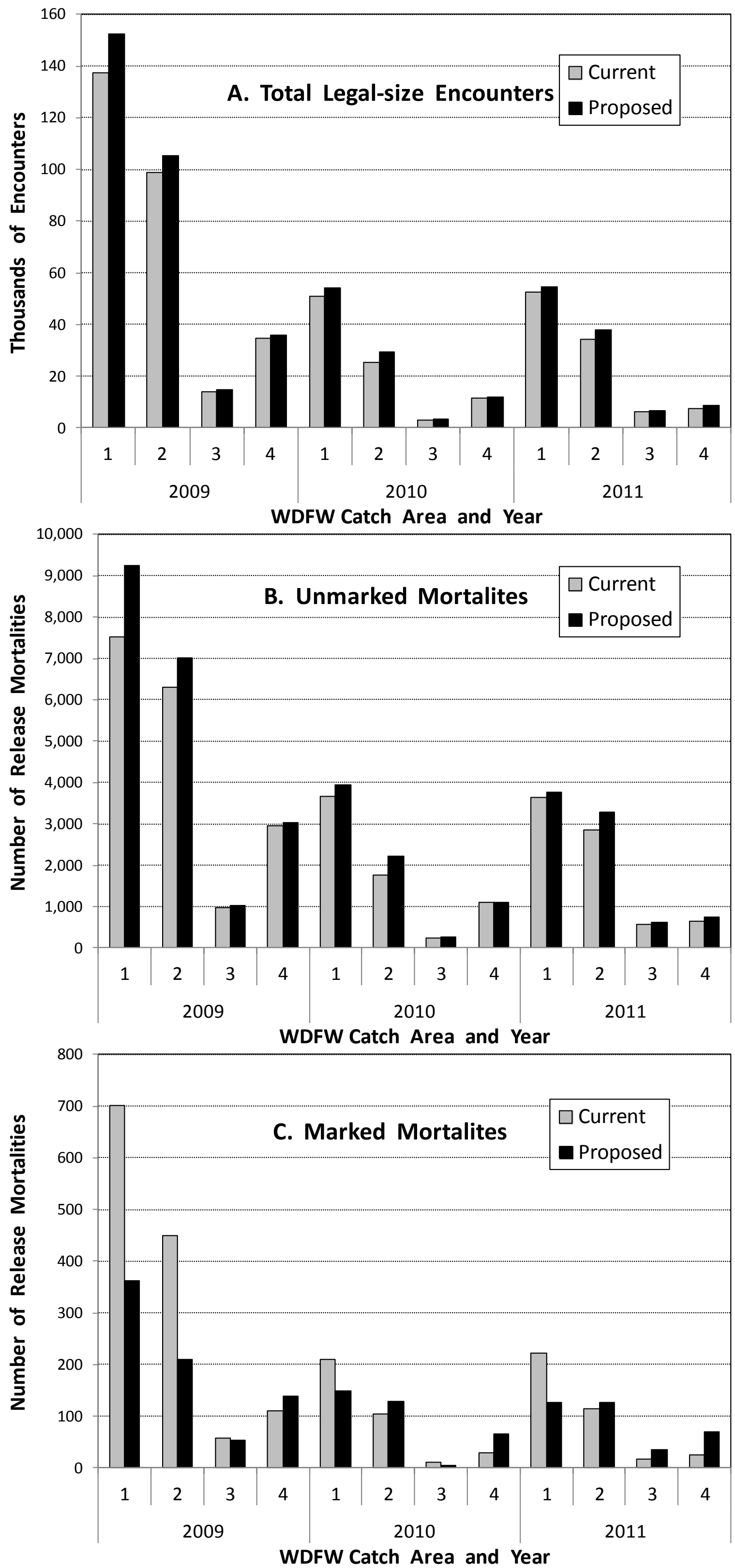

Figure 3. Comparison of estimates by current and proposed methods for (A) legal-size coho encounters, (B) unmarked coho release mortalities, and (C) marked coho release mortalities.

Discussion

The proposed method consistently estimated more total encounters with legal-size coho salmon and more release mortalities for unmarked coho than the current method. The difference between the methods in the estimated total number of legal-size coho encounters was about +8% to +9% each year. The difference between the methods in the estimated number of release mortalities of unmarked coho decreased gradually from 2009 to 2011 from +14% to +9% (Table 3).

Table 3. Summary of the annual percent difference[a] between the two methods for estimates of total legal-size coho salmon encounters and total number of unmarked coho release mortalities.

	Year		
Percent Difference in Estimates between Methods	**2009**	**2010**	**2011**
Total encounters	8.1%	9.0%	7.5%
Unmarked release mortalities	14.4%	11.6%	9.4%

[a] Percent Difference = (Proposed Method - Current Method)/Current Method.

From 2009 to 2011, there was a gradual decrease in the relative percent difference between the methods for the estimate of unmarked release mortalities. One major difference between the two estimation methods is that the proposed method estimates encounters and unmarked release mortalities separately for the charter boat and private boat fleets. A number of metrics associated with the estimates for the two fleets were examined to see if they might correspond to this trend in the data (Table 4). The metrics examined were:

- the percent of the estimated total harvest of legal-size coho taken by the charter boat fleet,
- the percent of the estimated total encounters with legal-size coho by the charter boat fleet,
- the percent of legal-size coho encounters by the charter boat fleet that are unmarked,
- the percent of legal-size coho encounters by the private boat fleet that are unmarked,
- the difference between the fleets in the percent of legal-size coho encounters that are unmarked,
- the percent of all legal-size coho encounters by the charter boat fleet that are released,
- the percent of all legal-size coho encounters by the private boat fleet that are released,
- the difference between the fleets in the percent of all legal-size coho encounters that are released,
- the percent of encounters with legal-size marked coho by the charter boat fleet that are released,
- the percent of encounters with legal-size marked coho by the private boat fleet that are released, and
- the difference between the fleets in the percent of encounters with legal-size marked coho that are released.

Table 4. Summary of metrics based on estimates from the proposed method that compare the charter boat and private boat fleets.

Metric	Year 2009	Year 2010	Year 2011
% difference in estimated unmarked mortalities	14.4%	11.6%	9.4%
% of total legal-size coho harvest taken by charter boat fleet	33.2%	37.0%	36.5%
% of total legal-size coho encounters by charter boat fleet	30.6%	32.1%	33.8%
% of total legal-size encounters that are unmarked - charter fleet	43.2%	50.0%	53.3%
% of total legal-size encounters that are unmarked - private fleet	49.0%	57.2%	57.1%
Difference between Fleets	-5.8%	-7.2%	-3.8%
% of all legal-size encounters that are released - charter fleet	44.4%	50.4%	54.1%
% of all legal-size encounters that are released - private fleet	50.9%	60.2%	59.9%
Difference between Fleets	-6.5%	-9.8%	-5.8%
% of all legal-size marked encounters that are released - charter fleet	2.3%	1.3%	3.0%
% of all legal-size marked encounters that are released - private fleet	3.9%	7.9%	6.7%
Difference between Fleets	-1.6%	-6.6%	-3.7%

The summary in Table 4 indicate that there are consistent annual differences between the fleets in the composition of all legal-size coho salmon encounters. Composition as defined here refers both to the mark status (mark or unmarked) and disposition (kept or released) of the encounters. Compared to the charter boat fleet, in all three years for the private boat fleet:

- a greater proportion of the total legal-size coho salmon encounters were unmarked coho,
- a greater proportion of the all legal-size coho salmon encounters were released, and
- a greater proportion of the all legal-size marked coho salmon encounters were released.

These differences between the fleets support the use of estimates stratified by fleet type.

Three of the metrics associated with the charter boat fleet have an increasing annual trend that corresponds to the decreasing annual trend in the percentage difference in the estimates of the number of unmarked release mortalities between the methods. They are:

- the percent of the estimated total encounters with legal-size coho by the charter boat fleet,
- the percent of legal-size coho encounters by the charter boat fleet that are unmarked, and
- the percent of all legal-size coho encounters by the charter boat fleet that are released.

Although the change over the three-year period is relatively minor for the percent of the estimated total encounters with legal-size coho by the charter boat fleet (3.2%), there is about a 10% change over the period for the other two metrics. Based on only three years of estimates further speculation of cause and effect is not warranted at this time, but it appears that differences between the two methods of estimation may be related to the composition of the pool of coho salmon targeted by the charter boat fleet and its differences from the pool targeted by the private boat fleet.

We also looked at the current estimation method for possible relationships of the difference between the methods in the estimates of unmarked mortalities. Examining the estimates on an area and year basis indicated that the percent differences between the estimates of the number of unmarked release mortalities from the two methods were most highly correlated with P_M^W, a weighted-by-month measure of the percent of encounters that were marked for the fleets combined (Figure 4). However, the correlation coefficient for this relationship was only 0.446 so it explained less than 25% of the variation of the differences between the estimates. Current method estimates of the percentage of the total marked coho harvest taken by the charter boat fleet and the percentage of encounters that are kept (fleets combined) have similar correlations (0.419 and 0.439, respectively).

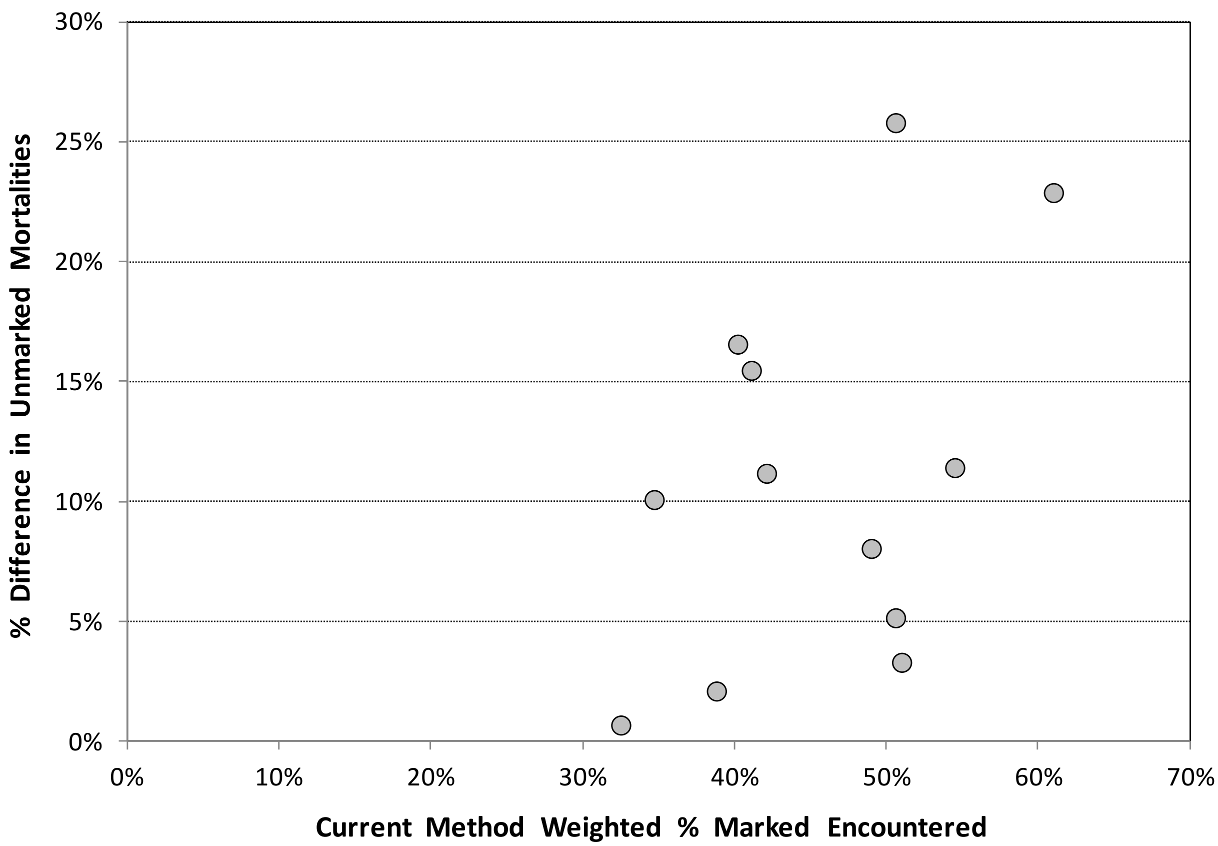

Figure 4. Relationship between the percent difference between the current and proposed estimates of the number of unmarked coho release mortalities and a weighted-by-month estimate of the overall percentage of all legal-size coho encounters that were marked for 2009-2011 data.

Finally, it should be noted that because the various components of the landed catch, number of encounters, and number of coho released are estimates based on sampling data, there is rarely perfect agreement between the estimated total encounters and the sum of its various components. I.e.,

$$\text{Total Landed Catch} + \text{Total Numbers Released} \neq \text{Total Encounters}$$

however, the differences between the two are typically small in both numbers of total encounters and as a percentage of total estimated encounters. Table 5 summarizes the annual differences for totals summed over all months for each area. Differences in the numbers of encounters range from -262 to +213 for the annual estimates by area. Differences expressed as a percentage of the total estimated encounters were all less than ±1% except for Area 3 in 2010 which was +6.4%. The Area 3 estimate was associated with the lowest estimated annual landed catch for any of the areas examined plus there was very little sample data (charter boat observer or VTR data) available for the estimates. VTR data were only available for the private fleet in August (total sample size = 18); all other encounter composition data were derived from dockside interview data. Therefore, this relatively large relative difference may result from the predominate use of the proxy estimates of disposition combined with poor estimate precision for landed catch.

Table 5. Summary of difference[a] between the total estimate of encounters and the sum of the components (landed catch estimate and total number released), by year and area.

Year	Area	Number of Coho	Percentage of Encounters[b]
2009	1	-262	-0.17%
	2	-145	-0.14%
	3	41	0.28%
	4	-208	-0.58%
Total		-574	-0.19%
2010	1	-6	-0.01%
	2	-52	-0.18%
	3	213	6.37%
	4	-73	-0.61%
Total		82	0.08%
2011	1	0	0.00%
	2	-142	-0.37%
	3	41	0.61%
	4	-60	-0.68%
Total		-161	-0.15%

[a] Difference = total encounter estimate - (total landed catch estimate + total release estimate).

[b] Percentage = (difference / total encounter estimate) x 100%.

LITERATURE CITED

Cochran, W. G. 1977. Sampling Techniques, third edition. John Wiley and Sons, Inc. New York.

Conover, W. J. 1980. Practical Nonparametric Statistics, second edition. John Wiley and Sons, Inc. New York.

Goodman, L. A. 1960. On the exact variance of products. Journal of the American Statistical Association. 55:708-713.

Lai, H-L., R. Moore, and J. Tagart. 1991. Methodologies for estimating catch and effort statistics of ocean sport fishery off the Washington Coast with users guide for the program 'OSFP.FOR'. Progress Report No. 289. Wash. Dept. of Fish and Wildlife, Olympia, WA. 35 pp.

PFMC (Pacific Fishery Management Council). 2000. Recommendations for Hooking Mortality Rates in 2000 Recreational Ocean Chinook and Coho Fisheries. Salmon Technical Team Report B.2. March 2000 meeting of the Pacific Fishery Management Council.

Seber, G. A. F. 1982. The Estimation of Animal Abundance, second edition. MacMillan Publishing Company, New York.

Appendix A

Estimates from Charter Boat Onboard Observers and Private Boat Voluntary Trip Reports

Onboard observers on charter boats and voluntary trip reports (VTRs) from private anglers provide data on the composition (marked or unmarked) and disposition (kept or released) of coho salmon encountered by each fleet. Although a small proportion of sublegal size coho are encountered each year[4], the following analyses use only legal-size coho salmon encounters.

For a specific data source (onboard observer or VTR), the composition and disposition of each legal-size coho salmon encounter can be categorized into one of four groups:

1. a marked coho that is kept (M_K),
2. a marked coho that is released (M_R),
3. an unmarked coho that is kept (U_K), or
4. an unmarked coho that is released (U_R).

The estimated proportion of legal-size marked coho encounters that are kept ($\hat{\Phi}_M^i$as previously defined) is then,

$$\hat{\Phi}_M^i = \frac{M_K}{(M_K + M_R)}. \quad [A1]$$

Similarly, $\hat{P}_M$ (the estimate of the proportion of all legal-size coho encounters in the fishery that are marked as defined previously) is estimated by:

$$\hat{P}_M^i = \frac{M_K + M_R}{(M_K + M_R + U_K + U_R)}. \quad [A2]$$

Therefore, the product of $\hat{\Phi}_M^i$ and $\hat{P}_M^i$ expressed in equation 12 of the text - which estimates the proportion of all legal-size coho salmon encountered by anglers from a fleet that are marked coho which are kept ($\hat{\Omega}_M^i$) - is equivalent to:

$$\hat{\Omega}_M^i = \frac{M_K}{(M_K + M_R)} \; x \; \frac{M_K + M_R}{(M_K + M_R + U_K + U_R)} = \frac{M_K}{(M_K + M_R + U_K + U_R)} \quad [A3]$$

with variance,

$$\hat{V}\left(\hat{\Omega}_M^i\right) = \frac{\hat{\Omega}_M^i \; x \; (1 - \hat{\Omega}_M^i)}{(M_K + M_R + U_K + U_R) - 1}. \quad [A4]$$

The estimated proportion of marked coho encountered that are released $\hat{\theta}_M^i$ is similarly estimated as,

$$\hat{\theta}_M^i = \frac{M_R}{(M_K + M_R + U_K + U_R)} \quad [A5]$$

with variance,

$$\hat{V}\left(\hat{\theta}_M^i\right) = \frac{\theta_M^i \; x \; (1 - \hat{\theta}_M^i)}{(M_K + M_R + U_K + U_R) - 1}. \quad [A6]$$

Corresponding estimates for the proportion of unmarked coho kept ($\hat{\Omega}_U^i$) and released ($\hat{\theta}_U^i$) can be estimated using U_K and U_R in the numerators of equations A3 and A5 with variances estimated similarly to the marked component.

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[4] In 2011, 5.3% of the total coho salmon encounters recorded on VTRs were sublegal in size and 2.4% of the total coho salmon encounters observed on charter boats were sublegal in size.

Appendix B

Table summarizing the estimates of the percentage of all coho salmon encounters that are marked coho which are retained (kept), by month-area cell, for onboard observer, voluntary trip report (VTR), and dockside data. Observer and VTR estimates are for the percentage of encounters with legal-size coho salmon only while dockside data is for the percentage of all coho salmon encountered.

			Onboard Observer Data			Charter Dockside Reports			Private VTR Data			Private Dockside Reports		
Year	Month	Area	Marked Kept	Total Encntrs	Marked Kept %	Marked Kept	Total Encntrs	Marked Kept %	Marked Kept	Total Encntrs	Marked Kept %	Marked Kept	Total Encntrs	Marked Kept %
2009	July	1	247	407	60.7%	5,225	9,266	56.4%	62	103	60.2%	7,046	13,726	51.3%
2009	August	1	184	316	58.2%	7,031	12,477	56.4%	28	55	50.9%	7,736	15,944	48.5%
2009	July	2	286	526	54.4%	2,854	5,783	49.4%	53	122	43.4%	1,706	3,828	44.6%
2009	August	2	257	470	54.7%	5,661	11,026	51.3%	111	224	49.6%	4,157	9,772	42.5%
		Average			57.0%			53.3%			51.0%			46.7%
2010	July	1	112	224	50.0%	1,877	3,957	47.4%	56	116	48.3%	1,454	2,725	53.4%
2010	August	1	121	244	49.6%	2,771	6,286	44.1%	126	295	42.7%	1,738	3,857	45.1%
2010	July	2	67	147	45.6%	588	1,316	44.7%	13	51	25.5%	509	1,366	37.3%
2010	August	2	53	95	55.8%	768	1,706	45.0%	13	25	52.0%	537	1,355	39.6%
2010	Sept.	2	56	110	50.9%	1,037	2,366	43.8%	4	10	40.0%	872	2,559	34.1%
2010	July	4	17	52	32.7%	85	194	43.8%	33	104	31.7%	593	2,068	28.7%
		Average			47.4%			44.8%			40.0%			39.7%
2011	June	1	15	27	55.6%	250	429	58.3%	19	31	61.3%	107	208	51.4%
2011	July	1	152	280	54.3%	2,419	4,837	50.0%	100	179	55.9%	1,017	2,056	49.5%
2011	August	1	94	215	43.7%	3,260	7,122	45.8%	133	279	47.7%	2,905	6,641	43.7%
2011	Sept.	1	25	41	61.0%	710	1,584	44.8%	18	40	45.0%	474	1,184	40.0%
2011	July	2	29	85	34.1%	662	1,457	45.4%	28	79	35.4%	807	2,176	37.1%
2011	August	2	99	229	43.2%	1,068	2,530	42.2%	41	140	29.3%	1,101	3,683	29.9%
2011	Sept.	2	12	20	60.0%	421	1,004	41.9%	11	25	44.0%	588	1,824	32.2%
		Average			50.3%			46.9%			45.5%			40.6%

Appendix C

Estimation of proxy estimates for $\hat{\Omega}_M^i$, $\hat{\theta}_M^i$, and $\hat{\theta}_U^i$

When onboard observer data for the charter boat fleet or voluntary trip report (VTR) data for the private boat fleet were missing or insufficient (less than 10 total encounters with legal-size coho salmon recorded), it was necessary to provide proxy estimates for $\hat{\Omega}_M^i$, $\hat{\theta}_M^i$, and $\hat{\theta}_U^i$ in order to estimate total legal-size coho salmon encounters and total release mortalities for marked and unmarked coho. As described in the report, ratio of means (ROM) estimators based on dockside angler interview data and sample data (onboard observer or VTR as appropriate) were used to estimate these proxies. This appendix provides further detail on the estimation methods and the data used to estimate the proxies.

There were 21 month-area cells with onboard charter boat observer data that could be compared to dockside interview data collected from charter boat anglers and 33 month-area cells with private boat VTR data that could be compared to dockside interview data collected from private boat anglers. The data used for the regressions and to estimate the ratio of means for the proxy estimates are shown in Appendix Tables C4 (charter boat fleet) and C5 (private boat fleet).

Methods:

The ratio of means was estimated as:

$$\widehat{ROM} = \frac{\text{parameter mean for observer or VTR sample data}}{\text{parameter mean for dockside sample data}} = \frac{\bar{Y}}{\bar{X}} \qquad [C1]$$

where the parameter is $\hat{\Omega}_M^i$, $\hat{\theta}_M^i$, or $\hat{\theta}_U^i$ for either the charter boat or private boat fleet in a specific month-area cell. The variance of $\widehat{ROM}$ was approximated by:

$$\hat{V}(\widehat{ROM}) \approx \frac{s_y^2 + (\widehat{ROM}^2 \ x \ s_x^2) - \left(2 \ x \ \widehat{ROM} \ x \ s_{yx}\right)}{n \ x \ \bar{X}^2} \qquad [C2]$$

where s_y^2 and s_x^2 are the sample variances, s_{yx} is the sample covariance, and *n* = the sample size (Cochran 1977). The proxy is used to estimate missing or insufficient data from the onboard observer or VTR sample programs ($\hat{Y}$) by,

$$\hat{Y} = \widehat{ROM} \ x \ \hat{X} \qquad [C3]$$

where $\hat{X}$ = the corresponding estimate for the parameter being estimated from the dockside sampling data corresponding to the month-area cell and fleet with missing or insufficient data. The variance of the proxy estimate is approximated by (Cochran 1977):

$$\hat{V}(\hat{Y}) \approx \frac{\hat{Y}^2}{n} \ x \left[\frac{s_y^2}{\bar{Y}^2} + \frac{s_x^2}{\bar{X}^2} - \frac{2 \ x \ s_{yx}}{\bar{Y} \ x \ \bar{X}}\right]. \qquad [C4]$$

Proxy Estimate for $\hat{\Omega}_M^i$:

Figure 2 in the report shows the relationship between the dockside interview data and the corresponding onboard observer data for the charter boat fleet (Figure 2A) and the VTR data for the private boat fleet (Figure 2B) estimates for $\hat{\Omega}_M^i$. Appendix Table C1 summarizes the ROM estimates of $\hat{\Omega}_M^i$ for the charter boat and private boat fleets.

Appendix Table C1. Summary statistics for the ROM estimators used to estimate a proxy for $\hat{\Omega}_M^i$ for the charter boat and private boat fleets.

Parameter	Statistic		
	Mean	Variance	Coef. of Variation[a]
Onboard Observer $\hat{\Omega}_M^C$	50.8%	0.006250	15.6%
Dockside Charter Interview $\hat{\Omega}_M^C$	47.1%	0.003320	12.2%
$\hat{\Omega}_M^C$ ROM	1.07981	0.001618	3.7%
VTR $\hat{\Omega}_M^P$	40.0%	0.011472	26.8%
Dockside Private Interview $\hat{\Omega}_M^P$	36.0%	0.008031	24.9%
$\hat{\Omega}_M^P$ ROM	1.10925	0.001526	3.5%

[a] Coefficient of variation = SQRT(Variance)/Mean x 100%.

Both ROM estimators were slightly greater than 1.0 indicating that the estimated proportion of coho salmon encounters that were marked coho that were kept was slightly less for the dockside interviews than observed during on-the-water sampling or reported on VTRs.

Proxy Estimate for $\hat{\theta}_U^i$:

There was not a significant linear relationship between the dockside interview and onboard charter boat observer estimates of $\hat{\theta}_U^C$ (regression $R^2 = 0.060$ and *P* for slope = 0.285). Therefore, the ratio of means estimator was selected as appropriate for estimating $\hat{\theta}_U^C$ when onboard observer data were not available. The linear relationship between the dockside interview and VTR estimates of $\hat{\theta}_U^P$ was significant (regression $R^2 = 0.456$ and *P* for slope < 0.001). However, the Y-intercept for this relationship was not significant ($P = 0.092$) indicating a line through the origin was appropriate. Since the appropriate regression line passes through the origin, for simplicity and consistency with the charter boat estimator we used the ROM estimator to estimate $\hat{\theta}_U^P$ when VTR data were not available for the private boat fleet.

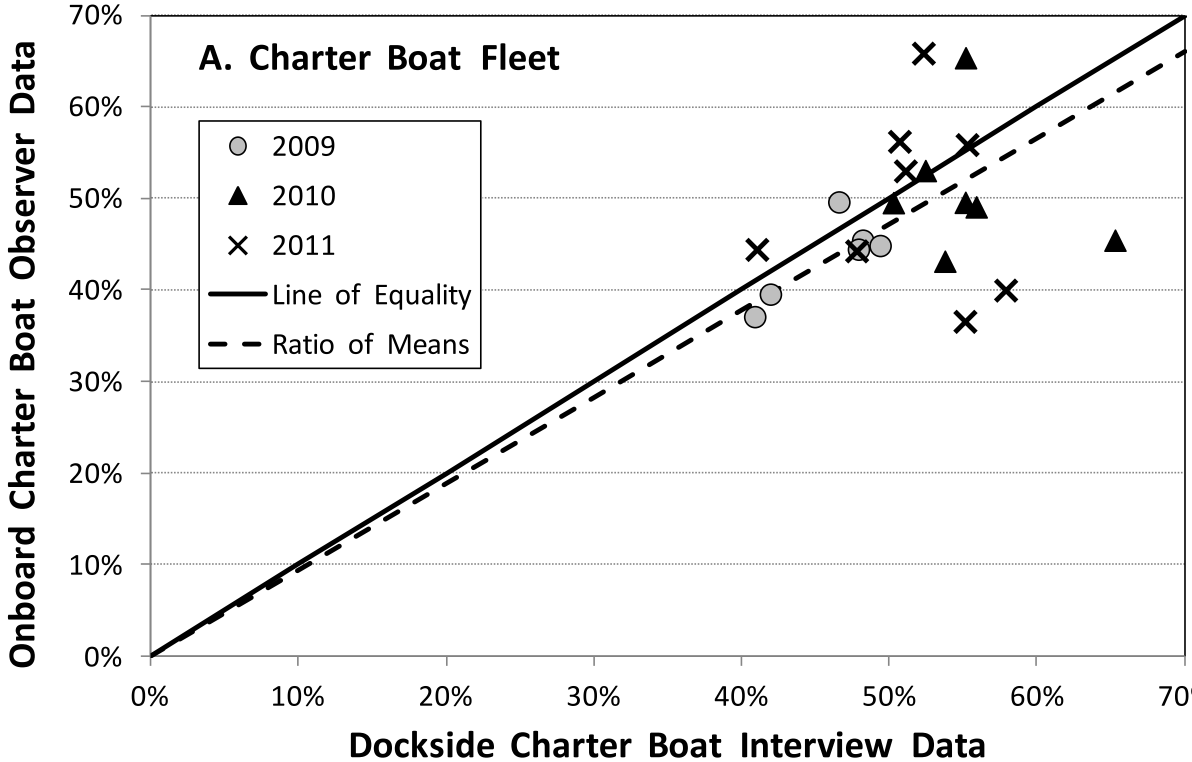
For $\hat{\theta}_U^i$, the relationship between the dockside interview data and the corresponding onboard observer data for the charter boat fleet is shown in Appendix Figure C1A and the relationship for the corresponding VTR data from the private boat fleet is shown in Appendix Figure C1B. Appendix Table C2 summarizes the ROM estimates of $\hat{\theta}_U^i$ for the charter boat and private boat fleets.

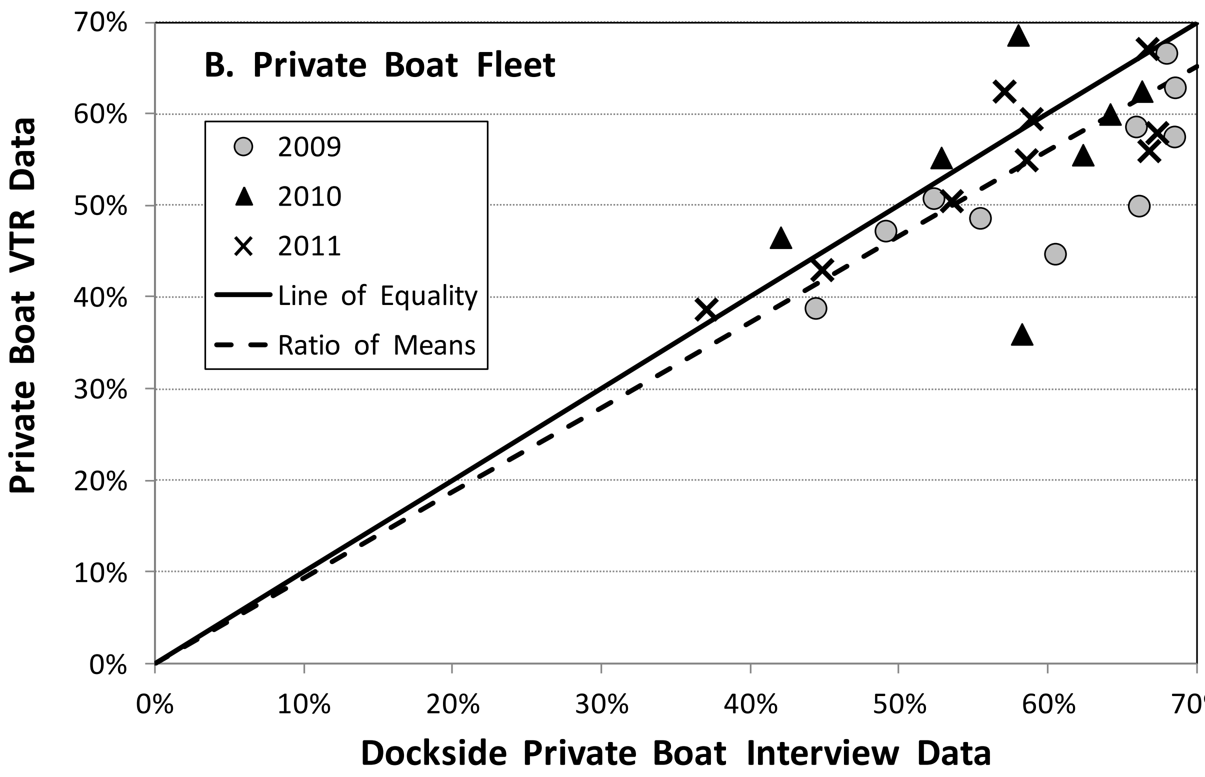
Appendix Table C2. Summary statistics for the ROM estimators used to estimate a proxy for $\hat{\theta}_U^i$ for the charter boat and private boat fleets.

Parameter	Statistic		
	Mean	Variance	Coef. of Variation[a]
Onboard Observer $\hat{\theta}_U^C$	48.2%	0.006402	16.6%
Dockside Charter Interview $\hat{\theta}_U^C$	51.4%	0.003420	11.4%
$\hat{\theta}_U^C$ ROM	0.93871	0.001311	3.9%
VTR $\hat{\theta}_U^P$	56.6%	0.010304	17.9%
Dockside Private Interview $\hat{\theta}_U^P$	60.8%	0.009796	16.3%
$\hat{\theta}_U^P$ ROM	0.93175	0.000506	2.4%

[a] Coefficient of variation = SQRT(Variance)/Mean x 100%.

Both ROM estimators were slightly less than 1.0 indicating that the estimated proportion of coho salmon encounters that were unmarked coho that were released was slightly greater for the dockside interviews than observed during on-the-water sampling or reported on VTRs.





Appendix Figure C1. Comparison of dockside interview data to (A) onboard charter boat observer data and (B) private boat voluntary trip report (VTR) data for the percent of all legal-size coho encounters that were both unmarked coho and released by the angler.

Proxy Estimate for $\hat{\theta}_M^i$:

There was not a significant linear relationship between the dockside interview and onboard charter boat observer estimates of $\hat{\theta}_M^C$ (regression R^2 = 0.044 and P for slope = 0.362). Therefore, the ratio of means estimator was selected as appropriate for estimating $\hat{\theta}_M^C$ when onboard observer data were not available. The linear relationship between the dockside interview and VTR estimates of $\hat{\theta}_M^P$ was not significant either (regression R^2 = 0.099 and P for slope = 0.075). Therefore, the ratio of means estimator was selected as appropriate for estimating $\hat{\theta}_M^P$ when VTR data were not available for the private boat fleet.

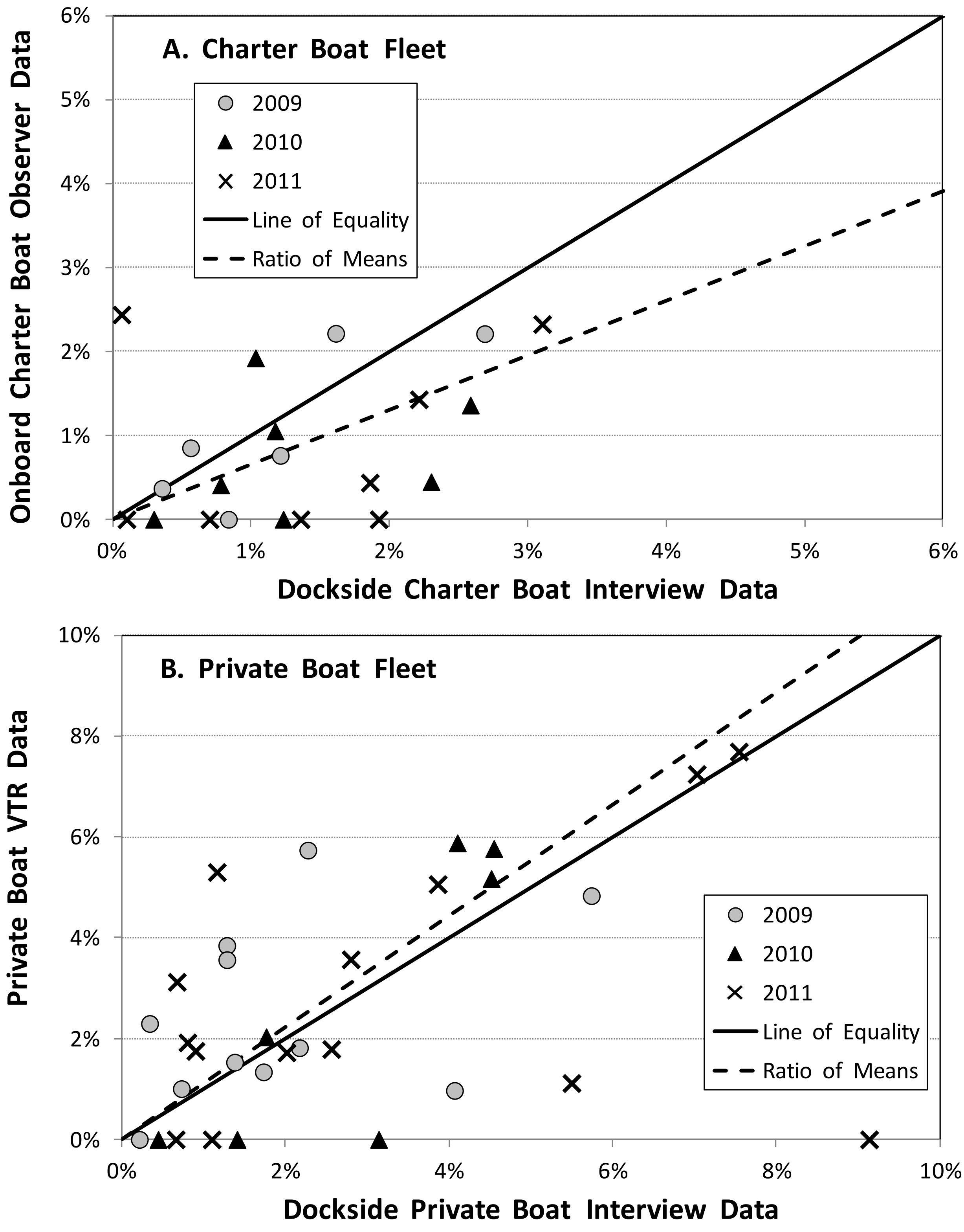
For $\hat{\theta}_M^i$, the relationship between the dockside interview data and the corresponding onboard observer data for the charter boat fleet is shown in Appendix Figure C2A and the relationship for the corresponding VTR data from the private boat fleet is shown in Appendix Figure C2B. Appendix Table C3 summarizes the ROM estimates of $\hat{\theta}_U^i$ for the charter boat and private boat fleets.

Appendix Table C3. Summary statistics for the ROM estimators used to estimate a proxy for $\hat{\theta}_M^i$ for the charter boat and private boat fleets.

Parameter	**Statistic**		
	Mean	**Variance**	**Coef. of Variation**[a]
Onboard Observer $\hat{\theta}_M^C$	0.9%	0.000080	103.1%
Dockside Charter Interview $\hat{\theta}_M^C$	1.5%	0.000102	68.9%
$\hat{\theta}_M^C$ ROM	0.59308	0.020775	24.3%
VTR $\hat{\theta}_M^P$	3.0%	0.000787	94.3%
Dockside Private Interview $\hat{\theta}_M^P$	2.7%	0.000514	84.4%
$\hat{\theta}_M^P$ ROM	1.10661	0.040873	18.3%

[a] Coefficient of variation = SQRT(Variance)/Mean x 100%.

Unlike the ROM estimates for $\hat{\Omega}_M^i$ and $\hat{\theta}_C^i$ which were very similar for the two fleets, the ROM estimates for $\hat{\theta}_C^i$ were very different for the fleets. Compared to the other ROM estimates, the ROM estimate for $\hat{\theta}_M^i$ was considerably less precise for both fleets with coefficients of variation greater than 18% compared to less than 5% for the ROM for $\hat{\Omega}_M^i$ and $\hat{\theta}_U^i$.



Appendix Figure C2. Comparison of dockside interview data to (A) onboard charter boat observer data and (B) private boat voluntary trip report (VTR) data for the percent of all legal-size coho encounters that were both marked coho and released by the angler.

Appendix Table C4. Data used for the ratio of mean proxy estimates of $\hat{\Omega}_M^i$, $\hat{\theta}_M^i$, and $\hat{\theta}_U^i$ for the charter boat fleet.

Year	Month	Catch Area	Charter Boat Onboard Observer Data				Charter Boat Dockside Data		
			Sample Size	$\hat{\Omega}_M^C$	$\hat{\theta}_M^C$	$\hat{\theta}_U^C$	$\hat{\Omega}_M^C$	$\hat{\theta}_M^C$	$\hat{\theta}_U^C$
2009	7	1	407	60.7%	2.2%	37.1%	56.4%	2.7%	40.9%
2009	8	1	316	58.2%	2.2%	39.6%	56.4%	1.6%	41.9%
2010	7	1	224	50.0%	0.4%	49.6%	47.4%	2.3%	50.3%
2010	8	1	244	49.6%	0.4%	49.6%	44.1%	0.8%	55.1%
2010	9	1	11	54.5%	0.0%	45.5%	33.5%	1.2%	65.3%
2011	6	1	27	55.6%	0.0%	44.4%	58.3%	0.7%	41.0%
2011	7	1	280	54.3%	1.4%	44.3%	50.0%	2.2%	47.8%
2011	8	1	215	43.7%	2.3%	53.0%	45.8%	3.1%	51.1%
2011	9	1	41	61.0%	2.4%	36.6%	44.8%	0.1%	55.1%
2009	6	2	33	54.5%	0.0%	45.5%	43.2%	3.6%	53.2%
2009	7	2	526	54.4%	0.8%	44.9%	49.4%	1.2%	49.4%
2009	8	2	470	54.7%	0.9%	44.5%	51.3%	0.6%	47.9%
2009	9	2	272	50.0%	0.4%	49.6%	52.9%	0.4%	46.6%
2010	7	2	147	45.6%	1.4%	53.1%	44.7%	2.6%	52.4%
2010	8	2	95	55.8%	1.1%	43.2%	45.0%	1.2%	53.8%
2010	9	2	110	50.9%	0.0%	49.1%	43.8%	0.3%	55.9%
2011	6	2	16	43.8%	0.0%	56.3%	48.0%	1.4%	50.7%
2011	7	2	85	34.1%	0.0%	65.9%	45.4%	1.9%	52.3%
2011	8	2	229	43.2%	0.4%	55.9%	42.2%	1.9%	55.3%
2011	9	2	20	60.0%	0.0%	40.0%	41.9%	0.1%	57.9%
2010	7	4	52	32.7%	1.9%	65.4%	43.8%	1.0%	55.2%

Appendix Table C5. Data used for the ratio of mean proxy estimates of $\hat{\Omega}_M^i$, $\hat{\theta}_M^i$, and $\hat{\theta}_U^i$ for the private boat fleet.

Year	Month	Catch Area	Private Boat VTR Data Sample Size	$\hat{\Omega}_M^p$	$\hat{\theta}_M^P$	$\hat{\theta}_U^p$	Private Boat Dockside Data $\hat{\Omega}_M^P$	$\hat{\theta}_M^P$	$\hat{\theta}_U^P$
2009	7	1	103	60.2%	1.0%	38.8%	51.3%	4.1%	44.4%
2009	8	1	55	50.9%	1.8%	47.3%	48.5%	2.2%	49.1%
2010	7	1	116	48.3%	5.2%	46.6%	53.4%	4.5%	42.0%
2010	8	1	295	42.7%	2.0%	55.3%	45.1%	1.8%	52.8%
2011	6	1	31	61.3%	0.0%	38.7%	51.4%	9.1%	37.0%
2011	7	1	179	55.9%	1.1%	43.0%	49.5%	5.5%	44.8%
2011	8	1	279	47.7%	1.8%	50.5%	43.7%	2.6%	53.5%
2011	9	1	40	45.0%	0.0%	55.0%	40.0%	1.1%	58.5%
2009	7	2	122	43.4%	5.7%	50.8%	44.6%	2.3%	52.3%
2009	8	2	224	49.6%	1.3%	48.7%	42.5%	1.7%	55.4%
2010	7	2	51	25.5%	5.9%	68.6%	37.3%	4.1%	58.0%
2010	8	2	25	52.0%	12.0%	36.0%	39.6%	1.8%	58.2%
2010	9	2	10	40.0%	0.0%	60.0%	34.1%	1.4%	64.2%
2011	7	2	79	35.4%	5.1%	59.5%	37.1%	3.9%	58.9%
2011	8	2	140	29.3%	3.6%	67.1%	29.9%	2.8%	66.7%
2011	9	2	25	44.0%	0.0%	56.0%	32.2%	0.7%	66.8%
2009	6	3	78	29.5%	3.8%	66.7%	30.5%	1.3%	67.9%
2009	7	3	497	41.4%	1.0%	57.5%	30.6%	0.7%	68.5%
2009	8	3	505	51.5%	3.6%	44.8%	38.2%	1.3%	60.5%
2009	9	3	20	50.0%	0.0%	50.0%	33.5%	0.2%	66.1%
2010	8	3	18	33.3%	0.0%	55.6%	36.9%	0.4%	62.3%
2011	6	3	32	34.4%	3.1%	62.5%	41.6%	0.7%	57.0%
2011	7	3	104	39.4%	1.9%	58.7%	24.9%	0.8%	74.0%
2011	8	3	132	28.8%	5.3%	65.9%	28.3%	1.2%	70.1%
2011	9	3	171	24.6%	1.8%	73.7%	19.8%	0.9%	79.3%
2009	7	4	1,117	36.5%	4.8%	58.6%	27.6%	5.7%	65.9%
2009	8	4	914	35.3%	1.5%	62.9%	29.4%	1.4%	68.5%
2009	9	4	87	36.8%	2.3%	59.8%	28.2%	0.3%	71.1%
2010	7	4	104	31.7%	5.8%	62.5%	28.7%	4.5%	66.3%
2010	8	4	59	28.8%	0.0%	71.2%	26.5%	3.1%	69.4%
2011	6	4	13	15.4%	7.7%	76.9%	34.8%	7.5%	57.4%
2011	7	4	69	34.8%	7.2%	58.0%	24.7%	7.0%	67.3%
2011	8	4	58	36.2%	1.7%	62.1%	25.3%	2.0%	71.8%

Appendix D

Appendix Table D1. Comparison of the estimates by the current and proposed methods for the total number of legal-size coho salmon encountered, by year and catch area (2009-2011).

Year	Catch Area	Current Method Estimate	CV[a]	Proposed Method Estimate	CV	Percent Difference[b]
2009	1	137,573	3.5%	152,206	7.4%	10.6%
	2	98,896	3.7%	105,397	3.6%	6.6%
	3	13,856	5.1%	14,628	4.9%	5.6%
	4	34,508	4.2%	35,740	4.2%	3.6%
	Total	284,832		307,970		8.1%
2010	1	50,994	4.0%	54,153	4.4%	6.2%
	2	25,174	6.0%	29,300	11.7%	16.4%
	3	2,910	25.1%	3,350	18.3%	15.1%
	4	11,570	12.2%	12,018	11.9%	3.9%
	Total	90,647		98,821		9.0%
2011	1	52,695	3.7%	54,467	4.0%	3.4%
	2	34,134	5.9%	38,039	7.2%	11.4%
	3	6,040	8.4%	6,740	8.0%	11.6%
	4	7,653	11.1%	8,839	11.8%	15.5%
	Total	100,522		108,085		7.5%

[a] CV = coefficient if variation.

[b] Percent Difference = (Proposed Method - Current Method)/Current Method x 100%.

Appendix Table D2. Comparison of the estimates by the current and proposed methods for the total number of unmarked release mortalities for legal-size coho salmon, by year and catch area (2009-2011).

Year	Catch Area	Current Method Estimate	Current Method CV[a]	Proposed Method Estimate	Proposed Method CV	Percent Difference[b]
2009	1	7,527	8.9%	9,249	11.7%	22.9%
	2	6,304	8.1%	7,024	4.6%	11.4%
	3	974	10.2%	1,024	5.6%	5.2%
	4	2,964	6.8%	3,026	4.6%	2.1%
	Total	17,769		20,323		14.4%
2010	1	3,651	7.7%	3,945	5.6%	8.0%
	2	1,766	12.1%	2,222	15.0%	25.8%
	3	242	42.1%	269	20.5%	11.2%
	4	1,104	17.9%	1,112	13.2%	0.7%
	Total	6,763		7,547		11.6%
2011	1	3,643	7.6%	3,763	5.4%	3.3%
	2	2,841	10.0%	3,281	8.3%	15.5%
	3	559	12.8%	615	8.7%	10.1%
	4	643	18.4%	750	13.2%	16.6%
	Total	7,686		8,409		9.4%

[a] CV = coefficient if variation.

[b] Percent Difference = (Proposed Method - Current Method)/Current Method x 100%.

Appendix Table D3. Comparison of the estimates by the current and proposed methods for the total number of marked release mortalities for legal-size coho salmon, by year and catch area (2009-2011).

Year	Catch Area	Current Method Estimate	Current Method CV[a]	Proposed Method Estimate	Proposed Method CV	Percent Difference[b]
2009	1	702	1.4%	363	58.1%	-48.4%
	2	450	2.3%	211	23.7%	-53.1%
	3	58	4.0%	53	18.0%	-9.3%
	4	110	2.9%	139	12.6%	26.5%
	Total	1,320		765		-42.0%
2010	1	209	1.9%	150	27.3%	-28.5%
	2	105	3.8%	129	37.8%	22.8%
	3	10	4.5%	5	26.1%	-52.7%
	4	30	4.8%	65	30.2%	117.3%
	Total	354		348		-1.6%
2011	1	223	1.4%	127	26.9%	-42.9%
	2	115	2.8%	127	32.8%	10.3%
	3	17	4.0%	35	26.9%	108.2%
	4	25	4.3%	69	36.3%	175.4%
	Total	380		358		-5.7%

[a] CV = coefficient if variation.

[b] Percent Difference = (Proposed Method - Current Method)/Current Method x 100%.

Oregon
John A Kitzhaber, MD., Governor

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September 10, 2012

To: Oregon PFMC Members Steve Williams, Dorothy Lowman, and Jeff Feldner
From: Chris Kern, ODFW Ocean Salmon Technical Program Manager
Subject: Request for SSC and STT review of proposed changes to the A13/OCN workgroup coho marine survival index

The current methodology for determining maximum allowable fishery impacts for OCN coho utilizes a marine survival index, derived by dividing OPI hatchery jack returns by total OPI hatchery smolts released from the same brood year. When this method was developed, it was recognized that survival rates of OPI hatchery coho, predominately from Columbia River stocks, may not fully reflect survival rates of coastal naturally-produced coho; however, lacking suitable alternatives, this method provided the best available information. Since the adoption of A13 and the OCN work group recommendations, new information has become available from ODFW's Life Cycle Monitoring program (LCM) which provides an alternative for predicting adult survival.

This new information allows for estimation of smolt abundance and jack returns for wild fish, which can be used in place of OPI hatchery analogs to index marine survival. The LCM index is directly applicable to OCN populations, and initial results confirm that it more appropriately captures the range of variation in observed OCN adult survival rates. The proposed revision would be a technical adjustment in predicting the categories of expected adult survival rates only. No changes to allowable exploitation rates, categorical equivalents to adult survival rates, or parental spawner abundance categories are proposed. The original language of A13 states that, should a better predictor be developed, the marine survival index may be replaced without plan amendment, following review and approval by the SSC and the Council.

It is ODFW's intent to propose these revisions for consideration during planning for 2013 fisheries, and we are requesting that the Council add this item to the methodology review for STT and SSC salmon subcommittee consideration at their October 10-11, 2012 meeting in Portland. We anticipate that the completed analysis will be distributed to both groups by Monday, September 24, 2012.

Thank you for your consideration,

Chris Kern

Agenda Item E.2.b
Supplemental SAS Report
September 2012

SALMON ADVISORY SUBPANEL REPORT ON 2012 SALMON METHODOLOGY REVIEW

The Salmon Advisory Subpanel (SAS) supports review of the Northwest Indian Fish Commission report on comparison of release mortalities by the ocean coho fisheries in mark-selective fisheries.

The SAS also requests the Southwest Region continue to investigate the feasibility of an abundance based management approach for California Coastal Chinook, and submit their findings to the Council through the salmon methodology review process.

PFMC
09/15/12

SCIENTIFIC AND STATISTICAL COMMITTEE REPORT ON 2012 SALMON METHODOLOGY REVIEW

The Scientific and Statistical Committee (SSC) met with Mr. Chuck Tracy and Dr. Robert Kope to identify which of the following topics prioritized by the Council at the April meeting would be available for the 2012 Salmon Methodology Review.

1. Implementation and assessment of proposed bias-correction methods for mark-selective fisheries into the Coho Fishery Regulation Assessment Model (FRAM). [Model Evaluation Workgroup (MEW)]
2. Review of modifications to Chinook FRAM size limit algorithms implemented to allow evaluation of changes to size-limits. [MEW]
3. Review of alternative forecast methodologies for the Sacramento Fall Chinook index. [Salmon Technical Team (STT)]
4. A multi-year review and evaluation of preseason forecasts and postseason estimates for mark-selective coho fisheries both north and south of Cape Falcon. [STT]
5. Preliminary assessment of the feasibility of abundance-based management for California Coastal Chinook. [National Marine Fisheries Service Southwest Region]
6. A user’s manual for the Visual Studio version of FRAM. [MEW]
7. Investigate Chinook FRAM’s sensitivity to age composition forecasts. [MEW]
8. Evaluate the feasibility of incorporating bias-correction methods for mark-selective fisheries into Chinook FRAM. [MEW]
9. Develop recommendations on management methodologies for Sacramento River Winter Chinook that better achieve the Council’s objective, particularly at low abundance. [STT]

Reports on topics 1, 2 and 4 will be available for the methodology review. The topic 4 report will be focused on impacts to Washington natural coastal coho stocks in Washington mark-selective ocean fisheries.

Two additional review topics were identified for review: a) comparison of two methods for estimating coho salmon encounters and release mortalities in the ocean mark-selective fishery [Northwest Indian Fisheries Commission]; and b) evaluation of alternative marine survival indices for the Oregon Coastal Natural (OCN) coho matrix [Oregon Department of Fish and Wildlife].

A report was also prepared on topic 9 and is available on the Council website. The SSC agrees with the STT that the topic 9 report would not be appropriate as a Salmon Methodology review topic at this time because the specific recommendations were not proposed for Council management in 2013.

The SSC will review reports on these topics at the November Council meeting. The SSC Salmon Subcommittee and STT will hold a joint meeting on October 10 and 11 in Portland, OR to review these issues. The SSC requires proper documentation and ample review time to make efficient use of the SSC Salmon Subcommittee’s time. Materials for review should be submitted to the Council office by September 24. Agencies should be responsible for ensuring that materials submitted to the SSC are technically sound, comprehensive, clearly documented, and identified by author.

PFMC
09/14/12

SALMON TECHNICAL TEAM REPORT ON 2012 SALMON METHODOLOGY REVIEW

The Salmon Technical Team (STT) was identified as the responsible advisory body for three Methodology Review topics:

1. Review alternative forecast methodologies for the Sacramento Fall Chinook index.
2. A multi-year review and evaluation of preseason forecasts and postseason estimates for mark-selective coho fisheries both north and south of Cape Falcon.
3. Develop recommendations on management methodologies for Sacramento River winter Chinook that better achieve Council's objective, particularly at low abundance.

Work on reviewing alternative forecast methodologies for the Sacramento Index is underway, but will not be completed in time for the Methodology Review.

The review of mark-selective coho fisheries, as written in the Council-adopted list topics, was presented at the 2011 Methodology Review. However, the STT will be presenting an analysis of recent (2006-2010) mark-selective recreational fishery impacts on Washington coast coho stocks. The description of this topic should be amended to reflect the subject of the analysis.

For the winter-run topic, the STT notes that alternative winter-run control rules, including those with *de minimis* exploitation rate provisions at low abundance, have been analyzed by the Southwest Fisheries Science Center using a management strategy evaluation model framework. The report detailing this work, entitled "Management strategy evaluation for Sacramento River winter Chinook", was uploaded to the Council website prior to the March 2012 meeting. This analysis has been through extensive peer review and a publication is currently in press. Justification for the form of the winter-run management framework was provided by the Southwest Region at the March 2012 meeting, both as a presentation to the Council and as a white paper with the title "Abundance-based ocean salmon fisheries management framework for Sacramento River Winter-run Chinook." Because alternative winter-run control rules with *de minimis* provisions have been analyzed, the model used for the analysis has been peer reviewed, and the requested Methodology Review topic does not pertain to a method under consideration for Council adoption for the 2013 preseason fishery planning process, the STT will not be bringing this topic forward for the Methodology Review.

The STT, therefore, anticipates evaluation of the following five topics at the 2012 Methodology Review:

1. Implementation and assessment of proposed bias-corrections methods for mark-selective fisheries into the Coho FRAM.
2. Review of modifications to Chinook FRAM size limit algorithms implemented to allow evaluation of changes to size-limits.
3. Impacts of mark-selective ocean recreational fisheries on Washington Coast coho stocks.
4. Revision to the marine survival index for the Oregon Coast natural (OCN) coho workgroup matrix.
5. Comparison of two methods for estimating coho salmon encounters and release mortalities in the ocean mark-selected fishery.

PFMC
09/14/12

Salmon Methodology Review

The tribes support having the following topics for the annual Salmon Methodology Review:

1) The NW Indian Fisheries Commissions, Ocean Mark Selective Fishery Methods Comparison be added to the for review in October;

2) Implementation and assessment of the bias-correction methods in Coho FRAM;

3) A multi-year review and evaluation of preseason forecasts and postseason estimates for mark selective coho fisheries both north and south of Cape Falcon; and

4) Evaluate the feasibility of incorporating bias correction methods in Chinook FRAM for fishery-related mortality introduced by mark selective fisheries.

SALMON FISHERY MANAGEMENT PLAN (FMP) AMENDMENT 17 ANNUAL REGULATORY CYCLE AND MINOR UPDATES

In the process of finalizing Amendment 16 to the Pacific Coast Salmon Fishery Management Plan (FMP), a number of items in the FMP were identified as needing to be updated to meet current practices, technology, regulatory protocol, or to correct inconsistencies between Council final action and the final published FMP. In addition, one element of Amendment 16 was disapproved, the maximum fishing mortality threshold (MFMT) for Quillayute fall coho. Most of these issues were identified under the scoping of Amendment 18, Update of Essential Fish Habitat for Salmon, at the March 2012 Council meeting; however, the Council subsequently determined that these issues should be addressed in a separate process.

A NMFS-led workgroup considered the scope of these issues, relationship to previous National Environmental Policy Act (NEPA) analyses, and anticipated impacts to the human environment and identified several that meet the criteria for Categorical Exclusion (CE) under NAO 216-6, specifically sections 6.03d.4(a): ongoing or recurring fisheries actions of a routine administrative nature and 6.03d.4(b): minor technical additions, corrections, or changes to an FMP. These issues are largely administrative in nature or have been previously analyzed; therefore, it was not necessary to develop additional alternatives, and the Council is being asked to take final action on Amendment 17 (Agenda Item E.3.a, Attachment 1) at this meeting.

One issue in particular is also time-sensitive – changing the regulatory cycle from May 1-April 30 to May 15-May 14. This would allow more time between the March and April Council meetings, and provide additional time for information from anticipated impacts from Canadian and Alaskan fisheries to be incorporated into the public comment period on management alternatives and the North of Falcon process. However, scheduling Council meetings requires more than a year of advance planning, so if approved at this meeting, the earliest this proposed change could be implemented would be 2014, and any delay would likely push implementation back another year or more.

Council Action:

1. **Adopt minor corrections to the Salmon FMP.**
2. **Provide guidance for addressing unresolved issues.**

Reference Materials:

1. Agenda Item E.3.a, Attachment 1: Pacific Coast Salmon Fishery Management Plan Amendment 17: Annual Regulatory Cycle and Minor Updates.

Agenda Order:

a. Agenda Item Overview — Chuck Tracy
b. Reports and Comments of Advisory Bodies and Management Entities
c. Public Comment
d. **Council Action**: Adopt Final Recommendations for Modifying the Annual Regulatory Cycle and Other Minor FMP Changes

PFMC
08/24/12

Pacific Coast Salmon Fishery Management Plan Amendment 17: Annual Regulatory Cycle and Minor Updates

(RIN 0648-BC28)

In the process of finalizing Amendment 16 to the Pacific Coast Salmon Fishery Management Plan (FMP), a number of items in the FMP were identified as needing to be updated to meet current practices, technology, and regulatory protocol. A series of meetings were held by a National Environmental Policy Act (NEPA) workgroup to consider the scope of these issues, relationship to previous NEPA analyses, and anticipated impacts to the human environment[1]. At the conclusion of these meetings, the workgroup determined that there were 16 separate issues to address, having no connecting actions among them. There are no significant environmental effects associated with any of these issues, and most have previously been analyzed in a NEPA document. For those needing NEPA documentation, the group felt that those items meet the criteria for Categorical Exclusion (CE) under NAO 216-6, specifically sections 6.03d.4(a) ongoing or recurring fisheries actions of a routine administrative nature and 6.03d.4(b) minor technical additions, corrections, or changes to an FMP. The group felt that these items do not meet the criteria for exceptions for CEs under the same order. Therefore, the group will be recommending to the deciding official that a CE memorandum is the appropriate NEPA document for this FMP Amendment.

The 16 issues to be addressed in Amendment 17 are listed below, in an order which generally corresponds to the affected sections of the FMP. Most issues only involve small text changes in the FMP. Changes recommended by the NEPA workgroup are indicated in redline/strikeout. Page numbers refer to the February 2012 version of the Salmon FMP (http://www.pcouncil.org/salmon/fishery-management-plan/current-management-plan/).

[1] Meetings were held on February 6, 2012, May 9, 2012, May 24, 2012, and June 5, 2012. The NEPA workgroup consisted of: Chuck Tracy (PFMC), Mike Burner (PFMC), Peter Dygert (NMFS-NWR), Peggy Mundy (NMFS-NWR), Sheila Lynch (NOAA-GCNW), and Sarah Biegel (NMFS-NWR NEPA Coordinator).

Issue 1. Maximum Fishing Mortality Threshold (MFMT) for Quillayute Fall Coho.

Description of the issue

One element of Amendment 16 was disapproved, the maximum fishing mortality threshold (MFMT) for Quillayute fall coho. The Council recommended adopting an MFMT of 0.65 for all Washington Coast coho to be consistent with the maximum exploitation rate allowed under the Pacific Salmon Treaty 2002 Southern Coho Management Plan. However, the Council had already accepted the Scientific and Statistical Committee approved estimate of 0.59 as the best estimate of F_{MSY} for Quillayute fall coho, as presented in Appendix E of the Amendment 16 Environmental Assessment. Because MFMT cannot exceed F_{MSY}, that element of Amendment 16 was not approved and therefore, MFMT is currently undefined for Quillayute fall coho in the FMP.

NEPA Considerations

This issue was analyzed in the EA for Amendment 16. Therefore, no further NEPA analysis is required, unless the Council were to choose to adopt an MFMT value outside the range of values already analyzed. The decisonmaker is referred to the EA for Amendment 16.

Affected FMP language

Table 3-1 (FMP page 25):

Species	Stock	MFMT
Coho	Quillayute Fall	MFMT ~~Undefined~~59%; FMSY=59% (SAC 2011b)

Issue 2. Update Table 3-1 relative to two Columbia River Chinook stocks.

Description of the issue

Table 3-1 of the FMP incorrectly states that Columbia Upper River Bright Fall and Columbia Upper River Summer Chinook salmon stocks are in the Far North Migrating Chinook Complex (FNMCC); this is not consistent with the Council's decision under Amendment 16. They are, however, subject to the International Exception.

NEPA Considerations

This issue was analyzed in the EA for Amendment 16. We are only correcting an error from Amendment 16. The decision maker is referred to the EA for Amendment 16.

Affected FMP language

Table 3-1 (FMP page 22):

Species	Stock	ACL
Chinook	Columbia River Upper River Bright Fall	~~FNMC complex;~~ International exception applies. ACLs are not applicable.
	Columbia Upper River Summer	

Issue 3. Update Table 3-1 relative to MFMT for four Chinook salmon stocks.

Description of the issue

Table 3-1 of the FMP states that the MFMT for four Chinook salmon stocks (Smith River, Southern Oregon, Central and Northern Oregon, and Quillayute spring/summer) is “undefined” when, in fact, , the MFMT value should be 0.78, see table 2-9 of the EA for Amendment 16, based on the Council’s motion in June 2011.

NEPA Considerations

The issue of MFMT for the four Chinook salmon stocks (Smith River, Southern Oregon, Central and Northern Oregon, and Quillayute spring/summer) was analyzed in the EA for Amendment 16. We are only correcting an error from Amendment 16. The decision maker is referred to the EA for Amendment 16.

Affected FMP language

Table 3-1 (FMP pages 20 and 21):

Species	**Stock**	**MFMT (F_{MSY})**
Chinook	Smith River	~~Undefined~~78% Proxy (SAC 2011a)
	Southern Oregon	~~Undefined~~78% Proxy (SAC 2011a)
	Central and Northern Oregon	~~Undefined~~78% Proxy (SAC 2011a)
	Quillayute Spring/Summer	~~Undefined~~78% Proxy (SAC 2011a)

Issue 4. Update information relative to ESA-listed Chinook salmon

Description of the issue

Section 5.2.1.1 of the FMP states that Sacramento River spring Chinook and California coastal Chinook are listed as threatened under the state's ESA. While this is correct, the paragraph should be modified to show the corresponding ESUs are actually listed as threatened under the Federal ESA.

NEPA Considerations

There is no environmental effect, simply updating language to reflect the correct status of these fish stocks. This issue meets the NAO 216-6 criteria for a CE under 6.03d.4(b) minor technical additions, corrections, or changes to an FMP.

Affected FMP language

Section 5.2.1.1 Management Considerations for Chinook Salmon South of Horse Mountain (FMP page 47):

"… Special consideration must be given to meeting the consultation or recovery standards for endangered Sacramento River winter Chinook, threatened Sacramento River Spring Chinook and threatened California Coastal Chinook in the area south of Point Arena and for threatened Snake River fall Chinook north of Pigeon Point. ~~Sacramento River spring Chinook and California coastal Chinook are also listed as threatened under the state ESA.~~"

Issue 5. Update description of OPI coho

Description of the issue

Section 5.2.2.1 describes obsolete modeling protocol for OPI coho; currently a Mixed Stock Model (MSM) system is used in measuring annual abundance of coho salmon. The MSM was adopted after approval by the SSC's methodology review. It may be better to make the text in this section more broad, to avoid multiple amendments each time a new methodology is approved by the SSC.

NEPA Considerations

Annual management measures are analyzed in an EA. This issue meets the NAO 216-6 criteria for a CE under 6.03d.4(b) minor technical additions, corrections, or changes to an FMP.

Affected FMP language

Section 5.2.2.1 Management Considerations for Coho Salmon South of Horse Mountain (FMP page 48):

5.2.2.1 South of Cape Falcon

Columbia River, Oregon, and California coho are managed together within the framework of the Oregon Production Index (OPI) since these fish are intermixed in the ocean fishery. These coho contribute primarily to ocean fisheries off the southern Washington coast and Oregon coast; coho fisheries are prohibited off the California coast. Ocean fishery objectives for the OPI area address the following (1) conservation and recovery of Oregon and California coastal coho, including consultation or recovery standards for LCN, OCN, SONCC and California Central coast coho; (2) providing viable fisheries inside the Columbia River, and; (3) impacts on conservation objectives for other key stocks.

Until 2010, t~~T~~he OPI wasis used as a measure of the annual abundance of adult three-year-old coho salmon resulting from production in the Columbia River and Oregon and California coastal basins. The index itself was~~is~~ simply the combined number of adult coho that can be accounted for within the general area from Leadbetter Point, Washington to as far south as coho are found. ~~Currently, it is the sum of (1) ocean sport and troll fishery impacts in the ocean south of Leadbetter Point, Washington, regardless of origin; (2) Oregon and California coastal hatchery returns; (3) the Columbia River in-river runs; (4) Oregon coastal natural spawner escapement and (5) Oregon coastal inside fishery impacts. Most of the California production is from hatcheries which provide a very small portion of the total hatchery production in the OPI area.~~Starting in 2010 a new method has been used to estimate ocean abundance. A "Mixed Stock Model" (MSM) uses hatchery returns, spawning escapements, and coded-wire-tag (CWT) data (recoveries and hatchery mark rates) and estimates of catch and incidental mortalities in all fisheries for OPI origin stocks. The primary difference between the traditional OPI and the MSM system is in the accounting of OPI origin stocks in ocean fisheries. In the traditional OPI accounting system, all coho in ocean fisheries south of Leadbetter Point, Washington were treated as OPI origin stocks. None of the coho caught in fisheries north of Leadbetter Point, Washington were counted in the OPI. The general assumption--backed by CWT data--was that the number of non-OPI coho caught South of Leadbetter Point equaled the number of OPI coho caught North of Leadbetter Point. This was a good assumption until 1996, when all coho fisheries in the OPI area were closed. Since then, OPI Area fisheries have been more restricted than northern fisheries. In the MSM system, CWT data are used to estimate the harvest of

OPI area stocks regardless of where they were caught. Thus, the MSM method takes into account changing harvest patterns in ocean fisheries that were assumed to be static in the original index.

The methodology used to estimate ocean abundance of OPI-area coho stocks may continue to evolve and will always be approved by the SSC in order to use the best available science.

Issue 6. Update language for coho stocks north of Cape Falcon

Description of the issue

FMP section 5.2.2.2 regarding management of coho salmon north of Cape Falcon needs to add Columbia River and southern British Columbia stocks to the stocks for which conservation objectives must be considered.

NEPA Considerations

Management already considers these stocks and has for many years. They are included in the EA for annual management measures. This issue meets the NAO 216-6 criteria for a CE under 6.03d.4(b) minor technical additions, corrections, or changes to an FMP.

Affected FMP language

Section 5.2.2.2 Management Considerations for Coho Salmon North of Horse Mountain (FMP page 48):

"…Coho occurring north of Cape Falcon, Oregon are comprised of a composite of coho stocks originating in Oregon, Washington, and southern British Columbia. Ocean fisheries operating in this area must balance management considerations for stock-specific conservation objectives for Southern Oregon/Northern California, Oregon Coast, Southwest Washington, Olympic Peninsula, ~~and~~ Puget Sound, Columbia River, and southern British Columbia stocks."

Issue 7. Revision to pink salmon text

Description of the issue

FMP section 5.2.3 requires minor text update to reflect the low actual exploitation rates of pink salmon in the ocean salmon fishery.

NEPA Considerations

No environmental impact, simply making language more accurate. Fishery impacts on pink salmon are analyzed in an EA annually. This issue meets the NAO 216-6 criteria for a CE under 6.03d.4(b) minor technical additions, corrections, or changes to an FMP.

Affected FMP language

Section 5.2.3 Management Considerations for Pink Salmon (FMP page 49):

5.2.3 Pink Salmon

Ocean pink salmon harvests occur off the Washington coast and are predominantly of Fraser River origin. Pink salmon of Puget Sound origin represent a minor portion of the ocean harvest. ~~although o~~Ocean impacts ~~can be significant~~are generally negligible in relation to the terminal return during years of very low abundance.

The Fraser River Panel of the PSC manages fisheries for pink salmon in the Fraser River Panel Area (U.S.) north of 48° N latitude to meet Fraser River natural spawning escapement and U.S./Canada allocation requirements. The Council manages pink salmon harvests in that portion of the EEZ which is not in the Fraser River Panel Area (U.S.) waters consistent with Fraser River Panel management intent and in accordance with the conservation objectives for Puget Sound pink salmon.

Pink salmon management objectives must address meeting natural spawning escapement objectives, allowing ocean pink harvest within fixed constraints of coho and Chinook harvest ceilings and providing for treaty allocation requirements.

Issue 8. *Federal Register* notice of annual management measures

Description of the issue

In FMP section 9, remove the schedule item "Close of public comment period." The annual management measures are published in the Federal Register as a Final Rule; public comment periods are applied to "Proposed Rules" or "Interim Final Rules," but not "Final Rules."

NEPA Considerations

No expected environmental effects as this would be an administrative change. This issue meets the NAO 216-6 criteria for a CE under 6.03d.4(a) ongoing or recurring fisheries actions of a routine administrative nature and 6.03d.4(b) minor technical additions, corrections, or changes to an FMP.

Affected FMP language

Section 9 Schedule and procedures for preseason modification of regulations (FMP page 70):

The process and schedule for setting the preseason regulations will be approximately as follows:

Approximate Date	Action
First week of March	Notice published in the Federal Register announcing the availability of team and Council documents, the dates and location of the two Council meetings, the dates and locations of the public hearings, and publishing the complete schedule for determining proposed and final modifications to the management measures. Salmon Technical Team reports which review the previous salmon season, project the expected salmon stock abundance for the coming season, and describe any changes in estimation procedures, are available to the public from the Council office.
First or second full week of March	Council and advisory entities meet to adopt a range of season regulatory alternatives for formal public hearing. Proposed options are initially developed by the Salmon Advisory Subpanel and further refined after analysis by the STT, public comment, and consideration by the Council.
Following March Council meeting	Council newsletter, public hearing announcement, and STT/Council staff report are released which outline and analyze Council-adopted alternatives. The STT/staff report includes a description of the alternatives, brief rationale for their selection, and an analysis of expected biological and economic impacts.
Last week of March or first week of April	Formal public hearings on the proposed salmon management alternatives.
First or second full week of April	Council and advisory entities meet to adopt final regulatory measure recommendations for implementation by the Secretary of Commerce.
First week of May	Final notice of Secretary of Commerce decision and final management measures in Federal Register.
~~May 15~~	~~Close of public comment period.~~

Issue 9. Update minimum size limits

Description of the issue

FMP section 6.2 describes examples of minimum size limits commonly used in ocean salmon fishery management. This language should be more broad as size limits can change annually in response to management needs. Minimum size limits will be specified in the annual management measures.

NEPA Considerations

Minimum size limits are set annually, and their impacts analyzed in an EA. This issue meets the NAO 216-6 criteria for a CE under 6.03d.4(b) minor technical additions, corrections, or changes to an FMP.

Affected FMP language

Section 6.2 Minimum Harvest Lengths for Ocean Commercial and Recreational Fisheries (FMP page 60):

6.2 MINIMUM HARVEST LENGTHS FOR OCEAN COMMERCIAL AND RECREATIONAL FISHERIES

Minimum size limits for ocean commercial and recreational fisheries may be changed each year during the preseason regulatory process or modified inseason under the procedures of Section 10.2. Recommended changes must serve a useful purpose which is clearly described and justified, and projections made of the probable impacts resulting from the change.

Minimum size limits have been relatively stable since the Council began management in 1977 and any changes are expected to occur infrequently. From 1977 through 1995 there were no changes in the size limits for non-Indian commercial fisheries except for the decision to use the California coho minimum length for the entire Klamath management area which extends into Oregon. Recreational minimum size limits did not change between 1988 and 1995. However, since the mid 2000's, size limits have changed more frequently to reduce impact on stocks of concern. The minimum size limits listed below (total length in inches) have been consistently used by the Council with only infrequent modifications in limited areas to address special needs or situations.

-TABLE 6-1.Minimum size limits.

	Chinook		Coho		Pink	
	Troll	Sport	Troll	Sport	Troll	Sport
North of Cape Falcon	28.0	24.0	16.0	16.0	None	None
Cape Falcon to OR/CA Border	28.0	24.0	16.0	16.0	None	None
South of OR/CA Border.	26.0	20.0	-	-	None	24

Chinook minimum size limits are set annually to address several specific issues, including but not limited to: targeting/avoiding specific stocks (Sacramento Winter Chinook) or broods (age-3/4 Klamath fall Chinook), market demand (preference for larger fish), enforcement (regional consistency), season length (slower quota attainment) bycatch reduction, and data collection (CWT recovery of smaller fish). Commercial size limits for Chinook are generally between 26 and 28 inches total length, and recreational size limits are generally between 20 and 24 inches total length. Coho minimum size limits are consistently set at 16 inches total length for both commercial and recreational fisheries. In Oregon and Washington, where pink salmon are available, there are no minimum size limits.

Issue 10. Update language on mark-selective fisheries

Description of the issue

FMP section 6.5.3 requires updates to the language to specify "mark-selective," rather than simply "selective" fisheries.

NEPA Considerations

Using mark-selective fisheries in the ocean salmon fishery was analyzed in the FPEIS (2003). This issue meets the NAO 216-6 criteria for a CE under 6.03d.4(b) minor technical additions, corrections, or changes to an FMP.

Affected FMP language

6.5.3 Species-Specific and Other Selective Fisheries

6.5.3.1 Guidelines

In addition to the all-species and single or limited species seasons established for the commercial and recreational fisheries, other species-limited fisheries, such as "ratio" fisheries and fisheries selective for marked or hatchery fish, may be adopted by the Council during the preseason regulatory process. In adopting such fisheries, the Council will consider the following guidelines:

1. Harvestable fish of the target species are available.

2. Harvest impacts on incidental species will not exceed allowable levels determined in the management plan.

3. Proven, documented, selective gear exists (if not, only an experimental fishery should be considered).

4. Significant wastage of incidental species will not occur or a written economic analysis demonstrates the landed value of the target species exceeds the potential landed value of the wasted species.

5. The ~~species specific or ratio~~ selective fishery will occur in an acceptable time and area where wastage can be minimized and target stocks are maximally available.

6. Implementation of selective fisheries for marked or hatchery fish must be in accordance with U.S. v. Washington stipulation and order concerning co-management and mass marking (Case No. 9213, Subproceeding No. 96-3) and any subsequent stipulations or orders of the U.S. District Court, and consistent with international objectives under the PST (e.g., to ensure the integrity of the coded-wire tag program).

6.5.3.2 Selective Fisheries Which May Change Allocation Percentages North of Cape Falcon

As a tool to increase management flexibility to respond to changing harvest opportunities, the Council may implement deviations from the specified port area allocations and/or gear allocations to increase harvest opportunity through mark-selective~~fisheries~~ ~~that are selective for marked salmon stocks (e.g., marked hatchery salmon)~~. The benefits of any mark-selective fishery will vary from year to year and fishery to fishery depending on stock abundance, the mix of marked and unmarked fish, projected hook-and-release mortality rates, and public acceptance. These factors should be considered on an annual and case-by-case basis when utilizing mark-selective fisheries. The deviations for mark-selective fisheries are subordinate to the allocation priorities in Section 5.3.1.1 and may be allowed under the following management constraints:

1. Mark-sSelective fisheries will first be considered during the months of May and/or June for Chinook and July through ~~August and/or~~ September for coho. However, the Council may consider selective fisheries at other times, depending on year to year circumstances identified in the preceding paragraph.

2. The total impacts within each port area or gear group on the critical natural stocks of management concern are not greater than those under the original allocation without the mark-selective fisheries.

3. Other allocation objectives (i.e., treaty Indian, or ocean and inside allocations) are satisfied during negotiations in the North of Cape Falcon Forum.

4. The mark-selective fishery is assessed against the guidelines in Section 6.5.3.1.

5. Mark-sSelective fishery proposals need to be made in a timely manner in order to allow sufficient time for analysis and public comment on the proposal before the Council finalizes its fishery recommendations.

If the Council chooses to deviate from ~~the~~ specified port and/or gear allocations, the process for establishing a mark-selective fishery would be as follows:

1. Allocate the TAC among the gear groups and port areas according to the basic FMP allocation process described in Section 5.3.1 without the mark-selective fishery.

2. Each gear group or port area may utilize the critical natural stock impacts allocated to its portion of the TAC to access additional harvestable, marked fish, over and above the harvest share established in step one, within the limits of the management constraints listed in the preceding paragraph.

Issue 11. Update “Data Needs” section

Description of the issue

FMP sections 7.1.2 and 7.2.1 need to be updated to reflect current technology and activities.

NEPA Considerations

No environmental effects. This issue meets the NAO 216-6 criteria for a CE under 6.03d.4(b) minor technical additions, corrections, or changes to an FMP.

Affected FMP language

Sections 7.1.2 Methods for Obtaining Inseason Data and 7.2.1 Data Needs (FMP pages 67 and 68):

7.1.2 Methods for Obtaining Inseason Data

Inseason management requires updating information on the fisheries daily. Thus, data will be collected by sampling the landings, ~~aerial surveys~~exit/trailer counts, radio reports, electronic media reports, and telephone interviews.

In general, data necessary for inseason management will be gathered by one or more of the following methods. ~~Flights over the fishing grounds~~ Port exit counts, radio or electronic media reports, and processor reports will be used to obtain information on the distribution, amount, and type of commercial fishing effort. Data on the current harvests by commercial and treaty Indian ocean fishermen will be obtained by telephoning selected (key) fish buyers, by sampling the commercial landings on a daily basis, and from radio or electronic media reports. Data on the current effort of, and harvests by, the recreational fisheries will be obtained by port exit counts, trailer counts, contacting~~telephoning~~ selected charter boat and boat rental operators, and by sampling landings at selected ports. Analyses of fish scales, recovered fish tags, genetic stock identification samples, and other methods will provide information on the composition of the stocks being harvested.

7.2.1 Data Needs

In addition to the data used for inseason management, a considerable amount of information is used for setting the broad measures for managing the fishery, evaluating the success of the previous year's management, and evaluating the effectiveness of the plan in achieving the long-term goals. Such data include landings, fishing effort, dam counts, smolt migration, returns to hatcheries and natural spawning areas, stock contribution estimates, and economic information.

The Council also produces a periodic research and data needs document, which identifies current priorities for information collection needs and contemporary management strategies.

Issue 12. Update reporting requirements

Description of the issue

FMP section 7.3 needs to be updated to reflect current communication technology.

NEPA Considerations

No environmental effects. This issue meets the NAO 216-6 criteria for a CE under 6.03d.4(b) minor technical additions, corrections, or changes to an FMP.

Affected FMP language

Section 7.3 Reporting Requirements (FMP page 68):

7.3 REPORTING REQUIREMENTS

This plan authorizes the local management authorities to determine the specific reporting requirements for those groups of fishermen under their control and to collect that information under existing state data-collection provisions. With one exception, no additional catch or effort reports will be required of fishermen or processors as long as the data collection and reporting systems operated by the local authorities continue to provide the Secretary with statistical information adequate for management. The one exception would be to meet the need for timely and accurate assessment of inseason management data. In that instance the Council may annually recommend implementation of regulations requiring brief radio, phone, or electronic media reports from commercial salmon fishermen who leave a regulatory area in order to land their catch in another regulatory area ~~open to fishing~~. The federal or state entities receiving these ~~radio~~ reports would be specified in the annual regulations.

Issue 13. Modify schedule for setting annual management measures

Description of the issue

NMFS has proposed adjusting the date of the April Council meeting. FMP sections 9 and 11 would need to be updated to adjust the date of the April Council meeting to the third full week in April and the start of the salmon regulatory cycle from May 1st to May 15th to better accommodate the data needs for the North of Falcon process. This schedule change would be implemented in 2014.

NEPA Considerations

No expected environmental effects as this would be an administrative change. This issue meets the NAO 216-6 criteria for a CE under 6.03d.4(a) ongoing or recurring fisheries actions of a routine administrative nature and 6.03d.4(b) minor technical additions, corrections, or changes to an FMP.

Affected FMP language

Section 9 Schedule and procedures for preseason modification of regulations (FMP page 70):

The process and schedule for setting the preseason regulations will be approximately as follows:

Approximate Date	Action
First week of March	Notice published in the Federal Register announcing the availability of team and Council documents, the dates and location of the two Council meetings, the dates and locations of the public hearings, and publishing the complete schedule for determining proposed and final modifications to the management measures. Salmon Technical Team reports which review the previous salmon season, project the expected salmon stock abundance for the coming season, and describe any changes in estimation procedures, are available to the public from the Council office.
First or second full week of March[a/]	Council and advisory entities meet to adopt a range of season regulatory alternatives for formal public hearing. Proposed options are initially developed by the Salmon Advisory Subpanel and further refined after analysis by the STT, public comment, and consideration by the Council.
Following March Council meeting	Council newsletter, public hearing announcement, and STT/Council staff report are released which outline and analyze Council-adopted alternatives. The STT/staff report includes a description of the alternatives, brief rationale for their selection, and an analysis of expected biological and economic impacts.
Last week of March or first week of April[a/]	Formal public hearings on the proposed salmon management alternatives.
~~First or second~~Third full week of April[a/]	Council and advisory entities meet to adopt final regulatory measure recommendations for implementation by the Secretary of Commerce.
~~First~~Second week of May	Final notice of Secretary of Commerce decision and final management measures in Federal Register.
~~May 15~~	~~Close of public comment period.~~ [Note: This item removed under issue 8]

[a/] Scheduling of the March and April Council meetings is determined by the need to allow for complete availability of pertinent management data, provide time for adequate public review and comment on the proposed alternatives, and afford time to process the Council's final recommendations into federal regulations by May ~~1~~15. Working backward from the May ~~1~~15 implementation date, the April Council meeting is generally set ~~as late as possible while not extending past April 15 for approval of final salmon management recommendations~~in the third week of April. The March Council meeting is set as late as possible while ensuring no less than three to four weeks between the end of the March meeting and beginning of the April meeting.

Section 11 Schedule and procedures for FMP Amendment and Emergency Regulations (FMP page 75):

11 SCHEDULE AND PROCEDURES FOR FMP AMENDMENT AND EMERGENCY REGULATIONS

Modifications not covered within the framework mechanism will require either an FMP amendment, notice and comment rulemaking, or emergency Secretarial action. The amendment process generally requires at least a year from the date of the initial development of the draft amendment by the Council. In order for regulations implementing an amendment to be in place at the beginning of the salmon regulatory cyclegeneral fishing season (May 115), the Council will need to begin the process by no later than April of the previous season. It is not anticipated that amendments will be processed in an accelerated December-to-May schedule and implemented by emergency regulations.

Emergency regulations may be promulgated without an FMP amendment. Depending upon the level of controversy associated with the action, the Secretary can implement emergency regulations within 20 days to 45 days after receiving a request from the Council. Emergency regulations can include non-resource emergencies and are generally in effect for 180 days. A second 180-day extension is possible if the public has had an opportunity to comment on the emergency regulation and the Council is actively preparing a plan amendment or proposed regulations to address the emergency on a permanent basis.

Part of the process for evaluating all future FMP amendment proposals will be to consider whether they will result in the need for temporary adjustments for fishery access due to weather, adverse oceanic conditions, or other safety considerations.

Issue 14. Update language regarding notifications

Description of the issue

FMP sections 10.1.1 and 10.3 need to be updated to reflect current notification procedures and technology.

NEPA Considerations

No environmental effects. Administrative changes. This issue meets the NAO 216-6 criteria for a CE under 6.03d.4(a) ongoing or recurring fisheries actions of a routine administrative nature and 6.03d.4(b) minor technical additions, corrections, or changes to an FMP.

Affected FMP language

Sections 10.1.1 Fixed Inseason Actions and 10.3 Procedures for Inseason Actions (FMP pages 71 and 73):

10.1.1 Automatic Season Closures When the Quotas Are Reached

The STT will attempt to project the date a quota will be reached in time to avoid exceeding the quota and to allow adequate notice to the fishermen. The State Directors and the Council Chairman will be consulted by the NMFS Regional Administrator before action is taken to close a fishery. Closures will be coordinated with the states so that the effective time will be the same for EEZ and state waters. A standard closure notice will be used and will specify areas that remain open as well as those to be closed. To the extent possible, all closures will be effective at midnight and a 48-hour notice will be given of any closure. When a quota is reached, the Regional Administrator will issue a notice of closure of the fishery on the telephone hotline and via USCG Notice to Mariners radio broadcast. Other means of notification may include posting on the NMFS NWR website, email or other electronic media. Notice of fishery closure is published in the *Federal Register* as soon as is practicable.~~through local news media at the same time that a notice of fishery closure is published in the *Federal Register*.~~

10.3 PROCEDURES FOR INSEASON ACTIONS

1.Prior to taking any inseason action, the Regional Administrator will consult with the Chairman of the Council and the appropriate State Directors.

2.As the actions are taken by the Secretary, the Regional Administrator will compile, in aggregate form, all data and other information relevant to the action being taken and shall make them available for public review upon request, contact information will be published annually in the *Federal Register* and announced on the telephone hotline~~during normal office hours at the Northwest Regional Office, National Marine Fisheries Service, 7600 Sand Point Way NE, Seattle, Washington 98115~~.

3.Inseason management actions taken under both the "fixed" and "flexible" procedures will become effective by announcement in designated information sources (rather than by filing with the Office of the Federal Register [OFR]). Notice of inseason actions will still be filed with the OFR as soon as is practicable~~quickly as possible~~.

The following information sources will provide actual notice of inseason management actions to the public: (1) the U.S. Coast Guard "Notice to Mariners" broadcast (announced over Channel 16 VHF-FM and 2182 KHZ); (2) state and federal telephone hotline numbers specified in the annual regulations and (3) filing with the *Federal Register*, email or other electronic forms of notification. Identification of the sources will be incorporated into the preseason regulations with a requirement that interested persons periodically monitor one or more source. In addition, all the normal channels of informing the public of regulatory changes used by the state agencies will be used.

~~4.If the Secretary determines, for a good cause, that a notice must be issued without affording a prior opportunity for public comment, public comments on the notice will be received by the Secretary for a period of 15 days after the effective date of the notice.~~

Issue 15. Update inseason actions language

Description of the issue

FMP section 10.2 describes inseason actions for "establishment of new quotas and/or seasons." This language should be deleted.

NEPA Considerations

No environmental effects. Administrative changes to reflect actual practices. This issue meets the NAO 216-6 criteria for a CE under 6.03d.4(a) ongoing or recurring fisheries actions of a routine administrative nature and 6.03d.4(b) minor technical additions, corrections, or changes to an FMP.

Affected FMP language

Section 10.2 Flexible Inseason Actions (FMP pages 72 and 73):

10.2 FLEXIBLE INSEASON ACTIONS

. . . . .

. . . . .

Flexible inseason provisions must take into consideration the factors and criteria listed above and would include, but not be limited to, the following.

1.Modification of quotas and/or fishing seasons would be permitted. Redistribution of quotas between recreational and commercial fisheries would be allowed if the timing and procedure are described in preseason regulations. If total quotas or total impact limitations by fishery are established, subarea quotas north and south of Cape Falcon, Oregon can be redistributed within the same fishery (north or south of Cape Falcon). Other redistributions of quotas would not be authorized. Also allowable would be the ~~establishment of new quotas and/or seasons, and~~ establishment of, or changes to, hooking mortality and/or total allowable impact limitations during the season. Action based on revision of preseason abundance estimates during the season would be dependent on development of a Council approved methodology for inseason abundance estimation.

2.Modifications in the species that may be caught and landed during specific seasons and the establishment or modification of limited retention regulations would be permitted (e.g., changing from an all-species season to a single-species season, or requiring a certain number of one species to be caught before a certain number of another species can be retained).

3.Changes in the recreational bag limits and recreational fishing days per calendar week would be allowed.

4.Establishment or modification of gear restrictions would be authorized.

5.Modification of boundaries, including landing boundaries, and establishment of closed areas would be permitted.

6.Temporary adjustments for fishery access due to weather, adverse oceanic conditions, or other safety considerations (see Council policy of September 18, 1992 regarding implementation of this action).

The flexibility of these inseason management provisions imposes a responsibility on the Regional Administrator to assure that affected users are adequately informed and have had the opportunity for input into potential inseason management changes.

Issue 16. Revise text on emergency regulations

Description of the issue

FMP section 11 should be updated to be consistent with MSA and to remove unnecessary language.

NEPA Considerations

No environmental effects. Administrative changes. This issue meets the NAO 216-6 criteria for a CE under 6.03d.4(a) ongoing or recurring fisheries actions of a routine administrative nature and 6.03d.4(b) minor technical additions, corrections, or changes to an FMP.

Affected FMP language

Section 11 Schedule and Procedures for FMP Amendment and Emergency Regulations (FMP page 75). These changes would be in addition to any changes made under Issue 13:

11 SCHEDULE AND PROCEDURES FOR FMP AMENDMENT AND EMERGENCY REGULATIONS

Modifications not covered within the framework mechanism will require either an FMP amendment, ~~notice and comment~~ rulemaking, or emergency Secretarial action. Depending on the required environmental analyses, t~~T~~he amendment process generally requires at least a year from the date of the initial development of the draft amendment by the Council. In order for regulations implementing an amendment to be in place at the beginning of the general fishing season (May 1), the Council will need to begin the process by no later than April of the previous season. It is not anticipated that amendments will be processed in an accelerated December-to-May schedule and implemented by emergency regulations.

Emergency regulations may be promulgated without an FMP amendment. Depending upon the level of controversy associated with the action, the Secretary can implement emergency regulations within 20 days to 45 days after receiving a request from the Council. Emergency regulations remain in effect for no more than 180 days after the date of publication in the *Federal Register*~~can include non-resource emergencies and are generally in effect for 180 days~~. A 186-day~~second 180-day~~ extension by publication in the *Federal Register* is possible if the public has had an opportunity to comment on the emergency regulation and the Council is actively preparing a plan amendment or proposed regulations to address the emergency on a permanent basis.

~~Part of the process for evaluating all future FMP amendment proposals will be to consider whether they will result in the need for temporary adjustments for fishery access due to weather, adverse oceanic conditions, or other safety considerations.~~

State of California – Natural Resources Agency
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EDMUND G. BROWN JR., Governor
CHARLTON H. BONHAM, Director

August ~~2~~ 23, 2012

RECEIVED
AUG 2 7 2012
PFMC

Robert Turner
Assistant Regional Administrator
Salmon Management Division
National Marine Fisheries Service
7600 Sand Point Way N.E., Building 1
Seattle, WA 98115

Dear Mr. Turner:

PROPOSED MODIFICATION TO OCEAN SALMON REGULATORY TIMELINE

Thank you for your June 7, 2012 letter requesting input from the California Department of Fish and Game (Department) on the proposed amendment by the Pacific Fishery Management Council (Council) that may affect our ocean fisheries or complicate the process for adopting conforming regulations in State waters. The amendment modifies the Salmon Fishery Management Plan by 1) delaying the Council's April meeting during which the final ocean salmon seasons are set from the first to the third full week of April, and 2) shifting the effective start date of salmon regulations from May 1 to May 15.

The primary reason for this amendment is to allow additional time for Alaskan and Canadian salmon population forecasts to be made available for the Council regulatory process. Salmon fisheries north of Cape Falcon are constrained by international agreements with Canada, and meeting these agreements requires the availability of population forecasts prior to setting seasons for federally-managed salmon fisheries in the northwest.

Traditionally, west coast ocean salmon seasons that begin prior to May 1 are adopted during the previous year's April Council meeting. Only California recreational salmon fisheries south of Horse Mountain open prior to May 1, usually the first Saturday in April. The recreational salmon fishery in the Klamath Management Zone (Humbug Mountain, Oregon to Horse Mountain, California) generally opens in mid to late May and the California commercial salmon season south of Point Arena has not opened prior to May 1 since 1984, with the exception of a few small April "test" fisheries. Commercial salmon fisheries north of Pt. Arena generally open in late summer or early fall. All California recreational salmon fisheries in inland waters do not open until well after May 15, and these seasons are not set as a part of the Council regulatory process. Shifting the Council schedule to the third week in April would require adopting regulations in the previous year for any fishery scheduled to open prior to May 15.

Salmon are managed on an annual basis using stock abundance forecasts and annual impact rate caps. These forecasts and rates are not available until the end of all fisheries and spawning has completed (ocean abundance forecasts are generally available in late February). Should ocean abundance forecasts fall below minimum thresholds or impact rate caps exceeded, emergency action by the U.S. Secretary of Commerce and the States may be required to close or modify fisheries that were scheduled to open prior to May 15. Commercial salmon seasons in California automatically conform to the regulations recommended by the Council and authorized by the Secretary of Commerce. However, recreational ocean (state waters only) and inland salmon regulations are adopted by the California Fish and Game Commission (Commission), immediately following the Council's decisions. Following the Commission's adoption, the new state regulations require review and approval by the Office of Administrative Law (OAL) before they become effective, and the amount of time that OAL is given to complete this review is established by law.

The Department changed its regulatory language structure in 2012 so that the Commission could adopt California recreational seasons in two-stages: 1) regulations in effect during April and 2) regulations in effect on or after May 1. The Department will need to modify its new structure slightly to match the proposed new regulatory time frame proposed by the Council. Since the information needed to evaluate pre-May 15 fisheries will be available in early March, this should allow the Department ample time to provide supplementary analyses and justifications for review by the Commission and OAL before adoption of these early fisheries.

As long as the Council adopts ocean salmon regulations no later than April 20th each year, the Department does not anticipate any significant issues with the modified timeline; however, Council action after this date will not provide adequate time for the Commission to adopt and OAL to review and approve state water regulations effective May 15. The Department also requests that decisions regarding changes to the federal regulatory process be made in a timely manner so that potential scheduling adjustments to the State's process can be implemented as soon as possible, as each year the Commission sets its meeting schedule to align with the Council's meeting schedule.

In summary, we do not anticipate California's recreational or commercial salmon fisheries or regulations to be negatively impacted by the proposed amendment so long as the Council adopts their federal management recommendations by April 20 each year. Thank you for taking the opportunity to solicit comments on this issue and for considering California's processes in the decision making.

Sincerely,

Charlton H. Bonham
Director

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SALMON ADVISORY SUBPANEL REPORT ON SALMON FISHERY MANAGEMENT PLAN AMENDMENT 17—ANNUAL REGULATORY CYCLE AND MINOR UPDATES

The Salmon Advisory Subpanel opposes changing the annual regulatory cycle by moving the process two weeks later. We recognize the hard work everyone put into the salmon process, but we fishermen also have businesses to run, advertising, and getting the word out to our customers and the public. The public needs time to plan vacations and fishing trips. Making the regulatory process longer would adversely affect the Coastal towns and businesses.

PFMC
09/14/12

SALMON TECHNICAL TEAM REPORT ON SALMON FISHERY MANAGEMENT PLAN (FMP) AMENDMENT 17 – ANNUAL REGULATORY CYCLE AND MINOR UPDATES

The Salmon Technical Team (STT) has reviewed the report of the NEPA Workgroup with recommendations for the 16 issues to be addressed in Amendment 17 and supports the inclusion of most all of the issues as identified in Agenda Item E.3.a, Attachment 1.

We did not come to a consensus on Issue 13, which is the modification of the schedule for setting annual management measures. It is unclear whether the modification to the schedule as proposed will better accommodate the data needs for the North of Falcon process.

PFMC
09/15/12

FMP AMENDMENT 18 – UPDATE OF ESSENTIAL FISH HABITAT (EFH) FOR SALMON

The most recent Essential Fish Habitat (EFH) review for Pacific salmon indicated that new information warranted consideration of changes to the existing identification and description of Pacific Coast salmon EFH. At its March, 2012 meeting, the Council considered a scoping document for addressing the range of issues to be included in Amendment 18 to the Pacific Coast Salmon Plan. The Council approved the overall scope, suggested consideration of a small number of non-EFH issues for inclusion in the amendment process, and recommended developing an alternatives document. The "options" described in that scoping document are now described as draft preliminary alternatives in Agenda Item E.4.a, Attachment 1.

At this meeting, the Council is being asked to adopt a suite of alternatives for further analysis and public review. The Council may wish to identify preliminary preferred alternatives at this meeting, but it is not necessary. The Council may choose to add, remove, or amend any of the alternatives.

Pacific Coast salmon EFH was established in 1999, as Appendix A to Amendment 14 to the Pacific Coast Salmon Fishery Management Plan. Periodic review of EFH is required under the National Marine Fisheries Service Regulatory Guidance (50 CFR §600.815). Reviews should be conducted at least every five years, and should include evaluation of published and unpublished scientific literature and reports, information from interested parties, and previously unavailable or inaccessible data.

Council Action:

1. Adopt alternatives for updating salmon EFH for public review.

Reference Materials:

1. Agenda Item E.4.a, Attachment 1: *Pacific Coast Salmon Plan Amendment 18 Draft Preliminary Alternatives.*

Agenda Order:

a. Agenda Item Overview — Kerry Griffin
b. Summary of the Pacific Coast Salmon Scoping Document — Kerry Griffin and John Stadler
c. Reports and Comments of Advisory Bodies and Management Entities
d. Public Comment
e. **Council Action**: Adopt Alternatives for Updating Salmon EFH for Public Review.

PFMC
08/24/12

Pacific Coast Salmon Plan Amendment 18 Draft Preliminary Alternatives

Considering Updates to Essential Fish Habitat

September 2012

Prepared by:

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1. Introduction

The Magnuson-Stevens Fishery Conservation and Management Act (MSA)(16 USC 1801 et seq) defines essential fish habitat (EFH) as “those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity,” and requires Fishery Management Councils (FMCs) to describe and identify EFH in fishery management plans (FMPs). The FMPs identify EFH based on current distribution, habitat components, historical presence, or other factors; identify habitat requirements at each life stage; and identify information and research needs. FMPs must evaluate potential adverse impacts from both fishing and non-fishing activities, as well as minimize adverse effects of Federally-regulated fishing to the extent practicable. FMPs should identify habitat areas of particular concern (HAPC) within EFH based on the habitat’s ecological function, sensitivity to human-induced disturbance, rarity, or whether development activities may stress a particular habitat. The National Marine Fisheries Service (NMFS) must approve the EFH designations, which should be reviewed at least every five years.

In Appendix A to Amendment 14 of the Pacific Coast Salmon FMP (Amendment 14)(PFMC 1999), the Pacific Fishery Management Council (Council) identified EFH for Pacific Coast salmon: Chinook salmon (*Oncorhynchus tshawytscha*), coho salmon (*O. kisutch*), and Puget Sound pink salmon (*O. gorbuscha*). The Council made minor revisions, primarily consisting of editorial corrections, to Pacific Coast salmon EFH in 2008, when the designations were codified in the Federal Register (2008 Final Rule)(78 FR 60987).

At its April 2011 meeting, the Council heard a report of the Salmon EFH Oversight Panel (OP), which completed the EFH review process. The report concluded that sufficient new information warranted further consideration of changes to the extent and/or description of EFH for Pacific Coast salmon. The Council accepted the report, but asked for additional information on fishing gear and non-gear effects. The Panel submitted a revised final report in June 2011 (Stadler et al. 2011). The Council and NMFS staff began work on a preliminary scoping document in July 2011.

At its March 2012 meeting, the Council considered a scoping document that described the major subject areas for potential inclusion in the scope of an amendment to the Pacific salmon FMP. The Council affirmed the overall scope as presented (in Agenda Item G.6.a, Attachment 1, March 2012), and requested consideration of the potential for adding abundance-based forecasting for California fall Chinook salmon to the scope of the action. The Plan Amendment Team (PAT), Council staff, and NMFS staff subsequently determined that the best approach would be to address the issue in the Council’s methodology review process, and is therefore not included in the scope of this action.

The PAT also considered including other items not related to EFH yet accomplishable via an FMP amendment. These included the Quillayute MFMT, changing the season start date, and housekeeping items. However, the PAT, Council Staff, and NMFS concluded that these items would be best addressed using other vehicles, and are therefore not included as Alternatives to be analyzed in this document.

The following list provides a brief description of the major topics for which changes to Pacific Coast salmon EFH could be considered. These are a combination of those EFH elements described in the NMFS EFH regulatory guidance (50 CFR 600), and those EFH components that are described in Amendment 14.

1. Identification of Pacific Coast salmon EFH: Consider changing the general identification of Pacific salmon EFH based on new information
2. Chinook salmon freshwater EFH: Update Chinook salmon EFH based on latest distribution data and new Hydrologic Unit designations
3. Coho salmon freshwater EFH: Update coho salmon EFH based on latest distribution data
4. Puget Sound pink salmon freshwater EFH: Update Puget Sound pink salmon EFH based on latest distribution data
5. Marine EFH: Update marine EFH based on new information
6. Impassable barriers designated as the upstream extent of EFH: Update the list of impassable dams that mark the upstream extent of EFH based on updated information
7. EFH descriptions: Update specific descriptions of EFH and components for each species and life stage
8. Habitat areas of particular concern (HAPC): Consider designating as HAPCs - channels and floodplains; thermal refugia; spawning habitat; estuaries; and marine and estuarine submerged aquatic vegetation
9. Fishing activities that may adversely affect EFH: Consider new information on fishing activities that may adversely affect EFH
10. Non-fishing activities that may adversely affect EFH: Consider updating the non-fishing activities and adding the newly identified activities and information
11. Information and research needs: Consider information and research needs for future refining of EFH, based on the data gaps identified in the review
12. Non-FMP procedures for EFH changes: Consider options for allowing certain changes to EFH that would not require an FMP amendment

The purpose of this document is to provide a suite of alternatives for the Council to consider and adopt for public review. The Council may, at this time, choose to adopt preliminary preferred alternatives (PPA); and may wish to amend, add, or eliminate some alternatives as it sees fit.

The document is organized into sections based on the subject areas in the list above. These subject areas are presented as Alternatives in Table 1. For each subject area, there are two or more alternatives, including a No Action Alternative. In all cases, the No Action Alternative is mutually exclusive of the other alternatives. Alternatives 5C and 5D are mutually exclusive of each other. None of the other Alternatives are mutually exclusive. This means that the Council could select multiple alternatives under each subject area. For example, under the HAPC subject area, the Council could select all five action alternatives, or any subset thereof.

Table 1: Summary of Alternatives

Subject Area	Alternatives
1. Identification of Pacific salmon EFH	1A. No Action 1B. Amend to clarify that EFH is designated only for stocks included in the fishery managed by the PFMC
2. Chinook salmon freshwater EFH	2A. No Action 2B. Add three hydrologic units (HUs) as Chinook salmon EFH: 17060108 (Palouse), 17060308 (Lower NF Clearwater), and 18050005 (Tomales-Drakes Bay) 2C. Designate the mainstem Columbia River and side channels as EFH for Chinook salmon, in HU 17070101. 2D. Update EFH maps to be consistent with new USGS California Central Valley 4th field hydrologic units.
3. Coho salmon freshwater EFH	3A. No Action 3B. Add five HUs as coho salmon EFH: 17070103 (Umatilla), 17060305 (South Fork Clearwater), 17060304 (Middle Fork Clearwater), 17060302 (Lower Selway), and 17060301 (Upper Selway). 3C: Remove coho salmon EFH from one HU: 18060006 (Central California Coast).
4. Puget Sound pink salmon freshwater EFH	4A. No Action 4B. Designate HU 17110013 (Duwamish) as PS pink salmon EFH 4C. Designate HU 17110017 (Skokomish) as PS pink salmon EFH 4D. Designate HU 17110021 (Crescent-Hoko) as PS pink salmon EFH 4E. Designate HU 17100102 (Queets-Quinault) and as PS pink salmon EFH
5. Impassable barriers	5A. No Action 5B. Make housekeeping updates, including correct names, minor corrections, and removing barriers that are now passable from the list: [Dexter Dam (HU 17090001, Middle Fork Willamette River); Big Cliff Dam (HU 19070005, North Santiam River); Soda Springs Dam (HU 17100301, North Umpqua River)]. 5C. Revise the list of dams based on the existing Amendment 14 criteria 5D. Revise the criteria for designating a dam as the upstream extent of EFH, and update the list based on the new criteria and new information. *Note: Alternatives 5C and 5D are mutually exclusive*
6. Marine and estuarine EFH – all species	6A. No Action 6B. Clarify that PS pink salmon marine EFH includes U.S. EEZ waters, Puget Sound/Straits of Juan de Fuca, and Alaskan waters that are designated salmon EFH by the NPFMC. *Considered but rejected: • Remove marine EFH designation for Alaska marine waters. • Refine marine EFH descriptions.

7. EFH descriptions	7A. No Action 7B. Update the text for EFH descriptions for each species of Pacific Coast salmon, based on best available science. Provide new references as an appendix to Amendment 18; and update EFH descriptions, life history, and habitats, based on new information regarding habitat needs, life history, etc.
8. HAPCs	8A. No Action 8B. Designate channels and floodplains as a HAPC 8C. Designate thermal refugia as a HAPC 8D. Designate spawning habitat as a HAPC 8E. Designate estuaries as a HAPC 8F. Designate marine and estuarine submerged aquatic vegetation as a HAPC
9. Fishing activities that may adversely affect EFH	9A. No Action 9B. Revise description of MSA fishing activities. 9C. Revise description of non-MSA fishing activities.
10. Non-fishing activities that may adversely affect EFH	10A. No Action 10B. Add 10 new non-fishing activities to the Amendment 14 list (Pile driving, over-water structures, alternative energy development, liquefied natural gas projects, desalination, power plant intakes, pesticide use, flood control maintenance, culvert construction, climate change), update the Amendment 14 list, and develop/update conservation measures for all 31 non-fishing activities.
11. Information and research	11A. No Action 11B. Identify and prioritize new information and research needs.
12. Procedures for changing EFH	12A. No Action 12B. Adopt procedures allowing for updates outside of an FMP amendment

2. Identification of Pacific Coast Salmon Essential Fish Habitat

Amendment 14 identifies Pacific Coast salmon EFH as those waters and substrate necessary for salmon production needed to support a long-term sustainable salmon fishery and salmon contributions to a healthy ecosystem. In the freshwater environment this means those streams, lakes, ponds, wetlands, and other currently viable water bodies and most of the habitat historically accessible to salmon in Washington, Oregon, Idaho, and California (Appendix A, Figure 1). In marine and estuarine environments, EFH extends from the nearshore and tidal submerged environments within state territorial waters out to the full extent of the EEZ offshore of the U.S. West Coast, north of Point Conception, California.

Salmon EFH excludes areas upstream of longstanding naturally impassible barriers (i.e., natural waterfalls in existence for several hundred years). Salmon EFH includes aquatic areas above all artificial barriers except the man-made impassible barriers (dams) listed in Amendment 14.

The Council chose a comprehensive approach to identifying salmon EFH, citing the large geographic range and the wide diversity of habitats that are vital in salmonid life cycles. The comprehensive approach also recognizes that Pacific Coast salmon presence can be somewhat transient from year to year, depending on hydrologic conditions and other factors. Just because a stream segment is unoccupied one year does not mean that it will not support salmon the subsequent year, and therefore it should retain EFH protections.

The MSA requires regional FMCs to "describe and identify" EFH in their FMPs, while the *definition* of EFH is established in the MSA. This document may use the terms "identify" and "describe" somewhat interchangeably, but in both cases it refers to the Pacific Council's task to identify and describe EFH for managed species.

Essential fish habitat can be designated only for those species that are part of the fishery management unit (FMU) of a Federal fishery management plan (FMP)[50 CRF 600.805(b)]. However, not all salmon in Washington, Oregon, and California are currently part of the Pacific Coast salmon FMU, and therefore cannot be used as a basis for designating EFH.

Alternatives for revising the identification of EFH for Pacific Coast salmon

Alternative 1A: No Action

This alternative would retain the existing language on identification of Pacific Coast salmon EFH. However, retaining the current language would be counter to the MSA because the current identification includes EFH for one stock of salmon that has been removed from the managed stocks. Only species managed under the MSA can have designated EFH.

Alternative 1B: Revise the identification of EFH

This alternative would add language to clarify that EFH may only be designated for Federally-managed stocks that are included in an FMU. The result would be better clarity regarding whether EFH can be designated for a particular stock of Pacific salmon.

3. Geographic Extent of Pacific Salmon EFH

FRESHWATER ESSENTIAL FISH HABITAT

Freshwater EFH for each of the three managed species is currently designated by watersheds, as the 4th field hydrologic unit[1] (HU), and is based on the information available at the time of Amendment 14. Applying an inclusive, watershed-based description of EFH using USGS hydrologic units is appropriate, because it (1) recognizes the species' need to use diverse habitats and underscores the need to account for all of the habitat types supporting the species' freshwater and estuarine life stages, from small headwater streams to migration corridors and estuarine rearing areas; (2) considers the variability of freshwater habitat as affected by environmental conditions (droughts, floods, etc.) that make precise mapping difficult; and (3) reinforces important linkages between aquatic and adjacent upslope areas. Habitat available and utilized by salmon changes frequently in response to floods, landslides, woody debris inputs, sediment delivery, and other natural events. To expect the distribution of salmon within a stream, watershed, province, or region to remain static over time is unrealistic. Furthermore, this watershed-based approach is consistent with other Pacific salmon habitat conservation and recovery efforts such as those implemented under the Endangered Species Act (ESA). See Stadler et al. (2011) for a more detailed discussion of the new information on freshwater EFH for Pacific Coast salmon. The list of man-made impassable barriers marking the upstream extent of freshwater EFH is addressed in Chapter 4.

Chinook salmon

New Distribution Data

The comparison of the new Chinook salmon distribution information with the current EFH designations in Amendment 14 shows that four 4th field HUs that are not currently designated as EFH have current Chinook salmon distribution data that shows that Chinook salmon are present. These HUs are: Lake Chelan (17020009); the Palouse (17060108); the lower north fork of the Clearwater River (17060308); and Tomales-Drakes Bay (18050005) (Appendix A, Figures 2 and 3). The distribution of Chinook salmon in the Lake Chelan and lower north fork of the Clearwater River HUs is limited to the relatively short portion of the HUs between the confluence with the mainstem rivers, upstream to either a natural barrier (17020009) or an impassable dam (17060108).

[1] The United States is divided into successively smaller hydrologic units based on distinctive features and watershed boundaries. Each hydrologic unit is identified by a unique hydrologic unit code consisting of two to eight digits based on four levels of classification in the hydrologic unit section. 4th field hydrologic units, referred to as "cataloging units", are assigned a unique 8-digit code and cover a geographic area representing part of or all of a surface drainage basin, a combination of drainage basins, or a distinct hydrologic feature.

Revised 4th field hydraulic units

As described in Stadler et al. (2011) the 4th field HUs were updated by the USGS, resulting in changes to the names, codes, and boundaries of several HUs in the California Central Valley and coast (Appendix A, Figures 4 and 5). All the changes result in larger, consolidated HUs. The EFH designations in this area should be updated to reflect the current classification system.

Mid-Columbia spring Chinook stocks

Amendment 16 to the Pacific Salmon FMP removed some stocks from the FMU. Therefore, any EFH designations based on those stocks no longer apply. Of the 17 4th field HUs occupied by Mid-Columbia Spring Chinook stocks which were removed from the FMU, six will retain EFH designation because they are occupied by other Chinook salmon and coho stocks. Two additional (or three, depending on selection of final alternatives) HUs will retain EFH designation because they are occupied by coho salmon stocks. Eight HUs (or nine, depending on final selection of alternatives) have no other Federally-managed salmon stocks, and therefore will lose all EFH coverage. Table 2 below summarizes this information.

Table 2. 4th Field HUs with mid-Columbia spring-run Chinook salmon. EFH designation for another stock means the HU will retain designation as EFH. Source: StreamNet (2012).

4th Field HUC	HU Name	Other Chinook Salmon Present in the HU			Coho Present?	Retain EFH?
		Spring	Summer	Fall		
17030001	Upper Yakima			X	X	Yes
17030002	Naches			X	X	Yes
17030003	Lower Yakima			X	X	Yes
17070101	Mid. Columbia-Lake Wallula[1]	X	X	X	X	Yes
17070102	Walla Walla					No
17070103	Umatilla			X	X	Yes
17070104	Willow					No
17070105	Mid. Columbia-Hood	X[2]	X	X	X	Yes
17070106	Klickitat			X	X	Yes
17070201	Upper John Day					No
17070202	N. Fork John Day					No
17070203	M. Fork John Day					No

17070204	Lower John Day					No
17070301	Upper Deschutes[3]					No
17070305	Lower Crooked[3]					No
17070306	Lower Deschutes			X	X	Yes
17070307	Trout Creek[4]					No

[1] Mid. Columbia-Lake Wallula is a migratory corridor and rearing habitat for upstream stocks of Chinook salmon.

[2] Lower Columbia River spring Chinook salmon.

[3] No current distribution data, EFH based on historical data. Unclear what Chinook salmon stocks historically occupied these HUs.

[4] Streamnet shows this HU is within Deschutes River summer/fall Chinook salmon ESU, but no distribution data.

The Council should note that although the tributaries in the mid-Columbia-Lake Wallula HU (17070101) lack Chinook salmon EFH designation, the mainstem Columbia River serves as a migration corridor and rearing habitat for upstream stocks. As noted earlier, EFH includes the habitats necessary for spawning, breeding, feeding, or growth to maturity. Therefore, the Council should consider designating this part of the HU as EFH for Chinook salmon.

Alternatives for revising Chinook salmon EFH

With the exception of Alternative 2A, these are not mutually exclusive. The Council may elect to implement some or all of these alternatives.

Alternative 2A: No Action

This alternative would retain the existing EFH description and geographic distribution for Chinook salmon, as contained in Amendment 14. As a result, the EFH designation would not be based on the latest distribution data; and would rely, in the California Central Valley, on outdated HU codes and descriptions.

Alternate 2B: Add three HUs as Chinook salmon EFH

This Alternative would add additional HUs that were not designated as EFH in Amendment 14 but have current distribution data showing the presence of Chinook salmon, and therefore follow the regulatory guidelines for designating EFH based on presence/absence data:

- 17020009 (Lake Chelan)
- 17060108 (Palouse)
- 17060308 (Lower North Fork Clearwater)
- 18050005 (Tomales-Drakes Bay)

Because these HUs have current Chinook distribution, the Council should consider designating them as EFH for Chinook salmon. The Tomales-Drakes Bay HU is also designated as EFH for coho salmon, so designation as EFH for Chinook salmon would not increase the consultation burden in this HU.

However, the other three HUs do not currently have EFH designated for any Pacific salmon species. Therefore, adding EFH coverage to those three HUs would result in EFH consultations being required in areas where they previously were not.

Alternative 2C: Designate the mainstem Columbia River and side channels as EFH for Chinook salmon, in HU 17070101

This alternative would ensure that the migratory corridor used by Chinook salmon to access upstream areas of designated EFH, would retain EFH protections, even if adjacent tributaries are not designated as EFH for Chinook salmon.

Alternative 2D: Update EFH designations and maps to be consistent with new USGS HU designations

This alternative would update the maps of the 4th field HUs designated as EFH for Chinook salmon to reflect changes in the Central Valley HU classifications. This would result in expansion of EFH into areas that were not previously designated as EFH. However, much of the new areas encompassed by the revised HU is above impassable barriers, and therefore is already excluded from EFH (Figure 4).

Coho Salmon

New distribution data

A comparison of new distribution information with the EFH designations contained in Amendment 14 indicates that there are several HUs with documented coho salmon distribution that are currently not identified as coho salmon EFH (Appendix A, Figure 6). In another case, the designation of HUC 18060006 (Central California Coast) was based on only sparse or anecdotal information (Appendix A, Figure 7). Maps comparing the current EFH designations of coho salmon to the most recent distribution data are in Appendix A.

Alternatives for revising coho salmon EFH

With the exception of Alternative 3A, these are not mutually exclusive. The Council may elect to implement some or all of these alternatives.

Alternative 3A. No Action

This alternative would retain the existing EFH description and geographic distribution for coho salmon, as contained in Amendment 14. As a result, the EFH designation would not be based on the latest distribution data, and some HUs with coho salmon would not be designated as EFH.

Alternative 3B. Add five HUs as coho salmon EFH:

- 17070103 (Umatilla)
- 17060305 (South Fork Clearwater)
- 17060304 (Middle Fork Clearwater)
- 17060302 (Lower Selway)
- 17060301 (Upper Selway)

Rationale: these five HUs show current coho salmon distribution, but are not designated as coho salmon EFH. All five are already designated as Chinook salmon EFH. Therefore, there would be negligible additional regulatory burden.

Alternative 3C: Remove coho salmon EFH from HU 18060006 (Central California Coast)

Rationale: the EFH review found that inclusion of this HU as EFH was based on sparse information that indicated presence only in the extreme northern portion of that HU. Given that HU 18060006 encompasses a significant amount of California coastline which has never been known to be coho salmon habitat, the Council could consider removing EFH coverage from that HU. The California Cooperative Anadromous Fish and Habitat Data Program (Calfish) indicates no current coho salmon distribution in that HU. This HU has been designated as critical habitat for the South-Central California Coast steelhead ESU, and would therefore retain habitat protections relative to ESA critical habitat, but would lose the protection provided by an EFH designation.

Puget Sound pink salmon

New distribution data

As shown in Appendix A, Figure 8, there are four 4th field HUs that indicate presence of pink salmon, but are not currently designated as EFH. Of these, the Duwamish (17110013) has experienced dramatic returns of pink salmon in recent years (Stadler et al. 2011). The Washington State Department of Fish and Wildlife estimated that 2.875 million pink salmon returned to the Duwamish system in 2009, and the 2011 escapement was approximately 864,000 (A. Bosworth, pers comm 2012). Despite the lack of data on presence in the Duwamish in 1999, there is no question that Puget Sound (PS) pink salmon now occupy this system.

The three remaining HUs (the Skokomish (17110017), the Crescent-Hoko (17110021) and the Queets-Quinault (17110102)) are shown in StreamNet (2012) as being occupied by pink salmon. However, their distribution in these systems is more limited than in the Duwamish.

Based on current distribution information, the Council should consider designating some or all of those four HUs as EFH for PS pink salmon. This decision should ultimately be based on a determination that the pink salmon present in those watersheds are indeed of Puget Sound pink salmon stock origin.

A 1996 status review (Hard, et al. 1996), found that two pink salmon ESUs (even-year and odd-year) were in the Elwha River and eastward. Although the review cited the presence of pink salmon in the Crescent-Hoko, Quillayute, and Queets-Quinault river systems, these were not included in the ESU due to the lack of information on these populations. The rationale for excluding the Crescent-Hoko and Queets-Quinault HUs from EFH was not provided in Amendment 14, but it appears that the 1999 designation of EFH for PS pink salmon is based on the ESUs. The Council should more clearly define the freshwater extent of the PS pink salmon stocks, in order to gain clarity on the issue.

Alternatives for revising PS pink salmon EFH

With the exception of Alternative 4A, these are not mutually exclusive.

Alternative 4A: No Action

The status quo alternative would retain the existing EFH designation for PS pink salmon, as contained in Amendment 14, and the PS pink salmon stock would not be further defined. As a result, the EFH designation would not be based on the most up-to-date information on historical and current distribution.

Alternative 4B: Add HU 17110013 (Duwamish) to PS pink salmon EFH

Alternative 4C: Add HU 17110017 (Skokomish) to PS pink salmon EFH

Alternative 4D: Add HU 17110021 (Crescent-Hoko) to PS pink salmon EFH

Alternative 4E: Add HU 17100102 (Queets-Quinault) to PS pink salmon EFH

The Council may select any combination, or none of Alternatives 4B through 4E, which would result in designation of the selected HUs as EFH for PS pink salmon. All four show presence of pink salmon. As a result, the EFH designation would be based on the most up-to-date information on the distribution of PS pink salmon. The result of designating these HUs as EFH for PS pink salmon would be to expand the protection of pink salmon habitat and require that Federal agencies consider the effects of their proposed actions on PS pink salmon EFH in this HU. However, because these HUs are currently designated as EFH for both Chinook salmon and coho salmon, the additional consultation burden on the Federal agencies and the public would be negligible.

4. Impassable Barriers Designated as the Upstream Extent of EFH

Amendment 14 includes four criteria used to determine whether any particular impassable barrier should represent the upstream extent of EFH. Based on those criteria (see Appendix B), Amendment 14 includes a list of about 45 dams that are of sufficient size, permanence, and lacked fish passage at the time. Amendment 14 language stated that when fish passage is implemented, the area upstream of the dam would then become EFH, up to the next impassable barrier. It also noted that if subsequent analyses determined the habitat above any of those dams is necessary for salmon conservation, the Council would modify the EFH designations.

During the EFH review, the OP reevaluated the list of impassable barriers in Amendment 14 and identified a number of them that merit reconsideration as the upstream extent of EFH. In addition, the OP identified some dams in Amendment 14 that were inadvertently omitted from the 2008 Final Rule and others that are in the California Central Valley HUs that have been modified. For more detailed discussions of these dams, see Stadler et al. (2011).

Should the Council ultimately designate EFH above any of the dams identified in Amendment 14, it would be necessary to then identify and evaluate any upstream dams and designate as EFH all upstream 4th field HUs that would become accessible when passage is provided, or that contained habitat deemed necessary for long-term survival of the species and sustainability of the fishery.

Of the four criteria listed in Amendment 14, two of them, 3 and 4, can be very broadly interpreted. For example the phrase "*is fish passage to upstream areas under consideration*" (consideration 3) is problematic because it is likely that fish passage has been "considered" at almost every dam, regardless of the practicality of doing so. Likewise, the phrase "*habitat that is key for the conservation of the* *species*" (considerations 3 and 4) is open to various interpretations, and lacks any specific metrics on which to make that determination. There are several means by which NMFS can identify such habitats. NMFS may issue fish passage "prescriptions" under Section 18 of the Federal Power Act, may designate critical habitat above an impassible dam for salmon listed under the Endangered Species Act (e.g., Dexter Dam on the Middle Fork of the Willamette River), or may issue such a determination in a recovery plan.

The Council may wish to refine the criteria, in order to provide a clearer and more subjective decision-making process in determining whether a particular dam should represent the upstream extent of EFH.

Alternatives for revising the list of impassable barriers

Of the following Alternatives, 5A is mutually exclusive with the others, while 5C and 5D are mutually exclusive with each other.

Alternative 5A: No Action

The status quo alternative would retain the existing list of dams that represent the upstream extent of EFH as contained in the 2008 Final Rule. As a result, the list would be based on outdated and incomplete data, and would not address housekeeping problems such as misnamed or erroneously-omitted dams. The revised USGS 4th field HU names, boundaries, and codes would not be used, likely leading to confusion when determining where EFH consultations are required. EFH consultations may be conducted where none are necessary or not conducted where they are warranted.

Alternative 5B: Housekeeping updates

There are several changes to the list of impassable barriers that can be considered "housekeeping" updates. These changes include:

- Correct the errors in the names and locations of dams (e.g., the Sandy River Basin dam complex);
- Add those dams that were inadvertently omitted from the 2008 Final Rule. These dams are listed in Table 3.
- Delete those dams that are upstream of other impassable barriers (e.g., Brownlee and Oxbow Dams on the Snake River Complex);
- Update the HU codes and names in the California Central Valley; and
- Remove from the list, those dams that have been removed or which now have fish passage. This includes:
    - Dexter Dam (HU 17090001, Middle Fork Willamette River). A trap and haul operation for spring Chinook salmon transports fish above this dam. Critical Habitat was designated above this dam, in 2005.

    - Big Cliff Dam (HU 19070005, North Santiam River). A trap and haul operation for spring Chinook transports fish above this dam as well as Detroit Dam, immediately upstream. There are no dams upstream of Detroit Dam, and therefore the rest of the HU would be included as EFH.

    - Soda Springs Dam (HU 17100301, North Umpqua River). Fish passage is under construction at this dam. The next impassible barrier upstream of Soda Springs Dam is

Toketee Falls, a naturally impassible barrier three miles upstream. There are no other impassible dams upstream of Soda Springs Dam, and no additional HUs, upstream of this dam, would be designated as EFH.

Implementing this alternative would reflect updated and new information. Where fish passage has been implemented, it would add to the geographic extent of EFH. This would result in additional EFH consultations being required in the newly designated EFH, but would have only a very modest effect on workload.

Table 3. Impassable dams from Amendment 14 that were inadvertently omitted from the 2008 Final Rule.

4th Field HU	State	Hydrologic Unit Name	Dam
17080001	OR/WA	Lower Columbia-Sandy River	Bull Run Dam #2
18010207	CA	Shasta	Dwinnell Dam
18020115	CA	Upper Stony	Black Butte Dam
18020126	CA	Upper Bear	Camp Far West Dam
18020159	CA	Honcut Headwaters- Lower Feather	Oroville Dam*
18040006	CA	Upper San Joaquin	Friant Dam**
18040008	CA	Upper Merced	Crocker Diversion Dam

* Oroville Dam is upstream of the impassable Feather River Fish Barrier Dam, which should be considered the upstream extent of EFH.

** Friant Dam is on the border between 18040001 and 18040006. Designating Friant Dam as the upstream extent of EFH is superfluous.

Alternative 5C: Update the list of impassable dams using the existing criteria and the new information

Strict adherence to the Amendment 14 considerations could result in the designation of EFH above all of the dams that are currently listed as the upstream extent of EFH, because of the ambiguity of the existing criteria (see Appendix B). Doing so would then result in EFH consultations in habitats that should not be considered EFH, and would appear to fall short of the Council's intent when Amendment 14 was adopted.

Alternative 5D: Revise the considerations/criteria for designating a dam as the upstream extent of EFH, and update the list based on the new criteria and new information

The criteria in Amendment 14 are subject to interpretation. Rewording of the considerations into straightforward questions, and making them into true criteria, would establish better guidance for designating a dam as the upstream extent of EFH. One possible reworking of the considerations/criteria is:

1. Is the dam federally owned or operated, licensed by the Federal Energy Regulatory Commission (FERC), state licensed, or subject to state dam safety supervision? Is the dam is of sufficient size, permanence, impassability, and legal identity to warrant consideration for inclusion in this list?
    - If Yes, go to 2.

- If No, then the dam is not the upstream extent and the habitat above the dam should be designated as EFH.

2. Is the dam upstream of any other impassable dam that is designated as the upstream extent of EFH?
   - If Yes, then the upstream extent of EFH is, by definition, downstream of the dam, and it should not be included in the list of impassable barriers.
   - if No, then go to 3.
3. Is fish passage around the dam in the construction phase? Is fish passage in the planning phase, initiated by a state or Federal agency, or the dam operator/owner? Is there a reasonable likelihood that passage will be implemented in a reasonable time frame? This criterion is intended to address dams for which fish passage is being actively pursued, and is likely to be implemented before the next EFH review.
   - If Yes to any of the three questions, then the dam should not be considered the upstream extent, and the habitat above the dam should be designated as EFH.
   - If no, then go to 4.
4. Has NMFS or the Council determined that restoration of passage and conservation of the habitat above the dam is necessary for the long-term survival of the species and sustainability of the fishery? In making this determination, NMFS or the Council should consider information contained in official NMFS documents such as a biological opinion, critical habitat designation, NMFS recovery plan, fish passage prescription under the Federal Power Act, or other formal NMFS policy position. This criterion provides for designation of habitat upstream of dams that would otherwise be listed as the upstream extent of EFH, and reflects the fact that the habitats in many portions of watersheds have not previously been formally evaluated.
   - If Yes, then the dam should not be considered the upstream extent and the habitat above the dam should be designated as EFH.
   - If No, then the dam should be designated as the upstream extent of EFH.

Excluding these dams would result in an expansion of EFH into the habitats above them. This would result in consultations for any Federal action that may adversely affect those additional habitats. However, the consultation requirements for those actions would be no different than currently applied to Federal actions in existing EFH.

5. Marine and Estuarine Essential Fish Habitat

Current EFH for Pacific Coast salmon includes all estuarine and marine waters from the nearshore and tidal submerged environments within state territorial waters out to the U.S. EEZ north of Point Conception, California, to the U.S. – Canada border (Appendix A, Figure 1). EFH also includes the marine areas of Alaska that are designated as salmon EFH by the North Pacific Fishery Management Council. Marine EFH for Pacific Coast salmon is necessarily broad, based on presence/absence data, as provided in the regulatory guidelines, due to insufficient data in 1999 that would have allowed for a more narrowly-defined description of marine EFH. Recent information was described in Stadler et al. (2011). However, there remains a paucity of definitive information on ocean habitat associations. Because of this lack of information, the OP concluded that it would be better to continue to rely on the presence/absence data, and wait to refine marine EFH until more information becomes available. Therefore, both the potential for re-visiting the inclusion of marine waters off Alaska, as well as the possibility of refining specific marine EFH descriptions, should both be treated as alternatives that were considered but rejected.

For PS pink salmon, Amendment 14 defines marine EFH "all nearshore marine waters north and east of Cape Flattery, Washington, including Puget Sound, the Strait of Juan de Fuca, and the Strait of Georgia." This is slightly inconsistent with the general designation of marine EFH for Pacific salmon that includes the marine waters beyond Cape Flattery, as described above. The Council should clarify the extent of PS pink salmon marine EFH.

Alternatives for revising marine EFH

These alternatives are mutually exclusive.

Alternative 6A: No Action

This alternative would retain the existing description of marine EFH for Pacific Coast salmon, including marine waters off Alaska as designated by the NPFMC. It would not clarify the extent of marine EFH for PS pink salmon.

Alternative 6B: Clarify PS pink salmon marine EFH

This alternative would clarify the extent of EFH for PS pink salmon in the West Coast EEZ and the waters off Alaska. The result would be better clarity regarding the extent of PS pink salmon marine EFH. Selection of this alternative implies that the Council's intent under Amendment 14 was to include those marine areas west and north of Cape Flattery to be EFH for PS pink salmon, as well as for Chinook and coho salmon. If the Council does not clarify the designation of PS pink salmon EFH, the ambiguity will remain.

6. Essential Fish Habitat Descriptions

According to the EFH regulatory guidelines [50 CFR 600.815 (a)(1)]:

> *FMPs must describe and identify EFH in text that clearly states the habitats or habitat types determined to be EFH for each life stage of the managed species. FMPs should explain the physical, biological, and chemical characteristics of EFH and, if known, how these characteristics influence the use of EFH by the species/life stage.*

This information can then be used to evaluate the potential effects of proposed actions on EFH.

NEW INFORMATION

The descriptions of the habitats by life stage determined to be EFH in Amendment 14 were developed through an extensive review and synthesis of the literature available in 1999. While much of that information remains accurate and relevant today, the 5-year review compiled a significant amount of new and newly-available information that needs to be used to refine, and improve upon, the life history characteristics and habitat parameters described in Amendment 14.

Alternatives for updating EFH descriptions

Alternative 7A: No change

This alternative would retain the EFH descriptions in Amendment 14, and would not expand upon the body of literature that was available in 1999. As a result, the analysis of Federal actions that may adversely affect EFH could be based on outdated or incomplete information.

Alternative 7B: Update the EFH summaries for each species of Pacific Coast salmon

This alternative would update the EFH descriptions in Amendment 14 using the new information, which can be used by the public, consultants, and state and Federal agencies to assess the potential effects on EFH from a proposed action. As a result, the analysis of Federal actions during the EFH consultation process would be based on more up-to-date information, which will result in improved EFH Conservation Recommendations. It would not increase the consultation burden on Federal agencies or the public. Providing the annotated bibliography as an appendix to Amendment 18 would enhance the utility of the updated summaries.

7. Habitat Areas of Particular Concern

The implementing regulations for the EFH provisions of the MSA (50 CFR part 600) recommend that the FMPs include specific types or areas of habitat within EFH as “habitat areas of particular concern” (HAPC) based on one or more of the following considerations: (1) the importance of the ecological function provided by the habitat; (2) the extent to which the habitat is sensitive to human-induced environmental degradation; (3) whether, and to what extent, development activities are, or will be, stressing the habitat type; and (4) the rarity of the habitat type. The intended goal of identifying such habitats as HAPCs is to provide additional focus for conservation efforts. While the HAPC designation does not add any regulatory burden, it highlights certain habitat types within EFH that are of high ecological importance. The benefits of HAPC designation are manifested in EFH consultations, in which NMFS can call attention to a HAPC and recommend that the Federal action agency make an extra effort to protect these important habitats. HAPCs, like all other aspects of EFH, are subject to periodic reviews and are therefore subject to being modified over time.

As part of the 5-year review, the OP developed five potential HAPCs. Habitat types were initially identified using the best available information and the collective professional knowledge and experience gained by the OP through scientific research and conducting EFH and ESA consultations. These habitats were then evaluated according to the four considerations listed above. The five potential HAPCs for Pacific Coast salmon are discussed below. For a more detailed discussion of how these habitats met the four considerations defined above, see Stadler et al. (2011).

Complex channels and floodplain habitats. Meandering, island-braided, pool-riffle and forced pool-riffle channels. Complex floodplain habitats, including wetlands, oxbows, side channels, sloughs and beaver ponds; and steeper, more constrained channels with high levels of large woody debris (LWD), provide valuable habitat for all Pacific Coast salmon species.

Thermal refugia. Thermal refugia typically include cool water tributaries, lateral seeps, side channels, tributary junctions, deep pools, areas of groundwater upwelling and other mainstem river habitats that are cooler than surrounding waters (≥2° C cooler) (Torgersen et al. 1999; Ebersole et al. 2003). As such, refugia can occur at spatial scales ranging from entire tributaries (e.g., spring-fed streams), to stream reaches (e.g., alluvial reaches with high hyporheic flow), to highly localized pockets of water only a few square meters in size embedded within larger rivers.

Spawning habitat. Salmon spawning habitat is typically defined as low gradient stream reaches (<3%), containing clean gravel with low levels of fine sediment and high inter gravel flow. Many spawning areas have been well defined by historical and current spawner surveys and detailed maps exist for some hydrologic units.

Estuaries. Estuaries include nearshore areas such as bays, sounds, inlets, river mouths and deltas, pocket estuaries, and lagoons influenced by ocean and freshwater. Because of tidal cycles and freshwater runoff, salinity varies within estuaries and results in great diversity of habitats, offering freshwater, brackish and marine habitats within close proximity (Haertel and Osterberg 1967). This HAPC also includes those estuary-influenced offshore areas of continuously diluted seawater.

Marine and estuarine submerged aquatic vegetation. Submerged aquatic vegetation (SAV) includes the kelps and seagrasses. The kelps are brown macroalgae and include those that float to form canopies and those that do not, such as *Laminaria* spp. Canopy-forming kelps of the eastern Pacific Coast are dominated by two species, giant kelp (*Macrocystis pyrifera*) and bull kelp (*Nereocystis leutkeana*). Kelp plants, besides requiring moderate to high water movement and energy levels, are most likely limited by the availability of suitable substrate (Mumford 2007). Eelgrass (*Zostera marina and Z. pacifica*) is prevalent in many west coast estuaries and nearshore areas, forms dense beds of leafy shoots year-round in the soft sediments of the lower intertidal and shallow subtidal zone, and they form a three-dimensional structure in an otherwise two-dimensional (sand or mud) environment (Mumford 2007).

Alternatives for considering HAPCs for Pacific salmon

Alternative 8A is mutually exclusive with the other alternatives. However, Alternatives 8B through 8F are not mutually exclusive, and the Council may decide to proceed with some or all of them.

Alternative 8A: No change

This alternative would maintain the current status of having no HAPCs designated as part of Pacific Coast salmon EFH. As a result, these important habitats would not receive any special focus during the EFH consultation process.

Alternative 8B: Designate complex channels and floodplain habitat as a HAPC

Alternative 8C: Designate thermal refugia as a HAPC

Alternative 8D: Designate spawning habitat as a HAPC

Alternative 8E: Designate estuaries as a HAPC

Alternative 8F: Designate marine and estuarine SAV as a HAPC

Each of the alternatives 8B through 8F was considered by the OP to have met between two and four of the HAPC criteria. Selecting some or all of alternatives 6B though 6F would establish HAPCs for Pacific Coast salmon. The practical effect of doing so would be that extra consideration would be given to these ecologically-important habitats during EFH consultations, providing focus for conservation efforts. There would be no additional regulatory burden, but designating HAPCs may increase the number of EFH Conservation Recommendations that are accepted by the Federal action agencies and result in greater habitat protection.

8. Activities That May Adversely Affect EFH

Fishery management plans are required to identify and describe three categories of activities that may adversely affect EFH: Fishing activities managed under the MSA, fishing activities not managed under the MSA (typically managed by states), and human activities not associated with fishing.

FISHING ACTIVITIES THAT MAY ADVERSELY AFFECT EFH

The EFH regulations require that FMPs identify fishing activities that may adversely affect EFH. For MSA-managed fishing activities, FMPs are required to minimize those effects to the extent practicable. FMPs are not required to minimize non-MSA fishing activities (managed by states, Tribes, interstate agreements, or treaties) that may adversely affect EFH, but the Council and NMFS may work cooperatively with states, Tribes, or other agencies to achieve appropriate habitat protection measures. For the purposes of the EFH review and this document, MSA and non-MSA fishing activities are described together.

Amendment 14 and Stadler et al. (2011) described the potential adverse effects on EFH for Pacific Coast salmon from fishing activities to include: alteration of habitat by fishing gear; removal of prey organisms in a fishery; the loss of salmon carcasses, an important source of marine-derived nutrients, in freshwater systems; and ghost fishing by derelict fishing nets.

Salmon fishing gear can harm EFH by catching prey species and harming important benthic habitat. Specifically, fishing gear can reduce habitat complexity by removing prey, removing or damaging epifauna, smoothing sedimentary bedforms and reducing bottom complexity, removing taxa which produce structure (i.e., taxa which produce burrows and pits), and decreasing seagrass density.

Because salmon are not known to be directly dependent on soft ocean bottom habitats, MSA-regulated salmon fishing gear that has the potential for disturbing these habitats, such as bottom trawls, is not likely to affect EFH for salmon. Removal of prey species could constitute an adverse effect to EFH if the prey becomes less available to Pacific salmon, or otherwise results in a decrease of the quality of quantity of EFH. See below for a brief discussion of impacts of fishing activities on prey species. Shallower habitats, such as eelgrass beds, mud flats, or river beds that are important to salmon could be affected by salmon fishing gear, but fisheries in these habitats are generally managed by the states and tribes, and are not regulated by the Council. Therefore, these activities will be identified in the FMP as non-Magnuson-Stevens Act fishing activities that may adversely affect EFH.

Habitats at depths of 30-70 m, where juvenile and adult salmon are associated with bottom topography and structure such as channels, ledges, pinnacles, reefs, vertical walls, and artificial structure in marine environments, can be damaged by bottom contact fishing gear. Amendment 14 noted that there is no research information that documents direct effects on salmon or their prey. However, the Council implemented regulations for the groundfish fishery, including restrictions on bottom contact gear in areas of high relief that provide a significant level of protection to these areas.

Removal of prey organisms through a directed fishery, bycatch in another fishery, or reduction in juveniles as a result of a fishery on adults of a prey species, has the potential to adversely affect EFH for Pacific Coast salmon, to the extent that decreased prey availability results in a decrease of EFH quality. However, there is insufficient information to determine the minimum prey abundances needed to support a sustainable salmon fishery. There is also a lack of sufficient information to indicate that fishing activities have limited the availability of prey species.

Of the likely Pacific salmon prey species, the Pacific sardine fishery provides the most information with respect to biomass estimates and harvest history. U.S. sardine harvest has ranged between approximately 50,000 and 130,000 metric tons in the past ~10 years, representing between (approximately) 10%-15% of the age 1+ biomass. However, sardines, as well as other forage species, are subject to large population fluctuations even in the absence of fishing pressure, and it is generally accepted among stock assessment scientists that natural mortality (linked to environmental parameters) outweighs fishing mortality, in affecting sardine abundance (Hill, pers comm. 2012). Baumgartner et al. (1992) studied sardine and anchovy scale deposition in the Southern California Bight, over a 1700-year period, noting major population fluctuations between 60-100 years.

As noted in Amendment 14, the harvest formulas for northern anchovy and sardine include ecosystem considerations, including forage for predator species, which include salmon. Some fisheries for prey species, such as Pacific herring, shrimp, and smelt, are managed by the states. Harvest of another major prey species, krill, is prohibited under Amendment 12 to the Coastal Pelagic Species FMP.

The EFH regulatory guidance states that each FMP must minimize to the extent practicable adverse effects on EFH from fishing. Adverse effects decrease the quantity or quality of EFH, and include harm to prey species. To the extent that reduced prey availability diminishes the quality of EFH, it should be considered an adverse impact. While there is not enough information to conclude that fishing activities reduce salmon prey availability, there is a need, based on new information, to update the descriptions in Am 14.

Ghost fishing of salmon by gillnets does occur (Stadler et al. 2011), but the overall impact of ghost fishing on salmon populations is unknown. In addition, because gillnet fisheries in state waters are managed by the states and tribes, they are not under direct Federal regulation.

Although several fishing activities may have the potential to adversely affect EFH, there is not sufficient information to conclude adverse effects. All the activities described in this document as well as in the OP report were also described in Amendment 14. There are no known new fishing activities that could potentially adversely affect Pacific salmon EFH. However, the Council may wish to update the descriptions of the fishing activities and gear contained in Amendment 14.

Alternatives for updating fishing activities that may adversely affect Pacific salmon EFH

With the exception of Alternative 9A, the alternatives described below are not mutually exclusive.

Alternative 9A: No Change

This alternative would retain the description of the effects from fishing activities in Amendment 14. Doing so would disregard the new information on the potential effects of fishing activity on EFH as well as the measures that the Council has taken that have reduced the level of these effects.

Alternative 9B: Revise the description of the potential adverse effects of fishing managed under the MSA.

This alternative would incorporate the new information since Amendment 14 into the description of the fishing activities and potential adverse effects on Pacific Coast salmon EFH from fishing activities. It does not imply a determination of adverse effects, and would not include minimization measures.

Alternative 9C: Revise the description of the potential adverse effects of fishing not managed under the MSA

This alternative would incorporate new information into the identification of non-MSA fishing activities that may adversely affect Pacific salmon EFH.

NON-FISHING ACTIVITIES THAT MAY ADVERSELY AFFECT EFH

Amendment 14 identified 21 non-fishing activities (Table 4) that may adversely affect EFH; and potential conservation recommendations to avoid, minimize, mitigate, or otherwise offset those adverse impacts. However, new information gathered since Amendment 14 indicates that some of these descriptions and conservation measures are out of date and should be updated. In addition to these 21 activities, the OP identified 10 additional activities that may adversely affect EFH (Table 4), and identified potential conservation measures for most of them.

The utility of describing the non-fishing threats and associated conservation recommendations is that the public and NMFS staff can efficiently reference the adverse effects as well as minimization measures associated with these effects. In many cases (e.g., culvert construction and pile driving), best practices are already established and in use. In those cases, there would be little if any change to current practices. It is important to note that while the list of non-fishing activities provides guidance, it does not preclude NMFS from including conservation recommendations for activities not on the list, and does not preclude NMFS from recommending additional or different conservation measures from those included in the FMP. It is also important to note that most projects consist of multiple threats, and the cumulative effects of those threats should be considered when making EFH conservation recommendations.

Table 4. Non-fishing activities that may adversely affect Pacific Coast salmon EFH

Threats Identified in Amendment 14 (1999)	New Activities Identified During EFH Review
Agriculture	Pile driving
Artificial Propagation of Fish and Shellfish	Over-water structures
Bank Stabilization	Alternative energy development
Beaver removal and Habitat Alteration	Liquefied natural gas projects
Construction/Urbanization	Desalination

Dam Construction/Operation	Power plant intakes
Dredging and Dredged Spoil Disposal	Pesticide use
Estuarine Alteration	Flood control maintenance
Forestry	Culvert construction
Grazing	Activities that contribute to climate change
Habitat Restoration Projects	
Irrigation/Water Management	
Mineral Mining	
Introduction/Spread of Nonnative Species	
Offshore Oil and Gas Drilling	
Road Building and Maintenance	
Sand and Gravel Mining	
Vessel Operation	
Wastewater/Pollutant Discharge	
Wetland and Floodplain Alteration	
Woody Debris/Structure Removal	

Alternatives for revising non-fishing activities that may adversely affect Pacific salmon EFH

Alternative 10A: No Action

By retaining the current descriptions and recommended conservation measures for the existing list of 21 identified non-fishing activities that may adversely affect EFH and not adding the newly-identified activities, consultations would be conducted as they are now, without the benefit to consulting agencies, the public and NMFS of additional information on these activities. However, NMFS would still be able to provide EFH Conservation Recommendations for any activities that may adversely affect EFH, regardless of whether the activity is on the list.

Alternative 10B: Update the existing 21 non-fishing activities that may adversely affect EFH

By updating the description of non-fishing activities that may adversely affect Pacific Coast salmon EFH, as well as identifying potential conservation recommendations, Amendment 18 would be providing relevant new information to assist consulting agencies, the public and NMFS staff when considering these activities. The addition of new activities and conservation recommendations to the FMP would not represent any net change in the consultation process. However, their inclusion would provide an increased level of consistency in how those activities are evaluated during the consultation process.

Alternative 10C: Add new non-fishing activities that may adversely affect EFH

This alternative includes options to include any or all of the 10 new non-fishing activities identified by the OP. It would add up to 10 new non-fishing activities to the Amendment 14 list, and would include the development of conservation measures to any of the activities selected. The options under this alternative are:

- **10C1: Pile driving**
- **10C2: over-water structures**
- **10C3: alternative energy development**

- **10C4: liquefied natural gas projects**
- **10C5: desalination**
- **10C6: power plant intakes**
- **10C7: pesticide use**
- **10C8: flood control maintenance**
- **10C9: culvert construction**
- **10C10: activities that contribute to climate change**

9. Information and Research Needs

The EFH regulatory guidance states that each FMP should contain recommendations, preferably in priority order, for research efforts that the Councils and NMFS view as necessary to improve upon the description and identification of EFH, the identification of threats to EFH, and the development of conservation recommendations. Numbers 1 through 3 (below) are summaries of those contained in Amendment 14, and numbers 4 and 5 are new, as identified by the OP. The priority order has not been established.

1. Improve fine scale mapping of salmon distribution to inform future reviews of EFH for Pacific Coast salmon and aid in more precise and accurate designation of EFH and the consultation process. Potential approaches include, but are not limited to:
    a. Develop distribution data at the 5th or 6th field HUs, across the geographic range of these species.
    b. Develop habitat models that can be used to predict suitable habitat, both current and historical, across the geographic range of these species.
    c. Develop seasonal distribution data at a 1:24,000 or finer scale.
2. Improve data on habitat conditions across the geographic range of Pacific Coast salmon to help refine EFH in future reviews.
3. Improve data on marine distribution of Pacific Coast salmon, and develop models to predict marine distribution to inform revisions to EFH in future reviews.
4. Improve data on the possibility of adverse effects of fishing gear on the EFH of Pacific Coast salmon.
5. Advance the understanding of how a changing climate, can affect Pacific Coast salmon.

Alternatives for updating information and research needs

Alternative 11A: No action

The three information and research needs identified in Amendment 14 would be retained, and would not include the two new research recommendations identified by the Panel.

Alternative 11B: Identify and prioritize new information and research needs

This alternative would include the information and research needs identified in Amendment 14, and would add two more, related to improving information on the adverse effects of fishing gear and climate change. By establishing the Council's information and research needs priorities, this alternative would meet the requirements of the MSA.

10. Non-FMP procedures for amending EFH

The EFH regulations state that the EFH provisions of FMPS should be reviewed and updated periodically, based on available information, and at least once every 5 years. The regulations also state that FMPs should outline the procedures they will use to update the EFH information. Currently EFH updates are done through an FMP amendment, although other alternatives may be available. The OP described many potential changes to Pacific salmon EFH. Some of those, especially actions that do not change the "footprint" of EFH, such as adding additional information on the effects of fishing and non-fishing activities on EFH, may warrant consideration for a mechanism to update EFH, outside of an FMP amendment process. Correcting errors or maintaining maps to reflect the most up-to-date geospatial information are other examples of elements that could potentially be changed without an FMP amendment.

If the Council includes this issue in the scope of Amendment 18, Council staff and NMFS would work with NOAA GC to identify and recommend likely mechanisms for implementing EFH updates outside an FMP amendment.

11. References

Baumgartner, T., A. Soutar, and V. Ferreira-Bartrina. 1992. A history of Pacific sardine and northern anchovy populations. CalCOFI Rep., Vol. 33. 1992.

Bosworth, A. 2012. WDFW Fishery Biologist, personal communication to J. Stadler. 2012.

Ebersole, J.L., W.J. Liss, and C.A. Frissell. 2003. Cold water patches in warm streams: Physicochemical characteristics and the Influence of shading. Journal of the American Water Resources Association 39(2):355-368.

Haertel, L. and C. Osterberg. 1967. Ecology of zooplankton, benthos and fishers in the Columbia River Estuary. Ecology 48(3):459-472.

Hill, K.T. 2012. Personal communication, August 2012.

Mumford, T.F. 2007. Kelp and Eelgrass in Puget Sound. Puget Sound Nearshore Partnership Report No. 2007-05. Published by Seattle District, U.S. Army Corps of Engineers, Seattle, Washington.

PFMC (Pacific Fishery Management Council). 1999. Identification and description of essential fish habitat, adverse impacts, and recommended conservation measures for salmon. Appendix A to Amendment 14, Pacific Coast salmon fishery management plan. Available at:

http://www.pcouncil.org/salmon/fishery-management-plan/adoptedapproved-amendments/amendment-14-to-the-pacific-coast-salmon-plan-1997/

Stadler, J., K. Griffin, E. Chavez, B. Spence, P. Roni, C. Gavette, B. Seekins, and A. Obaza. 2011. Pacific Coast Salmon 5-Year Review of Essential Fish Habitat. Final Report to the Pacific Fishery Management Council. 2011.

StreamNet 2012. Metadata for Pacific Northwest fish distribution spatial data sets. Portland, OR. URL: <http://www.streamnet.org/mapping_apps.cfm>.

Torgensen, C.E., D.M. Price, H.W. Li, and B.A. McIntosh. 1999. Multiscale thermal refugia and stream habitat associations of Chinook salmon in northeastern Oregon. Ecological Applications 9(1): 301-319.

Appendix A

FIGURES RELATED TO CURRENT AND POTENTIAL PACIFIC COAST SALMON EFH IN WASHINGTON, OREGON, CALIFORNIA, AND IDAHO.

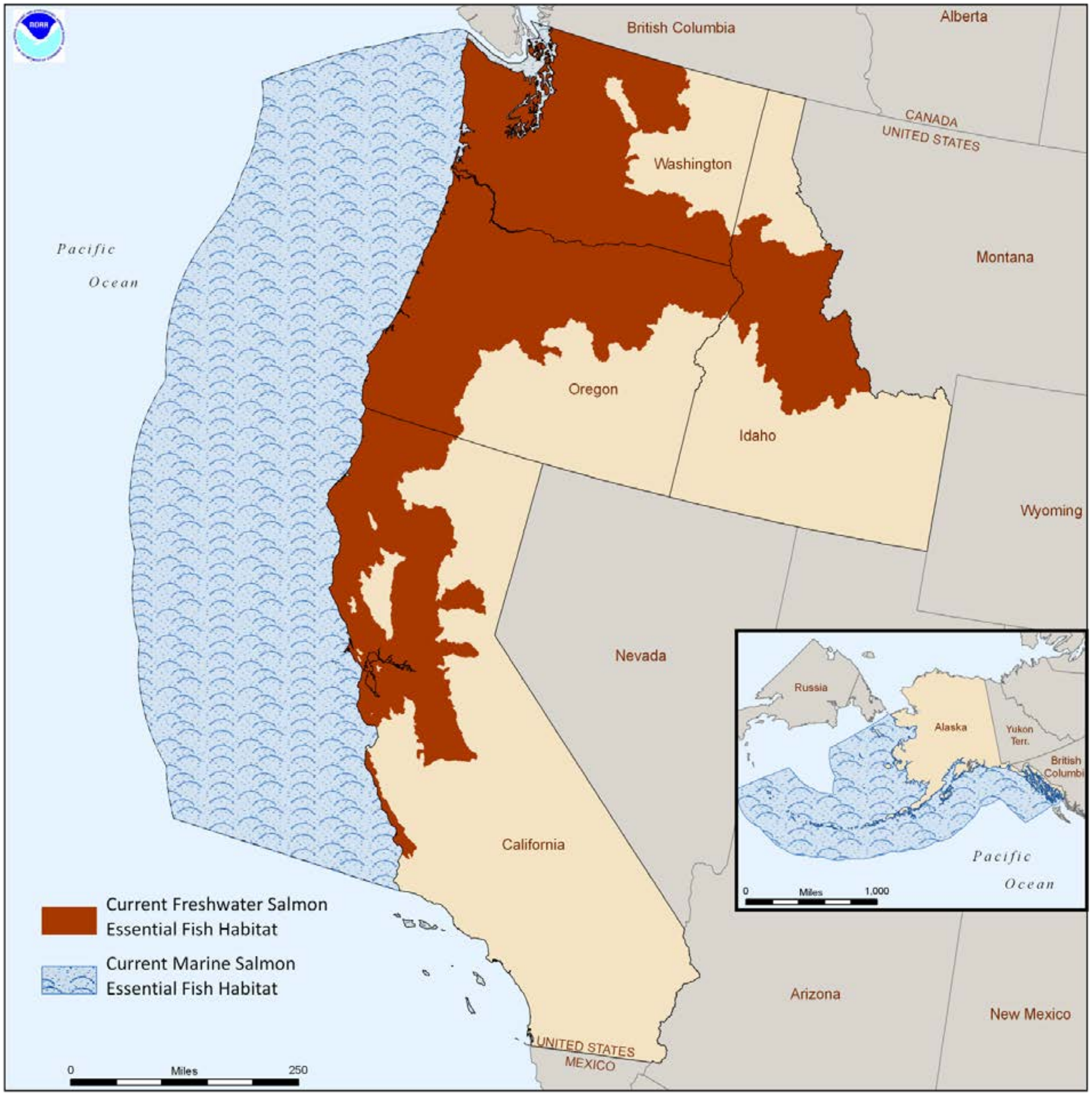

Figure 1. Freshwater, estuarine, and marine habitats currently designated as EFH for Pacific Coast salmon in Washington, Idaho, Oregon, and California, and marine waters off the west coast and Alaska.

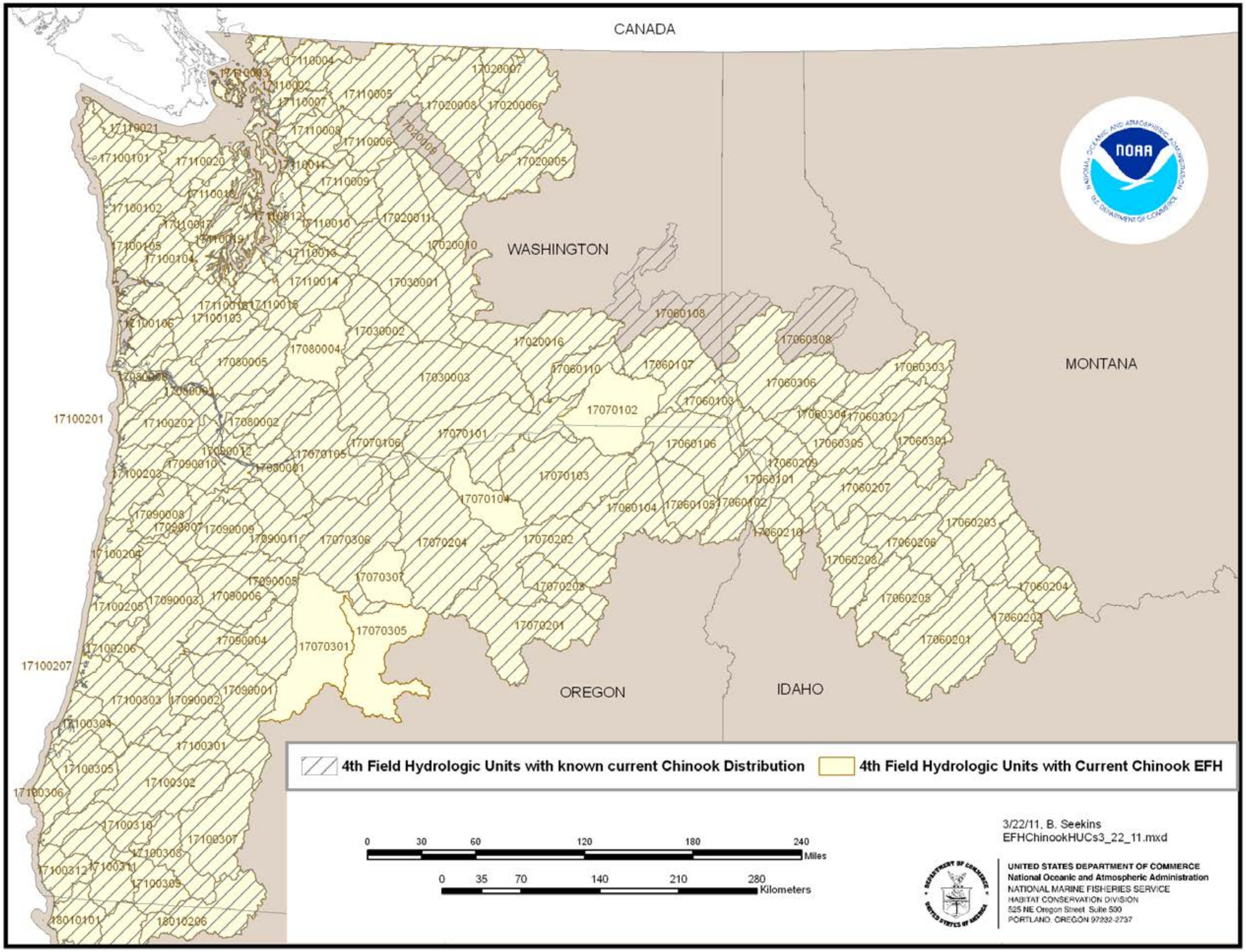

Figure 2. 4th field HUs currently identified as EFH for Chinook salmon in relation to current Chinook salmon distribution in Washington, Oregon, and Idaho.

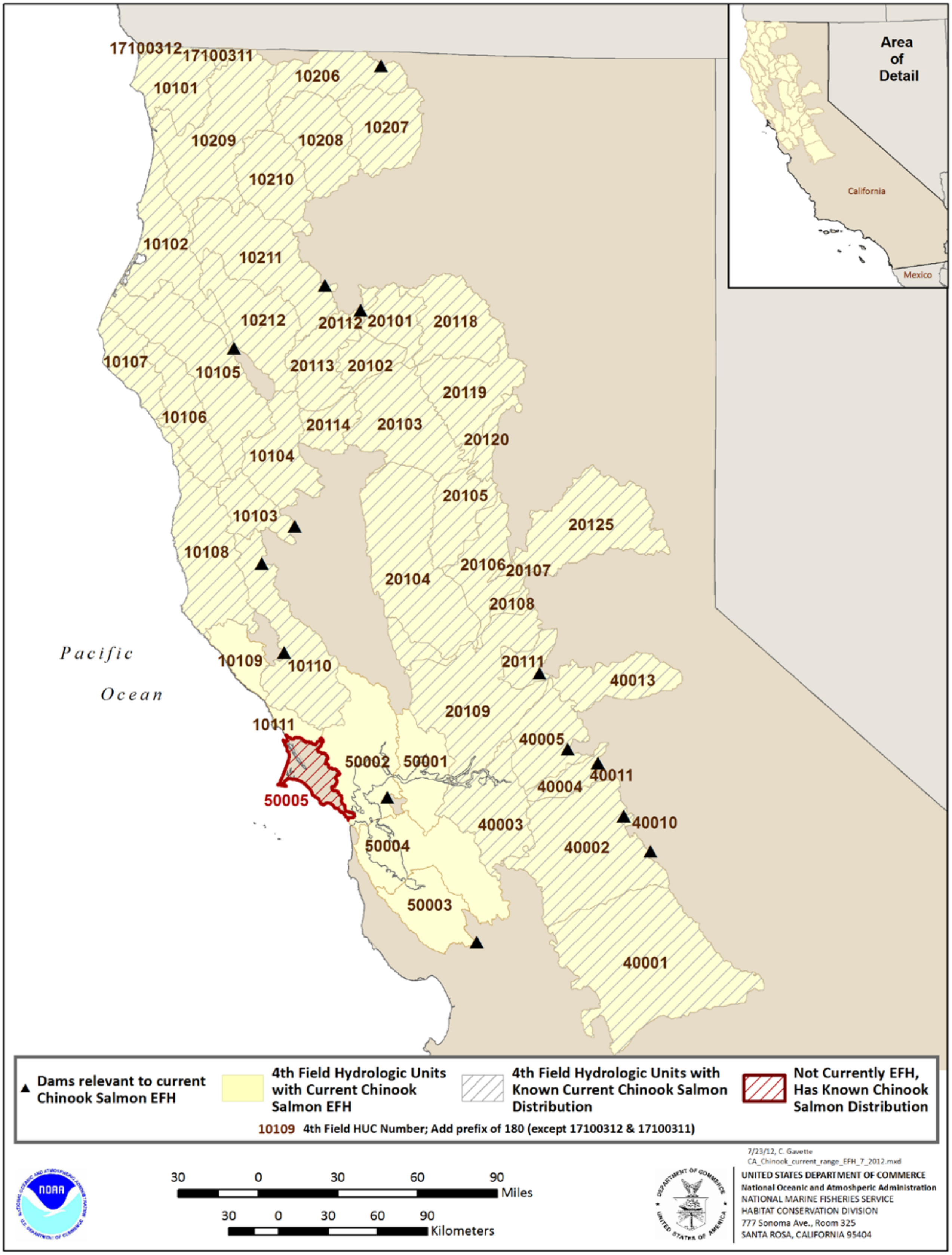

Figure 3. 4th field HUs currently identified as EFH for Chinook salmon in relation to current Chinook salmon distribution in California.

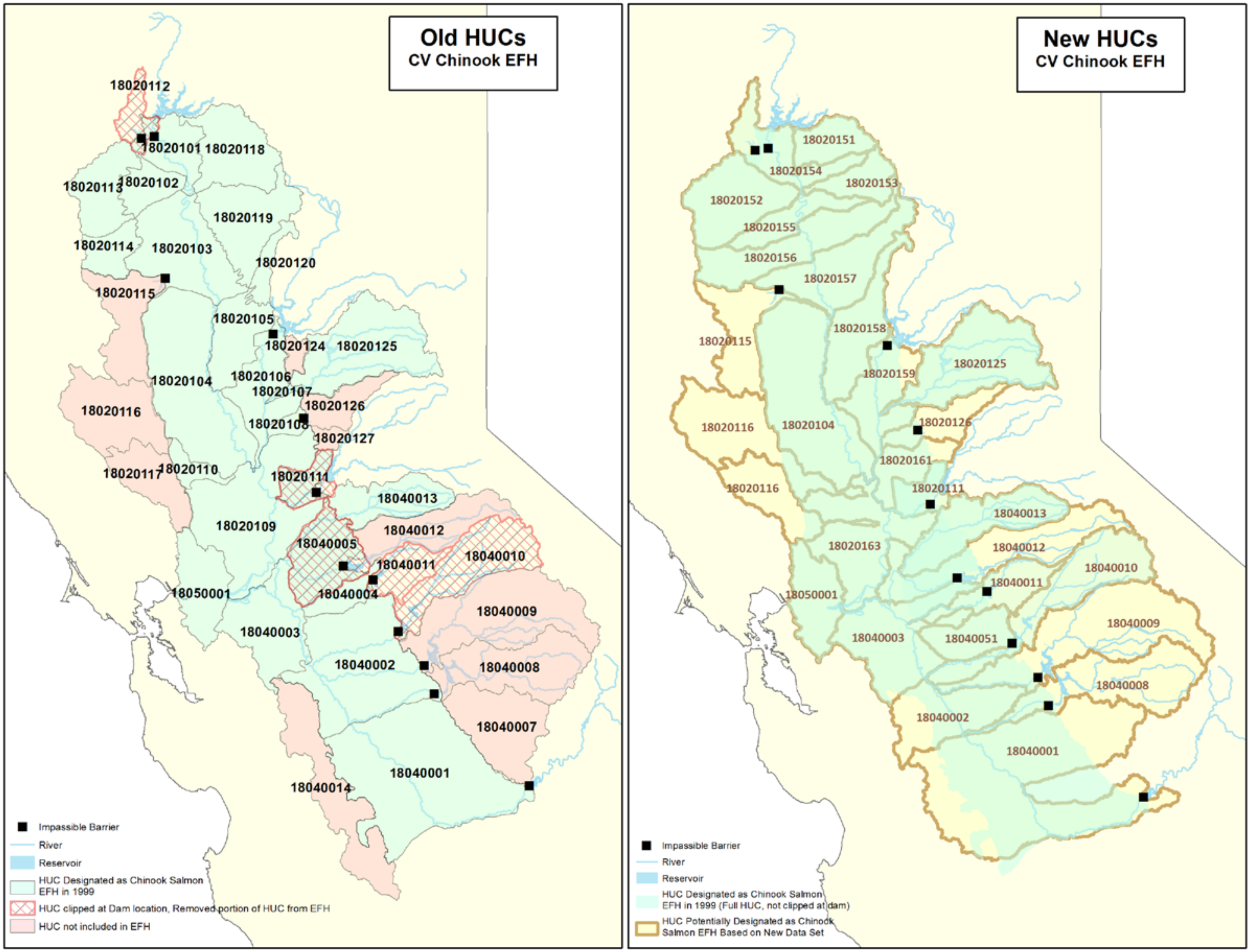

Figure 4. Comparison of the California Central Valley 4th field HUs designated as EFH in Amendment 14 with the newly defined HUs having current or historical Chinook salmon distribution data. Note that the spatial extent of EFH for Chinook salmon has expanded in some areas.

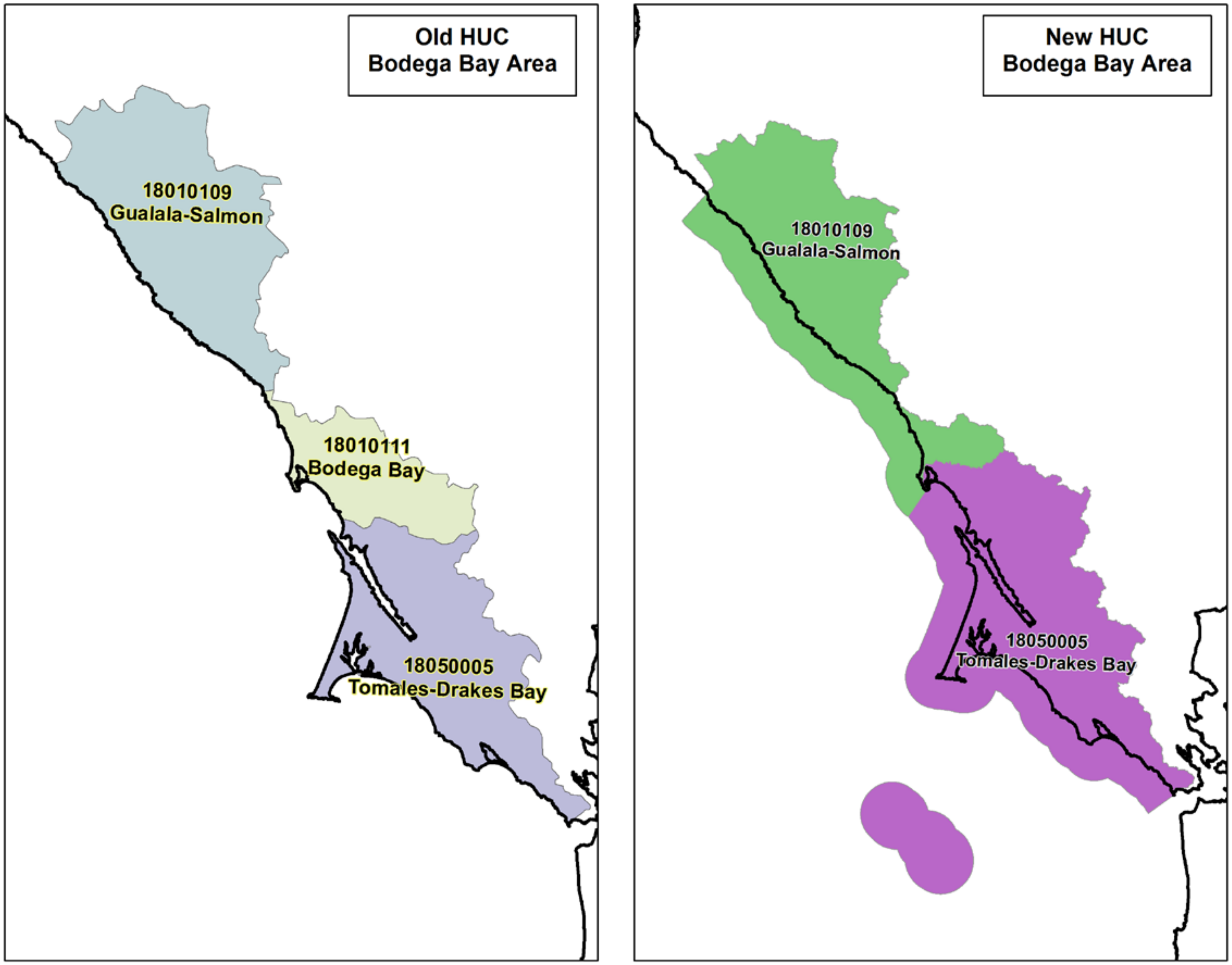

Figure 5. Comparison of California coast 4th field HUs designated as EFH in Amendment 14 with the newly defined HUs having current or historical Chinook salmon distribution data.

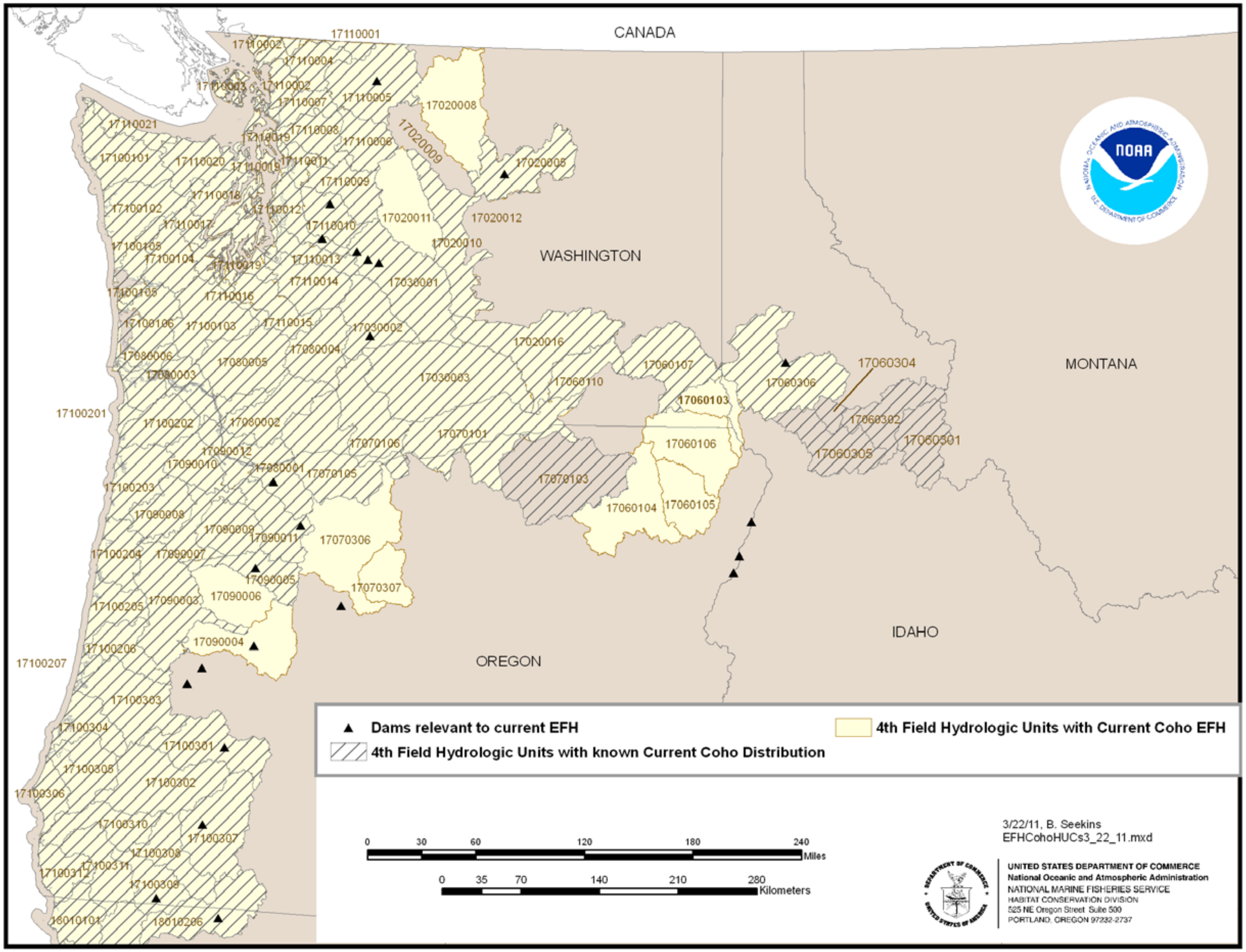

Figure 6. 4th field HUs currently identified as EFH for coho salmon in relation to current coho salmon distribution in Washington, Oregon, and Idaho.

Figure 7. 4th field HUs currently identified as EFH for coho salmon in California.

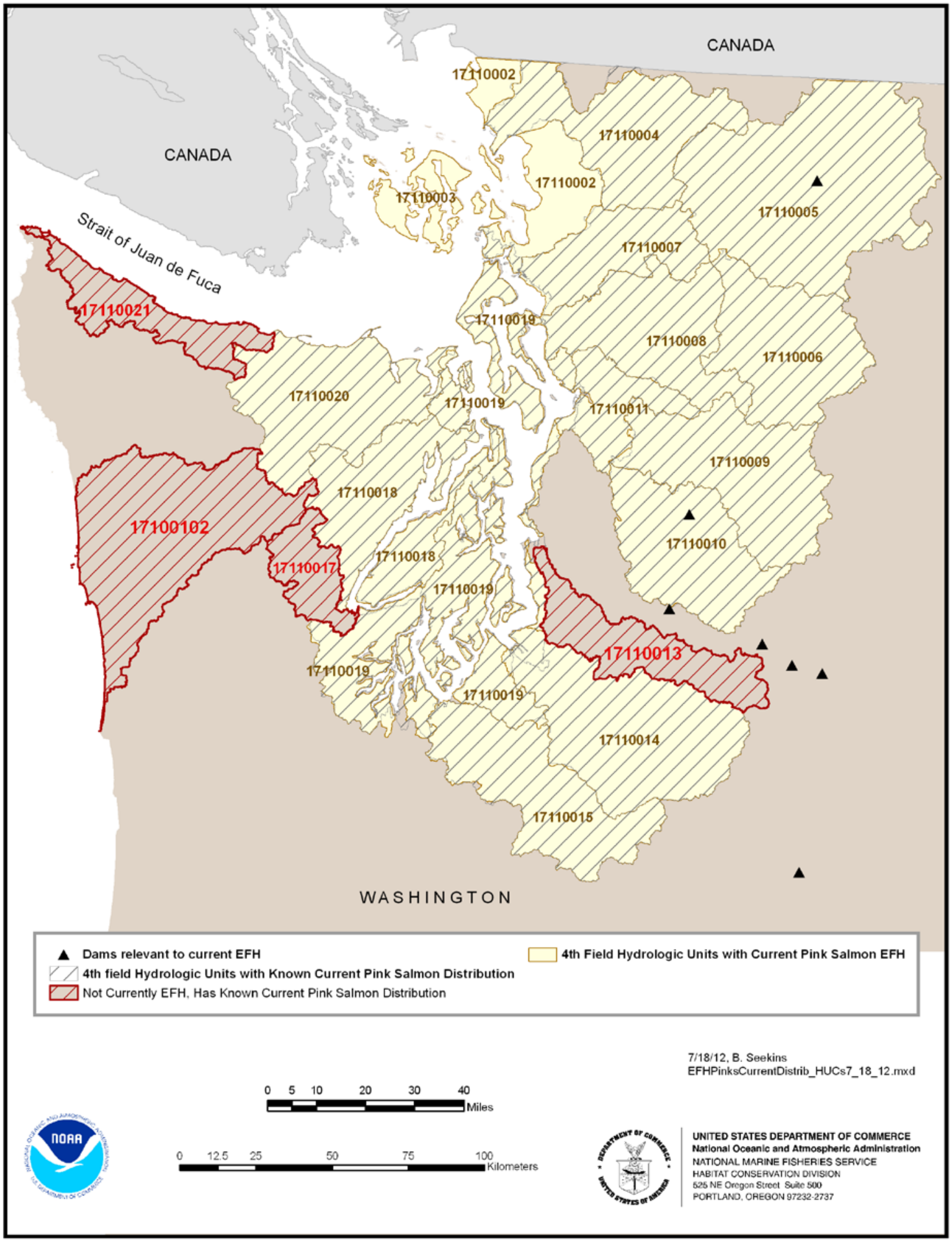

Figure 8. 4th field HUs currently identified as EFH for PS pink salmon in relation to current PS pink salmon distribution in western Washington.

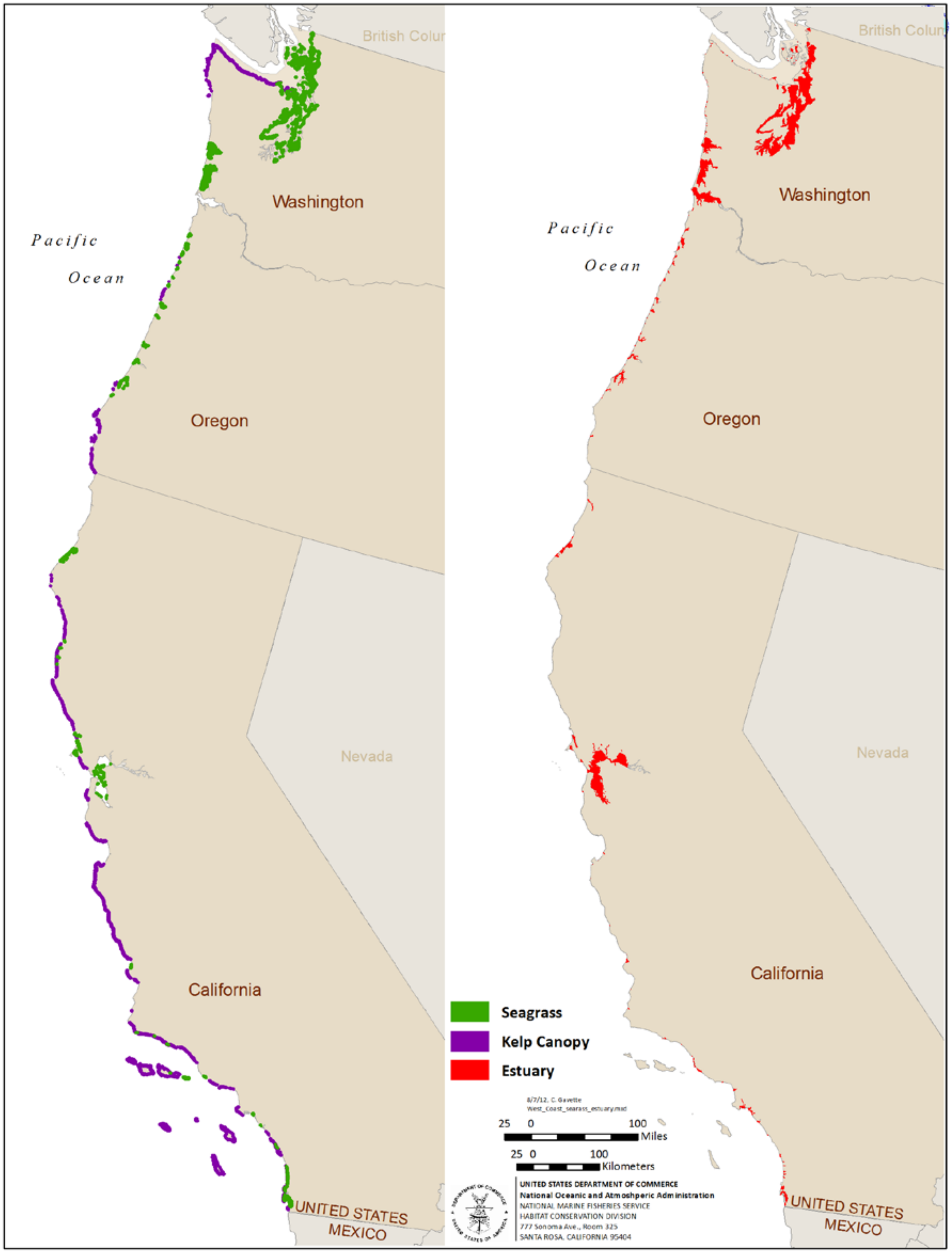

Figure 8. Seagrass and Estuaries as potential HAPCs for Pacific salmon. (Note that EFH is not designated south of Point Conception, CA)

Appendix B

LIST OF CRITERIA USED TO DETERMINE WHETHER IMPASSABLE DAMS REPRESENT THE UPSTREAM EXTENT OF PACIFIC SALMON EFH

The following excerpt from Appendix A of Amendment 14 to the Pacific Coast Salmon Plan describes how the Council and NMFS considered artificial barriers and whether they should represent the upstream extent of Pacific salmon EFH:

> In identifying EFH, the Council considered artificial barriers (dams) that affect salmon habitat. Numerous hydropower, water storage, and flood control projects have been built that either block access to areas used historically by salmonids or alter the hydrography of downstream river reaches. While available information is not sufficient to conclude that currently accessible habitat is sufficient for supporting sustainable salmon fisheries and a healthy ecosystem, subsequent analyses (e.g., in recovery planning, ESA consultations, or hydropower proceedings) may conclude that currently inaccessible habitat should be made available to the species. The Council, therefore, considered whether more than 50 large dams in Washington, Idaho, Oregon, and California should be designated as the upstream extent of EFH. The four criteria used to evaluate EFH and the dams were:

1. Is the dam federally owned or operated, licensed by the Federal Energy Regulatory Commission (FERC), state licensed, or subject to state dam safety supervision? This criterion assures the dam is of sufficient size, permanence, impassibility, and legal identity to warrant consideration for inclusion in this list.
2. Is the dam upstream of any other impassable dam? This criterion provides for a continuous boundary of designated habitat.
3. Is fish passage to upstream areas under consideration, or are fish passage facilities in the design or construction phase? There is no currently, or soon to be, accessible freshwater salmon habitat that is expendable. All such habitat is key to the conservation of these species and needs the special considerations for protection and restoration incumbent with designation.
4. Has NMFS determined the dam does not block access to habitat that is key for the conservation of the species? This criterion provides for designation of habitat upstream of, and exclusion of, otherwise listed dams when NMFS is able to determine restoration of passage and conservation of such habitat is necessary for long-term survival of the species and sustainability of the fishery.

Based on these considerations, the Council excluded certain dams from the list of those representing the upstream extent of EFH including Elwha Dam, Merwin Dam, Landsburg Dam, Howard Hanson Dam, Condit Dam, Cushman Dam, Mayfield Dam, Foster Dam, Pelton Dam, and Englebright Dam. Several large, impassable dams, (e.g., Grand Coulee and Shasta dams), were removed from the list, since they are above other impassible dams. Subsequent analyses may indicate other dams should be removed from Table A-2.

The table below replaces Table 1 in the Pacific Coast Salmon Amendment 18 Draft Preliminary Alternatives document (Agenda Item E.4.a Attachment 1).

Table 1: Summary of alternatives.

Subject Area	**Alternatives**
Identification of Pacific salmon EFH	1A. No Action 1B. Revise the identification of EFH ~~amend~~ to clarify that EFH is designated only for stocks included in the fishery managed by the PFMC
Chinook salmon freshwater EFH	2A. No Action 2B. Add ~~three~~ four hydrologic units (HUs) as Chinook salmon EFH: 17060108 (Palouse), 17060308 (Lower NF Clearwater), 18050005 (Tomales-Drakes Bay), and Lake Chelan (17020009) 2C. Designate the mainstem Columbia River and side channels as EFH for Chinook salmon, in HU 17070101. 2D. Update EFH designations and maps to be consistent with new USGS California Central Valley 4th field hydrologic units.
Coho salmon freshwater EFH	3A. No Action 3B. Add five HUs as coho salmon EFH: 17070103 (Umatilla), 17060305 (South Fork Clearwater), 17060304 (Middle Fork Clearwater), 17060302 (Lower Selway), and 17060301 (Upper Selway). 3C: Remove coho salmon EFH from one HU: 18060006 (Central California Coast).
Puget Sound pink salmon freshwater EFH	4A. No Action 4B. Designate HU 17110013 (Duwamish) as PS pink salmon EFH 4C. Designate HU 17110017 (Skokomish) as PS pink salmon EFH 4D. Designate HU 17110021 (Crescent-Hoko) as PS pink salmon EFH 4E. Designate HU 17100102 (Queets-Quinault) and as PS pink salmon EFH
Impassable barriers	5A. No Action 5B. Make housekeeping updates, including correct names, other minor corrections, removing dams from the list that are upstream of other impassable barriers, and removing barriers that are now passable from the list: [Dexter Dam (HU 17090001, Middle Fork Willamette River); Big Cliff Dam (HU 19070005, North Santiam River); Soda Springs Dam (HU 17100301, North Umpqua River)]. 5C. Update ~~revise~~ the list of dams based on the existing Amendment 14 criteria 5D. Revise the criteria for designating a dam as the upstream extent of EFH, and update the list based on the new criteria and new information. *Note: Alternatives 5C and 5D are mutually exclusive*

Marine and estuarine EFH – all species	6A. No Action 6B. Clarify that PS pink salmon marine EFH includes U.S. EEZ waters, Puget Sound/Straits of Juan de Fuca, and Alaskan waters that are designated salmon EFH by the NPFMC. *Considered but rejected: • Remove marine EFH designation for Alaska marine waters. • Refine marine EFH descriptions.
EFH descriptions	7A. No Action 7B. Update the ~~text for~~ EFH summaries and descriptions for each species of Pacific Coast salmon, based on best available science. Provide new references as an appendix to Amendment 18; and update EFH descriptions, life history, and habitats, based on new information regarding habitat needs, life history, etc.
HAPCs	8A. No Action 8B. Designate channels and floodplains as a HAPC 8C. Designate thermal refugia as a HAPC 8D. Designate spawning habitat as a HAPC 8E. Designate estuaries as a HAPC 8F. Designate marine and estuarine submerged aquatic vegetation as a HAPC
Fishing activities that may adversely affect EFH	9A. No Action 9B. Revise description of MSA fishing activities. 9C. Revise description of non-MSA fishing activities.
Non-fishing activities that may adversely affect EFH	10A. No Action 10B. Update the information on the existing 21 non-fishing activities that may adversely affect EFH. 10C. Add new non-fishing activities that may adversely affect EFH: 10C1. Pile driving 10C2. Over-water structures 10C3. Alternative energy development 10C4. Liquefied natural gas projects 10C5. Desalination 10C6. Power plant intakes 10C7. Pesticide use 10C8. Flood control maintenance 10C9. Culvert construction 10C10. Activities that contribute to climate change
Information and research	11A. No Action 11B. Identify and prioritize new information and research needs.
Procedures for changing EFH	No alternatives developed yet.

HABITAT COMMITTEE REPORT ON FMP AMENDMENT 18 – UPDATE OF ESSENTIAL FISH HABITAT (EFH) FOR SALMON

Mr. Kerry Griffin, Council staff, provided the Habitat Committee (HC) with an overview of the Pacific Coast Salmon Fishery Management Plan (FMP) amendment process to update essential fish habitat (EFH). The presentation focused on Agenda Item E.4.a, Attachment 1, which includes proposed alternatives in twelve subject areas. These alternatives are summarized in Agenda Item E.4.a, Supplemental Attachment 2.

The HC reviewed the draft preliminary alternatives and discussed whether they are appropriate to adopt for further analysis and public review, considering the recommendations from the five-year review of EFH report and previous Council action. The HC recommends the Council adopt the preliminary draft alternatives with the following modifications:

Alternative 1:
Note in the introduction that EFH designations also have ecosystem benefits (e.g., habitat for non-FMP stocks).

Alternative 4:
As currently written, the HC considers 4B and 4C as relatively straightforward alternatives to modifying the Puget Sound fishery management unit (FMU). For 4D and 4E, the HC calls attention to the fact that these hydrologic units are outside Puget Sound, but because they are inhabited by pink salmon, they should be included as alternatives. The Council could consider whether to redefine the FMU with a broader spatial designation (e.g., Washington pink salmon).

Alternative 5:
Under 5D, Criterion 1, the HC recommends retaining the original language in the FMP (also in Appendix B in Agenda item E.4.a, Attachment 1).

Under Criterion 3, the HC recommends removing the following language "…and is likely to be implemented before the next EFH review."

Alternative 9:
The HC recommends replacing the term "salmon fishing gear" with "fishing gear" throughout Section 8 ("Fishing Activities that May Adversely Affect EFH").

Alternative 10C1:
To include related impacts, the HC recommends replacing "pile driving" with "activities causing high intensity acoustic or pressure waves (e.g., pile driving, ordnance detonation, seismic surveys)."

Under Section 10 (no Alternative number), the HC recommends developing mechanisms outside an FMP amendment to make minor updates to EFH.

PFMC
09/14/12

PACIFIC SALMON AMENDMENT 18: UPDATE OF ESSENTIAL FISH HABITAT

Pacific salmon EFH was established in 1998, with the assumption that as new information became available, certain elements of EFH would be changed appropriately. Currently, the Pacific salmon FMP states that any changes to EFH will be made in an FMP amendment. The Council should consider adopting a process that would allow for specified changes to EFH to be made without an FMP amendment.

The following alternatives are suggested for consideration as part of the suite of alternatives to be adopted by the Pacific Fishery Management Council:

12A: No Action
This alternative would maintain the status quo and require that all changes to Pacific Coast salmon EFH be accomplished through an FMP amendment.

12B: Develop one or more alternatives that:

- describe a process for modifying EFH without a plan amendment,
- identify the types of changes to EFH that could be made without a plan amendment, and
- identify the types of changes to EFH that would continue to be made through a plan amendment.

Agenda Item E.4.c
Supplemental SAS Report
September 2012

SALMON ADVISORY SUBPANEL REPORT ON FMP AMENDMENT 18 – UPDATE OF ESSENTIAL FISH HABITAT (EFH) FOR SALMON

The Salmon Advisory Subpanel (SAS) recommends adding "coal terminal facilities" to the list of non-fisheries related activities noted in the essential fish habitat document.

PFMC
09/15/12

SCIENTIFIC AND STATISTICAL COMMITTEE REPORT ON FMP AMENDMENT 18 – UPDATE OF ESSENTIAL FISH HABITAT (EFH) FOR SALMON

Mr. Kerry Griffin presented a detailed review of alternatives under consideration for essential fish habitat (EFH) in Amendment 18 to the Pacific Coast Salmon Plan (Agenda Item E.4.a Attachment 1 with revised Table 1, E.4.a, Supplemental Attachment 2). Alternatives are organized under ten subject areas. The organizational structure and the alternatives were clearly laid out. The Scientific and Statistical Committee (SSC) had comments on the following specific alternatives which are labeled as in the document:

Freshwater EFH

Chinook:

- The SSC supports adoption of Alternatives 2B, 2C, and 2D.

Coho:

- The SSC supports adoption of Alternative 3B. We recommend considering the inclusion of HUC 60002 (Pajaro River) based on historic presence of coho salmon.
- The SSC supports adoption of Alternative 3C.

Pink:

- The SSC supports adoption of Alternatives 4B and 4C.
- Adoption of Alternatives 4D and 4E should depend on data establishing that Puget Sound Pink Salmon are occupying these areas, which lie outside of Puget Sound.

Impassible barriers

- The SSC supports adoption of Alternative 5B.
- The SSC supports adoption of Alternative 5D with a change to Criterion 3. We suggest Criterion 3 should read:

  3. Is fish passage in the construction or planning phase by a state or federal agency or facility operator?"
  - *If Yes, then the dam should not be considered the upstream extent, and the habitat above the dam should be designated as EFH.*
  - *If no, then go to 4.*

  Other cases, including EFH above barrier projects that are not yet in planning or construction phases, can be considered under Criterion 4.

EFH descriptions

- The SSC supports adoption of Alternative 7B.

Habitat Areas of Particular Concern (HAPCs)

- The SSC supports adopting the 5 HAPCs defined in Alternatives 8B – 8F.

- The SSC highlights the particular importance of Alternative 8E: estuaries and estuary-influenced offshore areas. These are utilized by multiple species and support a variety of ecosystem functions.

Fishing activities

- The SSC supports adoption of Alternatives 9B and 9C.

Non-fishing activities

- The SSC supports adoption of Alternative 10B. Dam removal should be added to the dam construction/operation item.
- The SSC supports adoption of Alternatives 10C1 through 10C9 but we recommend removing Alternative 10C10. Individual activities that contribute to climate change are impossible to relate directly to salmon EFH. Instead we encourage research to understand the effects of climate change on salmon populations, predator/prey relationships, and habitat needs.

Information and research needs

- Several data issues constrained the designation of EFH in this document. Research on these topics should be included in the data needs. Examples include: pink salmon populations, the role of fishing activities in reducing prey availability, and ocean habitat associations.
- Climate change impacts on salmon habitat should be included as a research topic.

PFMC
09/14/12

LOWER COLUMBIA ENDANGERED SPECIES ACT SALMON AND STEELHEAD RECOVERY PLAN

The National Marine Fisheries Service (NMFS) requested that the Council and its advisory bodies provide comments on the Public Review Draft Proposed Endangered Species Act (ESA) Recovery Plan for Lower Columbia River Coho Salmon, Lower Columbia River Chinook Salmon, Columbia River Chum Salmon, and Lower Columbia River Steelhead (Recovery Plan). The initial comment period expired July 16, but a second comment period is planned, although it has not yet been announced. Comments from the Council will be accepted under the second comment period.

The Recovery Plan is based largely on recovery plans developed by the states of Washington and Oregon, and a plan for the White Salmon River, an estuary recovery plan module, and a hydropower module, which are included as appendices of the Recovery Plan. A Fact Sheet (Agenda Item E.5.a, Attachment 1) and Executive Summary (Agenda Item E.5.a, Attachment 2) of the Recovery Plan are included in the briefing materials, while the entire Recovery Plan (Agenda Item E.5.a, Attachment 3) is available on the briefing book CD and online at http://www.nwr.noaa.gov/Salmon-Recovery-Planning/Recovery-Domains/Willamette-Lower-Columbia/LC/plan.cfm (appendices available online only).

Council Action:

1. **Consider comments and recommendations developed by advisory bodies.**
2. **Provide guidance on submitting comments and recommendations to NMFS.**

Reference Materials:

1. Agenda Item E.5.a, Attachment 1: Fact Sheet on Proposed Lower Columbia Recovery Plan.
2. Agenda Item E.5.a, Attachment 2: Executive Summary from Proposed Lower Columbia Recovery Plan.
3. Agenda Item E.5.a, Attachment 3: Proposed ESA Recovery Plan for Lower Columbia River Coho Salmon, Lower Columbia River Chinook Salmon, Columbia River Chum Salmon, and Lower Columbia River Steelhead **(full document available on the briefing book CD and online at** http://www.nwr.noaa.gov/Salmon-Recovery-Planning/Recovery-Domains/Willamette-Lower-Columbia/LC/plan.cfm**).**

Agenda Order:

a. Agenda Item Overview — Chuck Tracy
b. Reports and Comments of Advisory Bodies and Management Entities
c. Public Comment
d. **Council Action:** Review and Provide Comments

PFMC
08/22/12

NOAA FISHERIES SERVICE

Lower Columbia River ESA Listed Species:

- Lower Columbia River Chinook salmon
- Lower Columbia River steelhead
- Lower Columbia River coho salmon
- Columbia River chum salmon

Proposed Lower Columbia Recovery Plan

Overview

The proposed plan provides a road map to recover four salmon and steelhead species that spawn and rear in the lower Columbia River or its tributaries in Oregon and Washington: Lower Columbia River Chinook salmon, Lower Columbia River steelhead, Lower Columbia River coho salmon, and Columbia River chum salmon. These salmon and steelhead were listed as threatened under the Endangered Species Act (ESA) between 1998 and 2005.

Under the ESA, a recovered salmon or steelhead species must be self-sustaining and able to survive typical variations in ocean conditions and productivity. Healthy, abundant salmon runs can provide opportunities for sustainable harvest and allow local communities, including tribes, to engage in their historical traditions.

Local Oregon & Washington Recovery Plans Form the Basis of this Federal Plan

The Proposed Lower Columbia Recovery Plan is based on three locally developed plans, each of which covers a different portion of the species' range:

- The Oregon Lower Columbia Conservation and Recovery Plan for Salmon and Steelhead, by the Oregon Department of Fish and Wildlife (2010)
- The ESA Salmon Recovery Plan for the White Salmon River Subbasin, by NOAA Fisheries (2011)
- The Washington Lower Columbia Salmon Recovery and Fish & Wildlife Subbasin Plan, by the Lower Columbia Fish Recovery Board (2010)

Lower Columbia River

These plans were developed in collaborative processes that included tribes, other government entities (including NOAA Fisheries), industry, environmental groups, and the public. Two other documents— the Columbia River Estuary ESA Recovery Plan Module for Salmon and Steelhead and the Recovery Plan Module: Mainstem Columbia River Hydropower Projects, both by NOAA Fisheries—also inform the proposed plan. The locally developed plans and the modules are appendices to the Proposed Plan.

Key Factors Impeding Survival & Proposed Recovery Strategies

Recovery plans identify the key factors impeding salmon survival, known as limiting factors, and target the right actions in the right places to reduce those limiting factors. Recovery will require actions that conserve and restore the key biological, ecological, and landscape processes that support Lower Columbia salmon and steelhead and the ecosystems they depend on. The Proposed Plan calls for tributary and estuary habitat protection and restoration actions; changes in management of harvest, hatchery, and hydropower programs; and predation control.

Tributary habitat degradation from past and/or current land and water use is a limiting factor for all Lower Columbia salmon and steelhead populations. The tributary habitat strategy is directed toward habitat protection and restoration to achieve adequate quantities of high-quality, well-functioning salmon and steelhead habitat. This will be accomplished through a combination of (1) site-specific projects that will protect habitat or provide benefits relatively quickly, (2) watershed-based actions that will repair habitat forming processes and provide benefits over the long term, and (3) landscape-scale programmatic actions that affect a class of activities (such as stormwater management or forest practices) over multiple watersheds. Although many habitat-related actions already have been undertaken, current activities do not reflect the scale of improvements needed. Estuary habitat strategies focus on providing adequate off-channel and intertidal habitats, such as tidal swamp and marsh; restoring habitat complexity in areas modified by agricultural or rural residential use; and decreasing exposure to toxic contaminants.

Mainstem or tributary hydropower projects affect passage and local habitat conditions for some populations, and estuarine habitat conditions for all populations. The regional hydropower strategy focuses on: (1) improving passage survival at Bonneville Dam for Lower Columbia River populations that spawn above the dam, (2) addressing impacts in tributaries by implementing Federal Energy Regulatory Commission agreements regarding operation of tributary dams, and (3) implementing mainstem flow management operations designed to benefit migrants from the interior Columbia Basin, which we expect will improve estuarine survival.

When hatchery-origin fish spawn with natural-origin fish, adverse genetic changes can be transmitted to the naturally produced fish. The goals of the hatchery strategy for Lower Columbia salmon are to (1) reduce hatchery impacts on natural-origin populations as appropriate for each population, (2) ensure that some populations have no in-subbasin hatchery releases and are isolated from stray out-of-subbasin hatchery fish, (3) use hatchery stocks in the short term for reintroduction or supplementation programs to restore naturally spawning populations in some watersheds, and (4) ensure rigorous monitoring and evaluation to better understand existing population status and the effects of hatchery strategies on natural populations.

Maintaining harvest opportunities created by hatchery fish is a societal goal that NOAA Fisheries has carried forward from the local plans to the proposed recovery plan.

Harvest managers have substantially reduced impacts on Lower Columbia River species since they were listed under the ESA. For Lower Columbia River spring Chinook salmon, steelhead, and chum salmon, the recovery plan recommends precautionary measures to ensure that harvest does not adversely affect future conservation and recovery efforts. For Lower Columbia fall Chinook and coho salmon, efforts will focus on (1) refinements in harvest management to further reduce impacts to naturally produced fish, and (2) continued review of overall harvest rates.

The plan includes actions to reduce predation on salmon and steelhead by birds, fish, and marine mammals. It also incorporates a regional climate change strategy focused on (1) implementation of greenhouse gas reduction strategies, such as through the West Coast Governors' Global Warming Initiative and the Oregon Global Warming Commission's recommendations, and (2) adaptation to reduce the impacts of climate change. Local recovery planners have also developed or will develop specific research, monitoring, and evaluation plans for their respective geographic areas that are based on regional guidance.

Implementation & Costs

Recovery plans are not regulatory documents. Their implementation is voluntary (except when they incorporate actions required as part of an ESA regulatory process). NOAA Fisheries will rely on local citizens and organizations, other Federal and state agencies, local jurisdictions, and tribal governments to implement the actions proposed in this recovery plan.

The total estimated cost of recovery actions for the four threatened species in the lower Columbia River over the next 25 years is estimated at $2.1 billion, of which $614 million is anticipated to be needed in the first 5 years. The total cost includes $592 million ($164 in the first 5 years) for actions in the Columbia River estuary that are expected to benefit all Columbia Basin salmon and steelhead. The cost estimates are expected to change as implementation schedules are developed and actions are more clearly scoped and planned.

The keys to long-term success are full funding and implementation of this recovery plan and voluntary participation by residents in the lower Columbia region. Only through the involvement of all those who live and work in this region will recovery be achieved.

Executive Summary

About This Recovery Plan

This is a proposed plan for the recovery of Lower Columbia River Chinook salmon (*Oncorhynchus tshawytscha*), Lower Columbia River steelhead (*O. mykiss),* Lower Columbia River coho salmon (*O. kisutch*), and Columbia River chum salmon (*O. keta*), all of which spawn and rear in the lower Columbia River or its tributaries in Oregon and Washington. These salmon and steelhead were listed as threatened under the Endangered Species Act of 1973 (ESA) between 1998 and 2005. Each is considered an evolutionarily significant unit (ESU) or, for steelhead, a distinct population segment (DPS). An ESU or DPS is a group of Pacific salmon or steelhead that is discrete from other groups of the same species and that represents an important component of the evolutionary legacy of the species.[1] Under the Endangered Species Act, each ESU or DPS is treated as a species. For convenience this recovery plan frequently uses the term "ESU" to refer to both the salmon ESUs and the steelhead DPS.

The core of the plan is a set of goals and actions for each ESU that, if implemented, would reverse the ESU's decline and lead to recovery of the ESU. Biological recovery for an ESU means that it is naturally self-sustaining and no longer requires the protection of the ESA: enough fish spawn in the wild and return year after year that the ESU is likely to persist in the long run. A recovered ESU is resilient enough that it can survive typical variations in ocean conditions and productivity and has a high likelihood of withstanding catastrophic changes in the environment, such as floods, landslides, and earthquakes.

The ESA requires the National Marine Fisheries Service (NMFS) to develop recovery plans for all listed salmon and steelhead species. NMFS is a branch of the National Oceanic and Atmospheric Administration and is sometimes referred to as NOAA Fisheries. As the Federal agency charged with stewardship of the nation's marine resources, NMFS has the responsibility for listing and delisting salmon and steelhead species under the ESA.

Although NMFS is directly responsible for ESA recovery planning for salmon and steelhead, the agency believes that ESA recovery plans for salmon and steelhead should be based on the many state, regional, tribal, local, and private conservation efforts already under way throughout the region, and that local support of recovery plans is essential to success. Accordingly, NMFS based this recovery plan on the information, analyses, and strategies in three locally developed recovery plans, which are referred to as management unit plans.

Each ESU is made up of multiple independent populations, and each management unit plan covers populations in a different portion of the ESU's range:

[1] A DPS is defined based on discreteness in behavioral, physiological, and morphological characteristics, whereas the definition of an ESU emphasizes genetic and reproductive isolation. (For a fuller explanation see, Section 1.4.4 of the recovery plan.)

- *The Oregon Lower Columbia Conservation and Recovery Plan for Salmon and Steelhead* covers the Lower Columbia River salmon and steelhead populations that are within Oregon, including the Willamette River up to Willamette Falls. The Oregon Department of Fish and Wildlife (ODFW) developed this plan in collaboration with NMFS and numerous stakeholders, including governments, agencies, tribes, industry and environmental representatives, and the public (Oregon Department of Fish and Wildlife 2010).

- *ESA Salmon Recovery Plan for the White Salmon River Subbasin* covers Lower Columbia River salmon and steelhead populations in the White Salmon River basin in Washington. NMFS developed this plan in cooperation with stakeholders such as the Yakama Nation, Klickitat County, and Washington Department of Fish and Wildlife (National Marine Fisheries Service 2011b).

- *Washington Lower Columbia Salmon Recovery and Fish & Wildlife Subbasin Plan* covers Lower Columbia River salmon and steelhead populations in Southwest Washington, within the planning area of the Lower Columbia Fish Recovery Board (LCFRB). The LCFRB developed this plan using a collaborative process that involved multiple agencies (including NMFS), tribal and other governments, organizations, industry, and the public (Lower Columbia Fish Recovery Board 2010a).

Two other documents, both developed by NMFS, were key in development of this recovery plan: the *Columbia River Estuary ESA Recovery Plan Module for Salmon and Steelhead* (NMFS 2011a) and the *Recovery Plan Module: Mainstem Columbia River Hydropower Projects* (NMFS 2008a). These documents, which address regional-scale issues affecting Lower Columbia River salmon and steelhead, as well as other listed salmon ESUs and steelhead DPSs, provide a consistent set of assumptions and recovery actions that management unit recovery planners incorporated into their management unit plans.

Recovery plans are not regulatory documents. Their implementation is voluntary, except when they incorporate actions required as part of a regulatory process, such as ESA section 7, 10, and 4(d). For this recovery plan, NMFS will rely, to a great extent, on local citizens and organizations, as well as on other Federal and state agencies, local jurisdictions, and tribal governments, to voluntarily implement the proposed actions. In some cases, the plan proposes new recovery efforts that are not part of existing processes. In other cases, the plan recommends coordinating existing programs, both regulatory and non-regulatory, in ways that enhance benefits to Lower Columbia River salmon and steelhead and their ecosystems. Some actions that are integrated into this recovery plan originate in regulatory processes; examples include actions associated with the 2008 Bull Run Water Supply Habitat Conservation Plan (HCP), the 2008 Federal Columbia River Power System Biological Opinion and its 2010 Supplement, Federal Energy Regulatory Commission relicensing agreements (for tributary hydroelectric projects), and the regulation of fisheries that may affect the Lower Columbia River ESUs.

This recovery plan lays out an overall road map for recovery. After the plan is adopted, additional work will be needed in some cases to identify and prioritize[2] site-specific projects, determine costs and time frames, and identify responsible parties, based on strategies and actions in the recovery plan. To address these needs, each entity that developed a management unit plan (i.e., ODFW, NMFS, and LCFRB) also will prepare an "implementation schedule" that spells out the details of implementation for its specific geographical area. Implementation schedules will be updated every 3 to 6 years.

Overall Goal

In general, the goal of this plan is for the Lower Columbia River coho salmon ESU, Lower Columbia River Chinook salmon ESU, Lower Columbia River steelhead DPS, and Columbia River chum salmon ESU to reach the point at which they no longer need the protection of the Endangered Species Act and can be delisted. The delisting decision is made by NMFS, using the best available science. NMFS' delisting criteria are presented later in this summary, after some basic technical information and the population-specific goals are explained.

Technical Foundation

NMFS appointed teams of scientists with expertise in salmonid species to provide scientific support for recovery planners in the Pacific Northwest. These technical recovery teams (TRTs) worked from a common scientific foundation to ensure that recovery plans would be scientifically sound and based on consistent biological principles. All the TRTs based their work on biological principles established by NMFS for salmon recovery planning.

The Willamette-Lower Columbia Technical Recovery Team (WLC TRT) included biologists from NMFS, other federal agencies, states, tribes, academic institutions, and the private sector. The WLC TRT and a subsequent work group consisting of NMFS staff, ODFW staff, and a private consultant produced a set of technical reports that, taken together, present recommended biological criteria and methodologies for determining whether the four Lower Columbia River salmon and steelhead ESUs are viable. A viable ESU is naturally self-sustaining over the long term.

Consistent with principles established by NMFS, the WLC TRT described salmon and steelhead viability in terms of four interrelated parameters:

- **Abundance and productivity.** Abundance refers to the number of adult fish on the spawning grounds. Productivity is the population's growth rate, which indicates whether the population can sustain itself or rebound from low numbers. Productivity can be measured as spawner-to-spawner ratios (i.e., returns per spawner or recruits per spawner), annual population growth rate, or trends in abundance. Abundance and productivity are closely linked, and a population needs both: abundance to maintain genetic health and respond to normal

[2] Some prioritization work already has been done, in that the management unit plans identify high-priority reaches for tributary habitat protection and restoration actions. In addition, the Oregon and White Salmon management unit plans offer some guidance on how actions might be prioritized.

environmental variation, and productivity to bounce back if population numbers drop for some reason.

- **Spatial structure.** Spatial structure refers to both the geographic distribution of individuals in the population and the processes or conditions that generate that distribution. Factors affecting spatial structure include the amount of habitat available, how connected the habitat is, and how much neighboring populations mix with each other. Spatial structure is important because a species that is not geographically spread out is at risk of extinction from a single catastrophic event, such as a landslide.

- **Diversity**. Diversity refers to the variety of life history, behavioral, and physiological traits within and among populations. Some traits are determined completely by genetics, while others, such as appearance, behavior, and life history, vary as a result of a combination of genetic and environmental factors. Diversity is important because it gives populations an edge in surviving (and eventually adapting to) environmental change.

To understand the WLC TRT's biological criteria, it helps to know something about the biological structure of salmon and steelhead species. The Lower Columbia River Chinook salmon, Lower Columbia River coho salmon, Lower Columbia River steelhead, and Columbia River chum salmon ESUs each consist of multiple independent populations that spawn in different watersheds throughout the ESU's range. Additionally, within an ESU, independent populations can be organized into larger groups, known as strata. Stratum designation is based on the combination of ecological zone and life history strategy (indicated by the time of year when adults return to fresh water to spawn). In the lower Columbia region there are three ecological zones—Coast, Cascade, and Gorge. Two ESUs—Chinook and steelhead—display more than one life history strategy. Thus, the strata in this recovery plan include Coast, Cascade, and Gorge coho, Coast fall Chinook, Cascade fall Chinook, Gorge fall Chinook, Cascade spring Chinook, Gorge spring Chinook, etc.

The WLC TRT developed biological criteria and methodologies at three different levels: ESU, stratum, and population. The following are the TRT's key points in defining a viable ESU:

- Every stratum that historically existed should have a high probability of persistence.

- Within each stratum, there should be at least two populations that have at least a 95 percent probability of persisting over a 100-year time frame.

- Within each stratum, the average viability of the populations should be 2.25 or higher, using the WLC TRT's scoring system. Functionally, this is equivalent to about half of the populations in the stratum being viable; a viable population is one whose persistence probability is high or very high.

- Populations targeted for viability should include those within the ESU that historically were the most productive ("core" populations) and that best represent the historical genetic diversity of the ESU ("genetic legacy" populations). In addition, viable populations should be geographically dispersed in a way that protects against the effects of catastrophic events.

- Viable populations should meet specific criteria for abundance, productivity, spatial structure, and diversity.

There are various ways to refer to extinction risk: as viability, persistence probability, extinction risk, or—at the population level—population status. This recovery plan frequently uses the terms "persistence probability" and "population status." Only populations with a persistence probability of 95 percent or higher over a 100-year time frame are considered viable. These populations have a population status of high or very high.

Table ES-1
Population-level Probability of Persistence, Extinction Risk, and Status*

Probability of Persistence	Probability of Extinction	Extinction Risk	Population Status
0 – 40%	60 – 100%	Extinct or at very high risk of extinction (VH)	Very low (VL)
40 – 75%	25 – 60%	Relatively high risk of extinction (H)	Low (L)
75 – 95%	5 – 25%	Moderate risk of extinction (M)	Medium (M)
95 – 99%	1 – 5%	Low/negligible risk of extinction (L)	High (H)
> 99%	< 1%	Very low risk of extinction (VL)	Very high (VH)

+ Probability over a 100-year time frame.
Shading indicates levels at which a population is considered viable.

Population-specific Goals: The Recovery Scenario

The WLC TRT defined viability at the ESU, stratum, and population levels, but it did not specify the target status for each population because (1) there are many different combinations of target statuses that would meet the TRT's viability criteria, and (2) the "best" combination is a function of the biological and ecological conditions on the ground and local community values and interests. Oregon, Washington, and White Salmon management unit planners collaborated to reach agreement on which populations to target for which levels of viability. In making these decisions, management unit planners considered the WLC TRT's viability criteria and the following questions:

- Which populations historically were the most productive?
- Which populations represent important historical genetic diversity?
- Are the populations targeted for viability dispersed in a way that minimizes risk from catastrophic events?
- Which populations can be expected to make significant progress toward recovery because of existing programs, the absence of apparent impediments to recovery, and other management considerations?

- Are there populations that are unlikely to make significant progress toward recovery because of other societal goals, such as maintaining harvest or development opportunities?

The resulting target statuses for each ESU are collectively referred to as the recovery scenario and served as the basis from which to calculate numerical abundance and productivity goals for each population. (Table 3-1 of the recovery plan shows the recovery scenario for each ESU.)

Under the recovery scenario not all populations are targeted for a high degree of improvement, but all of them will need recovery actions—even so-called "stabilizing" populations. These are populations that are expected to remain at or near their current status (usually low or very low) because the feasibility of restoration is low and the uncertainty of success is high. "Primary" populations, on the other hand, are targeted for viability, meaning high or very high persistence probability. "Contributing" populations fall in the middle; they are targeted for some improvement in status so that the stratum-wide average viability is 2.25 or higher.

The recovery scenarios in the management unit plans are largely consistent with the WLC TRT's recommendations at the stratum and ESU level. Exceptions are the Gorge fall Chinook, Gorge spring Chinook, and Gorge chum strata, where the recovery scenarios target only one population to achieve a high probability of persistence, instead of two. As a way of mitigating for this increased risk in the Gorge strata, the recovery scenarios exceed the WLC TRT criteria in the Cascade fall Chinook, Cascade spring Chinook, and Cascade chum strata (i.e., more populations are targeted for viability than are needed to meet the 2.25 average). In addition, management unit recovery planners raised questions about the historical role of the Gorge fall Chinook, spring Chinook, and chum populations: were the populations highly persistent historically, did they function as independent populations within their stratum in the same way that the Coast and Cascade populations did, and should the Gorge stratum be considered a separate stratum from the Cascade stratum? Oregon recovery planners suggested that the Gorge strata's historical status and population structure be reevaluated and that recovery goals be revised if modifications are made; NMFS agrees that the historical role of the Gorge populations and strata merits further examination.

NMFS Delisting Criteria

As described above, the overall goal of this recovery plan is for the four ESUs to reach the point at which they no longer need the protection of the ESA and can be delisted. In order to be delisted, the species must no longer be in danger of extinction or likely to become endangered within the foreseeable future, based on evaluation of the factors that caused the species to be listed in the first place. In accordance with the ESA, this recovery plan incorporates objective, measurable criteria for determining whether an ESU can be delisted.[3] These criteria are of two types: biological viability criteria and threats criteria.

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[3] The ESA requires that recovery plans, to the maximum extent practicable, incorporate objective, measurable criteria that, when met, would result in a determination in accordance with the provisions of the

Biological Viability Criteria

NMFS has concluded that the WLC TRT's viability criteria, the recovery scenarios, and the population-level abundance and productivity goals in the management unit plans adequately describe the characteristics of an ESU that no longer needs the protections of the ESA. NMFS endorses the recovery scenarios and population-level goals in the management unit plans as one of multiple possible scenarios consistent with delisting. Therefore, NMFS proposes the following biological viability criteria:

- All strata that historically existed have a high probability of persistence or have a probability of persistence consistent with their historical condition.

- High probability of stratum persistence is defined as:

  A. At least two populations in the stratum have at least a 95 percent probability of persistence over a 100-year time frame (i.e., two populations with a score of 3.0 or higher based on the TRT's scoring system).

  B. Other populations in the stratum have persistence probabilities consistent with a high probability of stratum persistence (i.e., the average of all stratum population scores is 2.25 or higher, based on the TRT's scoring system). (See Section 2.6 of the recovery plan for a brief discussion of the TRT's scoring system.)

  C. Populations targeted for a high probability of persistence are distributed in a way that minimizes risk from catastrophic events, maintains migratory connections among populations, and protects within-stratum diversity.

- Probability of persistence consistent with historical condition refers to the concept that strata that historically were small or had complex population structures may not have met Criteria A through C, above, but could still be considered sufficiently viable if they provide a contribution to overall ESU viability similar to their historical contribution.

Threats Criteria

In addition, for a species to be delisted, the threats that brought it to its threatened or endangered condition must be ameliorated such that they do not keep the ESU from achieving the desired biological status. The ESA identifies five categories of threats (any one or a combination of which may be the basis for the initial listing):

A. Present or threatened destruction, modification, or curtailment of the species' habitat or range
B. Overutilization for commercial, recreational, scientific, or educational purposes
C. Disease or predation

ESA that the species be removed from the Federal List of Endangered and Threatened Wildlife and Plants (50 CFR 17.11 and 17.12).

D. Inadequacy of existing regulatory mechanisms
E. Other natural or human-made factors affecting the species' continued existence

The threats criteria in this recovery plan define the conditions under which the threats can be considered to be addressed or mitigated. Threats criteria for measuring recovery of Lower Columbia River salmon and steelhead ESUs are detailed in Section 3.2.2 of the recovery plan. In general, the threats criteria for the Lower Columbia River ESUs are considered met once the recovery plan actions have been substantially implemented, population-specific threat reduction targets have been met (or threat impacts are otherwise consistent with the desired status of the ESU and its constituent populations), threats have been ameliorated such that the desired status will be maintained, and regulatory mechanisms are being implemented in a way that supports attainment and maintenance of the desired status.

Site-specific Recovery Actions and Cost Estimates

Site-specific recovery actions are discussed in detail in the management unit plans. The FCRPS Biological Opinion and related recovery plan hydropower module describe proposed site-specific actions related to passage at Bonneville Dam, predation, and flow that affects conditions in the lower Columbia River, estuary, and, potentially, the plume. Proposed site-specific actions for the Columbia River estuary and plume are presented in the *Columbia River Estuary ESA Recovery Plan Module for Salmon and Steelhead*.

The total estimated cost of recovery actions for the four threatened species in the lower Columbia River over the next 25 years is approximately $2.1 billion, of which about $614 million is expected to be needed in the first 5 years. These estimates include expenditures by local, tribal, state, and Federal governments, private business, and individuals in implementing capital projects and non-capital work, as well as administrative costs for supervision and coordination. The total estimated cost includes $592 million ($164 in the first 5 years) for actions in the Columbia River estuary that are basinwide in scope and are expected to benefit all 13 listed ESUs and DPSs in the Columbia Basin.

The estimates are based on the best available information at the time the management unit plans were completed and are expected to change as implementation schedules are developed and actions are more clearly scoped and planned. Given that the costs for many actions could not be estimated at the time the management unit plans were completed, it is likely that actual costs will be substantially higher than the estimated costs in Table ES-2.

Table ES-2
Summary of Cost Estimates

Management Unit	5-Year Cost Estimate (millions)	25-Year Cost Estimate (millions)
Washington	$245	$738
Oregon	$189	$758
White Salmon	$16	$16
Columbia River Estuary	$164	$592
TOTAL	$614	$2,104

The remaining sections of this summary focus mostly on the results of the recovery analysis for each ESU. After briefly explaining the overall approach used to complete the ESU recovery analyses, the summary describes general categories of limiting factors that affect multiple ESUs throughout the Lower Columbia region and strategies for addressing those limiting factors at the regional or programmatic level. This is followed by an individual section for each ESU that highlights that ESU's baseline and target status, the factors that are limiting its viability, and the proposed strategy for reducing limiting factors and threats and achieving recovery. The summary concludes with thoughts on the role of research, monitoring, evaluation, and adaptive management and how recovery actions will be coordinated and implemented. Key documents referred to in this summary are listed at the end.

Overall Approach to ESU Recovery Analyses

This recovery plan addresses the needs of each ESU individually, based on analyses in the three management unit plans. Although each recovery planning team used a slightly different process in developing its management unit plan, all of the teams worked from the same TRT recommendations and a consistent set of assumptions about what elements should be included in their plans. Thus, the different recovery planning teams followed the same overall approach in their recovery analyses. In general, the management unit recovery planners did the following:

1. Evaluated the baseline status of their respective populations using techniques based on those recommended by the WLC TRT.[4]

2. Identified limiting factors for each Lower Columbia River salmon and steelhead population.

3. For each population, quantified the estimated baseline impacts of six categories of threats—tributary habitat loss and degradation, estuary habitat loss and degradation, hydropower, harvest, hatcheries, and ecological interactions.

[4] Both Oregon and Washington management unit planners established a baseline period from which to assess population status, limiting factors, and threat impacts. For more discussion, see Sections 5.1 and 5.5.

4. Established a target status for each population, taking into consideration (1) each population's potential for improvement, in view of available habitat and historical production, (2) the degree of improvement needed in each stratum to meet WLC TRT guidelines for a viable ESU, and (3) for some ESUs, the desire to accommodate objectives such as maintaining opportunities to harvest hatchery-origin fish.

5. Calculated the improvements in abundance and productivity and, in some cases, spatial structure and diversity, that each population would need to achieve its target status (i.e., to close the "conservation gap," which is the difference between the baseline and target status for each population).

6. Identified a "threat reduction scenario" for each population, meaning a specific combination of reductions in threats that would lead to the population achieving its target status.

7. Identified and scaled recovery strategies and actions to reduce threats by the targeted amount in each category. Management unit planners identified recovery strategies and actions through workshops and meetings with stakeholders, including representatives of implementing and affected entities.

8. Considered the probable effects of actions, established benchmarks for implementation, and identified critical uncertainties and research, monitoring, and evaluation needs for each species.

9. Developed implementation frameworks that address organizational structures for implementation of the actions, prioritization methods, tracking systems, coordination needs and approaches, and stakeholder involvement.

Given the complexity of the salmonid life cycle and the fact that complete data were not available for every population, some elements of the recovery analyses are subject to significant levels of uncertainty and should be considered working hypotheses that are testable as part of recovery plan implementation. Despite this uncertainty, it is the expert judgment of NMFS and the management unit scientists that, based on the best available information at this time, the results of the management unit plan analyses provide reasonable estimates of the relative magnitude of different threats to each population and the improvements that need to be addressed through recovery actions. Thus, NMFS considers the management plan analyses an adequate basis for designing initial recovery actions. As more and better information is collected, it will be applied to recovery efforts in an adaptive management framework that involves action implementation, monitoring of results, and adjustment of actions as needed.

The management unit plans' recovery analyses indicate that no single factor, threat, or threat category accounts for the declines in the species addressed in this recovery plan. Instead, the status of Lower Columbia River salmon and steelhead and Columbia River chum is the result of the cumulative impact of multiple limiting factors and threats. Thus, recovery will be accomplished through improvements in every general threat category. Even small increments of improvement will play an important role. When the need for improvement for most ESUs is so large, the contribution of no population or threat reduction can be discounted.

Regional Limiting Factors and Strategies

The reasons for a species' decline are generally described in terms of limiting factors and threats. Limiting factors are biological, physical, or chemical conditions and associated ecological processes and interactions that limit a species' viability. Threats are human activities or natural events, such as floodplain development or drought, that cause or contribute to limiting factors. Although the management unit plans analyze limiting factors and threats for each population, it also can be helpful to view limiting factors and threats from a regional, multi-species perspective—to discern large-scale patterns in ecological conditions that are affecting all or most of the listed ESUs. This aids in identifying regional approaches to recovery that can provide high biological benefit while making effective use of limited resources. The sections below describe such regional strategies, which are general approaches that either benefit multiple ESUs or can be tailored to meet the specific needs of each species. However, implementation of the regional strategies alone will not necessarily lead to recovery. The regional strategies are intended to supplement ESU-specific strategies that provide greater specificity and address specific needs at the species, stratum, and population levels.

Tributary Habitat

Tributary habitat degradation from past and/or current land and water use is a limiting factor for all Lower Columbia River salmon and steelhead populations. Widespread development and other land use activities have disrupted watershed processes, reduced water quality, and diminished habitat quantity, quality, and complexity in most lower Columbia River subbasins. Past and/or current land use or water management activities have adversely affected stream and side channel structure, riparian conditions, floodplain function, sediment conditions, and water quality and quantity, as well as the watershed processes that create and maintain properly functioning conditions for salmon and steelhead.

The regional tributary habitat strategy is directed toward habitat protection and restoration to achieve adequate quantities of high-quality, well-functioning salmon and steelhead habitat. This will be accomplished through a combination of (1) site-specific projects that will protect habitat or provide benefits relatively quickly, (2) watershed-based actions that will repair habitat-forming processes and provide benefits over the long term, and (3) landscape-scale programmatic actions that affect a class of activities (such as stormwater management or forest practices) over multiple watersheds. Although many habitat-related actions already have been undertaken, current activities do not reflect the scale of habitat improvements needed. Recovery of the listed species will require concerted efforts to protect remaining areas of favorable habitat and restore habitat quality in significant historical production areas. There is an immediate need to complete prioritization frameworks and get additional targeted, site-specific protection and restoration actions, as well as programmatic approaches, on the ground as soon as possible, especially because the benefits of some habitat actions will take years to accrue. Table ES-3 lists subbasins that will play a key role in recovery because they are targeted to support multiple primary populations, from different ESUs.

Table ES-3
Subbasins Targeted to Support Three or More Primary Populations

Ecozone	Subbasin	Primary Populations
Coast	Elochoman	Fall Chinook, chum, coho
	Clatskanie	Fall Chinook, chum, coho
	Scappoose	Fall Chinook, chum, coho
Cascade	Coweeman	Fall Chinook, winter steelhead, coho
	SF Toutle	Fall Chinook, winter steelhead, coho
	NF Toutle	Fall Chinook, winter steelhead, coho
	Cispus	Spring Chinook, winter steelhead, coho
	Upper Cowlitz	Spring Chinook, winter steelhead, coho
	NF Lewis	Fall Chinook, late-fall Chinook, spring Chinook, chum
	EF Lewis	Fall Chinook, chum, winter steelhead, summer steelhead, coho
	Washougal	Fall Chinook, chum, summer steelhead
	Sandy	Late-fall Chinook, spring Chinook, chum, winter steelhead, coho
Gorge	Lower Gorge tribs	Chum, winter steelhead, coho
	Hood	Fall Chinook, spring Chinook, winter steelhead, summer steelhead, coho

Estuary Habitat

Habitat conditions in the Columbia River estuary and plume are important to the survival of all Columbia River basin salmon and steelhead during critical rearing, migration, and saltwater acclimation periods in their life cycle. Yet the amount and accessibility of in-channel, off-channel, and plume habitat have been reduced as a result of habitat conversion for agricultural, urban, and industrial uses, hydroregulation and flood control, channelization, and higher bankfull elevations, which have been facilitated by diking, dredging, and filling. Sediment conditions and toxic contaminants also have been identified as limiting factors in the estuary, as have high water temperatures in late summer and fall, changes in the food web, and predation.

Estuary habitat strategies focus on providing adequate off-channel and intertidal habitats, such as tidal swamp and marsh; restoring habitat complexity in areas modified by agricultural or rural residential use; decreasing exposure to toxic contaminants; and lowering water temperatures. This will be accomplished over the long term by restoring hydrologic, sediment, and riparian processes that structure habitat in the estuary. An aggressive, strategic approach needs to be developed for implementation of estuary actions.

Hydropower

Bonneville Dam is the only mainstem hydropower facility within the geographic range of Lower Columbia River salmon and steelhead, but flow management at large storage reservoirs in the interior of the Columbia Basin affect habitat in the lower Columbia River mainstem and estuary, and potentially in the plume. In addition, significant tributary hydropower dams are located on the Cowlitz, Lewis, and White Salmon rivers in Washington and the Willamette, Clackamas, and Sandy rivers in Oregon.[5] The impacts of hydropower facility construction and operation on Lower Columbia salmon and steelhead occur both locally (at, above, and immediately below dams) and downstream, in the Columbia River estuary and, potentially, the plume. Impacts include habitat inundation, impaired fish passage, higher water temperatures during the late summer and fall, and alterations in the timing and magnitude of flow that affect downstream habitat conditions and habitat-forming processes.

The regional hydropower strategy focuses on (1) improving passage survival at Bonneville Dam for Lower Columbia River populations that spawn above the dam, (2) addressing impacts in tributaries by implementing actions prescribed in Federal Energy Regulatory Commission agreements regarding operation of individual tributary dams, and (3) implementing mainstem flow management operations designed to benefit spring migrants from the interior of the Columbia Basin; NMFS expects that these flow management operations will also improve survival in the estuary and, potentially, the plume for all Lower Columbia River salmon and steelhead populations. The regional hydropower strategy includes actions identified in the 2008 FCRPS Biological Opinion and its 2010 Supplement that will aid adults and juveniles from the Gorge populations in passing Bonneville Dam. For chum salmon, the strategy involves ensuring adequate flows in the Bonneville Dam tailrace and downstream habitats during chum salmon migration, spawning, incubation, and emergence.

Hatcheries

Hatchery practices such as broodstock collection and spawning protocols can cause genetic changes in hatchery fish. When hatchery-origin fish spawn with natural-origin fish, genetic changes can be transmitted to the naturally produced fish; the larger the proportion of hatchery-origin spawners, the larger the genetic effects to the natural population. These genetic effects can include domestication and loss of diversity within the population. For decades, high proportions of hatchery fish on the spawning grounds have been common among many Lower Columbia River salmon and steelhead populations, including the vast majority of Chinook and coho salmon populations. In addition, hatchery fish infected with pathogens or parasites have the potential to spread these organisms to natural-origin fish. Also, hatchery fish can sometimes prey directly on naturally produced juveniles, particularly chum salmon. Some scientists suspect that closely spaced releases of hatchery fish from Columbia Basin hatcheries may lead to increased competition with natural-origin fish for food and habitat space in the Columbia River estuary.

The overall goals of the hatchery recovery strategies for the Lower Columbia ESUs are to (1) reduce hatchery impacts on natural-origin populations as appropriate for each population, (2) ensure that some populations have no in-subbasin hatchery releases and are isolated from stray out-of-subbasin hatchery fish, (3) use hatchery stocks in the short term for reintroduction or supplementation programs to restore naturally spawning populations in some watersheds, and (4) ensure rigorous monitoring and evaluation to better understand existing population status and the effects of hatchery strategies on

[5] Powerdale Dam, on the Hood River, was removed in 2010, and Condit Dam, on the White Salmon River, was breached in October 2011, with complete removal expected by August 2012.

natural populations. Maintaining harvest opportunities created by hatchery fish is a societal goal that NOAA Fisheries has carried forward from the management unit plans to the ESU-level recovery plan.

Harvest

Lower Columbia River Chinook salmon, steelhead, and coho salmon are caught in commercial, recreational, and tribal fisheries along the West Coast of the United States and Canada as well as in the mainstem Columbia River and its tributaries. These various fisheries focus on different stocks and populations, taking fish to meet commercial, recreational, and tribal harvest allocations. Harvest affects the viability of Lower Columbia River salmon and steelhead populations by causing mortality to naturally produced adult fish, influencing population traits, and reducing nutrients in freshwater ecosystems. Harvest mortality can be either direct or indirect. Direct harvest mortality is associated with fisheries that target specific stocks. Indirect mortality includes mortality of fish harvested incidentally to the targeted species or stock, fish that die after being captured by fishing gear but not landed, and fish that die after being caught and released.

Harvest managers have implemented substantial reductions in harvest for Lower Columbia River species since they were listed under the ESA. Although each species' harvest management requirements are unique, in general the harvest strategy focuses on refining harvest management and reducing impacts to naturally produced fish where needed while maintaining harvest opportunities that target hatchery-produced fish. The recovery plan calls for the use of six general approaches as appropriate and feasible: abundance-based harvest management, weak-stock management, mark-selective harvest, filling information needs, ancillary and precautionary actions, and adaptive management.

Local recovery planners believe that for Lower Columbia River spring Chinook salmon, steelhead, and chum salmon, current harvest impacts are generally consistent with long-term recovery goals, at least in the near term. For these species the recovery plan recommends measures to ensure that harvest does not adversely affect future conservation and recovery. For Lower Columbia fall Chinook and coho salmon, efforts will focus on (1) refinements in harvest management (including abundance-based management) to reduce risk to naturally produced fish, and (2) continued review of overall harvest rates.

Ecological Interactions

Anthropogenic changes to habitat in the lower Columbia River region have altered the relationships between salmonids and other fish and wildlife species, leaving Lower Columbia River salmon and steelhead more vulnerable to predation by piscivorous fish, birds, and marine mammals (i.e., seals and sea lions) and subject to competition with introduced fish species and possibly hatchery-origin fish for limited food and habitat.

The regional ecological interactions strategy involves reducing predation on all Lower Columbia River salmon and steelhead populations by redistributing Caspian terns and cormorants, increasing the pikeminnow bounty program in the Columbia River mainstem, and reducing marine mammal predation at Bonneville Dam using non-lethal and possibly lethal measures. Managing predation by sea lions at Bonneville Dam is expected to benefit Gorge-stratum populations of Lower Columbia River salmon and steelhead ESUs. To reduce the risk of adverse ecological interactions between hatchery-origin and naturally produced salmon and steelhead, the recovery plan proposes a combination of critical uncertainties research and near-term precautionary measures, such as restoring estuary habitat and managing hatchery releases to prevent large numbers of hatchery-origin fish from accumulating in the estuary.

Climate Change

The warming rate for the Pacific Northwest over the next century is projected to be in the range of 0.1 to 0.6 °C per decade. Although total precipitation changes are predicted to be minor (+ 1 to 2 percent), increasing air temperature will alter snowpack, stream flow timing and volume, and water temperature in the Columbia Basin.

Changes in air temperatures, river temperatures, and river flows in the Pacific Northwest are expected to affect salmon and steelhead distribution, behavior, growth, and survival. The magnitude and timing of the changes are poorly understood, and specific effects are likely to vary among populations. However, likely effects on listed salmon and steelhead in fresh water include winter flooding of redds (i.e., salmon nests), earlier emergence of salmon fry, decreased parr to smolt survival, reductions in the quantity and quality of juvenile rearing habitat and possibly overwintering habitat, changes in the timing of smolt migration, and increased adult mortality or reduced spawning success as a result of higher water temperatures.

Possible effects on salmon and steelhead in estuaries include altered growth and disease susceptibility, reduced quality of rearing habitat, and changes in the distribution of salmonid prey and predators, including possible extension of the range of non-native species adapted to warm water.

Climate-related changes in the marine environment are expected to alter primary and secondary productivity, the structure of marine communities, and, in turn, the growth, productivity, survival, and migrations of salmonids, although the degree of impact on listed salmonids currently is poorly understood. A mismatch between earlier smolt migrations (because of earlier peak spring freshwater flows and shorter incubation periods) and altered coastal upwelling may reduce marine survival rates. Ocean warming also may change migration patterns, increasing distances to feeding areas.

In addition, rising atmospheric carbon dioxide concentrations drive changes in seawater chemistry, increasing the acidification of seawater and thus reducing the availability of carbonate for shell-forming invertebrates, including some that are prey items for juvenile salmonids. Ocean acidification has the potential to reduce survival of many marine organisms, including salmon and steelhead. However, because there is currently a paucity of research directly related to the effects of ocean acidification on salmon and steelhead and their prey, potential effects are uncertain.

The regional climate change strategy has two parts: (1) implementation of greenhouse gas reduction strategies, such as through the West Coast Governors' Global Warming

Initiative[6] and the Oregon Global Warming Commission's recommendations,[7] and (2) adaptation, to reduce the impacts of climate change on Pacific Northwest salmon and steelhead. Adaptation commonly involves the following:

- Conserving adequate habitat to support healthy fish populations and ecosystem functions in a changing climate
- Managing species and habitats to protect ecosystem functions in a changing climate
- Reducing stresses not caused by climate change
- Supporting adaptive management through integrated observation and monitoring and improved decision support tools

The management unit plans and estuary recovery plan module present specific actions that are responsive to these general strategies. The following documents also are relevant to adaptation:

- *Climate Change Impacts on Columbia River Basin Fish and Wildlife* (Independent Scientific Advisory Board 2007a)
- *Oregon Climate Change Adaptation Framework* (Oregon Department of Land Conservation and Development 2010)
- *Washington State Integrated Climate Change Response Strategy* (interim document) (Washington Department of Ecology 2011)
- *Draft National Fish, Wildlife, and Plants Climate Adaptation Strategy* (U.S. Fish and Wildlife Service et al. 2012)

Human Population Growth

The Oregon and White Salmon management unit plans identify human population growth as a future threat to Lower Columbia River salmon and steelhead, based in part on work done by the Independent Scientific Advisory Board (ISAB), which provides independent scientific advice and recommendations related to the fish and wildlife management responsibilities of the Northwest Power and Conservation Council, Columbia River Basin Indian tribes, and NMFS. The ISAB expects that human population growth in the Columbia Basin will increase the demand for water, land, and forests that are key to fish and wildlife populations. This demand for resources will increase threats to and extinction risks for fish and wildlife—including salmon and steelhead—through such mechanisms as loss, degradation, and fragmentation of habitat; increased stormwater runoff; and reduced groundwater recharge and thus base stream flows.

The recovery plan includes actions that will lessen the impacts of human population growth. The focus is on protecting existing high-quality habitat through acquisition and

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[6] For the West Coast Governors' Global Warming Initiative, go to http://www.ef.org/westcoastclimate/.

[7] For the Oregon Global Warming Commission's recommendations, see Oregon Department of Energy (2009) or go to http://www.oregon.gov/ENERGY/GBLWRM/GWC/docs/09CommissionReport.pdf.

conservation; using land use planning to guide future development away from ecologically sensitive areas, such as wetlands and floodplains; implementing best management practices; protecting and restoring instream flows, runoff processes, and water quality; and educating landowners and others.

Recovery Analysis: Lower Columbia River Coho Salmon

This recovery plan covers all naturally spawned coho salmon (*Oncorhynchus kisutch*) populations in the lower Columbia River and its tributaries, from the mouth of the Columbia upstream to the Hood River (in Oregon) and the White Salmon River (in Washington), including the Willamette River up to Willamette Falls. Twenty-five coho salmon hatchery programs also are part of the ESU.[8]

Historically, the Lower Columbia River coho salmon ESU consisted of a total of 24 independent populations that spawned in almost every accessible stream system in the lower Columbia River. Coho salmon typically spawn in small to medium, low- to-moderate elevation streams from valley bottoms to stream headwaters. Coho salmon particularly favor small, rain-driven, lower elevation streams characterized by (1) relatively low flows during late summer and early fall, and (2) increased river flows and decreased water temperatures in winter.

Baseline and Target Status: Coho Salmon

Today, 21 of the 24 Lower Columbia River coho salmon populations are considered to have a very low probability of persisting over the next 100 years, and none is considered viable. All three strata in the ESU fall significantly short of the WLC TRT criteria for viability.

Table ES-4
Baseline and Target Status of LCR Coho Salmon Populations*

Stratum	Population	Contribution to Recovery	Baseline Status	Target Status
Coast	Youngs Bay (OR)	Stabilizing	VL	VL
	Grays/Chinook (WA)	Primary	VL	H
	Big Creek (OR)	Stabilizing	VL	VL
	Elochoman/Skamokawa (WA)	Primary	VL	H
	Clatskanie (OR)	Primary	L	VH
	Mill/Abernathy/Germany (WA)	Contributing	VL	M
	Scappoose (OR)	Primary	M	VH
Cascade	Lower Cowlitz (WA)	Primary	VL	H
	Upper Cowlitz (WA)	Primary	VL	H
	Cispus (WA)	Primary	VL	H
	Tilton (WA)	Stabilizing	VL	VL
	Toutle SF (WA)	Primary	VL	H
	Toutle NF (WA)	Primary	VL	H

[8] Two of these programs were discontinued in 2009. In its 2011 5-year review, NMFS recommended that these two programs be removed from the ESU.

Stratum	Population	Contribution to Recovery	Baseline Status	Target Status
	Coweeman (WA)	Primary	VL	H
	Kalama (WA)	Contributing	VL	L
	NF Lewis (WA)	Contributing	VL	L
	EF Lewis (WA)	Primary	VL	H
	Salmon Creek (WA)	Stabilizing	VL	VL
	Clackamas (OR)	Primary	M	VH
	Sandy (OR)	Primary	VL	H
	Washougal (WA)	Contributing	VL	M+
Gorge	Lower Gorge (WA & OR)	Primary	VL	H
	Upper Gorge/White Salmon (WA)	Primary	VL	H
	Upper Gorge/Hood (OR)	Primary	VL	H*

*Status is equivalent to persistence probability. VL = very low, L = low, M = moderate, H = high, VH = very high.

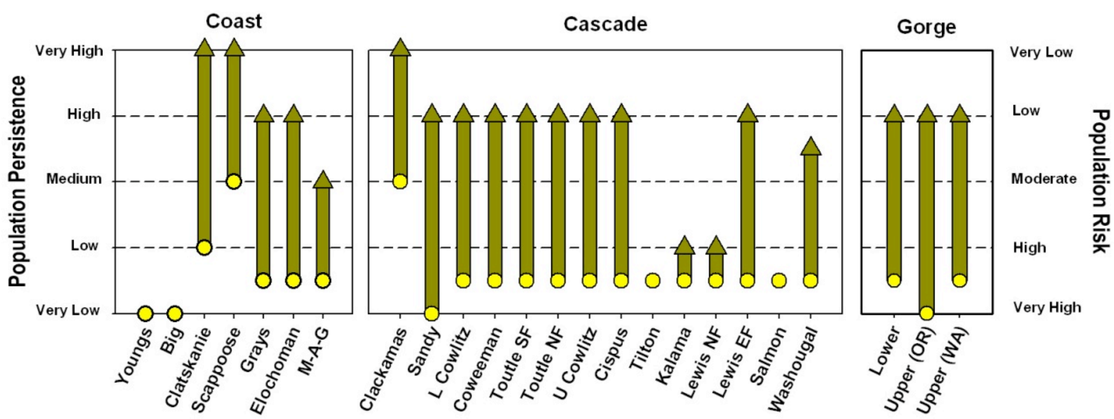

Figure ES-1. *Conservation Gaps for LCR Coho Salmon Populations (i.e., Difference between Baseline and Target Status)*

Prevalent Limiting Factors: Coho Salmon

Lower Columbia River coho salmon's poor status is due to a host of limiting factors that have affected the ESU for decades, or longer. Table ES-6 lists prevalent limiting factors that the management unit plans identified as having the greatest impact during the baseline period.

In addition, tributary hydropower dams are a primary limiting factor for the Upper Cowlitz, North Fork Lewis, Cispus, Tilton, and Upper Gorge/White Salmon populations.

Table ES-5
Prevalent Primary Limiting Factors for Coho Salmon during Baseline Period

Limiting Factor	Populations for Which This Is a Primary Limiting Factor
Degraded riparian conditions along tributaries	Almost all*
Impaired side channel and wetland conditions in tributaries	Almost all
Loss/degradation of floodplain habitat in tributaries	Almost all
Channel structure and form issues[9] in tributaries and the Columbia River estuary	Almost all
Sediment conditions in the estuary	Almost all
Water quantity issues (i.e., altered hydrology) in the estuary	Almost all
Direct mortality from fisheries	Almost all
Reduction in population diversity as a result of stray hatchery fish interbreeding with natural-origin fish	All except Clatskanie, Scappoose, Coweeman, NF Lewis, and Sandy

* "Almost all" means every population except one in each stratum.

Recovery Strategy: Coho Salmon

The ESU recovery strategy for coho salmon involves improvements in all threat categories to increase abundance, productivity, diversity, and spatial structure to the point that the Coast, Cascade, and Gorge strata are restored to a high probability of persistence. The ESU recovery strategy has seven main elements:

1. Protect and improve populations that have a clear record of continuous natural spawning and are likely to retain local adaptation (the Clackamas and Sandy), along with populations where there is documented natural production (the Clatskanie, Scappoose, and Mill/Abernathy/Germany).

2. Fill information gaps regarding the extent of natural production in other populations, and focus additional recovery efforts on populations that have the greatest prospects for improvement.

3. Protect existing high-functioning habitat for all populations.

4. Restore tributary habitat (particularly overwintering habitat) to the point that each subbasin can support coho salmon at the target status for that population. In most subbasins, this will mean having adequate habitat to support a viable population.

5. Reduce hatchery impacts on natural-origin fish so that impacts are consistent with the target status of each population. (The Grays/Chinook, Elochoman/Skamokawa, Mill/Abernathy/Germany, Clatskanie, Clackamas, Washougal, and Gorge-stratum populations are targeted for large reductions in hatchery impacts.)

[9] Includes conditions such as channelization, reduced instream habitat complexity, fill and scour, and associated loss of spawning habitat.

6. Refine harvest management so that impacts are consistent with population and overall ESU recovery goals.

7. Reestablish naturally spawning populations above tributary dams on the Cowlitz and North Fork Lewis rivers by improving passage at dams and continuing to reintroduce coho salmon in these mid- to high-elevation habitats.

For most coho salmon populations, loss and degradation of tributary habitat are the single largest threat—and where the greatest gains in viability are expected to be achieved. Notable exceptions are the Clackamas, Upper Cowlitz, and Cispus populations. For the Clackamas population, protection of existing well-functioning habitat and reductions in hatchery impacts will play a key role in achieving the target status. The Upper Cowlitz and Cispus populations are projected to benefit greatly from hatchery reintroduction programs and dam passage improvements designed to restore their access to key historical spawning and rearing habitats. However, significant tributary habitat protection and restoration efforts also will be necessary for these populations. In most cases, population recovery objectives cannot be achieved without substantial improvements in habitat, even when the impacts of other, non-habitat threats are practically eliminated.

Although recent actions have substantially reduced coho salmon harvest levels from baseline conditions, further refinements in harvest management are still needed. Reductions in hatchery impacts are called for in all strata because hatchery impacts remain significant for many populations.

Recovery Analysis: Lower Columbia River Chinook Salmon

This recovery plan covers all naturally spawned Chinook salmon (*Oncorhynchus tshawytscha*) populations in the lower Columbia River and its tributaries, from the mouth of the Columbia upstream to the Hood River (in Oregon) and the White Salmon River (in Washington), including the Willamette River up to Willamette Falls but excluding Clackamas River spring-run Chinook salmon.[10] Chinook salmon from 17 hatchery programs also are part of the ESU.[11]

Historically, the Lower Columbia River Chinook salmon ESU consisted of a total of 32 independent populations: 21 fall populations, two late-fall populations, and nine spring populations. These classifications are based on when adults return to fresh water. Spring and late-fall Chinook salmon are "stream-type" salmon, meaning that they generally rear in the river for a full year before emigrating to the ocean. Returning spring Chinook salmon adults spawn primarily in upstream, higher elevation portions of large subbasins. Fall Chinook display an "ocean-type" life history, meaning that juveniles begin emigrating downstream at 1 to 4 months old and make extensive use of

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[10] Clackamas River spring Chinook salmon are part of the Upper Willamette River Chinook ESU.

[11] One of these programs--the Elochoman tule fall Chinook salmon program--was discontinued in 2009. In its 2011 5-year review, NMFS recommended that this program be removed from the ESU and that four new fall Chinook salmon programs be added. The new programs are changes in release locations for fish produced at—and previously released from—hatchery programs that are currently part of the ESU.

the Columbia River estuary before entering the ocean. Returning fall Chinook spawn in moderate-sized streams and large river mainstems.

Fall Chinook are commonly referred to as "tule" stock, while late-fall Chinook are referred to as "brights."

Baseline and Target Status: Chinook Salmon

Today, only two of 32 historical populations—the North Fork Lewis and Sandy late-fall populations—are considered viable. Most populations (26 out of 32) have a very low probability of persistence over the next 100 years, and some populations are extirpated or nearly so. Five of the six strata fall significantly short of the WLC TRT criteria for viability. One stratum—Cascade late fall—meets the WLC TRT criteria.

Table ES-6
Baseline and Target Status of LCR Chinook Salmon Populations*

Stratum	Population	Core or Genetic Legacy?**	Contribution to Recovery	Baseline Status	Target Status
Cascade spring	Upper Cowlitz (WA)	C, GL	Primary	VL	H+
	Cispus (WA)	C	Primary	VL	H+
	Tilton (WA)		Stabilizing	VL	VL
	Toutle (WA)		Contributing	VL	M
	Kalama (WA)		Contributing	VL	L
	Lewis NF (WA)	C	Primary	VL	H
	Sandy (OR)	C, GL	Primary	M	H
Gorge spring	White Salmon (WA)	C	Contributing	VL	L+
	Hood (OR)		Primary	VL	VH
Coast fall	Youngs Bay (OR)		Stabilizing	L	L
	Grays/Chinook (WA)		Contributing	VL	M+
	Big Creek (OR)	C	Contributing	VL	L
	Elochoman/Skamokawa (WA)	C	Primary	VL	H
	Clatskanie (OR)		Primary	VL	H
	Mill/Abernathy/Germany (WA)		Primary	VL	H
	Scappoose (OR)		Primary	L	H
Cascade fall	Lower Cowlitz (WA)	C	Contributing	VL	M+
	Upper Cowlitz (WA)		Stabilizing	VL	VL
	Toutle (WA)	C	Primary	VL	H+
	Coweeman (WA)	GL	Primary	L	H+
	Kalama (WA)		Contributing	VL	M
	Lewis (WA)	GL	Primary	VL	H+
	Salmon Creek (WA)		Stabilizing	VL	VL
	Clackamas (OR)	C	Contributing	VL	M
	Sandy (OR)		Contributing	VL	M
	Washougal (WA)		Primary	VL	H+
Gorge fall	Lower Gorge (WA & OR)		Contributing	VL	M
	Upper Gorge (WA & OR)	C	Contributing	VL	M
	White Salmon (WA)	C	Contributing	VL	M
	Hood (OR)		Primary	VL	H

Stratum	Population	Core or Genetic Legacy?**	Contribution to Recovery	Baseline Status	Target Status
Cascade	Lewis NF (WA)	C, GL	Primary	VH	VH
late fall	Sandy (OR)	C, GL	Primary	H	VH

* Status is equivalent to persistence probability. VL = very low, L = low, M = moderate, H = high, VH = very high.

** C = Core populations, meaning those that historically were the most productive. G = Genetic legacy populations, which best represent historical genetic diversity.

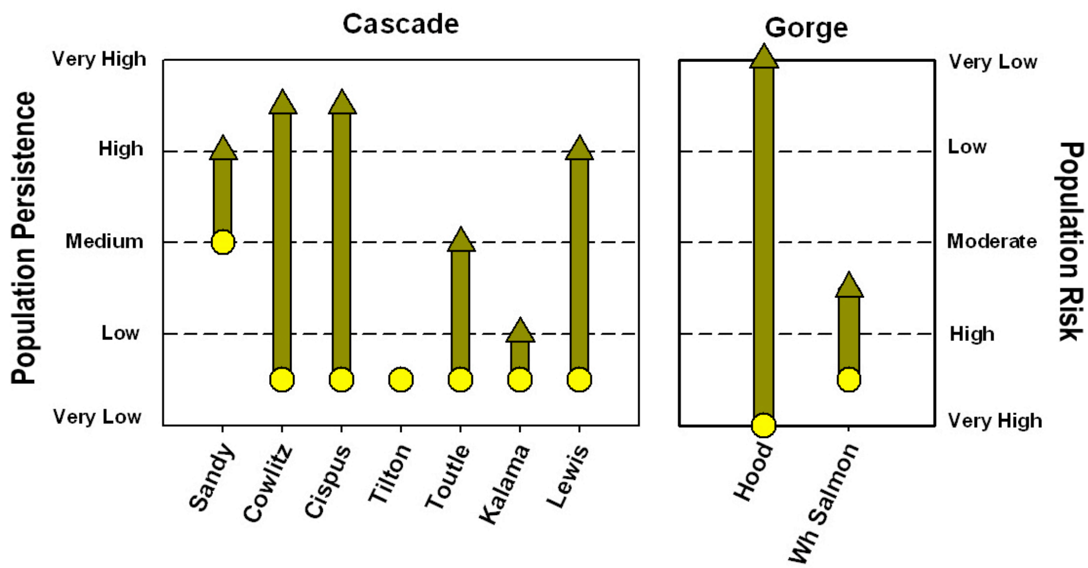

Figure ES-2. *Conservation Gaps for LCR Spring Chinook Salmon Populations (i.e., Difference between Baseline and Target Status)*

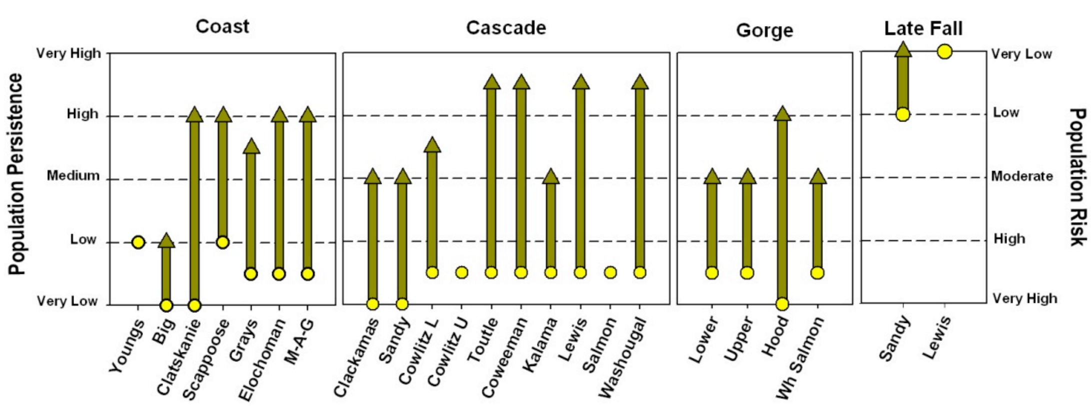

Figure ES-3. *Conservation Gaps for LCR Fall and Late-Fall Chinook Salmon Populations (i.e., Difference between Baseline and Target Status)*

Spring Chinook Recovery Analysis

Prevalent Limiting Factors: Spring Chinook Salmon

Lower Columbia River spring Chinook salmon's poor status is due to a host of limiting factors that have affected the ESU for decades, or longer. Table ES-8 lists prevalent limiting factors that the management unit plans identified as having the greatest impact during the baseline period.

Table ES-7
Prevalent Primary Limiting Factors for Spring Chinook Salmon during Baseline Period

Limiting Factor	Populations for Which This Is a Primary Limiting Factor
Channel structure and form issues[12] in the Columbia River estuary	Almost all*
Sediment conditions in the estuary	Almost all
Water quantity issues (i.e., altered hydrology) in the estuary	Almost all
Reduction in population diversity as a result of stray hatchery fish interbreeding with natural-origin fish	Almost all
Tributary hydropower dams	Upper Cowlitz, Cispus, Tilton, Lewis, and White Salmon
Direct mortality from fisheries	Upper Cowlitz, Cispus Tilton, Toutle, Kalama, Lewis, and Hood
Degraded riparian conditions in tributaries	All Cascade-stratum populations
Channel structure and form issues in tributaries	All Cascade-stratum populations
Impaired side channel and wetland conditions in tributaries	All Cascade-stratum populations
Loss/degradation of floodplain habitat in tributaries	All Cascade-stratum populations

* "Almost all" means every population except one in each stratum.

Recovery Strategy: Spring Chinook Salmon

The recovery strategy for spring Chinook salmon is aimed at restoring the Cascade spring stratum to a high probability of persistence and improving the persistence probability of the two Gorge spring populations. Although the strategy involves threat reductions in all categories, the most crucial elements are as follows:

1. Protect and improve the Sandy spring Chinook salmon population, which is the best-performing population and the only Lower Columbia River spring Chinook salmon population with appreciable natural production. This will be accomplished by protecting high-quality, well-functioning spawning and rearing

[12] Includes channelization, reduced instream habitat complexity, fill and scour, and associated loss of spawning habitat.

habitat, reducing the proportion of hatchery-origin spawners (pHOS), managing predation, and restoring tributary and estuarine habitat.[13]

2. Reestablish naturally spawning populations above dams on the Cowlitz and North Fork Lewis rivers, in areas that historically were highly productive, by improving adult and juvenile dam passage and developing hatchery reintroduction programs using broodstock from within-subbasin hatchery programs. Reestablishing populations in mid- to upper-elevation habitats is key to recovering the spring component of the Lower Columbia River Chinook salmon ESU.

3. Protect favorable tributary habitat and restore degraded but potentially productive habitat, particularly in the upper subbasins where spring Chinook salmon hold, spawn, and rear. Tributary habitat improvements are crucial for all populations.

4. Reestablish spring Chinook salmon in the White Salmon subbasin (after removal of Condit Dam) and in the Hood River subbasin.

Almost every spring Chinook salmon population is greatly affected by the loss and degradation of tributary habitat, and five populations—the Upper Cowlitz, Cispus, Tilton, Lewis, and White Salmon—have experienced impacts from tributary dams that are comparable to or even greater than those associated with degraded tributary habitat. Accordingly, for most populations, the greatest gains in viability are expected from tributary habitat and dam passage improvements (combined with hatchery reintroduction programs). Exceptions are the Tilton—a stabilizing population that is expected to remain at its baseline status—and the Sandy and Hood populations, for which reductions in hatchery impacts are targeted to provide the greatest benefit.

Although recent actions have substantially reduced harvest of spring Chinook salmon from baseline conditions, ancillary and precautionary actions are needed to ensure that harvest does not adversely affect conservation and recovery in the future. For all but the Tilton population, hatchery-related impacts are targeted to be reduced by half or more, with the largest reductions in the Sandy and Hood populations.

Fall Chinook Recovery Analysis

Prevalent Limiting Factors: Fall Chinook Salmon

Lower Columbia River fall Chinook salmon's poor status is due to a host of limiting factors that have affected the ESU for decades, or longer. Table ES-9 lists prevalent limiting factors that the management unit plans identified as having the greatest impact during the baseline period.

In addition, tributary hydropower dams are a primary limiting factor for the Upper Cowlitz and White Salmon populations, and inundation of historical spawning habitat by Bonneville Reservoir is a primary limiting factor for the Upper Gorge population.

[13] Some reduction in impacts on the Sandy population already have been achieved through removal of Marmot Dam and the Little Sandy River diversion in 2008 and protection of associated instream water rights for fish.

Table ES-8
Prevalent Primary Limiting Factors for Fall Chinook Salmon during Baseline Period

Limiting Factor	Populations for Which This Is a Primary Limiting Factor
Degraded riparian conditions along tributaries	Almost all*
Channel structure and form issues[14] in tributaries and the estuary	Almost all
Impaired side channel and wetland conditions in tributaries	Almost all
Loss/degradation of floodplain habitat in tributaries	Almost all
Loss/degradation of peripheral and transitional habitats[15] in the estuary	Almost all
Sediment conditions in the estuary	Almost all
Water quantity issues (i.e., altered hydrology) in the estuary	Almost all
Direct mortality from fisheries	Almost all
Reduction in population diversity as a result of stray hatchery fish interbreeding with natural-origin fish	Almost all

* "Almost all" means every population except one in each stratum.

Recovery Strategy: Fall Chinook Salmon

The recovery strategy for the tule fall component of the Lower Columbia River Chinook salmon ESU is designed to restore the Coast and Cascade tule strata to a high probability of persistence and to improve the persistence probability of all four Gorge stratum populations. The strategy involves transitioning from decades of management that allowed habitat degradation and emphasized hatchery production of fish for harvest (without adequate regard to effects on natural production) to management that supports a naturally self-sustaining ESU. This transition will be accomplished by addressing all threat categories and sharing the burden of recovery across categories. The most crucial elements are as follows:

1. Protect and improve the Coweeman and Lewis populations, which are currently performing the best, by ensuring that habitat is protected and restored, that the proportion of hatchery-origin spawners (pHOS) is reduced, and that harvest rates allow for gains in productivity to translate into continued progress toward recovery.

2. Fill information gaps regarding the extent of natural production and the extent of hatchery-origin spawners.

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14 Includes conditions such as channelization, reduced instream habitat complexity, fill and scour, and associated loss of spawning habitat.
15 Peripheral and transitional habitats are sloughs, side channels, wetlands, and similar features that are periodically inundated during high flows.

3. Focus recovery efforts on populations that have the greatest prospects for improvement; determine whether efforts to reestablish populations are needed.

4. Protect existing high-functioning habitat for all populations.

5. Implement aggressive efforts to improve the quality and quantity of both tributary and estuarine habitat.

6. Implement aggressive efforts to reduce the influence of hatchery fish on natural-origin fish.

7. Adjust harvest as needed to ensure appropriate increases in natural-origin abundance.

8. Assess habitat quantity, quality, and distribution.

In the Coast and Cascade strata, much of the gains in fall Chinook salmon viability are targeted to be achieved through reductions in harvest, hatchery, and habitat impacts. This is the case for the Grays/Chinook, Elochoman/Skamokawa, Toutle, East Fork Lewis, Sandy, and Washougal populations. For the Scappoose population, target status is expected to be achieved primarily through reductions in hatchery and harvest impacts. In the Gorge stratum, some threat reductions are also targeted from hydropower actions, as the Upper Gorge, White Salmon, and Hood populations are affected by dam passage issues at Bonneville, Powerdale, and Condit dams. (Powerdale Dam, on the Hood River, was removed in 2010; Condit Dam was breached in October 2011 and is scheduled to be completely removed by August 2012).

Impacts from multiple threat categories will need to be reduced for most populations if they are to achieve their target status. Exceptions are the Youngs Bay, Big Creek, Upper Cowlitz, and Salmon Creek populations. As stabilizing populations, the Youngs Bay, Upper Cowlitz, and Salmon Creek populations are not targeted for reductions in any threat impacts. (However, recovery actions will still be needed for these populations to remain at their baseline status of low [for Youngs Bay] or very low persistence probability.) The Salmon Creek population is not targeted for threat reductions because of the highly urbanized nature of the subbasin and the extent of habitat degradation there. Both the Youngs Bay and Big Creek populations will be used to provide harvest opportunity through terminal fisheries targeting hatchery fish; consequently, the proportion of hatchery-origin spawners (pHOS) and harvest impacts in these populations are expected to remain high.

Late-Fall Chinook Recovery Strategy

Prevalent Limiting Factors: Late-Fall Chinook Salmon

Table ES-10 lists prevalent limiting factors that the management unit plans identified as having the greatest impact on both late-fall Chinook populations during the baseline period.

Table ES-9
Prevalent Primary Limiting Factors for Late-fall Chinook Salmon during Baseline Period

Limiting Factor	Populations for Which This Is a Primary Limiting Factor
Sediment conditions in tributaries and the Columbia River estuary	Both populations
Water quantity issues (i.e., altered hydrology) in the estuary	Both populations
Direct mortality from fisheries	Both populations

In addition, primary limiting factors that affect the Sandy population only are degraded riparian conditions, channel structure and form issues, impaired side channel and wetland conditions, and loss/degradation of floodplain habitat in tributaries, along with reduction in population diversity as a result of stray hatchery fish interbreeding with natural-origin fish.

Recovery Strategy: Late-Fall Chinook Salmon

The recovery strategy for the late-fall component of the Lower Columbia River Chinook salmon ESU is designed to maintain the two healthy populations (North Fork Lewis and Sandy) and raise the persistence probability of the Sandy population from high to very high. Key elements of the strategy are as follows:

1. Implement the regional hatchery strategy. Minimize the impacts of hatchery releases of steelhead, coho, and spring Chinook salmon on late-fall Chinook salmon. Continue the current practice of not releasing hatchery fall Chinook salmon into the North Fork Lewis River.

2. Reduce harvest impacts on the Sandy late-fall population by using the same harvest strategies identified for tule fall Chinook salmon. Continue to manage fisheries to meet the spawning escapement goal for the Lewis River late-fall population and consider reassessing the goal as new data are acquired.

3. Implement actions in the regional tributary and estuary habitat strategy designed to benefit tule fall Chinook salmon. Implement the stratum-level tributary habitat strategies designated for tule fall Chinook.

Improving the persistence of the Sandy population will be accomplished primarily through reductions in harvest and hatchery impacts. As with spring and tule fall Chinook salmon, recent actions have substantially reduced harvest impacts on late-fall Chinook salmon over baseline conditions, but additional reductions in harvest impacts are identified to achieve the target status for the Sandy population. More modest reductions in the tributary and estuarine habitat, hydropower, and predation threat categories are expected to support the gains achieved through reductions in harvest and hatchery impacts.

Recovery Analysis: Columbia River Chum

This recovery plan covers all naturally spawned Columbia River chum salmon (*Oncorhynchus keta*) populations in the lower Columbia River and its tributaries. Chum salmon from three hatchery programs also are part of the ESU.[16]

Historically, the Columbia River chum salmon ESU consisted of 17 independent populations. Of these, 16 were fall-run populations and one was a summer-run population that returned to the Cowlitz River. Columbia River chum display an "ocean-type" life history, meaning that fry emigrate downstream shortly after emerging and rear in the Columbia River estuary before entering the ocean. Although chum salmon are strong swimmers, they rarely pass river blockages and waterfalls that pose no hindrance to other salmon or steelhead; thus, they spawn in low-gradient, low-elevation reaches and side channels. Spawning today is restricted largely to tributary and mainstem areas downstream of Bonneville Dam. Chum salmon need clean gravel for spawning, and spawning sites typically are associated with areas of upwelling water.

Baseline and Target Status: Chum Salmon

Today, 15 of the 17 populations that historically made up this ESU are so depleted that either their baseline probability of persistence is very low or they are extirpated or nearly so; this is the case for all six of the Oregon populations. Currently almost all natural production occurs in just two populations: the Grays/Chinook and the Lower Gorge. All three strata in the ESU fall significantly short of the WLC TRT criteria for viability.

Table ES-10
Baseline and Target Status of Columbia River Chum Salmon Populations*

Stratum	Population	Core or Genetic Legacy?**	Contribution to Recovery	Baseline Status	Target Status
Coast	Youngs Bay (OR)	C	Stabilizing	VL	VL
	Grays/Chinook (WA)	C, GL	Primary	M	VH
	Big Creek (OR)	C	Stabilizing	VL	VL
	Elochoman/Skamakowa (WA)	C	Primary	VL	H
	Clatskanie (OR)		Primary	VL	H
	Mill/Abernathy/Germany (WA)		Primary	VL	H
	Scappoose (OR)		Primary	VL	H
Cascade	Cowlitz - fall (WA)	C	Contributing	VL	M
	Cowlitz - Summer (WA)	C	Contributing	VL	M
	Kalama (WA)		Contributing	VL	M
	Lewis (WA)	C	Primary	VL	H
	Salmon Creek (WA)		Stabilizing	VL	VL
	Clackamas (OR)	C	Contributing	VL	M
	Sandy (OR)		Primary	VL	H
	Washougal (WA)		Primary	VL	H+

[16] In 2010, the Oregon Department of Fish and Wildlife initiated a new chum salmon hatchery program at Big Creek Hatchery to develop chum salmon for reintroduction into Lower Columbia River tributaries in Oregon. NMFS has not yet evaluated this hatchery program for inclusion in the ESU.

Stratum	Population	Core or Genetic Legacy?**	Contribution to Recovery	Baseline Status	Target Status
Gorge	Lower Gorge (WA & OR)	C, GL	Primary	H	VH
	Upper Gorge (WA & OR)		Contributing	VL	M

* Status is equivalent to persistence probability. VL = very low, L = low, M = moderate, H = high, VH = very high.

** C = Core populations, meaning those that historically were the most productive. G = Genetic legacy populations, which best represent historical genetic diversity.

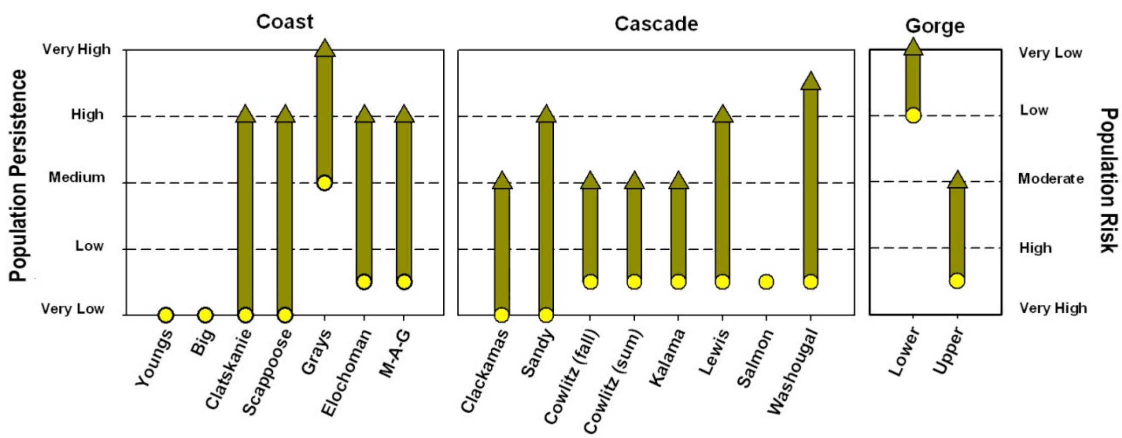

Figure ES-4. *Conservation Gaps for Columbia River Chum Salmon Populations (i.e., Difference between Baseline and Target Status)*

Prevalent Limiting Factors: Chum Salmon

Columbia River chum salmon's poor status is due to a host of limiting factors that have affected the ESU for decades, or longer. Table ES-12 lists prevalent limiting factors that the management unit plans identified as having the greatest impact during the baseline period.

Table ES-11
Prevalent Primary Limiting Factors for Chum Salmon during Baseline Period

Limiting Factor	Populations for Which This Is a Primary Limiting Factor
Channel structure and form issues[17] in the Columbia River estuary	Almost all*
Loss/degradation of peripheral and transitional habitats[18] in the estuary	Almost all
Sediment conditions in the estuary	Almost all
Water quantity issues (i.e., altered hydrology) in the estuary	Almost all

[17] Includes conditions such as channelization, reduced instream habitat complexity, fill and scour, and associated loss of spawning habitat.
[18] Peripheral and transitional habitats are sloughs, side channels, wetlands, and similar features that are periodically inundated during high flows.

Limiting Factor	Populations for Which This Is a Primary Limiting Factor
Degraded riparian conditions in tributaries	Almost all Washington** populations
Channel structure and form issues in tributaries	Almost all Washington populations
Impaired side channel and wetland conditions in tributaries	Almost all Washington populations
Loss/degradation of floodplain habitat in tributaries	Almost all Washington populations

* "Almost all" means every population except one in each stratum.
** Tributary habitat factors in this table are for Washington populations only because of differences in how Oregon and Washington recovery planners categorized limiting factors occurring in areas of tidal influence in the lower reaches of tributaries; see Table 8-3 of the recovery plan.

In addition, passage issues at Bonneville Dam and inundation of historical spawning habitat by Bonneville Reservoir are identified as primary limiting factors for the Upper Gorge population.

Recovery Strategy: Chum Salmon

The ESU recovery strategy for Columbia River chum salmon focuses on improving tributary and estuarine habitat conditions, reducing or mitigating hydropower impacts, and reestablishing chum salmon populations where they may have been extirpated. The goal of the strategy is to increase the abundance, productivity, diversity, and spatial structure of chum salmon populations such that the Coast and Cascade chum salmon strata are restored to a high probability of persistence and the persistence probability of the two Gorge populations improves. The ESU recovery strategy has the following main elements:

1. Protect and improve the Grays/Chinook and Lower Gorge populations, which together produce the majority of Columbia River chum salmon and are the only populations in the ESU not currently at very high risk of extinction.

2. Identify, protect, and restore chum salmon spawning habitat in lower mainstem and off-channel areas of large rivers and streams that are fed by upwelling from intergravel flows or springs. Restore hydrologic, riparian, and sediment processes (e.g., large woody debris recruitment) that support the accumulation of spawning gravel and reduce inputs of fine sediment.

3. Restore off-channel and side-channel habitats (alcoves, wetlands, floodplains, etc.) in the Columbia River estuary, where chum salmon fry rely on peripheral and transitional habitats for extended estuarine rearing.

4. Use hatchery reintroduction as appropriate in reestablishing chum salmon populations and continue using supplementation to enhance the abundance of the Grays and Lower Gorge populations.

Restoring tributary spawning and estuary rearing habitat is essential in the recovery of Columbia River chum salmon. Although the recovery strategy includes other components, no other factor can effectively bring about recovery.

Most of the gains in the viability of Washington chum salmon populations are targeted to be achieved by improving tributary and estuarine habitat. Because potentially manageable harvest, hatchery, and predation impacts on chum salmon already are relatively low, there is little opportunity to further reduce threats in these sectors. Hydropower actions are projected to benefit the Upper Gorge population, which is affected by Bonneville Dam and its reservoir.

Oregon recovery planners developed a chum salmon recovery strategy that involves identifying specific habitat needs and proceeding with reintroduction, initially in the Coast stratum.

Recovery Analysis: Lower Columbia River Steelhead

This recovery plan addresses steelhead in the Cascade and Gorge ecozones only, excluding the White Salmon population and populations in the Coast ecozone. This is because the White Salmon population is part of the Middle Columbia steelhead DPS (and thus is addressed in a separate recovery plan), and the Coast populations are part of the Southwest Washington DPS, which is not listed under the ESA. Also excluded is the resident, freshwater form of *Oncorhynchus mykiss*, which usually is called "rainbow" or "redband" trout. In contrast, steelhead are the anadromous form of *O. mykiss*, meaning that they spend a portion of their life cycle in the ocean but return to fresh water to breed. Thus, this recovery plan covers all naturally spawned anadromous *O. mykiss* populations in streams and tributaries to the Columbia River between and including the Cowlitz and Wind rivers in Washington and, in Oregon, between and including (1) the Willamette River up to Willamette Falls, and (2) the Hood River in Oregon. Steelhead from ten hatchery programs also are part of the DPS.[19]

Historically, the Lower Columbia River steelhead DPS consisted of 23 independent populations: 17 winter-run populations and six summer-run populations. Winter and summer steelhead differ in spawning timing, degree of sexual maturity when returning to fresh water, and other characteristics. Both winter steelhead and summer steelhead spawn in a wide range of conditions, from large streams and rivers to small streams and side channels. Within the same watershed, winter and summer steelhead generally spawn in geographically distinct areas. Summer steelhead can often reach headwater areas above waterfalls that are impassable to winter steelhead during the high-velocity flows common during the winter-run migration. Steelhead are iteroparous, meaning they can spawn more than once.

Baseline and Target Status: Steelhead

Today, 16 of the 23 Lower Columbia River steelhead populations have a low or very low probability of persisting over the next 100 years, and six populations have a moderate

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[19] The release of Cowlitz Hatchery winter steelhead into the Tilton River was discontinued in 2007, the Hood River winter steelhead program was discontinued in 2009, and the release of hatchery winter steelhead into the Upper Cowlitz and Cispus rivers was discontinued in 2010. In its 2011 5-year review, NMFS recommended removing these programs from the DPS and adding a Lewis River winter steelhead program that was initiated in 2009.

probability of persistence. Only the summer-run Wind population is considered viable. All four strata in the DPS fall short of the WLC TRT criteria for viability.

Table ES-12
Baseline and Target Status of LCR Steelhead Populations*

Stratum	Population	Core or Genetic Legacy?**	Contribution to Recovery	Baseline Status	Target Status
Cascade summer	Kalama (WA)	C	Primary	M	H
	NF Lewis (WA)		Stabilizing	VL	VL
	EF Lewis (WA)		Primary	VL	H
	Washougal (WA)	C	Primary	M	H
Gorge summer	Wind (WA)	C	Primary	H	VH
	Hood (OR)		Primary	VL	H
Cascade winter	Lower Cowlitz (WA)		Contributing	L	M
	Upper Cowlitz (WA)	C, GL	Primary	VL	H
	Cispus (WA	C, GL	Primary	VL	H
	Tilton (WA)		Contributing	VL	L
	SF Toutle (WA)		Primary	M	H+
	NF Toutle (WA)	C	Primary	VL	H
	Coweeman (WA)		Primary	L	H
	Kalama (WA)		Primary	L	H+
	NF Lewis (WA)	C	Contributing	VL	M
	EF Lewis (WA)		Primary	M	H
	Salmon Creek (WA)		Stabilizing	VL	VL
	Washougal (WA)		Contributing	L	M
	Clackamas (OR)	C	Primary	M	H
	Sandy (OR)	C	Primary	L	VH
Gorge winter	L. Gorge (OR & WA)		Primary	L	H
	U. Gorge (OR & WA)		Stabilizing	L	L
	Hood (OR)	C, GL	Primary	M	H

* Status is equivalent to persistence probability. VL = very low, L = low, M = moderate, H = high, VH = very high.

** C = Core populations, meaning those that historically were the most productive. G = Genetic legacy populations, which best represent historical genetic diversity.

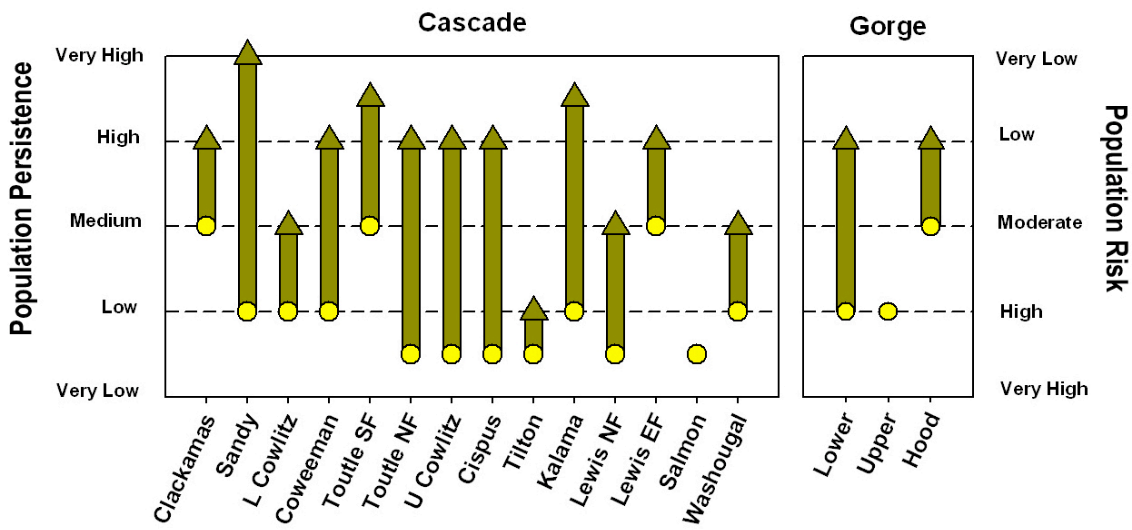

Figure ES-5. *Conservation Gaps for LCR Winter Steelhead Populations (i.e., Difference between Baseline and Target Status)*

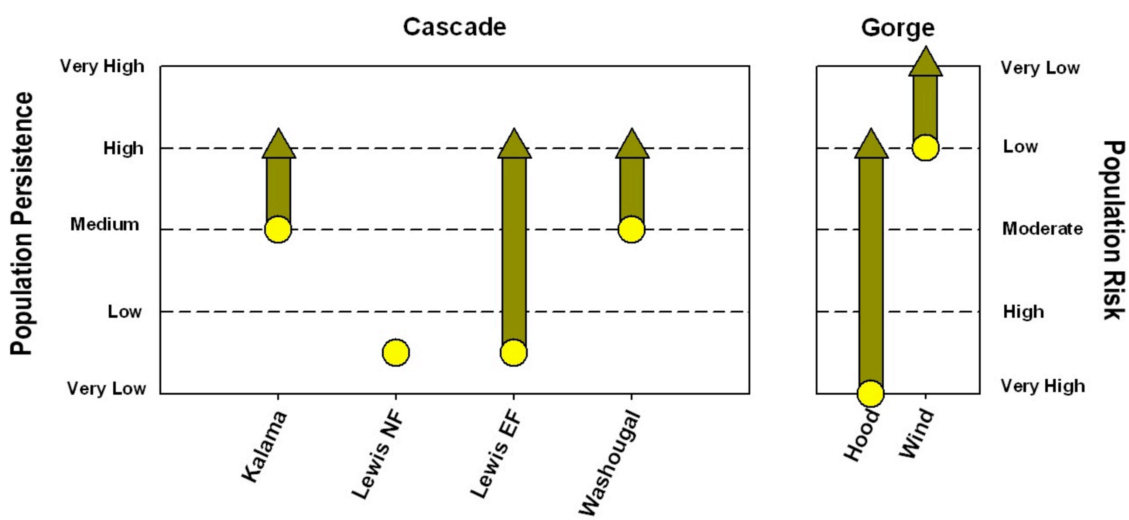

Figure ES-6. *Conservation Gaps for LCR Summer Steelhead Populations (i.e., Difference between Baseline and Target Status)*

Prevalent Limiting Factors: Steelhead

Lower Columbia River steelhead's poor status is due to a host of limiting factors that have affected the ESU for decades, or longer. Tables ES-14 and ES-15 list prevalent limiting factors that the management unit plans identified as having the greatest impact during the baseline period.

Table ES-13
Prevalent Primary Limiting Factors for Winter Steelhead during Baseline Period

Limiting Factor	Populations for Which This Is a Primary Limiting Factor
Degraded riparian conditions along tributaries	Almost all*
Channel structure and form issues[20] in tributaries and the Columbia River estuary	Almost all
Impaired side channel and wetland conditions in tributaries	Almost all
Loss/degradation of floodplain habitat in tributaries	Almost all
Sediment conditions in the estuary	Almost all
Water quantity issues (i.e., altered hydrology) in the estuary	Almost all

* "Almost all" means every population except one in each stratum.

Table ES-14
Prevalent Primary Limiting Factors for Summer Steelhead during Baseline Period

Limiting Factor	Populations for Which This Is a Primary Limiting Factor
Degraded riparian conditions along tributaries	Almost all*
Channel structure and form issues[21] in tributaries	Almost all
Impaired side channel and wetland conditions in tributaries	Almost all
Loss/degradation of floodplain habitat in tributaries	Almost all
Sediment conditions in tributaries and the Columbia River estuary	Almost all
Water quantity issues (i.e., altered hydrology) in the estuary	Almost all

* "Almost all" means every population except one in each stratum.

In addition, tributary hydropower development is a primary limiting factor for the North Fork Lewis summer steelhead population and several populations in the Cascade winter steelhead stratum, as is reduction in population diversity as a result of stray hatchery fish interbreeding with natural-origin fish.

Recovery Strategy: Steelhead

The recovery strategy for the Lower Columbia River steelhead DPS is aimed at restoring the Cascade and Gorge winter and summer strata to a high probability of persistence. Although the strategy involves threat reductions in all categories, the most crucial elements are as follows:

1. Protect favorable tributary habitat and restore degraded but potentially productive habitat, especially in subbasins where large improvements in

[20] Includes conditions such as channelization, reduced instream habitat complexity, fill and scour, and associated loss of spawning habitat.
[21] Includes conditions such as channelization, reduced instream habitat complexity, fill and scour, and associated loss of spawning habitat.

population abundance and productivity are needed to achieve recovery goals. This is the case in the Upper Cowlitz, Cispus, North Fork Toutle, Kalama, and Sandy subbasins for winter steelhead and in the East Fork Lewis and Hood subbasins for summer steelhead.

2. Protect and improve the South Fork Toutle, East Fork Lewis, Clackamas, and Hood winter steelhead populations, which currently are the best-performing winter populations, to a high probability of persistence. This will be accomplished through population-specific combinations of threat reductions, to include protection and restoration of tributary habitat (crucial for all except the Hood population), reductions in hatchery strays on the spawning grounds, and—for the Hood population—removal of Powerdale Dam (this was completed in 2010).

3. Significantly reduce hatchery impacts on the Hood summer steelhead population[22] and, to a lesser degree, on many other populations, especially the Upper Cowlitz, Cispus, Tilton, North Fork Lewis, and Clackamas winter populations and the East Fork summer population. Continue to limit hatchery impacts on the Kalama and Wind summer steelhead populations to improve population diversity.

4. Reestablish naturally spawning winter steelhead populations above tributary dams in the Cowlitz system (Upper Cowlitz and Cispus populations) and improve the status of the Tilton winter steelhead population through hatchery reintroductions and comprehensive threat reductions; reintroduce winter steelhead above dams on the North Fork Lewis River.

5. Reduce predation by birds, non-salmonid fish, and marine mammals.

Loss and degradation of tributary habitat, hatchery effects, and predation are pervasive threats that affect most steelhead populations, but the types of recovery actions that will be of most benefit vary by population. For the Upper Cowlitz, Cispus, Tilton, and North Fork Lewis winter populations, the greatest gains are expected to be achieved by reestablishing natural populations above tributary dams, but reductions in hatchery- and tributary habitat-related threats also will contribute significantly. For the East Fork Lewis summer population, improvements in tributary habitat are projected to provide the greatest benefit. The Sandy winter steelhead population is targeted for significant reductions in hatchery-related threats, but because of fairly recent changes in the management of the hatchery steelhead program, current stray rates in this population already are lower than the 10 percent called for for delisting. Hatchery- and tributary habitat-related actions will be of greatest benefit to Clackamas winter steelhead.

In the Gorge strata, reductions in tributary habitat-related threats will be significant for the Lower and Upper Gorge winter populations, especially in Oregon. For the Hood

[22] The Sandy winter steelhead population was also targeted for a significant reduction in hatchery impacts (i.e., 80 percent). However, the Oregon management unit plan states that, because of fairly recent changes in the management of the hatchery steelhead program, current stray rates in the Sandy winter steelhead population already are lower than the 10 percent called for in the threat reduction targets (ODFW 2010 p. 196).

winter population, the greatest gains in persistence probability are expected from reductions in hatchery- and hydropower-related threats. The Hood summer steelhead population is targeted for significant reductions in multiple threat categories, with particularly large reductions in tributary habitat- and hydropower-related threats and a complete elimination of hatchery threats (summer steelhead will no longer be released in the Hood River subbasin).

With harvest impacts on natural-origin winter steelhead having dropped substantially from historical highs, further reductions in harvest impacts do not figure prominently in the threat reduction scenarios for most steelhead populations. The recovery strategy involves continued management of fisheries to limit impacts to baseline levels.

Adaptive Management and Research, Monitoring, and Evaluation

The life cycles of salmon and steelhead are complex, and there is much we do not know about the range of factors that affect these species and how specific actions influence their characteristics and survival. For this recovery plan to be successful, we must do more than implement the strategies and actions the plan calls for. We also must learn during implementation, continually check our progress in reaching recovery goals, and make adjustments as necessary. Thus, the recovery plan calls for data gathering on the status and trends of populations, their habitats, and sources of threats; resolution of the many unknowns (which are referred to as critical uncertainties); and new or continued research, monitoring, and evaluation (RME) to assess the effectiveness of actions once they are implemented.

The recovery plan also incorporates adaptive management, which is the process of adjusting management actions and/or the overall approach to recovery based on new information, such as information derived from RME activities. Adaptive management works by offering a process for explicitly proposing, prioritizing, implementing, and evaluating alternative approaches and actions. This ensures that the best and most effective means of achieving recovery goals are used, even while scientific understanding of fish populations' needs and the benefits of specific actions continues to change and improve.

Local recovery planners have or will develop specific RME plans—for their respective geographic areas—that are based on regional guidance for adaptive management and RME. These RME plans will guide recovery planning RME efforts and funding in each management unit, within a context of ongoing regional guidance and coordination.

Implementation

Recovery actions will be implemented over a 25-year period, as specified in the management unit plans and estuary recovery plan module. Effective implementation will require that the recovery efforts of diverse private, local, state, tribal, and Federal parties across two states be coordinated at multiple levels.

At the management unit level, Washington's Lower Columbia Fish Recovery Board will lead implementation of actions in southwest Washington, and the Oregon Department of Fish and Wildlife implementation coordinator and stakeholder team will lead recovery plan implementation in Oregon, supported by the governance structure of the Oregon Plan for Salmon and Watersheds. In the White Salmon, NMFS, in coordination with the Washington Gorge Implementation Team (WAGIT), has taken the lead in coordinating implementation. Each of the lead implementing organizations will develop a series of 3-year or 6-year implementation schedules for their respective management unit. Implementation schedules will identify and prioritize[23] site-specific projects, determine costs and time frames, and identify responsible parties, based on strategies and actions in the recovery plan. Thus, the implementation schedules will provide more detail, clarity, and accountability for implementation than this recovery plan does.

At a higher level than the management units, the Lower Columbia Recovery Planning Steering Committee (which NMFS convened to guide development of this recovery plan) will lead efforts to coordinate the actions of the many entities that will play a role in implementation. For example, there is a need for coordination among the management units and the entities implementing Columbia River estuary recovery actions because the lower, tidal portions of the tributaries, which are within the management unit planning areas, overlap with the planning area of the *Columbia River Estuary ESA Recovery Plan Module for Salmon and Steelhead*. The steering committee will perform its coordination functions by working with subcommittees and other regional forums as needed.

Finally, NMFS has a unique role in recovery plan implementation. In addition to ensuring that its statutory responsibilities for recovery under the ESA are met, NMFS will support local recovery efforts by (1) helping to coordinate and encourage recovery plan implementation, (2) using recovery plans to guide regulatory decision making, (3) providing leadership in regional research, monitoring, and evaluation forums, and (4) providing periodic reports on species status and trends, limiting factors, threats, and plan implementation status.

The good news is that some recovery actions already are taking place. Harvest rates have dropped significantly since the first Lower Columbia River species were listed under the Endangered Species Act. Reforms of hatchery practices and programs are being implemented throughout the Columbia Basin. Dams have been removed or breached on the Sandy, Hood, and White Salmon rivers, and improvements in passage and operations to benefit salmon and steelhead are under way at other tributary hydropower facilities and in the Federal Columbia River hydropower system. Tributary and estuary habitat protection and restoration projects are under way. However, considerable additional work is needed to meet the goals of this plan. Habitat activities in particular need to be scaled up if they are to provide the needed benefits.

Conclusion

Recovery of ESA-listed Lower Columbia River salmon and steelhead will require actions that conserve and restore the key biological, ecological, and landscape processes that support the ecosystems that salmonid species depend on. These measures will require

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[23] Some prioritization work already has been done, in that the management unit plans identify high-priority reaches for tributary habitat protection and restoration actions. In addition, the Oregon and White Salmon management unit plans offer some guidance on how actions might be prioritized across threat categories.

implementation of specific tributary and estuary habitat protection and restoration actions; changes in management of harvest, hatchery, and hydropower programs; and predation control. Development of an effective implementation framework, coupled with a responsive RME and adaptive management plan, provides the best assurance that this recovery plan will be fully implemented and effective. The plan's identification of target statuses, primary and secondary limiting factors that have caused gaps between baseline and target status, and actions to close those gaps is intended to aid implementing entities as they take actions that will lead to delisting and, eventually, achievement of broad sense recovery goals. The keys to long-term success will be full funding and implementation of this recovery plan and voluntary participation of residents of the Lower Columbia region. It is only through the involvement of all of those who live and work in this region that recovery will be achieved.

Key Documents

Oregon Lower Columbia Conservation and Recovery for Salmon and Steelhead
Oregon Department of Fish and Wildlife, 2010
http://www.dfw.state.or.us/fish/CRP/lower_columbia_plan.asp

Draft ESA Recovery Plan for the White Salmon River Watershed
National Marine Fisheries Service, 2011

Washington Lower Columbia Salmon Recovery and Fish & Wildlife Subbasin Plan
Lower Columbia Fish Recovery Board, 2010
http://www.lcfrb.gen.wa.us/December%202004%20Final%20%20Plans/lower_columbia_salmon_recovery_a.htm

Columbia River Estuary ESA Recovery Plan Module for Salmon and Steelhead
National Marine Fisheries Service, 2011
http://www.nwr.noaa.gov/Salmon-Recovery-Planning/ESA-Recovery-Plans/Estuary-Module.cfm

Recovery Plan Module: Mainstem Columbia River Hydropower Projects
National Marine Fisheries Service, 2008
http://www.nwr.noaa.gov/Salmon-Recovery-Planning/ESA-Recovery-Plans/Other-Documents.cfm

2008 Federal Columbia River Power System Biological Opinion and 2010 Supplement
National Marine Fisheries Service, 2008 and 2010
http://www.nwr.noaa.gov/Salmon-Hydropower/Columbia-Snake-Basin/Final-BOs.cfm

Proposed ESA Recovery Plan for

Lower Columbia River Coho Salmon, Lower Columbia River Chinook Salmon, Columbia River Chum Salmon, and Lower Columbia River Steelhead

Prepared by the
National Marine Fisheries Service,
Northwest Region

April 2012

Disclaimer

Endangered Species Act (ESA) recovery plans delineate reasonable actions that the best available information indicates are necessary for the conservation and survival of listed species. Plans are published by the National Marine Fisheries Service (NMFS), usually with the assistance of recovery teams, state agencies, local governments, salmon recovery boards, non-governmental organizations, interested citizens of the affected area, contractors, and others. ESA recovery plans do not necessarily represent the views, official positions, or approval of any individuals or agencies involved in the plan formulation, other than NMFS. They represent the official position of NMFS only after they have been signed by the Northwest Regional Administrator. ESA recovery plans are guidance and planning documents only; identification of an action to be implemented by any public or private party does not create a legal obligation beyond existing legal requirements. Nothing in this plan should be construed as a commitment or requirement that any Federal agency obligate or pay funds in any one fiscal year in excess of appropriations made by Congress for that fiscal year in contravention of the Anti-Deficiency Act, 31 United States Code (USC) 1341, or any other law or regulation. Approved recovery plans are subject to modification as dictated by new information, changes in species status, and the completion of recovery actions.

With respect to the Lower Columbia River salmon and steelhead recovery plan, where areas of disagreement arose between a management unit plan and the species (i.e., ESU or DPS-level) plan, NMFS worked with the relevant parties to resolve the differences and in a few cases, identified in the species plan, decided not to incorporate the disputed material into the species plan.

Although an ESA recovery plan is not a regulatory document with the force of law, it provides important context for NMFS decisions under ESA section 7(a). The procedures for the section 7 consultation process are described in 50 Code of Federal Regulations (CFR) 402 and are applicable regardless of whether or not the actions are described in a recovery plan.

Acknowledgements

The Lower Columbia River ESA Recovery Plan represents the dedicated effort of numerous people over many years. The National Marine Fisheries Service would like to thank the individuals, organizations, and agencies listed below (alphabetically) for their contributions to this plan. Special thanks go to the members of the Lower Columbia Recovery Plan Steering Committee and the management unit recovery planning organizations for their input, support, and guidance throughout this recovery planning process.

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Lower Columbia Management Unit Organizations

Lower Columbia Fish Recovery Board
Lower Columbia River Estuary Partnership
Oregon Lower Columbia Stakeholder Team
Washington Gorge Implementation Team

Member Agencies of the Columbia Basin Federal Caucus

Bonneville Power Administration
National Marine Fisheries Service
U.S. Army Corps of Engineers
U.S. Bureau of Land Management
U.S. Bureau of Indian Affairs
U.S. Bureau of Reclamation
U.S. Environmental Protection Agency
U.S. Fish and Wildlife Service
U.S. Forest Service
U.S. Geological Survey

Contents

Appendices

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Figures

Acronyms and Abbreviations

AMIP	Adaptive Management Implementation Plan
AMS	Anadromous Salmonid Monitoring Strategy
ASMS	Anadromous Salmonid Monitoring Strategy
BACI	Before and After Control Impact
BiOp	Biological Opinion
BPA	Bonneville Power Administration
C&S	ceremonial and subsistence
C3	Climate Change Collaboration
CATAS	Conservation Assessment Tool for Anadromous Salmonids
CBFWA	Columbia Basin Fish and Wildlife Authority
CFR	Code of Federal Regulations
CREP	Conservation Reserve Enhancement Program
CRT	critical risk threshold
DEIS	Draft Environmental Impact Statement
DPS	distinct population segment
EDT	Ecosystem Diagnosis and Treatment
EIS	environmental impact statement
EPA	U.S. Environmental Protection Agency
ERME	*Research, Monitoring, and Evaluation for the Federal Columbia River Estuary Program*
ESA	Endangered Species Act
ESU	evolutionarily significant unit
FCRPS	Federal Columbia River Power System
FERC	Federal Energy Regulatory Commission

FR	Federal Register
GHG	greenhouse gas
GIS	geographical information system
GRTS	generalized random tessellation stratified
HGMP	Hatchery and Genetics Management Plan
HSRG	Hatchery Scientific Review Group
IMW	intensively monitored watershed
IP	intrinsic potential
IPCC	Intergovernmental Panel on Climate Change
ISAB	Independent Scientific Advisory Board
ISEMP	Integrated Status and Effectiveness Monitoring Program
ISTM	Integrated Status and Trend Monitoring
IWA	Integrated Watershed Assessment
kcfs	thousand cubic feet per second
LCFRB	Lower Columbia Fish Recovery Board
LCR	Lower Columbia River
LCREP	Lower Columbia River Estuary Partnership
MAT	minimum abundance threshold
MOA	Memorandum of Agreement
MPG	major population group
NEPA	National Environmental Protection Act
NFCP	Native Fish Conservation Policy
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NPCC	Northwest Power and Conservation Council
NWFSC	Northwest Fisheries Science Center

ODFW	Oregon Department of Fish and Wildlife
OWEB	Oregon Watershed Enhancement Board
PAHs	polycyclic aromatic hydrocarbons
PCBs	polychlorinated biphenyls
PCE	primary constituent element
PCSRF	Pacific Coastal Salmon Recovery Funds
pHOS	proportion of hatchery-origin spawners
PNAMP	Pacific Northwest Aquatic Monitoring Partnership
PNI	proportion of natural influence
PUD	public utility district
PVA	Population Viability Analysis
QET	quasi-extinction threshold
RCW	Revised Code of Washington
RIST	Recovery Implementation Science Team
RKM	river kilometer
RM	river mile
RME	research, monitoring, and evaluation
RPA	Reasonable and Prudent Alternative
RSW	removable spillway weirs
SRFB	Salmon Recovery Funding Board
SRS	sediment retention structure
TRT	Technical Recovery Team
USC	United States Code
USDA	U.S. Department of Agriculture
USDI	U.S. Department of the Interior
USFWS	U.S. Fish and Wildlife Service

VSP	viable salmonid populations
WAGIT	Washington Gorge Implementation Team
WDFW	Washington Department of Fish and Wildlife
WLC TRT	Willamette-Lower Columbia Technical Recovery Team
WRIA	Water Resource Inventory Area

Glossary

abundance: In the context of salmon recovery, unless otherwise qualified, abundance refers to the number of adult fish returning to spawn, measured over a time series.

adaptive management: Adaptive management in salmon recovery planning is a method of decision making in the face of uncertainty. A plan for monitoring, evaluation, and feedback is incorporated into an overall implementation plan so that the results of actions can become feedback on design and implementation of future actions.

anadromous fish: Species that are hatched in freshwater, migrate to and mature in salt water, and return to freshwater to spawn.

baseline monitoring: In the context of recovery planning, baseline monitoring is done before implementation, in order to establish historical and/or current conditions against which progress (or lack of progress) can be measured.

biogeographical region: an area defined in terms of physical and habitat features, including topography and ecological variations, where groups of organisms (in this case, salmonids) have evolved in common.

broad sense recovery goals: Goals defined in the recovery planning process, generally by local recovery planning groups, that go beyond the requirements for delisting, to address, for example, other legislative mandates or social, economic, and ecological values.

compliance monitoring: Monitoring to determine whether a specific performance standard, environmental standard, regulation, or law is met.

conservation gap: The difference between a population's baseline status and its target status.

contributing population: A population for which some restoration will be needed to achieve the stratum-wide average viability recommended by the Washington-Lower Columbia Technical Recovery Team (i.e., 2.25 or higher).

delisting criteria: Criteria incorporated into ESA recovery plans that define both biological viability (biological criteria) and alleviation of the causes for decline (threats criteria based on the five listing factors in ESA section 4[a][1]), and that, when met, would result in a determination that a species is no longer threatened or endangered and can be proposed for removal from the Federal list of threatened and endangered species. These criteria are a NMFS determination and may include both technical and policy considerations.

distinct population segment (DPS): A listable entity under the ESA that meets tests of discreteness and significance according to USFWS and NMFS policy. A population is considered distinct (and hence a "species" for purposes of conservation under the ESA) if it is discrete from and significant to the remainder of its species based on factors such as physical, behavioral, or genetic characteristics, it occupies an unusual or unique ecological setting, or its loss would represent a significant gap in the species' range.

diversity: All the genetic and phenotypic (life history, behavioral, and morphological) variation within a population. Variations could include anadromy vs. lifelong residence in freshwater, fecundity, run timing, spawn timing, juvenile behavior, age at smolting, age at maturity, egg size, developmental rate, ocean distribution patterns, male and female spawning behavior, physiology, molecular genetic characteristics, etc.

effectiveness monitoring: Monitoring set up to test cause-and-effect hypotheses about recovery actions: Did the management actions achieve their direct effect or goal? For example, did fencing a riparian area to exclude livestock result in recovery of riparian vegetation?

endangered species: A species in danger of extinction throughout all or a significant portion of its range.

ESA recovery plan: A plan to recover a species listed as threatened or endangered under the U.S. Endangered Species Act (ESA). The ESA requires that recovery plans, to the extent practicable, incorporate (1) objective, measurable criteria that, when met, would result in a determination that the species is no longer threatened or endangered; (2) site-specific management actions that may be necessary to achieve the plan's goals; and (3) estimates of the time required and costs to implement recovery actions.

evolutionarily significant unit (ESU): A group of Pacific salmon or steelhead trout that is (1) substantially reproductively isolated from other conspecific units and (2) represents an important component of the evolutionary legacy of the species.

extinct: No longer in existence. No individuals of this species can be found.

extirpated: Locally extinct. Other populations of this species exist elsewhere. Functionally extirpated populations are those of which there are so few remaining numbers that there are not enough fish or habitat in suitable condition to support a fully functional population.

factors for decline: Five general categories of causes for decline of a species, listed in the Endangered Species Act section 4(a)(1)(b): (A) the present or threatened destruction, modification, or curtailment of its habitat or range; (B) overutilization for commercial, recreational, scientific, or educational purposes; (C) disease or predation; (D) the inadequacy of existing regulatory mechanisms; or (E) other natural or human-made factors affecting its continued existence.

functionally extirpated: Describes a species that has been extirpated from an area; although a few individuals may occasionally be found, there are not enough fish or habitat in suitable condition to support a fully functional population.

hyporheic zone: Area of saturated gravel and other sediment beneath and beside streams and rivers where groundwater and surface water mix.

implementation monitoring: Monitoring to determine whether an activity was performed and/or completed as planned.

independent population: Any collection of one or more local breeding units whose population dynamics or extinction risk over a 100-year time period is not substantially altered by exchanges of individuals with other populations.

indicator: A variable used to forecast the value or change in the value of another variable.

interim regional recovery plan: A recovery plan that is intended to lead to an ESA recovery plan but that is not yet complete. These plans might address only a portion of an ESU or lack other key components of an ESA recovery plan.

intrinsic potential: The estimated relative suitability of a habitat for spawning and rearing of anadromous salmonid species under historical conditions inferred from stream characteristics including channel size, gradient, and valley width.

intrinsic productivity: The expected ratio of natural-origin offspring to parent spawners at levels of abundance below carrying capacity.

kelts: Steelhead that are returning to the ocean after spawning and have the potential to spawn again in subsequent years (unlike most salmon, steelhead do not necessarily die shortly after spawning).

large woody debris (LWD): A general term for wood naturally occurring or artificially placed in streams, including branches, stumps, logs, and logjams. Streams with adequate LWD tend to have greater habitat diversity, a natural meandering shape, and greater resistance to flooding.

legacy effects: Impacts from past activities that continue to affect a stream or watershed in the present day.

limiting factor: Physical, biological, or chemical features (e.g., inadequate spawning habitat, high water temperature, insufficient prey resources) experienced by the fish that result in reductions in viable salmonid population (VSP) parameters (abundance, productivity, spatial structure, and diversity). Key limiting factors are those with the greatest impacts on a population's ability to reach a desired status.

locally developed recovery plan: A plan developed by state, tribal, regional, or local planning entities to address recovery of a species. These plans are being developed by a number of entities throughout the region to address ESA as well as state, tribal, and local mandates and recovery needs.

maintained status: Population status in which the population does not meet the criteria for a viable population but does support ecological functions and preserve options for ESU/DPS recovery.

management unit: A geographic area defined for recovery planning purposes on the basis of state, tribal or local jurisdictional boundaries that encompass all or a portion of the range of a listed species, ESU, or DPS.

metrics: Something that quantifies a characteristic of a situation or process; for example, the number of natural-origin salmon returning to spawn to a specific location is a metric for population abundance.

morphology: The form and structure of an organism, with special emphasis on external features.

natural-origin fish: Fish that were spawned and reared in the wild, regardless of parental origin.

parr: The stage in anadromous salmonid development between absorption of the yolk sac and transformation to smolt before migration seaward.

persistence probability: The complement of a population's extinction risk (i.e., persistence probability = 1 – extinction risk).

phenotype: Any observable characteristic of an organism, such as its external appearance, development, biochemical or physiological properties, or behavior.

piscivorous: (Adj.) Describes fish that eat other fish.

primary population: A population that is targeted for restoration to high or very high persistence probability.

productivity: The average number of surviving offspring per parent. Productivity is used as an indicator of a population's ability to sustain itself or its ability to rebound from low numbers. The terms "population growth rate" and "population productivity" are interchangeable when referring to measures of population production over an entire life cycle. Can be expressed as the number of recruits (adults) per spawner or the number of smolts per spawner.

recovery domain: An administrative unit for recovery planning defined by NMFS based on ESU boundaries, ecosystem boundaries, and existing local planning processes. Recovery domains may contain one or more listed ESUs.

recovery goals: Goals incorporated into a locally developed recovery plan, which may include delisting (i.e. no longer considered endangered or threatened), reclassification (e.g., from endangered to threatened), and/or other goals. Broad sense goals are a subset of recovery goals (see glossary entry above).

recovery scenarios: Scenarios that describe a target status for each population within an ESU, generally consistent with TRT recommendations for ESU viability.

recovery strategy: Statements that identify the assumptions and logic – the rationale – for the species' recovery program.

redd: A nest constructed by female salmonids in streambed gravels where eggs are fertilized and deposited.

riparian area: Area with distinctive soils and vegetation between a stream or other body of water and the adjacent upland.

salmonid: Fish of the family *Salmonidae*, including salmon, trout, chars, grayling, and whitefish. In general usage, the term usually refers to salmon, trout, and chars.

smolt: A juvenile salmonid that is undergoing physiological and behavioral changes to adapt from freshwater to saltwater as it migrates toward the ocean.

spatial structure: Characteristics of a fish population's geographic distribution. Current spatial structure depends upon the presence of fish, not merely the potential for fish to occupy an area.

stabilizing population: A population that is targeted for maintenance at its baseline persistence probability, which is likely to be low or very low.

stakeholders: Agencies, groups, or private citizens with an interest in recovery planning, or those who will be affected by recovery planning and actions.

stratum: A group of salmonid populations that are geographically and genetically cohesive. The stratum is a level of organization between demographically independent populations and the ESU or DPS.

Technical Recovery Team (TRT): Teams convened by NMFS to develop technical products related to recovery planning. Planning forums unique to specific states, tribes, or regions may use TRT and other technical products to identify recovery actions.

threatened species: A species likely to become endangered within the foreseeable future throughout all or a significant portion of its range.

threat reduction scenario: A specific combination of reductions in threats from various sectors that would lead to a population achieving its target status.

threats: Human activities or natural events (e.g., road building, floodplain development, fish harvest, hatchery influences, volcanoes) that cause or contribute to limiting factors. Threats may exist in the present or be likely to occur in the future.

viability criteria: Criteria defined by NMFS-appointed Technical Recovery Teams to describe a viable salmonid population, based on the biological parameters of abundance, productivity, spatial structure, and diversity. These criteria are used as technical input into the recovery planning process and provide a technical foundation for development of biological delisting criteria.

viability curve: A curve describing combinations of abundance and productivity that yield a particular risk of extinction at a given level of variation over a specified time frame.

viable salmonid population (VSP): An independent population of any Pacific salmonid (genus *Oncorhynchus*) that has a negligible risk of extinction due to threats from demographic variation (random or directional), local environmental variation, and genetic diversity changes (random or directional) over a 100-year time frame.

VSP parameters: Abundance, productivity, spatial structure, and diversity. These describe characteristics of salmonid populations that are useful in evaluating population viability. See NOAA Technical Memorandum NMFS-NWFSC-42, *Viable salmonid populations and the recovery of evolutionarily significant units* (McElhany et al. 2000).

Executive Summary

About This Recovery Plan

This is a proposed plan for the recovery of Lower Columbia River Chinook salmon (*Oncorhynchus tshawytscha*), Lower Columbia River steelhead (*O. mykiss),* Lower Columbia River coho salmon (*O. kisutch*), and Columbia River chum salmon (*O. keta*), all of which spawn and rear in the lower Columbia River or its tributaries in Oregon and Washington. These salmon and steelhead were listed as threatened under the Endangered Species Act of 1973 (ESA) between 1998 and 2005. Each is considered an evolutionarily significant unit (ESU) or, for steelhead, a distinct population segment (DPS). An ESU or DPS is a group of Pacific salmon or steelhead that is discrete from other groups of the same species and that represents an important component of the evolutionary legacy of the species.[1] Under the Endangered Species Act, each ESU or DPS is treated as a species. For convenience this recovery plan frequently uses the term "ESU" to refer to both the salmon ESUs and the steelhead DPS.

The core of the plan is a set of goals and actions for each ESU that, if implemented, would reverse the ESU's decline and lead to recovery of the ESU. Biological recovery for an ESU means that it is naturally self-sustaining and no longer requires the protection of the ESA: enough fish spawn in the wild and return year after year that the ESU is likely to persist in the long run. A recovered ESU is resilient enough that it can survive typical variations in ocean conditions and productivity and has a high likelihood of withstanding catastrophic changes in the environment, such as floods, landslides, and earthquakes.

The ESA requires the National Marine Fisheries Service (NMFS) to develop recovery plans for all listed salmon and steelhead species. NMFS is a branch of the National Oceanic and Atmospheric Administration and is sometimes referred to as NOAA Fisheries. As the Federal agency charged with stewardship of the nation's marine resources, NMFS has the responsibility for listing and delisting salmon and steelhead species under the ESA.

Although NMFS is directly responsible for ESA recovery planning for salmon and steelhead, the agency believes that ESA recovery plans for salmon and steelhead should be based on the many state, regional, tribal, local, and private conservation efforts already under way throughout the region, and that local support of recovery plans is essential to success. Accordingly, NMFS based this recovery plan on the information, analyses, and strategies in three locally developed recovery plans, which are referred to as management unit plans.

Each ESU is made up of multiple independent populations, and each management unit plan covers populations in a different portion of the ESU's range:

[1] A DPS is defined based on discreteness in behavioral, physiological, and morphological characteristics, whereas the definition of an ESU emphasizes genetic and reproductive isolation. (For a fuller explanation see, Section 1.4.4 of the recovery plan.)

- *The Oregon Lower Columbia Conservation and Recovery Plan for Salmon and Steelhead* covers the Lower Columbia River salmon and steelhead populations that are within Oregon, including the Willamette River up to Willamette Falls. The Oregon Department of Fish and Wildlife (ODFW) developed this plan in collaboration with NMFS and numerous stakeholders, including governments, agencies, tribes, industry and environmental representatives, and the public (Oregon Department of Fish and Wildlife 2010).

- *ESA Salmon Recovery Plan for the White Salmon River Subbasin* covers Lower Columbia River salmon and steelhead populations in the White Salmon River basin in Washington. NMFS developed this plan in cooperation with stakeholders such as the Yakama Nation, Klickitat County, and Washington Department of Fish and Wildlife (National Marine Fisheries Service 2011b).

- *Washington Lower Columbia Salmon Recovery and Fish & Wildlife Subbasin Plan* covers Lower Columbia River salmon and steelhead populations in Southwest Washington, within the planning area of the Lower Columbia Fish Recovery Board (LCFRB). The LCFRB developed this plan using a collaborative process that involved multiple agencies (including NMFS), tribal and other governments, organizations, industry, and the public (Lower Columbia Fish Recovery Board 2010a).

Two other documents, both developed by NMFS, were key in development of this recovery plan: the *Columbia River Estuary ESA Recovery Plan Module for Salmon and Steelhead* (NMFS 2011a) and the *Recovery Plan Module: Mainstem Columbia River Hydropower Projects* (NMFS 2008a). These documents, which address regional-scale issues affecting Lower Columbia River salmon and steelhead, as well as other listed salmon ESUs and steelhead DPSs, provide a consistent set of assumptions and recovery actions that management unit recovery planners incorporated into their management unit plans.

Recovery plans are not regulatory documents. Their implementation is voluntary, except when they incorporate actions required as part of a regulatory process, such as ESA section 7, 10, and 4(d). For this recovery plan, NMFS will rely, to a great extent, on local citizens and organizations, as well as on other Federal and state agencies, local jurisdictions, and tribal governments, to voluntarily implement the proposed actions. In some cases, the plan proposes new recovery efforts that are not part of existing processes. In other cases, the plan recommends coordinating existing programs, both regulatory and non-regulatory, in ways that enhance benefits to Lower Columbia River salmon and steelhead and their ecosystems. Some actions that are integrated into this recovery plan originate in regulatory processes; examples include actions associated with the 2008 Bull Run Water Supply Habitat Conservation Plan (HCP), the 2008 Federal Columbia River Power System Biological Opinion and its 2010 Supplement, Federal Energy Regulatory Commission relicensing agreements (for tributary hydroelectric projects), and the regulation of fisheries that may affect the Lower Columbia River ESUs.

This recovery plan lays out an overall road map for recovery. After the plan is adopted, additional work will be needed in some cases to identify and prioritize[2] site-specific projects, determine costs and time frames, and identify responsible parties, based on strategies and actions in the recovery plan. To address these needs, each entity that developed a management unit plan (i.e., ODFW, NMFS, and LCFRB) also will prepare an "implementation schedule" that spells out the details of implementation for its specific geographical area. Implementation schedules will be updated every 3 to 6 years.

Overall Goal

In general, the goal of this plan is for the Lower Columbia River coho salmon ESU, Lower Columbia River Chinook salmon ESU, Lower Columbia River steelhead DPS, and Columbia River chum salmon ESU to reach the point at which they no longer need the protection of the Endangered Species Act and can be delisted. The delisting decision is made by NMFS, using the best available science. NMFS' delisting criteria are presented later in this summary, after some basic technical information and the population-specific goals are explained.

Technical Foundation

NMFS appointed teams of scientists with expertise in salmonid species to provide scientific support for recovery planners in the Pacific Northwest. These technical recovery teams (TRTs) worked from a common scientific foundation to ensure that recovery plans would be scientifically sound and based on consistent biological principles. All the TRTs based their work on biological principles established by NMFS for salmon recovery planning.

The Willamette-Lower Columbia Technical Recovery Team (WLC TRT) included biologists from NMFS, other federal agencies, states, tribes, academic institutions, and the private sector. The WLC TRT and a subsequent work group consisting of NMFS staff, ODFW staff, and a private consultant produced a set of technical reports that, taken together, present recommended biological criteria and methodologies for determining whether the four Lower Columbia River salmon and steelhead ESUs are viable. A viable ESU is naturally self-sustaining over the long term.

Consistent with principles established by NMFS, the WLC TRT described salmon and steelhead viability in terms of four interrelated parameters:

- **Abundance and productivity.** Abundance refers to the number of adult fish on the spawning grounds. Productivity is the population's growth rate, which indicates whether the population can sustain itself or rebound from low numbers. Productivity can be measured as spawner-to-spawner ratios (i.e., returns per spawner or recruits per spawner), annual population growth rate, or trends in abundance. Abundance and productivity are closely linked, and a population needs both: abundance to maintain genetic health and respond to normal

[2] Some prioritization work already has been done, in that the management unit plans identify high-priority reaches for tributary habitat protection and restoration actions. In addition, the Oregon and White Salmon management unit plans offer some guidance on how actions might be prioritized.

environmental variation, and productivity to bounce back if population numbers drop for some reason.

- **Spatial structure.** Spatial structure refers to both the geographic distribution of individuals in the population and the processes or conditions that generate that distribution. Factors affecting spatial structure include the amount of habitat available, how connected the habitat is, and how much neighboring populations mix with each other. Spatial structure is important because a species that is not geographically spread out is at risk of extinction from a single catastrophic event, such as a landslide.

- **Diversity**. Diversity refers to the variety of life history, behavioral, and physiological traits within and among populations. Some traits are determined completely by genetics, while others, such as appearance, behavior, and life history, vary as a result of a combination of genetic and environmental factors. Diversity is important because it gives populations an edge in surviving (and eventually adapting to) environmental change.

To understand the WLC TRT's biological criteria, it helps to know something about the biological structure of salmon and steelhead species. The Lower Columbia River Chinook salmon, Lower Columbia River coho salmon, Lower Columbia River steelhead, and Columbia River chum salmon ESUs each consist of multiple independent populations that spawn in different watersheds throughout the ESU's range. Additionally, within an ESU, independent populations can be organized into larger groups, known as strata. Stratum designation is based on the combination of ecological zone and life history strategy (indicated by the time of year when adults return to fresh water to spawn). In the lower Columbia region there are three ecological zones—Coast, Cascade, and Gorge. Two ESUs—Chinook and steelhead—display more than one life history strategy. Thus, the strata in this recovery plan include Coast, Cascade, and Gorge coho, Coast fall Chinook, Cascade fall Chinook, Gorge fall Chinook, Cascade spring Chinook, Gorge spring Chinook, etc.

The WLC TRT developed biological criteria and methodologies at three different levels: ESU, stratum, and population. The following are the TRT's key points in defining a viable ESU:

- Every stratum that historically existed should have a high probability of persistence.

- Within each stratum, there should be at least two populations that have at least a 95 percent probability of persisting over a 100-year time frame.

- Within each stratum, the average viability of the populations should be 2.25 or higher, using the WLC TRT's scoring system. Functionally, this is equivalent to about half of the populations in the stratum being viable; a viable population is one whose persistence probability is high or very high.

- Populations targeted for viability should include those within the ESU that historically were the most productive ("core" populations) and that best represent the historical genetic diversity of the ESU ("genetic legacy" populations). In addition, viable populations should be geographically dispersed in a way that protects against the effects of catastrophic events.

- Viable populations should meet specific criteria for abundance, productivity, spatial structure, and diversity.

There are various ways to refer to extinction risk: as viability, persistence probability, extinction risk, or—at the population level—population status. This recovery plan frequently uses the terms "persistence probability" and "population status." Only populations with a persistence probability of 95 percent or higher over a 100-year time frame are considered viable. These populations have a population status of high or very high.

Table ES-1
Population-level Probability of Persistence, Extinction Risk, and Status*

Probability of Persistence	Probability of Extinction	Extinction Risk	Population Status
0 – 40%	60 – 100%	Extinct or at very high risk of extinction (VH)	Very low (VL)
40 – 75%	25 – 60%	Relatively high risk of extinction (H)	Low (L)
75 – 95%	5 – 25%	Moderate risk of extinction (M)	Medium (M)
95 – 99%	1 – 5%	Low/negligible risk of extinction (L)	High (H)
> 99%	< 1%	Very low risk of extinction (VL)	Very high (VH)

[+] Probability over a 100-year time frame.
Shading indicates levels at which a population is considered viable.

Population-specific Goals: The Recovery Scenario

The WLC TRT defined viability at the ESU, stratum, and population levels, but it did not specify the target status for each population because (1) there are many different combinations of target statuses that would meet the TRT's viability criteria, and (2) the "best" combination is a function of the biological and ecological conditions on the ground and local community values and interests. Oregon, Washington, and White Salmon management unit planners collaborated to reach agreement on which populations to target for which levels of viability. In making these decisions, management unit planners considered the WLC TRT's viability criteria and the following questions:

- Which populations historically were the most productive?
- Which populations represent important historical genetic diversity?
- Are the populations targeted for viability dispersed in a way that minimizes risk from catastrophic events?
- Which populations can be expected to make significant progress toward recovery because of existing programs, the absence of apparent impediments to recovery, and other management considerations?

- Are there populations that are unlikely to make significant progress toward recovery because of other societal goals, such as maintaining harvest or development opportunities?

The resulting target statuses for each ESU are collectively referred to as the recovery scenario and served as the basis from which to calculate numerical abundance and productivity goals for each population. (Table 3-1 of the recovery plan shows the recovery scenario for each ESU.)

Under the recovery scenario not all populations are targeted for a high degree of improvement, but all of them will need recovery actions—even so-called "stabilizing" populations. These are populations that are expected to remain at or near their current status (usually low or very low) because the feasibility of restoration is low and the uncertainty of success is high. "Primary" populations, on the other hand, are targeted for viability, meaning high or very high persistence probability. "Contributing" populations fall in the middle; they are targeted for some improvement in status so that the stratum-wide average viability is 2.25 or higher.

The recovery scenarios in the management unit plans are largely consistent with the WLC TRT's recommendations at the stratum and ESU level. Exceptions are the Gorge fall Chinook, Gorge spring Chinook, and Gorge chum strata, where the recovery scenarios target only one population to achieve a high probability of persistence, instead of two. As a way of mitigating for this increased risk in the Gorge strata, the recovery scenarios exceed the WLC TRT criteria in the Cascade fall Chinook, Cascade spring Chinook, and Cascade chum strata (i.e., more populations are targeted for viability than are needed to meet the 2.25 average). In addition, management unit recovery planners raised questions about the historical role of the Gorge fall Chinook, spring Chinook, and chum populations: were the populations highly persistent historically, did they function as independent populations within their stratum in the same way that the Coast and Cascade populations did, and should the Gorge stratum be considered a separate stratum from the Cascade stratum? Oregon recovery planners suggested that the Gorge strata's historical status and population structure be reevaluated and that recovery goals be revised if modifications are made; NMFS agrees that the historical role of the Gorge populations and strata merits further examination.

NMFS Delisting Criteria

As described above, the overall goal of this recovery plan is for the four ESUs to reach the point at which they no longer need the protection of the ESA and can be delisted. In order to be delisted, the species must no longer be in danger of extinction or likely to become endangered within the foreseeable future, based on evaluation of the factors that caused the species to be listed in the first place. In accordance with the ESA, this recovery plan incorporates objective, measurable criteria for determining whether an ESU can be delisted.[3] These criteria are of two types: biological viability criteria and threats criteria.

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[3] The ESA requires that recovery plans, to the maximum extent practicable, incorporate objective, measurable criteria that, when met, would result in a determination in accordance with the provisions of the

Biological Viability Criteria

NMFS has concluded that the WLC TRT's viability criteria, the recovery scenarios, and the population-level abundance and productivity goals in the management unit plans adequately describe the characteristics of an ESU that no longer needs the protections of the ESA. NMFS endorses the recovery scenarios and population-level goals in the management unit plans as one of multiple possible scenarios consistent with delisting. Therefore, NMFS proposes the following biological viability criteria:

- All strata that historically existed have a high probability of persistence or have a probability of persistence consistent with their historical condition.

- High probability of stratum persistence is defined as:

    A. At least two populations in the stratum have at least a 95 percent probability of persistence over a 100-year time frame (i.e., two populations with a score of 3.0 or higher based on the TRT's scoring system).

    B. Other populations in the stratum have persistence probabilities consistent with a high probability of stratum persistence (i.e., the average of all stratum population scores is 2.25 or higher, based on the TRT's scoring system). (See Section 2.6 of the recovery plan for a brief discussion of the TRT's scoring system.)

    C. Populations targeted for a high probability of persistence are distributed in a way that minimizes risk from catastrophic events, maintains migratory connections among populations, and protects within-stratum diversity.

- Probability of persistence consistent with historical condition refers to the concept that strata that historically were small or had complex population structures may not have met Criteria A through C, above, but could still be considered sufficiently viable if they provide a contribution to overall ESU viability similar to their historical contribution.

Threats Criteria

In addition, for a species to be delisted, the threats that brought it to its threatened or endangered condition must be ameliorated such that they do not keep the ESU from achieving the desired biological status. The ESA identifies five categories of threats (any one or a combination of which may be the basis for the initial listing):

A. Present or threatened destruction, modification, or curtailment of the species' habitat or range
B. Overutilization for commercial, recreational, scientific, or educational purposes
C. Disease or predation

ESA that the species be removed from the Federal List of Endangered and Threatened Wildlife and Plants (50 CFR 17.11 and 17.12).

D. Inadequacy of existing regulatory mechanisms
E. Other natural or human-made factors affecting the species' continued existence

The threats criteria in this recovery plan define the conditions under which the threats can be considered to be addressed or mitigated. Threats criteria for measuring recovery of Lower Columbia River salmon and steelhead ESUs are detailed in Section 3.2.2 of the recovery plan. In general, the threats criteria for the Lower Columbia River ESUs are considered met once the recovery plan actions have been substantially implemented, population-specific threat reduction targets have been met (or threat impacts are otherwise consistent with the desired status of the ESU and its constituent populations), threats have been ameliorated such that the desired status will be maintained, and regulatory mechanisms are being implemented in a way that supports attainment and maintenance of the desired status.

Site-specific Recovery Actions and Cost Estimates

Site-specific recovery actions are discussed in detail in the management unit plans. The FCRPS Biological Opinion and related recovery plan hydropower module describe proposed site-specific actions related to passage at Bonneville Dam, predation, and flow that affects conditions in the lower Columbia River, estuary, and, potentially, the plume. Proposed site-specific actions for the Columbia River estuary and plume are presented in the *Columbia River Estuary ESA Recovery Plan Module for Salmon and Steelhead*.

The total estimated cost of recovery actions for the four threatened species in the lower Columbia River over the next 25 years is approximately $2.1 billion, of which about $614 million is expected to be needed in the first 5 years. These estimates include expenditures by local, tribal, state, and Federal governments, private business, and individuals in implementing capital projects and non-capital work, as well as administrative costs for supervision and coordination. The total estimated cost includes $592 million ($164 in the first 5 years) for actions in the Columbia River estuary that are basinwide in scope and are expected to benefit all 13 listed ESUs and DPSs in the Columbia Basin.

The estimates are based on the best available information at the time the management unit plans were completed and are expected to change as implementation schedules are developed and actions are more clearly scoped and planned. Given that the costs for many actions could not be estimated at the time the management unit plans were completed, it is likely that actual costs will be substantially higher than the estimated costs in Table ES-2.

Table ES-2
Summary of Cost Estimates

Management Unit	5-Year Cost Estimate (millions)	25-Year Cost Estimate (millions)
Washington	$245	$738
Oregon	$189	$758
White Salmon	$16	$16
Columbia River Estuary	$164	$592
TOTAL	$614	$2,104

The remaining sections of this summary focus mostly on the results of the recovery analysis for each ESU. After briefly explaining the overall approach used to complete the ESU recovery analyses, the summary describes general categories of limiting factors that affect multiple ESUs throughout the Lower Columbia region and strategies for addressing those limiting factors at the regional or programmatic level. This is followed by an individual section for each ESU that highlights that ESU's baseline and target status, the factors that are limiting its viability, and the proposed strategy for reducing limiting factors and threats and achieving recovery. The summary concludes with thoughts on the role of research, monitoring, evaluation, and adaptive management and how recovery actions will be coordinated and implemented. Key documents referred to in this summary are listed at the end.

Overall Approach to ESU Recovery Analyses

This recovery plan addresses the needs of each ESU individually, based on analyses in the three management unit plans. Although each recovery planning team used a slightly different process in developing its management unit plan, all of the teams worked from the same TRT recommendations and a consistent set of assumptions about what elements should be included in their plans. Thus, the different recovery planning teams followed the same overall approach in their recovery analyses. In general, the management unit recovery planners did the following:

1. Evaluated the baseline status of their respective populations using techniques based on those recommended by the WLC TRT.[4]

2. Identified limiting factors for each Lower Columbia River salmon and steelhead population.

3. For each population, quantified the estimated baseline impacts of six categories of threats—tributary habitat loss and degradation, estuary habitat loss and degradation, hydropower, harvest, hatcheries, and ecological interactions.

[4] Both Oregon and Washington management unit planners established a baseline period from which to assess population status, limiting factors, and threat impacts. For more discussion, see Sections 5.1 and 5.5.

4. Established a target status for each population, taking into consideration (1) each population's potential for improvement, in view of available habitat and historical production, (2) the degree of improvement needed in each stratum to meet WLC TRT guidelines for a viable ESU, and (3) for some ESUs, the desire to accommodate objectives such as maintaining opportunities to harvest hatchery-origin fish.

5. Calculated the improvements in abundance and productivity and, in some cases, spatial structure and diversity, that each population would need to achieve its target status (i.e., to close the "conservation gap," which is the difference between the baseline and target status for each population).

6. Identified a "threat reduction scenario" for each population, meaning a specific combination of reductions in threats that would lead to the population achieving its target status.

7. Identified and scaled recovery strategies and actions to reduce threats by the targeted amount in each category. Management unit planners identified recovery strategies and actions through workshops and meetings with stakeholders, including representatives of implementing and affected entities.

8. Considered the probable effects of actions, established benchmarks for implementation, and identified critical uncertainties and research, monitoring, and evaluation needs for each species.

9. Developed implementation frameworks that address organizational structures for implementation of the actions, prioritization methods, tracking systems, coordination needs and approaches, and stakeholder involvement.

Given the complexity of the salmonid life cycle and the fact that complete data were not available for every population, some elements of the recovery analyses are subject to significant levels of uncertainty and should be considered working hypotheses that are testable as part of recovery plan implementation. Despite this uncertainty, it is the expert judgment of NMFS and the management unit scientists that, based on the best available information at this time, the results of the management unit plan analyses provide reasonable estimates of the relative magnitude of different threats to each population and the improvements that need to be addressed through recovery actions. Thus, NMFS considers the management plan analyses an adequate basis for designing initial recovery actions. As more and better information is collected, it will be applied to recovery efforts in an adaptive management framework that involves action implementation, monitoring of results, and adjustment of actions as needed.

The management unit plans' recovery analyses indicate that no single factor, threat, or threat category accounts for the declines in the species addressed in this recovery plan. Instead, the status of Lower Columbia River salmon and steelhead and Columbia River chum is the result of the cumulative impact of multiple limiting factors and threats. Thus, recovery will be accomplished through improvements in every general threat category. Even small increments of improvement will play an important role. When the need for improvement for most ESUs is so large, the contribution of no population or threat reduction can be discounted.

Regional Limiting Factors and Strategies

The reasons for a species' decline are generally described in terms of limiting factors and threats. Limiting factors are biological, physical, or chemical conditions and associated ecological processes and interactions that limit a species' viability. Threats are human activities or natural events, such as floodplain development or drought, that cause or contribute to limiting factors. Although the management unit plans analyze limiting factors and threats for each population, it also can be helpful to view limiting factors and threats from a regional, multi-species perspective—to discern large-scale patterns in ecological conditions that are affecting all or most of the listed ESUs. This aids in identifying regional approaches to recovery that can provide high biological benefit while making effective use of limited resources. The sections below describe such regional strategies, which are general approaches that either benefit multiple ESUs or can be tailored to meet the specific needs of each species. However, implementation of the regional strategies alone will not necessarily lead to recovery. The regional strategies are intended to supplement ESU-specific strategies that provide greater specificity and address specific needs at the species, stratum, and population levels.

Tributary Habitat

Tributary habitat degradation from past and/or current land and water use is a limiting factor for all Lower Columbia River salmon and steelhead populations. Widespread development and other land use activities have disrupted watershed processes, reduced water quality, and diminished habitat quantity, quality, and complexity in most lower Columbia River subbasins. Past and/or current land use or water management activities have adversely affected stream and side channel structure, riparian conditions, floodplain function, sediment conditions, and water quality and quantity, as well as the watershed processes that create and maintain properly functioning conditions for salmon and steelhead.

The regional tributary habitat strategy is directed toward habitat protection and restoration to achieve adequate quantities of high-quality, well-functioning salmon and steelhead habitat. This will be accomplished through a combination of (1) site-specific projects that will protect habitat or provide benefits relatively quickly, (2) watershed-based actions that will repair habitat-forming processes and provide benefits over the long term, and (3) landscape-scale programmatic actions that affect a class of activities (such as stormwater management or forest practices) over multiple watersheds. Although many habitat-related actions already have been undertaken, current activities do not reflect the scale of habitat improvements needed. Recovery of the listed species will require concerted efforts to protect remaining areas of favorable habitat and restore habitat quality in significant historical production areas. There is an immediate need to complete prioritization frameworks and get additional targeted, site-specific protection and restoration actions, as well as programmatic approaches, on the ground as soon as possible, especially because the benefits of some habitat actions will take years to accrue. Table ES-3 lists subbasins that will play a key role in recovery because they are targeted to support multiple primary populations, from different ESUs.

Table ES-3
Subbasins Targeted to Support Three or More Primary Populations

Ecozone	Subbasin	Primary Populations
Coast	Elochoman	Fall Chinook, chum, coho
	Clatskanie	Fall Chinook, chum, coho
	Scappoose	Fall Chinook, chum, coho
Cascade	Coweeman	Fall Chinook, winter steelhead, coho
	SF Toutle	Fall Chinook, winter steelhead, coho
	NF Toutle	Fall Chinook, winter steelhead, coho
	Cispus	Spring Chinook, winter steelhead, coho
	Upper Cowlitz	Spring Chinook, winter steelhead, coho
	NF Lewis	Fall Chinook, late-fall Chinook, spring Chinook, chum
	EF Lewis	Fall Chinook, chum, winter steelhead, summer steelhead, coho
	Washougal	Fall Chinook, chum, summer steelhead
	Sandy	Late-fall Chinook, spring Chinook, chum, winter steelhead, coho
Gorge	Lower Gorge tribs	Chum, winter steelhead, coho
	Hood	Fall Chinook, spring Chinook, winter steelhead, summer steelhead, coho

Estuary Habitat

Habitat conditions in the Columbia River estuary and plume are important to the survival of all Columbia River basin salmon and steelhead during critical rearing, migration, and saltwater acclimation periods in their life cycle. Yet the amount and accessibility of in-channel, off-channel, and plume habitat have been reduced as a result of habitat conversion for agricultural, urban, and industrial uses, hydroregulation and flood control, channelization, and higher bankfull elevations, which have been facilitated by diking, dredging, and filling. Sediment conditions and toxic contaminants also have been identified as limiting factors in the estuary, as have high water temperatures in late summer and fall, changes in the food web, and predation.

Estuary habitat strategies focus on providing adequate off-channel and intertidal habitats, such as tidal swamp and marsh; restoring habitat complexity in areas modified by agricultural or rural residential use; decreasing exposure to toxic contaminants; and lowering water temperatures. This will be accomplished over the long term by restoring hydrologic, sediment, and riparian processes that structure habitat in the estuary. An aggressive, strategic approach needs to be developed for implementation of estuary actions.

Hydropower

Bonneville Dam is the only mainstem hydropower facility within the geographic range of Lower Columbia River salmon and steelhead, but flow management at large storage reservoirs in the interior of the Columbia Basin affect habitat in the lower Columbia River mainstem and estuary, and potentially in the plume. In addition, significant tributary hydropower dams are located on the Cowlitz, Lewis, and White Salmon rivers in Washington and the Willamette, Clackamas, and Sandy rivers in Oregon.[5] The impacts of hydropower facility construction and operation on Lower Columbia salmon and steelhead occur both locally (at, above, and immediately below dams) and downstream, in the Columbia River estuary and, potentially, the plume. Impacts include habitat inundation, impaired fish passage, higher water temperatures during the late summer and fall, and alterations in the timing and magnitude of flow that affect downstream habitat conditions and habitat-forming processes.

The regional hydropower strategy focuses on (1) improving passage survival at Bonneville Dam for Lower Columbia River populations that spawn above the dam, (2) addressing impacts in tributaries by implementing actions prescribed in Federal Energy Regulatory Commission agreements regarding operation of individual tributary dams, and (3) implementing mainstem flow management operations designed to benefit spring migrants from the interior of the Columbia Basin; NMFS expects that these flow management operations will also improve survival in the estuary and, potentially, the plume for all Lower Columbia River salmon and steelhead populations. The regional hydropower strategy includes actions identified in the 2008 FCRPS Biological Opinion and its 2010 Supplement that will aid adults and juveniles from the Gorge populations in passing Bonneville Dam. For chum salmon, the strategy involves ensuring adequate flows in the Bonneville Dam tailrace and downstream habitats during chum salmon migration, spawning, incubation, and emergence.

Hatcheries

Hatchery practices such as broodstock collection and spawning protocols can cause genetic changes in hatchery fish. When hatchery-origin fish spawn with natural-origin fish, genetic changes can be transmitted to the naturally produced fish; the larger the proportion of hatchery-origin spawners, the larger the genetic effects to the natural population. These genetic effects can include domestication and loss of diversity within the population. For decades, high proportions of hatchery fish on the spawning grounds have been common among many Lower Columbia River salmon and steelhead populations, including the vast majority of Chinook and coho salmon populations. In addition, hatchery fish infected with pathogens or parasites have the potential to spread these organisms to natural-origin fish. Also, hatchery fish can sometimes prey directly on naturally produced juveniles, particularly chum salmon. Some scientists suspect that closely spaced releases of hatchery fish from Columbia Basin hatcheries may lead to increased competition with natural-origin fish for food and habitat space in the Columbia River estuary.

The overall goals of the hatchery recovery strategies for the Lower Columbia ESUs are to (1) reduce hatchery impacts on natural-origin populations as appropriate for each population, (2) ensure that some populations have no in-subbasin hatchery releases and are isolated from stray out-of-subbasin hatchery fish, (3) use hatchery stocks in the short term for reintroduction or supplementation programs to restore naturally spawning populations in some watersheds, and (4) ensure rigorous monitoring and evaluation to better understand existing population status and the effects of hatchery strategies on

[5] Powerdale Dam, on the Hood River, was removed in 2010, and Condit Dam, on the White Salmon River, was breached in October 2011, with complete removal expected by August 2012.

natural populations. Maintaining harvest opportunities created by hatchery fish is a societal goal that NOAA Fisheries has carried forward from the management unit plans to the ESU-level recovery plan.

Harvest

Lower Columbia River Chinook salmon, steelhead, and coho salmon are caught in commercial, recreational, and tribal fisheries along the West Coast of the United States and Canada as well as in the mainstem Columbia River and its tributaries. These various fisheries focus on different stocks and populations, taking fish to meet commercial, recreational, and tribal harvest allocations. Harvest affects the viability of Lower Columbia River salmon and steelhead populations by causing mortality to naturally produced adult fish, influencing population traits, and reducing nutrients in freshwater ecosystems. Harvest mortality can be either direct or indirect. Direct harvest mortality is associated with fisheries that target specific stocks. Indirect mortality includes mortality of fish harvested incidentally to the targeted species or stock, fish that die after being captured by fishing gear but not landed, and fish that die after being caught and released.

Harvest managers have implemented substantial reductions in harvest for Lower Columbia River species since they were listed under the ESA. Although each species' harvest management requirements are unique, in general the harvest strategy focuses on refining harvest management and reducing impacts to naturally produced fish where needed while maintaining harvest opportunities that target hatchery-produced fish. The recovery plan calls for the use of six general approaches as appropriate and feasible: abundance-based harvest management, weak-stock management, mark-selective harvest, filling information needs, ancillary and precautionary actions, and adaptive management.

Local recovery planners believe that for Lower Columbia River spring Chinook salmon, steelhead, and chum salmon, current harvest impacts are generally consistent with long-term recovery goals, at least in the near term. For these species the recovery plan recommends measures to ensure that harvest does not adversely affect future conservation and recovery. For Lower Columbia fall Chinook and coho salmon, efforts will focus on (1) refinements in harvest management (including abundance-based management) to reduce risk to naturally produced fish, and (2) continued review of overall harvest rates.

Ecological Interactions

Anthropogenic changes to habitat in the lower Columbia River region have altered the relationships between salmonids and other fish and wildlife species, leaving Lower Columbia River salmon and steelhead more vulnerable to predation by piscivorous fish, birds, and marine mammals (i.e., seals and sea lions) and subject to competition with introduced fish species and possibly hatchery-origin fish for limited food and habitat.

The regional ecological interactions strategy involves reducing predation on all Lower Columbia River salmon and steelhead populations by redistributing Caspian terns and cormorants, increasing the pikeminnow bounty program in the Columbia River mainstem, and reducing marine mammal predation at Bonneville Dam using non-lethal and possibly lethal measures. Managing predation by sea lions at Bonneville Dam is expected to benefit Gorge-stratum populations of Lower Columbia River salmon and steelhead ESUs. To reduce the risk of adverse ecological interactions between hatchery-origin and naturally produced salmon and steelhead, the recovery plan proposes a combination of critical uncertainties research and near-term precautionary measures, such as restoring estuary habitat and managing hatchery releases to prevent large numbers of hatchery-origin fish from accumulating in the estuary.

Climate Change

The warming rate for the Pacific Northwest over the next century is projected to be in the range of 0.1 to 0.6 °C per decade. Although total precipitation changes are predicted to be minor (+ 1 to 2 percent), increasing air temperature will alter snowpack, stream flow timing and volume, and water temperature in the Columbia Basin.

Changes in air temperatures, river temperatures, and river flows in the Pacific Northwest are expected to affect salmon and steelhead distribution, behavior, growth, and survival. The magnitude and timing of the changes are poorly understood, and specific effects are likely to vary among populations. However, likely effects on listed salmon and steelhead in fresh water include winter flooding of redds (i.e., salmon nests), earlier emergence of salmon fry, decreased parr to smolt survival, reductions in the quantity and quality of juvenile rearing habitat and possibly overwintering habitat, changes in the timing of smolt migration, and increased adult mortality or reduced spawning success as a result of higher water temperatures.

Possible effects on salmon and steelhead in estuaries include altered growth and disease susceptibility, reduced quality of rearing habitat, and changes in the distribution of salmonid prey and predators, including possible extension of the range of non-native species adapted to warm water.

Climate-related changes in the marine environment are expected to alter primary and secondary productivity, the structure of marine communities, and, in turn, the growth, productivity, survival, and migrations of salmonids, although the degree of impact on listed salmonids currently is poorly understood. A mismatch between earlier smolt migrations (because of earlier peak spring freshwater flows and shorter incubation periods) and altered coastal upwelling may reduce marine survival rates. Ocean warming also may change migration patterns, increasing distances to feeding areas.

In addition, rising atmospheric carbon dioxide concentrations drive changes in seawater chemistry, increasing the acidification of seawater and thus reducing the availability of carbonate for shell-forming invertebrates, including some that are prey items for juvenile salmonids. Ocean acidification has the potential to reduce survival of many marine organisms, including salmon and steelhead. However, because there is currently a paucity of research directly related to the effects of ocean acidification on salmon and steelhead and their prey, potential effects are uncertain.

The regional climate change strategy has two parts: (1) implementation of greenhouse gas reduction strategies, such as through the West Coast Governors' Global Warming

Initiative[6] and the Oregon Global Warming Commission's recommendations,[7] and (2) adaptation, to reduce the impacts of climate change on Pacific Northwest salmon and steelhead. Adaptation commonly involves the following:

- Conserving adequate habitat to support healthy fish populations and ecosystem functions in a changing climate
- Managing species and habitats to protect ecosystem functions in a changing climate
- Reducing stresses not caused by climate change
- Supporting adaptive management through integrated observation and monitoring and improved decision support tools

The management unit plans and estuary recovery plan module present specific actions that are responsive to these general strategies. The following documents also are relevant to adaptation:

- *Climate Change Impacts on Columbia River Basin Fish and Wildlife* (Independent Scientific Advisory Board 2007a)
- *Oregon Climate Change Adaptation Framework* (Oregon Department of Land Conservation and Development 2010)
- *Washington State Integrated Climate Change Response Strategy* (interim document) (Washington Department of Ecology 2011)
- *Draft National Fish, Wildlife, and Plants Climate Adaptation Strategy* (U.S. Fish and Wildlife Service et al. 2012)

Human Population Growth

The Oregon and White Salmon management unit plans identify human population growth as a future threat to Lower Columbia River salmon and steelhead, based in part on work done by the Independent Scientific Advisory Board (ISAB), which provides independent scientific advice and recommendations related to the fish and wildlife management responsibilities of the Northwest Power and Conservation Council, Columbia River Basin Indian tribes, and NMFS. The ISAB expects that human population growth in the Columbia Basin will increase the demand for water, land, and forests that are key to fish and wildlife populations. This demand for resources will increase threats to and extinction risks for fish and wildlife—including salmon and steelhead—through such mechanisms as loss, degradation, and fragmentation of habitat; increased stormwater runoff; and reduced groundwater recharge and thus base stream flows.

The recovery plan includes actions that will lessen the impacts of human population growth. The focus is on protecting existing high-quality habitat through acquisition and

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[6] For the West Coast Governors' Global Warming Initiative, go to http://www.ef.org/westcoastclimate/.
[7] For the Oregon Global Warming Commission's recommendations, see Oregon Department of Energy (2009) or go to http://www.oregon.gov/ENERGY/GBLWRM/GWC/docs/09CommissionReport.pdf.

conservation; using land use planning to guide future development away from ecologically sensitive areas, such as wetlands and floodplains; implementing best management practices; protecting and restoring instream flows, runoff processes, and water quality; and educating landowners and others.

Recovery Analysis: Lower Columbia River Coho Salmon

This recovery plan covers all naturally spawned coho salmon (*Oncorhynchus kisutch*) populations in the lower Columbia River and its tributaries, from the mouth of the Columbia upstream to the Hood River (in Oregon) and the White Salmon River (in Washington), including the Willamette River up to Willamette Falls. Twenty-five coho salmon hatchery programs also are part of the ESU.[8]

Historically, the Lower Columbia River coho salmon ESU consisted of a total of 24 independent populations that spawned in almost every accessible stream system in the lower Columbia River. Coho salmon typically spawn in small to medium, low- to-moderate elevation streams from valley bottoms to stream headwaters. Coho salmon particularly favor small, rain-driven, lower elevation streams characterized by (1) relatively low flows during late summer and early fall, and (2) increased river flows and decreased water temperatures in winter.

Baseline and Target Status: Coho Salmon

Today, 21 of the 24 Lower Columbia River coho salmon populations are considered to have a very low probability of persisting over the next 100 years, and none is considered viable. All three strata in the ESU fall significantly short of the WLC TRT criteria for viability.

Table ES-4
Baseline and Target Status of LCR Coho Salmon Populations*

Stratum	Population	Contribution to Recovery	Baseline Status	Target Status
Coast	Youngs Bay (OR)	Stabilizing	VL	VL
	Grays/Chinook (WA)	Primary	VL	H
	Big Creek (OR)	Stabilizing	VL	VL
	Elochoman/Skamokawa (WA)	Primary	VL	H
	Clatskanie (OR)	Primary	L	VH
	Mill/Abernathy/Germany (WA)	Contributing	VL	M
	Scappoose (OR)	Primary	M	VH
Cascade	Lower Cowlitz (WA)	Primary	VL	H
	Upper Cowlitz (WA)	Primary	VL	H
	Cispus (WA)	Primary	VL	H
	Tilton (WA)	Stabilizing	VL	VL
	Toutle SF (WA)	Primary	VL	H
	Toutle NF (WA)	Primary	VL	H

[8] Two of these programs were discontinued in 2009. In its 2011 5-year review, NMFS recommended that these two programs be removed from the ESU.

Stratum	Population	Contribution to Recovery	Baseline Status	Target Status
	Coweeman (WA)	Primary	VL	H
	Kalama (WA)	Contributing	VL	L
	NF Lewis (WA)	Contributing	VL	L
	EF Lewis (WA)	Primary	VL	H
	Salmon Creek (WA)	Stabilizing	VL	VL
	Clackamas (OR)	Primary	M	VH
	Sandy (OR)	Primary	VL	H
	Washougal (WA)	Contributing	VL	M+
Gorge	Lower Gorge (WA & OR)	Primary	VL	H
	Upper Gorge/White Salmon (WA)	Primary	VL	H
	Upper Gorge/Hood (OR)	Primary	VL	H*

*Status is equivalent to persistence probability. VL = very low, L = low, M = moderate, H = high, VH = very high.

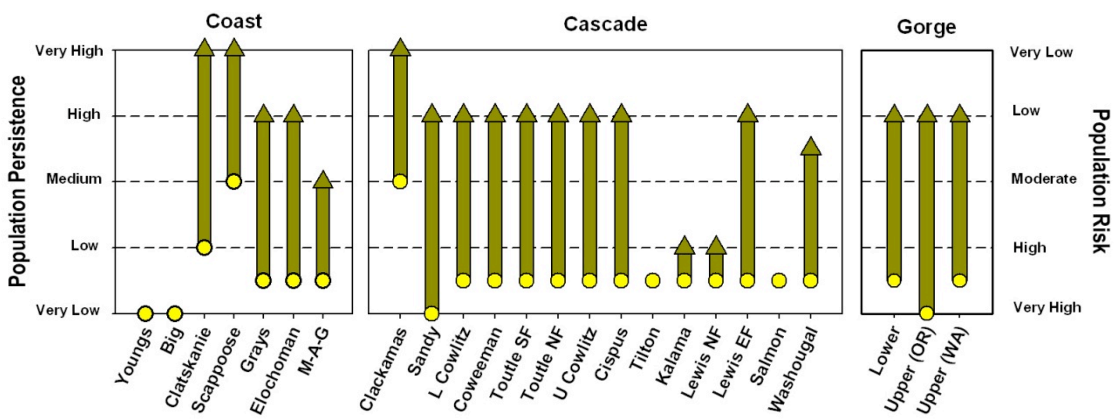

Figure ES-1. *Conservation Gaps for LCR Coho Salmon Populations (i.e., Difference between Baseline and Target Status)*

Prevalent Limiting Factors: Coho Salmon

Lower Columbia River coho salmon's poor status is due to a host of limiting factors that have affected the ESU for decades, or longer. Table ES-6 lists prevalent limiting factors that the management unit plans identified as having the greatest impact during the baseline period.

In addition, tributary hydropower dams are a primary limiting factor for the Upper Cowlitz, North Fork Lewis, Cispus, Tilton, and Upper Gorge/White Salmon populations.

Table ES-5
Prevalent Primary Limiting Factors for Coho Salmon during Baseline Period

Limiting Factor	Populations for Which This Is a Primary Limiting Factor
Degraded riparian conditions along tributaries	Almost all*
Impaired side channel and wetland conditions in tributaries	Almost all
Loss/degradation of floodplain habitat in tributaries	Almost all
Channel structure and form issues[9] in tributaries and the Columbia River estuary	Almost all
Sediment conditions in the estuary	Almost all
Water quantity issues (i.e., altered hydrology) in the estuary	Almost all
Direct mortality from fisheries	Almost all
Reduction in population diversity as a result of stray hatchery fish interbreeding with natural-origin fish	All except Clatskanie, Scappoose, Coweeman, NF Lewis, and Sandy

* "Almost all" means every population except one in each stratum.

Recovery Strategy: Coho Salmon

The ESU recovery strategy for coho salmon involves improvements in all threat categories to increase abundance, productivity, diversity, and spatial structure to the point that the Coast, Cascade, and Gorge strata are restored to a high probability of persistence. The ESU recovery strategy has seven main elements:

1. Protect and improve populations that have a clear record of continuous natural spawning and are likely to retain local adaptation (the Clackamas and Sandy), along with populations where there is documented natural production (the Clatskanie, Scappoose, and Mill/Abernathy/Germany).

2. Fill information gaps regarding the extent of natural production in other populations, and focus additional recovery efforts on populations that have the greatest prospects for improvement.

3. Protect existing high-functioning habitat for all populations.

4. Restore tributary habitat (particularly overwintering habitat) to the point that each subbasin can support coho salmon at the target status for that population. In most subbasins, this will mean having adequate habitat to support a viable population.

5. Reduce hatchery impacts on natural-origin fish so that impacts are consistent with the target status of each population. (The Grays/Chinook, Elochoman/Skamokawa, Mill/Abernathy/Germany, Clatskanie, Clackamas, Washougal, and Gorge-stratum populations are targeted for large reductions in hatchery impacts.)

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[9] Includes conditions such as channelization, reduced instream habitat complexity, fill and scour, and associated loss of spawning habitat.

6. Refine harvest management so that impacts are consistent with population and overall ESU recovery goals.

7. Reestablish naturally spawning populations above tributary dams on the Cowlitz and North Fork Lewis rivers by improving passage at dams and continuing to reintroduce coho salmon in these mid- to high-elevation habitats.

For most coho salmon populations, loss and degradation of tributary habitat are the single largest threat—and where the greatest gains in viability are expected to be achieved. Notable exceptions are the Clackamas, Upper Cowlitz, and Cispus populations. For the Clackamas population, protection of existing well-functioning habitat and reductions in hatchery impacts will play a key role in achieving the target status. The Upper Cowlitz and Cispus populations are projected to benefit greatly from hatchery reintroduction programs and dam passage improvements designed to restore their access to key historical spawning and rearing habitats. However, significant tributary habitat protection and restoration efforts also will be necessary for these populations. In most cases, population recovery objectives cannot be achieved without substantial improvements in habitat, even when the impacts of other, non-habitat threats are practically eliminated.

Although recent actions have substantially reduced coho salmon harvest levels from baseline conditions, further refinements in harvest management are still needed. Reductions in hatchery impacts are called for in all strata because hatchery impacts remain significant for many populations.

Recovery Analysis: Lower Columbia River Chinook Salmon

This recovery plan covers all naturally spawned Chinook salmon (*Oncorhynchus tshawytscha*) populations in the lower Columbia River and its tributaries, from the mouth of the Columbia upstream to the Hood River (in Oregon) and the White Salmon River (in Washington), including the Willamette River up to Willamette Falls but excluding Clackamas River spring-run Chinook salmon.[10] Chinook salmon from 17 hatchery programs also are part of the ESU.[11]

Historically, the Lower Columbia River Chinook salmon ESU consisted of a total of 32 independent populations: 21 fall populations, two late-fall populations, and nine spring populations. These classifications are based on when adults return to fresh water. Spring and late-fall Chinook salmon are "stream-type" salmon, meaning that they generally rear in the river for a full year before emigrating to the ocean. Returning spring Chinook salmon adults spawn primarily in upstream, higher elevation portions of large subbasins. Fall Chinook display an "ocean-type" life history, meaning that juveniles begin emigrating downstream at 1 to 4 months old and make extensive use of

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[10] Clackamas River spring Chinook salmon are part of the Upper Willamette River Chinook ESU.

[11] One of these programs--the Elochoman tule fall Chinook salmon program--was discontinued in 2009. In its 2011 5-year review, NMFS recommended that this program be removed from the ESU and that four new fall Chinook salmon programs be added. The new programs are changes in release locations for fish produced at—and previously released from—hatchery programs that are currently part of the ESU.

the Columbia River estuary before entering the ocean. Returning fall Chinook spawn in moderate-sized streams and large river mainstems.

Fall Chinook are commonly referred to as "tule" stock, while late-fall Chinook are referred to as "brights."

Baseline and Target Status: Chinook Salmon

Today, only two of 32 historical populations—the North Fork Lewis and Sandy late-fall populations—are considered viable. Most populations (26 out of 32) have a very low probability of persistence over the next 100 years, and some populations are extirpated or nearly so. Five of the six strata fall significantly short of the WLC TRT criteria for viability. One stratum—Cascade late fall—meets the WLC TRT criteria.

Table ES-6
Baseline and Target Status of LCR Chinook Salmon Populations*

Stratum	Population	Core or Genetic Legacy?**	Contribution to Recovery	Baseline Status	Target Status
Cascade spring	Upper Cowlitz (WA)	C, GL	Primary	VL	H+
	Cispus (WA)	C	Primary	VL	H+
	Tilton (WA)		Stabilizing	VL	VL
	Toutle (WA)		Contributing	VL	M
	Kalama (WA)		Contributing	VL	L
	Lewis NF (WA)	C	Primary	VL	H
	Sandy (OR)	C, GL	Primary	M	H
Gorge spring	White Salmon (WA)	C	Contributing	VL	L+
	Hood (OR)		Primary	VL	VH
Coast fall	Youngs Bay (OR)		Stabilizing	L	L
	Grays/Chinook (WA)		Contributing	VL	M+
	Big Creek (OR)	C	Contributing	VL	L
	Elochoman/Skamokawa (WA)	C	Primary	VL	H
	Clatskanie (OR)		Primary	VL	H
	Mill/Abernathy/Germany (WA)		Primary	VL	H
	Scappoose (OR)		Primary	L	H
Cascade fall	Lower Cowlitz (WA)	C	Contributing	VL	M+
	Upper Cowlitz (WA)		Stabilizing	VL	VL
	Toutle (WA)	C	Primary	VL	H+
	Coweeman (WA)	GL	Primary	L	H+
	Kalama (WA)		Contributing	VL	M
	Lewis (WA)	GL	Primary	VL	H+
	Salmon Creek (WA)		Stabilizing	VL	VL
	Clackamas (OR)	C	Contributing	VL	M
	Sandy (OR)		Contributing	VL	M
	Washougal (WA)		Primary	VL	H+
Gorge fall	Lower Gorge (WA & OR)		Contributing	VL	M
	Upper Gorge (WA & OR)	C	Contributing	VL	M
	White Salmon (WA)	C	Contributing	VL	M
	Hood (OR)		Primary	VL	H

Stratum	Population	Core or Genetic Legacy?**	Contribution to Recovery	Baseline Status	Target Status
Cascade late fall	Lewis NF (WA)	C, GL	Primary	VH	VH
	Sandy (OR)	C, GL	Primary	H	VH

* Status is equivalent to persistence probability. VL = very low, L = low, M = moderate, H = high, VH = very high.

** C = Core populations, meaning those that historically were the most productive. G = Genetic legacy populations, which best represent historical genetic diversity.

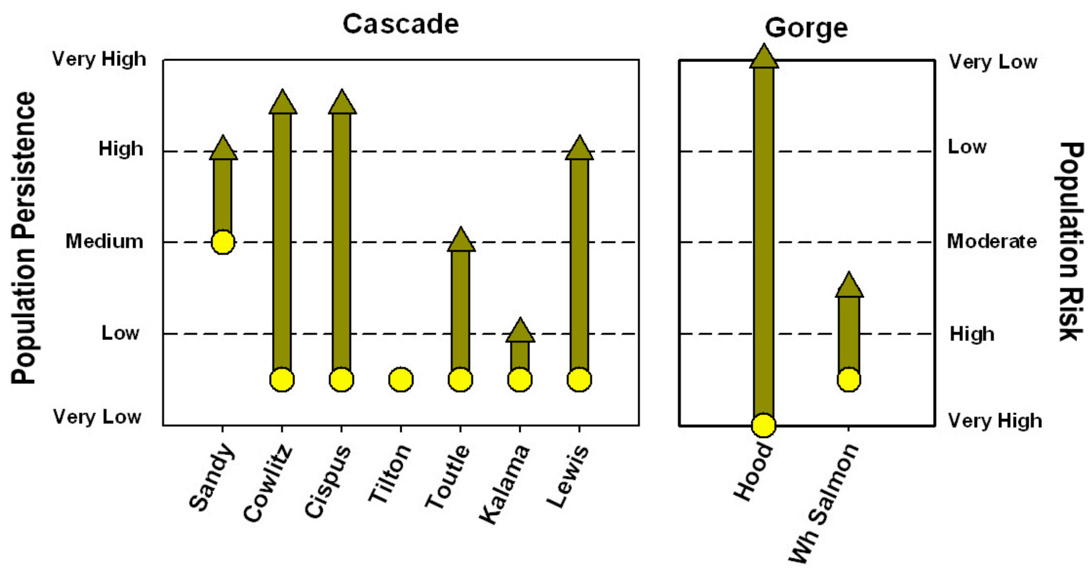

Figure ES-2. *Conservation Gaps for LCR Spring Chinook Salmon Populations (i.e., Difference between Baseline and Target Status)*

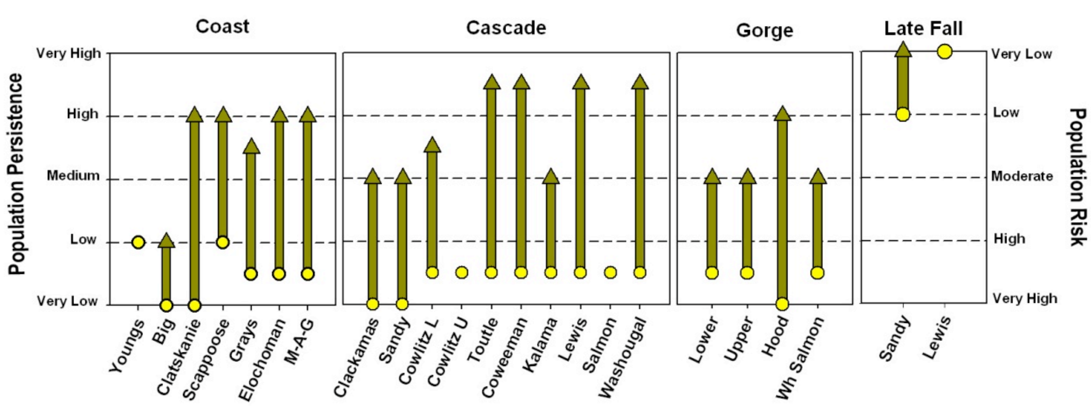

Figure ES-3. *Conservation Gaps for LCR Fall and Late-Fall Chinook Salmon Populations (i.e., Difference between Baseline and Target Status)*

Spring Chinook Recovery Analysis

Prevalent Limiting Factors: Spring Chinook Salmon

Lower Columbia River spring Chinook salmon's poor status is due to a host of limiting factors that have affected the ESU for decades, or longer. Table ES-8 lists prevalent limiting factors that the management unit plans identified as having the greatest impact during the baseline period.

Table ES-7
Prevalent Primary Limiting Factors for Spring Chinook Salmon during Baseline Period

Limiting Factor	Populations for Which This Is a Primary Limiting Factor
Channel structure and form issues[12] in the Columbia River estuary	Almost all*
Sediment conditions in the estuary	Almost all
Water quantity issues (i.e., altered hydrology) in the estuary	Almost all
Reduction in population diversity as a result of stray hatchery fish interbreeding with natural-origin fish	Almost all
Tributary hydropower dams	Upper Cowlitz, Cispus, Tilton, Lewis, and White Salmon
Direct mortality from fisheries	Upper Cowlitz, Cispus Tilton, Toutle, Kalama, Lewis, and Hood
Degraded riparian conditions in tributaries	All Cascade-stratum populations
Channel structure and form issues in tributaries	All Cascade-stratum populations
Impaired side channel and wetland conditions in tributaries	All Cascade-stratum populations
Loss/degradation of floodplain habitat in tributaries	All Cascade-stratum populations

* "Almost all" means every population except one in each stratum.

Recovery Strategy: Spring Chinook Salmon

The recovery strategy for spring Chinook salmon is aimed at restoring the Cascade spring stratum to a high probability of persistence and improving the persistence probability of the two Gorge spring populations. Although the strategy involves threat reductions in all categories, the most crucial elements are as follows:

1. Protect and improve the Sandy spring Chinook salmon population, which is the best-performing population and the only Lower Columbia River spring Chinook salmon population with appreciable natural production. This will be accomplished by protecting high-quality, well-functioning spawning and rearing

[12] Includes channelization, reduced instream habitat complexity, fill and scour, and associated loss of spawning habitat.

habitat, reducing the proportion of hatchery-origin spawners (pHOS), managing predation, and restoring tributary and estuarine habitat.[13]

2. Reestablish naturally spawning populations above dams on the Cowlitz and North Fork Lewis rivers, in areas that historically were highly productive, by improving adult and juvenile dam passage and developing hatchery reintroduction programs using broodstock from within-subbasin hatchery programs. Reestablishing populations in mid- to upper-elevation habitats is key to recovering the spring component of the Lower Columbia River Chinook salmon ESU.

3. Protect favorable tributary habitat and restore degraded but potentially productive habitat, particularly in the upper subbasins where spring Chinook salmon hold, spawn, and rear. Tributary habitat improvements are crucial for all populations.

4. Reestablish spring Chinook salmon in the White Salmon subbasin (after removal of Condit Dam) and in the Hood River subbasin.

Almost every spring Chinook salmon population is greatly affected by the loss and degradation of tributary habitat, and five populations—the Upper Cowlitz, Cispus, Tilton, Lewis, and White Salmon—have experienced impacts from tributary dams that are comparable to or even greater than those associated with degraded tributary habitat. Accordingly, for most populations, the greatest gains in viability are expected from tributary habitat and dam passage improvements (combined with hatchery reintroduction programs). Exceptions are the Tilton—a stabilizing population that is expected to remain at its baseline status—and the Sandy and Hood populations, for which reductions in hatchery impacts are targeted to provide the greatest benefit.

Although recent actions have substantially reduced harvest of spring Chinook salmon from baseline conditions, ancillary and precautionary actions are needed to ensure that harvest does not adversely affect conservation and recovery in the future. For all but the Tilton population, hatchery-related impacts are targeted to be reduced by half or more, with the largest reductions in the Sandy and Hood populations.

Fall Chinook Recovery Analysis

Prevalent Limiting Factors: Fall Chinook Salmon

Lower Columbia River fall Chinook salmon's poor status is due to a host of limiting factors that have affected the ESU for decades, or longer. Table ES-9 lists prevalent limiting factors that the management unit plans identified as having the greatest impact during the baseline period.

In addition, tributary hydropower dams are a primary limiting factor for the Upper Cowlitz and White Salmon populations, and inundation of historical spawning habitat by Bonneville Reservoir is a primary limiting factor for the Upper Gorge population.

[13] Some reduction in impacts on the Sandy population already have been achieved through removal of Marmot Dam and the Little Sandy River diversion in 2008 and protection of associated instream water rights for fish.

Table ES-8
Prevalent Primary Limiting Factors for Fall Chinook Salmon during Baseline Period

Limiting Factor	Populations for Which This Is a Primary Limiting Factor
Degraded riparian conditions along tributaries	Almost all*
Channel structure and form issues[14] in tributaries and the estuary	Almost all
Impaired side channel and wetland conditions in tributaries	Almost all
Loss/degradation of floodplain habitat in tributaries	Almost all
Loss/degradation of peripheral and transitional habitats[15] in the estuary	Almost all
Sediment conditions in the estuary	Almost all
Water quantity issues (i.e., altered hydrology) in the estuary	Almost all
Direct mortality from fisheries	Almost all
Reduction in population diversity as a result of stray hatchery fish interbreeding with natural-origin fish	Almost all

* "Almost all" means every population except one in each stratum.

Recovery Strategy: Fall Chinook Salmon

The recovery strategy for the tule fall component of the Lower Columbia River Chinook salmon ESU is designed to restore the Coast and Cascade tule strata to a high probability of persistence and to improve the persistence probability of all four Gorge stratum populations. The strategy involves transitioning from decades of management that allowed habitat degradation and emphasized hatchery production of fish for harvest (without adequate regard to effects on natural production) to management that supports a naturally self-sustaining ESU. This transition will be accomplished by addressing all threat categories and sharing the burden of recovery across categories. The most crucial elements are as follows:

1. Protect and improve the Coweeman and Lewis populations, which are currently performing the best, by ensuring that habitat is protected and restored, that the proportion of hatchery-origin spawners (pHOS) is reduced, and that harvest rates allow for gains in productivity to translate into continued progress toward recovery.

2. Fill information gaps regarding the extent of natural production and the extent of hatchery-origin spawners.

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[14] Includes conditions such as channelization, reduced instream habitat complexity, fill and scour, and associated loss of spawning habitat.
[15] Peripheral and transitional habitats are sloughs, side channels, wetlands, and similar features that are periodically inundated during high flows.

3. Focus recovery efforts on populations that have the greatest prospects for improvement; determine whether efforts to reestablish populations are needed.

4. Protect existing high-functioning habitat for all populations.

5. Implement aggressive efforts to improve the quality and quantity of both tributary and estuarine habitat.

6. Implement aggressive efforts to reduce the influence of hatchery fish on natural-origin fish.

7. Adjust harvest as needed to ensure appropriate increases in natural-origin abundance.

8. Assess habitat quantity, quality, and distribution.

In the Coast and Cascade strata, much of the gains in fall Chinook salmon viability are targeted to be achieved through reductions in harvest, hatchery, and habitat impacts. This is the case for the Grays/Chinook, Elochoman/Skamokawa, Toutle, East Fork Lewis, Sandy, and Washougal populations. For the Scappoose population, target status is expected to be achieved primarily through reductions in hatchery and harvest impacts. In the Gorge stratum, some threat reductions are also targeted from hydropower actions, as the Upper Gorge, White Salmon, and Hood populations are affected by dam passage issues at Bonneville, Powerdale, and Condit dams. (Powerdale Dam, on the Hood River, was removed in 2010; Condit Dam was breached in October 2011 and is scheduled to be completely removed by August 2012).

Impacts from multiple threat categories will need to be reduced for most populations if they are to achieve their target status. Exceptions are the Youngs Bay, Big Creek, Upper Cowlitz, and Salmon Creek populations. As stabilizing populations, the Youngs Bay, Upper Cowlitz, and Salmon Creek populations are not targeted for reductions in any threat impacts. (However, recovery actions will still be needed for these populations to remain at their baseline status of low [for Youngs Bay] or very low persistence probability.) The Salmon Creek population is not targeted for threat reductions because of the highly urbanized nature of the subbasin and the extent of habitat degradation there. Both the Youngs Bay and Big Creek populations will be used to provide harvest opportunity through terminal fisheries targeting hatchery fish; consequently, the proportion of hatchery-origin spawners (pHOS) and harvest impacts in these populations are expected to remain high.

Late-Fall Chinook Recovery Strategy

Prevalent Limiting Factors: Late-Fall Chinook Salmon

Table ES-10 lists prevalent limiting factors that the management unit plans identified as having the greatest impact on both late-fall Chinook populations during the baseline period.

Table ES-9
Prevalent Primary Limiting Factors for Late-fall Chinook Salmon during Baseline Period

Limiting Factor	Populations for Which This Is a Primary Limiting Factor
Sediment conditions in tributaries and the Columbia River estuary	Both populations
Water quantity issues (i.e., altered hydrology) in the estuary	Both populations
Direct mortality from fisheries	Both populations

In addition, primary limiting factors that affect the Sandy population only are degraded riparian conditions, channel structure and form issues, impaired side channel and wetland conditions, and loss/degradation of floodplain habitat in tributaries, along with reduction in population diversity as a result of stray hatchery fish interbreeding with natural-origin fish.

Recovery Strategy: Late-Fall Chinook Salmon

The recovery strategy for the late-fall component of the Lower Columbia River Chinook salmon ESU is designed to maintain the two healthy populations (North Fork Lewis and Sandy) and raise the persistence probability of the Sandy population from high to very high. Key elements of the strategy are as follows:

1. Implement the regional hatchery strategy. Minimize the impacts of hatchery releases of steelhead, coho, and spring Chinook salmon on late-fall Chinook salmon. Continue the current practice of not releasing hatchery fall Chinook salmon into the North Fork Lewis River.

2. Reduce harvest impacts on the Sandy late-fall population by using the same harvest strategies identified for tule fall Chinook salmon. Continue to manage fisheries to meet the spawning escapement goal for the Lewis River late-fall population and consider reassessing the goal as new data are acquired.

3. Implement actions in the regional tributary and estuary habitat strategy designed to benefit tule fall Chinook salmon. Implement the stratum-level tributary habitat strategies designated for tule fall Chinook.

Improving the persistence of the Sandy population will be accomplished primarily through reductions in harvest and hatchery impacts. As with spring and tule fall Chinook salmon, recent actions have substantially reduced harvest impacts on late-fall Chinook salmon over baseline conditions, but additional reductions in harvest impacts are identified to achieve the target status for the Sandy population. More modest reductions in the tributary and estuarine habitat, hydropower, and predation threat categories are expected to support the gains achieved through reductions in harvest and hatchery impacts.

Recovery Analysis: Columbia River Chum

This recovery plan covers all naturally spawned Columbia River chum salmon (*Oncorhynchus keta*) populations in the lower Columbia River and its tributaries. Chum salmon from three hatchery programs also are part of the ESU.[16]

Historically, the Columbia River chum salmon ESU consisted of 17 independent populations. Of these, 16 were fall-run populations and one was a summer-run population that returned to the Cowlitz River. Columbia River chum display an "ocean-type" life history, meaning that fry emigrate downstream shortly after emerging and rear in the Columbia River estuary before entering the ocean. Although chum salmon are strong swimmers, they rarely pass river blockages and waterfalls that pose no hindrance to other salmon or steelhead; thus, they spawn in low-gradient, low-elevation reaches and side channels. Spawning today is restricted largely to tributary and mainstem areas downstream of Bonneville Dam. Chum salmon need clean gravel for spawning, and spawning sites typically are associated with areas of upwelling water.

Baseline and Target Status: Chum Salmon

Today, 15 of the 17 populations that historically made up this ESU are so depleted that either their baseline probability of persistence is very low or they are extirpated or nearly so; this is the case for all six of the Oregon populations. Currently almost all natural production occurs in just two populations: the Grays/Chinook and the Lower Gorge. All three strata in the ESU fall significantly short of the WLC TRT criteria for viability.

Table ES-10
Baseline and Target Status of Columbia River Chum Salmon Populations*

Stratum	Population	Core or Genetic Legacy?**	Contribution to Recovery	Baseline Status	Target Status
Coast	Youngs Bay (OR)	C	Stabilizing	VL	VL
	Grays/Chinook (WA)	C, GL	Primary	M	VH
	Big Creek (OR)	C	Stabilizing	VL	VL
	Elochoman/Skamakowa (WA)	C	Primary	VL	H
	Clatskanie (OR)		Primary	VL	H
	Mill/Abernathy/Germany (WA)		Primary	VL	H
	Scappoose (OR)		Primary	VL	H
Cascade	Cowlitz - fall (WA)	C	Contributing	VL	M
	Cowlitz - Summer (WA)	C	Contributing	VL	M
	Kalama (WA)		Contributing	VL	M
	Lewis (WA)	C	Primary	VL	H
	Salmon Creek (WA)		Stabilizing	VL	VL
	Clackamas (OR)	C	Contributing	VL	M
	Sandy (OR)		Primary	VL	H
	Washougal (WA)		Primary	VL	H+

[16] In 2010, the Oregon Department of Fish and Wildlife initiated a new chum salmon hatchery program at Big Creek Hatchery to develop chum salmon for reintroduction into Lower Columbia River tributaries in Oregon. NMFS has not yet evaluated this hatchery program for inclusion in the ESU.

Stratum	Population	Core or Genetic Legacy?**	Contribution to Recovery	Baseline Status	Target Status
Gorge	Lower Gorge (WA & OR)	C, GL	Primary	H	VH
	Upper Gorge (WA & OR)		Contributing	VL	M

* Status is equivalent to persistence probability. VL = very low, L = low, M = moderate, H = high, VH = very high.

** C = Core populations, meaning those that historically were the most productive. G = Genetic legacy populations, which best represent historical genetic diversity.

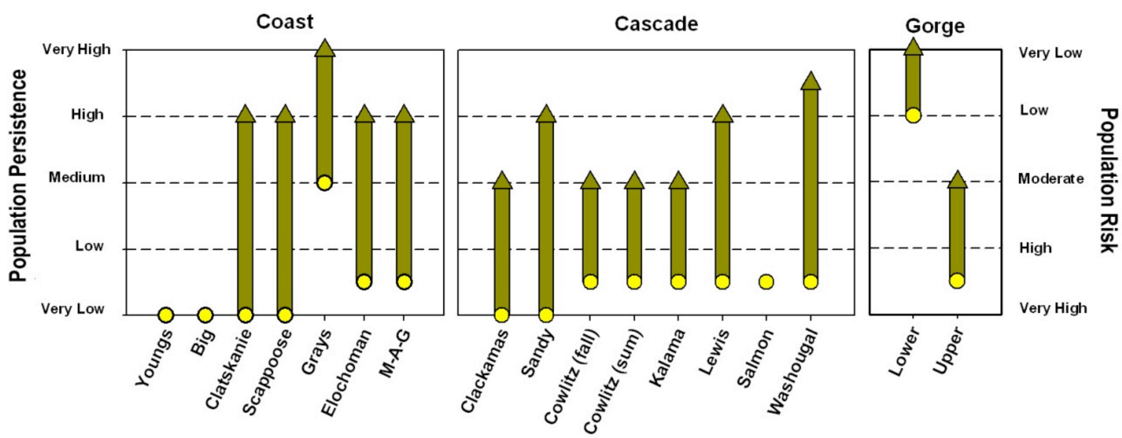

Figure ES-4. *Conservation Gaps for Columbia River Chum Salmon Populations (i.e., Difference between Baseline and Target Status)*

Prevalent Limiting Factors: Chum Salmon

Columbia River chum salmon's poor status is due to a host of limiting factors that have affected the ESU for decades, or longer. Table ES-12 lists prevalent limiting factors that the management unit plans identified as having the greatest impact during the baseline period.

Table ES-11
Prevalent Primary Limiting Factors for Chum Salmon during Baseline Period

Limiting Factor	Populations for Which This Is a Primary Limiting Factor
Channel structure and form issues[17] in the Columbia River estuary	Almost all*
Loss/degradation of peripheral and transitional habitats[18] in the estuary	Almost all
Sediment conditions in the estuary	Almost all
Water quantity issues (i.e., altered hydrology) in the estuary	Almost all

17 Includes conditions such as channelization, reduced instream habitat complexity, fill and scour, and associated loss of spawning habitat.

18 Peripheral and transitional habitats are sloughs, side channels, wetlands, and similar features that are periodically inundated during high flows.

Limiting Factor	Populations for Which This Is a Primary Limiting Factor
Degraded riparian conditions in tributaries	Almost all Washington** populations
Channel structure and form issues in tributaries	Almost all Washington populations
Impaired side channel and wetland conditions in tributaries	Almost all Washington populations
Loss/degradation of floodplain habitat in tributaries	Almost all Washington populations

* "Almost all" means every population except one in each stratum.
** Tributary habitat factors in this table are for Washington populations only because of differences in how Oregon and Washington recovery planners categorized limiting factors occurring in areas of tidal influence in the lower reaches of tributaries; see Table 8-3 of the recovery plan.

In addition, passage issues at Bonneville Dam and inundation of historical spawning habitat by Bonneville Reservoir are identified as primary limiting factors for the Upper Gorge population.

Recovery Strategy: Chum Salmon

The ESU recovery strategy for Columbia River chum salmon focuses on improving tributary and estuarine habitat conditions, reducing or mitigating hydropower impacts, and reestablishing chum salmon populations where they may have been extirpated. The goal of the strategy is to increase the abundance, productivity, diversity, and spatial structure of chum salmon populations such that the Coast and Cascade chum salmon strata are restored to a high probability of persistence and the persistence probability of the two Gorge populations improves. The ESU recovery strategy has the following main elements:

1. Protect and improve the Grays/Chinook and Lower Gorge populations, which together produce the majority of Columbia River chum salmon and are the only populations in the ESU not currently at very high risk of extinction.

2. Identify, protect, and restore chum salmon spawning habitat in lower mainstem and off-channel areas of large rivers and streams that are fed by upwelling from intergravel flows or springs. Restore hydrologic, riparian, and sediment processes (e.g., large woody debris recruitment) that support the accumulation of spawning gravel and reduce inputs of fine sediment.

3. Restore off-channel and side-channel habitats (alcoves, wetlands, floodplains, etc.) in the Columbia River estuary, where chum salmon fry rely on peripheral and transitional habitats for extended estuarine rearing.

4. Use hatchery reintroduction as appropriate in reestablishing chum salmon populations and continue using supplementation to enhance the abundance of the Grays and Lower Gorge populations.

Restoring tributary spawning and estuary rearing habitat is essential in the recovery of Columbia River chum salmon. Although the recovery strategy includes other components, no other factor can effectively bring about recovery.

Most of the gains in the viability of Washington chum salmon populations are targeted to be achieved by improving tributary and estuarine habitat. Because potentially manageable harvest, hatchery, and predation impacts on chum salmon already are relatively low, there is little opportunity to further reduce threats in these sectors. Hydropower actions are projected to benefit the Upper Gorge population, which is affected by Bonneville Dam and its reservoir.

Oregon recovery planners developed a chum salmon recovery strategy that involves identifying specific habitat needs and proceeding with reintroduction, initially in the Coast stratum.

Recovery Analysis: Lower Columbia River Steelhead

This recovery plan addresses steelhead in the Cascade and Gorge ecozones only, excluding the White Salmon population and populations in the Coast ecozone. This is because the White Salmon population is part of the Middle Columbia steelhead DPS (and thus is addressed in a separate recovery plan), and the Coast populations are part of the Southwest Washington DPS, which is not listed under the ESA. Also excluded is the resident, freshwater form of *Oncorhynchus mykiss*, which usually is called "rainbow" or "redband" trout. In contrast, steelhead are the anadromous form of *O. mykiss*, meaning that they spend a portion of their life cycle in the ocean but return to fresh water to breed. Thus, this recovery plan covers all naturally spawned anadromous *O. mykiss* populations in streams and tributaries to the Columbia River between and including the Cowlitz and Wind rivers in Washington and, in Oregon, between and including (1) the Willamette River up to Willamette Falls, and (2) the Hood River in Oregon. Steelhead from ten hatchery programs also are part of the DPS.[19]

Historically, the Lower Columbia River steelhead DPS consisted of 23 independent populations: 17 winter-run populations and six summer-run populations. Winter and summer steelhead differ in spawning timing, degree of sexual maturity when returning to fresh water, and other characteristics. Both winter steelhead and summer steelhead spawn in a wide range of conditions, from large streams and rivers to small streams and side channels. Within the same watershed, winter and summer steelhead generally spawn in geographically distinct areas. Summer steelhead can often reach headwater areas above waterfalls that are impassable to winter steelhead during the high-velocity flows common during the winter-run migration. Steelhead are iteroparous, meaning they can spawn more than once.

Baseline and Target Status: Steelhead

Today, 16 of the 23 Lower Columbia River steelhead populations have a low or very low probability of persisting over the next 100 years, and six populations have a moderate

[19] The release of Cowlitz Hatchery winter steelhead into the Tilton River was discontinued in 2007, the Hood River winter steelhead program was discontinued in 2009, and the release of hatchery winter steelhead into the Upper Cowlitz and Cispus rivers was discontinued in 2010. In its 2011 5-year review, NMFS recommended removing these programs from the DPS and adding a Lewis River winter steelhead program that was initiated in 2009.

probability of persistence. Only the summer-run Wind population is considered viable. All four strata in the DPS fall short of the WLC TRT criteria for viability.

Table ES-12
Baseline and Target Status of LCR Steelhead Populations*

Stratum	Population	Core or Genetic Legacy?**	Contribution to Recovery	Baseline Status	Target Status
Cascade summer	Kalama (WA)	C	Primary	M	H
	NF Lewis (WA)		Stabilizing	VL	VL
	EF Lewis (WA)		Primary	VL	H
	Washougal (WA)	C	Primary	M	H
Gorge summer	Wind (WA)	C	Primary	H	VH
	Hood (OR)		Primary	VL	H
Cascade winter	Lower Cowlitz (WA)		Contributing	L	M
	Upper Cowlitz (WA)	C, GL	Primary	VL	H
	Cispus (WA	C, GL	Primary	VL	H
	Tilton (WA)		Contributing	VL	L
	SF Toutle (WA)		Primary	M	H+
	NF Toutle (WA)	C	Primary	VL	H
	Coweeman (WA)		Primary	L	H
	Kalama (WA)		Primary	L	H+
	NF Lewis (WA)	C	Contributing	VL	M
	EF Lewis (WA)		Primary	M	H
	Salmon Creek (WA)		Stabilizing	VL	VL
	Washougal (WA)		Contributing	L	M
	Clackamas (OR)	C	Primary	M	H
	Sandy (OR)	C	Primary	L	VH
Gorge winter	L. Gorge (OR & WA)		Primary	L	H
	U. Gorge (OR & WA)		Stabilizing	L	L
	Hood (OR)	C, GL	Primary	M	H

* Status is equivalent to persistence probability. VL = very low, L = low, M = moderate, H = high, VH = very high.

** C = Core populations, meaning those that historically were the most productive. G = Genetic legacy populations, which best represent historical genetic diversity.

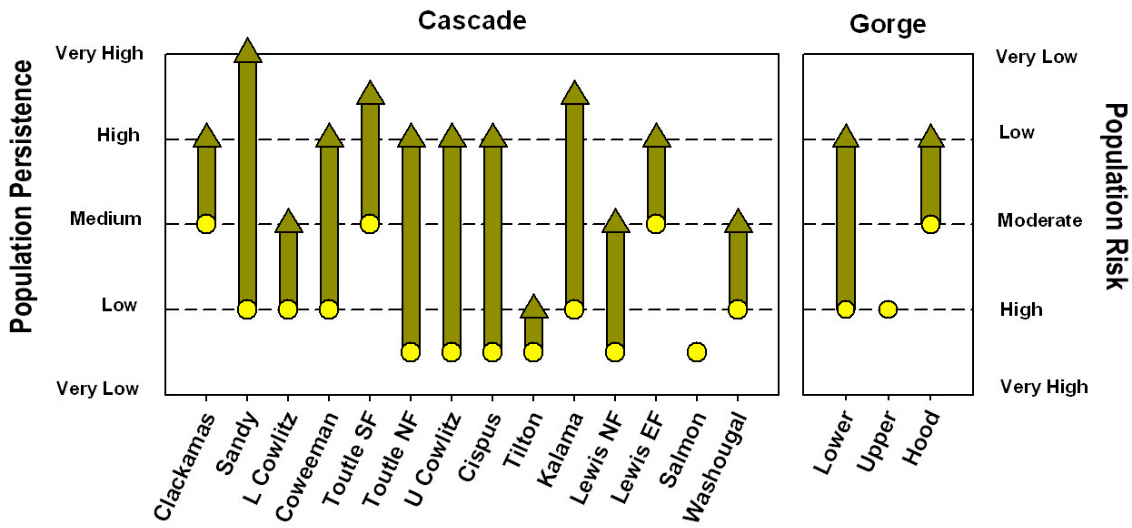

Figure ES-5. *Conservation Gaps for LCR Winter Steelhead Populations (i.e., Difference between Baseline and Target Status)*

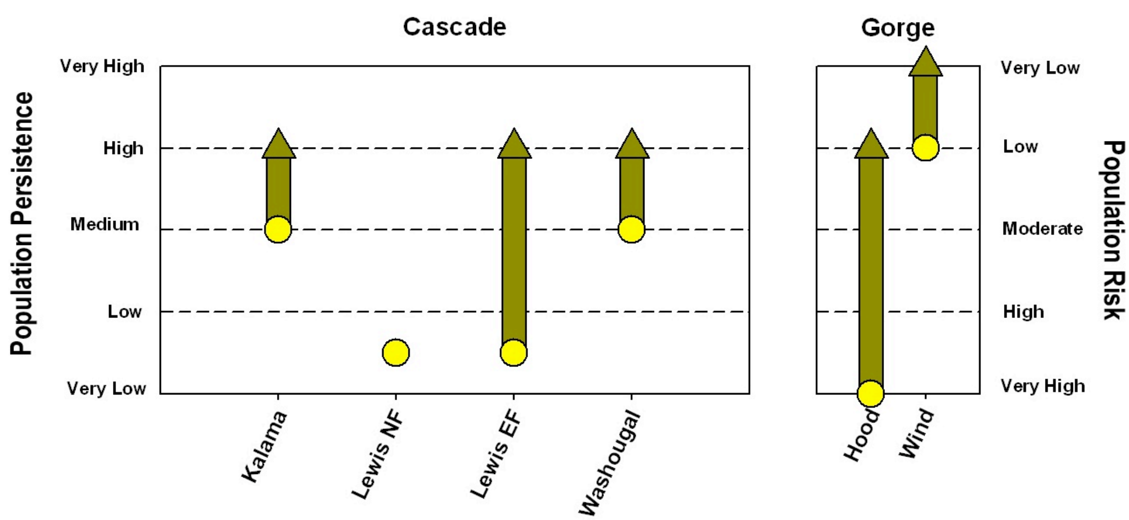

Figure ES-6. *Conservation Gaps for LCR Summer Steelhead Populations (i.e., Difference between Baseline and Target Status)*

Prevalent Limiting Factors: Steelhead

Lower Columbia River steelhead's poor status is due to a host of limiting factors that have affected the ESU for decades, or longer. Tables ES-14 and ES-15 list prevalent limiting factors that the management unit plans identified as having the greatest impact during the baseline period.

Table ES-13
Prevalent Primary Limiting Factors for Winter Steelhead during Baseline Period

Limiting Factor	Populations for Which This Is a Primary Limiting Factor
Degraded riparian conditions along tributaries	Almost all*
Channel structure and form issues[20] in tributaries and the Columbia River estuary	Almost all
Impaired side channel and wetland conditions in tributaries	Almost all
Loss/degradation of floodplain habitat in tributaries	Almost all
Sediment conditions in the estuary	Almost all
Water quantity issues (i.e., altered hydrology) in the estuary	Almost all

* "Almost all" means every population except one in each stratum.

Table ES-14
Prevalent Primary Limiting Factors for Summer Steelhead during Baseline Period

Limiting Factor	Populations for Which This Is a Primary Limiting Factor
Degraded riparian conditions along tributaries	Almost all*
Channel structure and form issues[21] in tributaries	Almost all
Impaired side channel and wetland conditions in tributaries	Almost all
Loss/degradation of floodplain habitat in tributaries	Almost all
Sediment conditions in tributaries and the Columbia River estuary	Almost all
Water quantity issues (i.e., altered hydrology) in the estuary	Almost all

* "Almost all" means every population except one in each stratum.

In addition, tributary hydropower development is a primary limiting factor for the North Fork Lewis summer steelhead population and several populations in the Cascade winter steelhead stratum, as is reduction in population diversity as a result of stray hatchery fish interbreeding with natural-origin fish.

Recovery Strategy: Steelhead

The recovery strategy for the Lower Columbia River steelhead DPS is aimed at restoring the Cascade and Gorge winter and summer strata to a high probability of persistence. Although the strategy involves threat reductions in all categories, the most crucial elements are as follows:

1. Protect favorable tributary habitat and restore degraded but potentially productive habitat, especially in subbasins where large improvements in

[20] Includes conditions such as channelization, reduced instream habitat complexity, fill and scour, and associated loss of spawning habitat.
[21] Includes conditions such as channelization, reduced instream habitat complexity, fill and scour, and associated loss of spawning habitat.

population abundance and productivity are needed to achieve recovery goals. This is the case in the Upper Cowlitz, Cispus, North Fork Toutle, Kalama, and Sandy subbasins for winter steelhead and in the East Fork Lewis and Hood subbasins for summer steelhead.

2. Protect and improve the South Fork Toutle, East Fork Lewis, Clackamas, and Hood winter steelhead populations, which currently are the best-performing winter populations, to a high probability of persistence. This will be accomplished through population-specific combinations of threat reductions, to include protection and restoration of tributary habitat (crucial for all except the Hood population), reductions in hatchery strays on the spawning grounds, and—for the Hood population—removal of Powerdale Dam (this was completed in 2010).

3. Significantly reduce hatchery impacts on the Hood summer steelhead population[22] and, to a lesser degree, on many other populations, especially the Upper Cowlitz, Cispus, Tilton, North Fork Lewis, and Clackamas winter populations and the East Fork summer population. Continue to limit hatchery impacts on the Kalama and Wind summer steelhead populations to improve population diversity.

4. Reestablish naturally spawning winter steelhead populations above tributary dams in the Cowlitz system (Upper Cowlitz and Cispus populations) and improve the status of the Tilton winter steelhead population through hatchery reintroductions and comprehensive threat reductions; reintroduce winter steelhead above dams on the North Fork Lewis River.

5. Reduce predation by birds, non-salmonid fish, and marine mammals.

Loss and degradation of tributary habitat, hatchery effects, and predation are pervasive threats that affect most steelhead populations, but the types of recovery actions that will be of most benefit vary by population. For the Upper Cowlitz, Cispus, Tilton, and North Fork Lewis winter populations, the greatest gains are expected to be achieved by reestablishing natural populations above tributary dams, but reductions in hatchery- and tributary habitat-related threats also will contribute significantly. For the East Fork Lewis summer population, improvements in tributary habitat are projected to provide the greatest benefit. The Sandy winter steelhead population is targeted for significant reductions in hatchery-related threats, but because of fairly recent changes in the management of the hatchery steelhead program, current stray rates in this population already are lower than the 10 percent called for for delisting. Hatchery- and tributary habitat-related actions will be of greatest benefit to Clackamas winter steelhead.

In the Gorge strata, reductions in tributary habitat-related threats will be significant for the Lower and Upper Gorge winter populations, especially in Oregon. For the Hood

[22] The Sandy winter steelhead population was also targeted for a significant reduction in hatchery impacts (i.e., 80 percent). However, the Oregon management unit plan states that, because of fairly recent changes in the management of the hatchery steelhead program, current stray rates in the Sandy winter steelhead population already are lower than the 10 percent called for in the threat reduction targets (ODFW 2010 p. 196).

winter population, the greatest gains in persistence probability are expected from reductions in hatchery- and hydropower-related threats. The Hood summer steelhead population is targeted for significant reductions in multiple threat categories, with particularly large reductions in tributary habitat- and hydropower-related threats and a complete elimination of hatchery threats (summer steelhead will no longer be released in the Hood River subbasin).

With harvest impacts on natural-origin winter steelhead having dropped substantially from historical highs, further reductions in harvest impacts do not figure prominently in the threat reduction scenarios for most steelhead populations. The recovery strategy involves continued management of fisheries to limit impacts to baseline levels.

Adaptive Management and Research, Monitoring, and Evaluation

The life cycles of salmon and steelhead are complex, and there is much we do not know about the range of factors that affect these species and how specific actions influence their characteristics and survival. For this recovery plan to be successful, we must do more than implement the strategies and actions the plan calls for. We also must learn during implementation, continually check our progress in reaching recovery goals, and make adjustments as necessary. Thus, the recovery plan calls for data gathering on the status and trends of populations, their habitats, and sources of threats; resolution of the many unknowns (which are referred to as critical uncertainties); and new or continued research, monitoring, and evaluation (RME) to assess the effectiveness of actions once they are implemented.

The recovery plan also incorporates adaptive management, which is the process of adjusting management actions and/or the overall approach to recovery based on new information, such as information derived from RME activities. Adaptive management works by offering a process for explicitly proposing, prioritizing, implementing, and evaluating alternative approaches and actions. This ensures that the best and most effective means of achieving recovery goals are used, even while scientific understanding of fish populations' needs and the benefits of specific actions continues to change and improve.

Local recovery planners have or will develop specific RME plans—for their respective geographic areas—that are based on regional guidance for adaptive management and RME. These RME plans will guide recovery planning RME efforts and funding in each management unit, within a context of ongoing regional guidance and coordination.

Implementation

Recovery actions will be implemented over a 25-year period, as specified in the management unit plans and estuary recovery plan module. Effective implementation will require that the recovery efforts of diverse private, local, state, tribal, and Federal parties across two states be coordinated at multiple levels.

At the management unit level, Washington's Lower Columbia Fish Recovery Board will lead implementation of actions in southwest Washington, and the Oregon Department of Fish and Wildlife implementation coordinator and stakeholder team will lead recovery plan implementation in Oregon, supported by the governance structure of the Oregon Plan for Salmon and Watersheds. In the White Salmon, NMFS, in coordination with the Washington Gorge Implementation Team (WAGIT), has taken the lead in coordinating implementation. Each of the lead implementing organizations will develop a series of 3-year or 6-year implementation schedules for their respective management unit. Implementation schedules will identify and prioritize[23] site-specific projects, determine costs and time frames, and identify responsible parties, based on strategies and actions in the recovery plan. Thus, the implementation schedules will provide more detail, clarity, and accountability for implementation than this recovery plan does.

At a higher level than the management units, the Lower Columbia Recovery Planning Steering Committee (which NMFS convened to guide development of this recovery plan) will lead efforts to coordinate the actions of the many entities that will play a role in implementation. For example, there is a need for coordination among the management units and the entities implementing Columbia River estuary recovery actions because the lower, tidal portions of the tributaries, which are within the management unit planning areas, overlap with the planning area of the *Columbia River Estuary ESA Recovery Plan Module for Salmon and Steelhead*. The steering committee will perform its coordination functions by working with subcommittees and other regional forums as needed.

Finally, NMFS has a unique role in recovery plan implementation. In addition to ensuring that its statutory responsibilities for recovery under the ESA are met, NMFS will support local recovery efforts by (1) helping to coordinate and encourage recovery plan implementation, (2) using recovery plans to guide regulatory decision making, (3) providing leadership in regional research, monitoring, and evaluation forums, and (4) providing periodic reports on species status and trends, limiting factors, threats, and plan implementation status.

The good news is that some recovery actions already are taking place. Harvest rates have dropped significantly since the first Lower Columbia River species were listed under the Endangered Species Act. Reforms of hatchery practices and programs are being implemented throughout the Columbia Basin. Dams have been removed or breached on the Sandy, Hood, and White Salmon rivers, and improvements in passage and operations to benefit salmon and steelhead are under way at other tributary hydropower facilities and in the Federal Columbia River hydropower system. Tributary and estuary habitat protection and restoration projects are under way. However, considerable additional work is needed to meet the goals of this plan. Habitat activities in particular need to be scaled up if they are to provide the needed benefits.

Conclusion

Recovery of ESA-listed Lower Columbia River salmon and steelhead will require actions that conserve and restore the key biological, ecological, and landscape processes that support the ecosystems that salmonid species depend on. These measures will require

[23] Some prioritization work already has been done, in that the management unit plans identify high-priority reaches for tributary habitat protection and restoration actions. In addition, the Oregon and White Salmon management unit plans offer some guidance on how actions might be prioritized across threat categories.

implementation of specific tributary and estuary habitat protection and restoration actions; changes in management of harvest, hatchery, and hydropower programs; and predation control. Development of an effective implementation framework, coupled with a responsive RME and adaptive management plan, provides the best assurance that this recovery plan will be fully implemented and effective. The plan's identification of target statuses, primary and secondary limiting factors that have caused gaps between baseline and target status, and actions to close those gaps is intended to aid implementing entities as they take actions that will lead to delisting and, eventually, achievement of broad sense recovery goals. The keys to long-term success will be full funding and implementation of this recovery plan and voluntary participation of residents of the Lower Columbia region. It is only through the involvement of all of those who live and work in this region that recovery will be achieved.

Key Documents

Oregon Lower Columbia Conservation and Recovery for Salmon and Steelhead
Oregon Department of Fish and Wildlife, 2010
http://www.dfw.state.or.us/fish/CRP/lower_columbia_plan.asp

Draft ESA Recovery Plan for the White Salmon River Watershed
National Marine Fisheries Service, 2011

Washington Lower Columbia Salmon Recovery and Fish & Wildlife Subbasin Plan
Lower Columbia Fish Recovery Board, 2010
http://www.lcfrb.gen.wa.us/December%202004%20Final%20%20Plans/lower_columbia_salmon_recovery_a.htm

Columbia River Estuary ESA Recovery Plan Module for Salmon and Steelhead
National Marine Fisheries Service, 2011
http://www.nwr.noaa.gov/Salmon-Recovery-Planning/ESA-Recovery-Plans/Estuary-Module.cfm

Recovery Plan Module: Mainstem Columbia River Hydropower Projects
National Marine Fisheries Service, 2008
http://www.nwr.noaa.gov/Salmon-Recovery-Planning/ESA-Recovery-Plans/Other-Documents.cfm

2008 Federal Columbia River Power System Biological Opinion and 2010 Supplement
National Marine Fisheries Service, 2008 and 2010
http://www.nwr.noaa.gov/Salmon-Hydropower/Columbia-Snake-Basin/Final-BOs.cfm

1. Introduction

This is a plan for the protection and restoration of Lower Columbia River Chinook salmon (*Oncorhynchus tshawytscha*), Lower Columbia River steelhead (*O. mykiss),* Lower Columbia River coho salmon (*O. kisutch*), and Columbia River chum salmon (*O. keta*), all of which are listed as threatened under the Endangered Species Act of 1973 (ESA). These salmon and steelhead, which spawn and rear in the lower Columbia River and its tributaries in Oregon and Washington, are among 19 evolutionarily significant units (ESUs) or distinct population segments (DPSs) of salmon and steelhead in the Pacific Northwest that have been listed as threatened or endangered under the ESA, out of a total of 40 salmon and steelhead ESUs and DPSs in the region.[1] An ESU or DPS is a group of Pacific salmon or steelhead, respectively, that is discrete from other groups of the same species and that represents an important component of the evolutionary legacy of the species. Under the Endangered Species Act, each ESU or DPS is treated as a species.[2]

The National Marine Fisheries Service (NMFS) of the National Oceanic and Atmospheric Administration (NOAA) is required, pursuant to section 4(f) of the Endangered Species Act of 1973, to develop recovery plans for marine species listed under the ESA.[3] Recovery plans identify actions needed to restore threatened and endangered species to the point that they no longer need the protections of the ESA. A recovery plan serves as a road map for species recovery—it lays out where we need to go and how best to get there. Without a plan to organize, coordinate, and prioritize the many possible recovery actions on the part of Federal, state, and local governments, tribal agencies, watershed councils and districts, and private citizens, our efforts may be inefficient or even ineffective. Prompt development and implementation of a recovery plan will help target limited resources effectively. Although recovery plans are guidance documents rather than regulatory documents, the ESA envisions recovery plans as the central organizing tool for guiding each species' recovery process. NMFS developed this ESU-level recovery plan by synthesizing material from (1) three geographically based and locally developed recovery plans for Oregon, White Salmon, and southwest Washington populations of Lower Columbia River salmon and steelhead, (2) related recovery plan modules, and (3) additional analyses as appropriate (see Sections 1.5.2 and 1.5.3).

Over the course of their life cycles, Lower Columbia River salmon and steelhead use habitats across a wide geographic range. They spawn and rear in the upper, middle, and lower reaches of freshwater tributaries to the Columbia River and in parts of the Columbia River estuary and lower mainstem. They then migrate as juveniles downstream through the tributaries and mainstem to the estuary and ocean. After

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[1] For updates on the number of ESA-listed salmon and steelhead, see the "Snapshot" link at http://www.nwr.noaa.gov/ESA-Salmon-Listings/Salmon-Populations/.

[2] A DPS is defined based on discreteness in behavioral, physiological, and morphological characteristics, whereas the definition of an ESU emphasizes genetic and reproductive isolation. (For a fuller explanation, see Section 1.4.4.)

[3] As anadromous species whose life cycles encompass freshwater, estuarine, and marine ecosystems, salmon and steelhead fall under the jurisdiction of NMFS. Steelhead, which are the migratory form of *Oncorhynchus mykiss*, are distinct from rainbow trout, the resident form of *O. mykiss*. Rainbow trout are under the jurisdiction of the U.S. Fish and Wildlife Service. This recovery plan addresses steelhead and not rainbow trout, as is consistent with the ESA listing decision.

spending years in the ocean, adults migrate back to their natal streams to spawn. The long-term biological success of salmon and steelhead is based on their ability to make use of the diverse habitats from river headwaters to the ocean. Thus, salmon and steelhead's resilience in the face of change depends on maintaining genetic, phenotypic, and behavioral diversity over a wide geographic area.

Human activities have dramatically changed the conditions encountered by Lower Columbia River salmon and steelhead. Although many of the deleterious effects on fish are due to past practices, current human uses of the land and river systems continue to threaten the viability of Lower Columbia River salmon and steelhead across much of their range. In many locations, urban and rural development, agricultural and forest management practices, dredging, and passage obstructions continue to put pressure on salmon and steelhead, whose habitat already has been reduced in amount and quality as a result of extensive loss of channel function and floodplain connectivity. Habitat changes have exacerbated predation by fish, birds, and marine mammals as salmon and steelhead migrate through the lower Columbia River and estuary. Hydropower development has altered river flow, which is a significant force in structuring aquatic and riparian habitats. In addition to eliminating key habitats, hydropower development has altered salmonid food sources, changed freshwater and saltwater balances in the Columbia River estuary, reduced access to habitat in the estuary, and disrupted the timing of salmonid migrations. Harvest mortality of ESA-listed salmon and steelhead occurs in various fisheries—commercial, tribal, and recreational—in the Pacific Ocean, in the lower Columbia River, and in tributaries to the Columbia. Lastly, hatchery-origin fish pose threats in terms of competition, predation, genetic effects, and mixed-stock harvest.

Fortunately, scientific understanding of the threats to Lower Columbia River salmon and steelhead is growing, as is interest in aligning land use, hatchery priorities, harvest practices, and hydropower operations with conservation objectives for salmon and steelhead. More people now recognize the opportunities and benefits of actively protecting and restoring stream corridors, wetlands, stream flows, and other natural features that support native fish and wildlife populations. Management of upland areas is changing to protect or restore watershed function, and cities are undertaking urban watershed protection and restoration. Recovery planning is an opportunity to search for common ground, to organize protection and restoration of salmonid habitat, to reduce other threats to the species, and to secure the economic and cultural benefits that accrue to human communities from healthy watersheds and rivers.

The primary goal of ESA recovery plans is for species to reach the point at which they no longer need the protection of the Endangered Species Act and thus can be delisted. With salmon and steelhead, the final recovery plan is based on locally developed recovery plans. These plans address not just delisting but also local interests and needs based on social, economic, and ecological values. To address these interests, local recovery planners have included "broad sense goals" that go beyond the requirements for delisting. Although the broad sense goals in the locally produced salmon and steelhead recovery plans may be stated in slightly different ways, they usually share some combination of the following elements: ensuring long-term persistence of viable populations of naturally produced salmon and steelhead distributed across their native range, enjoying the social and cultural benefits of meaningful harvest opportunities that are sustainable over the long term, and pursuing salmon recovery using an open and cooperative process that respects local customs and benefits local communities and economies.

The broad sense goal of ensuring the long-term persistence of viable populations of naturally produced salmon and steelhead distributed across their native range is consistent with ESA delisting, and NMFS' approach to recovery planning has been to use open and collaborative processes with extensive local engagement. NMFS is supportive of the broad sense recovery goals in locally developed plans and believes that the most expeditious way to achieve them is by achieving viability of natural populations and delisting. Upon delisting, NMFS will work with co-managers and local stakeholders, using our non-ESA authorities, to pursue broad sense recovery goals while continuing to maintain robust natural populations. Recovery goals and delisting criteria are discussed in more detail in Chapter 3.

1.1 ESA Requirements

Section 4(f) of the ESA requires that a recovery plan be developed and implemented for each species listed as endangered or threatened under the statute.

ESA section 4(a)(1) lists factors for delisting that are to be addressed in recovery plans:

A. The present or threatened destruction, modification, or curtailment of the species' habitat or range
B. Over-utilization for commercial, recreational, scientific, or educational purposes
C. Disease or predation
D. The inadequacy of existing regulatory mechanisms
E. Other natural or human-made factors affecting the species' continued existence

ESA section 4(f)(1)(B) directs that recovery plans, to the extent practicable, incorporate all of the following:

1. A description of such site-specific management actions as may be necessary to achieve the plan's goal for the conservation and survival of the species

2. Objective, measurable criteria which, when met, would result in a determination … that the species be removed from the list

3. Estimates of the time required and the cost to carry out those measures needed to achieve the plan's goal and to achieve intermediate steps toward that goal

In addition, it is important for recovery plans to provide the public and decision makers with a clear understanding of the goals and strategies needed to recover a listed species and the science underlying those goals and strategies (NMFS 2004a).

Once a species is deemed recovered and therefore removed from the list, section 4(g) of the ESA requires monitoring of the species for a period of not less than 5 years to ensure that it retains its recovered status.

1.2 How NMFS Intends to Use the Plan

Although recovery plans are not regulatory, they are important tools that help to do the following:

- Provide context for regulatory decisions
- Guide decision making by Federal, state, tribal, and local jurisdictions
- Provide criteria for status reporting and delisting decisions
- Organize, prioritize, and sequence recovery actions
- Organize research, monitoring, and evaluation efforts

NMFS will encourage Federal agencies and non-Federal jurisdictions to take recovery plans under serious consideration as they make the following sorts of decisions and allocate their resources:

- Actions carried out to meet Federal ESA section 7(a)(1) obligations
- Actions that are subject to ESA sections 4d, 7(a)(2), or 10
- Hatchery and Genetic Management Plans and permit requests
- Harvest plans and permits
- Selection and prioritization of subbasin planning actions
- Development of research, monitoring, and evaluation programs
- Revision of land use and resource management plans
- Other natural resource decisions at the state, tribal, and local levels

NMFS will emphasize recovery plan information in ESA section 7(a)(2) consultations, section 10 permit development, and application of section 4(d) rules by considering the following:

- The importance of affected populations to listed species' viability
- The importance of the action area to affected populations and species' viability
- How LFs identified in recovery plans inform analysis of the effects of the action on critical habitat
- The relation of the action to recovery strategies and management actions
- The relation of the action to the research, monitoring, and evaluation plan for the affected species

In implementing these programs, recovery plans will be used as a reference and a source of context, expectations, and goals. NMFS staff will encourage the Federal "action agencies" to describe in their biological assessments how their proposed actions will affect specific populations and limiting factors identified in the recovery plans, and to describe any mitigating measures and voluntary recovery activities in the action area.

1.3 Geographic Setting

With few exceptions, this recovery plan covers naturally produced and some artificially propagated salmon and steelhead in the Lower Columbia recovery subdomain, meaning the area that is drained by the streams and rivers in the lower Columbia Basin. This includes the Columbia River estuary and lower mainstem, the lower Willamette River below Willamette Falls, and all Columbia River tributaries downstream from and including the White Salmon River in Washington and the Hood River in Oregon. The plan does not cover steelhead populations in tributaries downstream of the Willamette River in Oregon and the Cowlitz River in Washington (these are part of the Southwest Washington steelhead DPS, which is not ESA listed),[4] salmon and steelhead populations in the upper Willamette River and its tributaries (which are part of the Upper Willamette ESU), and spring Chinook salmon in the Clackamas River (also part of the Upper Willamette ESU). Listed ESUs in the upper Willamette are addressed in a separate recovery plan.

1.3.1 Topography and Ecological Zones

The lower Columbia Basin is geographically and ecologically diverse. Draining 8,200 square miles, it spans parts of two states and two mountain ranges: the Coast Range and the Cascades. Elevations range from sea level (at the mouth of the Columbia River) to 14,410 feet (at the summit of Mt. Rainier). Topography includes low-elevation tidally influenced floodplains, which are where most of the urban and agricultural development has occurred. Higher elevations are characterized by alluvial valleys; steep, heavily timbered mountains; and volcanic peaks, specifically Mounts Rainier, St. Helens, and Adams in Washington and Mt. Hood in Oregon. Over geologic time the watersheds of the lower Columbia Basin have been shaped by volcanic, glacial, and alluvial processes, such as flooding, erosion, and sedimentation, and these forces continue to influence habitat conditions. As an example, volcanic activity has played a significant role in structuring habitat as recently as 1980, when Mount St. Helens erupted. Together, the various habitats in the region—from tidal marshes to high-elevation coniferous forests—support more than a dozen fish and wildlife species that are officially threatened, endangered, or of other special conservation concern.

For purposes of salmon and steelhead recovery planning, the lower Columbia Basin is divided into three ecological zones—Coast Range, Cascade, and Columbia Gorge—that were adapted in part from the U.S. Environmental Protection Agency's ecoregions (Omernik 1987, Myers et al. 2006). Ecological zones delineate major geographic areas within the ranges of the ESUs and DPS that have distinct environmental characteristics, such as elevation, soil type, vegetative land cover, rainfall, and climate. Each ecological zone spans the Columbia River and includes parts of both Oregon and Washington.

The individual subbasins in each ecological zone are shown in Table 1-1.

[4] Steelhead populations within the Coast ecozone are addressed, however, in the Oregon and Washington management unit plans to address state planning needs.

Table 1-1
Lower Columbia Subbasins, by State and Ecological Zone

Ecological Zone	Oregon Subbasins	Washington Subbasins
Coast Range	Youngs Bay Big Creek Clatskanie Scappoose	Estuary tributaries: Chinook, Wallacut, and Deep Grays Elochoman Skamakowa Mill, Abernathy, and Germany creeks
Cascade	Clackamas Sandy	Cowlitz (Lower Cowlitz, Upper Cowlitz, Cispus, Tilton) Coweeman Toutle Kalama North Fork Lewis East Fork Lewis Salmon Creek Washougal
Gorge	Lower Gorge and Upper Gorge tributaries (divided by Bonneville Dam) Hood	Lower Gorge tributaries (including Wind and Little White Salmon) Upper Gorge tributaries (above Bonneville Dam) White Salmon

Ecological zones are considered a meaningful structure to use in recovery planning because salmon and steelhead populations in different zones exhibit differences in life history characteristics. In addition, given the different climates, geology, and ecological processes in each zone, populations in different zones are unlikely to be affected by the same catastrophic event.

1.3.2 Climate

The lower Columbia Basin has a typical Pacific Northwest maritime climate, with cool, dry summers and wet, mild winters. Precipitation patterns are heavily influenced by the Coast and Cascade mountain ranges. In the Coast Range ecological zone, precipitation averages 80 to 95 inches per year, with the vast majority occurring as rain between October and March (Myers et al. 2006). The Cascade zone sees greater variation in precipitation, from 45 to 150 inches annually (Myers et al. 2006). Rain predominates at middle and lower elevations in the Cascade zone, while snow and freezing temperatures are common at high elevations. As in the Coast Range zone, most of the precipitation in the Cascade zone occurs between October and March.

The Columbia Gorge ecological zone has a transitional climate between the high-precipitation area of the Cascades and the drier Columbia Plateau to the east (Myers et al. 2006). Rain shadow effects keep precipitation in the eastern portion of this zone relatively low—to an annual mean of 30 inches in Hood River, Oregon, for example (Western Regional Climate Center 2003). Cooler winter temperatures can occur in this zone as the result of the influx of cold continental air masses from the east (Welch et al. 2002).

1.3.3 Land Uses and Economy

Land uses in the lower Columbia Basin vary from forestry and agriculture to urban and rural residential development. Much of the upper portions of the region's watersheds are forested and managed for timber production. In the Coast Range zone this is usually through private ownership of industrial forests; in the Cascade and Columbia Gorge zones, Federal or state ownership of forest land is more common. Within the Cascade zone, forest land in the Coweeman, Toutle, Kalama, lower North Fork Lewis, Salmon Creek, and Washougal subbasins is under predominately state or private ownership, while forest land in the upper Cowlitz, Cispus, Tilton, upper North Fork Lewis, East Fork Lewis, Clackamas, and Sandy subbasins is largely Federally owned. Federal ownership in the region includes portions of two national forests (Gifford Pinchot and Mt. Hood), three wilderness areas (Indian Heaven, Salmon-Huckleberry, and Mt. Hood), and other specially managed lands (e.g., Mt. Rainier National Park, Mount St. Helens National Volcanic Monument, and the Columbia River Gorge National Scenic Area).

Large urban and residential zones have developed in lower elevation valley floor areas along the Columbia River and I-5 corridor from Portland, Oregon, to Longview, Washington (LCFRB 2010a). The lower reaches of the Salmon Creek and Clackamas River subbasins, in particular, along with smaller drainages near the city of Portland such as Johnson Creek and Kellogg Creek, are heavily urbanized. High technology, manufacturing, and professional services support the economy of the area's two major population centers: Portland, Oregon (the state's largest city), and Vancouver, Washington (fourth largest city in Washington). Dozens of smaller cities and towns are located in the more rural portions of the region, which has a total human population of more than 2.5 million. Other common land uses in the lower reaches of most subbasins are rural residential development and agriculture, in the form of fruit and vegetable crops, nursery stock, and beef and dairy cattle.

Bonneville is the only dam on the lower mainstem of the Columbia River, but major hydropower or flood control facilities are located on a number of tributaries. Interstate Highway 84, the Union Pacific Railroad line, and the Columbia River constitute a key east-west transportation corridor. Five deep-water ports serve a shipping industry that transports 30 million tons of goods annually. Six major pulp mills contribute to the region's economy and, until the early 2000s, aluminum smelters along the Columbia River produced 40 percent of the country's aluminum. Commercial and recreational fishing continue to support some local communities, and outdoor recreation in general (fishing, wildlife observation, hunting, boating, hiking, and windsurfing) is a growing economic influence.

1.3.4 Human Population

An estimated 5 million people live in the Columbia Basin, and many more are expected to move to the area in the coming decades. Population forecasts predict that, by the end of the twenty-first century, between 40 million and 100 million people will be living in the region (National Research Council 2004). Some communities—both urban and rural—can expect their populations to double between 2000 and 2020. Significant growth also is projected for unincorporated areas. In Oregon, particularly fast population growth is predicted in Clackamas, Clatsop, Columbia, Hood River, and Multnomah counties—areas that support Lower Columbia River salmon and steelhead. The population of these counties is expected to increase by 41 percent from 2003 to 2040 (State of Oregon Office of Economic Analysis 2004). In Washington, the populations of Clark and Cowlitz counties are projected to grow by 65 and 53 percent, respectively, from 2000 to 2030 (Washington State Department of Transportation).

1.4 Species Covered by the Plan

Of the 19 ESUs or DPSs of salmon and steelhead in the Pacific Northwest that have been listed as threatened or endangered under the ESA, four occur in the lower Columbia Basin and are addressed in this plan: Lower Columbia River Chinook salmon, steelhead, and coho salmon, and Columbia River chum salmon.

Because ESA recovery is predicated on having enough natural production for the ESU to be self-sustaining, natural populations are the primary focus of most of the analyses and recovery actions in this plan. However, NMFS recognizes that in certain circumstances, hatchery populations are closely related to local natural populations and are representative of the genetic legacy of the ESU or DPS in question. NMFS' 2005 hatchery listing policy provides that the agency will include in ESUs or DPSs hatchery programs that are no more than moderately divergent from a natural population that is included in the ESU or DPS (70 *Federal Register* 37204) For this reason, each of the species described below consists of both natural- and hatchery-origin fish.

1.4.1 Lower Columbia River Coho Salmon ESU

The Lower Columbia River coho salmon ESU (*Oncorhynchus kisutch*) was listed as threatened under the Federal Endangered Species Act on June 28, 2005 (70 *Federal Register* 37160). The ESU includes the following:

- All naturally spawned populations of coho salmon in the lower Columbia River and its tributaries, from the mouth of the Columbia upstream to and including the Hood River (in Oregon) and the White Salmon River (in Washington), and including the Willamette River up to Willamette Falls

- Coho salmon from 25 artificial propagation programs[5]

1.4.2 Lower Columbia River Chinook Salmon ESU

The Lower Columbia River Chinook salmon ESU (*O. tshawytscha*) was listed as threatened under the Federal Endangered Species Act on March 24, 1999 (64 *Federal Register* 14308). The listing was reaffirmed on June 28, 2005 (70 *Federal Register* 37160).

The Lower Columbia River Chinook salmon ESU includes the following:

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[5] For a list of the hatchery programs included in the ESU, along with changes that NMFS proposed in its 2011 5-year review of the ESU's status, see Section 6.1.2.

- All naturally spawned populations of Chinook salmon from the Columbia River and its tributaries from the river's mouth at the Pacific Ocean upstream to and including the Hood River in Oregon and the White Salmon River in Washington, including the Willamette River to Willamette Falls, Oregon, but excluding spring-run Chinook salmon in the Clackamas River[6]

- Chinook salmon from 17 artificial propagation programs[7]

1.4.3 Columbia River Chum Salmon ESU

The Columbia River chum salmon ESU (*O. keta*) was listed as threatened on March 25, 1999 (64 *Federal Register* 14507). The listing was reaffirmed on June 28, 2005 (70 *Federal Register* 37160).

The Columbia River chum salmon ESU includes the following:

- All naturally spawned populations of chum salmon in the Columbia River and its tributaries in Oregon and Washington[8]

- Chum salmon from three artificial propagation programs[9]

1.4.4 Lower Columbia River Steelhead DPS

"Steelhead" are the anadromous (migratory) form of the biological species *Oncorhynchus mykiss*. Rainbow trout are the non-anadromous (resident) form of *O. mykiss*. NMFS originally listed Lower Columbia River steelhead as threatened on March 29, 1998, under the ESU policy (63 *Federal Register* 13347). NMFS revised the listing on January 5, 2006 (71 *Federal Register* 8844), this time applying the DPS policy (61 *Federal Register* 4722).[10] This recovery plan addresses steelhead only, not rainbow trout (which are under the jurisdiction of the U.S. Fish and Wildlife Service). To avoid confusion, references to ESUs in this recovery plan should be understood to include the steelhead DPS as well.

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[6] Spring Chinook salmon in the Clackamas subbasin are part of the Upper Willamette River spring Chinook ESU. Lower Columbia River coho salmon, chum salmon, steelhead, and fall Chinook salmon also occur in the Clackamas subbasin. For planning purposes, Oregon addressed all the Clackamas populations, including Clackamas River spring Chinook salmon, in its Lower Columbia recovery planning process (ODFW 2010). For ESA purposes, the Clackamas River spring Chinook salmon population is addressed in the *Upper Willamette River Conservation and Recovery Plan for Chinook Salmon and Steelhead* (ODFW and NMFS 2011)

[7] For a list of the hatchery programs included in the ESU, along with changes that NMFS proposed in its 2011 ESA 5-year review, see Section 7.1.2.

[8] The historical upstream boundary for chum salmon is generally considered to have been Celilo Falls, which historically was located approximately where The Dalles Dam is located.

[9] For a list of the hatchery programs included in the ESU, see Section 8.1.2.

[10] The ESA allows listing agencies to list at the level of a species, subspecies, or distinct population segment. For salmon, NMFS applies its ESU policy and treats ESUs as distinct population segments. For steelhead (*O. mykiss*) NMFS shares jurisdiction with the U.S. Fish and Wildlife Service. In 2006, NMFS and the U.S. Fish and Wildlife Service made a determination to apply the DPS policy to *O. mykiss*. The DPS policy recognizes discreteness in behavioral, physiological, and morphological characteristics as contributing to the distinctness of a population segment, whereas the ESU policy emphasizes genetic and reproductive isolation.

Steelhead found within the geographical boundaries of the Lower Columbia recovery subdomain fall into three separate DPSs as defined by NMFS: Lower Columbia, Middle Columbia, and Southwest Washington. The Middle Columbia DPS includes steelhead from the White Salmon and Little White Salmon rivers, while the Southwest Washington DPS includes steelhead from the Grays and Elochoman rivers and Skamakowa, Mill, Abernathy, and Germany creeks in Washington, and from the Youngs Bay, Big Creek, Clatskanie, and Scappoose subbasins in Oregon.

This recovery plan addresses steelhead from the Lower Columbia DPS only, not populations from the Middle Columbia and Southwest Washington DPSs.[11] Specifically, the Lower Columbia River steelhead DPS includes the following:

- All naturally spawned anadromous *O. mykiss* populations below natural and manmade impassable barriers in streams and tributaries to the Columbia River between and including the Cowlitz and Wind rivers in Washington

- All naturally spawned anadromous *O. mykiss* populations below natural and manmade impassable barriers in streams and tributaries to the Columbia River between and including (1) the Willamette River up to Willamette Falls, and (2) the Hood River in Oregon

- Steelhead from 10 artificial propagation programs[12]

1.5 Context of Plan Development

This plan is the product of a collaborative process initiated by NMFS that involves the State of Washington, regional salmon recovery organizations within Washington (the Lower Columbia Fish Recovery Board, in particular), the State of Oregon (led by the Oregon Department of Fish and Wildlife, with extensive participation by the Oregon Governor's Natural Resources Office), the Lower Columbia River Estuary Partnership, regional stakeholder teams within Oregon, other Federal and state agencies, tribal and local governments, representatives of industry and environmental groups, and the public.

While NMFS is directly responsible for ESA recovery planning for salmon and steelhead, the agency believes that ESA recovery plans for salmon and steelhead should

[11] The Mid-Columbia steelhead DPS, which includes the White Salmon population, is addressed in a separate recovery plan, the *Middle Columbia River Steelhead Distinct Population Segment ESA Recovery Plan* (National Marine Fisheries Service [Northwest Region] November 2009). Steelhead in the Youngs Bay, Big Creek, Grays, Elochoman, Skamakowa, Clatskanie, Mill, Abernathy, Germany, and Scappoose watersheds are part of the Southwest Washington DPS, which is not listed under the ESA(61 *Federal Register* 41541). However, these populations are included in the Oregon and Washington management unit plans because their status needs to be improved, they share geographic range and life history traits with the ESA-listed Lower Columbia River species, and they are expected to benefit from recovery actions targeted at the listed species. Similarly, the White Salmon management unit plan (NMFS 2011b) covers the White Salmon steelhead population, which is part of the Mid-Columbia DPS, because of this population's shared geography with the White Salmon coho, Chinook, and chum salmon populations, all of which are part of the Lower Columbia River ESUs.

[12] For a list of the hatchery programs included in the DPS, along with changes that NMFS proposed in its 2011 ESA 5-year review, see Section 9.1.2.

be based on the many state, regional, tribal, local, and private conservation efforts already under way throughout the region. Local support of recovery plans by those whose activities directly affect the listed species, and whose actions will be most affected by recovery efforts, is essential. NMFS therefore supports and participates in locally led collaborative efforts to develop recovery plans that involve local communities; state, tribal, and Federal entities; and other stakeholders.

NMFS developed this recovery plan with assistance from the Lower Columbia Recovery Plan Steering Committee, a group convened by NMFS (see Chapter 11) to provide input to the ESU-level plan. NMFS developed this plan by drawing upon the best available scientific information provided by three regional recovery plans, related recovery plan modules, the work of the Willamette-Lower Columbia Technical Recovery Team (see below) and technical experts from NMFS, Washington, Oregon, the Yakama Nation, and regional planning groups. The draft plan went through multiple reviews and revisions in response to comments from both technical reviewers and steering committee members.

1.5.1 Recovery Domains and Technical Recovery Teams

Currently, there are 19 ESA-listed ESUs and DPSs of Pacific salmon and steelhead in the Pacific Northwest. NMFS' Northwest Region also shares jurisdiction of an additional ESU—the Southern Oregon/Northern California coho salmon—with the agency's Southwest Region. For the purpose of recovery planning for these species, the Northwest Region designated five geographically based "recovery domains": the Interior Columbia, Willamette-Lower Columbia, Puget Sound, Oregon Coast, and Southern Oregon/Northern California Coast domains (see Figure 1-1). NMFS' Northwest Region delineated these domains by considering ESU or DPS boundaries, ecosystem boundaries, and local planning units.

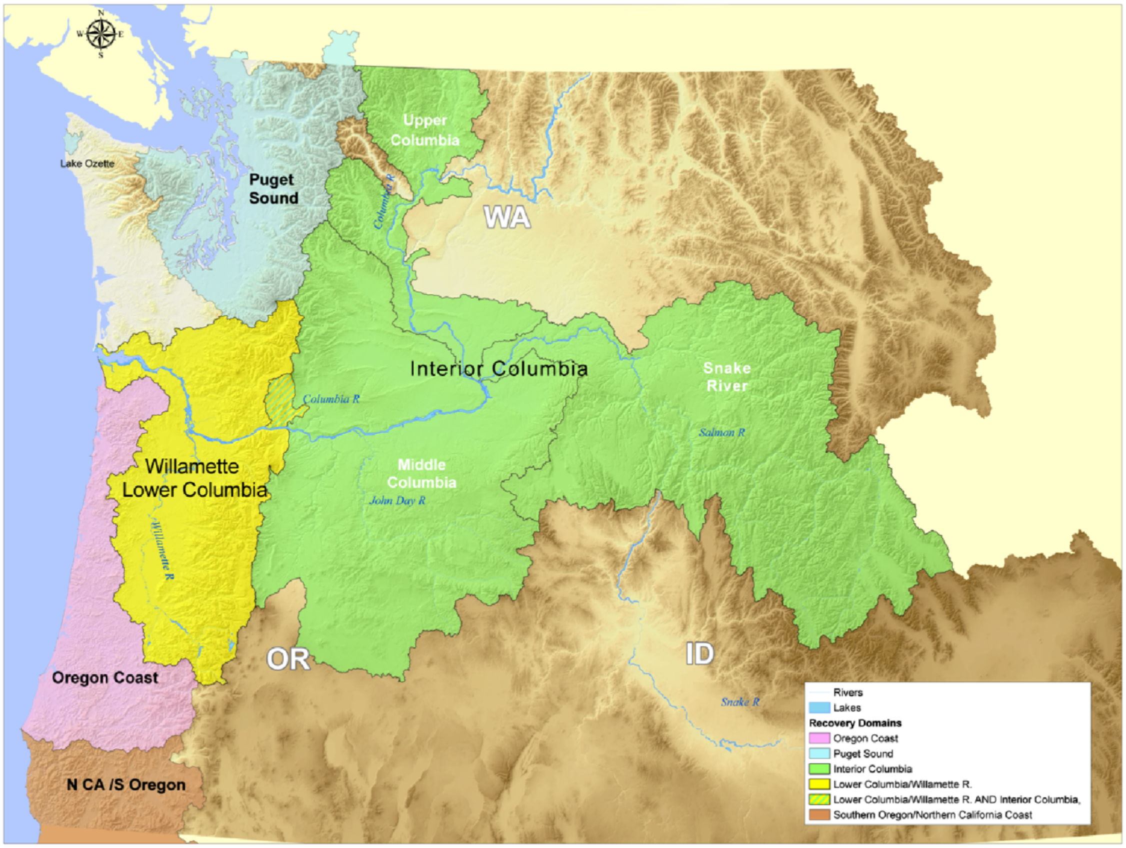

Figure 1-1. *NMFS Northwest Region Recovery Domains*

In the case of the Willamette-Lower Columbia domain, the domain was further divided into two subdomains to accommodate different planning processes and timelines. The range of the Lower Columbia River salmon and steelhead ESUs and DPS is within the Lower Columbia subdomain of the Willamette-Lower Columbia domain (see Figure 1-2).

For each domain, NMFS appointed a team of scientists who have geographic and species expertise to provide a solid scientific foundation for recovery plans. The charge of each Technical Recovery Team (TRT) was to define the historical population structure of each ESU or DPS, to recommend biological viability criteria for each ESU or DPS and its component populations, to provide scientific support to local and regional recovery planning efforts, and to provide scientific evaluations of proposed recovery plans. The Willamette-Lower Columbia TRT (WLC TRT) was formed in May 2000 and included representatives from NMFS' Northwest Fisheries Science Center, the Washington Department of Fish and Wildlife (WDFW), the U.S. Fish and Wildlife Service (USFWS), the University of Portland, and a private consultant.

Each TRT used the same biological principles to develop its recommended ESU and population viability criteria; these criteria will be used in combination with criteria based on mitigation of the factors for decline to determine whether a species has recovered sufficiently to be downlisted or delisted. The biological principles that underlie the viability criteria are described in the NMFS technical memorandum *Viable*

Salmonid Populations and the Recovery of Evolutionarily Significant Units (McElhany et al. 2000). A viable ESU or DPS is naturally self-sustaining over the long term. McElhany et al. describe viable salmonid populations (VSP) in terms of four parameters: abundance, population productivity or growth rate, population spatial structure, and life history and genetic diversity.

Each TRT's recommendations are based on the VSP framework and considerations related to data availability, the unique biological characteristics of the ESU or DPS and the habitats in the domain, and the TRT members' collective experience and expertise. Although NMFS has encouraged the TRTs to develop regionally specific approaches for evaluating viability and identifying factors limiting recovery, each TRT was working from a common scientific foundation to ensure that the recovery plans are scientifically sound and based on consistent biological principles.

TRT recommendations were used by NMFS and local planning groups to develop goals for the recovery plans. As the agency with ESA jurisdiction for salmon and steelhead, NMFS makes final determinations of ESA delisting criteria.

1.5.2 Management Units and Integration of Management Unit Plans

In each domain, NMFS collaborates with other Federal agencies and state, tribal, and local entities to develop planning forums appropriate to the domain, building to the extent possible on ongoing, locally led recovery efforts. These planning forums use the TRT and other technical resources to agree on recovery goals and limiting factors and then to develop locally appropriate and locally supported recovery actions needed to achieve recovery goals. Although the planning forums were working from a consistent set of assumptions regarding needed recovery plan elements, the process by which they develop those elements—and the form those elements take—may differ among domains.

The structure of recovery planning in the Willamette-Lower Columbia recovery domain, which includes parts of Washington and Oregon, differs in the two states. To accommodate the different planning efforts and jurisdictional boundaries, NMFS partitioned the domain into four management units: Washington (the portion of the Lower Columbia River salmon ESUs and steelhead DPS that occurs within the planning area of Washington's Lower Columbia Fish Recovery Board), White Salmon (the White Salmon subbasin in Washington), Oregon Lower Columbia (the portion of the Lower Columbia River salmon ESUs and steelhead DPS that occurs within Oregon), and Upper Willamette (predominantly the Willamette Basin above Willamette Falls). (See Figure 1-2.)

Figure 1-2. *Management Units of the Willamette-Lower Columbia Recovery Domain*

A locally developed recovery plan has been completed for each of these management units. This ESU-level recovery plan is a synthesis of relevant information from three of the management unit plans—Washington, White Salmon, and Oregon Lower Columbia. The three management unit plans and their associated planning processes are described below.

1.5.2.1 Washington Management Unit Recovery Plan

The recovery plan for the Washington management unit covers the portion of the Lower Columbia River salmon ESUs and steelhead DPS that occurs in Washington within the planning area of the Lower Columbia Fish Recovery Board (LCFRB), which was established by Washington statute in 1998 to oversee and coordinate salmon and steelhead recovery efforts in the lower Columbia region of Washington. The LCFRB comprises representatives from the state legislature, city and county governments, the Cowlitz Tribe, the environmental community, hydroelectric utilities, and concerned citizens.

The LCFRB led and coordinated a collaborative process to develop the Washington management unit plan, titled the *Washington Lower Columbia Salmon Recovery and Fish & Wildlife Subbasin Plan* (LCFRB 2010a). Partners in the planning process included Federal agencies, tribal governments, Washington state agencies, regional organizations, and city and county governments. In addition, workshops, presentations, and public comment periods offered opportunities for broader community and public input. The resulting document is an integrated plan that serves planning needs associated with the Endangered Species Act, the Northwest Power and Conservation Council's fish and wildlife subbasin planning process, and state salmon recovery and watershed planning. The plan is intended to protect and restore native fish, aquatic habitats, and sensitive wildlife species in Washington's lower Columbia River watersheds. In February 2006, NMFS approved the December 2004 version of the plan as an interim regional recovery plan for the listed salmon ESUs and steelhead DPS. In May 2010, the LCFRB completed a revision of its earlier plan. This ESU-level recovery plan includes the *Washington Lower Columbia Salmon Recovery and Fish & Wildlife Subbasin Plan* (LCFRB 2010a) as Appendix B.[13]

1.5.2.2 White Salmon Management Unit Recovery Plan

The recovery plan for the White Salmon management unit covers the portions of the Lower Columbia River Chinook, coho, and chum salmon ESUs that occur in the White Salmon subbasin in Washington. It also covers steelhead in the White Salmon subbasin, which are part of the ESA-listed Middle Columbia River DPS and are addressed in the *Middle Columbia River Steelhead Distinct Population Segment ESA Recovery Plan* (NMFS 2009a).

In the absence of a local planning forum for salmon recovery, NMFS developed the White Salmon management unit recovery plan for ESA-listed salmon and steelhead in the White Salmon subbasin in cooperation with the Yakama Nation, Klickitat County, WDFW, and other stakeholders. The plan, titled *Draft ESA Recovery Plan for the White Salmon River Watershed* (NMFS 2011b) is included in this ESU-level recovery plan as Appendix C.[14]

In 2009, NMFS, in coordination with the Yakama Nation, WDFW, U.S. Geological Survey, Klickitat County, Washington Gorge Conservation District, Washington Department of Ecology, and other local groups, established the Washington Gorge Implementation Team to support continued coordination of salmon and steelhead recovery efforts.

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[13] The Washington management unit plan is available at http://www.lcfrb.gen.wa.us/default1.htm.
[14] The White Salmon management unit plan is available at www.nwr.noaa.gov.

1.5.2.3 Oregon Lower Columbia Management Unit Recovery Plan

The recovery plan for the Oregon Lower Columbia management unit covers the portion of the Lower Columbia River salmon ESUs and steelhead DPS that occurs within Oregon. The Oregon Department of Fish and Wildlife (ODFW) led development of this plan in collaboration with NMFS and numerous stakeholders, including other Federal agencies, state agencies, local governments, tribes, industry and environmental representatives, and the public. An expert panel, stakeholder team, and planning team provided additional input and guidance. The resulting plan serves both as a Federal recovery plan under the ESA and a State of Oregon conservation plan under Oregon's Native Fish Conservation Policy. The plan also influences actions implemented for the Oregon Plan for Salmon and Watersheds, some of which are coordinated by the Oregon Watershed Enhancement Board. This ESU-level plan includes the *Lower Columbia River Conservation and Recovery Plan for Oregon Populations of Salmon and Steelhead* (ODFW 2010) as Appendix A.[15]

1.5.2.4 Relationship Between Management Unit Plans and ESU-Level Plan

This ESU-level recovery plan for the Lower Columbia River ESUs and DPS is a synthesis of the Washington, White Salmon, and Oregon Lower Columbia management unit plans, additional analyses as appropriate, and related recovery plan modules that address estuary habitat and hydropower (see Section 1.5.3). The ESU-level recovery plan provides an ESU-level perspective on the baseline status of the Lower Columbia River ESUs and DPS, goals and delisting criteria, limiting factors, scenarios for reducing threats, recovery actions, implementation, and research, monitoring and evaluation. As required by the ESA, this ESU-level recovery plan fully addresses the recovery needs of the Lower Columbia River salmon ESUs and steelhead DPS, throughout their life cycle and across their geographic range, which encompasses multiple management units.

The more detailed Washington, White Salmon, and Oregon Lower Columbia management unit recovery plans are part of this ESU-level plan, which includes them as appendices. By doing so, the ESU-level plan endorses the management unit plans' recommendations and acknowledges that certain recovery decisions (such as decisions about site-specific habitat actions) are most appropriately left to local recovery planners and implementers, as represented in the management unit plans. Where there are differences between the ESU-level plan and the management unit plans that affect regulatory decisions, management decisions, and implementation of recovery actions, NMFS will coordinate with the management unit leads (Washington's Lower Columbia Fish Recovery Board, the Oregon Department of Fish and Wildlife, and the Washington Gorge Implementation Team) to resolve those discrepancies.

1.5.3 Challenges of Bi-State Coordination and Multiple Management Units

The fact that the Lower Columbia River salmon ESUs and steelhead DPS span two states and three separate management units presents certain challenges in developing an ESU-level recovery plan. First, the sheer volume of information generated through three

[15] The Oregon management unit plan is available at http://www.dfw.state.or.us/fish/CRP/lower_columbia_plan.asp.

separate planning processes is large. This ESU-level plan selects the most relevant information from the three management unit plans to present a coherent overview of the baseline status and potential future of the listed ESUs and DPS; where appropriate, the document refers the reader to more detailed information available in the individual management unit plans.

Second, the level of effort needed to recover the listed ESUs and DPS also is large, and how the responsibility for achieving recovery is apportioned between Oregon and Washington has significant financial and organizational implications for implementing entities in each state. Early in the recovery planning process, management unit planners decided to share the recovery burden between the two states. However, they agreed that in doing so they would consider the historical proportion of populations in each state and where the prospects for recovery are most promising (LCFRB 2010a). Thus, for some ESUs the burden of recovery falls more heavily on one side of the Columbia River than the other. For example, Washington carries the greatest burden in recovering tule fall Chinook salmon, in part because most of the historical fall Chinook salmon populations were in Washington.

Third, the three management unit planning teams took different approaches to developing their recovery plans, in part because different salmon recovery planning structures are in place in Oregon and Washington but also because NMFS encourages recovery plans to be locally developed and supported. This naturally leads to unique approaches. Although each management unit plan contains the elements required for a recovery plan and draws on common scientific principles and resources provided by the WLC TRT, the specific approaches used to develop the required elements, and sometimes the results, varied among the management unit plans. Where relevant, this ESU-level plan acknowledges and describes the differences in approaches and results and discusses the implications of those differences.

Fourth, given the complexity of the salmonid life cycle, some regional issues that affect the Lower Columbia River ESUs and DPS are beyond the scope of any one management plan. Examples include the Federal Columbia River Power System (FCRPS) and the role of the Columbia River estuary in the life cycle of the listed ESUs and DPS. Such issues need to be addressed at the regional level. Thus, NMFS developed the following recovery plan modules that analyze regional issues:

- *Columbia River Estuary ESA Recovery Plan Module for Salmon and Steelhead* (NMFS 2011a; see Appendix D.) The estuary document focuses on habitat in the lower Columbia River below Bonneville Dam and how it affects the survival of ESA-listed, coho, Chinook, chum, and steelhead from throughout the Columbia Basin, including the Lower Columbia River ESUs and DPS. Geographically, the module covers the tidally influenced reaches of the lower river, estuary, and plume. The module identifies and prioritizes limiting factors and threats in the estuary that affect salmonid viability and describes 23 broad actions that, if implemented, would increase the survival of salmon and steelhead during their time in the estuary and plume. Costs, implementation considerations, and research, monitoring, and evaluation needs also are addressed. The actions and recommendations in the estuary module have been incorporated into this ESU-level recovery plan for the Lower Columbia River salmon ESUs and steelhead DPS.

- *Recovery Plan Module: Mainstem Columbia River Hydropower Projects* (NMFS 2008a; see Appendix E.) The hydropower module summarizes the general effects of Columbia River mainstem hydropower projects on all 13 ESA-listed anadromous salmonids in the Columbia Basin. The module's geographical area consists of the accessible mainstem habitat in the upper Columbia River (to the tailrace of Chief Joseph Dam) and Snake River (to the tailrace of Hells Canyon Dam) and downstream to the tailrace of Bonneville Dam. The module describes how salmon and steelhead use the mainstem, habitat limiting factors and threats related to mainstem hydropower projects and operations, and expected actions (including site-specific management actions) or strategy options to address those threats. The actions are those found in the 2008 Federal Columbia River Power System Biological Opinion and its 2010 Supplement (NMFS 2008f and 2010a), which constitute mitigation and recovery actions for the FCRPS through 2018. The hydropower module presents recent survival estimates for ESA-listed populations migrating past mainstem hydroelectric project, and prospective passage survival rates for juveniles for 2014 and beyond.

The estuary and hydropower recovery plan modules provided a consistent set of assumptions and recovery actions for regional-scale issues that management unit planning teams then incorporated into their management unit plans. Additional bi-state consultation and coordination were needed to ensure consistent treatment of hydropower and estuary issues across the management unit plans, as well as of hatchery and harvest issues. Chapter 4 presents additional information on regional-scale limiting factors and recovery strategies.

Topics such as implementation, monitoring, adaptive management, and funding priorities also have both local-scale and regional aspects. This ESU-level recovery plan presents a regional perspective on such topics. Again, considerable bi-state consultation and coordination were needed to integrate these topics across the individual management plans and to develop a regional perspective and approach for the ESU-level recovery plan.

1.5.4 Challenges of Addressing Multiple ESUs/DPSs in a Single Recovery Plan

Preparing a single recovery plan for multiple ESUs presents challenges in terms document organization, level of detail, and prioritization of actions. In some cases, the same limiting factors and threats affect more than one ESU, and the species-specific recovery strategies have the same or similar components. For example, for each ESU the management unit plans propose some similar tributary habitat actions to improve watershed health overall, which will benefit every ESU. In other cases the limiting factors, threats, and recovery actions are unique to an ESU or a run component of a species. To avoid unnecessary repetition from one species analysis to the next, this ESU-level recovery plan includes a chapter on regional-scale limiting factors and recovery strategies; this information applies to multiple ESUs. When appropriate, the individual species analyses refer readers to the regional chapter (Chapter 4) instead of repeating the same or similar recovery strategy information from one ESU to the next. This is the case with watershed-based tributary habitat actions, the estuary habitat strategy, mainstem hydropower actions, the predation strategy, and certain elements of the harvest and hatchery strategies.

Given the large amount of information available in three management unit plans on four different species, another (and related) challenge is to present relevant material at the appropriate level of detail in the ESU-level recovery plan. To maintain a cohesive narrative while not overwhelming the reader, this plan presents some information at a relatively abstract, summary level, with the understanding that readers will refer to the management unit plans for additional detail as their needs and interests dictate.

Lastly, addressing multiple ESUs in a single plan raises the question of how recovery actions will be prioritized across ESUs. This is an issue that the management unit plans, for the most part, did not explicitly address, although they did offer some guidance on the topic. As described in Section 11.2, additional prioritization work is needed at both the management unit and subdomain levels, both within and among threat categories. Section 11.2 discusses prioritization in more detail, summarizing the management unit plans' approaches and offering perspectives for potential consideration during implementation of this recovery plan.

1.5.5 Relationship to Other Processes

Development of this ESU-level recovery plan has been informed by many different conservation and recovery planning processes in Oregon, Washington, and the Pacific Northwest region. Some of these planning processes have been completed, but many are still under way and will continue to influence the content of this recovery plan as it is finalized, along with its implementation in the Lower Columbia subdomain. Planning efforts that have a significant bearing on the design or implementation of this recovery plan are described below.

1.5.5.1 Willamette-Lower Columbia ESA Executive Committee (Ex Com)

The Willamette-Lower Columbia ESA Ex Com performed a coordinating role during the early stages of recovery planning for this domain. Members included the Oregon and Washington Departments of Fish and Wildlife, the governors' offices of Oregon and Washington, Federal agencies, the Lower Columbia River Estuary Partnership, the Lower Columbia Fish Recovery Board, and the Willamette Partnership. During its tenure, the Ex Com worked to help align ongoing regional, state, and local processes with recovery planning; address bi-state and tribal coordination issues; develop agreement on recovery goals and other elements of recovery plans; ensure adequate integration of scientific information with recovery actions and strategies; and ensure that locally developed management unit plans address the needs of the full ESUs or DPSs.

1.5.5.2 Northwest Power and Conservation Council Subbasin Plans

Congress created the Northwest Power and Conservation Council (NPCC) in 1980 to give Washington, Oregon, Idaho, and Montana a voice in regional energy planning and in mitigating the effects of the Federal Columbia River Power System on fish and wildlife. The NPCC developed the Columbia Basin Fish and Wildlife Program, which solicits and evaluates proposals for on-the-ground projects and research to meet these responsibilities. The Bonneville Power Administration (BPA) provides funding for NPCC-identified priority projects. In 2005, to update the Columbia Basin Fish and Wildlife Program, the NPCC completed a watershed planning effort that resulted in locally developed plans for 58 of 62 designated subbasins (tributary watersheds or mainstem segments) in the Columbia Basin, including subbasins within the geographic range of the Lower Columbia River salmon ESUs and steelhead DPS. The plans address the needs of both fish and wildlife.

The subbasin plans provide valuable information on watershed-scale freshwater habitat conditions, limiting factors, and threats, as well as strategies at a subbasin level for addressing those limiting factors and threats. NMFS and its planning partners are using subbasin plans as building blocks for ESA salmon and steelhead recovery plans, and information from the Lower Columbia, White Salmon, Columbia Gorge, Hood, and Willamette subbasin plans has been incorporated into this ESU-level recovery plan. NMFS will continue to work with the NPCC and BPA to coordinate implementation of the Columbia Basin Fish and Wildlife program and ESA salmon recovery plans.

1.5.5.3 2008 FCRPS Biological Opinion and 2010 Supplement

As described in the *Columbia River Estuary ESA Recovery Plan Module for Salmon and Steelhead* (NMFS 2011a) and elsewhere, a limiting factor for Lower Columbia River salmon and steelhead during their time in the Columbia River estuary and, potentially, the plume is flow regulation and other effects related to the Federal Columbia River Power System (FCRPS) and non-Federal Columbia and Snake River dams. The FCRPS is a series of dams and reservoirs that are managed for multiple purposes: power production, flood control, irrigation, navigation, recreation, and fish, wildlife, and cultural resource protection. Dam-related alterations of natural flow patterns in the lower Columbia River, estuary, and plume are responsible for decreased water velocity, longer migratory travel time (which increases exposure to predators) and higher water temperatures during the spring freshet. Each of these factors is associated with mortality of ESA-listed salmon and steelhead.

The ESA requires that Federal actions neither jeopardize the continued existence of a listed species nor result in destruction or adverse modification of designated critical habitat. Under law, the agencies that operate the FCRPS—the Bonneville Power Administration, U.S. Army Corps of Engineers, and Bureau of Reclamation (collectively referred to as the Action Agencies)—must consult with NMFS on proposed FCRPS operations that may affect a listed fish species or its habitat. The product of such consultation is a Biological Opinion.

In preparation for NMFS' 2008 Biological Opinion on the FCRPS, the Action Agencies concluded that, without further mitigation, operation of FCRPS projects would jeopardize listed species. Consequently, the Action Agencies presented NMFS with a package of additional measures designed to benefit listed species, including the Lower Columbia River salmon ESUs and steelhead DPS. Some of these actions were drawn from the *Columbia River Estuary ESA Recovery Plan Module for Salmon and Steelhead* (NOAA Fisheries 2009), which describes the FCRPS's effects on fish and presents recommendations and strategies for action. NMFS incorporated the Action Agencies' proposed additional mitigation measures into its analysis for the 2008 FCRPS Biological Opinion, which considers the mainstem Columbia from Bonneville Dam to the river's mouth.

The 2008 FCRPS Biological Opinion was issued on May 5, 2008. In February 2010, NMFS issued the 2010 Supplemental Biological Opinion for the FCRPS (NMFS 2010a). This Supplemental Biological Opinion integrated elements from the 2008 Biological Opinion and the Adaptive Management Implementation Plan (AMIP). The AMIP included accelerated and enhanced actions to protect Columbia Basin salmon and steelhead, including commitments to additional estuary habitat improvement actions under a new agreement with the state of Washington and additional efforts to control native and exotic predators. It also included enhanced research and monitoring and specific biological triggers for contingencies linked to unexpected declines in the abundance of listed salmon and steelhead.

At the time this recovery plan was being drafted, it was the position of the State of Oregon that additional or alternative actions should be taken in mainstem operations of the FCRPS for ESA-listed salmon and steelhead. Some additional or alternative actions recommended by Oregon, while considered, were not included in NMFS' 2008 FCRPS Biological Opinion and its 2010 Supplement because NMFS is not in agreement regarding the need for or efficacy of these additional actions. At this time, Oregon is a plaintiff in litigation against various Federal agencies, including NMFS, challenging the adequacy of the measures contained in the current FCRPS Biological Opinion. On August 2, 2011, Judge James A. Redden of the U.S. District Court (District of Oregon) issued an opinion and order that remanded the 2008 Biological Opinion and its 2010 Supplement back to NMFS. Judge Redden left the Biological Opinion in place until a new opinion is issued no later than January 1, 2014, and ordered that all of the opinion's mitigation measures be funded and implemented in that time.

1.5.5.4 Columbia River Hatchery Scientific Review Group (HSRG)

In 2005, Congress directed NMFS to use the Puget Sound and coastal Washington hatchery reform project as a model for similar reform in the Columbia Basin. The Columbia River Hatchery Scientific Review Group (HSRG) conducted a collaborative, scientific review and identified alternatives for managing hatchery programs and fisheries to meet managers' goals for harvest and recovery (Hatchery Scientific Review Group 2009).

The HSRG concluded that hatcheries play an important role in the management of salmon and steelhead populations in the Pacific Northwest. Nevertheless, the traditional practice of replacing natural populations with hatchery fish to mitigate for habitat loss and mortality resulting from hydropower dams is not consistent with contemporary conservation principles and scientific knowledge. Hatchery fish cannot replace lost habitat or the natural populations that rely on that habitat.

The HSRG concluded that hatchery programs should be viewed as tools that can be managed as part of a coordinated strategy to meet watershed or regional resource goals, in concert with actions affecting habitat, harvest rates, water allocation, and other factors that influence salmon and steelhead survival. The HSRG summary conclusions regarding areas where current hatchery and harvest practices need to be reformed through policy, management, research, and monitoring practices were as follows:

- Manage hatchery broodstocks to achieve proper genetic integration with, or segregation from, natural populations.
- Promote local adaptation of natural and hatchery populations.
- Minimize adverse ecological interactions between hatchery- and natural-origin fish.
- Minimize effects of hatchery facilities on the ecosystem.
- Maximize survival of hatchery fish.

The HSRG also developed three principles for hatchery management that are applicable to hatchery programs across Puget Sound, the Washington Coast, and the Columbia Basin: (1) develop clear, specific, and quantifiable harvest and conservation goals for natural and hatchery populations within an "all-H" context, (2) design and operate hatchery programs in a scientifically defensible manner, and (3) monitor, evaluate, and adaptively manage hatchery programs. The HSRG concluded that the more closely hatchery programs adhere to these principles, the greater the likelihood of their contribution to the managers' harvest and conservation goals.

Local recovery planners considered the HSRG's general and population-specific recommendations in developing hatchery actions for their recovery plans.

1.5.5.5 State-Level Planning Processes

Native Fish Conservation Policy

The Oregon Fish and Wildlife Commission adopted the Native Fish Conservation Policy (NFCP) in November 2002 to provide a basis for managing fisheries, habitat, hatcheries, predators, competitors, and pathogens in balance with sustainable production of naturally produced native fish. The three goals of the policy are to (1) prevent the serious depletion of native fish, (2) restore and maintain naturally produced fish in order to provide substantial ecological, economic and cultural benefits to the citizens of Oregon, and (3) foster and sustain opportunities for fisheries consistent with the conservation of naturally produced fish and responsible use of hatcheries. The NFCP is to be implemented and its goals achieved through the development of conservation plans for individual groups of populations, or species management units. The *Lower Columbia River Conservation and Recovery Plan for Oregon Populations of Salmon and Steelhead* (Oregon Department of Fish and Wildlife 2010) meets the requirements for NFCP conservation plans as well as those for an ESA recovery plan for salmon and steelhead.

Oregon Plan for Salmon and Watersheds

In 1997 Oregon's Governor and Legislature adopted the Oregon Plan for Salmon and Watersheds to begin state-led recovery efforts. The mission of the plan is to restore Oregon's native fish populations and the aquatic systems that support them to productive and sustainable levels that will provide substantial environmental, cultural, and economic benefits. The plan has a strong focus on salmon, with actions designed to improve water quality and quantity and restore habitat.

Oregon is implementing the Oregon Plan for Salmon and Watersheds in a manner that is consistent with ESA recovery planning and other Oregon programs related to salmon. Watershed councils and soil and water conservation districts lead efforts in many subbasins, with support from landowners and other private citizens, recreational and commercial fishing interests, the timber industry, environmental groups, agriculture, utilities, businesses, tribes, and all levels of government. The Oregon Plan relies on volunteerism and stewardship, public education and awareness, scientific oversight, coordinated tribal and government efforts, and ongoing monitoring and adaptive management to achieve program success.

Oregon Watershed Enhancement Board

The Oregon Watershed Enhancement Board (OWEB) is a state agency that supports Oregon's efforts to improve water quality, strengthen ecosystems, and restore salmon runs. OWEB coordinates the Oregon Plan for Salmon and Watersheds' implementation of recovery plans for both state and Federally listed species, including ESA-listed salmonids in the Columbia River and Upper Willamette basins. OWEB administers a grant program funded from Oregon Lottery proceeds and salmon license plate sales. The program funds the cooperative conservation work of a wide variety of participants, with up to 70 percent of the grant funding apportioned to on-the-ground restoration projects. OWEB also administers three other salmon-related programs: (1) the Federal Pacific Coastal Salmon Recovery Funds (PCSRF) for the state, for projects that measurably contribute to the recovery of ESA-listed salmon and steelhead, (2) the OWEB Small Grant Program for local watershed restoration, and (3) the Conservation Reserve Enhancement Program (CREP), a voluntary land retirement program that helps agricultural landowners establish riparian vegetation along streams.

Washington Watershed Planning

The state Watershed Management Act (Revised Code of Washington [RCW] 90.82) gives local communities the opportunity to plan for the future use of their water resources in consultation with state agencies. To facilitate this planning, the state has been divided into Water Resource Inventory Areas (WRIAs), seven of which are within the Lower Columbia recovery planning area.[16] The Lower Columbia Fish Recovery Board coordinates watershed planning in four of the seven lower Columbia WRIAs. Klickitat County coordinates watershed planning in the White Salmon WRIA. Watershed plans for these WRIAs will address issues associated with water quantity, water quality, stream flows, and habitat, including the current condition of fish habitat and measures to protect or enhance habitat to support salmon recovery efforts.

Water quantity and quality and stream flow studies and data collected by the watershed planning initiatives have been incorporated into the *Washington Lower Columbia Salmon Recovery and Fish & Wildlife Subbasin Plan* (LCFRB 2010a), and habitat data collected

[16] WRIA 24 is partially in the Lower Columbia River subdomain; WRIAs 25, 26, 27, 28, and 29 are wholly within the Lower Columbia River subdomain; WRIA 29 is split into 29A (Wind) and 29B (White Salmon).

through the recovery planning effort has been shared with the watershed planning effort. Policies, strategies, actions, and priorities associated with ESA recovery planning and water resource planning are being coordinated to ensure that they are compatible and complement each other.

Washington Salmon Habitat Protection and Restoration

The Washington Salmon Recovery Act (RCW 77.85) provides for the funding of habitat protection and restoration efforts, requires local and regional program organizations to identify and prioritize project needs, and directs the Washington Department of Fish and Wildlife to develop guidance for regional salmon recovery efforts.

The Salmon Recovery Funding Board (SRFB) coordinates the funding process on the statewide level. It establishes program policies and directions and grant requirements, screens project proposals, and awards grants. Lead entities coordinate the process on the local or regional level. They develop habitat protection and restoration strategies for their area and solicit, evaluate, rank, and propose projects to the SRFB. The Lower Columbia Fish Recovery Board serves as the lead entity for most of the lower Columbia subdomain. In this capacity, the LCFRB has developed and annually updated and expanded a lower Columbia habitat strategy that provides a basis for prioritizing proposed habitat projects. Development of the strategy has been merged with ESA recovery planning in Washington such that elements of the strategy became an integral part of the *Washington Lower Columbia Salmon Recovery and Fish & Wildlife Subbasin Plan* (LCFRB 2010a) and thus this ESU-level recovery plan. Klickitat County serves as the lead entity for the White Salmon subbasin and has developed a strategy to guide prioritization of proposed habitat projects for that watershed.

1.6 Tribal Treaty and Trust Responsibilities

The salmon and steelhead that were once abundant in the watersheds of the lower Columbia Basin were crucial to Native Americans throughout the region. Pacific Northwest Indian tribes today retain strong spiritual and cultural ties to salmon and steelhead, based on thousands of years of use for tribal religious/cultural ceremonies, subsistence, and commerce. Many Northwest Indian tribes have treaties reserving their right to fish in usual and accustomed fishing places, including areas covered by this recovery plan. Additionally, four Washington coastal tribes have treaty rights to ocean salmon harvest that may include some Lower Columbia River salmon stocks. These Columbia Basin and Washington Coast treaty tribes are co-managers of salmon stocks and participate in management decisions, including those related to hatchery production and harvest. Some other tribes in the Columbia Basin, whose reservations were created by Executive Order, do not have treaty reserved rights but do have a trust relationship with the Federal government and an interest in salmon and steelhead management, including harvest and hatchery production. Other Indian tribes, while not asserting treaty reserved rights, do fish for subsistence and ceremonial purposes in areas covered by this plan, in compliance with agreements with the state of Oregon.

Native American treaty-reserved fishing rights in the Columbia basin are under the continuing jurisdiction of the U.S. District Court for the District of Oregon in the case *United States v. Oregon*, No. 68-513 (filed in 1968). In *U.S. v. Oregon*, the Court affirmed that certain treaties reserved for the tribes 50 percent of the harvestable surplus of fish destined to pass through their usual and accustomed fishing areas. The *U.S. v. Oregon* process affects the allocation of harvest among various fisheries and thus affects how fisheries are managed in the lower Columbia River; in addition, Lower Columbia River populations that spawn above Bonneville Dam are intercepted in tribal fisheries.

Restoring and sustaining a sufficient abundance of salmon and steelhead for harvest is an important requirement in fulfilling tribal fishing aspirations. NMFS is committed to meeting Federal treaty and trust obligations to the tribes. These obligations are described in a July 21, 1998, letter from Terry D. Garcia, Assistant Secretary for Oceans and Atmosphere, U.S. Department of Commerce, to Mr. Ted Strong, Executive Director of the Columbia River Inter-Tribal Fish Commission. This letter states that recovery "must achieve two goals: (1) the recovery and delisting of salmonids listed under the provisions of the ESA, and (2) the restoration of salmonid populations over time, to a level to provide a sustainable harvest sufficient to allow for the meaningful exercise of tribal fishing rights." Thus it is appropriate for recovery plans to take these conditions into account and plan for a recovery strategy that includes Indian harvest. In some cases, the desired abundances for harvest may come about through increases in the naturally spawning population. In others, the recovery strategy may include use of hatcheries to support tribal harvest, so long as the hatcheries do not impede biological recovery of the listed ESUs and DPS.

The NMFS Regional Administrator, in testimony before the U.S. Senate Indian Affairs Committee (Lohn 2003), emphasized the importance of this co-manager relationship: "We have repeatedly stressed to the region's leaders, tribal and non-tribal, the importance of our co-management and trust relationship to the tribes. NMFS enjoys a positive working relationship with our Pacific Northwest tribal partners. We view the relationship as crucial to the region's future success in recovery of listed salmon."

2. Defining Viability for Salmon and Steelhead

This chapter presents biological background information that will aid the reader in understanding the limiting factor and threats analyses, recovery criteria and goals, and recovery strategies that are part of this ESU-level recovery plan. Specifically, the chapter describes basic concepts in salmonid biology (i.e., biological structure, population viability, and critical habitat), presents biological criteria the WLC TRT developed for assessing the viability of Lower Columbia River salmon and steelhead, and briefly summarizes methods and benchmarks the WLC TRT recommends for evaluating individual population status. (Chapter 5 provides additional details on methods.) Recovery goals in the management unit plans and NMFS' criteria for delisting the Lower Columbia River species are both based on this work of the WLC TRT. (See Chapter 3 for recovery goals and delisting criteria.)

2.1 ESU/DPS Biological Structure

Salmonid species' homing propensity (their tendency to return to the locations where they originated) creates unique patterns of genetic variation and connectivity among spawning areas across the landscape. Diverse genetic, life history, and morphological characteristics have evolved in salmon and steelhead over generations, creating runs adapted to diverse environments. It is this variation that gives a salmonid species as a whole the resilience to persist over time.

Historically, a salmon ESU or steelhead DPS typically contained multiple populations connected by some small degree of genetic exchange that reflected the geography of the river basins in which they spawned. Thus, the overall biological structure of the ESU or DPS is hierarchical, and spawners in the same area of the same stream share more characteristics than those in the next stream over. Fish whose natal streams are separated by hundreds of miles generally have less genetic similarity. The ESU or DPS is essentially a metapopulation defined as a group of populations connected by limited exchange of migrants. Recovery planning efforts focus on this biologically based hierarchy, which reflects the degree of connectivity between the fish at each geographic and conceptual level.

McElhany et al. (2000) identified two levels in this hierarchy for recovery planning purposes: the evolutionarily significant unit and the independent population. The WLC TRT identified an additional level between the population and ESU/DPS levels: the stratum (McElhany et al. 2003). Strata are analogous to major population groups (MPGs) as defined by the Interior Columbia TRT and to geographic regions described by the Puget Sound TRT.

This recovery plan adopts the ESU/DPS, stratum, and population structure described below. NMFS and the WLC TRT identified the ESUs/DPS, strata, and populations of Lower Columbia River salmon and steelhead based on geography, migration rates, genetic attributes, life history patterns, phenotypic characteristics, population dynamics, and environmental and habitat characteristics (Myers et al. 2006), as well as an understanding of the characteristics of viable salmonid populations (McElhany et al. 2000).

2.1.1 Evolutionarily Significant Units and Distinct Population Segments

Two criteria define an ESU of salmon under NMFS' ESU policy: (1) it must be substantially reproductively isolated from other conspecific units, and (2) it must represent an important component of the evolutionary legacy of the species (Waples 1991).

Two similar but slightly different criteria define a DPS of steelhead under the joint NMFS-U.S. Fish and Wildlife Service DPS policy: (1) discreteness of the population segment in relation to the remainder of the species to which it belongs, and (2) significance of the population segment to the species to which it belongs.

An ESU or DPS can contain multiple populations that are connected by some degree of migration, and hence may have a broad geographic range across watersheds, river basins, and political jurisdictions.

2.1.2 Strata

Within an ESU or DPS, independent populations can be grouped into larger groups based on ecological zone and dominant life history strategy, expressed as run timing, meaning the time of year when salmon return to native freshwater systems. These major population groups, or strata, share similar genetic, geographic, and/or habitat characteristics. Strata are isolated from one another over a longer time scale than that defining the individual populations, but they retain a degree of connectivity greater than that between different ESUs or DPSs. Figure 2-1 shows the relationship between ESU/DPS, strata, and independent populations.

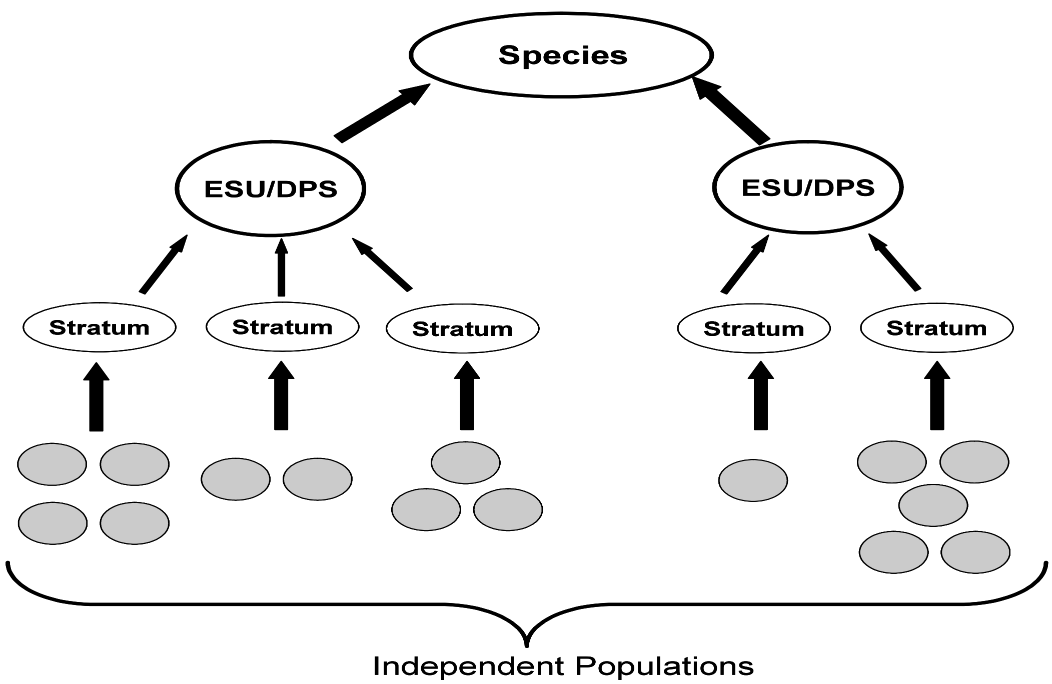

Figure 2-1. *Hierarchical Levels of Salmonid Species Structure for ESU/DPS Recovery Planning*
Source: ODFW 2010.

In the case of Lower Columbia River salmon and steelhead, strata are defined by a combination of ecological zone—Coast, Cascade, or Gorge—and dominant life history strategy, such as spring, fall, or late fall run timing. For example, Cascade fall Chinook and Cascade spring Chinook are separate strata. (See Tables 6-2, 7-2, 8-1, and 9-2 for the historical populations and strata for the salmon ESUs and steelhead DPS covered by this recovery plan.)

2.1.3 Independent Populations

McElhany et al. (2000) defined an independent population as follows:

> "… a group of fish of the same species that spawns in a particular lake or stream (or portion thereof) at a particular season and which, to a substantial degree, does not interbreed with fish from any other group spawning in a different place or in the same place at a different season. For our purposes, not interbreeding to a 'substantial degree' means that two groups are considered to be independent populations if they are isolated to such an extent that exchanges of individuals among the populations do not substantially affect the population dynamics or extinction risk of the independent populations over a 100-year time frame."

It is seldom possible to obtain exact measures of the degree of interbreeding between groups of fish. Therefore, the WLC TRT used several kinds of information to build up an understanding of population boundaries: geography, migration rates, genetic attributes, patterns of life history and phenotype (visible characteristics), abundance data, and environment (Myers et al. 2006). According to WLC TRT definitions, a population cannot be larger than a stratum or an ESU or DPS.

2.2 Viable Salmonid Populations

Viability is a key concept within the context of the Endangered Species Act. A viable salmonid ESU or DPS is naturally self-sustaining over the long term. A viable salmonid population has a negligible risk of extinction over a 100-year time frame (McElhany et al. 2000). McElhany et al. (2000) describe viable salmonid populations (VSPs) in terms of four parameters: abundance, population productivity or growth rate, population spatial structure, and life history and genetic diversity. Although these parameters sometimes are analyzed discretely, they are closely associated, such that improvements in one parameter typically cause or are related to improvements in another. For example, productivity improvements might depend on increased diversity or habitat quality and be accompanied by increased abundance and distribution.

2.2.1 Abundance and Productivity

Abundance refers to the number of spawners (adults on the spawning ground), averaged over a time period sufficient to account for year-to-year fluctuations that are due to natural environmental variation. The productivity of a population (the average number of surviving offspring per parent) is a measure of the population's ability to sustain itself. Productivity can be measured as spawner-to-spawner ratios (returns per spawner or recruits per spawner, meaning adult progeny to parent), annual population growth rate, or trends in abundance. Population-specific estimates of abundance and productivity are derived from time series of annual estimates, which typically are subject to a high degree of annual variability and sampling-induced uncertainties.

Abundance and productivity are linked. Populations with low productivity can still persist if they are sufficiently large, and small populations can persist if they are sufficiently productive. A viable salmonid population needs sufficient abundance to maintain genetic health and to respond to normal environmental variation, and sufficient productivity to enable the population to quickly rebound from periods of poor ocean conditions or freshwater perturbations.

The VSP guidelines for abundance recommend that a viable population should (1) be large enough to have a high probability of surviving environmental variation observed in the past and expected in the future, (2) be resilient to environmental and anthropogenic disturbances, (3) maintain genetic diversity, and (4) provide ecosystem functions (McElhany et al. 2000). Factors suggesting that a population is at a critically low size include decreased reproductive success because individuals cannot efficiently find mates, fixation of harmful genetic mutations or reduced fitness as a result of inbreeding, and random demographic effects, such as if the variation in individual reproduction becomes important.

Productivity guidelines for viability are reached when a population's productivity is such that abundance can be maintained above the viable level, viability is independent of hatchery subsidy, viability is maintained even during sequences of poor environmental conditions, declines in abundance are not sustained, life history traits are not in flux, and conclusions about a population's productivity are independent of uncertainty in parameter estimates (McElhany 2000).

Viability analyses of Lower Columbia River salmon and steelhead suggest that, in general, populations of at least 500 fish are needed to ensure that critically low numbers do not result from normal variations in environmental conditions (McElhany et al. 2003). However, this number does not reflect actual minimum viable population sizes for the purposes of recovery planning. The abundance and productivity needed for recovery varies from one population to the next because of differences in habitat quantity, habitat quality, fish distribution, juvenile production, spatial structure, and life history and genetic diversity. The recovery goals in Chapter 3 reflect these variations.

2.2.2 Spatial Structure and Diversity

Considerations of spatial structure and diversity are combined in the evaluation of a salmonid population's status because they often overlap. A population's spatial structure is made up of both the geographic distribution of individuals in the population and the processes that generate that distribution (McElhany et al. 2000). Spatial structure refers to the amount of habitat available, the organization and connectivity of habitat patches, and the relatedness and exchange rates of adjacent populations. Spatial structure influences the viability of salmon and steelhead because populations with restricted distribution and few spawning areas are at a higher risk of extinction as a result of catastrophic environmental events, such as a landslide, than are populations with more widespread and complex spatial structures. A population with a complex spatial structure, including multiple spawning areas, experiences more natural exchange of gene flow and life history characteristics. (However, excessive exchange of migrants above historical levels can impede the process of local adaptation.)

Diversity refers to the distribution of life history, behavioral, and physiological traits within and among populations. Some traits are completely genetically based, while others, including nearly all morphological, behavioral, and life history traits, vary as a result of a combination of genetic and environmental factors (McElhany et al. 2000).

Like spatial structure, population-level diversity is important for long-term persistence of salmon and steelhead. Populations exhibiting greater diversity are generally more resilient to short-term and long-term environmental changes. Phenotypic diversity, which includes variation in morphology and life history traits, allows more diverse populations to use a wider array of environments, and protects populations against short-term temporal and spatial environmental changes. Underlying genetic diversity provides the ability to survive long-term environmental changes.

Because neither the precise role that diversity plays in salmonid population viability nor the relationship of spatial processes to viability is completely understood, the management unit plans and this ESU-level recovery plan adopt the principle from McElhany et al. (2000) that historical spatial structure and diversity should be taken as a "default benchmark," on the assumption that historical, natural populations did survive many environmental changes and therefore must have had adequate spatial structure and diversity.

McElhany et al. (2000) also offers spatial structure and diversity guidelines for viable salmonid populations. Spatial structure guidelines are reached when the number of habitat patches is stable or increasing, stray rates are stable, marginally suitable habitat patches are preserved, refuge source populations are preserved, and uncertainty is taken into account. Diversity guidelines are reached when variation in life history, morphological, and genetic traits is maintained; natural dispersal processes are maintained; ecological variation is maintained; and the effects of uncertainty are considered.

For all four of the viable salmonid population parameters, the guidelines recommend that population-specific status evaluations, goals, and criteria take into account the level of scientific uncertainty about how an individual parameter relates to a population's viability (McElhany 2000).

2.3 Critical Habitat

The ESA requires the federal government to designate critical habitat for any species it lists under the ESA, with critical habitat defined as occupied areas that contain physical or biological features that are essential for the conservation of the species and that may require special management or protection, and unoccupied areas that are essential for conservation. Critical habitat designations must be based on the best scientific information available, in an open public process, within specific time frames. The designations are one factor to consider during the identification and prioritization of recovery actions in recovery plans.

A critical habitat designation applies only when federal funding, permits, or projects are involved. Under section 7 of the ESA, all federal agencies must ensure that any actions they authorize, fund, or carry out are not likely to jeopardize the continued existence of a listed species, or destroy or adversely modify its designated critical habitat. Before critical habitat is designated, careful consideration must be given to its economic impacts, impacts on national security, and other relevant impacts. The Secretary of Commerce may exclude an area from critical habitat if the benefits of exclusion outweigh the benefits of designation, unless excluding the area will result in the extinction of the species concerned.

In determining which areas should be critical habitat, NMFS identified the geographic areas occupied by the species and the physical or biological features essential for the conservation of the species. For all salmon ESUs and steelhead DPSs this includes sites and habitat components that support one or more life stages; examples include (1) freshwater spawning sites, (2) freshwater rearing sites, (3) freshwater migration corridors, and (4) estuarine areas. NMFS also identified features associated with these types of sites that play an essential role in maintaining habitat health. These features also describe the habitat factors associated with viability for all ESUs and DPSs (although the specific habitat requirements for each ESU and DPS differ by life history type and life stage).

On September 2, 2005, NMFS published a final rule (70 *Federal Register* 52630) to designate critical habitat for 13 ESUs and DPSs of ESA-listed salmon and steelhead. Lower Columbia River Chinook, steelhead, and chum were included in this rule, but critical habitat for Lower Columbia River coho has not yet been designated. Critical Habitat Assessment Review Teams rated the conservation value of all watersheds that supported populations of the listed species and, depending on the importance of the watersheds to salmonid survival, assigned ratings of high, medium, or low. These ratings were used in determining the final critical habitat designations.

The final designations focus on certain physical and biological elements that support one or more salmonid life stages (spawning, rearing, migration, and foraging) and that are essential to the conservation of the species. The designations balanced ratings of the areas that provide the greatest biological benefits for listed salmon and steelhead with economic and other costs.

Maps of the critical habitat areas are available at http://www.nwr.noaa.gov/Salmon-Habitat/Critical-Habitat/CH-Maps.cfm and in the Federal Register notice, which also contains legal descriptions of the critical habitat areas.

NMFS recognizes that salmon habitat is dynamic and that current understanding of areas important for conservation will likely change as recovery planning sheds light on areas that can and should be protected and restored. NMFS will update the critical habitat designations as needed based on information developed during recovery plan implementation.

2.4 WLC TRT Biological Viability Criteria

The WLC TRT developed biological viability criteria that it recommends be used to assess long-term extinction risk at the ESU, stratum, and population level. Based on best available science, these criteria consist of a combination of general statements and metrics that characterize viability; the WLC TRT also suggested methods of applying the criteria to assess the probability that a population, stratum, or ESU will persist. As described in Chapter 3, the biological viability criteria summarized below served as an important foundation from which the management unit planners decided on recovery goals and NMFS developed delisting criteria for Lower Columbia River salmon and steelhead ESUs.

2.4.1 Background

NMFS asked the WLC TRT to develop biological viability criteria for use as the basis of recovery goals and delisting criteria. Biological viability criteria describe ESU or DPS characteristics associated with a low risk of extinction for the foreseeable future and are defined at the ESU/DPS, stratum, and population levels. (A stratum is a group of independent populations that share similar environments, life-history characteristics, and geographic proximity.) The status of a salmon ESU or steelhead DPS as a whole is evaluated by considering the status of each of its strata; the status of a stratum, in turn, is determined by considering the status of each of its component populations.

At the ESU or DPS level, viability criteria inform the questions of how many and which populations need to be viable (i.e., at a low risk of extinction) and what the appropriate risk levels are for other populations so that the ESU or DPS as a whole has a low risk of extinction. For the Lower Columbia River salmon ESUs and steelhead DPS, biological viability criteria are based on guidelines developed by NMFS' Northwest Fisheries Science Center and published as a NMFS technical memorandum, *Viable Salmonid Populations and the Recovery of Evolutionarily Significant Units* (McElhany et al. 2000). The guidelines in McElhany et al. (2000) are intended to aid in the following:

1. Management of risks to the ESU or DPS from catastrophic events. Having multiple, geographically dispersed populations in an ESU or DPS reduces the risk of extinction from a single catastrophic event.

2. Maintenance of long-term demographic processes. Having multiple populations in an ESU or DPS—some in proximity and some dispersed—allows natural demographic processes to occur, such as population-level extinction and recolonization.

3. Maintenance of long-term evolutionary potential. Having multiple populations distributed across the geography of the ESU or DPS and representing diverse life histories and phenotypes allows for the genetic processes characteristic of long-term evolution.

At the stratum level, the WLC TRT developed criteria to guide decisions about which populations to target for various levels of viability. At the population level, the TRT developed criteria that describe viable salmonid populations (VSPs) in terms of the parameters of abundance, productivity, spatial distribution, and diversity, according to guidelines in McElhany et al. (2000). (See Section 2.5.5 of this recovery plan for the VSP guidelines.)

The TRT's biological viability criteria take the form of general statements that characterize viability, metrics that describe viable populations and strata, methodologies for evaluating whether a population or stratum is viable, and, if not, what its current extinction risk (or persistence probability) is. This chapter presents the WLC TRT's biological viability criteria and their recommended methods and metrics for evaluating population status.

2.4.2 Viability Criteria Technical Reports

The WLC TRT outlined its viability criteria for Lower Columbia River salmon and steelhead populations, strata, and ESUs in a series of technical reports. The *Interim Report on Viability Criteria for Willamette and Lower Columbia Basin Pacific Salmonids* (McElhany et al. 2003) presents the WLC TRT's initial recommendations regarding ESU-, stratum-, and population-level viability criteria. For population-level criteria, this report considered five population-level attributes: (1) adult abundance and productivity (combined into a single attribute because abundance and productivity are so interlinked in their effect on extinction risk), (2) juvenile outmigrant growth rate, (3) spatial structure, (4) habitat, and (5) diversity. The 2003 interim report also introduced general principles and approaches for evaluating current population status and suggested a qualitative scoring system based on the five population attributes.[1]

In 2006 the WLC TRT produced *Revised Viability Criteria for Salmon and Steelhead in the Willamette and Lower Columbia Basins* (McElhany et al. 2006). The revised criteria relied on three population-level attributes instead of five: (1) abundance and productivity (still combined into a single attribute), (2) spatial structure, and (3) diversity. (Juvenile outmigrant productivity was incorporated into abundance and productivity, and habitat attributes were addressed as part of the discussion of listing factors criteria [McElhany et al. 2006]). The revised viability criteria also recommended the use of viability curves and minimum abundance thresholds to evaluate abundance and productivity—rather than the population change criteria approach suggested in McElhany et al. (2003)—and provided initial viability curves and benchmarks for the Lower Columbia River ESUs.[2]

Additional work to refine approaches for evaluating population status was captured in *Viability Status of Oregon Salmon and Steelhead Populations in the Willamette and Lower Columbia Basins* (McElhany et al. 2007). This document is not a WLC TRT product, as the WLC TRT had dissolved in 2006 after completing the revised viability criteria in McElhany et al. (2006). Instead, *Viability Status of Oregon Salmon and Steelhead Populations*

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[1] The 2003 interim report was supplemented in 2004 by the *Status Evaluation of Salmon and Steelhead Populations in the Willamette and Lower Columbia River Basins* (McElhany et al. 2004), which applied the methodology described in McElhany et al. (2003) to Lower Columbia River salmon and steelhead populations and some Upper Willamette populations.

[2] The 2006 report also discussed methods for evaluating population status in more depth than previous reports; refined analyses, metrics, and benchmarks; and applied the spatial structure methodology to Oregon LCR coho as a demonstration and test case, using newly available habitat accessibility maps published in 2005 (Maher et al. 2005). For more detail on the TRT's population status assessment methodology, see Section 2.6 of this recovery plan.

in the Willamette and Lower Columbia Basins (McElhany et al. 2007) was a collaborative effort of NMFS Northwest Fisheries Science Center staff, ODFW staff, and a private consultant working for the Lower Columbia Fish Recovery Board to refine population status assessments for the Oregon and Washington management unit plans. The document is described here because it made valuable contributions to methods for population status assessment.

McElhany et al. (2007) provides modified minimum abundance thresholds and viability curves for the Lower Columbia River ESUs. It also provides additional detail on how to evaluate the diversity attribute. Lastly, the 2007 document applies the WLC TRT recommendations for evaluating population status to Oregon populations of Lower Columbia River salmon and steelhead. Especially for spatial structure, the methods and approaches are similar to those in the 2006 report; where they differ, the methods described and demonstrated in *Viability Status of Oregon Salmon and Steelhead Populations in the Willamette and Lower Columbia Basins* (McElhany et al. 2007) supersede those in the 2006 report and earlier WLC TRT documents.

The WLC TRT's viability criteria are summarized below.

2.4.3 TRT ESU-Level Viability Criteria

2.4.3.1 Defining ESU-Level Viability

As described in Section 2.1, each Lower Columbia River salmon and steelhead stratum is defined by a combination of ecological zone (Coast, Cascade, or Gorge) and dominant life history strategy, expressed as run timing (fall, winter, etc.). The WLC TRT defined a viable Lower Columbia River ESU or DPS in terms of the status of its component strata:

> In a viable ESU or DPS, "every stratum (life history and ecological zone combination) that historically existed should have a high probability of persistence" (McElhany et al. 2003 and 2006).

The strata represent major diversity units within the ESU or DPS. Given the correlation between diversity and species resilience, the persistence of every historical stratum provides a substantial buffer against the negative effects of environmental variation, catastrophic events, and loss of genetic variation. It is the TRT's view that the loss of any particular stratum within an ESU or DPS would significantly reduce the resilience of that ESU or DPS and significantly increase its risk of extinction.

2.4.3.2 ESU-Level Recovery Strategy Guidelines

The WLC TRT also suggested two guidelines for use in developing ESU-level recovery strategies:

- **Non-deterioration**: Until all ESU viability criteria have been achieved, no population should be allowed to deteriorate in its probability of persistence.

- **Safety factors:** High levels of recovery should be attempted in more populations than recommended for strata-level viability because not all attempts will be successful. (McElhany et al. 2003 and 2006)

These guidelines emphasize the uncertainties inherent in the recovery process and build in safety factors to increase the likelihood of achieving viability goals. The WLC TRT illustrated the benefit of targeting more than the minimum number of populations for high levels of recovery by calculating that the chances of recovering at least three populations within an ESU go from 51 percent to 95 percent if the number of populations in which recovery is attempted goes from three to six, assuming that the probability of successful recovery for any given population is 80 percent (McElhany et al. 2003).

2.4.4 TRT Stratum-Level Viability Criteria

If a viable ESU or DPS is one in which every stratum that existed historically has a high probability of persistence, what constitutes a high-persistence stratum? It is the WLC TRT's view that, although representative populations need to be preserved, not every historical population needs to be restored for a stratum to be highly persistent. The WLC TRT defined a high-persistence stratum in terms of two criteria, the first concerning the number of populations that need to be viable and the second concerning which populations need to be viable.

2.4.4.1 Criterion 1: How Many Populations in the Stratum Should Be Viable?

> **Criterion 1:** Individual populations within a stratum should have persistence probabilities consistent with a high probability of strata persistence (McElhany 2003 and 2006).

The WLC TRT further described this criterion in terms of an adequate persistence probability for each individual population, using a four-point scale. As shown in Table 2-1, 0 indicates a population that has a very low probability of persisting over a 100-year time frame and 4 indicates a population that has a very high probability of persisting.

Table 2-1
Population Viability Categories, Corresponding to 100-Year Extinction Risk

Probability of Persistence*	Extinction Risk	Population Viability	Persistence Score
0 – 40%	Extinct or very high risk of extinction (VH)	Very low (VL)	0
40 – 75%	Relatively high risk of extinction (H)	Low (L)	1
75 – 95%	Moderate risk of extinction (M)	Medium (M)	2
95 – 99%	Low/negligible risk of extinction (L)	High (H)	3
> 99%	Very low risk of extinction (VL)	Very high (VH)	4

* Probability of population persisting over a 100-year time frame.
Source: McElhany et al. (2006).

The extinction risk of the entire stratum is determined by averaging the viability scores for the individual populations that make up the stratum, with an average of 2.25 or higher indicating a stratum that has a high probability of persistence. Additionally, the WLC TRT recommended that a stratum have at least two populations with a viability score of 3 or higher for the stratum to be considered highly likely to persist. (Table 2-2 shows the stratum-level extinction risks associated with different averages of population risk.)

In other words, for a stratum to have a high probability of persistence, at least two populations must be at least 95 percent likely to persist over a 100-year time frame and the average viability of all the populations in the stratum must be 2.25 or higher. (This is roughly equivalent to requiring that at least 50 percent of the populations in a stratum be viable, but using the average population persistence score recognizes that population status is a continuum and not a simple dichotomy of viable or not viable.)

Table 2-2
Stratum-Level Extinction Risk Associated with Population Risk

Probability of Stratum Persistence	Population Persistence
Low Persistence	Average score: < 2
Moderate Persistence	Average score: 2 to < 2.25 At least two populations: 3 or higher
High Persistence	Average score: 2.25 or higher At least two populations: 3 or higher

Source: McElhany et al. (2003).

2.4.4.2 Criterion 2: Which Populations in the Stratum Should Be Viable?

The TRT presented a second stratum-level criterion that offers guidance on which populations need to be viable:

Criterion 2: Within a stratum, the populations restored/maintained at viable status or above should be selected to:

a. Allow for normative metapopulation processes, including the viability of "core" populations, which are defined as the historically most productive populations.
b. Allow for normative evolutionary processes, including the retention of the genetic diversity represented in relatively unmodified historical gene pools.
c. Minimize susceptibility to catastrophic events. (McElhany 2003 and 2006)

Thus, a stratum with a high probability of persistence should include "core" populations, meaning those that historically were the most productive; "genetic legacy" populations, which best represent historical genetic diversity; and populations dispersed in a way that protects against the effects of catastrophic events.

2.4.5 TRT Population-Level Viability Criteria

The status of an ESU and its component strata depend on the viability status of the individual populations that make up that stratum and the ESU. The WLC TRT developed criteria to describe a viable population, based on the population attributes of abundance, productivity, diversity, and spatial structure as described in McElhany et al. (2000). These attributes, also known as viable salmonid population (VSP) parameters, are important indicators of population extinction risk—or, conversely, a population's probability of persistence. Guidelines from McElhany et al. (2000) that describe viable populations in terms of the VSP attributes are described in Section 2.2 of this recovery plan and presented in Table 2-3.

The population-level viability criteria developed by the WLC TRT for Lower Columbia River salmon and steelhead can be summarized as follows:

- **Abundance/productivity:** A viable population demonstrates growth rates, productivity, and abundance that produce an acceptable probability of population persistence. In highly viable populations, average abundance is approximately equivalent to the estimated historical average and the population is either stable in size or growing.

- **Spatial structure:** A viable population has a spatial structure that supports the population at the desired productivity, abundance, and diversity levels through short-term environmental perturbations, longer-term environmental oscillations, and natural patterns of disturbance regimes.

- **Diversity:** A viable population has sufficient life-history and genetic diversity to sustain the population through short-term environmental perturbations and provide for long-term evolutionary processes.

Table 2-3 presents the WLC TRT's population-level viability criteria, along with its stratum- and ESU-level viability criteria and its ESU-level strategy guidelines. TRT-recommended metrics and methodologies for use in evaluating the current risk status of independent populations are presented in McElhany et al. 2006 and 2007 and explained in more detail in Section 2.6 of this recovery plan. In general, the WLC TRT advises that the viability of a population be evaluated by first scoring each VSP parameter individually and then integrating the VSP scores into an overall viability score using a weighted average that emphasizes abundance/productivity, as described in McElhany et al. (2007). This approach is recommended because abundance and productivity are considered better predictors of extinction risk than are spatial structure and diversity (McElhany et al. 2007).

Although the population assessment techniques described in McElhany et al. (2007) represent the most current methods available during the recovery planning process for Lower Columbia River ESUs, it is expected that evaluation techniques will be refined as more data become available and scientific understanding increases.

Table 2-3
Viability Criteria and Guidelines from the Willamette-Lower Columbia Technical Recovery Team

ESU-Level Viability Criteria

1. Every stratum (life history and ecological zone combination) that historically existed should have a high probability of persistence. For a stratum to have a high probability of persistence, at least two populations must be at least 95 percent likely to persist over a 100-year time frame and the average viability of all populations in the stratum must be 2.25 or higher, using the scoring system presented in McElhany et al. 2003. (This is roughly equivalent to requiring that at least 50 percent of the populations in a stratum be viable, but using the average population persistence score recognizes that population status is a continuum and not a simple dichotomy of viable or not viable.)

ESU-Level Strategy Guidelines

1. Until all ESU viability criteria have been achieved, no population should be allowed to deteriorate in its probability of persistence.
2. High levels of recovery should be attempted in more populations than identified in the strata viability criteria because not all attempts will be successful.

Stratum-Level Viability Criteria

1. Individual populations within a stratum should have persistence probabilities consistent with a high probability of stratum persistence.
2. Within a stratum, the populations restored/maintained at viable status or above should be selected to:
   a. Allow for normative meta-population processes, including eth viability of “core” populations, which are defined as the historically most productive populations.
   b. Allow for normative evolutionary processes, including the retention of the genetic diversity represented in relatively unmodified historical gene pools.
   c. Minimize susceptibility to catastrophic events.

Population-Level Viability Criteria

Abundance and Productivity

Recommendation 1: In general, viable populations should demonstrate a combination of population growth rate, productivity, and abundance that produces an acceptable probability of population persistence. Various approaches for evaluating population productivity and abundance combinations may be acceptable but must meet reasonable standards of statistical rigor.

Recommendation 2: A population with a non-negative growth rate and an average abundance approximately equivalent to estimated historical average abundance should be considered to be in the highest persistence category. The estimate of historical abundance should be credible, the estimate of current abundance should be averaged over several generations, and the growth rate should be estimated with an adequate level of statistical confidence. This criterion takes precedence over Recommendation 1.

Within-Population Diversity

Sufficient life-history diversity must exist to sustain a population through short-term environmental perturbations and to provide for long-term evolutionary processes. The metrics and benchmarks for evaluating the diversity of a population should be evaluated over multiple generations and should include:

a. Substantial proportion of the diversity of a life-history trait(s) that existed historically
b. Gene flow and genetic diversity should be similar to historical (natural) levels and origins
c. Successful utilization of habitats throughout the range
d. Resilience and adaptation to environmental fluctuations

Within-Population Spatial Structure

The spatial structure of a population must support the population at the desired productivity, abundance, and diversity levels through short-term environmental perturbations, longer-term environmental oscillations, and natural patterns of disturbance regimes. The metrics and benchmarks for evaluating the adequacy of a population's spatial structure should specifically address:

a. Quantity: Spatial structure should be large enough to support growth and abundance, and diversity criteria.
b. Quality: Underlying habitat spatial structure should be within specified habitat quality limits for life-history activities (spawning, rearing, migration, or a combination) taking place within the patches.
c. Connectivity: Spatial structure should have permanent or appropriate seasonal connectivity to allow adequate migration between spawning, rearing, and migration patches.
d. Dynamics: The spatial structure should not deteriorate in its ability to support the population. The processes creating spatial structure are dynamic, so structure will be created and destroyed, but the rate of flux should not exceed the rate of creation over time.
e. Catastrophic Risk: The spatial structure should be geographically distributed in such a way as to minimize the probability of a significant portion of the structure being lost because of a single catastrophic event, either anthropogenic or natural.

Source: McElhany et al. (2003).

2.4.6 Population Size

All else being equal, a small population is at greater risk of extinction than a large population because of the populations' responses to environmental variability and other processes. Very small populations (in the range of a few hundred fish or fewer) are subject to elevated risks from catastrophic events, random fluctuations in individual reproductive success (i.e., demographic stochasticity), genetic inbreeding, failure to find mates, and other effects. Populations at such small sizes are said to be below a quasi-extinction threshold (QET) or critical risk threshold (CRT).[3] The WLC TRT documents and McElhany et al. (2007) provide estimated CRT values for Lower Columbia River salmon and steelhead populations.

The CRT values vary by species and historical watershed size. Among species, different life histories suggest different demographic and other risks. Watershed size is a factor because some processes, such as finding a mate, depend on the density of fish rather than the absolute number of fish.

At abundances above the CRT but still relatively small, populations are at elevated risk because random fluctuations may drive them below the CRT. For example, a population with 200 fish that lost half its members because of environmental fluctuations would have 100 fish and might be below the CRT. A population with 2,000 fish that lost half its members would still have 1,000 fish, which is likely to be above any CRT. The WLC TRT referred to the abundance at which a population was substantially vulnerable to elevated extinction risk because of environmental fluctuation as a minimum abundance threshold (MAT). The most recent MAT values for Lower Columbia River salmon and steelhead populations are in McElhany et al. (2007). The MAT values differ by species

[3] McElhany et al. (2000) and the WLC TRT (McElhany et al. 2003 and 2006) used the term quasi-extinction threshold. McElhany et al. (2007) adopted the term critical risk threshold.

and historical watershed size because CRT values differ based on these same attributes and because responses to environmental fluctuations vary by species.

2.5 WLC TRT Approach to Assessing Population Status

The WLC TRT provided guidelines, recommended methodologies, and suggested benchmarks for evaluating the status of Lower Columbia River salmon and steelhead populations in two technical reports: the *Interim Report on Viability Criteria for Willamette and Lower Columbia Basin Pacific Salmonids* (McElhany et al. 2003) and *Revised Viability Criteria for Salmon and Steelhead in the Willamette and Lower Columbia Basins* (McElhany et al. 2006). Refinements in methodology were captured in *Viability Status of Oregon Salmon and Steelhead Populations in the Willamette and Lower Columbia Basins* (McElhany et al. 2007), which was prepared by the WLC TRT chair, other NMFS Northwest Fisheries Science Center staff, ODFW staff, and a consultant working for the Lower Columbia Fish Recovery Board.

The WLC TRT initially applied its techniques for scoring population status in a report completed in 2004 (McElhany et al. 2004). In 2006, the TRT applied revisions in its scoring methods to Oregon coho populations (McElhany et al. 2006). In 2007, the TRT chair, working with other Northwest Fisheries Science Center staff and technical recovery planning staff in Oregon and Washington, refined the TRT's approach and applied it to all Oregon salmon and steelhead populations (see McElhany et al. 2007).

The methodologies that the WLC TRT recommended for assessing population status are based on evaluation of the population parameters of abundance, productivity, spatial structure, and diversity, consistent with guidelines in the NOAA technical memorandum *Viable Salmonid Populations and the Recovery of Evolutionarily Significant Units* (McElhany et al. 2000). In general, the WLC TRT recommended that the status of a population be determined by first evaluating each population attribute separately and assigning it a numerical value, on a 0-to-4 scale, and then integrating those values to yield a score, also on a 0-to-4 scale, that reflects the overall status of that population (see Table 2-4).

As shown in Table 2-4, a score of zero includes a relatively broad range of persistence probabilities (i.e., 0 to 40 percent). The WLC TRT documents characterized this as either "very high risk" or "extirpated or nearly so."[4] It often is difficult to distinguish a truly extirpated population from one that is at significant short-term risk but not entirely extirpated, and the WLC TRT's 0-to-4 scale does not make this distinction. In discussions of population status in this document, we use the terms "very high risk" or "extirpated or nearly so" unless a population has been completely blocked from access to historical habitat and/or is assumed to have no remnants either in a hatchery program or in the

[4] The term "extirpated" is preferred to the term "extinct" when describing a population because extirpation tends to refer to a small unit (e.g., a population), whereas extinction usually refers to a global phenomenon (e.g., an entire ESU). Extirpation also suggests a possibility for recolonization, whereas global extinction does not. Despite the preference for the term extirpation over extinction when referring to populations, the term extinction is used throughout older WLC TRT documents and the management unit plans.

wild. In this latter case (e.g., White Salmon and Hood River spring Chinook salmon) we refer to the populations as extirpated.[5]

Table 2-4
Population Scores and Corresponding Probability of Persistence (or Extinction)

Score*	Probability of Persistence**	Population Status	Probability of Extinction**	Extinction Risk
0	0 – 40%	Very low (VL)	60 – 100%	Extinct or at very high risk of extinction (VH)
1	40 – 75%	Low (L)	25 – 60%	Relatively high risk of extinction (H)
2	75 – 95%	Medium (M)	5 – 25%	Moderate risk of extinction (M)
3	95 – 99%	High (H)	1 – 5%	Low/negligible risk of extinction (L)
4	> 99%	Very high (VH)	< 1%	Very low risk of extinction (VL)

* Population scores between whole numbers are rounded. For example, a score of 2.75 would be rounded up to 3; a score of 2.45 would be rounded down to 2.

** Probability over a 100-year time frame.

Source: McElhany et al. (2006).

In some cases, the WLC TRT suggested quantitative methods of evaluating a particular population parameter; when this was not possible because of limitations of data or analytical technique, the TRT suggested qualitative approaches (see Table 2-3). Even where the TRT did develop quantitative evaluation methods, data for use in evaluating the individual VSP attributes often are limited. For these reasons, the WLC TRT noted the necessity of applying professional judgment when assessing population status. (For more information on the WLC TRT's approach to evaluating and scoring the population attributes of abundance/productivity, spatial structure, and diversity, see McElhany et al. 2004, 2006, and 2007.)

The WLC TRT recommended that the abundance and productivity attributes be combined and receive a single attribute score, and that overall population status be determined by averaging the population attribute scores for abundance/productivity, diversity, and spatial structure, with abundance/productivity weighted twice as heavily as the other attributes because abundance and productivity are considered better predictors of extinction risk (i.e., total score = 2/3 A&P + 1/6 spatial + 1/6 diversity). Furthermore, the WLC TRT recommended that, if the abundance/productivity score is lower than the diversity or spatial structure score, the abundance/diversity score be used to characterize overall population status, instead of the weighted average method. This approach avoids what could be a misleadingly high characterization of overall status in cases where a risk factor is driving down a population's abundance and productivity but not affecting its diversity and spatial structure. (For additional guidance on how to integrate the population attribute scores for to yield a score that reflects overall population status, see McElhany et al. 2007, p. 8).

[5] A reintroduction program for spring Chinook salmon in the Hood subbasin is under way using out-of-ESU broodstock. Some natural production is occurring there. At this time, the origin of that natural production is unknown. For additional discussion of this reintroduction program, see Section 7.4.3.6.

The WLC TRT-recommended methods and benchmarks for evaluating population status reflect scientific understanding at the time they were developed. In NMFS' view, the WLC TRT's approach represents one of several possible ways of evaluating population status that are scientifically credible and that follow WLC TRT guidelines. The WLC TRT's approach itself is not static, as evidenced by the many refinements in technique described in the technical reports between 2000 and 2007. NMFS expects that techniques for assessing population status will continue to improve over time as scientific understanding increases, and that future status evaluations will not necessarily use the exact techniques demonstrated by the WLC TRT. As more data become available and scientific understanding increases, NMFS expects to work with its recovery planning partners to further refine techniques for assessing population status.

3. Recovery Goals and Delisting Criteria

This chapter provides an overview of the recovery goals in the management unit plans and the delisting criteria NMFS will use in future status reviews of the Lower Columbia River salmon ESUs and steelhead DPS to determine whether delisting is warranted. This overview is supplemented with additional detail at the species level in Chapters 6 through 9.

Management unit plans incorporate several types of recovery goals. These include biological goals that are intended to be consistent with delisting, as well as "broad sense" recovery goals that go beyond the requirements for delisting under the ESA to address other legislative mandates or social, economic, and ecological values. Broad sense recovery goals may have a biological component, or they may be expressed solely in terms of aspirations to provide these other values. The biological components of management unit plan recovery goals rely heavily on biological viability criteria developed by the TRTs.

The formal delisting criteria are determined by NMFS and must meet ESA requirements. The ESA requires that recovery plans, to the maximum extent practicable, incorporate objective, measurable criteria that, when met, would result in a determination in accordance with the provisions of the ESA that the species be removed from the Federal List of Endangered and Threatened Wildlife and Plants (50 Code of Federal Regulations [CFR] 17.11 and 17.12). These criteria are of two kinds: biological viability criteria, which deal with population or demographic parameters, and threats criteria, which relate to the five listing factors detailed in the ESA (see Sections 1.1 and 3.2.2 of this plan). The threats criteria define the conditions under which the listing factors, or threats, can be considered to be addressed or mitigated. Together the biological viability and threats criteria make up the "objective, measurable criteria" required under section 4(f)(1)(B) for the delisting decision.

Delisting criteria may include both technical and policy considerations, such as acceptable risk levels at the population, stratum, and ESU/DPS scales. They are based on the best available scientific information (including the WLC TRT's biological viability criteria) and incorporate the most current understanding of the ESU or DPS and the threats it faces. As this recovery plan is implemented, additional information may become available that improves our understanding of the status of populations and ESUs/DPSs, how best to evaluate population and ESU/DPS status, threats and how to evaluate their impacts on population and ESU/DPS status, or the extent to which threats have been abated. If appropriate, NMFS will review and revise delisting criteria in the future based on this new information.

NMFS has ultimate responsibility for final recovery plans and delisting decisions and must take into account all relevant information, including, but not limited to, biological and policy considerations developed during the recovery planning process.

3.1 Management Unit Plan Recovery Goals

Each management unit plan includes broad, conceptual statements of purpose and objectives, as well as broad sense recovery goals and biological goals that local planners believe are consistent with delisting.[1] Goals are identified at the population level but also have been coordinated among management unit plans to produce stratum- and ESU-level recovery scenarios. These recovery scenarios and their corresponding population-level biological goals are an important linkage between the management unit plans and the NMFS delisting criteria.

3.1.1 Plan Purposes and Broad Sense Recovery Goals

3.1.1.1 Washington Management Unit Recovery Plan

The Washington management unit plan is an integrated, ecosystem-focused plan that is intended to serve planning needs associated with the Endangered Species Act, the Northwest Power and Conservation Council's fish and wildlife subbasin planning process, and state salmon recovery and watershed planning. For this reason, the Washington plan includes some species that are not addressed in this recovery plan, such as steelhead in the Coast ecozone, which are part of the Southwest Washington DPS and not listed under the ESA, and also bull trout, a freshwater trout species that is listed as threatened under the ESA and is under the jurisdiction of the U.S. Fish and Wildlife Service.

The Washington management unit plan's overall vision is twofold:

- To recover Washington Lower Columbia River salmon, steelhead, and bull trout to healthy, harvestable levels that will sustain productive recreational, commercial, and tribal fisheries through the restoration and protection of the ecosystems upon which they depend and the implementation of supportive hatchery and harvest practices

- To sustain and enhance the health of other native fish and wildlife species in the lower Columbia through the protection of the ecosystems upon which they depend, the control of non-native species, and the restoration of balanced predator/prey relationships (LCFRB 2010a p. 1-3)

The first part of this vision encompasses a goal of delisting Lower Columbia River salmon and steelhead as one component of achieving the overall vision.

Harvestability is a key aspect of the vision for recovery presented in the Washington management unit plan and represents what is considered a "broad sense" recovery goal. The plan defines a viable species as one that is no longer in danger of extinction or likely to become endangered in the foreseeable future and can therefore be removed from listing under the ESA. The plan defines a harvestable species as one that has achieved viability and has abundance sufficient to allow direct and sustainable recreational, commercial, and tribal harvest without jeopardizing the species' viability (LCFRB 2010a).

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[1] Section 3.2 discusses NMFS' view of the management unit plans' recovery goals.

The Washington management unit plan also states that harvestability goals are reached when adult natural production exceeds recovery targets and fish can be directly harvested at levels that maintain spawning escapement at or above those targets (LCFRB 2010a). Harvest of listed fish that have not achieved their target status is typically limited to indirect harvest in mixed-stock fisheries targeted on strong wild runs or hatchery fish. Allowable levels of indirect harvest impacts are established through ESA regulatory processes (LCFRB 2010a).

3.1.1.2 Oregon Lower Columbia Management Unit Recovery Plan

Like the Washington management unit recovery plan, the Oregon Lower Columbia management unit recovery plan is designed to meet multiple needs. It serves as both a Federal recovery plan under the U.S. Endangered Species Act and a state conservation plan under Oregon's Native Fish Conservation Policy. The document's overall purpose is to guide the implementation of actions needed to recover Lower Columbia River salmon and steelhead in Oregon (ODFW 2010). In addition, the plan addresses some species and populations that are not part of the Lower Columbia River ESUs or DPS, such as steelhead in the Coast ecozone (these are part of the Southwest Washington DPS and not listed under the ESA) and Clackamas River spring Chinook salmon (which are part of the Upper Willamette ESU).

Also like the Washington management unit recovery plan, the Oregon Lower Columbia management unit plan contains broad sense goals that encompass ESA delisting. The plan's goals are as follows:

- To achieve ESA delisting.
- To achieve broad sense recovery, defined as having Oregon populations of naturally produced salmon and steelhead sufficiently abundant, productive, and diverse (in terms of life histories and geographic distribution) that the ESU as a whole will be self-sustaining and will provide significant ecological, cultural, and economic benefits (ODFW 2010)

The second goal was developed to fulfill the mission of the Oregon Plan for Salmon and Watersheds to restore "Oregon's native fish populations and the aquatic systems that support them to productive and sustainable levels that will provide substantial environmental, cultural, and economic benefits" (ODFW 2010).

Oregon's broad sense goal is consistent with ESA delisting but is designed to achieve levels of performance that are more robust than those needed to remove ESUs/DPSs from ESA protection. The plan's vision is that ESA delisting goals would be achieved first, during an extended and stepwise process of achieving the broad sense recovery goal, which would be based on a combination of legislative mandates, cultural commitments, social values, and voluntary contributions (ODFW 2010).

Oregon broke down its broad sense recovery goal into two criteria:

- All Oregon LCR salmon and steelhead populations have a very low extinction risk and are highly viable over 100 years throughout their historical range. A very low extinction risk means a less than 1 percent probability of extinction over a 100-year period, based on an integrated assessment of the population's abundance, productivity, spatial structure, and diversity.

- The majority of Lower Columbia salmon and steelhead populations are capable of contributing social, cultural, economic and aesthetic benefits on a regular and sustainable basis (ODFW 2010).

In working toward the broad sense recovery goal, the Oregon Lower Columbia plan focuses on the status of Oregon populations only; meeting the broad sense recovery criteria does not depend on the performance of populations in Washington.

3.1.1.3 White Salmon Management Unit Recovery Plan

The primary goal of the White Salmon management unit recovery plan is to restore White Salmon populations of the Lower Columbia River salmon ESUs to a status consistent with overall ESU delisting criteria. The White Salmon management unit plan incorporates a general broad sense recovery goal to achieve a status beyond ESA delisting that incorporates local and traditional uses of salmon, including those associated with rural and Native American values. Local recovery planners and plan implementers may choose to define additional broad sense goals for the White Salmon management unit recovery plan in the future (NMFS 2011b).

3.1.2 Management Unit Plan Biological Recovery Goals

Recovery planners at the management unit level largely followed the guidelines of the WLC TRT in assessing the viability of salmon and steelhead populations, strata, and ESUs/DPS for the purposes of setting recovery goals. The plans adopted the WLC TRT's definitions of a viable ESU or DPS (i.e., every historical stratum having a high probability of persistence) and a viable stratum (at least two populations being highly likely to persist and the average population persistence score being 2.25 or higher). In addition, the management unit planners relied heavily on the WLC TRT's guidelines regarding abundance and productivity, spatial structure, and diversity in setting viability goals for individual populations. In some cases, however, their approaches differed somewhat from the TRT's and from each other. Detail on methodologies, including discussion of any differences, can be found in Chapter 5. Chapters 6 through 9 present population-specific goals, such as abundance and productivity targets.

3.1.3 Recovery Scenarios for ESU/DPS

Although the WLC TRT defined ESU- and stratum-level viability, it did not specify target viability levels for individual populations consistent with those definitions. Conceivably, the TRT's ESU-level viability criteria could be met through many different combinations of individual population status, with the "best" combination being a function of biological and ecological conditions on the ground and local community values and interests. Management unit recovery planners used the TRT's ESU-level viability criteria to guide decisions about which populations to target for which levels of persistence probability.

Through an iterative process, recovery planners for the Washington Lower Columbia, Oregon Lower Columbia, and White Salmon management units collaborated to reach agreement on a target status for each population. The target statuses within an ESU or DPS are referred to collectively as the "recovery scenario" for that ESU or DPS. Setting the target status for each population in an ESU or DPS (i.e., developing the recovery scenario) involved consideration of several factors:

- Productivity. Which populations are "core" populations that historically were the most highly productive?

- Genetic diversity. Which populations are "legacy" populations that represent important historical genetic diversity?

- Geographical location. Are the populations targeted for high persistence probabilities dispersed in a way that minimizes risk from catastrophic events?

- Feasibility. Which populations can be expected to make significant progress toward recovery because of existing programs, the absence of apparent impediments to recovery, and other management considerations?

The recovery scenarios for the salmon ESUs and steelhead DPS are presented in Table 3-1. The table shows the target status of each population and that population's expected level of contribution to ESU/DPS recovery, using the terminology of "primary" (P), "contributing" (C), and "stabilizing" (S), taken from the Oregon and Washington management unit plans. Primary populations are targeted for restoration to a high or very high probability of persistence. Many primary populations currently have a medium probability of persistence, and some are at low or very low but are targeted for high or very high persistence probability in order to achieve a high probability of stratum and ESU persistence. Contributing populations are those for which some restoration will be needed to achieve a stratum-wide average persistence probability of 2.25 or higher. Stabilizing populations are those that are targeted for maintenance at their baseline persistence probabilities, which are likely to be low or very low. A population might be designated as stabilizing if the feasibility of restoration is low and the uncertainty associated with restoration is high. Chapters 6 through 9 describe the target status of each population further in terms of the viability parameters of abundance and productivity, diversity, and spatial structure (see Tables 6-4, 7-4, 8-2, and 9-4).

Table 3-1
Recovery Scenarios for LCR Chinook, Columbia River Chum, LCR Steelhead, and LCR Coho

		Chinook						Chum				Steelhead				Coho	
		Fall		Late Fall		Spring		Fall		Summer		Winter [3]		Summer			
		Contribu-tion [1]	Target [2]	Contribu-tion	Target	Contribu-tion	Target	Contribu-tion	Target	Contribu-tion	Target	Contribu-tion	Target	Contribu-tion	Target	Contrib-ution	Target
COAST	Youngs Bay (OR)	S	L	--	--	--	--	S	VL	--	--			--	--	S	VL
	Grays/Chinook (WA)	C	M+	--	--	--	--	P	VH	--	--			--	--	P	H
	Big Creek (OR)	C	L	--	--	--	--	S	VL	--	--			--	--	S	VL
	Eloch./Skam. (WA)	P	H	--	--	--	--	P	H	--	--			--	--	P	H
	Clatskanie (OR)	P	H	--	--	--	--	P	H	--	--			--	--	P	VH
	Mill/Aber./Ger. (WA)	P	H	--	--	--	--	P	H	--	--			--	--	C	M
	Scappoose (OR)	P	H	--	--	--	--	P	H	--	--			--	--	P	VH
CASCADE	Lower Cowlitz (WA)	C	M+	--	--	--	--	C (Cowlitz)	M	C (Cowlitz)	M	C	M	--	--	P	H
	Coweeman (WA)	P	H+	--	--	--	--					P	H	--	--	P	H
	SF Toutle (WA)	P (Toutle)	H+	--	--	C (Toutle)	M					P	H+	--	--	P	H
	NF Toutle (WA)			--	--							P	H	--	--	P	H
	Upper Cowlitz (WA)	S (Upper Cowlitz)	VL	--	--	P	H+					P	H	--	--	P	H
	Cispus (WA)			--	--	P	H+	--	--	--	--	P	H	--	--	P	H
	Tilton (WA)			--	--	S	VL	--	--	--	--	C	L	--	--	S	VL
	Kalama (WA)	C	M	--	--	C	L	C	M	--	--	P	H+	P	H	C	L
	NF Lewis (WA)	P (Lewis)	H+	P	VH	P	H	P (Lewis)	H	--	--	C	M	S	VL	C	L
	EF Lewis (WA)			--	--	--	--			--	--	P	H	P	H	P	H
	Salmon (WA)	S	VL	--	--	--	--	S	VL	--	--	S	VL	--	--	S	VL
	Clackamas (OR)	C	M	--	--	--[4]		C	M	--	--	P	H[6]	--	--	P	VH
	Sandy (OR)	C	M	P	VH	P	H	P	H	--	--	P	VH	--	--	P	H
	Washougal (WA)	P	H+	--	--	--	--	P	H+	--	--	C	M	P	H	C	M+
GORGE	Lower Gorge (WA/OR)	C[5]	M	--	--	--	--	P[5]	VH	--	--	P[5]	H	--	--	P[5]	H
	Upper Gorge (WA/OR)	C[5]	M	--	--	--	--	C[5] (Upper Gorge)	M	--	--	S[5]	L	P (Wind)	VH	P (U. Gorge/W. Salmon)	H
	White Salmon (WA)	C	M	--	--	C	L+			--	--	--	--	--	--		
	Hood (OR)	P	H[6]	--	--	P	VH			--	--	P	H	P	H[6]	P (U.Gorge/ Hood)	H[6]

¹ Indicates contribution to recovery: P = primary, C = contributing, S = stabilizing; for description, see Section 3.1.3.
² VL = very low persistence probability , L = low persistence probability, M = moderate persistence probability , H = high persistence probability, VH = very high persistence probability.
³ Winter steelhead of the Coast stratum are included in the Washington and Oregon management unit plans for state-level planning purposes, but they are not included in this table because they are part of the unlisted Southwest Washington DPS, not the listed Lower Columbia River DPS.
⁴ Clackamas spring Chinook are part of the Upper Willamette spring Chinook ESU.
⁵ Designation for shared population based on WA objectives, with support to be provided by OR portion of population, since WA has a larger proportion of the population area.
⁶ The Oregon management unit plan (ODFW 2010) notes that achieving this target status is highly unlikely for various reasons (see pp. 176-77, 186, 195, 200 of ODFW 2010).

The scenarios in Table 3-1 meet the WLC TRT criteria for high probability of persistence at the stratum and ESU or DPS levels with the exceptions of the Gorge fall Chinook, Gorge spring Chinook, and Gorge chum strata. In each of these strata, only one population is targeted to achieve a high probability of persistence. Local recovery planners documented the basis for this divergence from the TRT's criteria.

In Washington, planners factored feasibility into target status designations. Thus for the Gorge fall Chinook, spring Chinook, and chum strata, Washington recovery planners set the target status at levels they believed were feasible, even though these levels were not consistent with the WLC TRT's criteria for high probability of stratum persistence (LCFRB 2010a). Washington planners noted that the likelihood of meeting TRT criteria was highly uncertain because the Bonneville Dam reservoir inundates historical spawning habitat for fall Chinook and chum salmon that spawn in tributaries above the dam, the dam creates passage impediments, there is uncertainty regarding the extent to which some populations functioned independently historically, and, in the case of White Salmon spring Chinook, the population has been extirpated. In contrast, Oregon recovery planners set target viability status at levels consistent with the WLC TRT's criteria. However, in the case of the Hood River populations and the Oregon portions of the shared Gorge populations, Oregon recovery planners noted a very low probability of meeting those goals, in part because there is little habitat currently available and because anthropogenic impacts are unlikely to change in the near future (ODFW 2010).

In addition, both the Washington and Oregon management unit planners raised questions regarding stratum and population delineations and the historical role of the Gorge populations (LCFRB 2010a, ODFW 2010). Questions included whether the populations were highly persistent historically, whether they functioned as independent populations within their stratum in the same way that the Coast and Cascade populations did, and whether the Gorge stratum itself should be considered a separate stratum from the Cascade stratum. While the Washington management unit plan simply raised issues of uncertainty in stratum delineations between the Cascade and Gorge strata and in Chinook and chum population delineations (LCFRB 2010a), the Oregon management unit plan discussed the issue in more depth (see Appendix B of ODFW 2010). For example, the Oregon management unit plan cites a NMFS GIS analysis (see Busch et al. 2011) that used an intrinsic habitat potential model to show that potential habitat for Gorge populations, based on existing geomorphic features, is very small, even in relatively large watersheds (ODFW 2010). This suggests that, even historically, many Gorge populations might not have been sufficiently sized to be reproductively isolated from other populations and to exhibit the productivity required to ensure long-term sustainability. For all three salmon ESUs and the steelhead DPS, the Oregon management unit plan recommends that the Gorge stratum's historical status and population structure be reevaluated and that recovery goals be revised if modifications are made (ODFW 2010).

Finally, for Gorge fall and spring Chinook and Gorge chum, management unit planners developed recovery scenarios that exceed the TRT criteria in the Cascade stratum as a way of mitigating for increased risk to the ESU as a result of not achieving the WLC TRT's stratum-level criteria in the Gorge.

3.2 NMFS Delisting Criteria

The requirement for determining that a species no longer requires the protection of the ESA is that the species is no longer in danger of extinction or likely to become endangered within the foreseeable future, based on evaluation of the listing factors specified in ESA section 4(a)(1). To remove the Lower Columbia River Chinook ESU, Lower Columbia River steelhead DPS, Lower Columbia River coho ESU, or Columbia River chum ESU from the Federal List of Endangered and Threatened Wildlife and Plants, NMFS must determine that the ESU or DPS, as evaluated under the ESA listing factors, is no longer likely to become endangered.

The ESA requires that recovery plans, to the maximum extent practicable, incorporate objective, measurable criteria that, when met, would result in a determination in accordance with the provisions of the ESA that the species be removed from the Federal List of Endangered and Threatened Wildlife and Plants (50 CFR 17.11 and 17.12; 50 CFR 223.102 and 224.101). The biological and threats criteria in this plan, taken together, meet this statutory requirement.

3.2.1 Biological Criteria

NMFS has considered the WLC TRT's viability criteria (McElhany et al. 2003 and 2006, summarized in Table 2-3), the additional recommendations in McElhany et al. (2007), the recovery scenarios (summarized in Table 3-1) and population-level goals in the management unit plans, and the questions the management unit planners raised regarding the historical role of the Gorge strata.

NMFS has concluded that the WLC TRT's criteria adequately describe the characteristics of an ESU that meet or exceed the requirement for determining that a species no longer needs the protection of the ESA. These criteria provide a framework within which to evaluate specific recovery scenarios. NMFS has evaluated the management unit plan recovery scenarios (summarized in Table 3-1 of this recovery plan) and population-level abundance, productivity goals[2] (see Chapters 6 through 9) and has concluded that they also adequately describe the characteristics of an ESU that no longer needs the protections of the ESA.[3] NMFS endorses the recovery scenarios and population-level goals in the management unit plans (summarized here in Table 3-1 and Sections 6.3, 7.3, 8.3, and 9.3) as one of multiple possible scenarios consistent with delisting.

As noted above, the recovery scenarios in Table 3-1 are consistent with the WLC TRT's recommendations at the stratum and ESU or DPS level, except for the Gorge fall Chinook, Gorge spring Chinook, and Gorge chum strata. In those strata, the recovery scenarios target only one population to achieve a high probability of persistence. As a way of mitigating for increased risk in the Gorge strata, the recovery scenarios exceed

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[2] NMFS also evaluated the goals for spatial structure and diversity in the Oregon management unit plan (ODFW 2010). Washington recovery planners assumed that productivity and abundance levels consistent with significant improvements in persistence probability could not be achieved without also addressing limitations in spatial structure and diversity. Thus, spatial structure and diversity improvements are implicit in the abundance and productivity targets in the Washington management unit plan (LCFRB 2010a).
[3] See Sections 6.7, 7.7, 8.7, and 9.7 for additional detail on biological criteria at the species level.

the WLC TRT criteria in the Cascade fall Chinook, Cascade spring Chinook, and Cascade chum strata.

In its revised viability criteria (McElhany et al. 2006), the WLC TRT noted the need for case-by-case evaluations of the continuum of ESU-level risk associated with some strata not meeting the TRT's persistence criteria. In commenting on the recovery scenarios presented in the interim Washington management unit plan[4]—and by extension the recovery scenarios in Table 3-1 of this plan—the WLC TRT stated that achieving the recovery scenarios would improve the status of the Gorge strata, even if the TRT's criteria for those strata were not met. The TRT also noted that targeting the Cascade strata for very high persistence (above the minimum TRT criteria) would help lower ESU extinction risk. In addition, the TRT noted that the Gorge and Cascade strata are relatively similar compared to the Cascade and Coast strata. Also significant in the TRT's view was that options for recovery of the Gorge strata would be preserved, in case future conditions or analyses were to require high stratum persistence for ESU viability (McElhany et al. 2006).

Based on the information provided by the WLC TRT and the management unit recovery planners, NMFS concludes that the recovery scenarios in Table 3-1 and the associated population-level abundance and productivity goals in Sections 6.3, 7.3, 8.3, and 9.3 represent one of multiple possible scenarios that would meet biological criteria for delisting.

NMFS also agrees with the management unit planners that the historical role of the Gorge populations and strata merits further examination. The extent to which compensation in the Cascade strata is ultimately considered necessary to achieve an acceptably low risk level at the ESU or DPS level will depend on how questions regarding the historical role of the Gorge populations are resolved.

NMFS therefore proposes the following biological criteria for the four listed ESUs and DPS addressed by this plan (NMFS has amended the WLC TRT's criteria for clarity and to incorporate the concept that each stratum should have a probability of persistence consistent with its historical condition, thus allowing for resolution of questions regarding the Gorge strata):

- All strata that historically existed have a high probability of persistence or have a probability of persistence consistent with their historical condition.
- High probability of stratum persistence is defined as:
  a. At least two populations in the stratum have at least a 95 percent probability of persistence over a 100-year time frame (i.e., two populations with a score of 3.0 or higher based on the TRT's scoring system).
  b. Other populations in the stratum have persistence probabilities consistent with a high probability of stratum persistence (i.e., the average of all stratum

[4] In February 2006, NMFS approved the December 2004 *Washington Lower Columbia Salmon Recovery and Fish & Wildlife Subbasin Plan* as in interim regional recovery plan. The 2010 revised version of that plan (LCFRB 2010a) is incorporated into this ESU-level plan as Appendix B.

population scores is 2.25 or higher, based on the TRT's scoring system). (See Section 2.6 for a brief discussion of the TRT's scoring system.)

c. Populations targeted for a high probability of persistence are distributed in a way that minimizes risk from catastrophic events, maintains migratory connections among populations, and protects within-stratum diversity.

- A probability of persistence consistent with historical condition refers to the concept that strata that historically were small or had complex population structures may not have met Criteria A through C, above, but could still be considered sufficiently viable if they provide a contribution to overall ESU viability similar to their historical contribution.

The recovery scenarios in Table 3-1 are consistent with these biological criteria.

3.2.2 Threats Criteria

In addition to a species achieving a certain biological status to be considered for reclassification or delisting, the threats to a listed species must have been ameliorated so as not to limit attainment of its desired biological status. Section 4(a)(1) of the ESA organizes NMFS' consideration of threats into five factors:

A. The present or threatened destruction, modification, or curtailment of the species' habitat or range
B. Over-utilization for commercial, recreational, scientific, or educational purposes
C. Disease or predation
D. The inadequacy of existing regulatory mechanisms
E. Other natural or human-made factors affecting the species' continued existence

These factors may not all be equally important in securing the continuing recovery of a particular ESU, and each ESU faces a different set of threats. It also is possible that current perceived threats will become insignificant in the future as a result of changes in the natural environment or changes in the way threats affect the entire life cycle of salmon and steelhead.

NMFS will use the listing factor criteria below in determining whether an ESU or DPS has recovered to the point that it no longer requires the protections of the ESA:

A. The present or threatened destruction, modification, or curtailment of a species' habitat or range:
    1. Habitat-related threats have been ameliorated such that they do not limit attainment of the desired status of the ESU/DPS and its constituent populations as defined by the biological criteria in this recovery plan, and such that the desired status will be maintained.
        a. Recovery plan actions addressing habitat limiting factors have been substantially implemented, including related research, monitoring, and evaluation actions.
        b. The threat reduction targets for habitat outlined in Sections 6.5, 7.4.2, 7.5.2, 7.6.2, 8.5, and 9.5 of this recovery plan have been met

or habitat impacts are otherwise consistent with the desired status of the ESU/DPS and its constituent populations. To evaluate whether this criterion has been met, and to track and periodically evaluate progress, specific metrics for assessing habitat conditions and action effectiveness will be needed.

c. Trends in overall habitat conditions, based on evaluation of the combined effect of factors, including, but not limited to, habitat access, hydrograph/water quantity, physical habitat quality and quantity, and water temperature and other water quality parameters, are stable or improving.

d. Functioning habitat areas, including those expected to be less vulnerable to impacts from climate change, have been protected. Other actions to support adaptation to climate change impacts have been implemented.

2. Hydropower and/or flood control dam-related threats have been ameliorated such that they do not limit attainment of the desired status of the ESU/DPS and its constituent populations, as defined by the biological criteria in this recovery plan, and such that the desired status will be maintained.
    a. Recovery plan actions addressing hydropower limiting factors have been substantially implemented, including related research, monitoring, and evaluation actions.
    b. FERC Settlement Agreements and relevant actions from the applicable FCRPS Biological Opinion have been substantially implemented.
    c. The threat reduction targets for hydropower outlined in Sections 6.5, 7.4.2, 7.5.2, 7.6.2, 8.5, and 9.5 of this recovery plan have been met or hydropower impacts are otherwise consistent with the desired status of the ESU/DPS and its constituent populations. To evaluate whether this criterion has been met, and to track and periodically evaluate progress, specific metrics related to hydropower impacts (including passage, and flow, temperature, and sediment), population performance (where populations are being reestablished above dams), and action effectiveness will be needed.
    d. Hydropower management actions will support ESU persistence given projected effects of climate change.

B. Overutilization for commercial, recreational, or educational purposes:

1. Harvest-related threats have been ameliorated such that they do not limit attainment of the desired status of the ESU/DPS and its constituent populations as defined by the biological criteria in this recovery plan, and such that the desired status will be maintained.
    a. Recovery plan actions addressing harvest-related limiting factors have been substantially implemented, including related research, monitoring, and evaluation actions.

        b. The threat reduction targets for harvest outlined in Sections 6.5, 7.4.2, 7.5.2, 7.6.2, 8.5, and 9.5 of this recovery plan have been met or harvest impacts are otherwise consistent with the desired status of the ESU/DPS and its constituent populations. To evaluate whether this criterion has been met, and to track and periodically evaluate progress, specific metrics related to harvest impacts and action effectiveness will be needed.

    2. Any other threats related to overutilization for commercial, recreational, or educational purposes (for example, utilization for research purposes) have been ameliorated such that they do not limit attainment of the desired status of the ESU/DPS and its constituent populations as defined by the biological criteria in this recovery plan, and such that the desired status will be maintained.

C. Disease or predation:

    1. Predation-related threats have been ameliorated such that they do not limit attainment of the desired status of the ESU/DPS and its constituent populations as defined by the biological criteria in this recovery plan, and such that the desired status will be maintained.

        a. Recovery plan actions related to threats from predation by marine mammals, birds, and fish (including predation among salmon species and predation by hatchery-origin salmon on natural-origin salmon) have been substantially implemented, including related research, monitoring, and evaluation actions.

        b. The threat reduction targets for predation outlined in Sections 6.5, 7.4.2, 7.5.2, 7.6.2, 8.5, and 9.5 of this recovery plan have been met or threats from predation are otherwise consistent with the desired status of the ESU/DPS and its constituent populations. To evaluate whether this criterion has been met, and to track and periodically evaluate progress, specific metrics related to predation and action effectiveness will be needed.

    2. Disease-related threats have been ameliorated such that they do not limit attainment of the desired status of the ESU/DPS and its constituent populations as defined by the biological criteria in this recovery plan, and such that the desired status will be maintained.

        a. Hatchery management practices sufficient to limit disease-related threats are being implemented.

        b. Monitoring is in place to detect disease and disease impacts on population status.

D. The inadequacy of existing regulatory mechanisms:

    1. Regulatory mechanisms have been maintained and/or established and are being implemented in a way that supports attaining and maintaining the desired status of the ESU/DPS and its constituent populations, as defined by the biological criteria in this recovery plan.

        a. Regulatory programs that govern land use and resource utilization are in place and are adequate to protect salmon and steelhead habitat, including water quality, water quantity, and stream structure and function, and to attain and maintain the biological recovery criteria in this recovery plan.

b. States have established and protected instream flow levels in a manner consistent with achieving and maintaining the desired status for the ESU/DPS and its constituent populations as defined by the biological criteria in this recovery plan.

c. Regulatory programs are in place and are adequate to manage fisheries at levels consistent with the biological recovery criteria of this recovery plan.

d. Regulatory, control, and education measures are in place to prevent introductions of non-native plant and animal species.

e. Regulatory programs have adequate funding, prioritization, enforcement, coordination mechanisms, and research, monitoring, and evaluation to ensure habitat protection and effective management of fisheries.

E. Other natural or man-made factors affecting continued existence:

1. Hatchery-related threats have been ameliorated such that they do not limit attainment of the desired status of the ESU/DPS and its constituent populations as defined by the biological criteria in this recovery plan, and such that the desired status will be maintained.

    a. Recovery plan actions related to threats from hatcheries have been substantially implemented, including related research, monitoring, and evaluation actions. Hatchery and Genetics Management Plans are complete for all hatchery programs and NMFS has authorized all programs under the ESA.

    b. The threat reduction targets for hatcheries outlined in Sections 6.5, 7.4.2, 7.5.2, 7.6.2, 8.5, and 9.5 of this recovery plan have been met or hatchery impacts are otherwise consistent with the desired status of the ESU/DPS and its constituent populations. To evaluate whether this criterion has been met, specific metrics for evaluating the genetic and ecological risks posed to natural-origin salmon and steelhead by hatchery-origin salmon and steelhead may need to be developed, tracked, and periodically evaluated.

    c. Hatchery programs are being operated in a manner consistent with the target status of each population, and appropriate criteria are being used for managing the interaction of hatchery and natural populations, including hatchery-origin fish spawning naturally.

    d. Hatcheries are operated using appropriate ecological, genetic, and risk containment measures for (1) release of hatchery juveniles, (2) handling of natural-origin adults, (3) withdrawal of water for hatchery use, (4) discharge of hatchery effluent, and (5) maintenance of fish health during propagation in the hatchery.

    e. Monitoring and evaluation plans are in place and being implemented to measure population status, hatchery effectiveness, and ecological, genetic, and demographic risk containment measures.

2. Other natural or human-caused factors have been accounted for such that they do not limit attainment of the desired status of the ESU/DPS and its constituent populations as defined by the biological criteria in this recovery plan, and such that the desired status will be maintained.

3.2.3 Delisting Criteria Conclusion

NMFS will propose to delist the four listed ESUs addressed by this plan when the following criteria are achieved:

1. All strata that historically existed have a high probability of persistence or have a probability of persistence consistent with their historical condition.

   High probability of stratum persistence is defined as:

   a. At least two populations in the stratum have at least a 95 percent probability of persistence over a 100-year time frame (i.e., two populations with a score of 3.0 or higher based on the TRT's scoring system).

   b. Other populations in the stratum have persistence probabilities consistent with a high probability of stratum persistence (i.e., the average of all stratum population scores is 2.25 or higher, based on the TRT's scoring system). (See Section 2.6 for a brief discussion of the TRT's scoring system.)

   c. Populations targeted for a high probability of persistence are distributed in a way that minimizes risk from catastrophic events, maintains migratory connections among populations, and protects within-stratum diversity.

   A probability of persistence consistent with historical condition refers to the concept that strata that historically were small or had complex population structures may not have met Criteria A through C, above, but could still be considered sufficiently viable if they provide a contribution to overall ESU viability similar to their historical contribution.

2. The threats criteria identified in Section 3.2.2 have been met.

The recovery scenarios in Table 3-1 and the associated population-level abundance and productivity goals presented in Sections 6.3, 7.3, 8.3, and 9.3 of this recovery plan illustrate one possible set of scenarios in which these criteria could be met. The criteria stated above represent a point at which delisting is very likely but not necessarily the only scenario under which NMFS would propose to delist. Nothing in these criteria should be understood as precluding a delisting determination under a different scenario, provided that the ESU is no longer in danger of extinction or likely to become endangered within the foreseeable future.

In accordance with our responsibilities under section 4(c)(2) of the Act, NMFS will conduct reviews of status of each ESU at least once every 5 years to evaluate the ESUs' status and determine whether the ESUs should be removed from the list or changed in status. NMFS will base such evaluations on the best scientific information available at that time.

3.3 Achieving Broad Sense Goals after Delisting

NMFS is supportive of the broad sense recovery goals in the management unit plans and believes that the most expeditious way to achieve them is by achieving viability of natural populations and delisting. Upon delisting, NMFS will work with co-managers and local stakeholders, using our non-ESA authorities, to pursue broad sense recovery goals while continuing to maintain robust natural populations.

4. Regional Limiting Factors and Strategies

The reasons for a species' decline are generally described in terms of limiting factors and threats. Limiting factors are biological, physical, or chemical conditions and associated ecological processes and interactions that limit a species' viability. Threats are human activities or natural events, such as floodplain development or drought, that cause or contribute to limiting factors.[1] A single limiting factor may be caused by one or more threats. Likewise, a single threat may cause or contribute to more than one limiting factor and may affect more than one life stage. In addition, the impact of past threats may continue to contribute to current limiting factors through legacy effects. For example, current high water temperature could be the result of earlier riparian practices that removed vegetation from the streambank. Or the effects of previous harvest practices may be evident in the relatively small number of life history strategies that currently exist among salmon and steelhead. Designing effective recovery strategies and actions requires an understanding of the range and impact of limiting factors and threats affecting the species, across its entire life cycle.

Addressing multiple ESUs in a single recovery plan presents an opportunity to evaluate limiting factors and threats at the regional scale, discern large-scale patterns in ecological conditions, and identify regional approaches to recovery. This regional, multi-species perspective is useful in understanding the scale and scope of actions needed to recover the four species addressed by this plan; it also should aid in identifying recovery approaches that provide maximum biological benefit and make effective use of limited resources. Toward that end, this chapter takes a subdomain-scale look at recovery. The chapter gives overviews of limiting factors, at the regional scale, that have affected Lower Columbia River salmon and steelhead and describes regional strategies to address the specific limiting factors identified and analyzed in the management unit plans (see Chapters 6 through 9). The regional strategies are general approaches that either will benefit multiple ESUs or can be applied in ways that target the specific needs of each species. Chapters 6 through 9 supplement the regional strategies with complementary strategies that provide greater specificity at the species and stratum levels.

The regional strategies also highlight the need for domain-scale coordination to implement effective recovery strategies in tributary habitat, estuary habitat, hydropower, hatcheries, harvest, and ecological interactions. Coordination needs are discussed in Chapter 11, "Implementation."

4.1 Tributary Habitat

Historically, tributary habitat in the ranges of the Lower Columbia River salmon ESUs and steelhead DPS supported millions of fish in populations that were adapted to the characteristics of individual watersheds. Stream channels contained abundant large wood from the surrounding riparian forests that helped structure pools and create

[1] In this recovery plan, the term limiting factors is used to indicate the full range of factors that are believed to be affecting the viability of salmon and steelhead, and not to indicate the single factor that is most limiting.

complex habitat in streams. Beaver activity also contributed to diverse instream habitats, with deep pools and strong connections to floodplains. Water temperatures sufficient to support salmon and steelhead throughout the year were common. Upland and riparian conditions allowed for the storage and release of cool water during the dry summer months and provided sufficient shade to keep water temperatures cool. Extensive and abundant riparian vegetation armored streambanks, thus shading the water, protecting against erosion, and supporting an abundant food supply. Dynamic patterns of channel migration in floodplains continually created complex channel, side-channel, and off-channel habitats. Over the last 150 years, tributary habitat conditions have been severely degraded.

4.1.1 Tributary Habitat Limiting Factors and Threats

Tributary habitat degradation from past and/or current land and water use is a limiting factor for all Lower Columbia River salmon and steelhead populations. Widespread development and other land use activities have disrupted watershed processes, reduced water quality, and diminished habitat quantity, quality, and complexity in most lower Columbia River subbasins. Past and/or current land use or water management activities have adversely affected stream and side channel structure, riparian conditions, floodplain function, sediment conditions, and water quality and quantity, as well as the watershed processes that create and maintain properly functioning conditions for salmon and steelhead (LCFRB 2010a, ODFW 2010). Specific activities and their impacts include the following:

- Logging and other forest management practices. Logging on unstable slopes and in riparian areas has led to the degradation of watershed processes. Improperly located, constructed, or maintained forest roads have disrupted stream flow patterns and sediment supply processes, disconnected streams from floodplains, and, in riparian areas, reduced wood recruitment to streams. The historical use of splash dams to transport logs reduced instream structure and available spawning gravel in several stream systems.

- Agricultural activities. Agricultural activities have diminished overall habitat productivity and connectivity and degraded riparian areas and floodplains in the lower Columbia region, especially along lowland valley bottoms. Historical floodplain habitats have been lost through levee construction and the filling of wetlands. Runoff from agricultural lands where pesticides, herbicides, and fertilizers are applied has reduced water quality. Water withdrawal for irrigation has altered stream flow and raised water temperatures. Livestock grazing has affected soil stability (via trampling), reduced streamside vegetation (via foraging), and delivered potentially harmful bacteria and nutrients (animal wastes) to streams.

- Construction of fish passage barriers. The main barriers in lower Columbia watersheds are dams and culverts, with occasional barriers such as irrigation diversion structures, fish weirs, beaver dams, road crossings, tide gates, channel alterations, and localized temperature increases (LCFRB 2010a). Although dams are responsible for the greatest share of blocked habitat, inadequate culverts make up the vast majority of all barriers (LCFRB 2010a). Many culvert problems are related to private and public logging roads (Washington State Natural Resources Cabinet 1999 as cited in LCFRB 2010a). Hatchery structures also sometimes act as passage barriers in tributaries (ODFW 2010, LCFRB 2010a). Physical and thermal barriers limit access to spawning and rearing habitats. (See Section 4.4.1.3 for more on hatchery structures and Section 4.3 for passage issues at hydropower dams.)

- Urban and rural development. Development has diminished overall habitat productivity and connectivity and led to the degradation of riparian and floodplain conditions and an increase in surface water runoff from cities and towns. The drainage network from roads, ditches, and impervious surfaces alters the hydrograph and delivers sediment and contaminants to streams, thus reducing water quality and affecting the health and fitness of salmonids and other aquatic organisms. Loss of riparian vegetation to development has increased stream temperatures, and bank hardening and channelization of streams have simplified habitat and altered flow. Water withdrawal for municipal uses has contributed to altered stream flows and increases in water temperatures.

- Mining. Sand and gravel mining along some lower Columbia streams has altered instream substrate and sediment volumes (ODFW 2010).

Together these factors have reduced the amount and quality of spawning and rearing habitats available to Lower Columbia River salmon and steelhead, severed access to other historically productive habitats, and degraded watershed processes and functions that once created healthy ecosystems for salmon and steelhead production. Today, many streams have lower pool complexity and frequency compared to historical conditions. Channels also lack the complex structure needed to retain gravels for spawning and invertebrate production. Also missing from many channels is the connectivity with shallow, off-channel habitat and floodplain areas that once provided productive early-rearing habitat, flood refugia and overwintering habitat, and cover from predators. In many areas, contemporary watershed conditions are so different from those under which native fish species evolved that they now pose a significant impediment to achieving recovery (LCFRB 2010a, ODFW 2010).

Table 4-1 lists common tributary habitat limiting factors that adversely affect populations of Lower Columbia River salmon and steelhead.[2] As the table illustrates, Lower Columbia River salmon and steelhead commonly are limited by the shape, structure, and connectivity of the waterways they use; the amount of water (and thus habitat) available to them at different times of year; and the suitability of gravel for spawning. The fact that many of the most common limiting factors are related to basic ecosystem functions underscores the need for fundamental, widespread improvement in watershed processes through much of the lower Columbia Basin. Another message is that any actions implemented to address these most common limiting factors have the potential to benefit more than one ESU, especially when ESUs have overlapping habitat preferences (such as lower elevation off-channel rearing habitat used by both chum and fall Chinook salmon). Even so, Table 4-1 does not represent all of the limiting factors that

[2] Table 4-1 uses terminology from a "data dictionary" of ecological concerns developed by the NMFS Northwest Fisheries Science Center but is based on characterizations of limiting factors and threats in the management unit plans, as compiled in the species-specific NMFS limiting factors "crosswalk" tables presented in Appendix H (see also Section 5.4 for a description of the data dictionary and crosswalk tables).

affect any particular ESU, or even necessarily the most important limiting factors for a particular ESU or population; when implementing recovery actions, it is important to consider the specific needs of each ESU or population to ensure that important but less common limiting factors are not overlooked (see Chapters 6 through 9).

It also is worth noting that some of the limiting factors in Table 4-1, such as hydrology and sediment conditions, or loss of riparian cover, temperature, and sediment supply, are interrelated. This raises the possibility of synergistic or compounded effects of recovery actions. Future monitoring may clarify the nature of such effects and provide opportunities for adaptive management to ensure that such effects are realized.

Table 4-1
Common Tributary Habitat Limiting Factors and Threats

Limiting Factor	Subcategory	Associated Threats
Riparian conditions		Past/current land use practices
Peripheral and transitional habitats	Side channel and wetland conditions	Past/current land use practices Transportation corridor development and maintenance
	Floodplain condition	Past/current land use practices Transportation corridor development and maintenance
Impaired channel structure and form	Bed and channel form	Past/current land use practices Transportation corridor development and maintenance Inundation from Bonneville Reservoir
	Instream structural complexity	Past/current land use practices Transportation corridor development and maintenance Inundation from Bonneville Reservoir
Sediment conditions[3]	Decreased sediment quantity (impaired sediment/sand routing and gravel recruitment)	Dams
	Increased sediment quantity	Past and/or current land use practices (e.g., rural roads) Transportation corridor development and maintenance
Water quality	Elevated water temperature	Land uses that impair riparian function/decrease stream flow Large dam reservoirs

[3] The limiting factors crosswalk also identified turbidity as a common limiting factor (as a subcategory of the water quality limiting factor); however, when NMFS developed the limiting factors crosswalk, it indicated turbidity as a limiting factor for every population affected by sediment conditions, because the management unit plans did not necessarily distinguish between sediment and turbidity. The crosswalk results for turbidity should be validated at some point in the future and are not included in Table 4-1 or the species-specific limiting factor summary tables in Chapters 6 through 9 because of this uncertainty.

Limiting Factor	Subcategory	Associated Threats
Water quantity	Altered hydrology Decreased water quantity/downstream flows Altered flow timing	Low-head hydro diversions Upslope land uses Withdrawals for irrigation, hatchery, or municipal uses Hydropower dams

4.1.2 Regional Strategy for Tributary Habitat

To address the limiting factors and threats described above and in Chapters 6 through 9, the regional tributary habitat strategy is directed toward protecting and restoring high-quality, well-functioning salmon and steelhead habitat through a combination of (1) site-specific projects that will protect habitat or provide benefits relatively quickly, (2) watershed-based actions that will repair habitat-forming processes and provide benefits over the long term, and (3) landscape-scale programmatic actions that affect a class of activities (such as stormwater management or forest practices) over multiple watersheds. Although many habitat-related actions already have been undertaken, current activities do not reflect the scale of habitat improvements needed. Recovery of the listed species will require concerted efforts to protect remaining areas of favorable habitat and restore habitat quality in significant historical production areas. The management unit plans place a high value on protecting currently functioning habitat as a means of retaining and building out from current production. However, restoration also is essential because current habitat in most subbasins is inadequate to support viable populations of Lower Columbia River salmon and steelhead. Federal lands will play a significant role in providing and protecting anchor habitats, but substantial improvements also are needed in marginal areas of potentially productive habitat (LCFRB 2010a). Especially at low elevations, much of the land is in private ownership, where restoration activities are likely to be challenging and expensive.

Representative actions to address the most common limiting factors affecting Lower Columbia River salmon and steelhead are shown in Table 4-2.

There is an immediate need to develop prioritization frameworks and get additional targeted, site-specific protection and restoration actions, as well as programmatic approaches, on the ground as soon as possible, especially because the benefits of some habitat actions will take years to accrue. Some prioritization work has already occurred. The Washington management unit plan, for instance, has prioritized tributary actions by stream reach based on the needs of all populations in a particular watershed (LCFRB 2010a). The Oregon management unit plan has done some prioritization based on where an action will have the greatest beneficial effect and where implementation is most feasible (ODFW 2010), but in many Oregon watersheds additional assessment is needed to determine protection and restoration priorities at a meaningful spatial scale (ODFW 2010). The White Salmon management unit plan also identifies areas that are a high priority for habitat actions but points to the need for additional information to identify and prioritize specific habitat actions (NMFS 2011b). For example, now that Condit Dam has been breached,[4] habitat conditions downstream of the dam site, and in the area previously occupied by Northwestern Lake, will need to be assessed and priority restoration actions identified (NMFS 2011b). In addition, site-specific protection and restoration actions need to be prioritized at the subdomain scale, funding sources need to be coordinated, and benchmarks established by which to assess progress in implementation and evaluate biological benefits. In these efforts, opportunities to consider ecosystem function and benefits need to be balanced with individual species' needs.

Table 4-2
Representative Actions to Address Limiting Factors Affecting Most Populations

Limiting Factor	Subcategory	Representative Actions
Impaired channel structure and form	Bed and channel form	Restore degraded off-channel habitats Streamline delivery of large wood to restoration sites Restore degraded riparian areas through planting or fencing
	Instream structural complexity	Restore riparian areas to improve water quality, provide long-term supply of large wood to streams, and reduce impacts that alter other natural processes
Sediment conditions and water quality[5]	Decreased sediment quantity (impaired sediment/sand routing and gravel recruitment)	Place gravel for spawning (below dams) Remove Little Sandy River diversion (completed)
	Increased sediment quantity (turbidity from excessive fine sediment)	Conduct sediment source analyses and reduce inputs Develop/implement stormwater management plans for urban areas and roads Identify and rectify problem legacy roads
Water quantity	Altered hydrology Decreased water quantity/downstream flows Altered flow timing	Protect intact riparian areas via easements and acquisition Explore cooperative water conservation measures Restore connectivity to small tributaries Restore degraded off-channel and riparian habitat Establish minimum ecosystem-based instream flows Identify and halt illegal water withdrawals

Watershed-based actions of particular importance will include efforts to restore hydrologic, riparian, and sediment processes. Accordingly, the management unit plans identify systemic actions related to land use planning and management. In the Washington plan, such actions include managing forest lands to protect and restore watershed processes, managing growth and development to protect watershed processes and habitat conditions, and protecting and restoring stream corridor structure and function, hillslope processes, floodplain function, and channel migration (LCFRB

[4] Condit Dam was breached in October 2011; complete removal is expected by August 2012.
[5] The data dictionary and limiting factors crosswalk consider turbidity as a subcategory of the water quality limiting factor and thus separately from sediment conditions, but the two limiting factors are presented together in this table because their mechanisms, causes, and effects in the lower Columbia River basin are so similar.

2010a). The Oregon plan includes actions to (1) develop land management scenarios that address hydrograph changes resulting from altered runoff and climate change, (2) protect and restore riparian areas to provide long-term supplies of large wood to streams, (3) develop stormwater management plans, (4) conduct sediment source analyses and implement needed actions, (5) ensure that future development impacts in the 100-year floodplain are either low-impact or are mitigated, and (6) prohibit development of new dikes, levees, and floodwalls in the 100-year floodplain unless they will not increase flood volume, size, and/or intensity (ODFW 2010).

Managing the impacts of growth and development on watershed processes and habitat conditions will be key to protecting and improving habitat conditions for Lower Columbia River salmon and steelhead. Accordingly, the recovery strategy proposes actions such as managing urban stormwater and agricultural runoff to reduce contaminants in streams (LCFRB 2010a), limiting water withdrawals to maintain instream flows (LCFRB 2010a) and temperatures, and using land use planning to encourage low-impact development and to direct future development away from ecologically sensitive areas (LCFRB 2010a, ODFW 2010).

Subbasins vary in the role they will play in recovery, with some subbasins targeted to support several primary populations from different ESUs,[6] some that will not support any primary populations,[7] and some targeted to support a mix of primary and contributing populations. Table 4-3 shows subbasins targeted in the management unit plans to support three or more primary populations. Together, these are the subbasins used by most of the core and genetic legacy populations from the Lower Columbia River ESUs. These subbasins will play a key role in the recovery of multiple species and populations and are where much of the improvements in population status will take place, across ESUs.

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[6] As described in Section 3.1.3, primary populations are those targeted for high or very high probability of persistence, based on their historical productivity, their genetic contribution to the ESU, the geographical distribution of primary populations within the ESU (to reduce catastrophic risk), and the feasibility of improving a given population's status.

[7] Subbasins that the management unit plans designate as having no primary populations under the recovery scenario are the Youngs Bay, Big Creek, Tilton, and Salmon Creek. Because the Youngs Bay and Big Creek subbasins are terminal fishing areas, the impact of hatchery production and harvest on natural-origin fish in these subbasins is expected to remain high. The Tilton subbasin has passage barriers to its upper reaches, along with habitat degradation in its lower reaches. Habitat degradation also is an issue in the heavily urbanized Salmon Creek subbasin, where urban and rural development pressures are increasing. In the White Salmon subbasin, recovery prospects are highly uncertain and recovery is expected to take considerable time as habitat recovers from the impacts of Condit Dam, which was breached in October 2011 and is scheduled to be completely removed by August 2012. Uncertainties include the habitat response to dam breaching and removal and the success of recolonization or reintroduction efforts. In addition, the Lower Cowlitz subbasin has only one primary population—coho salmon—because of passage barriers to upper reaches, the largely non-forested state of the lower reaches, and growing cities and towns; however, some habitat in the Lower Cowlitz subbasin will support primary populations outmigrating from upstream subbasins (i.e., the Upper Cowlitz, Cispus, Toutle, and Coweeman).

Table 4-3
Subbasins Targeted to Support Three or More Primary Populations

Ecozone	Subbasin	Primary Populations
Coast	Elochoman	Fall Chinook, chum, coho
	Clatskanie	Fall Chinook, chum, coho
	Scappoose	Fall Chinook, chum, coho
Cascade	Coweeman	Fall Chinook, winter steelhead, coho
	SF Toutle	Fall Chinook, winter steelhead, coho
	NF Toutle	Fall Chinook, winter steelhead, coho
	Cispus	Spring Chinook, winter steelhead, coho
	Upper Cowlitz	Spring Chinook, winter steelhead, coho
	NF Lewis	Fall Chinook, late-fall Chinook, spring Chinook, chum
	EF Lewis	Fall Chinook, chum, winter steelhead, summer steelhead, coho
	Washougal	Fall Chinook, chum, summer steelhead
	Sandy	Late-fall Chinook, spring Chinook, chum, winter steelhead, coho
Gorge	Lower Gorge tribs	Chum, winter steelhead, coho
	Hood	Fall Chinook, spring Chinook, winter steelhead, summer steelhead, coho

NMFS encourages implementers of this recovery plan to carry out tributary habitat protection and restoration actions specified in the Oregon, Washington, and White Salmon management unit plans in a manner that addresses limiting factors at the population scale. NMFS also encourages relevant entities to revise or add regulatory and/or incentive programs where monitoring indicates that habitat function and conditions are not improving. Particularly relevant are programs that address activities in floodplains and riparian areas and that affect sedimentation and other watershed processes.

NMFS welcomes opportunities to work with implementers to pursue ESA regulatory assurances to ensure that programs meet the conservation needs of salmon and steelhead. Among non-Federal programs, for example, NMFS has determined that Washington's habitat conservation plan for state-owned forest land and its Forest Practices Rules for private forest land meet conservation needs for salmon and steelhead. NMFS' view is that some state land management and regulatory programs (e.g., state forest management and forest practice rules in Oregon and regulation of certain agricultural practices in Oregon and Washington) do not provide adequate certainty that they will protect and restore salmon and steelhead habitat in a manner sufficient to recover the subject ESA-listed species. Where population-level habitat monitoring indicates statistically significant trends in degradation of key habitat features, the Oregon management unit plan calls for encouraging new or revised regulatory measures to eliminate further degradation of key habitat features, protect existing high-quality areas, and allow long-term passive restoration (ODFW 2010); the management unit plan does not identify a specific implementing entity for this action.

NMFS considers this action a high priority and intends to work with ODFW and other appropriate agencies on its implementation.

Among Federal programs, since 1994, for example, land management by the U.S. Forest Service and Bureau of Land Management in western Oregon has been guided by the Northwest Forest Plan (U.S. Department of Agriculture and U.S. Department of Interior 1994). The aquatic conservation strategy in this plan includes elements such as designated riparian management zones, activity-specific management standards, watershed assessment, watershed restoration, and identification of key watersheds (USDA and USDI, 1994). The Northwest Forest Plan has large riparian management zones and relatively protective, activity-specific management standards (USDA and USDI, 1994). NMFS considers the Northwest Forest Plan, when fully implemented, sufficient to provide for the habitat needs of Lower Columbia River salmon and steelhead and Columbia River chum on Federal lands. (Although maintaining high-quality habitat on Federal lands is necessary for the recovery of these species, recovery is unlikely unless habitat also can be improved in streams with high potential on non-Federal lands.)

Many other Federal programs are also important to protection and restoration of salmon and steelhead habitat. In addition to working with agencies to fulfill their ESA section 7(a)(2) responsibilities, NMFS welcomes opportunities to work with Federal agencies to develop ESA section 7(a)(1) conservation programs that provide a more localized approach to priority threats and limiting factors.

For information on stratum-level tributary habitat strategies, see Sections 6.6.2, 7.4.3.2, 7.5.3.2, 7.6.3.1, 8.6.2, and 9.6.1.

4.2 Estuary Habitat

Habitat conditions in the Columbia River estuary and plume are important to the survival of all Columbia Basin salmon and steelhead during critical rearing, migration, and saltwater acclimation periods in their life cycle. For purposes of this recovery plan, the Columbia River estuary is defined as extending from the mouth of the Columbia River 146 miles upstream to Bonneville Dam and includes the Willamette River below Willamette Falls and the tidally influenced portions of other tributaries below Bonneville Dam. The Columbia River plume is generally defined by a reduced-salinity contour near the ocean surface off the immediate coasts of both Oregon and Washington and extending outward to the continental shelf.

The estuary and plume provide salmon and steelhead with a food-rich environment where they undergo the physiological changes needed to make the transition to and from saltwater and achieve the growth needed to bolster their marine survival (NMFS 2011a, LCFRB 2010a). Areas of adjacent habitat types distributed across the estuarine salinity gradient may be necessary to support annual migrations of juvenile salmonids (Bottom et al. 2005, cited in LCFRB 2010a). Observations of juveniles moving from low-tide refuge areas in deeper channels to salt marsh habitats at high tide and back again (Healey 1982, cited in LCFRB 2010a) reinforce the belief that access to suitable low-tide refugia near marsh habitat is an important factor in production and survival of salmonid juveniles in the Columbia River estuary. Ocean-type salmonids in particular (i.e., fall

Chinook and chum salmon) rely on the estuary for rearing opportunities. Ocean types typically spend weeks to months in the estuary, making use of shallow, vegetated habitats such as marshes and tidal swamps (NMFS 2011a). The plume—a unique low-salinity, high-productivity environment that extends well into the ocean—appears to serve a similar function for stream-type salmonids, offering feeding opportunities for coho salmon, spring Chinook salmon, and steelhead and distributing juveniles in the coastal environment (NMFS 2011a). These species typically make more use of the plume than ocean types do, spend less time in the estuary, and use mostly deeper, main-channel estuarine habitats rather than shallow vegetated wetlands (NMFS 2011a). However, feeding and refuge areas in the estuary may be important even for salmonid species that move through the estuary relatively quickly (LCFRB 2010a).

In addition, the physical refugia and turbidity in the estuary and possibly also the plume historically helped protect both ocean- and stream-type juveniles from predators (NMFS 2011a).

For more information on the Columbia River estuary, see the *Columbia River Estuary ESA Recovery Plan Module for Salmon and Steelhead* (NMFS 2011a).[8]

4.2.1 Estuary Habitat Limiting Factors and Threats

Currently a lack of habitat opportunity and reduced habitat quality limit the viability of salmon and steelhead in the Columbia River estuary and plume. The amount and accessibility of in-channel, off-channel, and plume habitat have been reduced as a result of habitat conversion for agricultural, urban, and industrial uses, hydroregulation and flood control, channelization, and higher bankfull elevations, which have been facilitated by diking, dredging, and filling. Overbank flooding that normally would aid juveniles in accessing off-channel refugia and food resources has been virtually eliminated, and sediment transport processes that structure habitat (and offer protection from predators) have been impaired (NMFS 2011a). Access to up to 77 percent of historical tidal swamps and many other peripheral wetlands has been eliminated, and the surface area of the estuary has decreased by approximately 20 percent over the past 200 years (Fresh et al. 2005). Similarly, over roughly the last century the annual mean river flow through the estuary has declined by about 16 percent and peak spring flows have declined about 44 percent (Jay and Naik 2002 as cited in NMFS 2011a).

Some reductions in Columbia River flow are attributable to water withdrawals for irrigation and commercial, industrial, municipal, domestic, and other human uses.

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[8] The *Columbia River Estuary ESA Recovery Plan Module for Salmon and Steelhead* (NMFS 2011a) synthesizes recently available information on the Columbia River estuary and plume to identify and analyze (1) limiting factors and threats in the estuary and plume that affect the viability of salmon and steelhead populations, (2) management actions whose implementation would reduce the threats and thus increase survival of salmon and steelhead during their time in the estuary, (3) the estimated cost of implementing each action over a 25-year period, and (4) monitoring, research, and evaluation needs related to the estuary and plume. Key source documents for the estuary module included two NMFS technical memoranda (Bottom et al. 2005 and Fresh et al 2005) and the subbasin plan for the lower Columbia River estuary and mainstem (Northwest Power and Conservation Council 2004a). Information from these sources was supplemented by input from NMFS' Northwest Fisheries Science Center and Northwest Regional Office, the Lower Columbia River Estuary Partnership, and the Lower Columbia Fish Recovery Board. For more on the estuary module, see Section 1.5.3.

Irrigation needs account for approximately 96 percent of surface water withdrawals and 75 percent of groundwater withdrawals (National Research Council 2004). In total, water withdrawals have reduced flows of the Columbia River by 7 percent since the latter part of the nineteenth century (Jay and Kukulka 2003).

Meanwhile, the quality of the habitat available to salmon and steelhead in the estuary has been compromised. Water temperatures above the upper thermal tolerance range for salmon and steelhead are occurring earlier and more often (NMFS 2011a) and are likely to continue to climb as a result of global climate change (Independent Scientific Advisory Board 2007a, as cited in NMFS 2011a). A variety of toxic contaminants have been found in water, sediments, and salmon tissue in the estuary at concentrations above the estimated thresholds for health effects in juvenile salmon. These contaminants include polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), DDT, and copper (Lower Columbia River Estuary Partnership 2007). Pesticides in current use also have been detected in the estuary, along with emerging contaminants such as pharmaceuticals, personal care products, and brominated fire retardants (Lower Columbia River Estuary Partnership 2007). Although the effects of emerging contaminants on salmon and steelhead are not well understood, these compounds appear to pose risks to salmonid development, health, and fitness through endocrine disruption, bioaccumulative toxicity, or other means. Toxic contaminants are widespread in the estuary, both geographically and in the food chain (Lower Columbia River Estuary Partnership 2007).

Construction of revetments, disposal of dredged material, removal of large wood, and reductions in flow in the estuary have altered the diet of juvenile salmon in the estuary by eliminating much of the vegetated wetlands that historically supplied insect prey for juvenile salmonids and macrodetrital inputs to the estuarine food web. The shift in diet has been compounded by increased microdetrital inputs to the estuary; microdetrital inputs originate in decaying phytoplankton delivered from upstream reservoirs and nutrient inputs from urban, industrial, and agricultural development. The microdetrital-based food web may be less efficient for salmon and steelhead and favor other fish species in the estuary, such as American shad. It is likely that estuarine food web dynamics are being furthered altered by the presence of native and exotic fish, introduced invertebrates, invasive plant species, and thousands of over-water and instream structures, which alter habitat in their immediate vicinity. These and other changes in habitat have left the estuary and plume in a degraded state compared to historical conditions (NMFS 2011a).

In addition, current habitat conditions in the estuary and plume support increased predation on salmonids by northern pikeminnow, pinnipeds, Caspian terns, and cormorants, and juvenile salmon and steelhead in the estuary are subject to mechanical hazards from dredging activities, ship ballast intake, and beach stranding as a result of ship wakes (NMFS 2011a).

The degraded habitat conditions in the estuary and plume affect the abundance, productivity, spatial structure, and diversity of ESA-listed salmon and steelhead and have led to estuarine habitat issues being identified in the Oregon and Washington management unit plans as one of six general categories of threats that limit the viability of Lower Columbia River Chinook, coho, and steelhead and Columbia River chum salmon. Both management unit plans cite water quantity and flow timing, impaired sediment and sand routing, altered channel structure, and loss or degradation of peripheral and transitional habitats in the Columbia River estuary and plume as primary limiting factors that affect all Lower Columbia River Chinook, coho, and steelhead and Columbia River chum salmon juveniles. Management unit recovery planners estimated baseline anthropogenic mortality in the estuary and plume—excluding mortality attributable to predation—at between 9 and 50 percent, depending on species and population; for most populations, the estimates range from 10 to 32 percent (see ODFW pp. 169-200 and LCFRB 2010a pp. 6-17, 6-38, 6-50, and 6-66). These estimates were based in part on mortality estimates in the estuary module (NMFS 2011a).

Additional information about limiting factors, threats, and mortality in the Columbia River estuary and plume is available in Chapters 3 and 4 of the estuary module (NMFS 2011a), ODFW (2010) pp. 88-90, and LCRFB (2010a) pp. 3-33 through 3-47.

4.2.2 Regional Strategy for Estuary Habitat

Actions and strategies presented in the Oregon and Washington management unit plans to reduce estuarine habitat-related threats are consistent with those in the *Columbia River Estuary ESA Recovery Plan Module for Salmon and Steelhead* (NMFS 2011a), which describes and analyzes actions to benefit all Columbia Basin salmon and steelhead species, including the Lower Columbia River ESUs. In general, estuary habitat strategies focus on providing adequate off-channel and intertidal habitats, such as tidal swamp and marsh; restoring habitat complexity in areas modified by agricultural or rural residential use; decreasing exposure to toxic contaminants; and lowering late summer and fall water temperatures. This will be accomplished over the long term by restoring hydrologic, sediment, and riparian processes that structure habitat in the estuary. Representative actions include protecting and restoring high-quality off-channel habitats and riparian areas; identifying and reducing current sources of pollutants; restoring contaminated sites; adjusting the timing, magnitude, and frequency of flows[9]; and breaching and lowering dikes and levees. Together, these actions are expected to increase the complexity and accessibility of estuarine habitat and improve water quality and flow patterns in the estuary and, potentially, the plume. Because the mechanisms of estuary habitat impacts and the techniques for reducing them are poorly understood, estuary habitat actions will need to be implemented under an adaptive management framework. Both the estuary module and the management unit plans identify research needs to reduce critical uncertainties and increase the effectiveness of actions (see Table 5-6 of NMFS 2011a, pp. 233-238 of ODFW 2010, and p. 9-72 of LCFRB 2010a).

An aggressive, strategic approach needs to be developed for implementation of actions in the *Columbia River Estuary ESA Recovery Plan Module for Salmon and Steelhead* (NMFS 2011a). The estuary module refrains from explicitly prioritizing habitat actions because it considers all of the management actions it identifies as necessary in improving the survival of juvenile salmonids in the Columbia River estuary and plume. But the

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[9] Adjusting timing, magnitude, and frequency of flows would be limited by international treaties, the need for flood control, fish management objectives, and power production. However, even slight modifications in the flow regime have the potential to provide significant ecosystem benefits.

module does identify priority reaches for each action and offers several analyses intended to inform future decisions about prioritization (i.e., actions likely to be most beneficial to stream-type salmonids, those that will benefit ocean types, and those that are most cost-effective; see Tables 7-2, 7-3, and 7-5 of NMFS 2011a). These analyses take into account the probable implementation constraints for each action (see Table 5-6 of NMFS 2011a). In addition, the module identifies a need to determine near-term implementation priorities by developing a 5-year implementation plan that provides specificity and certainty regarding near-term actions. For many actions, additional assessment is needed to determine implementation priorities and specific benefits to Lower Columbia River salmon and steelhead.

Developing implementation priorities for estuarine habitat actions should include establishment of milestones or expected trends in improved habitat condition in high-priority intertidal areas, which are particularly important for ocean-type salmon (i.e., fall Chinook and chum salmon). Less is known about the habitat needs of chum salmon than those of other ESUs addressed in this recovery plan, and the management unit plans call for habitat assessments to learn more on this subject. Yet what is known points to overlapping habitat needs with fall Chinook salmon, especially for rearing habitat. A topic to be investigated is whether Coast- and Cascade-stratum chum salmon populations, like fall Chinook salmon, make heavy use of the tidal portions of tributaries at their confluence with the mainstem Columbia. The Washington management unit plan notes that lower tidal reaches of streams were not typically assigned a high priority for habitat actions in the EDT-based watershed assessments, but these areas have been identified as critical rearing areas for both fall Chinook and chum salmon (LCFRB 2010a).

4.3 Hydropower

The Columbia Basin has more than 450 dams, which are managed for hydropower, flood control, and other uses. Together these dams provide active storage of 42 million acre-feet of water, with dams in Canada accounting for about half of the total storage (Northwest Power and Conservation Council 2001, as cited in NMFS 2011a). Within the United States, 14 multi-purpose hydropower projects operate as a coordinated system in the Columbia Basin. Bonneville Dam is the only mainstem hydropower facility within the geographic range of Lower Columbia River salmon and steelhead, but flow management operations at large storage reservoirs in the interior of the Columbia Basin (Grand Coulee, Dworshak, etc.) affect habitat in the lower Columbia River mainstem and estuary, and, potentially, the plume. In addition, significant tributary hydropower dams are located on the Cowlitz and Lewis rivers in Washington and the Willamette, Clackamas, and Sandy rivers in Oregon. Condit Dam, on the White Salmon River, was breached in October 2011, and complete removal is expected by August 2012.[10] The impacts of hydropower facility construction and operation on Lower Columbia salmon and steelhead occur both locally (at, above, and immediately below dams) and downstream, in the Columbia River estuary and, potentially, the plume.

[10] Powerdale Dam, on the Hood River, was removed in 2010.

4.3.1 Hydropower Limiting Factors and Threats

Hydropower limiting factors and threats can be categorized as those related to reservoirs and structures (including passage and habitat access impacts) and those related to flow modifications. These are described briefly below.

4.3.1.1 Reservoir-Related or Structural Impacts

Dam construction on the lower Columbia River and its tributaries has caused habitat loss by converting riverine habitat to large impoundments of slow-moving water and flooding upriver deltas, wetlands, and floodplains (ODFW 2010).

The impoundment of water in large storage reservoirs in the interior Columbia Basin and operations at mainstem hydropower projects in the lower Columbia Basin has contributed to increased water temperatures during the late summer and fall in the Columbia River, including the lower Columbia River mainstem and estuary. Even when elevated temperatures do not cause direct mortality, they can cause adverse physiological and behavioral effects and may enhance conditions for warm-water fish that prey on juvenile salmonids (NMFS 2011a).

Impoundments also alter food webs and enhance opportunities for some predators. In Bonneville Reservoir and just downstream of Bonneville Dam, a variety of fish species—northern pikeminnow, walleye, smallmouth bass, and salmonids—prey on juvenile salmon and steelhead. In addition, adult spring Chinook salmon and steelhead attempting to pass above Bonneville Dam are subject to predation by seals and sea lions that congregate at the dam (U.S. Army Corps of Engineers 2011a). For more on predation, see Section 4.6.1.1.

In addition, water can become supersaturated with atmospheric gases (primarily nitrogen) when spilled over high dams. These high concentrations of gases are absorbed into a fish's bloodstream during respiration. When the gas comes out of solution, bubbles may form and subject the fish to gas bubble disease, which can cause direct mortality or increase susceptibility to disease or predation (LCFRB 2010a). Dam operations have been modified to reduce what once were high dissolved gas levels, but some salmonid mortality continues to be associated with exceptionally high river flows (NMFS 2000a).

Impaired Fish Passage in the Columbia River Mainstem

Bonneville Dam on the Columbia River mainstem acts as a partial migration barrier to Lower Columbia River salmon and steelhead populations that originate above the dam—specifically, Upper Gorge, Hood River, and White Salmon populations. Both downstream-migrating juveniles and upstream-migrating adults experience delay, injury, and mortality while trying to pass the dam.

Although fish ladders provide for upstream passage of adult salmon and steelhead, historically—and during the baseline period for this recovery plan—they have not been completely effective (LCFRB 2010a). More recently in the lower Columbia River mainstem, average survival rates of adults at Bonneville Dam have been estimated at approximately 99 percent for spring Chinook salmon and steelhead and 97 percent for fall Chinook, coho, and chum salmon (NMFS 2008a).

Downstream fish passage at Bonneville Dam is complex, with two passage routes at each of two powerhouses, plus an unattached spillway. Outmigrating juveniles experience different mortality rates depending on whether passage occurs via turbines, spill, or a fish bypass system. NMFS estimates that recent average survival of juveniles from Lower Columbia River ESUs at Bonneville Dam is between 90 and 95 percent, depending on species (NMFS 2008a).

Impaired Fish Passage in Tributaries

Tributary dams create fish passage barriers that limit habitat connectivity and access to spawning and rearing habitats for some Lower Columbia River salmon and steelhead. As with Bonneville Dam, tributary dams can cause mortality of out-migrating juveniles, delay migration of returning adult salmon and steelhead, and hinder or totally block access to historical spawning areas above the dam. Within the lower Columbia recovery planning subdomain, major hydropower systems on the Cowlitz and Lewis rivers in Washington are responsible for the greatest share of blocked habitat access. Tributary dams also restrict fish passage in the Clackamas, Sandy, and White Salmon watersheds.[11] (Although dams are responsible for the greatest share of blocked habitat, inadequate culverts make up the vast majority of all barriers [LCFRB 2010a]; see Section 4.1.1.)

4.3.1.2 Flow-Related Impacts

Before development of the hydropower system, Columbia River flows were characterized by high spring runoff from snowmelt and regular winter and spring floods. Today, the interception and retention of spring freshets in multiple dams and their use for irrigation, reservoir storage, and other purposes cause flow volumes to the Columbia River estuary to be more uniform throughout the year than they were historically (see Figure 4-1). Over the last century, annual mean flow in the Columbia River estuary has declined, the volume of the spring freshet has dropped by 44 percent, and the timing of the freshet has shifted to 14 to 30 days earlier in the year (Jay and Kukulka 2003). Although changes in flow entering the estuary are due to a combination of factors, including water withdrawals and the effects of climate change, the management unit plans and *Columbia River Estuary ESA Recovery Plan Module for Salmon and Steelhead* (NMFS 2011a) identify mainstem dams as the primary contributor to flow alterations in the estuary.

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[11] Powerdale Dam, on the Hood River, was removed in 2010. Condit Dam, on the White Salmon River, was breached in October 2011; complete removal is expected by August 2012.

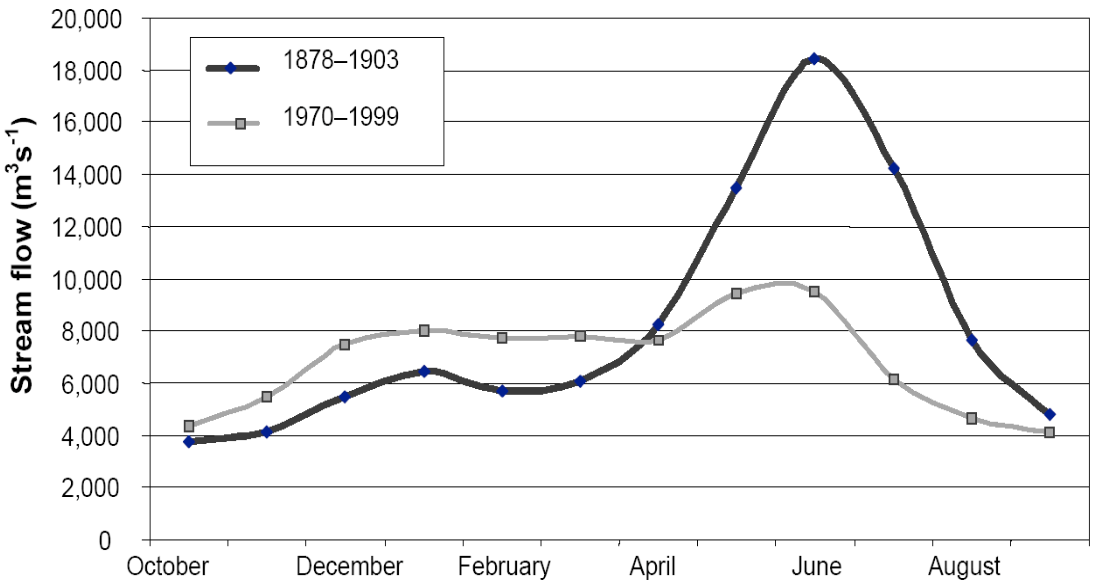

Figure 4-1. *Changes in Annual Columbia River Flow*
(Measured at Beaver Army Terminal, near Quincy, Oregon. Source: Bottom et al. 2005).

Flow alterations have disrupted habitat-forming processes such as the recruitment of large woody debris and sediment delivery to the Columbia River estuary. Historically, sediment was delivered to the estuary largely via spring freshets. That vehicle for sediment delivery has been curtailed, and today reservoirs commonly act to trap upstream supplies of fine sediments (NMFS 2011a). Since the late nineteenth century, sediment transport from the interior of the Columbia Basin to the Columbia River estuary has decreased approximately 60 percent (Jay and Kukulka 2003). This has altered deposition and erosion processes that shape estuarine habitat for salmonids.

Together with diking and the placement of dredged materials on or near the shore, flow alterations have also virtually eliminated the overbank flooding that once allowed juvenile salmonids to access large areas of off-channel habitat for refuge and rearing. Without periodic inundation—tidal, seasonal, or annual—much habitat that formerly was used by juvenile salmonids has disappeared or been transformed into different habitat types (NMFS 2011a).

By reducing wetland and foraging habitat, simplifying habitats, and altering sediment inputs, flow alterations have contributed to changes in the estuarine food web, particularly in detrital food sources. The current food web is based on decaying phytoplankton delivered from upstream reservoirs, instead of macrodetrital inputs from plants and animals originating from emergent forest and other wetland rearing areas in the estuary, as was the case historically. The switch from macrodetrital- to microdetrital-based food sources has lowered the productivity of the estuary (Bottom et al. 2005), provided different and possibly less favorable food sources to juvenile salmonids, and concentrated food sources within the estuarine turbidity maximum, in the middle region of the estuary (Bottom et al. 2005). This location is less accessible to ocean-type salmon, such as chum, that use peripheral habitats (LCFRB 2010a).

Both juvenile and adult migration behavior and travel rates are influenced by the changes in river flow. Artificial regulation of flow can stimulate or delay juvenile emigration or adult migration, thereby affecting the timing of juvenile arrival in the estuary and ocean (ODFW 2010, LCFRB 2010a) or adult arrival at spawning areas (LCFRB 2010a).

Rapid diurnal flow fluctuations can cause unintended and adverse redistribution of mainstem spawners, leave redds dewatered, or strand juveniles (LCFRB 2010a). Although daily flow fluctuations as a result of power production occurred in the past and resulted in dewatering of chum redds, a minimum flow now applies from November through April to reduce the potential for such dewatering.

4.3.2 Regional Hydropower Strategy

The regional hydropower strategy focuses on hydropower operations on the Columbia River mainstem and has three principal components: (1) improving passage survival at Bonneville Dam for Lower Columbia River populations that spawn above the dam, (2) addressing impacts in tributaries by implementing actions prescribed in Federal Energy Regulatory Commission agreements regarding operation of individual tributary dams, and (3) implementing mainstem flow management operations designed to benefit spring migrants from the interior of the Columbia Basin; NMFS expects that these flow management operations will also improve survival in the estuary and, potentially, the plume for all Lower Columbia River salmon and steelhead populations. Actions identified in the 2008 FCRPS Biological Opinion and its 2010 Supplement (NMFS 2008f and 2010a) will aid adults and juveniles from the Gorge populations in passing Bonneville Dam. Specific actions include structural improvements, changes in configuration and operations, and development and implementation of year-round fish passage plans for Bonneville Dam.[12] NMFS' estimates of recent survival of lower Columbia River species are shown in Table 4-4. NMFS expected that implementation of actions in the 2008 FCRPS Biological Opinion would improve juvenile salmon and steelhead survival at Bonneville Dam by less than ½ percent, and that the recent high level of adult survival would be maintained at the levels shown in Table 4-4 (NMFS 2008a and 2010a). Consequently, Oregon did not incorporate survival benefits from passage improvements at Bonneville into the hydropower threat reduction targets for Oregon populations above Bonneville.[13] The Washington management unit plan assumed that actions identified in the 2008 FCRPS Biological Opinion and its 2010 Supplement would aid adults and juveniles from all populations originating above Bonneville Dam. However, preliminary information indicates that survival gains for yearling Chinook and steelhead at Bonneville Dam are higher than expected, and that juvenile passage survivals are above 96 percent in both cases (U.S. Army Corps of Engineers 2011b).

In addition, for chum salmon, the regional hydropower strategy will focus on ensuring adequate flows in the Bonneville Dam tailrace and downstream habitats during chum salmon migration, spawning, incubation, and emergence. FCRPS Biological Opinion

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[12] For more specificity, see the actions in the 2008 FCRPS Biological Opinion Reasonable and Prudent Alternative (NMFS 2008f).

[13] Hydropower-related threat reductions for Oregon populations above Bonneville Dam are associated with removal of Powerdale Dam on the Hood River.

actions will protect chum salmon spawning areas in the mainstem Columbia River in the area of the Ives Island complex and/or will provide access to Hamilton and Hardy creeks. These areas currently constitute significant spawning areas for the Lower Gorge population.

Table 4-4
Estimated Average Survival Rates of Lower Columbia Salmon and Steelhead Passing Bonneville Dam

	Average Survival Rate (%)	
	Juveniles 2002 – 2009	**Adults 2002 – 2007**
Coho salmon	95.1	96.9
Spring Chinook salmon	95.1	98.6
Fall Chinook salmon	95.1	96.9
Chum salmon	95.1	96.9
Steelhead	90.6	98.5

Source: NMFS (2008a) and (2010a).

In its management unit plan, Oregon incorporated four actions addressing impacts of the Columbia River hydropower system that are not included in the 2008 FCRPS Biological Opinion and its 2010 Supplement (NMFS 2008f and 2010a) but that Oregon maintains are needed to benefit Lower Columbia River salmon and steelhead:

- Action 1: Operate lower Columbia reservoirs at minimum operating pool during spring and summer as long as barge transport and irrigation needs are met.
- Action 2: Provide spill to total dissolved gas limits of water quality waivers or biological constraints at all dams, except maximize transportation at Snake River collector projects during lower (10^{th} percentile) flow years.
- Action 3: Draft storage reservoirs to meet Lower Columbia summer flow and velocity equivalent objectives on a seasonal and weekly basis.
- Action 4: Operate reservoirs at rule curves and seek additional flow augmentation volumes from Snake River and Canadian reservoirs to better meet spring and summer flow and velocity objectives.

The state of Oregon's position is that the FCRPS action agencies should conduct operations in addition to those incorporated in the 2008 FCRPS Biological Opinion and its 2010 Supplement to address the needs of ESA-listed salmon and steelhead. Oregon is a plaintiff in litigation against various Federal agencies, including NMFS, challenging the adequacy of measures in the 2008 FCRPS Biological Opinion and its 2010 Supplement. NMFS does not agree with Oregon regarding the need for or likely efficacy of the additional actions that Oregon proposed in that litigation, including the items noted above; thus NMFS is not adopting as part of this recovery plan the additional actions proposed by Oregon.

In the Columbia River estuary, under the terms of the 2008 FCRPS Biological Opinion and its 2010 Supplement (NMFS 2008f and 2010a), the action agencies will implement an expanded estuary habitat program to address limiting factors that affect juvenile salmonids rearing in the estuary. These estuary habitat projects will increase the amount of juvenile salmonid shallow-water habitat and benefit all ESA-listed ESUs. The 2008 FCRPS Biological Opinion and its 2010 Supplement incorporate a relative survival improvement estimate of 9.0 percent for ocean-type ESUs (including Lower Columbia River fall Chinook and Columbia River chum salmon) to be derived from habitat improvements, and an estimate of 5.7 percent for stream-type ESUs (including Lower Columbia River coho salmon, spring Chinook salmon, and steelhead). In addition, the Biological Opinion projects that actions to reduce predation in the estuary will increase survival by additional amounts, as shown in Table 4-5.

Table 4-5
Projected Survival Improvements for Lower Columbia Salmon and Steelhead from Actions to Reduce Predation in the Estuary

	Survival Improvement (%)
Coho salmon	8.8
Spring Chinook salmon	3.1
Fall Chinook salmon	1.7
Chum salmon	1.0
Steelhead	4.4

Source: NMFS (2008f and 2010a).

As noted in the *Columbia River Estuary ESA Recovery Plan Module for Salmon and Steelhead* (NMFS 2011a), actions in the 2008 FCRPS Biological Opinion and its 2010 Supplement that relate to estuarine habitat, predation, and flow are contributing to implementation of actions called for in the module; however, these Biological Opinion actions are projected to yield only a portion of the total survival improvements that the estuary module hypothesizes are possible in those categories. Thus, the module identifies habitat, predation, and flow actions that are larger in scope than the actions that are required under the 2008 FCRPS Biological Opinion and its 2010 Supplement.

For information on stratum-level hydropower strategies, see Sections 6.6.4, 7.4.3.4, 7.5.3.4, 7.6.3.2, 8.6.4, and 9.6.3.

4.4 Hatcheries

For more than a century, fish managers have used hatcheries in the Lower Columbia River to produce fish for harvest. Although some early hatchery programs supplemented already large naturally spawning populations, most were developed to compensate for declining numbers of naturally spawned salmon and steelhead, which were experiencing the detrimental effects of habitat loss (particularly related to hydropower dams) (LCFRB 2010a). Today, salmon and steelhead production in the lower Columbia region is dominated by hatchery-origin fish (ODFW 2010, LCFRB 2010a).

Although the actual number of artificial production programs changes annually based on funding and broodstock availability, in 2011 there were more than 80 separate artificial production programs in the lower Columbia region. Almost all of these programs produce fish for harvest; a few produce fish for reintroduction purposes or to supplement severely depressed natural populations. Most Lower Columbia programs produce either coho or Chinook salmon, while a smaller number produce steelhead, and four programs produce chum salmon (Turner, personal communication 2011).[14]

As shown in Table 4-6, artificial production programs release millions of fall Chinook salmon, spring Chinook salmon, coho salmon, chum salmon, and steelhead into lower Columbia River subbasins each year, although Lower Columbia production has been reduced substantially over the past 15 years. In addition to these releases, hatchery fish released elsewhere in the Columbia Basin migrate through the lower Columbia River as juveniles and adults.

Table 4-6
Hatchery Releases of Salmon and Steelhead in the Lower Columbia River, 2011

LCR Release	By ODFW	By WDFW	By USFWS	Total
Fall Chinook*	11,991,500	14,800,000	17,034,500	43,826,000
Spring Chinook**	1,225,000	2,940,400	1,714,000	5,879,400
Coho	5,404,000	6,689,000	643,900	12,746,900
Summer Steelhead	255,000	1,066,100	0	1,321,100
Winter Steelhead	510,000	1,234,300	111,500	1,855,800
Chum	0	307,000	0	307,000
All releases				65,936,200

* Fall Chinook includes tules, upriver brights, and Select Area brights.
**Excludes Clackamas hatchery spring Chinook salmon, which are in the Upper Willamette spring Chinook ESU.
Source: Turner, personal communication (2011).

Annual returns of adult hatchery-origin fish are large relative to returns of adult fish produced naturally in the Columbia Basin. For example, from 2000 to 2010, the number of adult Lower Columbia River hatchery-origin fall Chinook salmon returning annually to the Columbia River ranged from 27,000 to 156,400, while natural-origin Lower Columbia River fall Chinook salmon returns numbered between 4,300 and 26,000 fish (Joint Columbia River Management Staff 2011). From 2000 to 2008, annual coho salmon returns ranged from 318,600 to more than 1.1 million, with almost all being hatchery-origin fish (NMFS 2008b).[15]

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[14] Only three of these chum salmon hatchery programs are part of the ESU; NMFS has not yet evaluated the fourth, which the Oregon Department of Fish and Wildlife initiated in 2010, for inclusion in the ESU.
[15] Over this same time period, the geometric mean number of natural-origin spawners for the two largest coho salmon populations totaled less than 3,000 (http://www.nwfsc.noaa.gov/trt/trt_documents/lcolumbia_coho.pdf).

At the time many hatchery programs were developed, little was known about the impacts of hatchery fish on natural populations. Instead, it was generally believed that hatchery fish could be substituted for naturally spawning fish without lasting consequences; there was little understanding of the negative impacts hatchery fish could have on naturally spawning populations and of the need to protect naturally spawning populations and their habitats.

Today scientists and managers understand that hatchery programs have the potential both to benefit and to harm Lower Columbia River salmon and steelhead. The weight of available scientific evidence indicates that any artificial breeding and rearing will result in some degree of genetic change and fitness reduction in hatchery fish, and in the progeny of hatchery-origin fish that spawn naturally, relative to desired levels of diversity and productivity for natural populations. Hatchery fish thus pose a threat to the rebuilding and recovery of natural populations when they interbreed with fish from natural populations. That risk is outweighed in certain circumstances, such as when the near-term demographic risks of extinction outweigh longer term risks to population diversity and productivity. The extent and duration of genetic change and fitness loss and the near- and long-term implications and consequences for different species, for species with multiple life-history types, and under different hatchery practices and protocols remains unclear and should be the subject of further scientific investigation. NMFS believes that in certain circumstances, hatchery intervention is an appropriate tool to help avert salmon and steelhead extinction in the near term and to accelerate the recolonization of habitat. Otherwise, managers should limit interactions between hatchery- and natural-origin fish during the transition to hatchery practices consistent with recovery of listed populations, treaty fishing rights, and other applicable laws and policies.

4.4.1 Hatchery Limiting Factors and Threats

4.4.1.1 Genetic Effects

Hatchery practices such as broodstock collection and spawning protocols can cause genetic changes in hatchery fish. When hatchery-origin fish spawn with natural-origin fish, these genetic changes can be transmitted to the naturally produced fish; the larger the proportion of hatchery-origin spawners, the larger the genetic effects to the natural population. These genetic effects can be summarized as follows (NMFS 2011d):

- Loss of within-population diversity. Loss of within-population genetic diversity is a loss in the amount or type of genetic variability in a population, which can be caused by genetic drift and inbreeding depression. Genetic drift typically results from using small numbers of broodstock fish, having an unbalanced sex ratio in the broodstock, or pooling gametes from many adults during spawning. Inbreeding depression is a reduction in fitness caused by mating related individuals (Busack and Currens 1995, NMFS 2011d). The smaller the population, the higher the probability of inbreeding.

- Outbreeding effects. Outbreeding effects refer to changes in fitness and diversity caused by gene flow (i.e., interbreeding) in excess of natural rates among genetically distinct populations (NMFS 2011d). One outbreeding effect is loss of within-population diversity, which may have no immediate impact on fitness. Large-scale loss of diversity is called "genetic swamping" or homogenization. The other outbreeding effect is outbreeding depression, in which changes in diversity caused by gene flow result in loss of fitness. Decreased disease resistance (Currens et al. 1997) and diminished ability to avoid predators (Tymchuk et al. 2007) are demonstrated results of outbreeding depression.

- Domestication selection. Domestication selection is intentional or inadvertent change to the natural selection regime caused by hatchery culture, resulting in the fish being less well adapted in the wild. Traits such as fish size, timing of spawning, growth rate, and feeding behaviors are subject to domestication selection. Domestication selection can also include the relaxation of selection. For example, hatchery fish do not participate in mate-choice behaviors, and the ability to perform these behaviors effectively can diminish in hatchery populations. When naturally produced fish interbreed with hatchery-origin fish, the level of domestication selection that occurs to the total population is a function of the fraction of hatchery-origin fish on the spawning grounds and the composition of the hatchery broodstock (NMFS 2011d, Berejikian and Ford 2004).

High proportions of hatchery fish on the spawning grounds have been common for decades in many Lower Columbia River salmon and steelhead populations, including the vast majority of Chinook and coho salmon populations. The impacts are likely a mix of outbreeding effects and domestication selection. For example, homogenization already has occurred in natural-origin coho salmon, which are now genetically indistinguishable from hatchery fish (Flagg et al. 1995). Fitness impacts from domestication selection are difficult to quantify in the Lower Columbia River, but a recent review of the literature worldwide suggests that progeny of hatchery fish that spawn in the wild are less likely to survive and return as adults than the progeny of natural-origin spawners (Berejikian and Ford 2004). In addition, Chilcote et al. (2011) found a negative relationship between the reproductive performance in natural, anadromous populations of steelhead, coho salmon, and Chinook salmon and the proportion of hatchery fish in the spawning population, including populations in the Lower Columbia.

4.4.1.2 Competition (Density-Dependent Mortality) and Predation

Density dependence refers to changes in the productivity of a population that are a result of the size of the population (productivity here refers to the number of returning offspring per spawner). In a density-dependent process, the number of offspring produced per spawner is higher when there are few spawners but decreases to one offspring per spawner (i.e., replacement) when the number of spawners is at the habitat's carrying capacity). With salmon and steelhead, density-dependent mortality can occur at any stage in the animal's life cycle and may be exacerbated by the introduction of large numbers of hatchery fish released over a relatively short time (NMFS 2011a).

Some scientists suspect that closely spaced releases of hatchery fish from Columbia Basin hatcheries may lead to increased competition with natural-origin fish for food and habitat space in the Columbia River estuary. NMFS (2011) and LCFRB (2010a) identified competition for food and space among hatchery and natural-origin juveniles in the estuary as a critical uncertainty. ODFW (2010) acknowledged this uncertainty but listed competition for food and space as a secondary limiting factor for juveniles of all populations. The NMFS Northwest Region and Northwest Fisheries Science Center are working to better define and describe the scientific uncertainty associated with ecological interactions between hatchery-origin and natural-origin salmon in freshwater, estuarine, and nearshore ocean habitats.

In addition, hatchery fish can sometimes prey directly on naturally produced juveniles, particularly chum salmon (ODFW 2010). Chum salmon fry from all populations may experience predation by hatchery-origin coho salmon, steelhead, and Chinook salmon smolts, although differences in life history patterns may moderate effects and the significance of interactions is unknown.

4.4.1.3 Other Effects: Disease Transmission, Passage Blockages, Water Withdrawals, and Mixed Stock Harvest

Hatchery fish can be infected with pathogens or parasites and have the potential to spread these organisms to natural-origin fish, although disease transmission from hatchery to natural-origin fish does not appear to be widespread in the lower Columbia region (LCFRB 2010a). (For more on this topic, see Section 4.6.1.3.) Hatchery structures, such as weirs, ladders, and screens, can injure fish and block or delay the passage of naturally produced adults and juveniles and thus reduce population spatial structure. Water withdrawals for hatchery operations can reduce tributary flow and habitat quality. Lastly, when hatchery production stimulates harvest, the incidental mortality of naturally produced fish can increase.

4.4.2 Regional Hatchery Strategy

For most Lower Columbia River ESUs, the general goals of the hatchery strategies developed by local recovery planners, and the basic approaches they recommend for achieving those goals, are similar. These goals and approaches are summarized below. Although these strategies are especially relevant for Lower Columbia River coho, spring and fall Chinook salmon, and Lower Columbia River steelhead (which have been subject to the most hatchery influence), they also are relevant to Columbia River chum salmon and late-fall Chinook salmon to the extent that hatcheries have created or may create limiting factors for these fish. Although the overall hatchery strategy will be applied consistently throughout the domain, management unit planners have or will establish specific targets for reductions in hatchery impacts at the population level and specific actions for achieving those targets; consequently, the specifics of how the regional hatchery strategy is applied will differ among populations and among hatchery programs.

The overall goals of the hatchery recovery strategies for the Lower Columbia ESUs are to (1) reduce hatchery impacts on natural-origin populations as appropriate for each population, (2) ensure that some populations have no in-subbasin hatchery releases and are isolated from stray out-of-subbasin hatchery fish, (3) use hatchery stocks in the short term for reintroduction or supplementation programs to restore naturally spawning populations in some watersheds, and (4) ensure rigorous monitoring and evaluation to better understand existing population status and the effects of hatchery strategies on natural populations. The management unit plans include the additional societal goal of maintaining harvest opportunities created by hatchery fish. To accomplish these goals, hatchery programs will be managed in one of two general ways: as genetically integrated with or segregated from the natural populations they most directly influence.

In integrated programs, the intent is for the natural environment to drive the adaptation and fitness of a composite population of fish that spawns both in a hatchery and in the wild (i.e., to limit domestication). When hatcheries are used for conservation purposes (e.g., increasing the abundance of natural spawners, reintroducing fish into historically occupied habitats, or conserving genetic resources), integrated programs are the tool of choice because, by design, they allow a certain number of hatchery-origin fish to spawn in the wild. Integrated programs are also sometimes used to provide harvest opportunities, in which case the intent is to produce a desired set of fishery characteristics; however, there is still the need to reduce the effects of hatchery-origin fish spawning naturally. Integrated programs promote local adaptation and natural productivity through measures such as use of local broodstock, inclusion of naturally produced fish in the hatchery broodstock, and limits on the proportion of hatchery fish spawning in the wild.

In segregated programs, the intent is to maintain a hatchery population that is genetically isolated from and does not interact with the natural population. In contrast to integrated programs, segregated programs reduce domestication solely by minimizing spawning between natural-origin and hatchery-origin fish. The purpose of segregated programs is almost always to provide harvest opportunities. Risks posed to the natural population by the hatchery fish are reduced by minimizing interactions throughout the fishes' life cycles, including the proportion of hatchery-origin spawners (pHOS) on the spawning grounds. Managers control the proportion of hatchery-origin spawners through measures such as reducing overall production, shifting production to reduce straying into certain watersheds, changing production strategies to reduce straying (e.g., using different acclimation or release strategies), physically removing hatchery-origin fish (distinguishable by their clipped adipose fins) from natural spawning areas at weirs or other physical barriers, maintaining some wild fish sanctuaries (i.e., populations or substantial portions of subbasins where the pHOS target is very low), and improving habitat conditions to increase the number of natural-origin fish.

Theoretically the two approaches can be equally effective at limiting domestication impacts. Guidelines exist for applying both approaches to primary, contributing, and stabilizing populations (see Appendix A of Hatchery Scientific Review Group 2009.). The risks posed by a particular program are based not on the program type but on the gene flow levels involved (i.e., the proportion of natural-origin broodstock and the proportion of hatchery-origin spawners). Chilcote et al. (2011) evaluated the effects of hatchery programs on 89 steelhead, coho, and Chinook salmon populations and concluded that the proportion of hatchery-origin fish on the spawning grounds (pHOS) was negatively correlated with population productivity; furthermore, there seemed to be no difference in the impact of integrated and segregated programs on productivity. The authors concluded that, under most circumstances, ensuring that hatchery-origin fish are segregated from natural-origin fish on the spawning grounds (i.e., reducing pHOS) may be the best long-term conservation strategy regardless of brood type. A note about Chilcote et al.'s integrated-segregated comparison is that integrated programs complying with modern gene flow guidelines for reducing domestication are still uncommon and typically quite new, so a more detailed assessment and finer scale research of truly integrated hatchery programs is needed.

In addition to managing potential genetic effects of hatchery-origin fish on natural-origin fish, another important management consideration for both integrated and segregated programs is potential ecological effects, such as competition for food or space between hatchery-origin and natural-origin fish. Therefore controlling pHOS and managing juvenile release levels to minimize detrimental interactions are important considerations in both integrated and segregated programs.

Collectively, both Oregon and Washington will use both segregated and integrated programs, for fishery enhancement and to help recover natural populations above tributary dams that have blocked access to historical habitat and in other areas where the abundance of natural-origin fish is very low and hatchery supplementation can reduce extinction risk in the short term. Managers will limit the proportion of hatchery-origin fish spawning naturally by using measures such as reducing overall production, changing production strategies to reduce straying (e.g., using different acclimation or release strategies), and physically removing hatchery-origin fish (distinguishable by their clipped adipose fins) from natural spawning areas at weirs or other physical barriers. Managing the genetic and ecological risks posed by hatchery fish with the demographic risks of low natural abundance and productivity is an important aspect of the strategy—one that is characterized by many uncertainties. Decisions about whether to use artificial propagation to help conserve populations must take into consideration the benefits to the population and ESU versus the risks.

In both states, efforts to reduce hatchery impacts will be targeted at achieving a level of hatchery influence appropriate to each population, based on its target status. For example, for populations targeted for a high probability of persistence, Oregon has established a target of no more than 10 percent hatchery-origin spawners in natural spawning areas (ODFW 2010). Washington will establish similar targets in the Conservation and Sustainable Fisheries Plan being developed by the Washington Department of Fish and Wildlife.

The management unit plans also call for continuing existing programs to mark all hatchery-produced coho salmon with an adipose fin clip and for coded wire tagging enough fish from each hatchery to allow identification of the hatchery program of origin (ODFW 2010). The latter strategy will allow rearing and release strategies to be modified where needed to further reduce straying. Another element of the hatchery strategy will be to continue best management practices such as juvenile release strategies that minimize impacts to natural populations.

There are critical uncertainties associated with the approaches described above. For integrated programs, the primary uncertainties include the availability of sufficient numbers of naturally produced fish for incorporation into the hatchery broodstock and the validity of assumptions concerning the natural fitness of hatchery-origin fish produced using natural broodstock. (For example, for a population with very low natural-origin abundance, what are the tradeoffs of introducing natural-origin fish into hatchery broodstock versus waiting until natural production has increased?) For both integrated and segregated programs, a primary uncertainty concerns the effectiveness of measures such as weirs, acclimation, or release sites in achieving desired reductions in pHOS. A key unknown for all hatchery reforms is how quickly natural population diversity and productivity will respond to limiting the numbers of hatchery fish on the spawning grounds, and the extent to which limiting hatchery fish on the spawning grounds will affect the short-term demographic risks to the natural population by reducing the total number of spawners.

NMFS and other recovery planning entities will work with hatchery managers to develop more detail about how and when the strategies described above will be implemented, including detail about how strategies will reduce the proportion of hatchery fish in naturally spawning populations in a manner that addresses short-term demographic risks while promoting progress toward recovery objectives. A near-term priority is for state and Federal hatchery program managers, working with NMFS and other recovery planning entities, to develop detailed schedules for implementation of hatchery strategies that address these questions and that lay out plans for transitioning from existing hatchery management to practices consistent with recovery of listed populations, treaty fishing rights, and other applicable laws and policies.[16] Through reduction of hatchery impacts, long-term priorities include achieving the recovery targets for each population and providing harvest opportunities.

NMFS expects that in general these "transition schedules" will reflect a plan to determine the extent to which naturally produced adults are returning to a population's habitat, as well as whether the intent for each population is to use hatchery supplementation. Use of hatchery supplementation should be considered an experimental strategy and not applied everywhere (that is, for some populations, the strategy should be to let the population restart based on stray spawners from nearby populations, an approach that has been demonstrated to work in the Scappoose and Clatskanie coho salmon populations). The schedules should also reflect an experimental design that will implement and evaluate several short-term recovery strategies to evaluate how different levels of natural and hatchery-origin fish on the spawning grounds affect progress toward recovery. The schedules should also address whether the long-term strategy for the use of hatchery fish is to isolate hatchery fish from the natural spawning population or to develop an integrated hatchery/natural population.

For information on stratum-level hatchery strategies, see Sections 6.6.6, 7.4.3.6, 7.5.3.6, 7.6.3.4, 8.6.6, and 9.6.5.

[16] In 2011, hatchery managers developed transition schedules for Lower Columbia River fall Chinook populations designated in this recovery plan as primary (see "Task E" at http://www.nwr.noaa.gov/Salmon-Recovery-Planning/Recovery-Domains/Willamette-Lower-Columbia/LC/BO-tasks.cfm).

4.5 Harvest

Because of their wide-ranging migrations, anadromous salmonids are exposed to a variety of freshwater and ocean fisheries. Lower Columbia River salmonids are caught in commercial, recreational, and tribal fisheries along the West Coast of the United States and Canada as well as in the mainstem Columbia River and its tributaries. These various fisheries focus on different stocks and populations, taking fish to meet commercial, recreational, and tribal harvest allocations (see Table 4-7). A given fishery may be selective for fin-clipped hatchery fish or non-selective.

In the early part of the 20th century, nearly all commercial salmon fisheries in the Pacific Northwest operated in fresh water, where they harvested only mature salmon. Ocean fisheries became more important in the late 1950s as more restrictions were imposed on freshwater and coastal fisheries. Ocean harvest of salmon peaked in the 1970s and 1980s, after which commercial and recreational harvest of Columbia River salmon and steelhead declined. Harvest on Lower Columbia River tule fall Chinook salmon has been reduced from rates that averaged 69 percent during the years 1983 to 1993 (and that at one time exceeded 80 percent) to an average of 48 percent in the years since listing (NMFS 2008c). Tule fall Chinook salmon harvest rates recently have been further reduced, to 38 percent in 2009 and 2010 and 37 percent in 2011. Lower Columbia River spring Chinook salmon harvest averaged 51 percent during the years prior to listing (1980 to 1993) and has been reduced to around 20 percent since listing (NMFS 2008c). Harvest rates on Lower Columbia River coho salmon in the mid-1990s ranged from 75 to 90 percent, but since 2005, when NMFS listed this ESU, rates have averaged 16 percent. Before the mid-1970s, harvest impacts on Lower Columbia River steelhead were 70 percent or more. These impacts were reduced in 1975 when commercial harvest of steelhead in non-treaty fisheries was prohibited. Through implementation of mass marking and selective harvest, these rates were further reduced in the late 1980s and are now 10 percent or less. Columbia River chum salmon are not significantly affected by either direct or indirect harvest mortality (although historically harvest impacts were in the 90 percent range).

Table 4-7
Fisheries Affecting Lower Columbia ESUs

Area	Fishery Type	Targeted LCR ESU
Canada, Southeast Alaska (ocean)	Commercial troll and net Recreational fishing	Chinook (fall and spring) Coho
U.S. West Coast (ocean)	Commercial troll Treaty Indian commercial troll Recreational	Chinook (fall and spring) Coho
Lower Columbia River Mainstem	Commercial net; includes Select Area fisheries on fish returning to off-channel areas from net pen and hatchery releases in those places	Chinook (fall and spring) Coho
Lower Columbia River Mainstem	Recreational; includes Select Areas	Chinook (fall and spring) Coho Steelhead
Columbia River Mainstem above Bonneville (Zone 6a)	Treaty Indian set net fishing, both commercial and ceremonial and subsistence Recreational	Steelhead Chinook (fall and spring)
Oregon and Washington Tributaries	Recreational	Steelhead Coho Chinook (fall and spring)

Table 4-8 summarizes average harvest rates for natural- and hatchery-origin Lower Columbia River salmon and steelhead since the time of listing, along with the higher rates that generally occurred throughout the 1980s and early 1990s. Estimates of harvest impacts on a given ESU or run component can vary widely depending on the ESU, run component, and fisheries in question, the methods used, and the purpose of a given estimate. For example, estimates may be derived from coded-wire tags or through use of fishery models or other methods, depending on available information. Estimates may be for all fisheries or just those in the ocean or fresh water. In some cases, generalizations are sufficient to communicate the general magnitude of harvest impacts; in other cases, it is important to specify the source and methods used to derive a given estimate. The values in Table 4-8 rely where possible on published reports that contain specific estimates and explanations of how they were derived. These estimates may differ slightly from estimates in the management unit plans (which, in turn, may differ from each other). For purposes of indicating harvest impacts in general, all of these estimates are acceptable.

Table 4-8
Recent (Since Listing) Estimated Harvest Rates on Lower Columbia River Salmon and Steelhead Compared to Historical Highs

Stock	Natural-origin Fish (% harvested)	Hatchery-origin Fish (% harvested)	Historical High (Natural-origin Fish) (% harvested)
Spring Chinook[1]	20	34	51
Fall Chinook (Tule)[2]	48	48	69
Fall Chinook (Bright)[3]	36	NA	54
Chum[4]	1.6	1.6	NA
Coho[5]	16	NA	82
Steelhead (winter)[6]	4.1	NA	70
Steelhead (summer)[7]	6.7	NA	70

[1] 20 percent = average since listing (1999-2006), derived assuming that freshwater exploitation rates were 2 percent as a result of selective fisheries and constraints on upriver spring Chinook salmon); 34 percent = average since listing (1999-2006); 51 percent = average for the years 1980-1993 (NMFS 2008c).
[2] 48 percent = average since listing (1999-2006); 69 percent = average for the years 1983-1993 (NMFS 2008c).
[3] 36 percent = average since listing (1999-2006); 54 percent = average for the years 1979-1993 (NMFS 2008c).
[4] Source: NMFS 2008c. Although a specific estimate of historical harvest rates is not available, harvest on chum salmon was high through the 1950s but has been limited since the 1960s to a few hundred fish per year, at most (Washington Department of Fish and Wildlife and Oregon Department of Fish and Wildlife 2002).
[5] 16 percent = average since listing (2005-2007); 82 percent = average for the years 1970-1993 (NMFS 2008c).
[6] 4.1 percent = average for the years 2001-2007 (NMFS 2008c); 70 percent = generalization from LCFRB (2010a).
[7] 6.7 percent = average for the years 1998-2007 (NMFS 2008c); 70 percent = generalization from LCFRB (2010a).

Fisheries affecting Lower Columbia River salmon and steelhead are managed by a number of regional and international organizations and agreements, including the Pacific Salmon Commission (which implements the Pacific Salmon Treaty between the United States and Canada), the Pacific Fishery Management Council, state fishery regulations in Oregon and Washington, the Columbia River Compact, and management agreements negotiated between the parties to *U.S. v. Oregon*. In addition, Federal statutes such as the ESA and Magnuson-Stevens Fisheries Conservation and Management Act influence harvest management decisions. Fishery managers continually review population abundance and marine survival conditions, and adjust harvest rates and timing to minimize impacts to natural-origin stocks. They generally try to manage fisheries using a combination of gear, timing, area, and mark-selective regulations to optimize the harvest of hatchery-origin fish and strong natural stocks and protect weaker natural-origin stocks. Because of these fishing regulations and other actions, harvest rates for hatchery-produced Chinook salmon, coho salmon, and steelhead are higher than for natural-origin fish of the same species.

Both the Oregon and Washington management unit plans provide detailed information on the fisheries that affect Lower Columbia River salmon and steelhead and the organizations, agreements, and statutes that guide harvest management decisions (see

LCFRB 2010a pp. 3-62 through 3-69 and 3-70 through 3-75 and ODFW 2010 pp. 91 and 94).

4.5.1 Harvest Limiting Factors and Threats

Harvest affects the viability of Lower Columbia River salmon and steelhead populations by causing mortality to naturally produced adult fish, influencing population traits, and reducing nutrients in freshwater ecosystems.

4.5.1.1 Harvest Mortality

Harvest mortality can be either direct or indirect. Direct harvest mortality is associated with fisheries that target specific stocks. This includes both single-stock (terminal) and mixed-stock (intercept) fisheries. Single-stock fisheries are the most effective method for targeting a specific stock and commonly occur in terminal harvest areas where one stock is known to be present. In mixed-stock fisheries, the management challenge is to harvest from mixed populations having various available surpluses (sometimes including populations with no surplus) as the populations move through the fishery area at various rates and abundances. Harvest of a specific stock in the mix can be achieved through management decisions (e.g., fishery openings that use time and area to target stocks when and where they are abundant relative to other stocks), fishery adaptations (e.g., gear designed to target specific stock/species), or fishery regulations (e.g., prohibitions against retaining certain species).

Indirect mortality includes mortality of fish harvested incidentally to the targeted species or stock, fish that die after being captured by fishing gear but not landed, and fish that die after being caught and released. Despite the various methods used to target a specific stock, incidental bycatch—the harvest of nontargeted stocks—still occurs, largely because various stocks intermingle. Most fisheries have specific reporting requirements and limits for incidental bycatch that are intended to lessen the harvest impacts to non-targeted stocks. For the Columbia River, Federal, state, and tribal harvest managers set specific incidental harvest percentages for protected stocks and manage fisheries so as not to exceed these limits. They also employ catch and release regulations that allow anglers to retain hatchery-origin salmon and steelhead but require them to release natural-origin fish. Mortality occurs as a result of catch and release because fish experience injury and trauma when they are caught and released, though the degree to which this occurs varies depending on the gear, timing and location of the fishery, and angler knowledge and skill.

4.5.1.2 Selection for Size, Age, Sex, Distribution, or Timing

Harvest may selectively remove fish based on size, age, sex, distribution, or run timing, depending on the gear, timing, and location of the fishery. Such selection can affect the reproductive success, genetics, structure, and biodiversity of populations. Gear or run timing selectivity may influence population productivity by removing older, larger individuals, too many individuals of one sex, or the larger females carrying the most eggs. Fishing-influenced changes in the average sizes and ages of salmon populations have been well documented (Ricker 1981). Body size is related to redd digging success (Beacham and Murray 1987) and/or fecundity, and larger fish usually carry more eggs

(Sandercock 1991). When too many individuals with high reproductive potential are removed, the population's productivity is reduced. A fishery might also disproportionately harvest the early portion of a run because of market- or industry-driven needs, or because of the timing of hatchery fish runs. Run timing is heritable (Garrison and Rosentreter 1981), so when fish that run at a certain time are selectively removed, the run timing of the entire population can shift. There is evidence that this may have occurred in Lower Columbia River coho salmon, with hatchery practices being a contributing factor (Cramer and Cramer 1994). However, it is likely that the reductions in coho salmon harvest in recent years have addressed concerns regarding selective effects of harvest because selective pressure is proportional to the magnitude of harvest impact.

4.5.1.3 Nutrient Supply and Carrying Capacity

Adult salmon carcasses in streambeds promote primary production, and their flesh and eggs are directly consumed by aquatic insects (Wipfli et al. 1999) and rearing fish (Bilby et al. 1996). This creates a biological feedback loop that benefits future salmon production. The chronic depression of salmon biomass to freshwater ecosystems may be contributing to reduced carrying capacity for salmon (Cederholm et al. 1999, Knudsen 2002). By reducing the number of spawners, harvest plays a role in diminishing the amount of nutrients provided to the system.

4.5.2 Regional Harvest Strategy

As noted above and described in more detail in Chapters 6 through 9, harvest managers have implemented substantial reductions in harvest for Lower Columbia River Chinook salmon, coho salmon, and steelhead since around the time NMFS listed these species under the ESA. Local recovery planners believe that for spring Chinook salmon, steelhead, and chum salmon, current harvest impacts are generally consistent with long-term recovery goals, at least in the near term. For these species the management unit plans recommend ancillary and precautionary measures to ensure that harvest does not adversely affect conservation and recovery in the future. For spring Chinook salmon, the Washington management unit plan notes that in the near term, harvest rates may need to be lower in some years to reduce the risks of critically low escapements during poor ocean conditions and to protect local populations. For fall Chinook and coho salmon, efforts will focus on (1) refinements in harvest management (including abundance-based management) to reduce risk to naturally produced fish, and (2) continued review of overall harvest rates.

Although the harvest management requirements of each ESU are unique and must be addressed separately, the management unit recovery plans rely on several principles and general approaches that harvest managers will employ to address recovery needs related to harvest impacts on Lower Columbia River salmon and steelhead. In general, the harvest strategy focuses on refining harvest management and reducing impacts where needed so that the target status of each population can be attained within an acceptable time frame, while still maintaining harvest opportunities that target hatchery-produced fish.

To accomplish these overall objectives, the management unit plans call for the use of six general approaches as appropriate and feasible (see Chapters 6 through 9 for details):

- **Abundance-based harvest management**: In abundance-based harvest management, managers base annual harvest decisions on the predicted adult returns for that year. In some cases the management unit plans call for (1) refining the existing harvest matrix to ensure that it adequately accounts for weaker components of the ESU or reflects changes in natural production as recovery actions are implemented, or (2) developing methods to predict the abundance of natural-origin fish so that abundance-driven harvest principles can be effectively applied.

- **Weak stock management principles**: In using weak stock management principles, harvest managers consider the impact of harvest rates on the abundance and productivity of weaker populations or population groupings in the ESU. For fall Chinook salmon harvest management, until recently harvest rates were established based on an indicator stock that was relatively healthy, because it was one of the few for which data on natural-origin returns were available. In response to actions outlined in the management unit recovery plans, managers have been exploring ways to incorporate additional, and weaker, stocks into those used to evaluate harvest impacts on the ESU.

- **Mark-selective harvest:** By marking hatchery fish and focusing harvest on them, managers can maintain harvest opportunity and increase harvest of hatchery-origin fish while limiting impacts to natural-origin fish. The harvest recovery strategy includes actions to broaden the use of mark-selective fishing methods, including, in some cases, the development of new gear and methods for commercial fishing.

- **Filling information needs**: Filling information needs will allow harvest managers to make management decisions that better protect natural-origin fish. Needs include better information on natural-origin and hatchery-origin spawner escapement, better estimates of natural population productivity, and, for coho salmon, better estimates of harvest impact rates for natural-origin fish in ocean and Columbia River mainstem fisheries.

- **Ancillary and precautionary actions:** For some species or runs (steelhead and chum salmon), recovery planners believe that current harvest impacts are generally consistent with long-term recovery goals, at least in the near term. For these species they recommend ancillary and precautionary measures to ensure that harvest does not adversely affect conservation and recovery in the future.

- **Adaptive management:** As recovery proceeds and populations that now have little natural production begin to exhibit appreciable natural production, the management unit plans note that managers will need to reevaluate the impacts of harvest on the recovering populations and possibly readjust harvest management.

In terms of recommended harvest rates, Oregon management unit planners did not recommend specific annual harvest rates; instead, in its analyses it used modeled, long-term average harvest rates for each species and assumed that harvest actions such as abundance-based, weak-stock management and mark-selective commercial fisheries would be implemented. The Washington management unit plan recommends a phased harvest strategy involving lower near-term rates to reduce population risks until habitat improvements are achieved. Modeling in the Washington management unit plan shows scenarios in which harvest rates would be managed for benchmarks in each of three 12-year implementation periods. The benchmark range is a target to be met within the designated period and to assess progress toward recovery. Generally the modeling projects that harvest rates eventually would increase as the benefits of other recovery actions were realized and natural production improved. These modeling results are planning targets and not predictions of future harvest rates; managers will establish future harvest rates based on observed indicators in Lower Columbia River salmon and steelhead populations.

In addition to these general approaches outlined above, NMFS will ensure that best available science continues to be used to determine harvest rates that, when combined with other threat reduction strategies, are likely to achieve positive growth rates and move populations to their target status over the long term. In ESA evaluations of hatchery and harvest actions, NMFS expects to analyze the combinations of effects of multiple actions when appropriate. For example, when harvest levels being evaluated are supported by hatchery production, the ecological, genetic, and other effects of hatchery production on both the juvenile and adult life stages also need to be considered as part of the harvest impact analysis.

4.6 Ecological Interactions

4.6.1 Limiting Factors and Threats Related to Ecological Interactions

Anthropogenic changes to habitat in the lower Columbia River region have altered the relationships between salmonids and other fish and wildlife species, leaving Lower Columbia River salmon and steelhead more vulnerable to predation by piscivorous fish, birds, and pinnipeds (i.e., seals and sea lions) and subject to competition with introduced fish species and possibly hatchery-origin fish for limited food and habitat.

4.6.1.1 Predation

Significant numbers of salmon and steelhead are lost to fish, avian, and pinniped predators during migration and residency in the lower Columbia River and estuary (Northwest Power and Conservation Council 2004a). Although predation on salmon and steelhead has always occurred, predation rates in the lower Columbia River and estuary are believed to be higher now than they were historically because of anthropogenic changes in physical habitat that have increased predator abundance, predation effectiveness, or both. In addition, when hatchery-origin fish are present in large numbers, they can attract avian and fish predators of salmonids and spur predatory behavior that results in mortality of natural-origin juveniles. In the Columbia Basin this typically occurs at reservoir heads, at the face of dams, and at turbine spillway and bypass discharge areas (LCFRB 2010a). Researchers have also hypothesized that it is possible that a mass of hatchery-origin fish migrating through an area could also overwhelm predators, providing a beneficial, protective effect to co-occurring naturally produced fish (Fresh and Schroder 1987, Fritts and Pearsons 2008).

Dams, pile dikes, and other in-water structures in the lower Columbia River and estuary have created slack-water refuges and micro-habitats preferred by the northern pikeminnow, a native fish that feeds on juvenile salmonids. A bounty program on pikeminnow instituted in 1990 has reduced predation by 25 percent (Friesen and Ward 1999, NMFS 2000b). Still, pikeminnow in the lower Columbia mainstem have been estimated to consume up to 9.7 million juvenile salmon per year (Beamesderfer et al. 1996). Introduced fish such as walleye, smallmouth bass, and catfish also prey on juvenile salmonids in the estuary and mainstem, although in smaller numbers than pikeminnow; these warm-water species may benefit from the elevated water temperatures in Bonneville Reservoir and the Columbia River estuary.

Human alterations of the Columbia River estuary have contributed to increased predation by native birds, specifically Caspian terns, double-crested cormorants, and various gull species. Piscivorous birds congregate near dams and in the estuary around man-made islands and consume large numbers of emigrating juvenile salmon and steelhead (Roby et al. 1998). Populations of terns and cormorants in the estuary have increased significantly, in part because the deposition of dredged materials has created high-quality habitat for terns (Bottom et al. 2005). These habitats include Rice Island (at River Mile [RM] 21), which terns used for nesting from 1984 to 2000, and East Sand Island (RM 5), which has been an active nesting site since 1986. Double-crested cormorants are attracted to the estuary in part because of its tens of thousands of pilings, pile dikes, and other structures that provide perching opportunities. The loss of habitat elsewhere in the world has contributed to Caspian terns and double-crested cormorants relocating to the Columbia River estuary, which now has the world's largest nesting colonies of these species. In addition to being more numerous than they were historically, terns and cormorants in the estuary may be more effective in their predation because decreased fine sediment inputs to the estuary have reduced the turbidity that otherwise would help shield juvenile salmonids from predators.

The increased numbers of terns and cormorants have translated into measurable predation impacts on juvenile salmonids (Bonneville Power Administration, U.S. Bureau of Reclamation, and U.S. Army Corps of Engineers 2004). In 2006, Caspian terns and double-crested cormorants each were estimated to consume approximately 3.6 million juvenile salmon and steelhead (Collis and Roby 2006). How many of these juveniles are from the Lower Columbia River salmon ESU or steelhead DPS is unknown. However, evidence suggests that the steelhead DPS is likely to be affected by predation more than the other ESUs. Species-specific estimates of predation by Caspian terns from 1988 to 2000 were consistently highest for steelhead (9.4 to 12.7 percent), followed by coho salmon (3.6 to 4.1 percent), with the lowest rates observed in yearling Chinook salmon (1.6 to 2.9 percent) (Ryan et al. 2003).

Pinniped predation on adult spring Chinook salmon and winter steelhead in the Columbia River estuary continues to increase. On the West Coast, the total abundance of California sea lions is approximately 250,000; Stellar sea lions total about 31,000, and Pacific harbor seals total about 25,000 (Griffin 2006). Each spring about 1,000 Stellar sea lion males, 3,000 Pacific harbor seals, and 800 California sea lions take up residence in the lower estuary (Griffin 2006). Approximately 1,000 sea lions and harbor seals enter the freshwater portion of the estuary; of these, approximately 80 animals (primarily California sea lions) congregate at Bonneville Dam. The U.S. Army Corps of Engineers estimates that annual adult mortality at Bonneville Dam because of pinnipeds (primarily California sea lions) ranged from 0.4 percent (2002) to 4.2 percent (2007) during the study period ending in 2011 (U.S. Army Corps of Engineers 2011a).[17] Other, radio-telemetry-based studies suggest that annual pinniped predation on spring Chinook salmon and winter steelhead at Bonneville Dam may be as high as 8.5 percent and 20 percent, respectively (NMFS 2008c, Appendix G). There is a need for reliable estimates of the mortality caused by pinnipeds throughout the entire estuary and plume.

4.6.1.2 Competition

Habitat loss and alteration and releases of large numbers of hatchery fish have the potential to increase competition among salmonids and between salmonids and other fish species for food and habitat. In the case of salmon and steelhead, competition can occur in the tributaries, estuary, or ocean.

Competition among Salmonids

Competition is a natural process that helped shape the abundance of salmon and steelhead throughout their evolutionary history (Fresh 1997). The pressures of natural selection on salmon and steelhead promoted development of an array of life history strategies, involving differences in migration timing and habitat usage, so that populations could avoid competing for limited spatial and food resources (Quinn 2007, Naish et al. 2008) and, ultimately, maximize their marine survival.

At current levels of natural production it is unlikely that competition among salmonids is a limiting factor in the tributaries of the lower Columbia region. Even when hatchery fish are released to tributaries in large numbers, releases usually are timed so that the juveniles are ready to migrate. It is more likely that competition between hatchery-origin fish and natural-origin fish is occurring in the Columbia River estuary, where food resources are limited and juvenile salmon and steelhead become concentrated on their way to the ocean (Fresh 1997).

Over the last century, habitat loss in the Columbia River estuary[18] has simplified Chinook salmon life history diversity there and concentrated the remaining salmon in more limited and fragmented regions (Bottom et al. 2005)—a process that may have increased competition. However, the impact of habitat loss on the Columbia River estuary's capacity to support juvenile salmon is unknown (Bottom et al. 2005).

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[17] Estimated consumption of adult salmonids ranged from a low of 1,010 in 2002 to a high of 6,081 in 2010; the percent of run consumed varied among reporting years in part because of changes in run size.

[18] Diking and filling have reduced the surface area of the estuary by approximately 20 percent compared to historical levels, and approximately 43 percent of the tidal marshes and 77 percent of tidal swamps that existed in the Columbia River estuary before 1870 have been lost (Fresh 2005). In the Skagit River system in Washington, scientists have linked comparable habitat losses (i.e., 75 percent loss of tidal delta habitat) with density-dependent mortality of Skagit River fall Chinook (Beamer et al. 2005).

Another unknown is the cumulative impact of hatchery-origin salmon and steelhead on natural-origin salmon and steelhead. When hatchery-origin fall Chinook subyearlings overlap spatially and temporally with natural-origin fall Chinook and chum salmon in the Columbia River estuary, they may compete directly for limited resources of food and space (Berejikian et al 2009), especially if the hatchery fish are released within a relatively short period or are larger than their naturally produced counterparts (NMFS 2011a, ODFW 2010). The competitive advantage that larger size or greater numbers imparts may result in so-called density-dependent mortality among Lower Columbia River salmon and steelhead (ODFW 2010) or compromise growth in natural-origin fall Chinook salmon juveniles, such that it takes longer to reach a critical size threshold above which mortality from predation will be reduced (Allee 2011). However, so little is known about the ecological interactions of hatchery- and natural-origin fish in the Columbia River estuary that it is difficult to conclude that competition for limited resources is occurring (Flagg et al. 2000). NMFS' Northwest Fisheries Science Center currently is investigating this topic. For more information see Appendix F.

Competition between Salmonids and Other Species

The new microdetritus-based food web in the estuary has benefited zooplanktivores, including American shad (*Alosa sapidissima*) (Sherwood et al. 1990). Shad were introduced to the Columbia River system in 1885, and their populations have grown substantially since then (Welander 1940, Lampman 1946), with up to 4 million adults returning to the estuary each year (Northwest Power and Conservation Council 2004a as cited in NMFS 2011a). The shad diet overlaps with that of subyearling salmonids in the Columbia River estuary, and juvenile shad and subyearling salmonids use similar heavily vegetated backwater habitats (McCabe et al. 1983). By their sheer numbers, shad represent a threat to trophic relationships in the Columbia River (NMFS 2011a). Other exotic fish species such as introduced walleye and catfish also have been able to capitalize on degraded conditions in the upper reaches of the estuary and altered food web dynamics through predation and competition for food resources (Northwest Power and Conservation Council 2004a).

4.6.1.3 Disease Transfer

Salmon and steelhead can be infected by a variety of bacterial, viral, fungal, and microparasitic pathogens. Numerous diseases can result from pathogens that occur naturally in the wild or that may be transmitted to natural-origin fish via infected hatchery-origin fish. Disease transmission from hatchery-origin fish to natural-origin fish does not appear to be widespread in the lower Columbia region (LCFRB 2010a). To reduce the likelihood of disease transmission from hatchery salmonids to naturally produced fish, hatchery managers have established practices for monitoring fish health and sanitation and ensuring that hatchery fish are reared and released in healthy condition.[19]

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[19] For example, see Pacific Northwest Fish Health Protection Committee 1989, Integrated Hatchery Operations Team 1995, Washington Department of Fish and Wildlife 1996, Washington Department of Fish and Wildlife and Western Washington Treaty Indian Tribes 1998, U.S. Fish and Wildlife Service 1995, and U.S. Fish and Wildlife Service 2004.

4.6.2 Regional Ecological Interactions Strategy

The regional ecological interactions strategy involves reducing predation on all Lower Columbia River salmon and steelhead populations by redistributing Caspian terns and cormorants, increasing the pikeminnow bounty program in the Columbia River mainstem, and reducing marine mammal predation at Bonneville Dam using non-lethal and possibly lethal measures. Managing predation by sea lions at Bonneville Dam is expected to benefit Gorge-stratum populations of Lower Columbia River salmon and steelhead ESUs. Pikeminnow are the focus of piscivorous predator reduction efforts because they are much more abundant in the region than introduced fish predators such as bass, walleye, and channel catfish (NMFS 2011a, LCFRB 2010a).

To reduce the risk of adverse ecological interactions between hatchery-origin and naturally produced salmon and steelhead, the Oregon and Washington management unit plans propose a combination of critical uncertainties research and near-term precautionary measures. Research needs include determining the degree of temporal and spatial overlap of hatchery- and natural-origin fish in the Columbia River estuary, the effect of competition on natural-origin fish, and the impact of predation of hatchery-origin fish on naturally produced fish. Near-term measures focus on restoring estuary habitat for fall Chinook and chum salmon and managing hatchery releases to minimize the risk of competition in the tributaries and Columbia River estuary (i.e., do not release hatchery-origin fish into the tributary rearing areas of natural-origin fish, coordinate releases to keep large numbers of hatchery-origin fish from accumulating in the estuary, and time releases so that hatchery-origin juveniles are at the optimal age and size to emigrate rapidly downstream and exit the estuary quickly, thus limiting interactions with natural-origin fish).

In addition, Allee (2011; see Appendix F) recommends research, modeling, and expert panel workshops to identify and evaluate potential methods of reducing the ecological interactions between hatchery-origin and natural-origin fish in the Columbia River estuary and thus lowering the risk of such interactions to natural-origin fish. These activities would focus on increasing scientific understanding of the habitat needs of hatchery-origin and natural-origin fish, habitats in the estuary, and risk to natural-origin fish in different habitats. Allee also supports recommendations by the Hatchery Scientific Review Group (HSRG) (2009) that would reduce the risk of negative cumulative impacts of hatchery-origin fish on naturally produced salmon and steelhead. For example, the HSRG recommends limiting hatchery production to the minimum needed to meet the systemwide harvest and conservation goals of the various managers, taking into account the carrying capacity of the mainstem, estuary and ocean; working with agencies and tribes to maximize survival of hatchery-origin fish consistent with conservation goals; and monitoring, evaluating, and adaptively managing hatchery programs to become more effective in meeting goals for conservation and harvest (Allee 2011).

4.6.3 Effects of Recovery Actions on Other Species

Recovery actions for listed Lower Columbia River salmon and steelhead have the potential to affect other species, both positively and negatively. These effects would most likely be manifested either through changes in habitat or through changes in predator/prey relations and interspecies competition resulting from shifts in the abundance and spatial distribution of LCR salmon and steelhead. In addition, one possible effect as salmon and steelhead recover and productivity improves is the increased delivery of marine-derived nutrients to inland ecosystems; these nutrients support other, non-salmonid species, including terrestrial species.

The species that share habitat or interact with LCR salmon and steelhead as predators or prey are numerous, as are the potential effects to those species from recovery actions. It is not possible to discuss them in detail in this plan. Nevertheless, in implementation, it will be useful and at times imperative to consider the effects of salmon recovery actions on other species. The National Environmental Policy Act requires Federal agencies to evaluate such impacts for Federal actions that significantly affect the environment. For species listed under the ESA, section 7(A)(2) of the ESA requires Federal agencies to ensure that any actions they authorize, fund, or carry out are not likely to jeopardize the continued existence or adversely modify critical habitat of a listed species.

Generally, habitat-related recovery actions for Lower Columbia River salmon and steelhead would be likely to benefit many other species that share those habitats. For instance, the overall goals of the habitat recovery strategy to protect and restore functioning habitats and watershed processes are likely to benefit all native aquatic and riparian species, and it may be possible to specifically design protection and restoration projects in ways that benefit additional native species. For instance, culverts can be designed to pass not only salmon and steelhead but also lamprey, which do not have the jumping abilities of salmon and steelhead. Riparian habitat restoration projects can benefit not only aquatic but wildlife species, such as by providing micro-topographic features that would allow refuge from flooding.

Overall, NMFS expects that implementation of habitat protection and restoration actions for LCR salmon and steelhead would have concomitant benefits to many other native species and that adverse impacts would be rare. However, it is important that project developers consider such impacts. For example, dewatering of streams during instream restoration work can have adverse impacts on other aquatic species, and projects that create new equilibriums of species composition can shift predator/prey relationships in ways that could be adverse to a species. It is especially important that, during implementation of this recovery plan, entities consider potential impacts of habitat projects on other Federally or state protected species or species of concern. Design of recovery actions involving large-scale changes in habitat, such as actions to reduce Caspian tern and cormorant nesting habitat or large scale changes from freshwater to saltwater marsh habitat should consider impacts to target and non-target species.

A potential adverse impact of hatchery recovery actions on other species could occur through changes in numbers of hatchery fish produced. It is possible that hatchery production locally or throughout the Lower Columbia would be decreased as part of a recovery strategy. Although other recovery actions are aimed at increasing numbers of natural-origin salmon and steelhead, total salmon and steelhead production could be temporarily or permanently less than it is at present. Lower total production would mean less availability of salmon as predators or prey. In addition, the use of weirs at hatcheries to prevent hatchery-origin fish from spawning naturally could affect other species' habitat access.

Changes in harvest management could affect other species through shifts in predator/prey relationships and through impacts to species affected as bycatch in salmon fisheries. In addition, efforts to control predation on salmon by species such as marine mammals and birds could potentially affect the predator species.

Table 4-9 lists other Federally listed aquatic species that could be affected by salmon recovery actions described in this plan. These species and the potential for salmon recovery actions to affect them are discussed briefly below.

Table 4-9
Federally Listed Fish and Wildlife Species in the Lower Columbia Recovery Planning Area

Species	Range in Lower Columbia River Basin	Federal Listing Status	Type of Interaction with Salmon and Steelhead
Bull trout *(Salvelinus confluentus)*	Lewis and Clackamas subbasins, Lower Columbia River mainstem	Federally threatened	Predator of salmon and steelhead
Eulachon *(Thaleichthys pacificus)*	Lower Columbia River and tributaries	Southern DPS Federally threatened	Freshwater prey of salmon and steelhead
Green Sturgeon (*Acipenser medirostris*)	Columbia River estuary	Southern DPS Federally threatened	Bycatch in salmon fisheries
Southern resident killer whale	Occasionally forage on salmon in the mouth of the Columbia River	Federally endangered	Saltwater predator of salmon
Steller sea lion	Forage on salmon along lower Columbia River and estuary	Federally threatened	Predator of salmon

Adapted from NMFS (2010c), Tables 3-9 and 3-29.

4.6.3.1 Bull Trout

Bull trout exhibit both resident and migratory forms and require complex habitat characterized by cold water and a variety of pools, riffles, water depths, and velocities. Bull trout occur from the Northwest Territories of Canada south to northern Nevada. Historically they were found in about 60 percent of the Columbia Basin, but their distribution and abundance in the basin have declined significantly (Natural Resources Conservation Service 2006, U.S. Fish and Wildlife Service 2010).

In 1999, bull trout were listed as a threatened species under the ESA (64 *Federal Register* 58909). Oregon has also listed them as a sensitive species. In 2002, the U.S. Fish and Wildlife Service published a draft recovery plan for bull trout. Twenty-two recovery units support bull trout listed in the Columbia Basin, three of which—the Willamette, Lower Columbia, and Hood River—overlap with the area addressed by this plan (U.S. Fish and Wildlife Service 1998, 2010).

Bull trout, salmon, and steelhead can occur in similar habitat types; however, bull trout are more sensitive than salmon and steelhead to increased water temperatures, poor water quality, habitat conditions, and low-flow conditions; thus, they more often occur in higher elevations with less disturbed habitats. Bull trout also require colder water temperatures than other salmon and trout, so they are more likely to occur in headwater streams where temperatures tend to be cooler. Because bull trout feed primarily on fish as subadults and adults, they can be a substantial predator of young salmon and steelhead. Juvenile bull trout feed on similar prey as salmon and steelhead (Natural Resources Conservation Service 2006; U.S. Fish and Wildlife Service 2008, 2010).

The primary interaction between bull trout and salmon and steelhead is that bull trout, as subadults and adults, prey on juvenile salmon and steelhead.[20] Overall changes in abundance of salmon and steelhead or bull trout could shift predator-prey relations. In addition, because bull trout use similar aquatic habitats as salmon and steelhead, the species can compete for food resources and space. In general, actions to protect and improve salmon habitat would also likely benefit bull trout.

4.6.3.2 Eulachon

The eulachon (also known as Columbia River smelt) is a small anadromous fish that occurs in the eastern North Pacific Ocean. Eulachon spend most of their lives in salt water but return to fresh water to spawn at 3 to 5 years of age. Juvenile eulachon rear in shallow to moderately deep nearshore marine areas. The Columbia River and its tributaries are believed to support the largest eulachon run in the world (NMFS 2008g). Eulachon regularly spawn in the mainstem Columbia River (up to Bonneville Dam), in Skamokawa Creek, and in the Cowlitz, Grays, Elochoman, Kalama, Lewis, and Sandy rivers (NMFS 2010b).

The southern eulachon DPS (i.e., populations spawning in rivers from the Nass River in British Columbia south to the Mad River in California) is listed as a threatened species under the ESA and is a Washington State species of concern.

Newly hatched and juvenile eulachon are a prey species for salmon and steelhead (although predation of eulachon by salmon and steelhead has not been cited as a reason for eulachon declines). In addition, spawned-out and decomposing eulachon contribute to the nutrient cycle of freshwater streams (NMFS 2010c).

4.6.3.3 Green Sturgeon

The green sturgeon is a long-lived, slow-growing anadromous fish that ranges from Alaska to Mexico. Juvenile green sturgeon rear and feed in both fresh and estuarine waters for 1 to 4 years before dispersing into marine waters. They spend 6 to 10 years at sea before returning to fresh water to spawn for the first time. Adults spawn multiple times and spend 2 to 4 years at sea between spawning events (71 *Federal Register* 17757). Green sturgeon feed on benthic invertebrates and small fish; salmon and steelhead have not been documented as part of their diet (NMFS 2005b and 2009b).

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[20] Bull trout also prey on other fish species (e.g., non-native trout); this may reduce predation by those species on juvenile salmon and steelhead.

The southern green sturgeon DPS, which occurs in freshwater rivers and coastal estuaries and bays along the west coast of North America, including estuaries of Oregon and Washington and the lower Columbia River, is listed as a threatened species under the ESA (71 *Federal Register* 17757). The DPS aggregates in the Columbia River estuary and Washington estuaries in the late summer (NMFS 2009b).

Interactions among green sturgeon and salmon and steelhead are limited to the Columbia River estuary and Pacific Ocean marine waters. The primary interaction between green sturgeon and salmon and steelhead is green sturgeon bycatch in salmon and steelhead fisheries (NMFS 2009b).

4.6.3.4 Southern Resident Killer Whale

The southern resident killer whale stock has been observed in ocean waters of Washington and Oregon and near the mouth of the Columbia River during winter and early spring months (Ford et al. 2000, Wiles 2004, Zamon et al. 2007, NMFS 2008h, and NMFS 2008i). As of July 2011, the total estimated population of southern resident killer whales was 88 individuals (Center for Whale Research). Southern resident killer whales are ESA-listed as endangered and are also protected under the Marine Mammal Protection Act.

Southern resident killer whales consume a variety of fish and one species of squid, but salmon—Chinook salmon in particular—are their preferred prey (NMFS 2008i). Although the prey base of southern resident killer whales that forage near the mouth of the Columbia River is unknown, prey of southern resident killer whales that forage elsewhere in the Pacific Northwest has been recorded. Sampling in diet studies of southern resident killer whales has been conducted primarily during spring, summer, and fall months in inland waters off Washington and British Columbia (Ford and Ellis 2006, Hanson et al. 2007, and Hanson et al. 2010a). In inland waters from May to September, the southern residents' diet consists of a high percent of Chinook salmon, with on overall average of 88 percent of their diet consisting of Chinook salmon (Hanson et al. 2010a). Other salmonids eaten include steelhead (5 percent), coho salmon (3 percent), sockeye salmon (2 percent), and chum salmon (less than 1 percent). Ford and Ellis (2006) found that killer whales captured older (i.e., larger) than average Chinook salmon.

Other results indicated that, during fall months in inland waters, southern resident killer whales foraging within Puget Sound shift their diet to primarily chum salmon (Hanson et al. 2007). Although southern resident killer whales are thought to feed on salmon and steelhead year-round, their diet from January through April is poorly understood; during this period they range in ocean waters from British Columbia to central California (Krahn et al. 2002, Krahn et al. 2007, Ford and Ellis 2006, NMFS 2008h).

The preference of southern resident killer whales for Chinook salmon in inland waters, even when other species are more abundant, combined with information indicating that these whales consume salmon year-round, makes it reasonable to expect that southern resident killer whales prefer Chinook salmon when available in coastal waters. Sightings of resident killer whales off Westport, Washington, and in the mouth of the Columbia River may coincide with the spring Chinook salmon run in the Columbia River (Krahn et al. 2004, Zamon et al. 2007, NMFS 2008i). There are direct observations of two southern resident killer whale predation events in coastal waters; in both cases, the prey species was identified as Columbia River Chinook salmon (Hanson et al. 2010b). Chemical analyses also indicate the importance of salmon in the year-round diet of southern resident killer whales (Krahn et al. 2002; Krahn et al. 2007). Furthermore, Ford et al. (2009) found that southern resident killer whale survival rates correlated directly with the availability of Chinook salmon.

Based on recent estimates assuming a diet of only Chinook salmon, the southern resident killer whale stock requires, in total, approximately 289,000 to 347,000 Chinook salmon annually (Noren 2010), but the extent to which they depend on specific salmon runs is not known. At different times of the year, southern resident killer whales may consume Chinook salmon that originate in the Fraser River, Puget Sound, Washington and Oregon coastal streams, the Columbia River, and central California streams (Hanson et al. 2010a), but data are insufficient to identify the proportion of different stocks in the year-round southern resident killer whale diet.

There is no evidence that southern resident killer whales distinguish between hatchery-origin and natural-origin salmon (Hanson et al. 2010a). Salmon production from Columbia River hatcheries may have partially compensated for declines in many natural-origin salmon populations to the benefit of resident killer whales (NMFS 2008i). The contribution of all salmon and steelhead from the Columbia Basin to the prey available to the whales in the ocean is substantial.

4.6.3.5 Steller Sea Lion

The eastern stock of Steller sea lions is resident year-round on the coasts of Oregon and Washington, and from the mouth of the Columbia River up to Bonneville Dam (NMFS 2008i and 2008c). No Steller sea lion rookeries (i.e., mating areas) exist near the Columbia River, but individuals use the South Jetty at the mouth of the river as a haul-out site year-round (Jeffries et al. 2000). Numbers vary seasonally, with peak counts of approximately 1,000 individuals during fall and winter months (NMFS 2008h). The eastern stock of Steller sea lions is listed as threatened under the ESA and is protected under Marine Mammal Protection Act.

Steller sea lions forage opportunistically on a wide variety of fishes in response to seasonal abundance. Foraging studies in the lower Columbia River and at Pacific Northwest coastal sites describe a variety of Steller sea lion prey species, including Pacific whiting, rockfish, eulachon, Pacific hake, anchovy, Pacific herring, staghorn sculpin, salmonids, octopus, and lamprey (Jeffries 1984, NMFS 2008c).

The extent to which eastern stock Steller sea lions depend on salmon in the lower Columbia River and nearby coastal waters is unknown, although some Steller sea lions exploit salmon at Bonneville Dam (NMFS 2008k). Salmon remains were found in 25 percent of the scat samples obtained in 2007 at Bonneville Dam. Surface observation at Bonneville Dam suggests that Steller sea lions in the Columbia River rely more on sturgeon than on salmon and steelhead (NMFS 2008h and 2008k and Stansell et al. 2011). However, predation by Steller sea lions on salmon elsewhere by (e.g., south Oregon coast) (NMFS 1997) appears to have increased since the 1980s and Steller sea lions have been observed preying on salmon smolts and adults (NMFS 1996).

4.7 Climate Change

4.7.1 Climate Change Limiting Factors and Threats

Likely changes in temperature, precipitation, wind patterns, ocean acidification, and sea level height have implications for survival of Lower Columbia River salmon and steelhead in their freshwater, estuarine, and marine habitats.

4.7.1.1 Information Sources

Recent descriptions of expected changes in Pacific Northwest climate that are relevant to listed salmon and steelhead include the U.S. Global Change Research Program's national climate change impacts assessment (Karl et al. 2009), the *Washington Climate Change Impacts Assessment* (Climate Impacts Group 2009), and the *Oregon Climate Change Assessment Report* (Oregon Climate Change Research Institute 2010).[21] These assessments are based on empirical observations and climate model projections. The regional climate assessments include projections from the Intergovernmental Panel on Climate Change's (IPCC) global climate models (Intergovernmental Panel on Climate Change 2007b), which were downscaled to reflect regional terrestrial and aquatic conditions (e.g., Salathe 2005) and ocean conditions (e.g., Stock et al. 2011). A new IPCC global climate assessment and a new national climate assessment, which will include updated analyses for the Pacific Northwest, are currently under way, with new climate projections expected by 2014.

Trends and projections of ocean acidification are reviewed in chapters of the Oregon and Washington climate assessments or subsequent publications of those chapters (Mote et al. 2010, Ruggiero et al. 2010, Huppert et al. 2009), based on primary research such as Feely et al. (2008).

Mote et al. (2008) and Ruggiero et al. (2010) described observed sea level height changes along the Pacific coast and reviewed literature projecting sea level changes in the Pacific Northwest. The West Coast Governors Alliance, along with the U.S. Geological Survey, NOAA, and the U.S. Army Corps of Engineers, have sponsored a study that the National Academies of Science will complete by 2013 that will provide sea level rise estimates for California, Oregon, and Washington for the years 2030, 2050, and 2100.[22] Various localized studies of projected sea level height changes are also available (e.g., Glick et al. 2007).

[21] These documents are highlighted because they are recent comprehensive reviews of observed and expected climate change impacts in the United States and Pacific Northwest. Numerous other primary literature publications are available, many of which are cited in these reports. Additionally, NMFS annually reviews and summarizes scientific literature relevant to the effects of climate change on Pacific salmon and steelhead. The review of 2009 literature is included as Chapter 2.2.1 of NMFS (2010a); Crozier (2011) reviews 2010 literature.

[22] See http://www8.nationalacademies.org/cp/projectview.aspx?key=49290.

Recent reviews of the effects of climate change on the biology of salmon and steelhead in the Columbia Basin and the California Current region[23] include the Independent Scientific Advisory Board (ISAB) (2007a), the Oregon and Washington climate assessments (Huppert et al. 2009, Mantua et al. 2009 and 2010, and Hixon et al. 2010), NMFS (2010a), Ford (2011), and Crozier (2011). Crozier (2011, Section 9.3) includes a review of what is currently known regarding effects of ocean acidification on salmon and steelhead. In addition to these reviews, the NMFS Northwest Fisheries Science Center will be producing annual updates describing new information regarding effects of climate change relevant to salmon and steelhead as part of the FCRPS Adaptive Management Implementation Plan.

The following text summarizes expected climate change effects on listed Lower Columbia River salmon and steelhead, based on the above sources.

4.7.1.2 Effects of Climate Change on LCR Salmon and Steelhead

Freshwater Environment

Climate records show that the Pacific Northwest has warmed about 1.0 °C since 1900, or about 50 percent more than the global average warming over the same period. The warming rate for the Pacific Northwest over the next century is projected to be in the range of 0.1 to 0.6 °C per decade. Although total precipitation changes are predicted to be minor (+ 1 to 2 percent), increasing air temperature will alter snowpack, stream flow timing and volume, and water temperature in the Columbia Basin. Climate experts predict the following physical changes to rivers and streams in the basin:

- More precipitation falling as rain rather than snow (as a result of warmer temperatures)
- Diminished snowpack and alterations in stream flow volume and timing
- A trend toward loss of snowmelt-dominant and transient subbasins
- Continued increases in summer and fall water temperatures

More winter flooding is expected in transient and rainfall-dominated subbasins. Transient subbasins are those where stream flow is strongly influenced both by direct runoff from rainfall and by springtime snowmelt because surface temperatures in winter typically fluctuate around the freezing point. Over the course of a given winter, precipitation in transient subbasins frequently fluctuates between snow and rain, depending on relatively small changes in air temperature (Mantua et al. 2009).

Historically transient subbasins, such as those in which Gorge and some Cascade populations spawn and rear, will experience lower late-summer flows. For example, Figure 4-2 shows the expected patterns of stream flow in the White Salmon River, the Kalama River, and the Columbia River at Bonneville Dam in the 2020s, 2040s, and 2080s. The White Salmon River is a transient subbasin that currently exhibits a November-December peak hydrograph caused by rain and an April-May peak that is associated with melting snow. In future years the April-May snowmelt-driven peak is expected to

[23] The California current is a Pacific Ocean current that moves south along the western coast of North America, beginning off southern British Columbia and ending off southern Baja, California.

be much lower or possibly nonexistent. As a more rainfall-driven river, the Kalama currently does not exhibit a distinct spring peak. Future flows are expected to increase in the winter and decrease in the spring, but the general rainfall-driven pattern will continue. The hydrograph for the mainstem Columbia River at Bonneville Dam is strongly influenced by spring snowmelt in Canada and the western Rocky Mountains. In the future, the spring freshet is expected to occur earlier, with fall and winter flows increasing and summer and early fall flows decreasing.

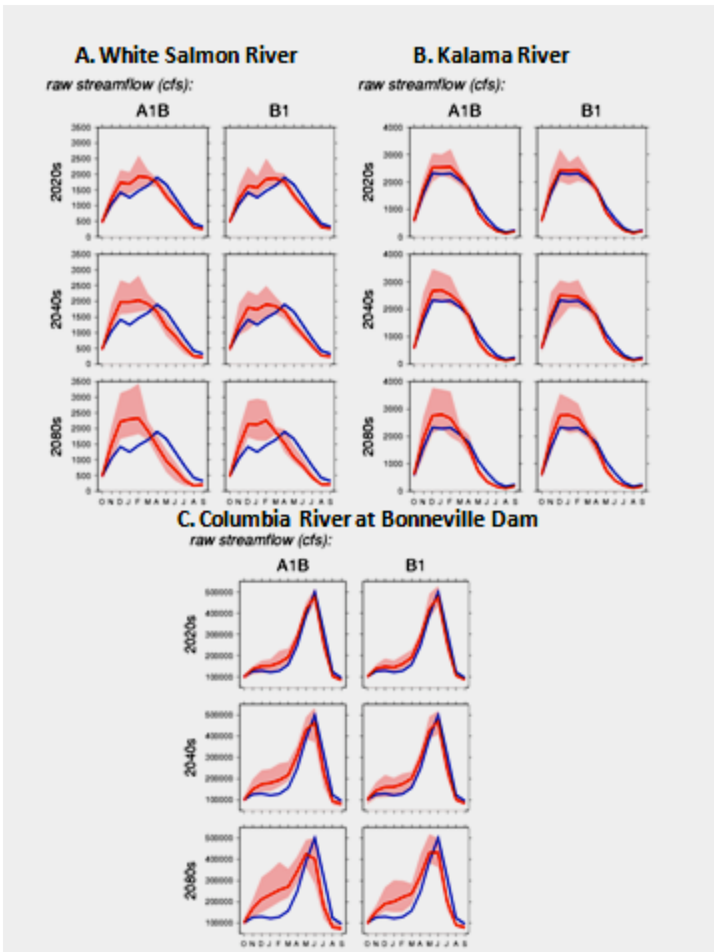

Figure 4-2. Projected Average Monthly Stream Flow (cfs) for the White Salmon and Kalama Rivers and the Mainstem Columbia River at Bonneville Dam[24]

(Note: Blue = historical average stream flow; red = projected stream flow for the 2020s, 2040s, and 2080s; shading = range of simulation results)

The predicted trend toward loss of snowmelt-dominant and transient subbasins will be most pronounced for some Gorge and Cascade subbasins with high-elevation headwaters that currently experience a spring freshet from melting snow. The

24 Projections are made under two IPCC (2007) anthropogenic aerosol and greenhouse gas emission scenarios: A1B corresponds to "moderate" and B1 corresponds to "low" emissions during the 21st century (Stock et al. 2011). Figures are from the University of Washington Climate Impacts Group and are available at: http://www.hydro.washington.edu/2860/products/sites.

hydrographs of most subbasins in the Lower Columbia domain are currently rainfall-dominated and will continue to be so as climate changes (Figure 4-3).

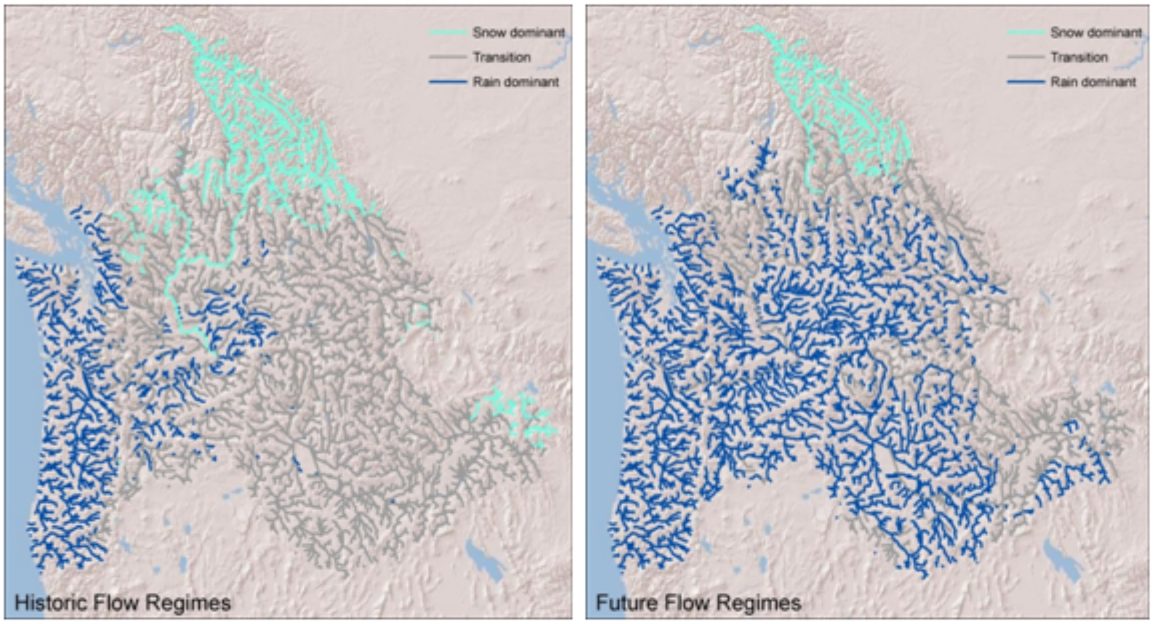

Figure 4-3. *Preliminary Maps of Predicted Hydrologic Regime for 1970-1999 and 2070-2099*[25]
Source: University of Washington Climate Impacts Group (www.hydro.washington.edu/2860/).

In the state of Washington, summer and fall water temperatures will continue to rise, with an increase of less than 1 °C expected by the 2020s but an increase of 2 to 8 °C predicted by the 2080s. By the 2080s, the number of Washington subbasins with a maximum weekly water temperature that exceeds 21.5 °C is expected to double, and thermal barriers greater than 21 °C are expected to increase in duration from 1 to 5 weeks in the 1980s to 10 to 12 weeks in the 2080s.

The changes in air temperatures, river temperatures, and river flows in the Pacific Northwest are expected to cause changes in salmon and steelhead distribution, behavior, growth, and survival. Although the magnitude and timing of these changes currently are poorly understood and specific effects are likely to vary among populations, the following effects on listed salmon and steelhead in fresh water are likely:

- Winter flooding in transient and rainfall-dominated subbasins may scour redds, reducing egg survival.

- Warmer water temperatures during incubation may result in earlier fry emergence, which could be either beneficial or detrimental, depending on location and prey availability.

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[25] Uses emission scenario A1B and global climate model CGCM3.1(T47), based on classification of annual hydrographs as in Beechie et al. (2006).

- Reduced summer and fall flows may reduce the quality and quantity of juvenile rearing habitat, strand fish, or make fish more susceptible to predation and disease.

- Reduced flows and higher temperatures in late summer and fall may decrease parr-smolt survival.

- Warmer temperatures will increase metabolism, which may either increase or decrease juvenile growth rates and survival, depending on availability of food.

- Overwintering survival may be reduced if increased flooding reduces suitable habitat.

- Timing of smolt migration may be altered such that there is a mismatch with ocean conditions and predators.

- Higher temperatures during adult migration may lead to increased mortality or reduced spawning success as a result of lethal temperatures, delay, increased fallback for Gorge populations at Bonneville Dam, or increased susceptibility to disease and pathogens.

The degree to which phenotypic or genetic adaptations may partially offset these effects is being studied but currently is poorly understood.

Estuarine Environment

Climate change will also affect salmon and steelhead in the estuarine and marine environments. Effects of climate change on salmon and steelhead in estuaries include the following:

- Warmer waters in shallow rearing habitat may alter growth, disease susceptibility, and direct lethal or sublethal effects.

- Higher winter freshwater flows and higher sea level elevation may increase sediment deposition and wave damage, possibly reducing the quality of rearing habitat.

- Lower freshwater flows in late spring and summer may lead to upstream extension of the salt wedge, possibly influencing the distribution of salmonid prey and predators.

- Increased temperature of freshwater inflows and seasonal expansion of freshwater habitats may extend the range of non-native, warm-water species that are normally found only in fresh water.

In all of these cases, the specific effects on salmon and steelhead abundance, productivity, spatial distribution and diversity are poorly understood.

Marine Environment

Effects of climate change in marine environments include increased ocean temperature, increased stratification of the water column, changes in the intensity and timing of coastal upwelling, and ocean acidification. Hypotheses differ regarding whether coastal upwelling will decrease or intensify, but even if it intensifies, the increased stratification of the water column may reduce the ability of upwelling to bring nutrient-rich water to the surface. There are also indications in climate models that future conditions in the North Pacific region will trend toward conditions that are typical of the warm phases of the Pacific Decadal Oscillation, but the models in general do not reliably reproduce the oscillation patterns. Hypoxic conditions observed along the continental shelf in recent years appear to be related to shifts in upwelling and wind patterns that may be related to climate change.

Climate-related changes in the marine environment are expected to alter primary and secondary productivity, the structure of marine communities, and, in turn, the growth, productivity, survival, and migrations of salmonids, although the degree of impact on listed salmonids currently is poorly understood. A mismatch between earlier smolt migrations (because of earlier peak spring freshwater flows and decreased incubation period) and altered upwelling may reduce marine survival rates. Ocean warming also may change migration patterns, increasing distances to feeding areas.

In addition, rising atmospheric carbon dioxide concentrations drive changes in seawater chemistry, increasing the acidification of seawater and thus reducing the availability of carbonate for shell-forming invertebrates, including some that are prey items for juvenile salmonids. This process of acidification is under way, has been well documented along the Pacific coast of the United States, and is predicted to accelerate with increasing greenhouse gas emissions.

Ocean acidification has the potential to reduce survival of many marine organisms, including salmon and steelhead. However, because there is currently a paucity of research directly related to the effects of ocean acidification on salmon and steelhead and their prey, potential effects are uncertain. Laboratory studies on salmonid prey taxa have generally indicated negative effects of increased acidification, but how this translates to the population dynamics of salmonid prey and the survival of salmon and steelhead is uncertain. Modeling studies that explore the ecological impacts of ocean acidification and other impacts of climate change concluded that salmon landings in the Pacific Northwest and Alaska are likely to be reduced.

Summary of Likely Impacts of Climate Change

NMFS' 2010 5-year status report for salmon and steelhead in the Pacific Northwest (Ford 2011) includes a summary of likely effects of climate changes on Pacific Northwest salmon and steelhead. Table 4-10, which is reproduced from Table 79 of Ford (2011), summarizes the main climate change effects and indicates the certainty of their occurrence and their expected magnitude. Table 4-10 addresses all listed salmon and steelhead in the Pacific Northwest, so some effects, such as some terrestrial climate effects on forest and riparian structure, are more relevant to interior Columbia Basin species. Ford (2011) point out that we need to consider the cumulative impacts of climate change across the salmon life cycle and across multiple generations. Because these climate effects are multiplicative across the life cycle and across generations, small effects at individual life stages can result in large changes in the overall dynamics of populations. This means that the mostly negative effects predicted for individual life history stages will most likely result in a substantially negative overall effect of climate change on Pacific Northwest salmonids over the next few decades.

Table 4-10
Summary of Expected Climate Effects on Pacific Northwest ESUs

Habitat	Physical Change	Processes Affecting Salmon	Effect on Pacific Northwest Salmonid ESUs	Certainty
Terrestrial	Warmer, drier summers	Increased fires, increased tree stress, and disease will affect large woody debris, sediment supplies, and riparian zone structure	- - to 0 Largest effects likely to be felt in Interior Columbia populations, particularly in areas at lower and middle elevations	Low
	Reduced snowpack, warmer winters	Increased growth of higher elevation forests will affect large woody debris, sediment processes, and riparian zone structure	0 to +	Low
Freshwater	Reduced summer flow	Less accessible summer rearing habitat	- - to - Effects most pronounced in areas that currently have low flow, particularly in Interior Columbia populations	Moderate
	Earlier peak flow	Potential migration timing mismatch	-- to 0 Largest effects in “transition” areas that move from a snowmelt-dominated hydrograph to a rain-driven hydrograph	Moderate
	Increased floods	Redd disruption, juvenile displacement, upstream migration	- - to 0 Largest effects in “transition” areas that move from a snowmelt-dominated hydrograph to a rain-driven hydrograph	Moderate
	Higher stream temperature	Thermal stress, restricted habitat availability, increased susceptibility to disease and parasites	- - to - Largest effects likely to occur in what currently are high-temperature areas of the Interior Columbia and low-elevation areas	Moderate

Habitat	Physical Change	Processes Affecting Salmon	Effect on Pacific Northwest Salmonid ESUs	Certainty
Estuarine	Higher sea level	Reduced availability of wetland habitats	-- to - Largest effects on ESUs with a life history highly dependent on relatively long-term rearing in estuarine and tidally influenced areas	High
	Higher water temperature	Thermal stress and increased susceptibility to disease and parasites	- - to – Largest effects on ESUs with highly estuarine-dependent life cycles and ESUs subject to stress at earlier life stages	Moderate
	Combined effects	Changing estuarine ecosystem composition and structure	- - to +	Low
Marine	Higher ocean temperature	Thermal stress, shifts in migration, susceptibility to disease and parasites	- - to - Effects likely to vary by ESU, depending on ocean distribution	Moderate
	Intensified upwelling	Increased nutrients (food supply), coastal cooling, and ecosystem shifts; increased offshore transport	0 to ++ Effects likely to vary by ESU and correspondence of outmigration with upwelling patterns	Moderate
	Delayed spring transition	Food timing mismatch with outmigrants, ecosystem shifts	- - to 0 Effects likely to vary by ESU depending on correspondence of outmigration with upwelling patterns	Moderate
	Increased acidity	Disruption of food supply, ecosystem shifts	- - to - Effects likely to vary by ESU, dependent upon age and size at outmigration and ocean distribution	Moderate
	Combined effects	Changing composition and structure of ecosystem, changing food supply and predation	- - to + Effects likely to vary by ESU depending on age and size at outmigration and ocean distribution	Low

Effect ratings are: + +, strongly positive; +, positive; 0, neutral; -, negative, - -, strongly negative. Certainty level combines the certainty of the physical change with the certainty of the effect.

Source: Table 79 of Ford (2011); Table 79 was adapted from Stout et al. (2010) and includes citations for the main sources of information relied on for each entry.

4.7.2 Regional Climate Change Strategy

4.7.2.1 Mitigation Strategy

The IPCC (Intergovernmental Panel on Climate Change 2007b) defines climate change mitigation as implementing policies and technological changes to reduce greenhouse gas (GHG) emissions and enhance greenhouse gas sinks. Reduction of greenhouse gas emissions is the most reliable solution to the adverse effects of climate change on listed Lower Columbia River salmon and steelhead over the long term. The climate change mitigation strategy for this recovery plan is for relevant entities to implement greenhouse gas reduction strategies. Possible mechanisms for doing so include the West Coast Governors' Global Warming Initiative (http://www.ef.org/westcoastclimate/) and the Oregon Global Warming Commission's recommendations (Oregon Department of Energy 2009). There is also a need to integrate these local strategies with mitigation strategies at larger spatial scales.

4.7.2.2 Adaptation Strategy

The IPCC (Intergovernmental Panel on Climate Change 2007c) defines climate change adaptation as adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities. Adaptation strategies that contain measures to reduce impacts of climate change on Pacific Northwest salmon and steelhead include the Northwest Power and Conservation Council's Independent Scientific Advisory Board (2007a) review, the interim *Washington State Integrated Climate Change Response Strategy* (Washington Department of Ecology 2011), the *Oregon Climate Change Adaptation Framework* (Oregon Department of Land Conservation and Development 2010), and the draft *National Fish, Wildlife, and Plants Climate Adaptation Strategy* (U.S. Fish and Wildlife Service et al. 2012).

These adaptation plans commonly include the following general elements:

- Conserve adequate habitat to support healthy fish populations and ecosystem functions in a changing climate.
- Manage species and habitats to protect ecosystem functions in a changing climate.
- Reduce stresses not caused by climate change.
- Support adaptive management through integrated observation and monitoring and improved decision support tools.

The ISAB's recommendations for incorporating climate change considerations into restoration and recovery planning and recommended actions for reducing climate change impacts on Columbia Basin salmon and steelhead are specifically targeted to salmon and steelhead populations in the Pacific Northwest (Independent Scientific Advisory Board 2007a). NMFS incorporates the ISAB's recommendations by reference into this recovery plan, including those displayed in Table 4-11, some of which have been slightly modified to specifically apply to recovery of Lower Columbia River species. The management unit plans contain actions that implement many of these strategies. There will be a need throughout implementation for additional evaluation of the extent to which the management unit plan actions have been tailored specifically to address climate change impacts in the Lower Columbia.

A number of the strategies in Table 4-11 are currently being implemented through the 2008 FCRPS Biological Opinion and its 2010 Supplement, the Northwest Power and Conservation Council's Fish and Wildlife Program, local recovery plans, and activities and research of other Federal and non-Federal agencies.

In addition, the management unit plans and estuary recovery plan module (NMFS 2011) identify climate change as a threat, incorporate general approaches to climate change, and present specific actions that are responsive to the general strategies outlined above.[26] Some of these actions overlap with tributary habitat actions or, in the case of the Oregon management unit plan, actions to reduce the impacts of human population growth. The following actions from ODFW (2010) are representative of management unit plan actions to reduce the impacts of climate change on salmon and steelhead:

- Develop recommendations for land management scenarios that address hydrograph changes that are due to climate change, impervious surfaces, and other factors that result in altered water runoff.

- Protect and restore riparian areas to improve water quality, provide long-term supplies of large wood to streams, and reduce impacts that alter other natural processes.

- Develop a methodology to assess and identify, and then protect, stream reaches and population strongholds that will be resilient/resistant to climate change impacts.

- Protect and restore headwater rivers and streams (salmon- and non-salmon-bearing) to protect the sources of cool, clean water and normative hydrologic conditions.

- Conduct a detailed climate change risk analysis for all populations and use this to help prioritize actions, or develop new ones, that are contained in the implementation schedule.

- Implement credible, science-based programs, policies, and rules that contribute collectively to protect fish and water resources.

These actions are examples only. For more information, see Table 7-3A of ODFW (2010) and p. 5-70 of LCFRB (2010a).

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[26] In calculating target abundances, Oregon recovery planners included an additional 20 percent "buffer" to account for the impacts of future threats—both climate change and human population growth—and expect that targets and actions will be adjusted as more specific information on the impacts of climate change becomes available. Washington recovery planners did not incorporate the impact of climate change or human population growth into its calculations of target abundances. NMFS' view is that this difference in approach is not significant for the reasons explained in Section 5.2.2.

Table 4-11
Strategies and Representative Actions to Address Climate Change Impacts

Category	Strategy	Representative Actions
Planning Actions	Assess potential climate change impacts in each subbasin and develop a strategy to address these concerns as part of updates to subbasin and recovery plan. NMFS will help provide technical assistance to planners to help ensure that climate change is addressed thoroughly and consistently in subbasin and recovery plans.	
	Ensure that subbasin and recovery planners are aware of pertinent resources. As needed, NMFS and other entities will direct planners to tools and climate change projections that will aid them in assessing the subbasin impacts of climate change. Resources currently include: • Pacific Northwest Climate Impacts Consortium: http://pnwclimate.org/ • Northwest Climate Science Center: http://www.doi.gov/csc/northwest/index.cfm • University of Washington Climate Impacts Group: http://cses.washington.edu/cig/ • Oregon State University's Oregon Climate Change Research Institute: http://occri.net/ • NOAA's climate sciences program: http://www.climate.gov/ • North Pacific Landscape Conservation Cooperative: http://www.fws.gov/pacific/Climatechange/nplcc/	
	Establish reserves through the purchase of land or conservation easements in locations likely to be sensitive to climate change that have high ecological value. Landscape-scale considerations will be critical in the choice of reserve sites because habitat fragmentation and changes of habitat will influence the ability of such reserves to support particular biota in the future. (Independent Scientific Advisory Board 2007a summarizes some generally accepted guidelines for selection of reserves or protected areas that are specifically intended to preserve biodiversity in the face of changing climate.)	
Tributary Habitat	Minimize temperature increases in tributaries by implementing measures to retain shade along stream channels and augment summer flow	• Protect or restore riparian buffers, particularly in headwater tributaries that function as thermal refugia • Remove barriers to fish passage into thermal refugia
	Manage water withdrawals to maintain as high a summer flow as possible to help alleviate both elevated temperatures and low stream flows during summer and autumn	• Buy or lease water rights • Increase efficiency of diversions

Category	Strategy	Representative Actions
	Protect and restore wetlands, floodplains, or other landscape features that store water to provide some mitigation for declining summer flow	• Identify cool-water refugia (subbasins with extensive groundwater reservoirs) • Protect these groundwater systems and restore them where possible • May include tributaries functioning as cool-water refugia along the mainstem Columbia where migrating adults congregate • Maintain hydrological connectivity from headwaters to sea
Mainstem and Estuary Habitat	Reduce temperatures and create thermal refugia	• Remove dikes to open backwater, slough, and other off-channel habitat, thus increasing flow through these areas and encouraging increased hyporheic flow
Mainstem and Tributary Hydropower	Augment flow from cool or cold-water storage reservoirs to reduce water temperatures, or create cool-water refugia in mainstem reservoirs and the estuary	• Investigate increasing storage in existing reservoirs or adding new storage facilities,, but must be cautious with this strategy • Investigate the possibility of implementing a seasonal flow strategy that includes cool-water releases from storage reservoirs in Lower Columbia River tributaries in late summer
	Use methods to increase surface passage of juveniles at Bonneville and The Dalles dams to move fish quickly through warm forebays and past predators in the forebays.	• Use corner collector at Bonneville Dam
	Reduce water temperatures in adult fish ladders at Bonneville and The Dalles dams	• Use water drawn from lower cool strata of forebay • Cover ladders to provide shade
	Reduce the impact of higher fish predation rates caused by warming water temperature by reducing predator populations	• Reduce predation by introduced piscivorous species (e.g., smallmouth bass, walleye, and channel fish) in mainstem reservoirs and the estuary
Harvest	When setting annual quotas and harvest limits, conduct and use assessments that take into consideration the changing climate	• Reduce harvest during favorable climate conditions to allow stocks that are consistently below sustainable levels during poor phase ocean conditions to recover their numbers and recolonize areas of freshwater habitat • Use stock identification to target hatchery stocks or robust wild stocks, especially when ocean conditions are not favorable
Hatcheries	Reduce density-dependent interactions among hatchery- and natural-origin fish; such interactions can cause lower growth and survival at times when climate effects reduce ocean productivity	• Control juvenile migration by reducing hatchery releases or modifying release timing to reduce competition and ensure that ocean entry coincides with favorable ocean conditions • Consider changing systemwide habitat conditions in determining appropriate stocks for reintroduction programs

4.8 Human Population Growth

4.8.1 Limiting Factors and Threats Related to Human Population Growth

An estimated 5 million people live in the Columbia Basin, and the human population in the region is expected to increase significantly in coming years. By the end of the twenty-first century, between 40 million and 100 million people are predicted to be living in the Columbia Basin (National Research Council 2004). Some communities—both urban and rural—can expect their populations to double between 2000 and 2020; significant growth also is projected for unincorporated areas. In Oregon, particularly fast growth is predicted in Clackamas, Clatsop, Columbia, Hood River, and Multnomah counties—areas that support Lower Columbia River coho, Chinook, and steelhead and Columbia River chum salmon. The population of these counties is expected to increase by 41 percent from 2003 to 2040 (State of Oregon Office of Economic Analysis 2004). In Washington, the populations of Clark and Cowlitz counties are projected to grow by 65 and 53 percent, respectively, from 2000 to 2030 (Washington State Department of Transportation).

The Oregon management unit plan describes in general the expected future impacts of human population growth on Columbia Basin fish and wildlife populations, based on work by the Independent Scientific Advisory Board (ISAB) for the Northwest Power and Conservation Council, Columbia River Basin Indian tribes, and NMFS (Independent Scientific Advisory Board 2007b). The ISAB reached the following conclusions:

- Population growth will increase the demand for water, land, and forests that are key to fish and wildlife populations. This demand for resources will increase threats to and extinction risks for fish and wildlife.
- Changes in land use related primarily to increases in human population size and per-capita consumption rates will increase water use, affect land management and, ultimately, affect fish and wildlife habitat.
- Increased demand for residential land is accelerating the rate of conversion of forest and agricultural lands.
- The dominant ongoing pattern of settlement in the Columbia Basin is exurban sprawl—i.e., the building of new communities on the fringes of urban growth boundaries. Exurban sprawl causes loss, degradation, and fragmentation of habitat and increases infrastructure costs, social conflict, and harmful interactions among people and wildlife.
- Urbanization will increase the amount of impervious surfaces (pavement, roofs etc.) in watersheds, increasing surface runoff during storm events and reducing groundwater recharge and thus base flows.
- The effects of population growth will combine with those of climate change to increase pressure on fish and wildlife habitats.

- Demands for fresh water from surface and groundwater will increase. Climate change-related decreases in the snowpack at higher elevations will exacerbate this situation, especially during low-flow summer and fall seasons.

- Population-related factors external to the Columbia Basin, such as international trade, shipping, dredging, hazardous material transport, and airborne pollution, will affect fish and wildlife habitat in the basin. (See ODFW 2010, and Independent Scientific Advisory Board 2007b.)

4.8.2 Regional Strategy for Human Population Growth

The Oregon and White Salmon management unit plans identified both human population growth and climate change as future threats to lower Columbia salmon and steelhead. Although Oregon recovery planners believe that actions should be implemented now to prevent or mitigate for the future impacts of these threats (ODFW 2010), the magnitude of the impacts is unknown. Given this uncertainty, in developing improvement targets for Oregon populations, recovery planners added an additional 20 percent in abundance above that needed to achieve the WLC TRT criteria for stratum viability. This 20 percent conservation "buffer" is intended as a precautionary measure, to help mitigate for the impacts of both human population growth and climate change in the interim until the magnitude of these threats is better understood. Once the impacts of human population growth and climate change can be estimated more accurately, targets and actions in the Oregon management unit plan can be adjusted accordingly (ODFW 2010).

The Washington management unit plan did not identify future growth in the human population as a threat to lower Columbia salmonids or incorporate the impacts of future threats—either population growth or climate change—in its calculations of target abundance for recovery of its populations. Instead, managers and scientists expect to use the adaptive management process to refine strategies, measures, and actions as the Washington management unit plan is implemented, based on the observed response to initial recovery efforts. Effective adaptive management will require that initial actions be of a magnitude sufficient to produce a measurable response, and that monitoring be sufficient to detect a response (LCFRB 2010a).

All three management unit plans include actions or strategies that will lessen the impacts of human population growth. The Oregon management unit plan identifies specific actions as mitigation for this threat, while the Washington management unit plan incorporates mitigation measures into larger scale principles and strategies that are intended to address six major categories of threats to lower Columbia salmon and steelhead. Representative actions and strategies from the Oregon and Washington management unit plans are shown in Table 4-12. The White Salmon management unit plan includes broader scale strategies that, although not linked specifically to human population growth, will help mitigate this threat; examples include protecting the highest quality habitats through acquisition and conservation, conserving rare and unique functioning habitats, consistently applying best management practices and existing laws to protect and conserve natural ecological processes, and providing public outreach to educate river uses and others (NMFS 2011).

Table 4-12
Representative Actions and Strategies to Mitigate for Human Population Growth

Oregon Management Unit Plan	Washington Management Unit Plan
• Prevent impacts from future development in the 100-year floodplain—i.e., impacts on wetlands and vegetation, stormwater effects, and the net impacts of new dikes, levees, and floodwalls. Mechanisms to prevent impacts in the 100-year floodplain include updating floodplain maps and incorporating them into land use planning, providing FEMA funding for land acquisition in the floodplain, developing new regulations, and enhancing efforts to enforce existing land use regulations, laws, and ordinances. • Encourage the Oregon Division of State Lands to (1) require avoidance and minimization of impacts to waters of the state in priority areas identified in the Oregon management unit plan, (2) work with landowners to design projects that avoid and minimize impacts to wetlands and other waters of the state, (3) explore opportunities to target compensatory mitigation towards areas that have high intrinsic potential for salmon and/or have been identified as priority areas for restoration, and (4) explore conservation easements for state-owned lands with high value for salmon recovery. • Protect existing high-quality or intact habitat, including riparian areas and off-channel habitat in the Columbia River estuary; actively purchase off-channel estuarine habitats in urban and rural settings. • Encourage and provide incentives for local, state, and Federal regulatory entities to maintain, improve, and enforce habitat protections throughout the lower Columbia region. • Provide more resources and incentives to small (non-metropolitan) communities so they have the infrastructure to better manage runoff from impervious surfaces. • Educate landowners about the benefits of protecting and stewarding intact ecosystems and the costs of degraded systems. • Remove or modify over-water structures to provide beneficial habitats. • Reduce the stranding of juvenile salmonids on estuarine beaches as a result of ship wakes. • Reduce salmonid exposure to toxic contaminants: implement pesticide and fertilizer best management practices; identify and reduce industrial, commercial, and public sources of pollutants; and restore or mitigate contaminated sites in the Columbia River estuary. • Implement stormwater best management practices in cities and towns.	• Consider salmon recovery needs up front in the comprehensive land use planning process, along with other social, infrastructure, and service needs. • Protect habitat conditions and watershed functions through land use planning that guides population growth and development—i.e., plan growth and development to avoid sensitive areas (wetlands, riparian zones, floodplains, unstable geology, etc.), encourage the use of low-impact development methods and materials, and apply mitigation measures to offset potential impacts • Protect and restore instream flows through water rights closures, purchase or lease of existing water rights, relinquishment of existing unused water rights, enforcement of water withdrawal regulations, and implementation of water conservation, use efficiency, and water re-use measures to decrease consumption. • Protect and restore runoff processes, in part by limiting additional watershed imperviousness, managing stormwater runoff, and protecting and restoring wetlands in developed and developing areas. • Protect and restore water quality, in part by reducing fecal coliform bacteria levels and inputs of chemical contaminants from developed lands. This involves managing industrial point sources of pollution, eliminating urban and rural sewage discharge to streams, and treating storm runoff before it is discharged to streams. • Manage recreation to protect and restore sensitive areas, such as by rehabilitating damaged terrain, limiting use, and managing human waste. • Maintain and/or establish adequate resources, priorities, regulatory frameworks, and coordination mechanisms for effective enforcement of land and water use regulations for the protection and restoration of habitats significant to fish and wildlife resources. This involves establishing cooperative enforcement partnerships among agencies, public, land owners, and industry and establishing priorities to emphasize protection in key areas and facilities where recovery efforts are focused.

For more detail on mitigating for the growing human population in the Columbia Basin, see the Oregon and Washington management unit plants (ODFW 2010 pp. 100-101, 226-239; LCFRB 2010a Chapter 5, S.S10, S.M1, S.M3, S.M12, S.M13, S.M15, and 2.M16).

4.9 Summary

No single factor, threat, or threat category accounts for the declines in the species addressed in this recovery plan; instead, the status of Lower Columbia River salmon and steelhead and Columbia River chum salmon is the result of the cumulative impact of multiple limiting factors and threats. Although this chapter and the recovery analyses that follow highlight major recovery topics, factors, and actions, recovery of the Lower Columbia species will be accomplished through improvements in every general threat category. Even small increments of improvement will play an important role. When the need for improvement for most ESUs is so large, the contribution of no population or threat reduction can be discounted.

5. Overall Approach to Species Recovery Analyses

This chapter describes the management unit recovery planners' overall analytical approach to species recovery and summarizes the key analyses that formed the basis of their recovery strategies. Where relevant, the chapter describes differences in approaches and discusses the implications of those differences. For more detailed information on these methodologies, see the management unit plans (LCFRB 2010a, ODFW 2010, NMFS 2011b). The chapters that follow describe the results of these analyses as applied to each Lower Columbia River ESU or DPS.

In general, the management unit recovery planners did the following:

1. Evaluated the baseline status of their respective populations using techniques based on those recommended by the WLC TRT (McElhany et al. 2003, McElhany et al. 2004, McElhany et al. 2006) and demonstrated in McElhany et al. (2007).[1]

2. Identified limiting factors for each Lower Columbia River salmon and steelhead population.

3. For each population, quantified the estimated baseline impacts of six categories of threats—tributary habitat, estuary habitat, hydropower, harvest, hatcheries, and ecological interactions or predation—that were useful as an organizing construct for grouping limiting factors.

4. Established a target status for each population, taking into consideration (1) each population's potential for improvement, in view of available habitat and historical production, (2) the degree of improvement needed in each stratum to meet WLC TRT guidelines for a viable ESU, and (3) for some ESUs, the desire to accommodate objectives such as maintaining opportunities to harvest hatchery-origin fish. Management unit recovery planners used the term "conservation gap" to refer to the difference between the baseline and target status for each population.

5. Calculated the population-specific improvements in abundance and productivity and, in some cases, spatial structure and diversity that would be needed to achieve each population's target status (i.e., to close the conservation gap).[2]

6. Identified a "threat reduction scenario" for each population, meaning a specific combination of reductions in threats that would lead to that population achieving its target status.

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[1] McElhany et al. (2007) was a collaborative effort by NMFS Northwest Fisheries Science Center staff, ODFW staff, and a consultant working for the Lower Columbia Fish Recovery Board to refine the approach to population status assessment.

[2] The Oregon management unit plan contains explicit targets for spatial structure and diversity; in the Washington management unit plan, spatial structure and diversity improvements are implicit in the abundance and productivity targets.

7. Identified and scaled recovery strategies and actions to reduce threats by the targeted amount in each category. Management unit planners identified recovery strategies and actions through meetings and workshops with stakeholders, including representatives of implementing and affected entities.

8. Considered the probable effects of actions, established benchmarks for implementation, and identified critical uncertainties and research, monitoring, and evaluation needs for each species for incorporation into an adaptive management framework (see Chapter 10 of this plan).

9. Developed implementation frameworks that address organizational structures, prioritization methods, systems for tracking implementation, coordination needs and approaches, and stakeholder involvement (see Chapter 11of this plan).

The following text further describes the analytical framework used by the management unit recovery planners.

5.1 Baseline Population Status

Management unit recovery planners assessed each population's status based on methods described in technical reports developed by the WLC TRT and demonstrated in McElhany et al. (2007). (For a description of these reports, see Section 2.5.2). For each population, management unit recovery planners evaluated and scored the four VSP attributes of productivity/abundance, spatial structure, and diversity individually and then integrated the VSP attribute scores to yield an overall population score; this overall score reflects the population's baseline probability of persistence, as shown in Table 5-1. For information on specific benchmarks and scoring techniques, see McElhany et al. (2003, 2004, 2006, and 2007, primarily the latter two documents), pp. 50 through 75 of ODFW (2010), and pp. 4-11 through 4-18 of LCFRB (2010a).

Readers should note that in the management unit plans, Oregon described its populations in terms of extinction risk, while Washington described its populations in terms of persistence probability. This is a difference in terminology only, as persistence probability is simply the inverse of extinction risk status (e.g., high persistence probability is the equivalent of low extinction risk, as shown in Table 5-1). This ESU-level plan presents the status of all populations in terms of persistence probability (this is consistent with the language of the WLC TRT technical documents) but uses "extinction risk" in some contexts when that term is more illuminating.

Table 5-1
Population Scores and Corresponding Probability of Persistence (or Extinction)

Score*	Probability of Persistence**	Population Status	Probability of Extinction **	Extinction Risk
0	0 – 40%	Very low (VL)	60 – 100%	Extinct or at very high risk of extinction (VH)
1	40 – 75%	Low (L)	25 – 60%	Relatively high risk of extinction (H)
2	75 – 95%	Medium (M)	5 – 25%	Moderate risk of extinction (M)
3	95 – 99%	High (H)	1 – 5%	Low/negligible risk of extinction (L)
4	> 99%	Very high (VH)	< 1%	Very low risk of extinction (VL)

* Population scores between whole numbers are rounded. For example, a score of 2.75 would be rounded up to 3; a score of 2.45 would be rounded down to 2.

** Probability over a 100-year time frame.

Source: McElhany et al. (2006).

5.1.1 Oregon Approach to Assessing Baseline Status

Oregon recovery planners established a "baseline period" from which to assess population status based on the most recent data available at the time of their assessment—generally up through 2006-2008 for modeling of abundance and productivity and through 2004 for assessment of other VSP parameters and threat assessments (ODFW 2010).

Consistent with the WLC TRT's approach (described in McElhany et al. 2003 and 2006 and demonstrated in McElhany et al. 2007), the four VSP parameters of productivity/abundance, spatial structure, and diversity were the foundation of the status assessment for Oregon populations. Oregon recovery planners also used the WLC TRT's scoring method—i.e., total score = 2/3 A&P + 1/6 spatial + 1/6 diversity (see McElhany et al. 2007)—to derive a composite score for each population. As in McElhany et al. (2007), Oregon recovery planners based scoring of the abundance/productivity attribute on population viability modeling and used a mix of quantitative and qualitative metrics to score the spatial structure and diversity attributes.

To reflect the uncertainty associated with both the data and the assessment methods, and consistent with McElhany et al. (2007), Oregon recovery planners presented results as a distribution of possible extinction risk scores, displayed graphically as a diamond shape (see Figure 5-1), rather than as a single score. The widest point of the diamond reflects the most likely extinction risk category, while the upper and lower points correspond to the extremes of possible extinction risk values. The height of the diamond represents the degree of uncertainty about the assessment. During later steps in their recovery analyses, Oregon recovery planners used the extinction risk category at the diamond's widest point as the baseline extinction risk.

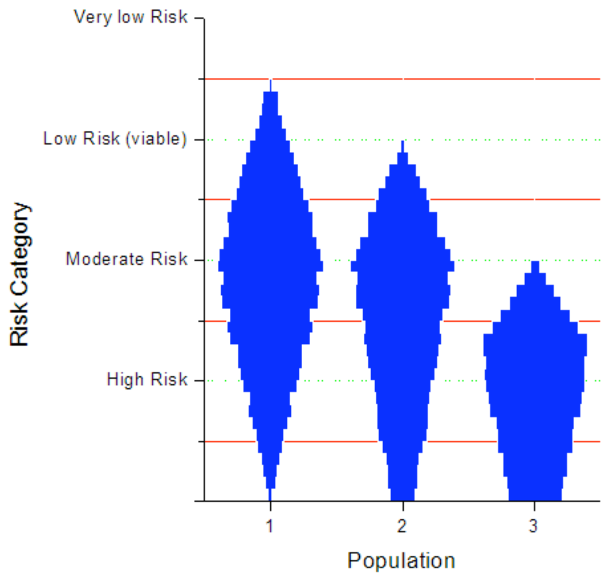

Figure 5-1. *Sample "Diamond Graph" Showing Populations with Different Distributions of Extinction Risk (Inverse of Persistence Probability***)**

5.1.2 Washington Approach to Assessing Baseline Status

Washington recovery planners evaluated population status circa 1999—around the time when most Lower Columbia River salmon and steelhead were listed under the ESA (LCFRB 2010a)—and did not use time series information after the baseline period in any quantitative analysis; they considered spatial structure and diversity conditions as of 1999). The Washington recovery planners chose this point because it ensures that the baseline assessments reflect the conditions that led to the initial ESA listings and that must be addressed through recovery actions.

As in Oregon, the four VSP parameters of productivity/abundance, spatial structure, and diversity were the foundation of the Washington status assessments. However, instead of deriving an overall population score using the WLC TRT's formula (total population status score = 2/3 A&P + 1/6 spatial structure + 1/6 diversity), Washington recovery planners assessed population status by (1) scoring the abundance/productivity, diversity, and spatial structure attributes for each population (see Table 4-4 in LCFRB 2010a) and then (2) designating the lowest of the individual attribute scores as the overall population status. The Washington recovery planners considered this "lowest attribute" approach intuitively simpler, less subjective, and more effective in capturing spatial structure and diversity concerns.

A consultant to the Lower Columbia Fish Recovery Board developed abundance/productivity scores for each Washington population using a quantitative population viability analysis that uses a stochastic stock-recruitment model. This approach is similar to the risk analyses in McElhany et al. (2007) and the Oregon management unit plan. Scores for spatial structure and diversity that go into the overall population status scores were based on qualitative analyses and expert judgment using criteria established by a technical work group and based on guidance established by the WLC TRT (McElhany et al. 2003).

The Washington management unit plan notes that there is significant uncertainty in the population status assessments—on the order of at least one point in the population score. The uncertainty is a consequence of the limited data and limited understanding of the relationships between population attributes and persistence probability (LCFRB 2010a).

5.1.3 White Salmon Approach to Assessing Baseline Status

For baseline population status, the White Salmon recovery planners used status assessments completed by the WLC TRT in 2004 (McElhany et al. 2004), the most current assessment of the White Salmon populations available at the time of plan development. The 2004 evaluation involved individual WLC TRT members ranking the VSP attributes based on best available information and professional judgment and providing an estimate of "data quality" based on their assessment of the overall amount of information available for each attribute. Overall population viability was determined using the WLC TRT's formula for a weighted average of the VSP attributes (McElhany et al. 2004).

5.1.4 Differences in Status Assessment Methods

The population assessment methods used by Oregon, Washington, and White Salmon recovery planners were similar to each other and consistent with the approach outlined in McElhany et al. (2000), but they differed in specific application, such as selection of the baseline period and integration of VSP attribute scores to yield an overall population score (see Table 5-2). As a result, the status assessments in the different plans are not necessarily directly comparable. However, the actual results of the assessments are generally in agreement on the relatively poor status of most populations. This suggests that the fundamental similarities of the approaches outweigh their differences, which appear to have relatively little effect on overall conclusions about population status. NMFS' view is that the status assessment methods used by the WLC TRT, McElhany et al. (2007), and the management unit plans all are scientifically sound, are based on the best information available, and provide a credible assessment of population status and a solid foundation for additional assessments and identification of initial recovery actions.

As described in more detail in Section 5.10, NMFS is required to complete reviews of the status of listed salmon and steelhead every 5 years. The most recent reviews, which were completed in 2011, used the same VSP concept that the management unit planners used and reached conclusions about population status similar to those in the management unit plans (76 *Federal Register* 50448). As new methods for status assessment are developed and new and better data become available, NMFS will employ the improved techniques in future 5-year reviews and recovery plan updates.

Table 5-2
Key Differences in Status Assessment Methodologies

Element	Oregon	Washington	White Salmon
Baseline period	Modeled baseline abundance assuming environmental conditions similar to those through 2006-2008	Used circa 1999 (i.e., ESA listing dates) as the baseline period	Used 2004 as the baseline period
Population score	Used weighted average of VSP attribute scores to determine population score	Used lowest VSP attribute score to determine population score	Used weighted average of VSP attribute scores,* tempered by professional judgment
Uncertainty	Expressed uncertainty graphically, using diamond shapes and reduced extinction risk thresholds to account for uncertainty	Stated that population score may be off by one or more points	Scored the quality of the data for each VSP attribute

* McElhany et al. (2004), which was the source of the status assessments for the White Salmon populations, used a slightly different list of VSP attributes than did the Oregon and Washington recovery planners—namely, productivity, juvenile outmigrants, diversity, habitat, and spatial structure. The WLC TRT later refined the VSP parameters to abundance, productivity, spatial structure, and diversity.

5.2 Target Status

5.2.1 Recovery Scenario

Through an iterative process, management unit recovery planners collaborated to reach agreement on a target status for each population that either was consistent with the WLC TRT's stratum and ESU/DPS viability criteria or that would contribute to comparable ESU/DPS risk levels. Where a population's target status was inconsistent with the WLC TRT's stratum or ESU/DPS criteria, the management unit plans documented the basis for the divergence. In this ESU-level recovery plan and the management unit plans, the target viability statuses are referred to collectively as the "recovery scenario" for the ESU or DPS (see Table 3-1 for the actual scenarios). Recovery planners also designated each population as "primary," "contributing," or "stabilizing" to reflect its expected level of contribution to recovery of the ESU or DPS (see Section 3.1.3 for a description of these designations).

5.2.2 Conservation Gaps

The difference between a population's baseline status and its target status reflects the magnitude of improvement needed to close the "conservation gap." Oregon and Washington management unit recovery planners estimated the abundance, productivity, spatial structure, and diversity improvements that would be necessary for each population to achieve its target status.[3] They quantified gaps in abundance and

[3] Washington management unit recovery planners quantified the conservation gap for the White Salmon populations as part of their conservation gap analysis (see LCFRB 2010a). The White Salmon management unit plan (NMFS 2011b) does not include this gap analysis. Instead, the plan presents a baseline status for

productivity using the same stochastic population viability analysis models used to estimate baseline risk status and treated gaps in spatial structure and diversity qualitatively because of a lack of rigorous quantitative analytical methods and criteria for these parameters.[4] For more on information on how management unit recovery planners calculated population-specific conservation gaps in terms of the VSP parameters, see pp. 58 to 78 of ODFW (2010) and pp. 4-28 through 4-30 of LCFRB (2010a).

Although population-specific gap analyses are subject to a significant level of uncertainty that is difficult to quantify, management unit planners and NMFS consider the results of these analyses useful in conveying the order of magnitude of improvements that need to be addressed through recovery strategies and actions.

Quantification of population-specific gaps in abundance and productivity is one area where Oregon and Washington recovery planners took slightly different approaches in their analyses. In calculating the abundance and productivity improvements needed to achieve each population's target status, Oregon recovery planners built in two numerical "buffers": one to account for expected future threats (i.e., climate change and human population growth in the region), and one to serve as a "safety factor," to compensate for scientific uncertainty and possible measurement errors. In contrast, Washington recovery planners based their calculations of needed abundance and productivity improvements on known baseline conditions and expect to respond to future threats and account for scientific uncertainty through adaptive management.

A result of this difference in approach to future threats and scientific uncertainty is that the numerical estimates of abundance and productivity needed to fill the conservation gaps for Oregon populations are bigger than those for corresponding gaps for the Washington populations. NMFS' view is that this difference in approach is not significant because (1) management unit recovery planners did not do quantitative modeling of the probable effects of recommended recovery actions, and (2) both states will rely on adaptive management as actions are implemented and conditions in the region change.

5.3 Limiting Factors and Threats

NMFS defines limiting factors as various biological, physical, or chemical conditions (such as high water temperatures) and the associated ecological processes and interactions that limit a species' viability[5]; NMFS defines threats as human activities or natural events that cause or contribute to limiting factors. For example, the limiting factor of high water temperature could be caused by any number of threats, either alone

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each population (based on McElhany et al. 2004) and a target status for each population (based on LCFRB 2010a).

[4] The Oregon management unit plan contains explicit targets for spatial structure and diversity; in the Washington management unit plan, spatial structure and diversity improvements are implicit in the abundance and productivity targets.

[5] In this recovery plan, the term "limiting factors" is used to indicate the full range of factors that are believed to be impairing the viability of salmon and steelhead and not to indicate the single factor that is most limiting. Some NMFS scientists are now using the term "ecological concerns" instead of "limiting factors" to connote this full range of factors affecting viability.

or in combination, such as warm water discharged to a stream, loss of bank vegetation that otherwise would shade the stream, low stream flow, or climate change. Threats can be caused by past or present actions or events. Understanding threats allows recovery planners to identify actions that will change the actual activities or events that cause a limiting factor, thus reducing the limiting factor itself.

The management unit recovery planners identified population-specific limiting factors and threats that are contributing to the threatened status of Lower Columbia River ESUs through review and synthesis of published and unpublished literature, supplemented by EDT modeling (for Washington populations) and professional judgment (for Oregon and White Salmon populations). Each management unit plan presents limiting factors for all populations within its planning area (see, for example, Table 5-1 of ODFW 2010), with impacts falling into six associated threat categories: tributary habitat, estuary habitat, hydropower, harvest, hatcheries, and predation (or ecological interactions, in the Washington management unit plan). The management unit plans describe limiting factors and threats in relation to the biological needs of the species and across the full spectrum of conditions that affect salmon and steelhead throughout their life cycle. Because data linking limiting factors to specific effects on population risk status are generally lacking, each management unit plan presents the limiting factors as hypotheses to be tested through action implementation and monitoring of results, with adaptive management as needed.

Oregon recovery planners used a multi-step process to identify limiting factors and threats. Using available published and unpublished information and professional judgment, an expert panel developed an initial set of population-level limiting factors and threats by life stage (juvenile or adult) and categorized them as having either a key or secondary impact on population status.[6] The Oregon recovery planning team and the Oregon Lower Columbia River stakeholder team then worked iteratively to review the initial set of limiting factors and threats and modify them based on additional information and deliberation. For additional discussion of the expert panel process and detailed results for each population, see Chapter 5 of ODFW (2010).

Washington recovery planners based their descriptions of limiting factors and threats on review and synthesis of published and unpublished literature for the listed species in the lower Columbia region. They also used Ecosystem Diagnosis and Treatment (EDT) modeling to identify primary and secondary habitat limiting factors by juvenile and adult life stages at the population and stream reach scale. Detailed results of the EDT modeling are presented in Volume II of the LCFRB plan and are reflected in the population-level limiting factors reported in this ESU-level recovery plan (see Section 5.4 and Appendix H).

White Salmon recovery planners identified limiting factors and threats based on a substantial body of research, local field data and observations, and the opinions of regional experts (NMFS 2011b).

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[6] For discussion of the thresholds used to determine whether a factor was key or secondary, see Section 5.1.4 of ODFW (2010).

5.4 NMFS Limiting Factors Crosswalk

Each of the management unit plans use somewhat different terms to describe limiting factors and threats, and in some cases, the plans characterize limiting factors and threats at different levels of specificity. To facilitate the use of a common parlance in discussing limiting factors in all salmon and steelhead recovery plans, the NMFS Northwest Fisheries Science Center developed a standardized set of limiting factors (also known as ecological concerns) that affect salmon and steelhead (Hamm 2012). NMFS refers to this standardized list of limiting factors as a "data dictionary" and intends to use it to track and report on recovery plan limiting factors and actions regionwide. For this recovery plan, NMFS developed a set of limiting factor "crosswalk" tables that correlate each management unit plan's population-specific limiting factor information with the terms used in the data dictionary. Appendixes G and H present the data dictionary and crosswalk tables, respectively.

The crosswalk tables indicate the limiting factors (i.e., the "ecological concerns" in the data dictionary) that affect each population, as well as the life stage affected, the degree of impact (primary or secondary), the location of the impact (in tributaries or in the Columbia River estuary and plume), and, in certain cases, whether there is uncertainty regarding the accuracy of the data. NMFS used the crosswalk tables in Appendix H to derive the summaries of stratum- and ESU-level limiting factors and threats in Chapters 6 through 9 of this ESU recovery plan.

Appendix H explains the methodology that NMFS used to develop the limiting factor crosswalks. Briefly, the limiting factors identified in the Oregon management unit plan tracked quite readily to the subcategories of ecological concerns in the Northwest Fisheries Science Center data dictionary. For Washington populations, it was necessary for NMFS staff and an independent contractor to examine the EDT results, draw information from various parts of the Washington management unit plan, and confer with Lower Columbia Fish Recovery Board staff and the board's consultant to distinguish between primary and secondary limiting factors.

5.5 Baseline Threat Impacts

Once management unit recovery planners had identified population-specific limiting factors, they estimated the baseline mortality impacts to each population caused by six categories of threats—tributary habitat, estuary habitat, hydropower, harvest, hatcheries, and predation (or ecological interactions, in the Washington management unit plan)—that also proved useful as an organizing construct for grouping limiting factors. Only potentially manageable impacts were considered. In estimating impacts, management unit recovery planners evaluated each threat category independently (i.e., impacts reflect the mortality of fish exposed to that particular category of threats, whether or not they are exposed to threats in the other categories). The estimates of baseline threat impacts have high levels of uncertainty and in many cases should be considered working hypotheses that are testable as part of recovery plan implementation. Despite this uncertainty, it is the expert judgment of NMFS and management unit scientists that, based on the best available information at this time, the baseline threat impacts provide a reasonable estimate of the relative magnitude of different sources of anthropogenic mortality on each population and serve as an adequate basis for designing initial recovery actions. As more and better information is collected, it will be applied to recovery efforts in an adaptive management framework.

Management unit recovery planners used the population-specific baseline threat impacts when (1) evaluating the effects of possible reductions in each threat category (see Tables 6-6, 7-6, 7-8, 7-10, 8-4, and 9-7), and (2) scaling actions to achieve the target status for each population (see Section 5.7, "Recovery Strategies and Actions").

5.5.1 Oregon Approach to Quantifying Baseline Threat Impacts

Oregon recovery planners estimated the baseline impacts of threats as summarized below:

- Hydropower impacts: Estimated dam passage mortality among juveniles and adults based on estimates in the 2008 FCRPS Biological Opinion (NMFS 2008f) or FERC relicensing documents, and in some cases professional judgment. Excluded non-passage impacts such as habitat blockage, habitat inundation, and flow modification in the Columbia River estuary.

- Harvest impacts: Calculated average fishery exploitation rates for a reference period that extends loosely from 1994 to 2004 (ODFW 2010 p. 72-74 and Table 4-8, p. 73).

- Hatchery impacts: Estimated hatchery impacts as mortality resulting from the reduced overall population productivity of natural-origin fish; assumed that mortality corresponds to the proportion of hatchery fish in natural spawning populations (except for Chinook salmon populations, where hatchery impact rates were assumed to be one-half the rates at which hatchery fish were found on natural spawning grounds; see pp. 156 to 158 of ODFW 2010). This approach reflects a concern for both the genetic and ecological effects of hatcheries and excludes the benefits of conservation hatchery programs.

- Predation impacts: Estimated overall predation rates based on information in the literature and then adjusted those rates downward to exclude non-anthropogenic predation.

- Estuary habitat impacts: Derived estimates of baseline mortality from estimates of total juvenile mortality in the *Columbia River Estuary ESA Recovery Plan Module for Salmon and Steelhead* (NMFS 2011a). Adjusted the module estimates downward assuming that 70 percent of subyearling migrant mortality and 35 percent of yearling migrant mortality in the estuary is anthropogenic. Further adjusted the estimates downward to subtract estimated mortality that is due to predation on juveniles.

- Tributary habitat impacts: Estimated the baseline mortality associated with estuary habitat degradation, hydropower, harvest, hatcheries, and predation and assigned all remaining mortality (relative to the difference between the baseline modeled abundance and estimated historical abundance) to tributary habitat impacts.

Throughout the Oregon management unit plan, ocean conditions were considered to be part of the environmental, variable baseline and thus not a discrete threat. However, the Oregon management unit plan notes that anthropogenic impacts in the ocean and other locations may be increasing, and that past assumptions about natural variability may not hold true in the future. Oregon recovery planners increased the size of the abundance and productivity gap by 20 percent in part to account for effects of future climate change, including changes in ocean conditions.

Oregon recovery planners did not quantify baseline and target threat impacts for chum salmon populations because data were inadequate to do so.

For more detailed information on how Oregon recovery planners estimated baseline threat impacts, see Section 6.2.1 of ODFW (2010).

5.5.2 Washington Approach to Quantifying Baseline Threat Impacts

Washington recovery planners estimated the baseline impact of threats as summarized below:

- Hydropower impacts: Estimated impacts from dam passage mortality, habitat loss caused by inundation, and loss of access to historical production areas because of the presence of large, impassable tributary and mainstem dams; excluded indirect hydropower impacts. Inferred the production potential of inaccessible habitat from EDT results. Estimated mainstem hydropower impacts based on the *Recovery Plan Module: Mainstem Columbia River Hydropower Projects* (NMFS 2008a).

- Harvest impacts: Used baseline fishery impacts rates from a reference period in the late 1990s; rates included harvest and indirect mortality and generally reflected the maximum estimated impacts.

- Hatchery impacts: Estimated hatchery impacts as mortality resulting from reduced overall population productivity of natural-origin fish; assumed that mortality is a function of the proportion and productivity of hatchery-origin fish that are spawning naturally. Inferred estimates of the relative fitness of hatchery- and natural-origin spawners from Columbia River Hatchery Scientific Review Group (HSRG) analyses. Limited hatchery impacts to not more than 50 percent per population, in accordance with HSRG assessments of the potential for genetic effects. Excluded impacts from interactions between hatchery- and natural-origin fish and the beneficial impacts of conservation hatchery programs.

- Ecological interactions: Estimated aggregate predation rates in the Columbia River mainstem and estuary by northern pikeminnow, marine mammals, Caspian terns, and cormorants, based on a combination of data, anecdotal information, and clearly articulated assumptions.

- Estuary habitat impacts: Derived estimates of baseline mortality from estimates of total juvenile mortality in the *Columbia River Estuary ESA Recovery Plan Module for Salmon and Steelhead* (NMFS 2011a). Excluded predation mortality and assumed that manageable habitat mortality in the estuary was half of the non-predation-related total mortality.

- Tributary habitat impacts: Used EDT to derive estimates of the relative reduction in fish numbers resulting from changes in stream habitat conditions compared to a historical template.

Washington recovery planners did not quantify the effects of ocean conditions and long-term climate changes because of uncertainty about the magnitude and timing of their effects. However, the effects of normal variability in ocean conditions on annual fish survival were accounted for in the models that were used to evaluate population-level abundance and productivity and to establish abundance and productivity goals and threat reduction targets. The Washington management unit plan intends to address potential future changes in ocean and climate effects through adaptive management, prioritization of habitat restoration and protection actions, and setting recovery goals higher than necessary to achieve delisting (see Section 5.9 of LCFRB 2010a).

For more detailed information on how Washington recovery planners estimated baseline threat impacts, see Sections 3.7.2 through 3.7.4 of LCFRB (2010a).

5.5.3 White Salmon Approach to Quantifying Baseline Threat Impacts

The White Salmon management unit plan does not include an analysis of the baseline threat impacts. However, Washington recovery planners developed baseline threat impacts for the White Salmon populations to facilitate establishment of ESU-level recovery scenarios (see LCFRB 2010a). These threat impacts will be used to inform implementation and monitoring for the White Salmon management unit plan.

5.6 Threat Reduction Scenarios

Once management unit planners had quantified the baseline impacts of the six categories of threats (tributary habitat, estuary habitat, dams, harvest, hatcheries, and predation), they were able to evaluate the effects of possible reductions in each threat category. In this recovery plan, a given combination of threat reduction targets that would lead to a population achieving its target status is termed a threat reduction scenario. The scenario describes how much of a gain in population abundance and productivity is needed from recovery actions in each threat category to achieve a population's target status.

For each Oregon population, recovery planners developed and evaluated multiple threat reduction scenarios and then selected one. Washington recovery planners, on the other hand, developed a single threat reduction scenario for each population by assigning threat reduction targets to the six threat categories in proportion to the baseline impacts of each category. The different management unit plan approaches to developing threat reduction scenarios and population-specific threat reduction targets are summarized below. For more detail, see Section 4.5.2 of LCFRB (2010a) and Section 6.2.1 of ODFW (2010).

5.6.1 Oregon's Threat Reduction Scenarios

Oregon recovery planners evaluated how a number of different combinations of reductions in the six threat categories would affect each population's persistence probability. Evaluating multiple combinations of threat reductions across the six categories allowed the planning team and stakeholders to examine the tradeoffs among the various threat reduction options.

Oregon recovery planners evaluated the following threat reduction scenarios for each population:

- 20 percent reduction in each threat category's baseline rate
- Maximum harvest and hatchery (assumes essentially zero harvest, with a remaining 5 percent incidental impact rate, eliminating all LCR hatchery programs, and maintaining other threats at baseline levels)
- Maximum feasible reduction (assumes reductions in all threat categories that were considered feasible with current biological, social, political, and economic realities)
- Minimum tributary habitat (explores the minimum tributary habitat impact reduction required if reductions in other threat categories are maximized)
- Maintain into future (evaluates the threat reductions needed in each category to achieve a 20 percent increase in abundance to account for unknown future threats and maintain baseline risk status)
- Low extinction risk (evaluates the threat reductions needed to achieve low extinction risk, i.e., high persistence probability)
- Very low extinction risk (evaluates the threat reductions needed to achieve very low extinction risk, i.e., very high persistence probability)

The first four scenarios evaluated the persistence probability that would result from reducing two or more threat categories a given amount; the last three scenarios evaluated the threat reductions necessary to achieve a specific persistence probability.

Eventually, Oregon recovery planners selected a specific threat reduction scenario for each population based on factors such as feasibility, societal goals (including harvest opportunity, in some cases), and consistency with the WLC TRT's viability criteria. In addition, for the selected threat reduction scenario, Oregon assigned a level of confidence of whether the reductions could be achieved. In some cases the confidence was low. For more information on how Oregon developed its threat reduction scenarios, see Section 6.2.1 of ODFW (2010).

Once Oregon recovery planners had selected a threat reduction scenario, they used a simple, independent, threat impact model to apportion the needed abundance and productivity improvements (which had been calculated as part of the gap analysis) across the six threat categories, in accordance with the selected scenario.

5.6.2 Washington's Threat Reduction Scenarios and Interim Benchmarks

Washington recovery planners developed a single threat reduction scenario for each population, setting a target impact level for each threat category that reflects long-term future conditions when recovery objectives are achieved. To establish these threat reduction targets, planners distributed the needed abundance and productivity improvements across the threat categories in proportion to the baseline impacts of each category. This was a policy decision by the Lower Columbia Fish Recovery Board that will lead to each sector being responsible for reducing its impacts in proportion to its contribution to the total baseline impacts. Thus, sectors with small baseline impacts are responsible for effecting a smaller reduction than sectors with large baseline impacts.

Washington recovery planners calculated proportionate reductions in each threat category directly from the population productivity improvement targets identified in the conservation gap analysis. The resulting impact reduction targets provide guidance on the scale of threat-specific improvement that must be accomplished by threat-specific strategies and measures.

The Washington management unit plan's threat reduction targets do not explicitly consider the timing of recovery action implementation, or the potential lag time in the realization of benefits. Some threats respond quickly to actions aimed at reducing them, while others respond more slowly. For example, reductions in harvest translate into immediate increases in survival and abundance, while the benefits of hatchery and habitat measures typically take much longer to be realized. To address this problem and provide some immediate reductions in extinction risk (until the benefits of all recovery measures can be realized), the Washington management unit plan includes a schedule of interim threat reduction benchmarks that, for some threat categories, define relatively large reductions in impacts in the near term; specific values were determined based on a combination of biological benefits and implementation feasibility. The benchmarks also include a combination of action implementation, impact reduction, and biological improvement standards by which recovery plan implementation can be scheduled and evaluated. The interim benchmarks are presented in Tables 6-3, 6-4, 6-8, 6-11, and 6-14 of LCFRB (2010a).

5.6.3 White Salmon Threat Reduction Scenarios

The White Salmon management unit plan does not include an analysis of the relative impact of baseline threat categories or the reductions needed in each threat category to reach recovery targets. However, Washington recovery planners developed threat reduction scenarios for the White Salmon populations to facilitate establishment of ESU-level recovery scenarios (see LCFRB 2010a). These threat reduction scenarios will be used to inform implementation and monitoring for the White Salmon management unit plan.

5.7 Recovery Strategies and Actions

The threat reduction targets provided a foundation from which management unit recovery planners could identify and scale recovery strategies and actions intended to reduce threats by the targeted amount in each category. The actions in the management unit plans address threats across the entire salmonid life cycle and include a balance of (1) actions intended to provide relatively immediate benefits, and (2) actions whose benefits are expected to be realized over a longer period of time. The management unit plans recommend both new activities and the continuation of existing programs that currently are benefiting Lower Columbia River ESUs (ODFW 2010, LCFRB 2010a). Actions identified in the management unit plans are intended to reduce threats in each category consistent with the conservation gaps and threat reduction targets described in Sections 5.2.2 and 5.6.

The Oregon and Washington management unit plans emphasize that recovery success will require not just local action but combined effort at the state, regional, national, and—in the case of harvest and hydropower—international level (ODFW 2010, LCFRB 2010a). Also, because there is a high degree of uncertainty about the biological response to actions and the level to which actions will need to be implemented to achieve the desired benefits, the plans consider proposed actions to some extent as hypotheses that will need to be tested. None of the management unit plans quantified the incremental benefit of any specific action; instead, actions were selected and scaled based on scientific judgment. (For a discussion of the sufficiency of recovery actions, see Section 5.8) All three management unit plans stress that adaptive management will play a central role in the recovery process, with research, monitoring, and evaluation activities providing crucial information on the effects of individual actions and overall progress toward recovery goals (ODFW 2010, LCFRB 2010a). (For more on research, monitoring, evaluation, and adaptive management, see Chapter 10.) Background information on recovery strategies and actions is presented in Section 5.1 of LCFRB (2010a) and 7.1 of ODFW (2010) and summarized below.

5.7.1 Oregon Approach to Developing Recovery Strategies and Actions

To develop recovery strategies and actions for Oregon populations, Oregon recovery planners began with the limiting factors and threats identified for each population by life stage and location. They then developed 14 overarching recovery strategies to provide an ecological context for identifying recovery actions (see Table 7-1 of ODFW 2010). Each strategy was associated with one or more of the six threat categories and was consistent with goals of biological diversity, ecological integrity, and ecological health (ODFW 2010).

Next, recovery planners developed recovery actions. The Oregon Lower Columbia River stakeholder team, which included state and Federal agency staff and representatives of agricultural, commercial, conservation, recreational, forestry, and fishing interests, reviewed the recovery actions and provided additional input. The Oregon management unit plan includes actions that address all key or secondary limiting factors. For some habitat actions, Oregon recovery planners identified specific locations for implementation, using reach-scale assessments, other action plans, and professional judgment; for some locations, they identified a need for completion of reach-scale assessments so that recovery actions could be targeted to where they are most needed.

Recovery actions in the Oregon management unit plan are organized by species and population (see Tables 7-3B, 7-3C, 7-3D, and 7-3E of ODFW 2010), with specific locations noted separately (see Table 9-3 of ODFW 2010). The threat category that each action addresses is indicated. The plan also identifies actions that address threats common to all Lower Columbia River salmon and steelhead populations (see Table 7-3A of ODFW 2010) and actions that apply to a single ESU or run component at multiple locations.

The Oregon management unit plan recommends that priority be given to recovery actions that do the following:

- Benefit populations that must achieve high persistence probability
- Address a key limiting factor or large conservation gap
- Will protect or result in accessible and connected high-quality habitat
- Are in locations with high intrinsic potential[7]
- Protect threatened high-quality or highly productive habitat
- Provide resiliency against climate change

In addition, Oregon recovery planners suggested funding strategies and recommended quick action for populations targeted for high persistence probability, especially in the case of tributary habitat actions (ODFW 2010).

5.7.2 Washington Approach to Developing Recovery Strategies and Actions

Washington recovery planners developed an integrated regional strategy for recovery, a series of threat-specific strategies and measures, and corresponding working hypotheses regarding the facts and assumptions that the strategies and measures are based on. Measures provide initial recovery guidance. Some apply generally to most Lower Columbia River ESUs; others apply to a single species. Measures are categorized based on whether they are existing or new activities and whether they provide primarily protection or restoration benefits (LCFRB 2010a).

To develop the regional strategies and measures, Lower Columbia Fish Recovery Board staff conducted meetings and workshops attended by representatives from affected entities and implementing agencies. The strategies and measures are based on a combination of expected biological results and economic, political, social, and cultural considerations, with the expectation that they will be refined during implementation.

Habitat protection and restoration actions targeted to specific stream reaches are identified in a series of subbasin chapters that constitute Volume II of the Washington

[7] Analyses based on the relationship between certain landscape features (e.g., channel gradients or geology) and species' habitat preferences can form the basis of a consistent approach to evaluating habitat potential to support a particular species. These analyses can inform species conservation and habitat restoration activities. Intrinsic potential models use geospatial data to identify stream reaches with high, low, or no potential to host a particular species. The models rate habitat potential at the level of a stream reach but provide a method for estimating habitat quantity and quality across local or regional scales.

management unit plan (LCFRB 2010a). Washington recovery planners prioritized these actions based on subbasin and stream reach fish production values and habitat limiting factors in all current and historical anadromous production areas. This prioritization considered the needs of the multiple populations within each subbasin. Geographically specific management actions for tributary habitat were developed using EDT and a geographical information system (GIS)-based tool known as the Integrated Watershed Assessment (IWA), which is used to assess stream habitat conditions and watershed process impairments at the subwatershed scale (3,000 to 12,000 acres). For further descriptions of the EDT and IWA analyses, see Chapter 7 and Appendix E of LCFRB (2010a).

5.7.3 White Salmon Approach to Developing Recovery Strategies and Actions

Recovery strategies and actions in the White Salmon management unit plan fall into two categories: (1) those aimed at reintroducing naturally produced salmon and steelhead into historical habitat after the removal of Condit Dam and (2) those aimed at improving and increasing freshwater habitat for salmon and steelhead production in key reaches (NMFS 2011b). Actions for reintroduction were developed by the White Salmon Working Group, which consisted of Federal, state, and tribal fisheries managers and representatives of PacifiCorp (the operator of Condit Dam). For each ESU, the group developed and evaluated a number of reintroduction options and proposed one for implementation. Options are described in more detail in Section 6.1 and Appendix 1 of the White Salmon management unit plan (NMFS 2011b).

As part of the White Salmon recovery planning process, NMFS worked with the White Salmon Working Group to review and analyze available information and define freshwater habitat strategies, actions, and priority reaches (NMFS 2011b). The habitat strategies and actions include gathering additional information to use in prioritizing actions, protecting existing ecological processes and functioning habitats, restoring vegetation along stream reaches that exceed state standards for water temperature, restoring habitat in the reservoir footprint now that Condit Dam has been breached,[8] and improving habitat in upriver reaches in preparation for the time when reintroduced populations exceed the carrying capacity of the existing habitat.

The White Salmon management unit plan also briefly discusses hatchery, harvest, and hydropower-related strategies and actions (NMFS 2011b).

5.8 Analysis of Actions

A question relevant to recovery planning is the level of effort that will be required to close the gap between baseline and target population status, and whether the actions identified in the recovery plan are sufficient to attain target status for each population. Because any analysis of such questions involves significant uncertainty, it is essential for any recovery plan to link hypotheses regarding level of effort and sufficiency of actions to rigorous research, monitoring, and adaptive management programs.

[8] Condit Dam was breached in October 2011; complete removal is expected by August 2012.

Management unit recovery planners addressed the question of the level of effort needed to close conservation gaps by identifying threat reduction targets in each major threat category. They addressed the question regarding sufficiency of actions through varying levels of analysis, depending on threat category, and by taking what the Washington management unit plan termed a "directional approach." The directional approach is based on the hypotheses that (1) the set of actions in this plan is sufficient to establish a trajectory toward recovery, (2) mechanistic analyses of the effects of actions are too uncertain to provide adequate confidence that any initial set of actions will be sufficient, and (3) modifications and refinements will be made as necessary within an adaptive management framework.

As described in the sections above, Oregon and Washington management unit planners did the following:

1. Quantified the abundance and productivity improvements—and in some cases the spatial structure and diversity improvements—needed for each population to move from its baseline persistence probability to its target persistence probability.

2. Quantified the baseline impact on population abundance and productivity for each of six major threat categories.

3. Quantified the amount by which each major threat impact would need to be reduced to close the gap between baseline and target status for each population.

4. Identified strategies and actions in each threat category that are intended to reduce the impact of each threat and improve abundance and productivity by the amount consistent with the target for each population.

Although the management unit planners hypothesized that actions would be sufficient to achieve the targeted threat reductions, the level of analysis carried out to confirm this varied by plan and by threat category. The different approaches in the Washington and Oregon management unit plans make it difficult to generalize; however, in general, the plans provide relatively detailed quantitative documentation for the expected benefits of harvest and hydropower actions. The potential benefits of hatchery, tributary habitat, and estuary habitat actions are assessed systematically but rely more heavily on extrapolations and general assumptions. In some cases, analysis of the sufficiency of actions in the management unit plans is based on professional judgment.

In addition, as part of developing recovery action cost estimates for habitat actions, Washington and Oregon management unit planners developed rough estimates of the number of stream miles that would need to be restored to achieve the habitat improvements targeted in the plans. (In Washington, estimates were for the number of stream miles that would need to be restored in each subbasin, while in Oregon the estimates were species-specific at the population scale; in both cases these estimates were rough and based on multiple assumptions.)

The management unit plans also incorporated monitoring and evaluation programs and an adaptive management framework for implementation to allow us to evaluate whether we are on course and to adjust as needed. This basic approach is useful in understanding the scale of actions that need to be implemented and in laying the groundwork for understanding and evaluating whether the actions have been effective.

The Washington management unit plan incorporates explicit interim benchmarks, defined as "reference points for planning and evaluating recovery progress over the duration of plan implementation," for action implementation, action effectiveness, and status improvements (see LCFRB 2010a, Section 6.1). The interim benchmarks provided in the Washington management unit plan reflect the incremental implementation strategies described in the plan and explicitly recognize the range in expected response times associated with different actions (e.g., adjustments to harvest rates versus restoring riparian habitats). The interim benchmarks are at 12-year intervals, corresponding to the adaptive management schedule called for in the plan (see LCFRB 2010a, Chapter 10).

The Oregon management unit plan (ODFW 2010) recognizes the importance of periodic assessments of plan performance, although it does not explicitly establish benchmarks equivalent to those in the Washington management unit plan. The adaptive management section of the Oregon management unit plan identifies the need for specific reviews of population status and plan performance at 5-year intervals and recognizes that such reviews would serve as the basis for considering major revisions to the plan on a 12-year cycle (see ODFW 2010, Chapter 9). Although the Oregon management unit plan does not include specific benchmarks, it does provide some general guidance on the expected timing of particular actions (including high-priority research, monitoring, and evaluation efforts) (see ODFW 2010, Section 9.3). This guidance includes specific time frames for full implementation of individual actions (see Table 9-3) and some general guidance on assessing implementation progress for tributary habitat actions ("Note that if the quantity of restoration action indicated in Table 9-2 is divided by the implementation schedule for that action in Section 9.1.3, an annual rate of restoration can be calculated. This can be compared to reported restoration projects and progress toward these habitat recovery action goals can be tracked").

5.9 Research, Monitoring, and Evaluation

Strategic research, monitoring, and evaluation (RME) programs that are designed to inform key questions and critical uncertainties and to feed information into an adaptive management framework are key components of salmon and steelhead recovery plans. The management unit plans contain or will contain specific RME plans for their areas. (See Chapter 8 of ODFW 2010 and Chapter 9 of LCFRB 2010a.) These RME plans are based on regional guidance for adaptive management and RME and will guide recovery planning RME efforts and funding in their respective areas, within a context of ongoing regional guidance and coordination. Chapter 10 of this plan describes RME in more detail.

As Chapter 10 also describes, a number of regional entities, including NMFS, are involved in research, monitoring, and evaluation for salmon and steelhead recovery. One component of the RME system for recovery planning is the NMFS 5-year reviews, which are described briefly below because of their relevance to the baseline population status completed by the management unit planners. The NMFS 5-year reviews are discussed in more detail in Chapter 10.

5.10 NMFS 2011 5-Year Reviews

Because the management unit plans evaluated baseline status several years ago, when the plans were in development, it is reasonable to ask whether the status of any population has changed since those assessments. Under ESA section 4(c)(2)(B), NMFS is required to conduct a review of listed species at least once every 5 years. Based on such reviews, NMFS determines whether any species should be removed from the list (i.e., delisted) or reclassified from endangered to threatened or from threatened to endangered. During these reviews, NMFS considers the best scientific and commercial data available. In 2011, NMFS published a 5-year review covering the period 2005-2010 that included review of the four species addressed by this recovery plan (76 *Federal Register* 50448). In the 2011 5-year review, NMFS generally relied on information through 2008 or 2009. Evaluation methods and information on species' status will continue to evolve and be updated over time. NMFS' next 5-year review will provide updated summaries of species' status based on best available information.

For the 2011 review, the NMFS Northwest Fisheries Science Center collected and analyzed new information about ESU and DPS viability, using the viable salmonid population concept developed by McElhany et al. (2000) (Ford 2011). NMFS Northwest Region salmon management biologists also reviewed the status of the ESA section 4(a)(1) listing factors (NMFS 2011c).

The updated 5-year review indicates that, although a number of populations in each ESU or DPS have high or medium persistence probability, not a single stratum in any of the ESUs or DPS is currently viable. Multiple populations in each stratum of each ESU or DPS will need improved status to meet the recovery criteria. Although little improvement in ESU or DPS viability has been observed over the last 5 years, there is also no new information to indicate that the extinction risk has increased. In addition, NMFS' analysis of ESA section 4(a)(1) factors indicates that the collective risk to the persistence of the Lower Columbia River Chinook, coho, and steelhead and Columbia River chum has not changed significantly since NMFS' final listing determination in 2006. The 2011 review emphasizes the importance of continuing to implement recovery actions that address the factors limiting population viability, as well as the importance of monitoring the effects of the actions over time.

6. Lower Columbia River Coho Salmon

6.1 Coho Salmon Biological Background

6.1.1 Coho Salmon Life History and Habitat

Lower Columbia River coho salmon (*Oncorhynchus kisutch*) are typically categorized into early- and late-returning stocks. Early-returning (Type S) adult coho salmon enter the Columbia River in mid-August and begin entering tributaries in early September, with peak spawning from mid-October to early November. Late-returning (Type N) coho salmon pass through the lower Columbia from late September through December and enter tributaries from October through January. Most spawning occurs from November to January, but some occurs as late as March (see Figure 6-1) (LCFRB 2010a). Migration and spawning timing of specific local populations may be mediated by factors such as latitude, migration distance, flows, water temperature, maturity, or migration obstacles (ODFW 2010). For example, coho salmon spawning in warmer tributaries spawn later than those spawning in colder tributaries (LCFRB 2010a).

Historically, coho salmon spawned in almost every accessible stream system in the lower Columbia River (LCFRB 2010a). Coho salmon generally occupy intermediate positions in tributaries, typically further upstream than chum or fall-run Chinook, but often downstream of steelhead or spring-run Chinook (ODFW 2010). Early-run fish usually spawn farther upstream within a basin than late-run fish. Coho salmon typically spawn in small to medium, low- to-moderate elevation streams from valley bottoms to stream headwaters. Coho salmon particularly favor small, rain-driven, lower elevation streams characterized by relatively low flows during late summer and early fall, and increased river flows and decreased water temperatures in winter (LCFRB 2010a). On their return, adult fish often mill near the river mouths or in lower river pools until the first fall freshets occur (LCFRB 2010a).

Coho salmon construct redds in gravel and small cobble substrate in pool tailouts, riffles, and glides, with sufficient flow depth for spawning activity (NMFS 2011b). Eggs incubate over late fall and winter for about 45 to 140 days, depending on water temperature, with longer incubation in colder water. Fry may thus emerge from early spring to early summer (ODFW 2010). Hatching success depends on clean gravel that is not choked with sediment or subject to extensive scouring by floods (LCFRB 2010a).

Juveniles typically rear in freshwater for more than a year. After emergence, coho salmon fry move to shallow, low-velocity rearing areas, primarily along the stream edges and inside channels. Juvenile coho salmon favor pool habitat and often congregate in quiet backwaters, side channels, and small creeks with riparian cover and woody debris. Side-channel rearing areas are particularly critical for overwinter survival, which is a key regulator of freshwater productivity (LCFRB 2010a).

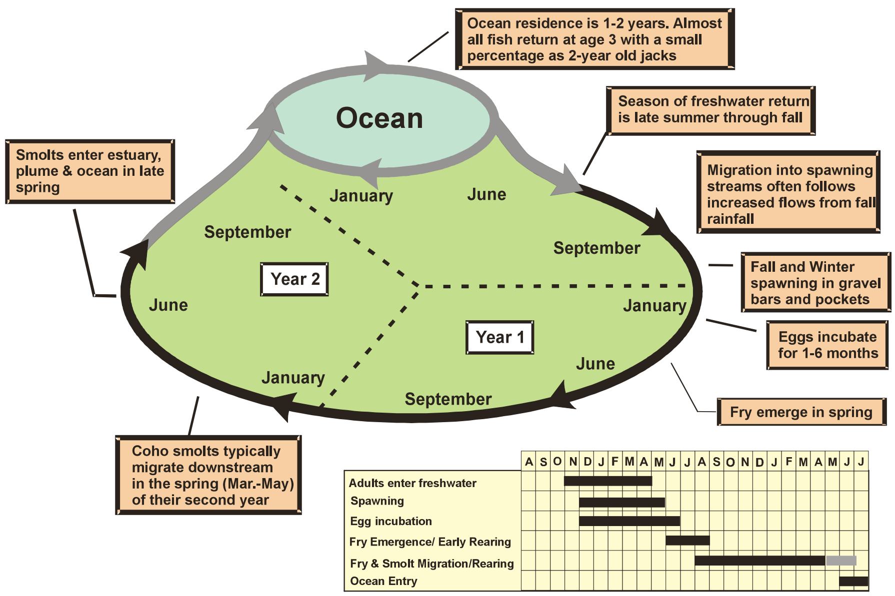

Figure 6-1. *Life Cycle of Lower Columbia River Coho Salmon*
(Source: LCFRB 2010a)

The key freshwater habitat needs of Lower Columbia River coho salmon at different life stages are shown in Table 6-1.

Table 6-1
Key Habitat for Coho Salmon, by Life Stage

Life Stage	Key Habitat Descriptions
Spawning	Riffles, tailouts, and the swifter areas in glides containing a mixture of gravel and cobble sizes with flow of sufficient depth for spawning activity
Incubation	As for spawning, but with sufficient flow for egg and alevin development and protection from high flow scour
Fry Colonization	Shallow, slow-velocity areas within the stream channel, including backwater areas, often associated with stream margins and back eddies and usually in relatively low-gradient reaches
Active Rearing	Relatively slow-water habitat types, often near velocity shears, often associated with relatively low-gradient stream channel reaches, including primary pools, backwaters, tailouts, glides, and beaver ponds
Inactive Rearing	Non-turbulent habitat types, particularly deeper water types within the main channel, but also including slower portions of large cobble riffles
Migrant	All habitat types having sufficient flow for free movement of juvenile migrants and adequate structure for protection from predators
Pre-Spawning Migrant	All habitat types having sufficient flow for free movement of sexually mature adult migrants
Pre-Spawning Holding	Relatively slow, deep-water habitat types typically associated with (or immediately adjacent to) the main channel

Source: Adapted from Northwest Power and Conservation Council (2004b) and McElhany (2010).

Most juvenile coho salmon migrate seaward as smolts in April to June, typically during their second year. Salmon that have stream-type life histories, such as coho, typically do not linger for extended periods in the Columbia River estuary, but the estuary is a critical habitat used for feeding during the physiological adjustment to salt water. Juvenile coho salmon are present in the Columbia River estuary from March to August (LCFRB 2010a).

Columbia River coho salmon typically range throughout the nearshore ocean over the continental shelf off of the Oregon and Washington coasts. Early-returning (Type S) coho salmon are typically found in ocean waters south of the Columbia River mouth. Late-returning (Type N) coho salmon are typically found in ocean waters north of the Columbia River mouth (LCFRB 2010a). Coho salmon grow relatively quickly in the ocean, reaching up to 6 kilograms after about 16 months of ocean rearing (ODFW 2010). Most coho salmon sexually mature at age three, except for a small percentage of males (called "jacks") who return to natal waters at age two, after only 5 to 7 months in the ocean (LCFRB 2010a). All coho salmon die after spawning. Weather-related upwelling patterns in the ocean and the short 3-year life cycle of this species cause highly variable population cycles (LCFRB 2010a).

6.1.2 Historical Distribution and Population Structure of LCR Coho Salmon

The Lower Columbia River coho salmon ESU historically consisted of a total of 24 independent populations (see Table 6-2). Because NMFS had not yet listed the ESU in 2003 when the WLC TRT designated core and genetic legacy populations for other ESUs, there are no such designations for Lower Columbia River coho salmon. However, the Clackamas and Sandy subbasins contain the only populations in the ESU that have clear records of continuous natural spawning (McElhany et al. 2007). Figure 6-2 shows the historical geographical distribution of Lower Columbia River coho salmon strata and populations.[1]

[1] Willamette Falls, on the Willamette River at Oregon City, Oregon, marked the historical upstream extent of coho salmon in the Willamette River. Coho salmon now spawn above Willamette Falls because a fish ladder constructed there in the late-nineteenth century allows them to pass the falls in low flow conditions that would have prevented their passage historically and because hatchery coho salmon were introduced above the falls. In its 2005 listing decision, NMFS noted that coho salmon spawning above Willamette Falls were not considered part of the Lower Columbia River coho ESU (70 *Federal Register* 37160).

Table 6-2
Historical LCR Coho Salmon Populations

Stratum	Historical Populations	Early or Late Stock
Coast	Youngs Bay (OR)	Late
	Grays/Chinook (WA)	Late
	Big Creek (OR)	Late
	Elochoman/Skamokawa (WA)	Late
	Clatskanie (OR)	Late
	Mill/Abernathy/Germany (WA)	Late
	Scappoose (OR)	Late
Cascade	Lower Cowlitz (WA)	Late
	Upper Cowlitz (WA)	Early, late
	Cispus (WA)	Early, late
	Tilton (WA)	Early, late
	SF Toutle (WA)	Early, late
	NF Toutle NF (WA)	Early, late
	Coweeman (WA)	Late
	Kalama (WA)	Late
	NF Lewis (WA)	Early, late
	EF Lewis (WA)	Early, late
	Salmon Creek (WA)	Late
	Clackamas (OR)	Early, late
	Sandy (OR)	Early, late
	Washougal (WA)	Late
Gorge	Lower Gorge (WA & OR)	Late
	Upper Gorge/White Salmon (WA)	Late
	Upper Gorge/Hood (OR)	Early

Source: Myers et al. (2006).

Up through 2008, 25 artificial propagation programs produced coho salmon considered to be part of this ESU, as shown in Table 6-3. In 2009, the Elochoman Type-S and Type-N programs were discontinued. In 2011, NMFS recommended that these two programs be removed from the ESU (76 *Federal Register* 50448, Jones 2011). For a list of coho salmon hatchery programs not included in the ESU, see Jones (2011).

Table 6-3
Artificial Propagation Programs for LCR Coho Salmon

Washington Programs	Oregon Programs
Grays River	Big Creek Hatchery
Sea Resources Hatchery	Astoria High School (STEP)
Peterson Project	Warrenton High School (STEP)
Elochoman Type S*	Eagle Creek National Fish Hatchery
Elochoman Type N*	Sandy Hatchery
Cathlamet High School FFA Type N	Bonneville/Cascade/Oxbow complex
Cowlitz Type N - Upper Cowlitz	
Cowlitz Type N -Lower Cowlitz	
Cowlitz Game and Anglers Program	
Friends of the Cowlitz Program	
North Fork Toutle River Hatchery	
Kalama River Type S	
Kalama River Type N	
Lewis River Type S	
Lewis River Type N	
Washougal Type N	
Fish First Wild Coho Salmon	
Fish First Type N	
Syverson Project Type N	

* Program has been discontinued and NMFS has recommended removing it from the ESU (76 *Federal Register* 50448, Jones 2011).

Source: 70 *Federal Register* 37178.

6.2 Baseline Population Status of LCR Coho Salmon

Out of the 24 populations that make up this ESU, 21 are considered to have a very low probability of persisting for the next 100 years (see Figure 6-2), and none is considered viable (LCFRB 2010a, ODFW 2010, Ford 2011).[2] All three strata in the ESU fall significantly short of the WLC TRT criteria for viability.

The very low persistence probability for most Lower Columbia River coho salmon populations is related to low abundance and productivity, loss of spatial structure, and reduced diversity. Although poor data quality prevents precise quantification, most

[2] As described in Section 2.6, the WLC TRT recommended methods for evaluating the status of Lower Columbia River salmon and steelhead populations. The TRT approach is based on evaluating the population parameters of abundance, productivity, spatial structure, and diversity and then integrating those assessments into an overall assessment of population persistence probability. As also described in Section 5.1, management unit recovery planners evaluated their respective populations' baseline status in a manner generally consistent with the WLC TRT's approach, with the baseline period being circa 1999 (for Washington populations) or 2006-2008 (for Oregon populations). Unless otherwise noted, NMFS and the management unit planners believe that those assessments accurately reflect the status of the population at that time; the assessments are the basis for the summaries presented here and are consistent with the conclusions of the Northwest Fisheries Science Center in its *Status Review Update for Pacific Salmon and Steelhead Listed under the Endangered Species Act* (Ford 2011). New information on population status will continue to accumulate over time and will be taken into account as needed to reflect the best available science regarding a population's status.

populations are believed to have very low abundance of natural-origin spawners (50 fish or fewer, compared to historical abundances of thousands or tens of thousands); data quality has been poor because of inadequate spawning surveys and, until recently, the presence of unmarked hatchery-origin spawners. [3] The spatial structure of some populations is constrained by migration barriers (such as tributary dams) and development in lowland areas. Low abundance, past stock transfers, other legacy hatchery effects, and ongoing hatchery straying may have reduced genetic diversity within and among coho salmon populations (LCFRB 2010a, ODFW 2010). It is likely that hatchery effects have also decreased population productivity.

Only in the Clackamas and Sandy subbasins is there a clear record of continuous natural spawning from the 1990s to the present. Spawner abundance for both these populations is, however, still well below long-term minimum abundance thresholds, although there was a generally positive trend from the 1990s through 2005 (Ford 2011). More recent spawning surveys indicate short-term increases in natural production in the Clatskanie, Scappoose, and Mill/Abernathy/Germany populations (ODFW 2010, Ford 2011). Although McElhany et al. (2007) and ODFW (2010) reached the same conclusions about the persistence probability of most Oregon coho salmon populations, conclusions for three Oregon populations (the Scappoose, Clackamas, and Sandy) did change as a result of considering additional years of data and adjusting the risk models used by Oregon in the assessments (ODFW 2010).[4]

The generally poor baseline population status of coho salmon reflects long-term trends: natural-origin coho salmon in the Columbia Basin have been in decline for the last 50 years (ODFW 2010).[5] For additional discussion of Lower Columbia River coho salmon population status, see the management unit plans (LCFRB 2010a, pp. 6-44 through 6-47; ODFW 2010, Chapter 4; and NMFS 2011b, p. 4-2) and Ford (2011).

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[3] Since 1997, all Lower Columbia River hatchery coho salmon have been marked, and both Oregon and Washington have begun efforts to identify and address data gaps for coho salmon. Unmarked, out-of-ESU coho salmon released in the Klickitat subbasin may stray into the Hood subbasin; these fish are expected to be marked in the near future.

[4] It is particularly notable that the Sandy coho salmon population was assigned a higher risk rating for abundance and productivity in the ODFW (2010) assessment than in the McElhany et al. (2007) assessment; however, although the abundance and productivity risk category changed, the relative gap between current abundance and target abundance did not change appreciatively.

[5] Coho populations upstream of Hood River have been extirpated (ODFW 2010).

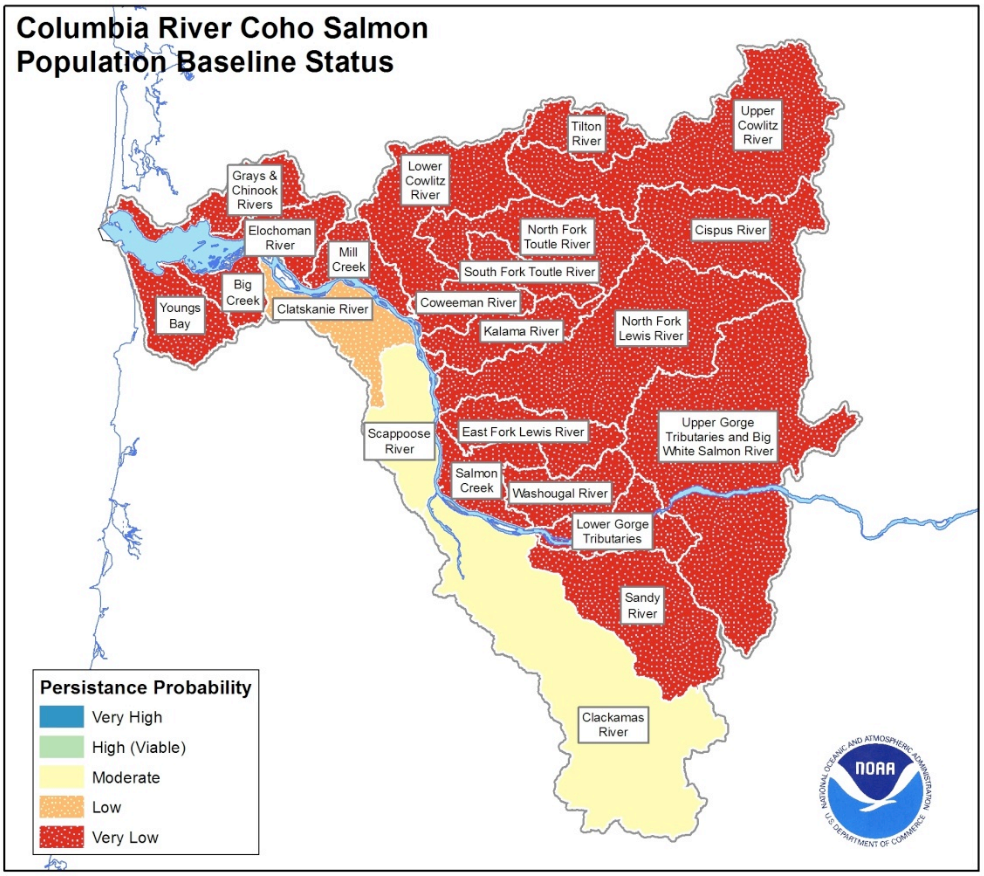

Figure 6-2. *Baseline Status of Historical LCR Coho Salmon Populations*

6.3 Target Status and Conservation Gaps for Coho Salmon Populations

Table 6-4 shows the baseline and target status for each Lower Columbia River coho salmon population, along with historical and target abundance. Local recovery planners coordinated with NMFS in making decisions about the target status for each population, taking into consideration opportunities for improvement in view of historical production, current habitat conditions and potential, and the desire to accommodate objectives such as maintaining harvest opportunities. (Note: the target statuses in Table 6-4 are the same as the persistence probabilities in the recovery scenario presented in Table 3-1 in Section 3.1.3.) As described in Section 5.1.4, although Oregon and Washington recovery planners used somewhat different methodologies to estimate baseline status and target abundance and productivity, NMFS and the management unit planners agree that the methodologies led to similar conclusions regarding the very low baseline status for most Lower Columbia River coho salmon populations.

Very large improvements are needed in the persistence probability of most coho salmon populations if the ESU is to achieve recovery. For example, 16 of the 24 historical populations are targeted for high or very high persistence probability. Of these, 14 have a low or very low baseline persistence probability. Some level of recovery effort will be needed for every population—even stabilizing populations that are expected to remain at their baseline status—to arrest or reverse long-tem declining trends. For most populations, meeting recovery objectives will require improvement in all VSP parameters: abundance, productivity, diversity, and spatial structure.

In the Coast stratum, four of seven populations are targeted for high or very high persistence probability. Two populations—Youngs Bay and Big Creek—are not targeted for improvements in their baseline persistence probability of very low. This decision represents a strategic choice to provide harvest opportunity through terminal fisheries targeting hatchery fish in these subbasins; consequently, the proportion of hatchery-origin spawners (pHOS) in these two populations is expected to remain high.

Of fourteen populations in the Cascade stratum, nine are targeted for high or very high persistence probability. The Kalama and Washougal populations are designated as contributing, in part so that fishery enhancement hatchery programs in those subbasins can continue to support harvest. The North Fork Lewis population is designated as contributing in part because of uncertainties regarding the success of reestablishing natural production above tributary dams. Two populations—Salmon Creek and the Tilton—are not targeted for improvements in their baseline persistence probability of very low. The Salmon Creek subbasin is highly urbanized. In the Tilton subbasin, habitat is of lower quality than in the Upper Cowlitz and Cispus subbasins.

All three of the Gorge stratum populations are targeted to move from very low to high persistence probability. However, the Oregon management unit plan notes that the feasibility of meeting abundance and productivity targets for the Upper Gorge/Hood River population (see Table 6-4) is very low. Challenges include the small amount of historical and current habitat (and thus the limited options for restoration); anthropogenic impacts that are unlikely to change in the near future (e.g., inundation of historical spawning habitat by Bonneville Reservoir and roads that restrict access to habitat); high uncertainty in the data and analyses for small populations[6]; and the possibly inaccurate designation of population structure for this stratum. The Oregon management unit plan states that most of these issues are related to the population structure designation and suggests re-evaluating the Gorge stratum population structure for all species (ODFW 2010). As discussed in Section 3.2.1, NMFS agrees that such an evaluation is needed.

If the scenario in Table 6-4 were achieved, it would exceed the WLC TRT's viability criteria, particularly in the Cascade stratum.[7] Exceeding the criteria in the Cascade stratum was intentional on the part of local recovery planners to compensate for uncertainties about the feasibility of meeting the WLC TRT's criteria in the Gorge stratum, in particular the questions raised by Oregon recovery planners about the

[6] In the method used by the WLC TRT and management unit planners to establish abundance goals, target abundance is based to some extent on the gap between current and historical abundance. If the historical abundance of the Upper Gorge/Hood coho population has been significantly overestimated, then the abundance needed to achieve its target status may also be overestimated (ODFW 2010).

[7] As discussed in Section 2.5.4, the TRT's criteria for high probability of stratum persistence require that two or more populations be viable and that, using the WLC TRT's scoring system, the average score for all populations in the stratum be 2.25 or higher. In the Cascade stratum, nine populations are targeted for high or very high persistence probability, and, using the WLC TRT's scoring system, the average score for all populations in the stratum would be 2.39.

feasibility of meeting the target status for the Upper Gorge/Hood population. (Delisting criteria for the Lower Columbia River coho ESU are described in Sections 3.2 and 6.7)

Figure 6-3 displays the population-level conservation gaps for Lower Columbia River coho salmon graphically. The conservation gap reflects the magnitude of improvement needed to move a population from its baseline status to the target status. For additional discussion of targets and conservation gaps for Lower Columbia River coho salmon populations, see the management unit plans (LCFRB 2010a, pp. 6-44 to 6-48; ODFW 2010, pp. 148, 169 to 177; and NMFS 2011b, p. 3-12).

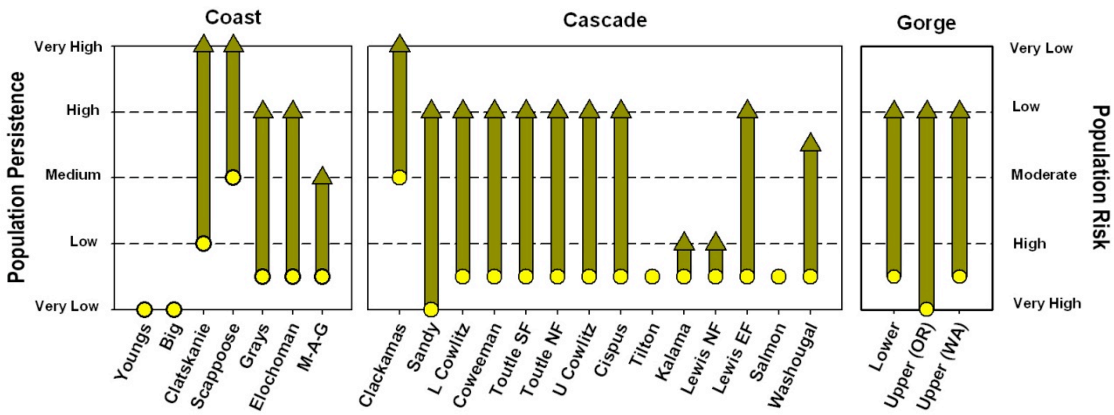

Figure 6-3. *Conservation Gaps for LCR Coho Salmon Populations: Difference between Baseline and Target Status*

Source: LCFRB 2010a.

Table 6-4

Baseline and Target Persistence Probability and Abundance of LCR Coho Salmon Populations

			Baseline Persistence Probability[8]					Abundance		
Stratum	**Population**	**Contribution**	**A&P**	**S**	**D**	**Net**	**Target Persistence Probability**	**Historical**	**Baseline[9]**	**Target**
Coast	Youngs Bay (OR)	Stabilizing	VL	VH	VL	VL	VL	18,588	4	7
	Grays/Chinook (WA)	Primary	VL	H	VL	VL	H	3,800	< 50	2,400
	Big Creek (OR)	Stabilizing	VL	H	L	VL	VL	10,830	8	12
	Elochoman/Skamokawa (WA)	Primary	VL	H	VL	VL	H	6,500	< 50	2,400
	Clatskanie (OR)	Primary	L	VH	M	L	VH	16,781	1,363	3,201
	Mill/Abernathy/Germany (WA)	Contributing	VL	H	L	VL	M	2,800	< 50	1,800
	Scappoose (OR)	Primary	M	H	M	M	VH	22,164	1,942	3,208
Cascade	Lower Cowlitz (WA)	Primary	VL	M	M	VL	H	18,000	500	3,700
	Upper Cowlitz (WA)	Primary	VL	M	L	VL	H	18,000	< 50	2,000
	Cispus (WA)	Primary	VL	M	L	VL	H	8,000	< 50	2,000
	Tilton (WA)	Stabilizing	VL	M	L	VL	VL	5,600	< 50	--
	SF Toutle (WA)	Primary	VL	H	M	VL	H	27,000	< 50	1,900
	NF Toutle (WA)	Primary	VL	M	L	VL	H		< 50	1,900
	Coweeman (WA)	Primary	VL	H	M	VL	H	5,000	< 50	1,200
	Kalama (WA)	Contributing	VL	H	L	VL	L	800	< 50	500
	NF Lewis (WA)	Contributing	VL	L	L	VL	L	40,000	200	500
	EF Lewis (WA)	Primary	VL	H	M	VL	H	3,000	< 50	2,000
	Salmon Creek (WA)	Stabilizing	VL	M	VL	VL	VL	-- [10]	< 50	--

[8] A&P = Abundance and productivity, S = spatial structure, and D = genetic and life history diversity. Net = overall persistence probability of the population. VL = very low, L = low, M = moderate, H = high, VH = very high.

[9] Baseline abundance was estimated as described in Section 5.1 and does not equal observed natural-origin spawner counts. The baseline is a modeled abundance that represents 100-year forward projections under conditions representative of a recent baseline period using a population viability analysis that is functionally equivalent to the risk analyses in McElhany et al. (2007). Projections generally assume conditions similar to those from 1974 to 2004. Oregon numbers reflect fishery reductions between the 1990s and about 2004, while Washington numbers reflect fishery impacts prevalent circa 1999.

[10] " – " indicates that no data are available from which to make a quantitative assessment.

Table 6-4
Baseline and Target Persistence Probability and Abundance of LCR Coho Salmon Populations

			Baseline Persistence Probability[8]					Abundance		
Stratum	Population	Contribution	A&P	S	D	Net	Target Persistence Probability	Historical	Baseline[9]	Target
	Clackamas (OR)	Primary	M	VH	H	M	VH	52,565	6,548	11,232
	Sandy (OR)	Primary	VL	H	M	VL	H	19,647	1,622	5,685
	Washougal (WA)	Contributing	VL	H	L	VL	M+	3,000	< 50	1,500
Gorge	Lower Gorge (WA & OR)	Primary	VL	M	VL	VL	H	--	< 50	1,900
	Upper Gorge/White Salmon (WA)	Primary	VL	M	VL	VL	H	--	< 50	1,900
	Upper Gorge/Hood (OR)	Primary	VL	VH	L	VL	H*	8,846	41	5,162

*Oregon's analysis indicates a low probability of meeting the delisting objective of high persistence probability for this population.

Source: LCFRB (2010a) and ODFW (2010).

6.4 Limiting Factors and Threats for LCR Coho Salmon

Lower Columbia River coho salmon have been—and continue to be—affected by habitat degradation, hydropower impacts, harvest, and hatchery production. The combined effects of these factors have reduced the persistence probability of all Lower Columbia River coho salmon populations.

Table 6-5 and the text that follows summarize baseline limiting factors and threats for Lower Columbia River coho salmon strata based on population-specific limiting factors and threats identified in the management unit plans. In cases where conditions have changed significantly since the management unit plans' analyses of limiting factors and threats (e.g., if harvest rates have dropped or a dam is no longer present), this is noted in the text. Unless otherwise noted, NMFS agrees that the management unit plans' identification of limiting factors provide a credible hypothesis for understanding population performance and identifying management actions.

Because the individual management unit plans used somewhat different terms in identifying limiting factors, NMFS has translated those terms into standardized and more general terminology taken from a NMFS "data dictionary" of possible ecological concerns that could affect salmon and steelhead (Hamm 2012; see Section 5.4). In addition, in Table 6-5 NMFS has rolled up the population-specific limiting factors (see Appendix H) to the stratum level—a process that has resulted in some loss of specificity.

In addition, each management unit plan used a different approach for identifying limiting factors and threats (see Section 5.3). One difference relevant to the crosswalk is that while the Oregon management unit plan identified primary and secondary limiting factors for each population in each threat category,[11] the Washington management unit plan categorized limiting factors in this way only for habitat-related limiting factors, and the White Salmon plan and the estuary module did not use the primary and secondary terminology. For the crosswalk and this table, NMFS assigned primary and secondary status to non-habitat limiting factors for Washington populations (based on the Washington management unit plan's quantification of threat impacts and the professional judgment of the Lower Columbia Fish Recovery Board's staff and consultants). For populations that historically spawned in the White Salmon subbasin, NMFS staff inferred primary and secondary designations based on discussion in the Washington and White Salmon management unit plans (LCFRB 2010a, NMFS 2011b). It is likely that some apparent distinctions in results between Washington and Oregon populations are artifacts of differences in limiting factor assessment methodologies and not an actual difference in conditions or their effects on salmon and steelhead populations. In addition, there is not necessarily a bright line between primary and secondary limiting factor designations. Nevertheless, NMFS believes that the designations are useful, particularly for looking across ESUs and populations and identifying patterns (see Chapter 4).

The management unit plans provide more detail on limiting factors and threats affecting

[11] In the Oregon management unit plan, primary limiting factors are those that have the greatest impact and secondary limiting factors have a lesser but still significant impact.

each Lower Columbia River coho salmon population, including magnitude, spatial scale, and relative impact (see LCFRB 2010a, Chapter 3 and various sections of Volume II; ODFW 2010, pp. 102-115; and NMFS 2011b, Chapter 5). For a regional perspective on limiting factors and threats that affect multiple salmon and steelhead ESUs, see Chapter 4 of this recovery plan. For a description of the data dictionary, the approach NMFS used to correlate management unit terms for limiting factors with the standardized NMFS terminology at the population scale, and the approach for rolling up from the population to the stratum scale, see Section 5.4 and Appendix H.

Management unit recovery planners in Oregon and Washington recognized that six major categories of manageable threats—tributary habitat, estuary habitat, hydropower, harvest, hatcheries, and predation—were useful as an organizing construct for grouping limiting factors, quantifying impacts on population productivity, and determining how much different categories of threats would need to be reduced to close the gap between baseline and target population status. Planners in both Washington and Oregon quantified the impacts of each of these major threat categories on population status, along with a reduction in each impact that would be consistent with achieving population target status. The results of that analysis are presented in Section 6.5 and provide a related but slightly different perspective on limiting factors. The threat reduction targets also allow actions to be scaled to achieve a specific impact reduction, and to be linked to monitoring and performance benchmarks.

Table 6-5

Baseline Limiting Factors and Threats Affecting LCR Coho Salmon: Stratum-Level Summary

Ecological Concern	Threat(s)	VSP Parameters Affected	Coast	Cascade	Gorge
Tributary Habitat Limiting Factors					
Habitat Quantity	Small dam (irrigation)	All			Secondary for Upper Gorge/Hood adults
Riparian Condition	Past and/or current land use practices	All	Primary for juveniles in all populations		
Channel Structure and Form	Past and/or current land use practices/ transportation corridor	All	Primary for juveniles in all populations		
Peripheral and Transitional Habitats: Side Channel and Wetland Conditions	Past and/or current land use practices/ transportation corridor	All	Primary for juveniles in all populations		
Peripheral and Transitional Habitats: Floodplain Conditions	Past and/or current land use practices/ transportation corridor	All	Primary for juveniles in all populations		

Table 6-5
Baseline Limiting Factors and Threats Affecting LCR Coho Salmon: Stratum-Level Summary

Ecological Concern	Threat(s)	VSP Parameters Affected	Coast	Cascade	Gorge
Sediment Conditions	Past and/or current land use practices/ transportation corridor	All	Primary for WA juveniles; secondary for OR juveniles[12]	Secondary for Clackamas, Sandy, Kalama, and Washougal juveniles; primary for juveniles in all other populations	Secondary for juveniles in all populations
Water Quality (Temperature)	Land uses that impair riparian function/decrease streamflow, dams	A,P,D	Secondary for juveniles in all populations		Secondary for Upper Gorge/White Salmon juveniles[13] and Upper Gorge/Hood juveniles
Water Quantity (Flow)	Dams, land use, irrigation, municipal, and hatchery withdrawals	All	Primary for Youngs Bay and Big Creek juveniles; secondary for juveniles in all other populations	Primary for Tilton, Kalama, and Washougal juveniles; secondary for juveniles in all other populations	Primary for Upper Gorge/Hood juveniles (irrigation withdrawals); secondary for juveniles in all other populations
Estuary Habitat Limiting Factors[14]					
Toxic Contaminants	Agricultural chemicals, urban and industrial practices	A,P,D	Secondary for juveniles in all populations		
Food[15]	Dam reservoirs	All	Secondary for juveniles in all populations		

[12] This distinction is likely an artifact of differences in limiting factor assessment methodologies between the two states and not an actual difference in sediment conditions in tributary streams or their effects on coho populations.

[13] For the Upper Gorge/White Salmon population, water temperature in the mainstem White Salmon River is at or near optimum levels for salmonids. Maximum temperature within the expected range of anadromous fish within the White Salmon subbasin meets Washington state water quality standards, with the exception of Rattlesnake Creek. Rattlesnake Creek is a significant habitat area where water temperature approaches lethal levels in some locations during some years (NMFS 2011b).

[14] The Washington and Oregon management unit plans both relied on the *Columbia River Estuary ESA Recovery Plan Module for Salmon and Steelhead* (NMFS 2011a) for information on estuary limiting factors, but there were some differences in how the plans translated the information into limiting factors experienced at the population level. The estuary module does not designate limiting factors as primary or secondary; instead, it ranks them in terms of assumed impact on ocean- and stream-type salmonids. Because the Oregon management unit plan integrated the module information with more specificity than did the Washington management unit plan, and because NMFS assumes that estuarine limiting factors affect all populations equally within the ESU, the estuarine limiting factors in this table and Section 6.4.2 reflect the determinations in the Oregon management unit plan, applied to all Lower Columbia River coho salmon populations, unless otherwise noted. As with other limiting factors, the designations of estuarine limiting factors as primary or secondary reflect working hypotheses that will need to be tested (and possibly revised) through adaptive management.

[15] Although the Oregon management unit plan lists food web shifts as a primary limiting factor in the estuary, NMFS and the management unit planners agreed to consider such shifts secondary in this recovery plan to more closely reflect conclusions in the *Columbia River Estuary ESA Recovery Plan Module for Salmon and Steelhead* (NMFS 2011a). The extent to which food web shifts limit salmonid survival in the estuary is

Table 6-5

Baseline Limiting Factors and Threats Affecting LCR Coho Salmon: Stratum-Level Summary

Ecological Concern	Threat(s)	VSP Parameters Affected	Coast	Cascade	Gorge
(Shift from macrodetrital- to microdetrital-based food web)					
Peripheral and Transitional Habitats: Estuary Condition	Past and/or current land use practices/transportation corridor, mainstem dams	All	Secondary for juveniles in all populations		
Channel Structure and Form	Past and/or current land use practices/ transportation corridor	All	Primary for juveniles in all populations		
Sediment Conditions	Past and/or current land use practices/transportation corridor, dams	All	Primary for juveniles in all populations		
Water Quality (Temperature)	Land uses that impair riparian function/decrease streamflow; dam reservoirs	A,P,D	Secondary for juveniles in all populations		
Water Quantity (Flow)	Columbia River mainstem dams	All	Primary for juveniles in all populations		
Hydropower Limiting Factors					
Habitat Quantity (Access)	Bonneville Dam	All			Secondary for Upper Gorge/White Salmon and Upper Gorge/Hood adults and juveniles
Habitat Quantity (Inundation)	Bonneville Dam	All			Secondary for Upper Gorge/Hood and Upper Gorge/White Salmon juveniles[16]
Habitat Quantity (Access)	Tributary Dams	All		Primary for Upper Cowlitz, North Fork Lewis, Cispus, and Tilton adults and juveniles; secondary for Clackamas juveniles	Primary for Upper Gorge/White Salmon adults and juveniles; secondary for Upper Gorge/Hood

unclear.

[16] The exact extent to which Bonneville Reservoir inundated habitats for any species is unknown. Some biologists have hypothesized impacts to coho salmon as a result of inundation. Based on spawning habitat preferences, it is likely that the impacts of inundation were greatest on fall Chinook and chum salmon.

Table 6-5
Baseline Limiting Factors and Threats Affecting LCR Coho Salmon: Stratum-Level Summary

Ecological Concern	Threat(s)	VSP Parameters Affected	Coast	Cascade	Gorge
					adults and juveniles
Harvest Limiting Factors					
Direct Mortality	Fisheries	A,D	Primary for adults in all populations		
Hatchery Limiting Factors					
Food[17]	Smolts from all Columbia Basin hatcheries competing for food and space in the estuary	All	Secondary for juveniles in all populations		
Population Diversity	Stray hatchery fish interbreeding with wild fish	A,P,D	Secondary for Clatskanie adults; primary for adults in all other populations except Scappoose	Secondary for Coweeman, Lewis(N&E), and Salmon Creek adults; primary for adults in all other populations except Sandy	Primary for adults in all populations
Predation Limiting Factors					
Direct Mortality	Land use	A,P,D	Secondary for juveniles in all populations		
Direct Mortality	Dams	A,P,D			Secondary for Upper Gorge/Hood and Upper Gorge/White Salmon adults

6.4.1 Tributary Habitat Limiting Factors

Impaired side channel and wetland conditions and degraded floodplain habitat have significant negative impacts on juvenile coho salmon throughout the ESU and are identified as primary limiting factors for all populations. Degraded riparian conditions also are a primary limiting factor for juveniles and adults of all populations within the ESU, as are channel structure and form issues. Extensive channelization, diking, wetland conversion, stream clearing, and, in some subbasins, gravel extraction have severed access to historically productive habitats, simplified many remaining tributary habitats, and weakened the watershed processes that once created healthy ecosystems. In

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[17] Some scientists suspect that closely spaced releases of hatchery fish from all Columbia Basin hatcheries may lead to increased competition with natural-origin fish for food and habitat space in the estuary. NMFS (2011a) and LCFRB (2010a) identified competition for food and space among hatchery and natural-origin juveniles in the estuary as a critical uncertainty. ODFW (2010) acknowledged that uncertainty but listed competition for food and space as a secondary limiting factor for juveniles of all populations. The NMFS Northwest Region and Northwest Fisheries Science Center are working to better define and describe the scientific uncertainty associated with ecological interactions between hatchery-origin and natural-origin salmon and steelhead in freshwater, estuarine, and nearshore ocean habitats.

addition, the lack of large woody debris and appropriately sized gravel has significantly reduced the amount of suitable spawning and rearing habitat.

Sediment conditions (affecting egg to fry survival) are identified as a primary limiting factor for all Washington populations and a secondary limiting factor for the Oregon portion of the ESU.[18] The high density of forest and rural roads throughout the Lower Columbia subdomain leads to an abundance of fine sediment in tributary streams that covers spawning gravel and increases turbidity. Water quantity issues related to withdrawals or to land uses that alter hydrology have been identified as either primary or secondary for all coho salmon populations. In addition, water quality—specifically, elevated water temperature, generally brought about through land uses, lack of functional riparian habitat, and water withdrawals—is a secondary limiting factor for all populations except the Lower Gorge.[19]

In the Coast stratum, tributary habitat limiting factors are generally the same as those described for the ESU and are attributable largely to past and current land uses in Coast-stratum watersheds. Private and state forest land used for timber harvest predominates in the upper reaches of these watersheds, while lower reaches are mostly in agricultural and rural residential use and have been extensively modified by bank stabilization, levees, and tide gates. Water quantity issues related to withdrawals or to land uses that alter hydrology are identified as a primary limiting factor for winter parr in Youngs Bay and Big Creek and as secondary for all other Coast-stratum populations.

Habitat limiting factors in the Cascade stratum are generally the same as those described for the ESU. Altered hydrology and flow timing are identified as a primary limiting factor for the Tilton, Kalama, and Washougal populations and a secondary limiting factor for the other Cascade-stratum populations. Land uses that have led to these conditions include forest management and timber harvest, agriculture, urban and rural residential development, and gravel extraction. A mix of private, state, and Federal forest land predominates in the upper mainstem and headwater tributaries of the Cascade subbasins, while the lower mainstem and tributary reaches of most subbasins are characterized by agricultural and rural residential land use, with some urban development, especially in the Salmon Creek and lower Clackamas subbasins. The Oregon management unit plan notes that in the Clackamas, high water temperatures are attributed in part to hydropower reservoirs.

A unique issue in the Cascade stratum is legacy effects in the Toutle subbasin of the 1980 Mount St. Helens eruption. The North Fork Toutle in particular was heavily affected by sedimentation from the eruption. A sediment retention structure was constructed on the North Fork Toutle in an attempt to prevent continued severe sedimentation of stream

[18] This distinction likely is an artifact of differences in limiting factor assessment methodologies between the two states and not an actual difference in sediment conditions in tributary streams or their effects on coho populations.

[19] For the Upper Gorge/White Salmon population, water temperature in the mainstem White Salmon River is at or near optimum levels for salmonids. Maximum temperature within the expected range of anadromous fish within the White Salmon subbasin meets Washington state water quality standards, with the exception of Rattlesnake Creek. Rattlesnake Creek is a significant habitat area where temperature approaches lethal levels in some locations during some years (NMFS 2011b).

channels and associated flood conveyance, transportation, and habitat degradation problems. The structure currently blocks access to as many as 50 miles of habitat for anadromous fish. Although fish are transported around the structure via a trap and haul system, it remains a source of chronic fine sediment to the lower river; this reduces habitat quality and has interfered with fish collection at its base.

In the Gorge stratum, habitat limiting factors are generally the same as those described for the ESU and result largely from past and current land uses. A mix of private, state, and Federal forest land predominates in the upper mainstem and headwater reaches of the Gorge subbasins, while the lower mainstem and tributary reaches are characterized by agricultural and rural residential land use, with some urban development. Water quantity issues caused by irrigation withdrawals are a primary limiting factor for the Upper Gorge/Hood population and a secondary limiting factor for the other populations. Highway and railroad transportation corridors run parallel to the Columbia River shoreline, traversing all creek drainages in ways that restrict access and disconnect upland and lowland habitat processes. For the Upper Gorge populations, inundation of historical habitat by Bonneville Reservoir also is a limiting factor.[20] In addition, Laurance Lake Dam, operated by the Middle Fork Irrigation District, blocks access to coho salmon habitat in the Hood subbasin and is identified as a secondary limiting factor.

Habitat within the White Salmon subbasin was altered by the breaching of Condit Dam (in October 2011, with full removal expected by August 2012). Alterations include near-term negative effects from sediment release and scouring. Scientists and managers expect long-term positive effects as the result of restoration of natural flow regimes and sediment transport, but monitoring is needed to evaluate habitat and fish response to dam removal, and additional assessment of habitat limiting factors will be needed to refine understanding of limiting factors.

6.4.2 Estuary Habitat Limiting Factors[21]

As stream-type fish, coho salmon spend less time in the Columbia River estuary and plume than do ocean-type salmon such as fall Chinook, yet estuary habitat conditions nevertheless play an important role in the survival of coho salmon juveniles, particularly those displaying less dominant life history strategies. Water quantity issues related to altered hydrology and flow timing are identified as a primary limiting factor for all

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[20] The exact extent to which Bonneville Reservoir inundated habitats for any species is unknown. Some biologists have hypothesized impacts to coho salmon as a result of inundation. Based on spawning habitat preferences, it is likely that the impacts of inundation were greatest on fall Chinook and chum salmon.

[21] The Washington and Oregon management unit plans both relied on the *Columbia River Estuary ESA Recovery Plan Module for Salmon and Steelhead* (NMFS 2011a) for information on estuary limiting factors, but there were some differences in how the plans translated the information into limiting factors experienced at the population level. The estuary module does not designate limiting factors as primary or secondary; instead, it ranks them in terms of assumed impact on ocean- and stream-type salmonids. Because the Oregon management unit plan integrated the module information with more specificity than did the Washington management unit plan, and because NMFS assumes that estuarine limiting factors affect all populations equally within the ESU, the estuarine limiting factors in this section and in Table 6-5 reflect the determinations in the Oregon management unit plan, applied to all Lower Columbia River coho salmon populations, unless otherwise noted. As with other limiting factors, the designations of estuarine limiting factors as primary or secondary reflect working hypotheses that will need to be tested (and possibly revised) through adaptive management.

populations, as is impaired sediment and sand routing; these limiting factors are associated with hydroregulation at large storage reservoirs in the interior of the Columbia Basin, and, in the case of sediment issues, land uses both past and present. Much of the land surrounding the Columbia River estuary is in agricultural or rural residential use and has been extensively modified via dikes, levees, bank stabilization, and tide gates. Altered hydrology and sediment routing influence habitat-forming processes, the quantity and accessibility of habitats such as side channels and wetlands, the dynamics of the Columbia River plume, and the estuarine food web. Channel structure issues, in the form of reduced habitat complexity and diversity, also are a primary limiting factor for juveniles from all populations. Again, simplification of channel structure is related to conversion of land to other uses—agricultural, rural residential, and as a transportation corridor.

Lack of access to peripheral and transitional habitats, such as side channels and wetlands, is a secondary limiting factor for juveniles from all populations, with access being impaired by land uses—including the transportation corridor—and by flow alterations caused by mainstem dams. Other secondary limiting factors in the estuary that affect all coho salmon populations are exposure to toxic contaminants (from urban, industrial, and agricultural sources) and elevated late summer and fall water temperatures, which are related to (1) land use practices that impair riparian function or decrease streamflow, and (2) large hydropower reservoirs.[22] Altered food web dynamics involving a transition from a macrodetrital-based food web to a microdetrital-based food web also are considered a secondary limiting factor for all populations.[23] These changes in the estuarine food web are caused primarily by increased microdetrital inputs from hydropower reservoirs and the loss of wetland habitats through diking and filling.

6.4.3 Hydropower Limiting Factors

The severity of dam-related impacts on coho salmon populations varies throughout the ESU. Flow management operations at large storage reservoirs in the interior of the Columbia Basin (Grand Coulee, Dworshak, etc.) affect all juvenile Lower Columbia River coho salmon in the lower mainstem and estuary, and potentially in the plume—primarily by altering flow volume and timing. These alterations impair sediment routing, influence habitat-forming processes, reduce access to peripheral habitat, and change the dynamics of the Columbia River plume and the estuarine food web (see Section 6.4.2).[24] Moreover, the large reservoirs associated with mainstem dams contribute to elevated water temperatures downstream in late summer and fall. Although the management unit recovery plans identified temperature impacts of the

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[22] Although the management unit plans identified temperature impacts in the estuary as a secondary limiting factor for juveniles in all populations, the timing of juvenile coho salmon migration raises questions about the significance of this limiting factor; see Section 6.4.3.

[23] Although the Oregon management unit plan lists food web shifts as a primary limiting factor in the estuary, NMFS and the management unit planners agreed to consider such shifts secondary in this recovery plan to more closely reflect conclusions in the *Columbia River Estuary ESA Recovery Plan Module for Salmon and Steelhead* (NMFS 2011a). The extent to which food web shifts limit salmonid survival in the estuary is unclear.

[24] It is likely that flow impacts of the hydropower system affect Lower Columbia River ESUs more through changes in habitat-forming processes (including impacts to the plume) and food web impacts than through changes in migratory travel time.

hydropower system as a secondary limiting factor for all juvenile coho salmon, migration of juvenile coho salmon peaks in mid-April through mid-July. Thus, it is unlikely that elevated mainstem temperatures are having a significant impact on this currently dominant coho salmon life history type. However, some coho salmon juveniles may be present year-round in the estuary (Dawley et al. 1986, McCabe et al. 1986, Roegner et al. 2004, Bottom et al. 2008, cited in Figure 2.2 of Carter et al. 2009). In addition, if recovery is successful in achieving more diverse life-history patterns for coho salmon, it is possible that temperature impacts of the hydropower system could become more significant in localized areas. For the Upper Gorge/Hood and Upper Gorge/White Salmon populations, which spawn above Bonneville Dam, passage issues at Bonneville and inundation of historical spawning habitat by Bonneville Reservoir are identified as secondary limiting factors.[25]

The effects of tributary dams vary by stratum. There are no tributary hydropower dams in the Coast stratum. In the Cascade stratum, tributary hydropower facilities are a primary limiting factor in the Cowlitz subbasin (for the Upper Cowlitz, Cispus, and Tilton populations, but not for the Lower Cowlitz population) and in the Lewis subbasin (for the North Fork Lewis population). Tributary hydropower facilities are a secondary limiting factor for the Clackamas population, impairing downstream passage of juveniles. Tributary hydropower was not identified as a limiting factor in the Sandy subbasin (the PGE Bull Run Hydroelectric Project, which consisted of Marmot Dam and the Little Sandy diversion dam, was removed in 2007-2008). There are no tributary hydropower facilities in the Coweeman, Toutle, Kalama, East Fork Lewis, Salmon Creek, or Washougal subbasins.[26]

In the Gorge stratum, the presence of Condit Dam was identified as a primary limiting factor for the Upper Gorge/White Salmon population. (The dam was breached in October 2011 and complete removal is expected by August 2012, so this limiting factor is in the process of being addressed.) Powerdale Dam on the Hood River was identified as a secondary limiting factor for adult and juvenile passage but was removed in 2010. Tributary hydropower is not a limiting factor for the Lower Gorge population.

6.4.4 Harvest Limiting Factors

Harvest-related mortality is identified as a primary limiting factor for all populations within the ESU and occurs as a result of direct and incidental mortality of natural-origin fish in ocean fisheries, Columbia River recreational fisheries, and commercial gillnet fisheries. The harvest targets hatchery-origin fish, which make up the vast majority of coho salmon returning to the Columbia River (Ford 2011). For the period from 1970 to 1993, harvest rates averaged 82 percent (NMFS 2008c). Since 2005, when NMFS listed Lower Columbia River coho salmon, harvest impacts have been reduced through measures such as mark-selective fisheries and time and area closures in both ocean and in-river fisheries, such that exploitation rates on natural-origin Lower Columbia River

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[25] The exact extent to which Bonneville Reservoir inundated habitats for any species is unknown. Some biologists have hypothesized impacts to coho salmon as a result of inundation. Based on spawning habitat preferences, it is likely that the impacts of inundation were greatest on fall Chinook and chum salmon.
[26] However, the North Fork Toutle sediment retention structure currently blocks access to as many as 50 miles of habitat for anadromous fish.

coho salmon have averaged 16 percent.[27] However, some populations experience higher impacts. ODFW estimated that harvest impacts on natural- and hatchery-origin fish from the Youngs Bay and Big Creek populations are as high as 90 percent and 70 percent, respectively, because of terminal fisheries that target hatchery-origin returns to these off-mainstem areas. Some additional harvest affects the populations that pass Bonneville Dam as a result of tribal fisheries in Zone 6.[28] Although harvest has been reduced substantially in recent years, recovery efforts will continue to focus on refinements in harvest management.

6.4.5 Hatchery-Related Limiting Factors

From 2005 to 2009, an average of approximately 13 million hatchery coho salmon were released per year in the lower Columbia basin (Ford 2011). Additional hatchery coho salmon are released upstream in the Columbia Basin with potential effects on Lower Columbia River coho salmon through straying and competition and predation in the lower mainstem and estuary. Although this production is reduced from the peak in the late 1980s, legacy effects of hatchery fish and current hatchery production continue to pose a significant threat to Lower Columbia River coho salmon. It is likely that most coho salmon spawning naturally in the lower Columbia River are of hatchery origin. Population-level effects resulting from stray hatchery fish interbreeding with natural-origin fish are a primary limiting factor for the majority of the populations in the ESU and a secondary limiting factor for all other populations except the Scappoose and Sandy. Hatchery straying, combined with past stock transfers, has likely reduced genetic diversity within and among Lower Columbia River coho salmon populations. This, combined with the small number of populations with significant natural production, has resulted in reduced diversity within the ESU. Population productivity, abundance, and resilience has likewise declined as a result of the influence of hatchery-origin fish.

Some scientists suspect that closely spaced releases of hatchery fish from all Columbia Basin hatcheries may lead to increased competition with natural-origin fish for food and habitat space in the estuary. NMFS (2011a) and LCFRB (2010a) identified competition for food and space among hatchery and natural-origin juveniles in the estuary as a critical uncertainty. ODFW (2010) acknowledged that uncertainty but listed competition for food and space as a secondary limiting factor for juveniles of all populations. The NMFS Northwest Region and Northwest Fisheries Science Center are working to better define and describe the scientific uncertainty associated with ecological interactions between hatchery-origin and natural-origin salmon and steelhead in freshwater, estuarine, and nearshore ocean habitats.

6.4.6 Predation Limiting Factors

Direct mortality from predation is a secondary limiting factor for all coho salmon populations. Anthropogenic changes to habitat structure have led to increased predation by Caspian terns, double-crested cormorants, and various other seabird species in the

[27] Fishery impact rates for LCR coho are based on data for the Clackamas and Sandy populations, but because of differences in ocean distribution among populations, there is uncertainty about whether this impact rate applies to all populations.
[28] The mainstem Columbia River is divided into management areas (i.e., zones) in order to manage harvest under the *U.S. v. Oregon* agreement. Zone 6 extends from Bonneville Dam upstream to McNary Dam.

Columbia River estuary and plume. Coho salmon, particularly those spawning above Bonneville Dam, also are subject to predation by non-salmonid fish (primarily pikeminnows above and below the dam but also walleye and smallmouth bass in the reservoir).

6.5 Baseline Threat Impacts and Reduction Targets

Table 6-6 shows the estimated impact on each Lower Columbia River coho salmon population resulting from potentially manageable threats, organized into six categories: tributary habitat degradation, estuary habitat degradation, hydropower, harvest, hatcheries, and predation. Both baseline and target impacts are shown, with the targets representing levels that would be consistent with long-term recovery goals. Impact values indicate the percentage reduction in abundance and productivity that is attributable to human activities related to a particular threat category. The value associated with any particular threat category can be interpreted as the percent reduction in abundance and productivity from historical conditions if that threat category were the only one affecting the population. The table also shows the overall percentage improvement that is needed to achieve the target impacts and corresponding population status.[29] These cumulative values across all threat categories (both baseline and target) are multiplicative rather than additive. Both the Oregon and Washington management unit plans use cumulative survivals across threat categories to illustrate the overall level of improvement needed. Each plan assumes that there is a direct proportional relationship between the projected changes in cumulative survival and the required changes in natural-origin spawner abundance and productivity. For populations where the survival improvement needed is larger than 500 percent, Table 6-6 does not report the exact value, in part because the value is highly uncertain.[30]

As an example, the baseline status of the Grays/Chinook subbasin coho population, circa 1999, has been severely reduced by the combined effects of multiple threats. The cumulative reduction in status was estimated at 94.6 percent from the multiplicative impacts of multiple threats acting across the salmon life cycle. Thus, current status is just 5.4 percent of the historical potential with no human impact. Tributary habitat, harvest, and hatchery impacts each accounted for reductions in population productivity of 50 percent or more, with corresponding reductions in abundance, spatial structure, and diversity. The Washington management unit plan identifies a recovery strategy involving significant reductions in the impact of several threats. For instance, the plan targets tributary habitat impacts to be reduced from the estimated baseline level of 70 percent to 40 percent (i.e., an approximately 100 percent improvement relative to

[29] The percentage of survival improvement needed is the percentage change in net impacts, is derived from information in the Washington and Oregon management unit plans, and is calculated as follows: $[(1-\text{Cumulative}_{\text{Target}})-(1-\text{Cumulative}_{\text{Baseline}})]/[1-\text{Cumulative}_{\text{Baseline}}] \times 100$. These values generally correspond to population improvement targets identified for Washington populations in LCFRB (2010). Comparable numbers are not explicitly reported in ODFW (2010) but are implicit in the modeling approach that Oregon recovery planners used to derive target impacts.

[30] For some populations—many of them small—the survival improvement needed is very large and highly uncertain because various other factors also are uncertain (i.e., the population's baseline persistence probability, the exact degree of impact of human activities on tributary habitat, and whether the population's response to reductions in impacts will be linear). In addition, very small populations do not necessarily follow predictable patterns in their response to changing conditions.

baseline conditions). With the targeted reductions in individual impacts, the cumulative effect of all impacts would drop from 94.6 percent at baseline to 74.7 percent at the target status. This change would translate into a 370 percent improvement in survival relative to the baseline. Although the population would still be experiencing abundance and productivity that are 74.7 percent lower than historical conditions, the extinction risk at this mortality level would be estimated sufficient to meet the targets for this plan.

Oregon and Washington recovery planners used somewhat different definitions or methods to quantify the estimated impacts of anthropogenic threats. Baseline impacts for Washington populations reflect conditions prevalent at the time of ESA listing (circa 1999), while the baseline impacts for Oregon populations reflect conditions through 2004. Dam impacts for Washington populations reflect passage mortality, habitat loss caused by inundation, and loss of access to historical production areas; for Oregon populations, the estimates of impacts in the "Dams" column of Table 6-6 reflect direct upstream and downstream passage mortality only, with other dam impacts accounted for in the habitat and predation threat categories. Hatchery impacts for Washington populations were limited to not more than 50 percent per population, in accordance with Hatchery Scientific Review Group (HSRG) assessments of the potential for genetic effects (Hatchery Scientific Review Group 2009); Oregon recovery planners estimated that hatchery impacts were equivalent to the rates at which hatchery fish were found on natural spawning grounds, based on analyzed relationships and reflecting a concern for both genetic and ecological effects. Washington recovery planners derived estimates of impacts to tributary habitat using the Ecosystem Diagnosis and Treatment (EDT) model. Oregon recovery planners estimated the mortality associated with estuary habitat degradation, hydropower, harvest, hatcheries, and predation and assigned all remaining mortality (relative to the difference between the current modeled abundance and estimated historical abundance) to tributary habitat. In general, the tributary habitat values in Table 6-6 have the highest degree of uncertainty relative to the other threat categories and, for Oregon populations, may include causes of mortality associated with the other threat categories but not directly captured in those mortality estimates. (See Section 5.5 for more on the methodologies used to estimate baseline impacts.)

Estimates of threat impacts are useful in showing the relative magnitude of impacts on each population. Given the differences in methodologies, some values in Table 6-6 for Oregon and Washington populations are not necessarily directly comparable. Thus, values for Oregon populations are most directly comparable to those for other Oregon populations, and values for Washington populations are most directly comparable to those for other Washington populations. Regardless of differences in specific threat impact definitions and methods, the net effect of changes from all threats is useful in understanding the magnitude of population improvement needed to achieve the target population status.

The target impacts in Table 6-6 represent one of several possible combinations of threat reductions that could conceivably close the conservation gap and lead to a population achieving its target status. The particular threat reductions shown in Table 6-6 reflect policy decisions and the methodologies and assumptions used by the different recovery planning teams. (For a description of how target impacts were developed, see Section 5.6.) In estimating impacts, management unit recovery planners evaluated each threat category independently (i.e., values in the table reflect the mortality of coho exposed to that particular category of threats, whether or not they are exposed to threats in the other categories). The estimates of baseline threat impacts have high levels of uncertainty and in many cases should be considered working hypotheses that are testable as part of recovery plan implementation. Despite this uncertainty, it is the expert judgment of NMFS and management unit scientists that, based on the best available information at this time, the estimates of baseline threat impacts provide a reasonable estimate of the relative magnitude of different sources of anthropogenic mortality and serve as an adequate basis for designing initial recovery actions.[31] As more and better information is collected, it will be applied to recovery efforts in an adaptive management framework.

As shown in Table 6-6, loss and degradation of tributary habitat are the single largest threat to most coho salmon populations—and where the greatest gains in viability are expected to be achieved. Notable exceptions are the Clackamas, Upper Cowlitz, and Cispus populations. For the Clackamas population, protection of existing well-functioning habitat and reductions in hatchery impacts will play a key role in achieving the target status. The Upper Cowlitz and Cispus populations are projected to benefit greatly from hatchery reintroduction programs and dam passage improvements designed to restore their access to key historical spawning and rearing habitats. However, significant tributary habitat protection and restoration efforts also will be necessary for these populations. In most cases, population recovery objectives cannot be achieved without substantial improvements in habitat, even when the impacts of other non-habitat threats are practically eliminated.

Harvest and hatchery effects have been a significant threat to most Lower Columbia River coho salmon populations. Although recent actions have substantially reduced coho salmon harvest levels from baseline conditions, further refinements in harvest management are still needed. Hatchery impacts remain significant for many populations, including the Youngs Bay, Grays, Big Creek, Elochoman, and Mill/Abernathy/Germany populations in the Coast stratum; the Upper Cowlitz, Cispus, Washougal, and, to a lesser degree, the Clackamas populations in the Cascade stratum; and all Gorge-stratum populations. Threat reductions associated with estuary habitat improvements and predation management are needed for recovery and will benefit every Lower Columbia River coho salmon population; however, net reductions targeted in these threat categories are smaller than those for tributary habitat, harvest, hatcheries, and, in some cases, hydropower because for most populations the impacts of estuarine and predation threats are less.

Several populations designated as primary are targeted for significant reductions in almost every threat category. These include the Grays, Elochoman, Upper Cowlitz and Cispus, Lower Gorge, Upper Gorge/White Salmon, and Upper Gorge/Hood populations. However, Oregon notes in its management unit plan that the tributary habitat and hatchery-related threat reductions targeted for the Upper Gorge/Hood population probably are unattainable. (See Sections 6.3 and 6.7 for additional discussion

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[31] As implementation proceeds, research, monitoring, and evaluation and adaptive management will be key in helping to refine scientific understanding of the impact of threats on population persistence and of the extent to which management actions are reducing threats.

of issues related to the feasibility of achieving abundance and productivity targets for the Upper Gorge/Hood population.)

More information on threat reduction scenarios, including descriptions of the methodologies used to determine baseline and target impacts, is available in the management unit plans (ODFW 2010, pp. 151-177 and LCFRB 2010a, pp. 4-30 through 4-33, and 6-49 through 6-52).

Table 6-6

Impacts of Potentially Manageable Threats and Impact Reduction Targets Consistent with Recovery of LCR Coho Salmon Populations

	Impacts at Baseline[32]							Impacts at Target							% Survival Improvement Needed[40]
Population	T.Hab[33]	Est[34]	Dams[35]	Harv[36]	Hat[37]	Pred[38]	Cumulative[39]	T.Hab	Est	Dams	Harv	Hat	Pred	Cumulative	
Coast															
Youngs Bay (OR)	0.98	0.10	0.00	0.90	0.86	0.06	0.9998	0.97	0.08	0.00	0.90	0.86	0.03	0.9996	60

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32 Impact figures represent a percentage reduction in abundance and productivity that is attributable to human activities related to a particular threat category. Methods used to estimate impacts differ for Oregon and Washington populations. For example, baseline impacts reflect conditions circa 1999 for Washington populations and through 2004 for Oregon populations. Given the methodological differences, impact figures are not necessarily directly comparable. See Sections 5.5 and 5.6 for more on methodologies.

33 Reduction in tributary habitat production potential relative to historical conditions. Oregon and Washington used different methods to estimate historical abundance. Oregon's approach, which incorporates safety margins and includes causes of mortality that are not captured in the other five threat categories, tends to indicate a higher potential impact from tributary habitat loss and degradation than does Washington's.

34 Reduction in juvenile survival in the Columbia River estuary as a result of habitat changes (relative to historical conditions); excludes predation.

35 Reflects passage mortality, habitat loss caused by inundation, and loss of access to historical production areas for Washington populations; for Oregon populations, dam impacts reflect direct passage mortality only.

36 Includes direct and indirect mortality.

37 Reflects only the negative impacts of hatchery-origin fish, such as high pHOS and low PNI (proportion of natural influence), not the benefits of conservation hatchery programs.

38 Includes the aggregate predation rate in the mainstem and estuary by northern pikeminnow, marine mammals, Caspian terns, and cormorants.

39 Cumulative values (both baseline and target) are multiplicative rather than additive and are equal to $(1-[(1-M_{thab})(1-M_{est})(1-M_{dams})(1-M_{harv})(1-M_{hatch})(1-M_{pred})])$. Minor differences from numbers in ODFW (2010) are due to rounding.

40 Survival improvements indicate the percentage improvement (rounded to the nearest 10) in population survival needed to achieve target impacts and are derived from the cumulative values (baseline and target). For most populations this was calculated using the following equation: $[(1-\text{Cumulative}_{Target})-(1-\text{Cumulative}_{Baseline})]/[1-\text{Cumulative}_{Baseline}] \times 100$. For some Washington populations (Mill/Abernathy/Germany, Lower Cowlitz, Kalama, Upper Gorge), this equation yields a different result than that reported in LCFRB (2010a) because, for populations that have a very low probability of persistence and require very large improvements, the Washington management unit plan limited threat-specific reductions to 50 percent of the current impact as interim targets until the population response to improvements can be accurately gauged. For those populations, the numbers reported in this table are consistent with LCFRB (2010a) rather than with the aforementioned equation. In addition, these cumulative impact numbers are not explicitly reported in ODFW (2010) but are implicit in the modeling approach that Oregon recovery planners used to derive target impacts. For populations where the survival improvement needed is larger than 500 percent, this table does not report the exact value, for the reasons explained in Section 6.5. For Oregon populations designated as stabilizing (Youngs Bay and Big Creek), a survival improvement is shown because of improvements that are expected in tributary habitat, estuary conditions, and predation.

Table 6-6

Impacts of Potentially Manageable Threats and Impact Reduction Targets Consistent with Recovery of LCR Coho Salmon Populations

Population	Impacts at Baseline[32]							Impacts at Target							% Survival Improve-ment Needed[40]
	T.Hab[33]	Est[34]	Dams[35]	Harv[36]	Hat[37]	Pred[38]	Cumul-ative[39]	T.Hab	Est	Dams	Harv	Hat	Pred	Cumul-ative	
Grays/Chinook (WA)	0.70	0.16	0.00	0.50	0.50	0.14	0.9458	0.40	0.09	0.00	0.29	0.29	0.08	0.7468	370
Big Creek (OR)	0.98	0.10	0.00	0.70	0.86	0.06	0.9993	0.97	0.08	0.00	0.70	0.86	0.03	0.9989	60
Eloch/Skam (WA)	0.60	0.16	0.00	0.50	0.50	0.14	0.9278	0.42	0.11	0.00	0.35	0.35	0.10	0.8037	170
Clatskanie (OR)	0.83	0.10	0.00	0.35	0.13	0.06	0.9187	0.68	0.08	0.00	0.25	0.10	0.04	0.8092	140
Mill/Ab/Germ (WA)	0.50	0.16	0.00	0.50	0.50	0.15	0.9108	0.25	0.08	0.00	0.25	0.25	0.08	0.6429	>500
Scappoose (OR)	0.83	0.10	0.00	0.35	0.05	0.06	0.9112	0.77	0.08	0.00	0.25	0.05	0.04	0.8553	60
Cascade															
Lower Cowlitz (WA)	0.70	0.16	0.00	0.50	0.50	0.15	0.9465	0.58	0.13	0.00	0.42	0.45	0.13	0.8986	100
Upper Cowlitz (WA)	0.40	0.16	1.00	0.50	0.50	0.15	1.00	0.20	0.08	0.50	0.25	0.25	0.08	0.8096	>500
Cispus (WA)	0.50	0.16	1.00	0.50	0.50	0.15	1.00	0.25	0.08	0.50	0.25	0.25	0.08	0.82	>500
Tilton (WA)	0.95	0.16	1.00	0.50	0.50	0.15	1.00	0.95	0.16	1.00	0.50	0.50	0.15	1.00	0[41]
SF Toutle (WA)	0.90	0.16	0.00	0.50	0.50	0.15	0.9822	0.79	0.14	0.00	0.44	0.44	0.13	0.9507	180
NF Toutle (WA)	0.90	0.16	0.00	0.50	0.50	0.15	0.9822	0.79	0.14	0.00	0.44	0.44	0.13	0.9507	180
Coweeman (WA)	0.80	0.16	0.00	0.50	0.20	0.15	0.9429	0.62	0.12	0.00	0.39	0.15	0.12	0.8474	170
Kalama (WA)	0.70	0.16	0.00	0.50	0.50	0.15	0.9465	0.56	0.12	0.00	0.40	0.40	0.12	0.8773	>500
NF Lewis (WA)	0.40	0.15	0.85	0.50	0.24	0.16	0.9756	0.38	0.14	0.80	0.47	0.22	0.15	0.9625	50
EF Lewis (WA)	0.80	0.15	0.00	0.50	0.21	0.16	0.9436	0.40	0.08	0.00	0.25	0.11	0.08	0.6610	>500
Salmon Creek (WA)	0.90	0.15	0.00	0.50	0.50	0.16	0.9822	0.90	0.15	0.00	0.50	0.50	0.16	0.9822	0
Clackamas (OR)	0.62	0.10	0.08	0.35	0.35	0.06	0.8750	0.61	0.08	0.06	0.25	0.10	0.04	0.7814	70
Sandy (OR)	0.83	0.10	0.04	0.35	0.09	0.06	0.9183	0.52	0.08	0.00	0.25	0.09	0.04	0.6948	250

41 The Upper Cowltiz, Cispus, and Tilton populations require improvements in every threat category. However, given that hydropower impacts are 100 percent for these populations, they will not benefit from improvements in the other threat categories until some degree of passage is restored. Although passage improvements alone will not lead to recovery, how successful passage improvements are will greatly influence how much improvement is needed in the other threat categories. In addition, the formula for percent survival improvement for these populations was modified to account for the 100 percent hydropower impacts (i.e., to avoid having to divide by zero).

Table 6-6

Impacts of Potentially Manageable Threats and Impact Reduction Targets Consistent with Recovery of LCR Coho Salmon Populations

	Impacts at Baseline[32]							Impacts at Target							% Survival Improvement Needed[40]
Population	T.Hab[33]	Est[34]	Dams[35]	Harv[36]	Hat[37]	Pred[38]	Cumulative[39]	T.Hab	Est	Dams	Harv	Hat	Pred	Cumulative	
Washougal (WA)	0.80	0.15	0.00	0.50	0.50	0.16	0.9643	0.40	0.08	0.00	0.25	0.25	0.08	0.7143	>500
Gorge															
L Gorge — WA portion	0.50	0.15	0.00	0.50	0.50	0.16	0.9108	0.20	0.06	0.00	0.20	0.20	0.07	0.5524	400
L Gorge — OR portion	0.95	0.10	0.00	0.35	0.80	0.06	0.9945	0.63	0.08	0.00	0.25	0.10	0.04	0.8162	>500
U Gorge/White Salmon (WA)[42]	0.50	0.14	0.06	0.50	0.75	0.19	0.9591	0.31	0.09	0.04	0.31	0.46	0.12	0.7475	>400
U Gorge/Hood (OR)[43]	0.94	0.10	0.27	0.35	0.80	0.07	0.9952	0.08	0.08	0.23	0.05	0.00	0.05	0.4412	>500

[42] Baseline and target impacts for the Upper Gorge/White Salmon population are from LCFRB (2010a).

[43] Oregon's analysis indicates a low probability of meeting the delisting objective of high viability persistence probability for this population.

6.6 ESU Recovery Strategy for LCR Coho Salmon

This section describes the recovery strategy for Lower Columbia River coho salmon. A general summary of the ESU-level strategy is presented first. This is followed by subsections on each of the threat categories and critical uncertainties that pertain to the strategy. Where appropriate, stratum-specific strategies are described for each threat category.

6.6.1 Strategy Summary

The ESU recovery strategy for coho salmon involves improvements in all threat categories to increase abundance, productivity, diversity, and spatial structure to the point that the Coast, Cascade, and Gorge strata are restored to a high probability of persistence. The ESU recovery strategy has seven main elements:

1. Protect and improve populations that have a clear record of continuous natural spawning and are likely to retain local adaptation (the Clackamas and Sandy), along with populations where there is documented natural production (the Clatskanie, Scappoose, and Mill/Abernathy/Germany).

2. Fill information gaps regarding the extent of natural production in other populations, and focus additional recovery efforts on populations that have the greatest prospects for improvement.

3. Protect existing high-functioning habitat for all populations.

4. Restore tributary habitat (particularly overwintering habitat) to the point that each subbasin can support coho salmon at the target status for that population. In most subbasins this will mean having adequate habitat to support a viable population.

5. Reduce hatchery impacts on natural-origin fish so that impacts are consistent with the target status of each population. (The Grays/Chinook, Elochoman/Skamokawa, Mill/Abernathy/Germany, Clatskanie, Clackamas, Washougal, and Gorge-stratum populations are targeted for large reductions in hatchery impacts.)

6. Refine harvest management so that impacts are consistent with population and overall ESU recovery goals.

7. Reestablish naturally spawning populations above tributary dams on the Cowlitz and North Fork Lewis rivers by improving passage at dams and continuing to reintroduce coho salmon in these mid- to high-elevation habitats.

Very large improvements are needed in the persistence probability of most coho salmon populations if the ESU is to achieve recovery. (See Table 6-4 for the target status for each coho salmon population and Figure 6-3 for the gaps between baseline and target status.)

The recovery strategy for Lower Columbia River coho salmon is a long-term, "all-H" approach in which plan implementers begin work on all of the elements described above immediately and implement actions associated with each of the six threat categories simultaneously.[44] As part of a series of 3- to 5-year implementation schedules, management unit planners will work with NMFS staff to prioritize individual actions within each threat category, rather than across threat categories (see Chapter 11 for more on implementation). Recovery will require improvements in every threat category, even those improvements in Table 6-6 that are relatively small. Substantial actions are needed to improve tributary habitat and reduce the effects of hatcheries, harvest, and hydropower; without improvements in all of these threat categories, the benefits of actions in any individual sector are unlikely to be fully realized and the expected threat reductions will not be achieved.

Immediate implementation of certain actions is expected to reduce short-term population risk relatively quickly. Examples include reducing harvest impacts (this has already begun), providing access to blocked habitat, and carrying out site-specific habitat restoration to provide crucial overwintering habitat. Hatchery actions are needed immediately to begin reducing the influence of hatchery-origin fish on natural populations; over the long term, the type and extent of hatchery actions will be adjusted based on the results of new, more extensive population monitoring. The benefits of some actions, such as restoring riparian conditions to improve watershed function, will not be felt for years or decades after implementation. These actions also must be begun as soon as possible so that adequate habitat is in place to support increasing and eventually viable coho salmon populations. Recovery also will require contributions from estuary habitat and predation management actions; however, for stream-type fish such as coho salmon, these gains are expected to be less than those from coordinated efforts to address tributary habitat, hatchery, harvest, and hydropower impacts. In addition, substantial increases are needed in the monitoring of coho salmon spawner abundance, the proportion of hatchery-origin spawners, and fishery impacts in order to fill information gaps, especially in Washington.

The subsections below describe recovery strategies and near-term and long-term priorities for each threat category. For specific management actions in each threat category, linked to population and location, see the management unit plans (LCFRB 2010a, ODFW 2010, NMFS 2011b).

6.6.2 Tributary Habitat Strategy

Coho salmon will benefit from the regional tributary habitat strategy described in Section 4.1.2. The regional strategy is directed toward protecting and restoring high-quality, well-functioning salmon and steelhead habitat through a combination of (1) site-specific projects that will protect habitat and provide benefits relatively quickly, (2) watershed-based actions that will repair habitat-forming processes and provide benefits over the long term, and (3) landscape-scale programmatic actions that affect a class of activities (such as stormwater management or forest practices) over multiple watersheds. Because the lack of complex overwintering habitat is a primary limiting factor for coho salmon, an immediate priority is to implement actions to increase off-channel, side-channel, and floodplain habitat in a network of high- and low-elevation tributary and Columbia River floodplain locations. Improving riparian cover and

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[44] In fact, implementation of recovery actions to reduce threats in each category is already under way, although the scale of effort is less than that called for in this recovery plan.

recruitment of large wood to streams also will be a priority. The subsections below summarize additional, stratum-specific tributary habitat strategies for coho salmon.

6.6.2.1 Coast-Stratum Tributary Habitat Strategies

In implementing the Lower Columbia River coho salmon tributary habitat strategy in the Coast stratum, considerations include the following:

- Upland areas are predominantly state and private timber land; these lands must be managed to protect and restore watershed processes.
- Lowland areas are primarily in agricultural or rural residential use. These areas have been extensively modified by dikes, levees, bank stabilization, and tide gates; efforts to protect and restore habitat complexity will be priorities here.
- Sediment source analyses and implementation of actions to reduce sediment will be needed in most Coast stratum tributaries.

In addition to the actions described as part of the regional strategy for tributary habitat, the Washington management unit plan calls for restoring passage at culverts and other artificial barriers in the Elochoman subbasin; this would restore access to as many as 10 miles of habitat for coho salmon (LCFRB 2010a, Volume II). The Oregon management unit plan identifies a need to investigate whether headwater springs in the Clatskanie and Scappoose are drying up as a result of land management practices (ODFW 2010).

Assuming that the impacts of other threats are reduced to the levels shown in Table 6-6, the scale of tributary habitat improvements needed for Coast-stratum coho salmon ranges from minimal in the Youngs Bay and Big Creek subbasins to increases of 45 to 50 percent in the productive capacity of tributary habitat in the Grays/Chinook and Mill/Abernathy/Germany subbasins, respectively (LCFRB 2010a, ODFW 2010). For Oregon populations, estimates of the number of additional miles of high-quality coho salmon habitat that are needed range from minimal in Youngs Bay and Big Creek to 19 miles and 10 miles in the Clatskanie and Scappoose subbasins, respectively (ODFW 2010).

6.6.2.2 Cascade-Stratum Tributary Habitat Strategies

In implementing the Lower Columbia River coho salmon tributary habitat strategy in the Cascade stratum, considerations include the following:

- Upper portions of the Upper Cowlitz, Cispus, Tilton, East Fork Lewis, Washougal, Clackamas, and Sandy subbasins are primarily Federal forest lands. Continued implementation of the Northwest Forest Plan will be crucial in protecting and restoring coho salmon habitats in these areas.
- State or private forest land predominates in the upper portions of the Coweeman, Toutle, Kalama, North Fork Lewis, and Salmon Creek subbasins. These lands must be managed to protect and restore watershed processes.

- In the lower reaches of most Cascade subbasins, including the Lower Cowlitz, Coweeman, North Fork Lewis, East Fork Lewis, Toutle, Salmon Creek, and Clackamas, floodplains have been drastically altered or disconnected as a result of channel modification to facilitate and protect urban and industrial development, agricultural land, and, in some cases, gravel mining. Restoration in these areas will need to be balanced with the need to protect existing infrastructure and control flood risk.

- This stratum includes the most heavily urbanized areas in the Columbia Basin. Managing the impacts of growth and development on watershed processes and habitat conditions will be key to the protection and improvement of habitat conditions for coho salmon in these areas.

In addition to the actions described as part of the regional strategy for tributary habitat, addressing passage barriers such as culverts will benefit coho salmon by restoring access to habitat in a number of locations, including the Tilton, Cispus, Lower Cowlitz, and Upper Cowlitz subbasins (in some cases, additional assessment is needed to inventory and prioritize these blockages). Addressing sedimentation issues associated with the sediment retention structure will be a priority for the North Fork Toutle subbasin. In the Sandy subbasin, implementation of the city of Portland's Bull Run water supply habitat conservation plan will contribute significantly to the habitat improvements needed to achieve the recovery target.

Assuming that the impacts of other threats are reduced to the levels shown in Table 6-6, the scale of habitat improvements needed for Cascade-stratum coho salmon populations ranges from minimal—for the Tilton and Salmon Creek populations (which, as stabilizing populations are expected to remain at their baseline status of very low probability of persistence)—to a 35 to 50 percent increase in the productive capacity of tributary habitat in the Sandy, Washougal, and East Fork Lewis subbasins. Oregon estimated that, for the Clackamas population, existing habitat is adequate to achieve a very high probability of persistence. For the Sandy population, 37 additional miles of high-quality habitat (or 74 miles of moderate-quality habitat) are needed.

6.6.2.3 Gorge-Stratum Tributary Habitat Strategies

In implementing the Lower Columbia River coho salmon tributary habitat strategy in the Gorge stratum, considerations include the following:

- Gorge populations occur in watersheds that are largely Federal, state, and private forest land. These lands must be managed to protect and restore watershed processes.

- In the lower reaches of most Gorge tributary streams, floodplains have been drastically altered or disconnected as a result of channel modification to facilitate and protect development and agricultural land. For the Lower Gorge population, site-specific actions will include addressing or mitigating the impacts of the highway and railroad transportation corridors that run parallel to the Columbia River shoreline, traversing all creek drainages in ways that restrict access and disconnect upland and lowland habitat processes.

In addition to the actions described as part of the regional strategy for tributary habitat, for the Upper Gorge/Hood coho salmon population, reduced instream flow from irrigation withdrawals is a primary threat, so actions to identify and implement flow improvements will be important. Improving fish passage at Laurance Lake Dam on the Clear Branch River and at other barriers in the Hood subbasin, such as irrigation diversions and road and railroad crossings, also will benefit the Upper Gorge/Hood population.

In the White Salmon subbasin, the breaching of Condit Dam in October 2011 (with full removal expected by August 2012) created near-term negative effects in the habitat below the dam and the habitat within the footprint of the former reservoir because of sediment release and scouring. Long-term effects are expected to be positive because of restored natural flow and sediment transport regimes. The White Salmon management unit plan outlines four broad tributary habitat strategies: (1) gain information to identify and prioritize habitat actions, (2) when the dam is removed, restore mainstem habitat, (3) protect and conserve natural ecological processes, and (4) improve habitat in upriver reaches (NMFS 2011b). In the near-term, evaluating the effects of the dam breaching and removal on habitat and performing additional assessment of habitat limiting factors are high priorities.

Restoring floodplain connectivity and function is called for at locations below Bonneville Dam; however, there is little opportunity to implement floodplain measures above Bonneville Dam because most mainstem floodplain habitat was inundated by Bonneville Reservoir. For this reason, habitat efforts above the dam will rely on other strategies.

Assuming that the impacts of other threats are reduced to the levels shown in Table 6-6, the Washington management unit plan identifies a 60 percent reduction in baseline tributary habitat impacts to meet the recovery target for the Washington portion of the Lower Gorge population and a 38 percent reduction to meet the target for the Upper Gorge/White Salmon population. Oregon calculated a 35 percent reduction in impact (equivalent to an additional 10 miles of high-quality habitat) needed in the Oregon portion of the Lower Gorge population to achieve recovery targets. For the Upper Gorge/Hood population, achieving delisting targets would entail reducing habitat impacts by about 90 percent, or creating 53 additional miles of high-quality habitat. The Oregon planning team believed that 10 miles of additional high-quality habitat is a feasible goal. There is significant uncertainty surrounding the estimate of 53 additional miles of high-quality habitat because of questions about the historical size of the Upper Gorge/Hood population.

6.6.3 Estuary Habitat Strategy

Improving Columbia River estuary habitat as described in the regional estuary habitat strategy will benefit all Columbia Basin ESUs, including Lower Columbia River coho salmon. (For a summary of the regional estuarine habitat strategy, see Section 4.2.2.) The regional strategy reflects actions presented in the Oregon and Washington management unit plans to reduce estuarine habitat-related threats and is consistent with actions in the *Columbia River Estuary ESA Recovery Plan Module for Salmon and Steelhead* (NMFS 2011a).

The *Columbia River Estuary ESA Recovery Plan Module for Salmon and Steelhead* (NMFS 2011a) assumes that feasible estuarine habitat improvements and predation management measures could result in a maximum increase of 20 percent in the number of coho salmon outmigrating from the Columbia River estuary. Oregon and Washington recovery planners set targets of reducing anthropogenically enhanced mortality in the estuary for coho salmon populations based on the estuary module and their own approaches to threat reductions (ODFW 2010, pp. 160, 166-173, and Tables 6-5 through 6-12; LCFRB 2010a, p. 2-79, Table 2-16).

6.6.4 Hydropower Strategy

The hydropower recovery strategy for Lower Columbia River coho salmon is to address impacts of tributary hydropower dams through implementation of Federal Energy Regulatory Commission (FERC) relicensing agreements and thereby reestablish viable populations in the Upper Cowltiz, Cispus, North Fork Lewis, and White Salmon subbasins; achieve survival gains in the Hood and Clackamas subbasins; maintain the Tilton population at its baseline persistence probability of very low; and address downstream habitat impacts of the operation of some tributary hydropower dams.

The strategy also includes measures to improve passage survival at Bonneville Dam for the Upper Gorge/Hood and Upper Gorge/White Salmon populations and implementation of mainstem flow management operations designed to benefit spring migrants from the interior of the Columbia Basin; NMFS expects that these flow management operations will also improve survival in the estuary and, potentially, the plume for all Lower Columbia River salmon and steelhead populations. NMFS estimates that survival of Columbia River coho salmon passing Bonneville Dam was 95.1 percent for juveniles from 2002 to 2009 and 96.9 percent for adults from 2002 to 2007 (NMFS 2008a). NMFS expects that implementation of actions in the 2008 FCRPS Biological Opinion and its 2010 Supplement will improve juvenile coho salmon survival at Bonneville Dam by less than ½ percent, and that adult survival will be maintained at recent high levels (NMFS 2008a). Consequently, Oregon has not incorporated survival benefits from passage improvements at Bonneville into the hydropower threat reduction targets for Oregon populations above Bonneville.[45] The Washington management unit plan assumes that actions identified in the 2008 FCRPS Biological Opinion and its 2010 Supplement will aid adults and juveniles from all coho salmon populations originating above Bonneville Dam. For more on actions to improve mainstem dam passage, see the regional hydropower strategy in Section 4.3.2.

In its management unit plan, Oregon incorporated several actions addressing impacts of the Columbia River hydropower system that are not included in the FCRPS Biological Opinion and its 2010 Supplement but that Oregon maintains are needed to benefit Lower Columbia River salmon and steelhead populations that spawn above Bonneville Dam. The state of Oregon's position is that the FCRPS action agencies should conduct operations in addition to those incorporated in the FCRPS Biological Opinion to address the needs of ESA-listed salmon and steelhead. Oregon is a plaintiff in litigation against various Federal agencies, including NMFS, challenging the adequacy of measures in the

[45] Hydropower-related threat reduction targets for Oregon populations above Bonneville Dam are associated with removal of Powerdale Dam on the Hood River.

FCRPS Biological Opinion and its 2010 Supplement. NMFS does not agree with Oregon regarding the need for or likely efficacy of the additional actions Oregon proposed in that litigation, including the actions in the Oregon management unit plan that are not part of the FCRPS Biological Opinion and its 2010 Supplement. For more detail on these actions and NMFS' view of them, see the regional hydropower strategy in Section 4.3.2.

The subsections below summarize stratum-level hydropower strategies for coho salmon.

6.6.4.1 Coast-Stratum Hydropower Strategy

There are no tributary dams in the Coast ecozone, so the hydropower strategy for Coast-stratum coho salmon is to implement the flow management operations designed to benefit spring migrants from the interior of the Columbia Basin; these flow management operations will also improve survival in the estuary and, potentially, the plume for all Lower Columbia River salmon and steelhead populations.

6.6.4.2 Cascade-Stratum Hydropower Strategy

The hydropower strategy for Cascade-stratum coho salmon is to create or improve passage at projects on the Cowlitz and Lewis rivers and to use hatchery reintroduction programs to reestablish viable populations in the Upper Cowlitz and Cispus subbasins and improve the persistence probability of the North Fork Lewis population (the Tilton population, in the Cowlitz system, is not expected to improve above its baseline persistence probability of very low). In addition, the efficiency of downstream passage facilities at hydropower dams in the Clackamas subbasin will be improved. These changes will be implemented under the terms of FERC relicensing agreements completed with (1) Tacoma Power for the Cowlitz River Project (settlement agreement completed in 2000), (2) PacifiCorp and the Cowlitz PUD for the Lewis River Hydroelectric Projects (settlement agreement in 2004), and (3) PGE for the Clackamas River Hydro Project in 2006. Habitat above the dams in these systems is relatively intact, with well-functioning watershed processes and a high percentage of Federal land ownership (although the Tilton subbasin contains more development and a higher percentage of non-Federal lands than do the Upper Cowlitz, Cispus, and Lewis subbasins). High-elevation habitat may also become increasingly important as lower elevation habitats are affected by changing climate (LCFRB 2010a).

In the Cowlitz subbasin, the hatchery Barrier Dam prevents all volitional passage of anadromous fish above RM 49.5. As of late 2011, coho salmon are collected at the dam, natural-origin fish are separated from hatchery broodstock, and hatchery- and natural-origin fish are transported upstream of Cowlitz Falls dam and released into the Upper Cowlitz and Cispus rivers.[46] Coho salmon smolts are collected at Cowlitz Falls Dam, briefly held in stress-relief ponds, and released into the lower Cowlitz (LCFRB 2010a). Passage at these dams is expected to be improved at some point as part of the 2000 FERC relicensing agreement. Tacoma Power will evaluate fish returns and survival through the reservoirs and assess passage options. Adult passage will be by trap and haul unless certain settlement agreement criteria (fish sorting, productivity, etc.) are met. If met, then passage at Mayfield Dam is likely to be provided through construction of a ladder,

[46] Hatchery coho salmon also are released into the Tilton subbasin to support a fishery.

whereas passage at the much larger Mossyrock Dam will likely be provided by either trap and haul or a tramway.

In the North Fork Lewis subbasin, three dams (Merwin, Yale, and Swift) block passage to the upper North Fork Lewis, beginning with Merwin Dam at RM 20. As part of the 2004 FERC relicensing agreement for these dams, reintroduction of coho salmon into habitat upstream of the three dams is being evaluated and is likely to occur beginning in 2012-2013. The keys to successful reintroduction will be adequate passage of juveniles and adults to and from the upper watershed, hatchery supplementation, and habitat improvements. In addition, hydroregulation on the Lewis River has altered the natural flow regime below Merwin Dam, and the flow regime will be need to be adjusted to provide adequate flows for habitat formation, fish migration, water quality, floodplain connectivity, habitat capacity, and sediment transport. However, floodplain and channel alterations in the lower river will limit the ability to restore the natural flow regime, and flow modifications will need to take place in concert with restoration of lower river floodplain function and with management considerations for Lewis River late-fall Chinook salmon.

In the Clackamas subbasin, there are both upstream and downstream passage facilities at the River Mill-Faraday-North Fork Dam complex operated by PGE. Early-run coho salmon, which are mostly of hatchery origin, also reproduce naturally in lower river tributaries and in the upper Clackamas above North Fork Dam. Clackamas late-run coho salmon are naturally produced fish and spawn mostly above North Fork Dam. As part of the 2006 FERC relicensing agreement, PGE agreed to improve downstream juvenile mortality through the dam complex to 3 percent or less and has already rebuilt the ladder and trap at North Fork Dam.

6.6.4.3 Gorge-Stratum Hydropower Strategy

Tributary hydropower impacts for the Upper Gorge/White Salmon and Upper Gorge/Hood populations will be addressed by the removal of Condit and Powerdale dams, respectively. Condit Dam, on the White Salmon River, was breached by PacifiCorp in October 2011 and, under the terms of a 1999 decommissioning agreement and a 2006 Biological Opinion, is scheduled for complete removal by August 2012. Removal will reopen access to 17.7 miles of historical coho salmon habitat and allow reestablishment of natural spawning in an area where coho salmon have been extirpated. The strategy calls for 4 to 5 years of monitoring after dam removal to determine whether natural recolonization is occurring through natural straying and then use of a hatchery reintroduction program if needed.

Powerdale Dam, on the Hood River, was operated by PacifiCorp and removed in 2010 under the terms of a settlement agreement reached in 2003. The dam had passage systems in place, but removal is expected to improve access to historical coho salmon spawning and rearing habitat, further improve upstream and downstream survival, and reduce hydropower-related mortality for the Upper Gorge/Hood coho salmon population (ODFW 2010).

Actions in the 2008 FCRPS Biological Opinion and its 2010 Supplement will also provide slight improvements in juvenile survival at Bonneville Dam for the two Upper Gorge populations (see the regional hydropower strategy in Section 4.3.2).

6.6.5 Harvest Strategy

Managers have implemented substantial reductions in coho salmon harvest impacts, which averaged 82 percent for the period from 1970 to 1993 (NMF 2008c). Since NMFS listed Lower Columbia River coho salmon in 2005, harvest rates have averaged 16 percent. Consistent with the regional harvest strategy (see Section 4.5.2), the Oregon and Washington management unit plans both call for further refinements in harvest management practices so that they are consistent with population and overall ESU recovery goals while also maintaining harvest opportunities that target hatchery coho salmon.

Harvest rates on naturally produced coho salmon currently are established using an abundance-based harvest matrix that considers spawning escapement and marine survival. Annual coho salmon harvest rates are set through the Pacific Fishery Management Council's annual planning process in consultation with NMFS. The matrix is based on the status of the Clackamas and Sandy populations—the only populations within the ESU that were being monitored at the time the matrix was developed, and the two populations believed to be the ESU's strongest. Consequently, the matrix does not adequately consider the effects of harvest on the ESU's weaker populations. All coho salmon recreational fisheries have been mark-selective since 1998. Some commercial ocean fisheries have also been mark-selective in recent years, but mainstem gillnet fisheries currently are not.

The management unit plans envision refinements in coho salmon harvest through (1) replacement or refinement of the existing harvest matrix to ensure that it adequately accounts for weaker components of the ESU, (2) continued use of mark-selective recreational fisheries, and (3) management of mainstem commercial fisheries to minimize impacts to natural-origin coho salmon.[47] In refining the harvest matrix, the objective is to ensure that harvest management is consistent with maintaining trajectories in populations where natural production is beginning to be observed (e.g., the Clatskanie and Scappoose), with the assumption that additional refinements will be evaluated as natural production is documented in additional populations. Managing coho salmon harvest to minimize impacts to natural-origin fish is complicated by uncertainties regarding annual natural-origin spawner abundance and actual harvest impacts on natural-origin fish (in both ocean and mainstem Columbia fisheries). The management unit plans note these uncertainties and highlight the need for improved monitoring of harvest mortality and natural-origin spawner abundance.

In terms of recommended harvest rates, Oregon modeled a harvest rate of 25 percent as a long-term average under an abundance-based framework. The Washington management unit plan recommends a phased harvest strategy involving lower near-term rates to reduce population risks until habitat has improved. Modeling in the

[47] The Youngs Bay and Big Creek populations would continue to experience higher harvest rates to accommodate terminal fisheries targeting hatchery fish in those areas.

Washington management unit plan shows a scenario in which harvest rates would be managed for benchmarks of 8 to 25 percent throughout the first three of multiple 12-year evaluation periods (i.e., from 1999 through 2034). Then, the modeling shows that, assuming that benchmarks for habitat and other improvements have been met, harvest rates could rise (to 15 to 35 percent in the 2035 to 2046 period and to 20 to 50 percent thereafter) (LCFRB 2010a). These modeling results are planning targets and not predictions of future harvest rates; managers will establish future harvest rates based on observed indicators in Lower Columbia River coho salmon populations.

Near-term priorities for implementing this harvest strategy include:

- Obtaining better information on natural-origin and hatchery-origin spawner escapement and better estimates of natural population productivity
- Obtaining a better estimate of harvest impact rates for natural-origin Lower Columbia River coho salmon in ocean and Columbia River mainstem fisheries (and, in particular, addressing uncertainties related to harvest impacts in mainstem fisheries)
- Evaluating and refining harvest strategies for periods of poor ocean conditions and for years when returns are strong
- Incorporating into the matrix a method of managing for weaker stocks that would benefit from harvest reductions
- Developing mark-selective fishing methods that can be used in the commercial mainstem fisheries

6.6.5.1 Coast-Stratum Harvest Strategies

The ESU-level harvest strategies will reduce harvest impacts on most populations in the Coast stratum. Exceptions are the Youngs Bay and Big Creek populations, which are and will continue to be subject to higher harvest rates than most coho salmon populations because of Select Area fisheries. These fisheries, which are separate from the mainstem Columbia River fisheries, target hatchery coho salmon that return a few weeks earlier than the historical coho salmon run did (ODFW 2010). Under the harvest recovery strategy, the Select Area fisheries will continue, as will the corresponding high harvest impacts on the Youngs Bay and Big Creek populations (estimated at 90 and 70 percent, respectively). ODFW may adjust the end dates for the Youngs Bay and Big Creek fisheries to further reduce impacts to natural-origin coho salmon in those subbasins (ODFW 2010). WDFW also opens fisheries in the Grays to target coho salmon originating in the Deep River net pen program and straying to the Grays.

6.6.5.2 Cascade-Stratum Harvest Strategies

ESU-level harvest strategies will benefit populations in this stratum. In addition, if the hatchery coho salmon program in the Clackamas subbasin is maintained, ODFW may increase the within-basin harvest rate on those hatchery fish to help reduce pHOS.

6.6.5.3 Gorge-Stratum Harvest Strategies

ESU-level harvest strategies will benefit populations in this stratum.

6.6.6 Hatchery Strategy

The regional hatchery strategy described in Section 4.4.2 summarizes goals and approaches relevant to Lower Columbia River coho salmon. Details of how the hatchery strategy will be implemented in each coho stratum will be developed as part of the transition schedules, but the subsections below provide some information.

6.6.6.1 Coast-Stratum Hatchery Strategies

The preliminary intent for hatcheries in the Coast stratum includes maintaining the Youngs Bay and Big Creek subbasins as areas of hatchery production to support Select Area fisheries. Some hatchery coho salmon production from the Clackamas, Sandy, and Lower Gorge populations will be shifted to Youngs Bay to reduce hatchery-origin spawners in those upriver populations. Existing weirs in both Youngs Bay and Big Creek will be used to exclude hatchery-origin fish and create natural-origin spawning areas.[48] The Clatskanie, Scappoose, Elochoman, and Mill/Abernathy/Germany subbasins will remain areas where no hatchery fish are released. If the level of hatchery fish straying from programs in other subbasins to spawn naturally in the Clatskanie and Scappoose systems is found to exceed 10 percent over a 9-year period, then ODFW will consider additional actions to reduce pHOS, including the installation of a weir and trap to sort hatchery fish. In the Grays subbasin, hatcheries will continue to be operated to support coho salmon harvest and potentially to enhance natural production through development of hatchery broodstocks similar to the late-returning historical populations (LCFRB 2010a).

6.6.6.2 Cascade-Stratum Hatchery Strategies

In the Cascade stratum, hatcheries will be used in the near term to reintroduce coho salmon in the Upper Cowlitz subbasin (Upper Cowlitz, Cispus, and Tilton populations) and North Fork Lewis subbasin (LCFRB 2010a). Hatchery-origin adult coho salmon already are being released upstream of dams to spawn naturally in the Upper Cowlitz, Cispus, and Tilton rivers, and in the North Fork Lewis, hatchery programs will be used to reintroduce coho salmon to the upper Lewis.

The preliminary intent is also that the Coweeman River in Washington will remain an area with no hatchery releases, along with the Clackamas River above North Fork Dam. For the Clackamas population, ODFW intends to meet a pHOS target of 10 percent or less by reducing coho salmon hatchery releases (from 500,000 to 350,000 beginning in 2009), increasing harvest rates on hatchery coho salmon below North Fork Dam, and operating the trap at Eagle Creek hatchery for longer periods of time if needed. Coho salmon produced at the Eagle Creek hatchery are also used in reintroduction programs

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[48] Clackamas coho production was reduced from 500,000 to 350,000 beginning in 2009. Sandy coho production was reduced from 700,000 to 500,000 in 2010, with the difference shifted to Youngs Bay. Lower Gorge releases were reduced from 1.2 million to 725,000 in 2010, with the difference shifted to the lower Columbia.

in the Yakima and Umatilla subbasins. When the Yakima and Umatilla programs are able to obtain broodstock from coho salmon returning to those subbasins, ODFW expects to work with the U.S. Fish and Wildlife Service (which manages the Eagle Creek hatchery) to explore options for eliminating the in-basin program altogether (ODFW 2010).

WDFW may consider short-term supplementation programs in some Cascade populations to bolster natural fish numbers above critical levels in selected areas until habitat is restored to levels where a population can be self-sustaining (LCFRB 2010a, Vol. II). Hatchery production for fishery enhancement will be the focus of hatchery programs in the Washougal, some programs in the Lower Cowlitz and North Fork Lewis, the North Fork Toutle, the Kalama, the Clackamas, and the Sandy (LCFRB 2010a, ODFW 2010). A weir will be installed in the lower Washougal River to separate hatchery- and natural-origin fish and to control the proportion of hatchery-origin fish on the spawning grounds. An existing weir in the lower Kalama River will be used for the same purpose.

6.6.6.3 Gorge-Stratum Hatchery Strategies

For the Lower Gorge population, Oregon proposes to reduce pHOS by reducing coho salmon releases from the Bonneville hatchery from 1.2 million to 725,000 (with the difference in production shifted to Youngs Bay) and, possibly, using a trap and weir to separate hatchery-origin adults. Additionally, Oregon proposes discussions with tribes regarding longer acclimation and rearing at tribal release sites; this would increase imprinting to reduce hatchery-origin fish straying into the lower Gorge tributaries (ODFW 2010). Washington may consider a supplementation program for its Lower Gorge tributaries at some point in the future (LCFRB 2010a, Vol. II)

For the Upper Gorge/Hood population, Oregon outlines a strategy to reduce hatchery strays and to evaluate whether a reintroduction program is needed. The primary source of stray hatchery-origin coho salmon in the Hood subbasin is from releases of hatchery coho salmon into the Klickitat and Umatilla subbasins as part of reintroduction programs. Releases into the Umatilla subbasin dropped from 1.5 million to 1 million in 2010. Additional reductions are expected for Klickitat River releases; however, reductions in these programs must be balanced with their intended purpose to support fisheries. Coho produced in tribal hatchery programs in the Klickitat River will also be marked. ODFW also will investigate opportunities to place weirs to trap and sort hatchery fish, but feasibility depends on finding a site where enough fish would be intercepted to achieve management objectives and that would allow for safe and reliable operation at an acceptable cost in a large system such as the Hood (ODFW 2010).

For the Upper Gorge/White Salmon population, coho salmon releases from the Little White Salmon National Fish Hatchery ended in 2004, under an agreement among the parties to U.S. v. Oregon. In the White Salmon subbasin, the White Salmon Working Group, made up of Federal, state, and tribal fisheries managers and representatives of PacifiCorp, has recommended monitoring natural coho salmon escapement and production for 4 to 5 years after Condit Dam is removed.[49] Depending on the results,

[49] Condit Dam was breached in October 2011; complete removal is expected by August 2012.

they will then recommend either proceeding with natural recolonization or with supplementation (perhaps with hatchery juveniles from the Washougal and/or Bonneville/Cascade hatchery or offspring of wild broodstock from the Klickitat or White Salmon rivers) (NMFS 2011b).

6.6.7 Predation Strategy

The regional predation strategy (see Section 4.6.2) involves reducing predation by birds, fish, and marine mammals and will benefit all Lower Columbia ESUs, including coho salmon.

6.6.8 Critical Uncertainties

Each aspect of the coho salmon recovery strategy has a number of critical uncertainties; in addition, there are critical uncertainties related to the historical structure of coho salmon populations, primarily in the Gorge ecozone. For all ESUs, there are uncertainties regarding how habitat actions will translate into changes in productivity and capacity (Roni et al. 2011). Prioritizing and identifying next steps in resolving uncertainties is a near-term priority. Critical uncertainties specific to the Lower Columbia River coho salmon recovery strategy include the following:

- Historical role of the Gorge populations and appropriate target persistence probabilities and abundance and productivity targets for those populations
- Current natural-origin and hatchery-origin spawner escapement and productivity
- Relationship of current run timings (early/late) to historical run timings, harvest impacts on specific populations relative to their return timing, and the appropriate harvest strategy in light of this information (particularly the suitability of timing harvest to coincide with the return of the Cowlitz coho salmon population)
- Impact of climate change on freshwater and ocean habitats, including the impact of ocean acidification on the marine food webs on which salmon depend[50]
- Effectiveness of various approaches to developing integrated hatchery/natural populations
- Effectiveness of weirs in achieving pHOS targets
- Feasibility of achieving hatchery production and performance targets and maintaining harvest levels
- Effective methods of providing adequate downstream passage efficiency for juveniles migrating past tributary dams

[50] The impact of climate change is a critical uncertainty for all species addressed in this recovery plan but is particularly pertinent to coho because coho are sensitive to local ocean conditions. See Section 4.7 for additional discussion of the impacts of climate change on Lower Columbia River salmon and steelhead.

- Diversity of coho salmon life history strategies and how much coho salmon displaying less dominant life history strategies use the Columbia River estuary

These critical uncertainties represent preliminary priorities identified by Oregon and Washington recovery planners and NMFS Northwest Regional Office and Northwest Fisheries Science Center staff during a November 2010 workshop. They are preliminary priorities only (and are not in ranked order); as described in Chapter 10, additional discussion among local recovery planners and NMFS staff will be needed to finalize future research and monitoring priorities for Columbia River coho salmon.

The management unit plans identify more comprehensive critical uncertainties and research, monitoring, and evaluation needs that, along with the list above, will provide the basis for these future discussions. The White Salmon and Washington management unit plans have discrete sections on critical uncertainties for all of the ESUs in general (see Section 8.3 of NMFS 2011b, pp. 8-4 through 8-6, and Section 9.6 of LCFRB 2010a, pp. 9-68 through 9-73), while the Oregon management unit plan embeds relevant critical uncertainties within subsections on monitoring and evaluation needs related to the four VSP parameters and five ESA listing factors (see Sections 8.4 and 8.5, respectively, of ODFW 2010). In addition, in June 2010, the Lower Columbia Fish Recovery Board completed the *Research, Monitoring, and Evaluation Program for Lower Columbia Salmon and Steelhead* as a companion to its recovery plan (LCFRB 2010b). This document also describes critical uncertainties. The list above also does not include critical uncertainties that apply to multiple ESUs; these will be discussed and considered as decisions are made in implementation. In addition, the critical uncertainties above are of a technical nature; there are also many critical uncertainties related to social, political, and economic issues.

Critical uncertainties are one element of research, monitoring, and evaluation (RME) and adaptive management, which will be key components of the coho salmon recovery strategy (see Chapter 10 for more discussion of RME and adaptive management for this recovery plan).

6.7 Delisting Criteria Conclusion for LCR Coho Salmon

The requirement for determining that a species no longer requires the protection of the ESA is that the species is no longer in danger of extinction or likely to become endangered within the foreseeable future, based on evaluation of the listing factors specified in ESA section 4(a)(1). To remove the Lower Columbia River coho salmon ESU from the Federal List of Endangered and Threatened Wildlife and Plants (that is, to delist the ESU), NMFS must determine that the ESU, as evaluated under the ESA listing factors, is no longer likely to become endangered.

The ESA requires that recovery plans, to the maximum extent practicable, incorporate objective, measurable criteria that, when met, would result in a determination in accordance with the provisions of the ESA that the species be removed from the Federal List of Endangered and Threatened Wildlife and Plants (50 CFR 17.11 and 17.12). The recovery criteria in this plan (both biological and threats criteria) meet this statutory requirement.

As described in Section 6.3, if the scenario in Table 6-4 were achieved, it would exceed the WLC TRT's viability criteria, particularly in the Cascade stratum (see Table 6-7).[51] Exceeding the criteria in the Cascade stratum was intentional on the part of local recovery planners to compensate for uncertainties about the feasibility of meeting the WLC TRT's criteria in the Gorge stratum, in particular the questions raised by Oregon about the feasibility of meeting the target status for the Upper Gorge/Hood population.

Table 6-7
Coho Salmon Recovery Scenario Scores Relative to WLC TRT's Viability Criteria

Species	Number of Primary Populations					Stratum Average Criteria			
Coho		Coast	Cascade	Gorge	Total		Coast	Cascade	Gorge
	n ≥ high	4	9	3	16	Avg. score	2.29	2.39	3
	TRT criterion (n ≥ 2) met?	Yes	Yes	Yes		TRT criterion (avg. ≥ 2.25) met?	Yes	Yes	Yes

Source: Based on LCFRB (2010a), Table 4-7.

Oregon recovery planners' uncertainty about the feasibility of meeting the recovery target of high persistence probability for the Upper Gorge/Hood population is based in part on questions about the feasibility of meeting the habitat and hatchery threat reduction targets for this population (ODFW 2010) and in part on questions raised by both Oregon and Washington management unit planners regarding Gorge strata and population delineations and the historical role of the Gorge populations (LCFRB 2010a, ODFW 2010). These questions include whether the Gorge populations were highly persistent historically, whether they functioned as independent populations within their stratum in the same way that the Coast and Cascade populations did, and whether the Gorge stratum itself should be considered a separate stratum from the Cascade stratum.

As discussed in Section 3.2, NMFS has considered the WLC TRT's viability criteria (from McElhany et al. 2003 and 2006 and summarized in Table 2-3), the additional recommendations in McElhany et al. (2007), the recovery scenarios and population-level goals in the management unit plans, and the questions management unit planners raised regarding the historical role of the Gorge strata.

NMFS has concluded that the WLC TRT's criteria adequately describe the characteristics of an ESU that meet or exceed the requirement for determining that a species no longer needs the protection of the ESA. These criteria provide a framework within which to evaluate specific recovery scenarios. NMFS has evaluated the recovery scenario presented in the management unit plans for Lower Columbia River coho salmon (summarized in Table 3-1 of this recovery plan) and the associated population-level abundance and productivity goals (see Section 6.3) and has concluded that they also

[51] For example, in the Cascade stratum, nine populations are targeted for high or very high persistence probability, and, using the WLC TRT's scoring system, the average viability score for all populations in the stratum would be 2.39. As discussed in Section 2.5.4, the TRT's criteria for high probability of stratum persistence require that two or more populations be viable and that the average score for all populations in the stratum be 2.25 or higher.

adequately describe the characteristics of an ESU that no longer needs the protections of the ESA. NMFS endorses the Lower Columbia River coho salmon recovery scenario and the associated population-level goals in the management unit plans (summarized in Table 3-1 and Section 6.3) as one of multiple possible scenarios consistent with delisting.

NMFS also agrees with the management unit planners that the historical role of the Gorge populations and stratum merits further examination. The extent to which compensation in the Cascade stratum is ultimately considered necessary to achieve an acceptably low risk at the ESU level will depend on how questions regarding the historical role of the Gorge populations are resolved.

NMFS therefore proposes the following delisting criteria for the Lower Columbia River coho salmon ESU. (NMFS has amended the WLC TRT's criteria to incorporate the concept that each stratum should have a probability of persistence consistent with its historical condition, thus allowing for resolution of questions regarding the Gorge stratum):

1. All strata that historically existed have a high probability of persistence or have a probability of persistence consistent with their historical condition. High probability of stratum persistence is defined as:

    a. At least two populations in the stratum have at least a 95 percent probability of persistence over a 100-year time frame (i.e., two populations with a score of 3.0 or higher based on the TRT's scoring system).

    b. Other populations in the stratum have persistence probabilities consistent with a high probability of stratum persistence (i.e., the average of all stratum population scores is 2.25 or higher, based on the TRT's scoring system). (See Section 2.6 for a brief discussion of the TRT's scoring system.)

    c. Populations targeted for a high probability of persistence are distributed in a way that minimizes risk from catastrophic events, maintains migratory connections among populations, and protects within-stratum diversity.

    A probability of persistence consistent with historical condition refers to the concept that strata that historically were small or had complex population structures may not have met Criteria A through C, above, but could still be considered sufficiently viable if they provide a contribution to overall ESU viability similar to their historical contribution.

2. The threats criteria described in Section 3.2.2 have been met.

7. Lower Columbia River Chinook Salmon

7.1 Chinook Salmon Biological Background

7.1.1 Life History and Habitat

Lower Columbia River Chinook salmon (*Oncorhynchus tshawytscha*) are classified as spring, fall, or late fall based on when adults return to fresh water. Other life history differences among run types include the timing of spawning, incubation, emergence in freshwater, migration to the ocean, maturation, and return to fresh water. This life history diversity allows different runs of Chinook salmon to use streams as small as 10 feet wide and rivers as large as the mainstem Columbia. Stream characteristics determine the distribution of run types among lower Columbia River streams. Depending on run type, Chinook rear for a few months to a year or more in freshwater streams, rivers, or the estuary before migrating to the ocean in spring, summer, or fall. All runs migrate far into the north Pacific on a multi-year journey along the continental shelf to Alaska before circling back to their river of origin. The spawning run typically includes three or more age classes. Adult Chinook salmon are the largest of the salmon species, and Lower Columbia River fish occasionally reach sizes up to 25 kilograms. Chinook salmon require clean gravels for spawning and pool and side-channel habitats for rearing (see Table 7-1 for freshwater habitat needs). All Chinook salmon die after spawning (LCFRB 2010a).

7.1.1.1 Spring Chinook Salmon Life History

Lower Columbia River spring Chinook salmon spawn primarily in upstream, higher elevation portions of large subbasins. Adults enter the lower Columbia River from March through June, well in advance of spawning in August and September (see Figure 7-1).

Spring Chinook salmon are "stream-type" salmon that generally rear in the river for a full year. This extended freshwater residency is characteristic of Chinook salmon that inhabit watersheds where temperature and flow conditions provide suitable habitat conditions throughout the year. Most stream-type juveniles emigrate from fresh water as yearlings, typically in the spring of their second year. However, some juveniles from Lower Columbia River spring Chinook salmon populations migrate downstream from their natal tributaries in the fall and early winter into larger rivers, including the mainstem Columbia River, where they are believed to over-winter before outmigrating the next spring as yearling smolts (LCFRB 2010a).

Once spring Chinook salmon leave freshwater, they usually move quickly through the estuary, into coastal waters, and ultimately to the open ocean. Once in the ocean, spring Chinook salmon migrate as far north as the Aleutian Islands and are widely distributed in the open ocean, far from coastal waters. Most remain at sea from 1 to 5 years (more commonly 2 to 4 years) and return to spawn at 3 to 6 years of age (LCFRB 2010a).

Table 7-1
Key Habitat for Fall and Spring Chinook Salmon, by Life Stage

Life Stage	Key Habitat Descriptions
Spawning	Riffles, tailouts, and the swifter areas in glides containing a mixture of gravel and cobble sizes with flow of sufficient depth for spawning activity
Incubation	As for spawning, but with sufficient flow for egg and alevin development
Fry Colonization	Shallow, slow-velocity areas within the stream channel, including backwater areas, often associated with stream margins and back eddies and usually in relatively low-gradient reaches.
Active Rearing	Relatively slow-water habitat types, often near velocity shears, often associated with relatively low-gradient stream channel reaches, including primary pools, backwaters, tailouts, glides, and beaver ponds.
Inactive Rearing	Non-turbulent habitat types, particularly deeper water types within the main channel, but also including slower portions of large cobble riffles.
Migrant	All habitat types having sufficient flow for free movement of juvenile migrants.
Pre-Spawning Migrant	All habitat types having sufficient flow for free movement of sexually mature adult migrants.
Pre-Spawning Holding	Relatively slow, deep-water habitat types typically associated with (or immediately adjacent to) the main channel.

Source: Adapted from Northwest Power and Conservation Council (2004b).

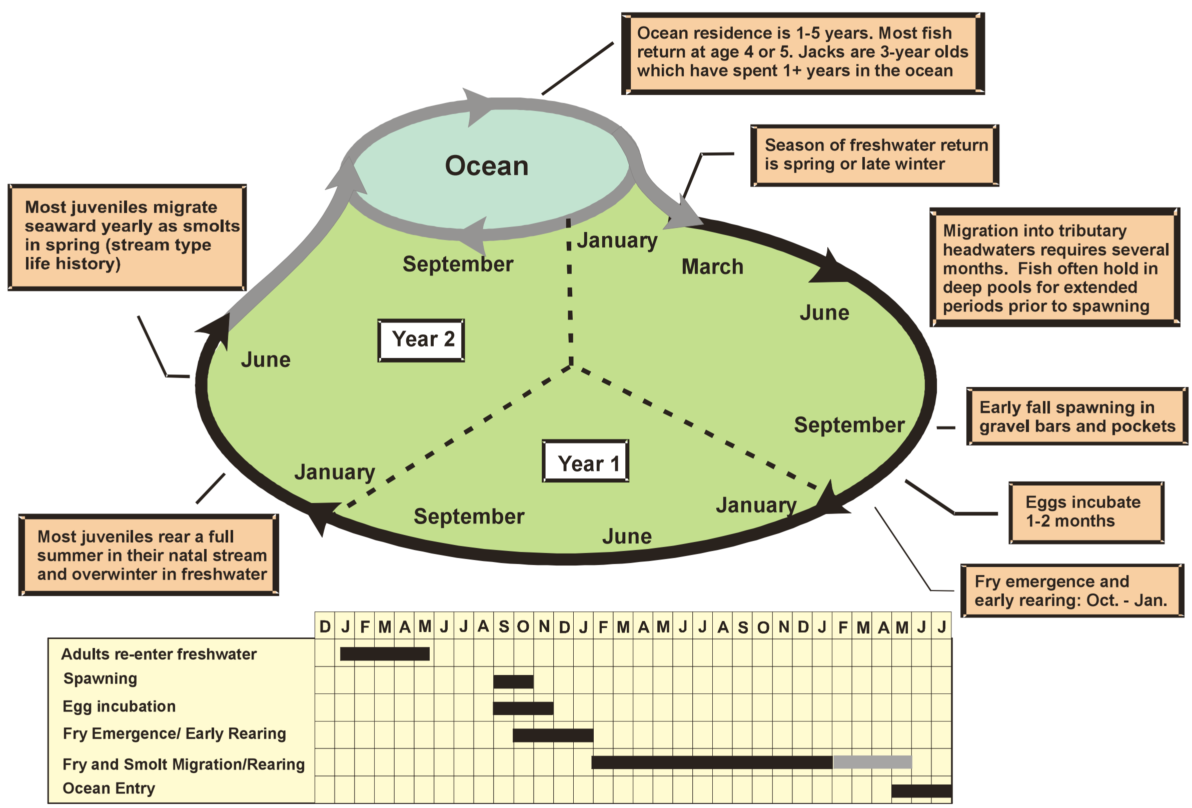

Figure 7-1. *Life Cycle of Lower Columbia River Spring Chinook Salmon*

(Source: LCFRB 2010a)

7.1.1.2 Fall Chinook ("Tule") Salmon Life History

Fall Chinook salmon spawn in moderate-sized streams and large river mainstems, including most tributaries of the lower Columbia River. Most Lower Columbia River fall Chinook salmon enter freshwater from August to September and spawn from late September to November, with peak spawning activity in mid-October (see Figure 7-2). These fish, referred to as "tule" stock, are distinguished by their dark skin coloration and advanced state of maturation at their return to fresh water. Tule fall Chinook salmon populations historically spawned in rivers and streams from the mouth of the Columbia River to the Klickitat River.

Lower Columbia River fall Chinook salmon display an "ocean-type" life history. Juveniles typically begin emigrating downstream as subyearlings at 1 to 4 months of age and enter salt water in late summer or autumn. Juvenile trapping indicates that individual populations display different combinations of two basic temporal patterns: an early fry outmigration downstream into intertidal areas in the early spring, followed by a component that rears for a longer period in natal tributary habitat and outmigrates in late spring/early summer (Cooney and Holzer 2011). Ocean-type juveniles make extensive use of the estuary. Rivers with well-developed estuaries, such as the Columbia, are able to sustain large populations of ocean-type salmon. Subyearling Chinook salmon can be found in the Columbia River estuary during every month of the year. After spending weeks or months rearing in the estuary, Lower Columbia River fall Chinook salmon migrate northward into ocean waters off of Washington, British Columbia, and Southeast Alaska. Most fall Chinook salmon remain at sea from 1 to 5 years (more commonly 3 to 5 years) and return to spawn at 2 to 6 years of age. They return to fresh water in late summer or fall and usually spawn within a few weeks (LCFRB 2010a).

7.1.1.3 Late-Fall ("Bright") Chinook Salmon Life History

Late-fall Chinook salmon, commonly referred to as "brights," generally return later than tule fall Chinook salmon, are less mature when they enter the Columbia, and spawn later in the year. Late-fall Chinook salmon enter the Columbia River from August to October and spawn from November to January, with peak spawning in mid-November. Late-fall Chinook salmon return to Washington's Lewis River and the Sandy River in Oregon.[1] Late-fall Chinook salmon exhibit a stream-type life history (LCFRB 2010a).

[1] In addition, bright fall Chinook salmon that originate from out-of-ESU hatchery fish spawn in the Columbia River mainstem immediately downstream of Bonneville Dam and in the Wind and White Salmon subbasins; these fish are not part of the Lower Columbia River ESU and are not addressed in this recovery plan. Natural-origin Lower Columbia River bright Chinook are referred to as the "lower river wild" stock in the US v. Oregon process.

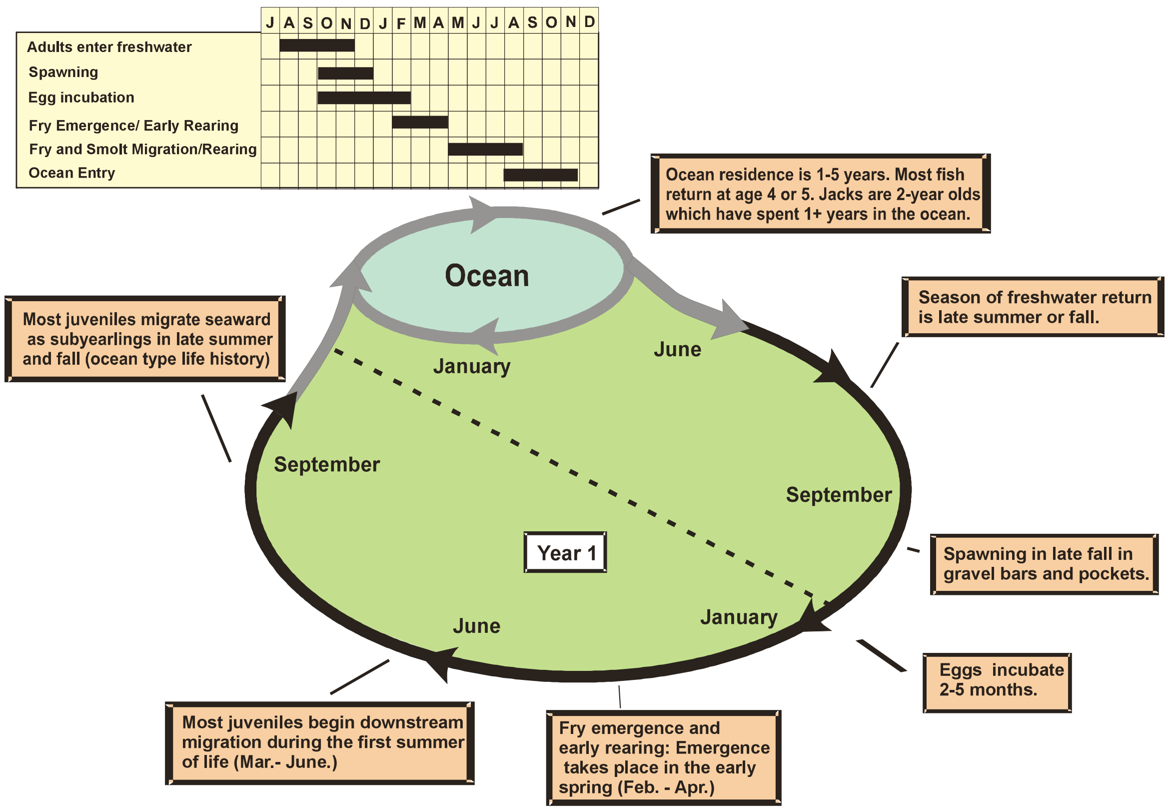

Figure 7-2. *Life Cycle of Lower Columbia River Fall Chinook Salmon*

(Source: LCFRB 2010a)

7.1.2 Historical Distribution and Population Structure of LCR Chinook Salmon

The WLC TRT identified a total of 32 historical independent populations in this ESU: 21 fall, two late-fall, and nine spring-run populations. Table 7-2 lists these populations and indicates core populations (which historically were highly productive) and genetic legacy populations (which represent important historical genetic diversity). Figures 7-3, 7-4, and 7-5 show the geographical distribution of Lower Columbia River Chinook salmon strata and populations.

Up through 2008, 17 artificial propagation programs produced Chinook salmon considered to be part of this ESU, as shown in Table 7-3; in 2009, the Elochoman tule fall Chinook salmon program was discontinued. In 2011, NMFS recommended removing this program from the ESU (76 *Federal Register* 50448). Four new fall Chinook salmon programs have been initiated: Deep River Net-Pen Fall Chinook, Klaskanine Hatchery Fall Chinook, Bonneville Hatchery Tule Fall Chinook, and Little White Salmon National Fish Hatchery Tule Fall Chinook. These programs are changes in release locations for fish produced at, and previously released from, existing hatchery programs that are part of the ESU. In 2011, NMFS recommended including these programs in the ESU (76 *Federal Register* 50448; Jones et al. 2011). For a list of Chinook salmon hatchery programs not included in the ESU, see Jones (2011).

Table 7-2
Historical LCR Chinook Salmon Populations

Stratum	Historical Populations	Core or Genetic Legacy Populations
Cascade spring	Upper Cowlitz (WA)	Core, genetic legacy
	Cispus (WA)	Core
	Tilton (WA)	
	Toutle (WA)	
	Kalama (WA)	
	Lewis (WA)	Core
	Sandy (OR)	Core, genetic legacy
Gorge spring	White Salmon (WA)	Core
	Hood (OR)	
Coast fall	Youngs Bay (OR)	
	Grays (WA)	
	Big Creek (OR)	Core
	Elochoman (WA)	Core
	Clatskanie (OR)	
	Mill (WA)	
	Scappoose (OR)	
Cascade fall	Lower Cowlitz (WA)	Core
	Upper Cowlitz (WA)	
	Toutle (WA)	Core
	Coweeman (WA)	Genetic legacy
	Kalama (WA)	
	Lewis (WA)	Genetic legacy
	Salmon Creek (WA)	
	Clackamas (OR)	Core
	Sandy River early (OR)	
	Washougal (WA)	
Gorge fall	Lower Gorge (WA & OR)	
	Upper Gorge (WA & OR)	Core
	White Salmon (WA)	Core
	Hood (OR)	
Cascade late fall	Lewis (WA)	Core, genetic legacy
	Sandy (OR)	Core, genetic legacy

Source: McElhany et al. (2003), Myers et al. (2006).

Table 7-3
Artificial Propagation Programs Included in the LCR Chinook Salmon ESU

Run Type	Washington Programs	Oregon Programs
Spring Chinook	Upper Cowlitz Cispus Friends of the Cowlitz Kalama Lewis River Fish First	Sandy River
Tule Fall Chinook	Sea Resources Elochoman River* Cowlitz North Fork Toutle Kalama Washougal Spring Creek	Big Creek Astoria High School (STEP) Warrenton High School (STEP)

* Program has been discontinued, and in 2011, NMFS proposed removing it from the ESU (76 *Federal Register* 50448; Jones 2011).
Source: 70 *Federal Register* 37177.

7.2 Baseline Population Status for LCR Chinook Salmon

Populations of Lower Columbia River Chinook salmon have declined substantially from historical levels. Out of the 32 populations that make up this ESU, only the two late-fall runs—the North Fork Lewis and Sandy—are considered viable. Most populations (26 out of 32) have a very low probability of persistence over the next 100 years (and some are extirpated or nearly so (LCFRB 2010a, ODFW 2010, Ford 2011).[2] Five of the six strata fall significantly short of the WLC TRT criteria for viability; one stratum, Cascade late-fall, meets the WLC TRT criteria (see Figures 7-3, 7-4, and 7-5).

Low abundance, poor productivity, losses of spatial structure, and reduced diversity all contribute to the very low persistence probability for most Lower Columbia River Chinook salmon populations. Many of the ESU's populations are believed to have very

[2] As described in Sections 2.5 and 2.6, the WLC TRT recommended methods for evaluating the status of Lower Columbia River salmon and steelhead populations. The TRT's approach is based on evaluating the population parameters of abundance, productivity, spatial structure, and diversity and then integrating those assessments into an overall assessment of population persistence probability. As also described in Section 5.1, management unit recovery planners evaluated their respective populations' baseline status in a manner generally consistent with the WLC TRT's approach, with the baseline period being either circa 1999 (for Washington populations) or 2006-2008 (for Oregon populations). Unless otherwise noted, NMFS and the management unit planners believe that those assessments accurately reflect the status of the population at that time; the assessments are the basis for the summaries presented here and are consistent with the conclusions of the Northwest Fisheries Science Center in its *Status Review Update for Pacific Salmon and Steelhead Listed under the Endangered Species Act* (Ford 2011). New information on population status will continue to accumulate over time and will be taken into account as needed to reflect the best available science regarding a population's status.

low abundance of natural-origin spawners (100 fish or fewer), which increases genetic and demographic risks. Other populations have higher total abundance, but several of these also have high proportions of hatchery-origin spawners. Particularly for tule fall Chinook salmon populations, poor data quality prevents precise quantification of population abundance and productivity; data quality has been poor because of inadequate spawning surveys and the presence of unmarked hatchery-origin spawners (Ford 2011).3 Spatial structure has been substantially reduced in several populations. Low abundance, past broodstock transfers and other legacy hatchery effects, and ongoing hatchery straying may have reduced genetic diversity within and among Lower Columbia River Chinook salmon populations. Hatchery-origin fish spawning naturally may also have reduced population productivity (LCFRB 2010a, ODFW 2010).

7.2.1 Baseline Status of LCR Spring Chinook Salmon

Six out of the nine spring Chinook salmon populations that are part of this ESU are estimated to have a very low probability of persistence (see Figure 7-3). Two—the White Salmon and Hood River populations—are considered extirpated, either because dams have blocked or impeded access to historical spawning habitat and/or because it is assumed that no remnants exist either in a hatchery or in the wild.[4] No spring Chinook salmon population is considered viable at baseline levels.

The very low persistence probabilities (and, in some cases, the likely extirpation) of most spring Chinook salmon populations are a function of losses in abundance, productivity, spatial structure, and diversity. The spatial structure of most spring Chinook salmon populations has been severely reduced by tributary dams that block access to core headwater spawning areas. In areas that remain accessible, distribution has been limited by habitat degradation. The genetic and life history diversity of spring Chinook salmon also has likely been greatly reduced, primarily as a result of population bottlenecks within the natural populations, habitat loss, and hatchery practices. Although hatchery programs are an important conservation tool for spring Chinook populations in some subbasins—primarily the Cowlitz and Lewis, where hatchery programs are serving as genetic reserves for use in reintroduction program—the long-term effects of the high fraction of hatchery-origin spawners in natural production areas is a concern (LCFRB 2010a, ODFW 2010).

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[3] Both Oregon and Washington have recently begun efforts to identify and address data gaps, and all hatchery fall Chinook salmon are now marked.

[4] A reintroduction program for spring Chinook salmon in the Hood subbasin is under way using out-of-ESU broodstock. Some natural production is occurring there. At this time, the origin of that natural production is unknown. For additional discussion of this reintroduction program, see Section 7.4.3.6.

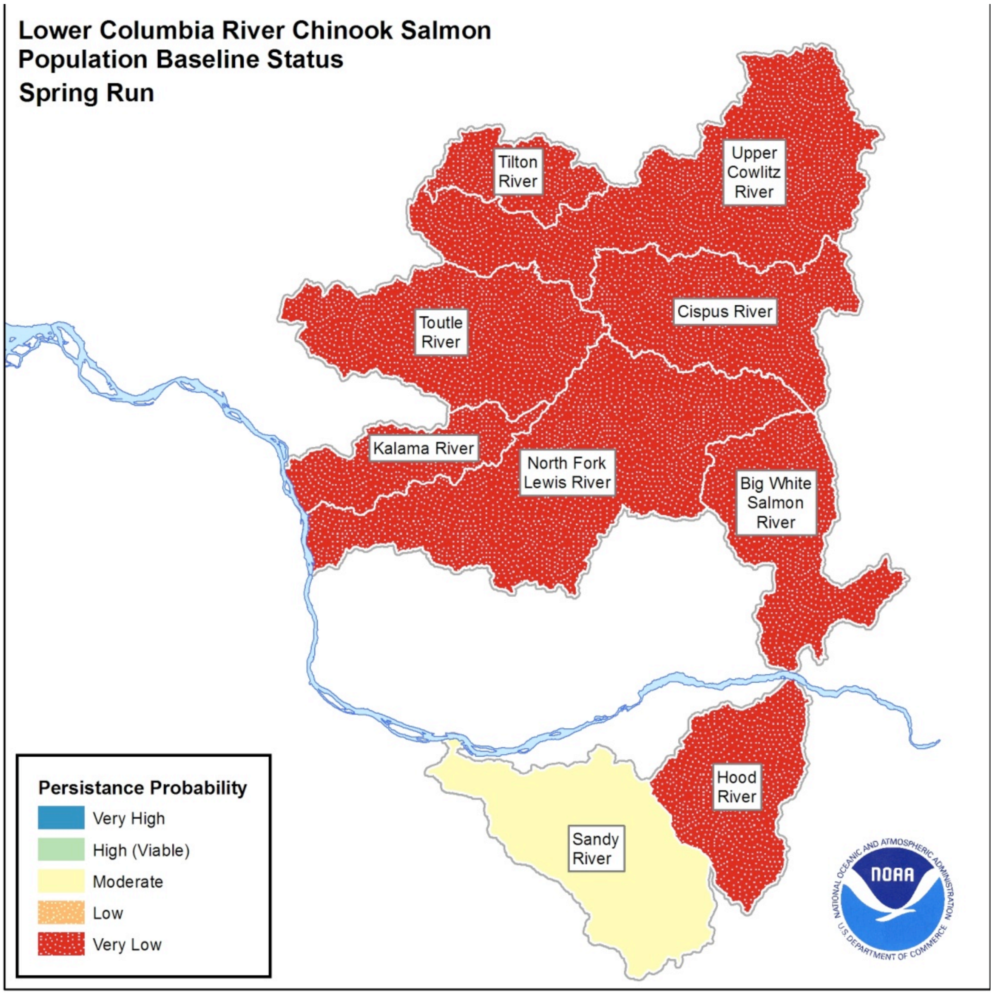

Figure 7-3. *Baseline Status of Lower Columbia River Spring Chinook Salmon Populations*

7.2.2 Baseline Status of LCR Tule Fall Chinook Salmon

Population status assessments conducted by Oregon and Washington management unit planners and based on the WLC TRT's recommended methods and criteria indicate that all 21 Lower Columbia River tule fall Chinook salmon populations have a baseline persistence probability of low or very low (see Figure 7-4) (LCFRB 2010a, ODFW 2010).

Spawner abundance and productivity estimates for these populations are generally based on expanded index-reach spawner counts and associated carcass sampling. In the past, data series used to estimate the hatchery proportion for most tule populations have been based on limited recoveries and, as a result, have had high uncertainty. Both the Oregon and Washington management unit plans identify obtaining improved estimates of annual abundance and wild/hatchery proportions of spawners as a short-term high-priority. In recent years, marking rates of tule Chinook salmon released from Lower Columbia River hatchery programs have significantly increased, facilitating estimates of hatchery-origin fish on natural spawning grounds. In addition, managers have reviewed carcass sampling efforts and expanded them in selected areas. Expansion methodologies used to estimate total spawner abundance based on sub-area counts are also being reviewed and evaluated against mark-recapture methods. The Oregon and Washington management unit plans will incorporate improved estimates of spawner abundance and productivity into periodic updates of population persistence probability.

Declines in persistence probability among tule fall Chinook salmon are related primarily to losses in abundance, productivity, and diversity. With the exception of the Upper Cowlitz and White Salmon populations, whose access to historical habitat is blocked by tributary dams,[5] Lower Columbia River tule fall Chinook salmon populations generally can access most areas of historical spawning habitat. However, the abundance of most natural populations is very low. Abundance and genetic and life history diversity likely have been reduced through habitat degradation, historically high harvest rates, historical stock transfers, pervasive hatchery effects, and small population bottlenecks in the natural populations. In addition, hatchery-origin fish spawning naturally may have decreased population productivity. Hatchery-origin fish make up a large fraction of the spawners in most natural production areas. Exceptions are the Coweeman and East Fork Lewis subbasins, where hatchery influence has been relatively low. These two populations are considered genetic legacy populations (LCFRB 2010a, ODFW 2010). Coast stratum populations in particular have been subject to high levels of non-local hatchery broodstock, which raises questions about the extent to which tule Chinook salmon currently spawning there represent the genetic diversity and adaptation that was originally present. The probable lack of locally adapted populations may be a contributing factor to the apparent low productivity of these populations; however, we have no direct information on the level of local adaptation in these populations, and we do not know the geographic scale at which local adaptation occurred historically (an uncertainty that is not limited to this stratum or ESU).

To be consistent with the management unit plans and the methodologies recommended by the WLC TRT, this recovery plan uses status information from the Oregon and Washington management unit plans (ODFW 2010 and LCFRB 2010a) in describing baseline status for Lower Columbia River fall Chinook salmon populations. However, two additional analyses have been conducted in recent years to inform Biological Opinions related to harvest. Ford et al. (2007) describes the results of two quantitative population viability models used to evaluate the probability of persistence for three tule populations—the Coweeman, Grays/Chinook, and Lewis—under alternative assumptions about future harvest rates. NMFS' Northwest Fisheries Science Center (NWFSC 2010) used a life-cycle modeling approach to analyze the impact of various harvest rates on population risk, taking into consideration the effects of hatcheries, habitat conditions, and a subset of recovery actions; this assessment evaluated eight of the tule populations targeted for high persistence probability.

The various assessments show considerable agreement about the status of Lower Columbia tule populations; for example, all of the assessments suggest that the Coast stratum tule Chinook salmon populations have low or very low probabilities of persistence, and most of the assessments suggest that the Coweeman and Lewis tule populations have slightly higher persistence probabilities than other tule populations.

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[5] Condit Dam, on the White Salmon River, was breached in October 2011; complete removal is expected by August 2012.

However, the assessments sometimes differ in their estimates of the status of individual populations, with Ford et al. (2007) and the Northwest Fisheries Science Center (2010) suggesting higher persistence probabilities for some populations than the management unit plans. It is likely that these differences are due in part to the different purposes, assumptions, baseline dates, data sets, and applications of data sets among the assessments.

The Northwest Fisheries Science Center (2010) modeling suggests that there may be important distinctions in viability within the populations categorized by ODFW (2010) and LCFRB (2010a) as having a low or very low probability of persistence—especially in the populations' ability to sustain harvest. Populations modeled by the NWFSC generally fell into three categories: (1) relatively large populations with relatively low projected quasi-extinction risks under current habitat conditions, reduced harvest rate scenarios, and a range of hatchery impact assumptions, (2) those with very high current or past hatchery and habitat impacts that modeling suggests could not be naturally self-sustaining without substantial improvements, even with no harvest, and (3) populations that are intermediate between these two and could possibly sustain themselves without hatchery input at low harvest rates under current conditions and under some modeled assumptions but not others.

In the Northwest Fisheries Science Center (2010) modeling, the Coweeman, Lewis, and Washougal populations fall into the first category, while the Elochoman/Skamokawa, Clatskanie, and Scappoose populations fall into the second category; however, LCFRB's (2010a) population viability analysis suggests that the Lewis and Elochoman/Skamokawa fit more appropriately in the intermediate category, and that the Lower Cowlitz and Grays populations fall into the first and second categories, respectively.

These differences in results point to the need for better understanding of the factors driving the very low productivity of some populations, including the influence of hatchery-origin spawners on natural tule populations, the impact of harvest on different populations, and the ability of current and projected habitat conditions to support self-sustaining populations.

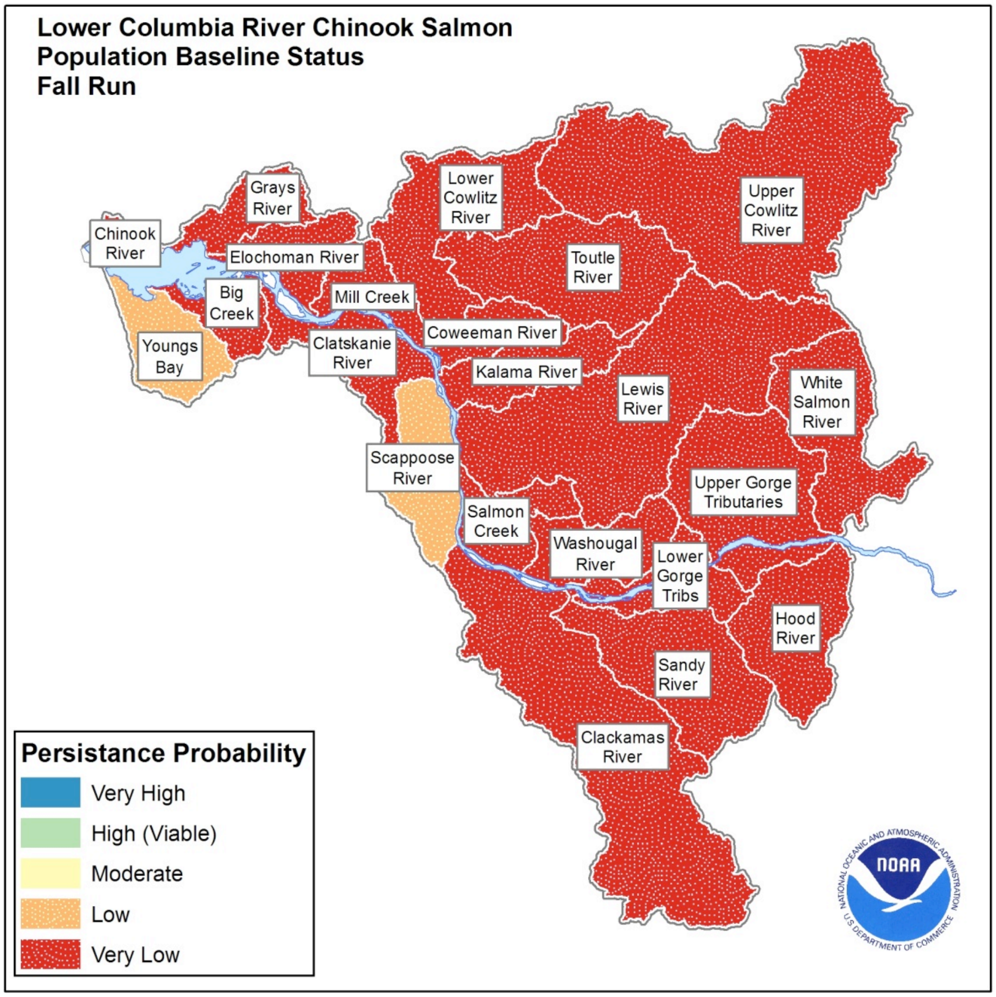

Figure 7-4. *Baseline Status of Lower Columbia River Fall (Tule) Chinook Salmon Populations, per Management Unit Plans*

7.2.3 Baseline Status of LCR Late-Fall (Bright) Chinook Salmon

The two late-fall Chinook salmon populations—North Fork Lewis and Sandy—are the only populations in this ESU whose baseline probability of persistence is estimated to be high (LCFRB 2010a, ODFW 2010). Both populations have remained largely uninfluenced by hatchery production and have not experienced the population bottlenecks seen in most tule fall Chinook salmon populations.

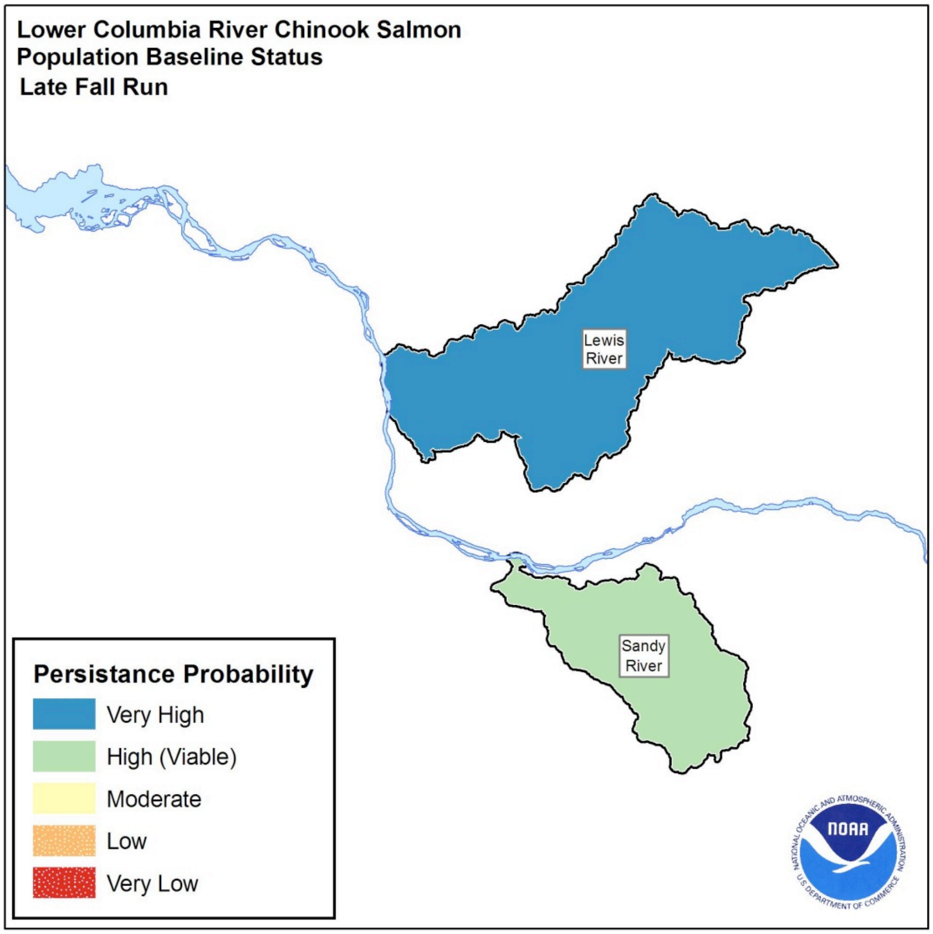

Figure 7-5. *Baseline Status of Columbia River Late-Fall Chinook Salmon Populations*

For additional discussion of Lower Columbia River Chinook salmon population status, see the management unit plans (LCFRB 2010a, pp. 6-7 through 6-13; ODFW 2010, pp. 54-55; and NMFS 2011b, p. 4-1), Ford (2011), and, for Lower Columbia River tule fall Chinook salmon, Ford et al. (2007) and Northwest Fisheries Science Center (2010).

7.3 Target Status and Conservation Gaps for LCR Chinook Salmon Populations

Table 7-4 shows the baseline and target status for each Lower Columbia River Chinook salmon population, along with historical and target abundance. Local recovery planners coordinated with NMFS in making decisions about the target status for each population, taking into consideration opportunities for improvement in view of historical production, current habitat conditions and potential, and the desire to accommodate objectives such as maintaining harvest opportunities. (Note: the target statuses in Table 7-4 are the same as the persistence probabilities in the recovery scenario presented in Table 3-1.) As described in Chapter 5, although Oregon and Washington recovery planners used somewhat different methodologies to estimate baseline status and target abundance and productivity, the management unit planners agree that the methodologies led to similar conclusions regarding the generally low baseline status for most Lower Columbia River Chinook salmon populations.

Very large improvements are needed in the persistence probability of most spring and tule fall Chinook salmon populations if the ESU is to achieve recovery. For example, among the nine historical spring Chinook salmon populations, five are targeted for high or better persistence probability; four of these have baseline persistence probabilities of low or very low, or are extirpated or nearly so. Nine out of 21 tule fall Chinook salmon populations are targeted for high or better probability of persistence; all of these have a baseline persistence probability of very low or low. Some level of effort will be needed for every population to arrest or reverse long-term declining trends; this is true for stabilizing populations, which are expected to remain at their baseline persistence probability of low or very low, as well as for the two late-fall Chinook salmon populations, which need minimal improvement only. For most populations, meeting recovery objectives will require improvements in all VSP parameters: abundance, productivity, diversity, and spatial structure.

To achieve the recovery scenario for Cascade spring Chinook salmon, populations with high or better persistence probabilities must be reestablished in historical habitat blocked by tributary hydropower dams in the Upper Cowlitz, Cispus, and North Fork Lewis subbasins (all three of these populations were historically among the most productive, and the Upper Cowlitz is also a genetic legacy population), and in the Sandy subbasin (a core and genetic legacy population). In this stratum, only the Tilton population is expected to remain at its baseline persistence probability of very low, in part because of lower quality habitat. The Toutle spring Chinook salmon population is targeted to move from very low to medium persistence probability; this target status reflects uncertainties about how much spring Chinook salmon production the Toutle subbasin supported historically and concerns about the extent to which legacy effects of the Mount St. Helens eruption limit habitat productivity. The Kalama population is targeted to achieve low persistence probability, because habitat there was probably not as productive historically for spring Chinook salmon and because of the intent to maintain a fishery enhancement hatchery program there.

Achieving target status in the Gorge spring Chinook stratum will depend on reestablishing populations in the White Salmon and Hood River systems, where the historical populations are considered extirpated. Removal of Condit Dam in the White Salmon subbasin will enhance prospects for recovery there, although questions remain about historical production and the potential to reestablish a population. (The dam was breached in October 2011, with full removal expected by August 2012.) These questions led to a target of low-plus persistence probability for White Salmon spring Chinook salmon. The Oregon management unit plan is more optimistic that a viable spring Chinook salmon population can be reestablished in the Hood subbasin.[6]

Among the seven fall Chinook salmon populations in the Coast stratum, four are targeted for high persistence probability, including the Elochoman/Skamokawa, which is one of two core populations in the stratum. Big Creek, which is the other core

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[6] Current reintroduction efforts in the Hood subbasin are using an out-of-ESU hatchery stock. See additional discussion of this issue below, in Section 7.4.3.6.

population, and the Youngs Bay population are targeted for low probability of persistence (up from very low for Youngs Bay). This decision reflects a strategic choice to provide harvest opportunity through terminal fisheries targeting hatchery fish in the Youngs Bay and Big Creek areas; consequently, the proportion of hatchery-origin spawners (pHOS) in these populations is expected to remain high. The Grays population is targeted to move from very low to medium-plus persistence probability; this target status reflects concerns about potential habitat productivity and the ability to control stray hatchery fish, particularly from the Youngs Bay terminal fishery program.

In the Cascade fall Chinook stratum, four of ten populations are targeted for high-plus persistence probability, including the Toutle and Clackamas, which historically were among the most productive, and the Coweeman and Lewis, which are genetic legacy populations. Two populations are expected to remain at their very low baseline persistence probability: Salmon Creek, which is in a highly urbanized subbasin with limited habitat recovery potential, and the Upper Cowlitz, where reintroduction of spring Chinook salmon is the focus of recovery efforts (although fall Chinook are being passed into the Upper Cowlitz subbasin, as of 2010, in an effort to enhance that population).

In the Gorge fall Chinook stratum, only one of four populations—the Hood—is targeted for high persistence probability, with the other three populations targeted for medium persistence probability. In addition, the Oregon management unit plan notes that the feasibility of achieving the target status for the Hood population is low. Constraints to recovery for fall Chinook salmon in the Gorge include the small amount of historical and current habitat (and thus the limited options for restoration); anthropogenic impacts that are unlikely to change in the near future (e.g., inundation by Bonneville Reservoir and roads that restrict access to habitat); high uncertainty in the data and analyses for small populations[7]; and potentially inaccurate designation of population structure for this stratum. The Oregon management unit plan states that most of these issues are related to the population designation and suggests reevaluating the Gorge stratum population structure for all species (ODFW 2010).

The two populations of late-fall Chinook salmon are viable at their baseline levels, but the recovery scenario calls for the persistence probability of the Sandy population to be raised from high to very high.

If the scenario in Table 7-4 were achieved, it would exceed the WLC TRT's stratum-level viability criteria in the Coast and Cascade fall strata, the Cascade spring stratum, and the Cascade late-fall stratum (see Table 7-11).[8] However, the scenario for Gorge spring and Gorge fall Chinook salmon does not meet WLC TRT criteria because, within each

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[7] In the method used by the WLC TRT and management unit planners to establish abundance goals, target abundance is based to some extent on the gap between current and historical abundance. If the historical abundance of Gorge stratum Chinook salmon populations has been significantly overestimated, then the abundance needed to achieve target status may also be overestimated (ODFW 2010).

[8] For example, in the Cascade fall stratum, four populations are targeted for high or very high persistence probability, and, using the WLC TRT's scoring system, the average viability score for all populations in the stratum would be 2.35. As discussed in Section 2.5.4, the TRT's criteria for high probability of stratum persistence require that two or more populations be viable and that the average score for all populations in the stratum be 2.25 or higher.

stratum, the scenario targets only one population (the Hood) for high persistence probability. Exceeding the WLC TRT criteria, particularly in the Cascade fall and Cascade spring Chinook strata, was intentional on the part of local recovery planners to compensate for uncertainties about meeting the WLC TRT's criteria in the Gorge fall and spring strata. In addition, multiple spring Chinook salmon populations are prioritized for aggressive recovery efforts to balance risks associated with the uncertainty of success in reintroducing spring Chinook salmon populations above tributary dams in the Cowlitz and Lewis systems. (Delisting criteria for the Lower Columbia River Chinook salmon ESU are described in Section 3.2 and below in Section 7.7.)

Figures 7-6 and 7-7 display the population-level conservation gaps for tule fall Chinook, late-fall Chinook, and spring Chinook graphically. The conservation gap reflects the magnitude of improvement needed to move a population from its baseline status to the target status. For additional discussion of target status and conservation gaps for Lower Columbia River Chinook salmon populations, see the management unit plans (LCFRB 2010a, pp. 6-13 to 6-15 and ODFW 2010, pp. 148-150).

Given the structure of the Lower Columbia River Chinook salmon ESU, with its three major adult run components and both ocean- and stream-type juvenile life histories represented, the remainder of the Chinook salmon recovery analysis is broken down by run component: spring, fall, and late-fall. Limiting factor summaries, threat impacts, and recovery strategies at the run component level are nested appropriately within these three larger sections.

Table 7-4

Baseline and Target Persistence Probability and Abundance of LCR Chinook Salmon Populations

			Baseline Persistence Probability[9]					Abundance		
Stratum	**Population**	**Contribution**	**A&P**	**S**	**D**	**Net**	**Target Persistence Probability**	**Historical**	**Baseline[10]**	**Target**
Cascade spring	Upper Cowlitz (WA)[C, G]	Primary	VL	L	M	VL	H+	22,000	300	1,800
	Cispus (WA)[C]	Primary	VL	L	M	VL	H+	7,800	150	1,800
	Tilton (WA)	Stabilizing	VL	VL	VL	VL	VL	5,400	100	100
	Toutle (WA)	Contributing	VL	H	L	VL	M	3,100	100	1,100
	Kalama (WA)	Contributing	VL	H	L	VL	L	4,900	100	300
	NF Lewis (WA)[C]	Primary	VL	L	M	VL	H	15,700	300	1,500
	Sandy (OR)[C, G]	Primary	M	M	M	M	H	26,899	714	1,230
Gorge spring	White Salmon (WA)[C]	Contributing	VL	VL	VL	VL	L+	--[11]	< 50	500
	Hood (OR)	Primary	VL	VH	VL	VL	VH	15,041	327	1,493
Coast fall	Youngs Bay (OR)	Stabilizing	L	VH	L	L	L	15,115	379	505
	Grays/Chinook (WA)	Contributing	VL	H	VL	VL	M+	800	< 50	1,000
	Big Creek (OR)[C]	Contributing	VL	H	L	VL	L	8,785	216	577
	Elochoman/Skamokawa (WA)[C]	Primary	VL	H	L	VL	H	3,000	< 50	1,500
	Clatskanie (OR)	Primary	VL	VH	L	VL	H	14,354	6	1,277
	Mill/Abernathy/Germany (WA)	Primary	VL	H	L	VL	H	2,500	50	900
	Scappoose (OR)	Primary	L	H	L	L	H	12,515	356	1,222
Cascade fall	Lower Cowlitz (WA)[C]	Contributing	VL	H	M	VL	M+	24,000	500	3,000
	Upper Cowlitz (WA)	Stabilizing	VL	VL	M	VL	VL	28,000	0	--

[9] A&P = Abundance and productivity, S = spatial structure, and D = genetic and life history diversity. Net = overall persistence probability of the population. VL = very low, L = low, M = moderate, H = high, VH = very high.

[10] Baseline abundance was estimated as described in Section 5.1 and does not equal observed natural-origin spawner counts. The baseline is a modeled abundance that represents 100-year forward projections under conditions representative of a recent baseline period using a population viability analysis that is functionally equivalent to the risk analyses in McElhany et al. (2007). Projections generally assume conditions similar to those from 1974 to 2004. Oregon numbers reflect fishery reductions between the 1990s and about 2004, while Washington numbers reflect fishery impacts prevalent in the period immediately prior to listing in 1999.

[11] " — " indicates that no data are available from which to make a quantitative assessment.

Table 7-4

Baseline and Target Persistence Probability and Abundance of LCR Chinook Salmon Populations

			Baseline Persistence Probability[9]					Abundance		
Stratum	**Population**	**Contribution**	**A&P**	**S**	**D**	**Net**	**Target Persistence Probability**	**Historical**	**Baseline[10]**	**Target**
	Toutle (WA)[C]	Primary	VL	H	M	VL	H+	11,000	< 50	4,000
	Coweeman (WA)[G]	Primary	L	H	H	L	H+	3,500	100	900
	Kalama (WA)	Contributing	VL	H	M	VL	M	2,700	< 50	500
	Lewis (WA)[G]	Primary	VL	H	H	VL	H+	2,600	< 50	1,500
	Salmon Creek (WA)	Stabilizing	VL	H	M	VL	VL	--	< 50	--
	Clackamas (OR)[C]	Contributing	VL	VH	L	VL	M	22,554	558	1,551
	Sandy (OR)	Contributing	VL	M	L	VL	M	6,237	144	1,031
	Washougal (WA)	Primary	VL	H	M	VL	H+	2,600	< 50	1,200
Gorge fall	Lower Gorge (WA & OR)	Contributing	VL	M	L	VL	M	--	< 50	1,200
	Upper Gorge (WA & OR)[C]	Contributing	VL	M	L	VL	M	--	< 50	1,200
	White Salmon (WA)[C]	Contributing	VL	L	L	VL	M	--	< 50	500
	Hood (OR)	Primary	VL	VH	L	VL	H*	1,391	33	1,245
Cascade late fall	NF Lewis (WA)[C, G]	Primary	VH	H	H	VH	VH	23,000	7,300	7,300
	Sandy (OR)[C, G]	Primary	VH	M	M	H	VH	10,000	1,794	3,561

C = Core populations, meaning those that historically were the most productive.

G = Genetic legacy populations, which best represent historical genetic diversity.

*Oregon's analysis indicates a low probability of meeting the delisting objective of high persistence probability for this population.

Source: LCFRB (2010a) and ODFW (2010).

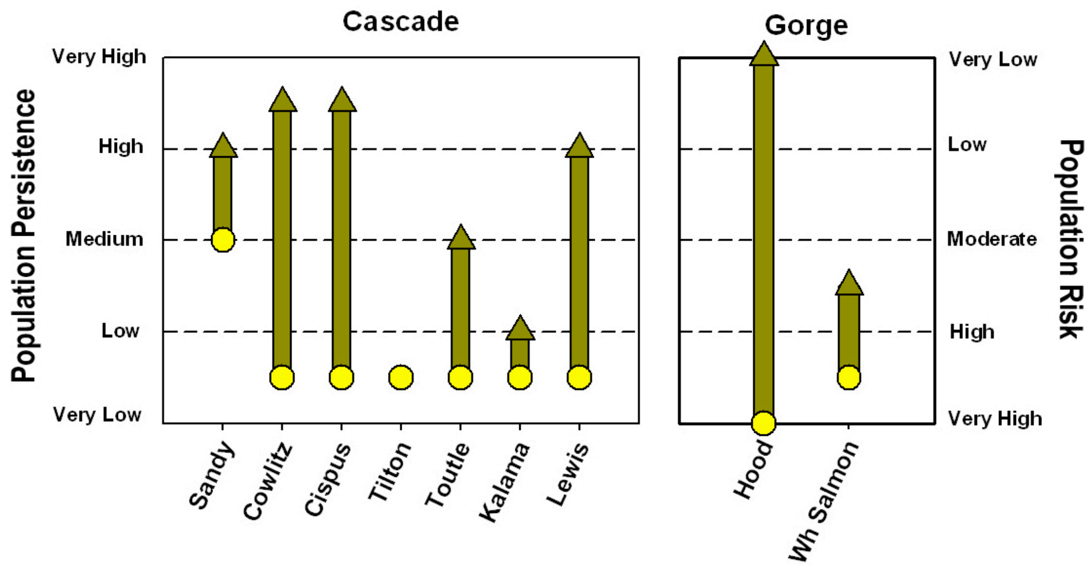

Figure 7-6. *Conservation Gaps for LCR Spring Chinook Salmon Populations: Difference between Baseline and Target Status*

Source: LCFRB 2010a.

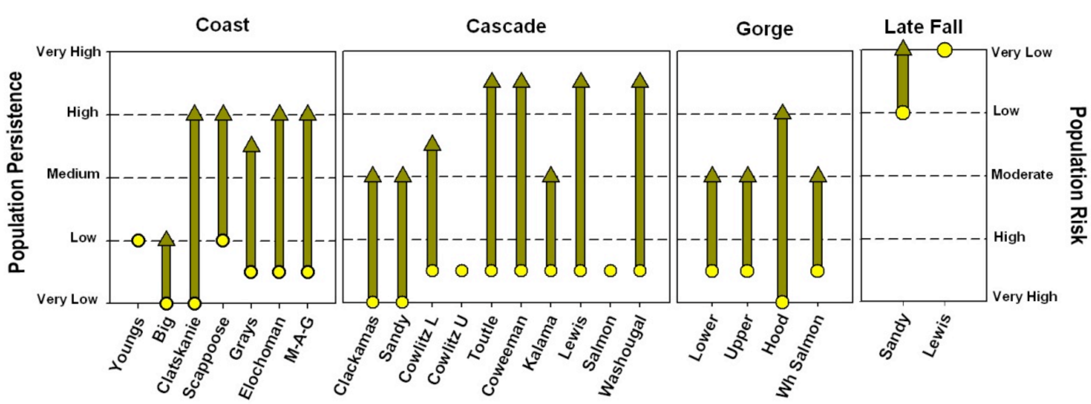

Figure 7-7. *Conservation Gaps for LCR Fall and Late-Fall Chinook Salmon Populations: Difference between Baseline and Target Status*

Source: LCFRB 2010a.

7.4 Spring Chinook Salmon Analysis: Limiting Factors, Threat Reductions, and Recovery Strategies

7.4.1 Spring Chinook Salmon Limiting Factors

Lower Columbia River spring Chinook salmon have been—and continue to be—affected by a legacy of habitat degradation, hydropower impacts, harvest, and hatchery production that, together, have reduced the persistence probability of all Lower Columbia River spring Chinook salmon populations. One of the largest factors limiting this component of the Lower Columbia River Chinook salmon ESU has been the existence of tributary dams that block access to core headwater spawning areas in upper subbasins.[12] Spatial structure, productive potential, and survival are further constrained by widespread degradation of tributary habitat in downstream areas. In addition, the high historical harvest rates and the effects of hatchery fish on natural populations have undermined the genetic and life history diversity of spring Chinook salmon populations and contributed to significant losses in production and abundance.

Table 7-5 and the text that follows summarize baseline limiting factors and threats for Lower Columbia River spring Chinook salmon strata based on population-specific limiting factors and threats identified in the management unit plans. In cases where conditions have changed significantly since the management unit plans' analyses of limiting factors and threats (e.g., if harvest rates have dropped or a dam is no longer present), this is noted in the text. Unless otherwise noted, NMFS agrees that the management unit plans' identification of limiting factors provide a credible hypothesis for understanding population performance and identifying management actions.

Because the individual management unit plans used somewhat different terms in identifying limiting factors, NMFS has translated those terms into standardized and more general terminology taken from a NMFS "data dictionary" of possible ecological concerns that could affect salmon and steelhead species (Hamm 2012; see Section 5.4). In addition, in Table 7-5, NMFS has rolled up the population-specific limiting factors (see Appendix H) to the stratum level—a process that has resulted in some loss of specificity.

In addition, each management unit plan used a different approach for identifying limiting factors and threats (see Section 5.3).One difference relevant to the crosswalk is that although the Oregon management unit plan identified primary and secondary limiting factors for each population in each threat category,[13] the Washington management unit plan categorized limiting factors in this way only for habitat-related limiting factors, and the White Salmon plan and the estuary module did not use the

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[12] Steel and Sheer (2003) analyzed the number of stream kilometers of potential habitat historically and currently available to salmon populations in the lower Columbia River. For several spring Chinook salmon populations, historical habitat is almost completely blocked (100 percent in the White Salmon, Cispus, and Tilton subbasins, 99 percent in the Upper Cowlitz, and 76 percent in the Lewis). In the Toutle and Kalama subbasins much lower but still significant proportions of habitat are blocked (31 percent blocked in the Toutle and 23 percent in the Sandy). In the Kalama subbasin only 6 percent is blocked, and in the Hood, 1 percent. (Condit Dam, on the White Salmon River, was breached in October 2011, and complete removal is expected by August of 2012, which will eliminate the major blockage in that subbasin.)

[13] In the Oregon management unit plan, primary limiting factors are those that have the greatest impact and secondary limiting factors have a lesser but still significant impact.

primary and secondary terminology. For the crosswalk and this table, NMFS assigned primary and secondary status to non-habitat limiting factors for Washington populations (based on the Washington management unit plan's quantification of threat impacts and the professional judgment of Lower Columbia Fish Recovery Board's staff and consultants). For populations that historically spawned in the White Salmon subbasin, NMFS staff inferred primary and secondary designations based on discussion in the Washington and White Salmon management unit plans (LCFRB 2010a, NMFS 2011b). It is likely that some apparent distinctions in results between Washington and Oregon populations are artifacts of differences in limiting factor assessment methodologies and not an actual difference in conditions or their effects on salmon and steelhead populations. In addition, there is not necessarily a bright line between primary and secondary limiting factor designations. Nevertheless, NMFS believes that the designations are useful, particularly for looking across ESUs and populations and identifying patterns (see Chapter 4).

The management unit plans provide more detail on limiting factors and threats affecting Lower Columbia River spring Chinook salmon, including magnitude, spatial scale, and relative impact (see LCFRB 2010a, Chapter 3 and various sections of Volume II; ODFW 2010, pp. 116-128; and NMFS 2011b, Chapter 5). For a regional perspective on limiting factors and threats that affect multiple salmon and steelhead ESUs, see Chapter 4 of this recovery plan. For a description of the data dictionary, the approach NMFS used to correlate management unit terms for limiting factors with the standardized NMFS terminology at the population scale, and the approach for rolling up from the population to the stratum scale, see Section 5.4 and Appendix H.

Management unit recovery planners in Oregon and Washington recognized that six major categories of manageable threats—tributary habitat, estuary habitat, hydropower, harvest, hatcheries, and predation—were useful as an organizing construct for grouping limiting factors, quantifying impacts on population productivity, and determining how much different categories of threats would need to be reduced to close the gap between baseline and target population status. Planners in both Washington and Oregon quantified the impacts of each of these major threat categories on population status, along with a reduction in each impact that would be consistent with achieving population target status. The results of that analysis are presented in Sections 7.4.2, 7.5., and 7.6.2 and provide a related but slightly different perspective on limiting factors. The threat reduction targets also allow actions to be scaled to achieve a specific impact reduction, and to be linked to monitoring and performance benchmarks.

Table 7-5

Baseline Limiting Factors and Threats Affecting LCR Spring Chinook Salmon: Stratum-Level Summary

Ecological Concern	Threat(s)	VSP Parameters Affected	Cascade Spring	Gorge Spring
Tributary Habitat Limiting Factors				
Riparian Condition	Past and/or current land use practices	All	Primary for juveniles in all populations	Secondary for juveniles in all populations

Table 7-5

Baseline Limiting Factors and Threats Affecting LCR Spring Chinook Salmon: Stratum-Level Summary

Ecological Concern	Threat(s)	VSP Parameters Affected	Cascade Spring	Gorge Spring
Channel Structure and Form	Past and/or current land use practices/ transportation corridor	All	Primary for juveniles in all populations	Secondary for juveniles in all populations
Peripheral and Transitional Habitats: Side Channel and Wetland Conditions	Past and/or current land use practices/ transportation corridor	All	Primary for juveniles in all populations	Secondary for juveniles in all populations
Peripheral and Transitional Habitats: Floodplain Conditions	Past and/or current land use practices/ transportation corridor	All	Primary for juveniles in all populations	Secondary for juveniles in all populations
Sediment Conditions	Past and/or current land use practices/ transportation corridor	All	Secondary for Sandy juveniles, primary for juveniles in all other populations	Secondary for juveniles in all populations
Water Quality (Temperature)	Land uses that impair riparian function/decrease streamflow, dams	A,P,D	Primary for Tilton and Toutle juveniles, secondary for Kalama and Lewis juveniles	Secondary for White Salmon juvenile and adults
Water Quantity (Flow)	Dams, land use, irrigation, municipal, and hatchery withdrawals	All	Secondary for juveniles in all populations	
Estuary Habitat Limiting Factors[14]				
Toxic Contaminants	Agricultural chemicals, urban and industrial practices	A,P,D	Secondary for juveniles in all populations	
Food[15] (Shift from macrodetrital- to microdetrital-based food web)	Dam reservoirs	All	Secondary for juveniles in all populations	
Peripheral and Transitional Habitats: Estuary Condition	Past and/or current land use practices/transportation corridor, mainstem dams	All	Secondary for juveniles in all populations	

[14] The Washington and Oregon management unit plans both relied on the *Columbia River Estuary ESA Recovery Plan Module for Salmon and Steelhead* (NMFS 2011a) for information on estuary limiting factors, but there were some differences in how the plans translated the information into limiting factors experienced at the population level. The estuary module does not designate limiting factors as primary or secondary; instead, it ranks them in terms of assumed impact on ocean- and stream-type salmonids. Because the Oregon management unit plan integrated the module information with more specificity than did the Washington management unit plan, and because NMFS assumes that estuarine limiting factors affect all populations equally within the ESU, the estuarine limiting factors in this table and Section 7.4.1.2 reflect the determinations in the Oregon management unit plan, applied to all Lower Columbia River spring Chinook salmon populations, unless otherwise noted. As with other limiting factors, the designations of estuarine limiting factors as primary or secondary reflect working hypotheses that will need to be tested (and possibly revised) through adaptive management.

[15] Although the Oregon management unit plan lists food web shifts as a primary limiting factor in the estuary, NMFS and the management unit planners agreed to consider such shifts secondary in this recovery plan to more closely reflect conclusions in the *Columbia River Estuary ESA Recovery Plan Module for Salmon and Steelhead* (NMFS 2011a). The extent to which food web shifts limit salmonid survival in the estuary is unclear.

Table 7-5

Baseline Limiting Factors and Threats Affecting LCR Spring Chinook Salmon: Stratum-Level Summary

Ecological Concern	Threat(s)	VSP Parameters Affected	Cascade Spring	Gorge Spring
Channel Structure and Form	Past and/or current land use practices/ transportation corridor	All	Primary for juveniles in all populations	
Sediment Conditions	Past and/or current land use practices/transportation corridor, dams	All	Primary for juveniles in all populations	
Water Quality (Temperature)	Land uses that impair riparian function/decrease streamflow, dam reservoirs	A,P,D	Secondary for juveniles in all populations[16]	
Water Quantity (Flow)	Columbia River mainstem dams	All	Primary for juveniles in all populations	
Hydropower Limiting Factors				
Habitat Quantity (Access)	Bonneville Dam	All		Secondary for White Salmon and Hood
Habitat Quantity (Inundation)	Bonneville Dam	All		Secondary for Hood juveniles[17]
Habitat Quantity (Access)	Tributary dams	All	Primary for Upper Cowlitz, Cispus, Tilton, and North Fork Lewis adults and juveniles, secondary for Sandy adults and juveniles	Primary for White Salmon adults and juveniles, secondary for Hood adults and juveniles
Harvest Limiting Factors				
Direct Mortality	Fisheries	A,D	Primary for Upper Cowlitz, Cispus, Tilton, Toutle, Kalama, and Lewis adults, secondary for Sandy adults	Primary for Hood adults, secondary for White Salmon adults

[16] For the White Salmon population, water temperature in the mainstem White Salmon River is at or near optimum levels for salmonids. Maximum temperature within the expected range of anadromous fish within the White Salmon subbasin meets Washington state water quality standards, with the exception of Rattlesnake Creek. Rattlesnake Creek is a significant habitat area where water temperature approaches lethal levels in some locations during some years (NMFS 2011b).

[17] The exact extent to which Bonneville Reservoir inundated habitats for any species is unknown. Some biologists have hypothesized impacts to spring Chinook salmon as a result of inundation. Based on spawning habitat preferences, it is likely that impacts of inundation were greatest on fall Chinook and chum salmon.

Table 7-5
Baseline Limiting Factors and Threats Affecting LCR Spring Chinook Salmon: Stratum-Level Summary

Ecological Concern	Threat(s)	VSP Parameters Affected	Cascade Spring	Gorge Spring
Hatchery Limiting Factors				
Food[18]	Smolts from all Columbia Basin hatcheries competing for food and space in the estuary	All	Secondary for all populations	
Population Diversity	Stray hatchery fish interbreeding with wild fish	A,P,D	Primary for adults in all populations	Primary for adults in all populations
Predation Limiting Factors				
Direct Mortality	Land use	A,P,D	Secondary for juveniles in all populations	
Direct Mortality	Dams	A,P,D		Secondary for adults (marine mammals) and juveniles (non-salmonid fish) in all populations

7.4.1.1 *Tributary Habitat Limiting Factors*

Because spring Chinook salmon are stream-type salmon that typically rear in tributary reaches for a full year, they depend heavily on tributary habitat conditions for their survival (LCFRB 2010a). Loss and degradation of tributary habitat is one of the main limiting factors for Lower Columbia River spring Chinook salmon, along with blocked access to historical spawning habitat as a result of tributary hydropower dams (see Table 7-5).

Impaired side channel and wetland conditions and degraded floodplain habitat have significant negative impacts on juvenile spring Chinook salmon throughout the ESU and are identified as primary limiting factors for all Cascade spring populations and secondary factors for all Gorge spring populations. Extensive channelization, diking, wetland conversion, stream clearing, and, in some subbasins, gravel extraction have barred spring Chinook salmon from historically productive habitats and simplified much of the remaining tributary habitats, weakening watershed processes that are essential to the maintenance of healthy ecosystems. Degraded riparian conditions and channel structure and form issues also are primary limiting factors for all Cascade spring populations and secondary factors for all Gorge spring populations within the

[18] Some scientists suspect that closely spaced releases of hatchery fish from all Columbia Basin hatcheries may lead to increased competition with natural-origin fish for food and habitat space in the estuary. NMFS 2011a and LCFRB (2010) identified competition for food and space among hatchery and natural-origin juveniles in the estuary as a critical uncertainty. ODFW (2010) acknowledged that uncertainty but listed competition for food and space as a secondary limiting factor for juveniles of all populations. The NMFS Northwest Region and Northwest Fisheries Science Center are working to better define and describe the scientific uncertainty associated with ecological interactions between hatchery-origin and natural-origin salmon in freshwater, estuarine, and nearshore ocean habitats.

ESU. Lack of large woody debris and appropriately sized gravel in the remaining accessible tributary habitat has significantly reduced the amount of suitable spawning and rearing habitat for spring Chinook salmon.

Sediment conditions are identified as a primary limiting factor for all Washington populations with the exception of the White Salmon, but are considered to be secondary for the Oregon portion of the ESU.[19] The high density of forest and rural roads in the Lower Columbia subdomain, combined with past, and in some cases current, logging and other forest management practices and other land use patterns on unstable slopes adjacent to riparian habitat, contributes to an abundance of fine sediment in tributary streams. The resulting excess fine sediment covers spawning gravel, limiting egg development and incubation, and increases turbidity. In addition, water quality—specifically elevated water temperature brought about through land use, lack of functioning riparian habitat, and reservoir operations—is a primary limiting factor for the Tilton and Toutle populations and a secondary limiting factor for the Kalama, Lewis, and White Salmon populations.[20] The influence of water storage and release operations, land use, and water withdrawals for irrigation, municipal use, and hatchery operations has led to altered hydrology and flow timing being identified as secondary factors for all spring Chinook salmon populations.

In the Cascade stratum, tributary habitat limiting factors are largely the same as those described above for all spring Chinook salmon populations. Land uses that have led to the conditions limiting habitat productivity in this stratum include forest management and timber harvest, agriculture, rural residential and urban development, and gravel extraction. A mix of private, state, and Federal forest land predominates in the upper mainstem and headwater tributaries of the Cascade subbasins, while the lower mainstem and tributary reaches of most subbasins are characterized by agricultural and rural residential land use, with some urban development.

A unique issue in the Cascade stratum is legacy effects in the Toutle subbasin of the 1980 Mount St. Helen's eruption. The North Fork Toutle in particular was heavily affected by sedimentation from the eruption. A sediment retention structure (SRS) was constructed on the North Fork Toutle in an attempt to prevent continued severe sedimentation of stream channels and associated flood conveyance, transportation, and habitat degradation problems. The SRS currently blocks access to as many as 50 miles of habitat for anadromous fish. Although fish are transported around the structure via a trap and haul system, the SRS remains a source of chronic fine sediment to the lower river; this reduces habitat quality and has interfered with fish collection at the base of the SRS.

[19] This distinction is likely an artifact of differences in limiting factor assessment processes between the two states and not an actual physical difference in sediment conditions in tributary streams or their effects on Chinook populations.

[20] For the White Salmon population, water temperature in the mainstem White Salmon River is at or near optimum levels for salmonids. Maximum temperature within the expected range of anadromous fish within the White Salmon subbasin meets Washington state water quality standards, with the exception of Rattlesnake Creek. Rattlesnake Creek is a significant habitat area where temperature approaches lethal levels in some locations during some years (NMFS 2011b).

In addition, spawning of Sandy spring Chinook salmon is negatively affected by impaired gravel recruitment related to the City of Portland's Bull Run water system dams.

In the Gorge spring Chinook stratum, habitat limiting factors are generally the same as those described for all spring Chinook salmon populations, although tributary habitat limiting factors are identified as secondary. Riparian, side-channel, wetland, and floodplain habitat conditions have been compromised by land uses and inundation by the reservoirs behind Bonneville and Condit dams.[21] Land uses that have contributed to habitat limiting factors include forest management and timber harvest in the upper mainstem and headwater reaches of the Hood and White Salmon, and agricultural and rural residential land use, with some urban development, in lower mainstem and tributary reaches. Water quantity issues related to altered hydrology and flow timing—specifically caused by irrigation withdrawals or diversions or low-head hydro diversions—have been identified as secondary limiting factors.

Habitat within the White Salmon subbasin was altered by the breaching of Condit Dam (in October 2011, with full removal expected by August 2012). Alterations include near-term negative effects from sediment release and scouring. Scientists and managers expect long-term positive effects as the result of restoration of natural flow regimes and sediment transport, but monitoring is needed to evaluate habitat and fish response to dam removal, and additional assessment of habitat limiting factors will be needed to refine understanding of limiting factors.

7.4.1.2 Estuary Habitat Limiting Factors[22]

As stream-type fish, spring Chinook salmon spend less time in the Columbia River estuary and plume than do ocean-type salmon such as fall Chinook, yet estuary habitat conditions nevertheless play an important role in the survival of spring Chinook salmon juveniles, particularly those displaying less dominant life history strategies. Water quantity issues related to altered hydrology and flow timing are identified as a primary limiting factor for all populations, as is impaired sediment and sand routing; these limiting factors are associated with hydroregulation at large storage reservoirs in the interior of the Columbia Basin, and, in the case of sediment issues, land uses both past and present. Much of the land surrounding the Columbia River estuary is in agricultural or rural residential use and has been extensively modified via dikes, levees, bank

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[21] Condit Dam, in the White Salmon subbasin, was breached in October 2011; complete removal is expected by August 2012.

[22] The Washington and Oregon management unit plans both relied on the *Columbia River Estuary ESA Recovery Plan Module for Salmon and Steelhead* (NMFS 2011a) for information on estuary limiting factors, but there were some differences in how the plans translated the information into limiting factors experienced at the population level. The estuary module does not designate limiting factors as primary or secondary; instead, it ranks them in terms of assumed impact on ocean- and stream-type salmonids. Because the Oregon management unit plan integrated the module information with more specificity than did the Washington management unit plan, and because NMFS assumes that estuarine limiting factors affect all populations equally within the ESU, the estuarine limiting factors in this section and in Table 7-5 reflect the determinations in the Oregon management unit plan, applied to all Lower Columbia River spring Chinook salmon populations, unless otherwise noted. As with other limiting factors, the designations of estuarine limiting factors as primary or secondary reflect working hypotheses that will need to be tested (and possibly revised) through adaptive management.

stabilization, and tide gates. Altered hydrology and sediment routing influence habitat-forming processes, the quantity and accessibility of habitats such as side channels and wetlands, the dynamics of the Columbia River plume, and the estuarine food web. Channel structure issues, in the form of reduced habitat complexity and diversity, also are a primary limiting factor for juveniles from all populations. Again, simplification of channel structure is related to conversion of land to other uses—agricultural, rural residential, and as a transportation corridor.

Lack of access to peripheral and transitional habitats, such as side channels and wetlands, is a secondary limiting factor for juveniles from all populations, with access being impaired by land uses—including the transportation corridor—and by flow alterations caused by mainstem dams. Other secondary limiting factors in the estuary that affect all spring Chinook populations are exposure to toxic contaminants (from urban, industrial, and agricultural sources) and elevated late summer and fall water temperatures, which are related to (1) land use practices that impair riparian function or decrease streamflow, and (2) large hydropower reservoirs.[23] Altered food web dynamics involving a transition from a macrodetrital-based food web to a microdetrital-based food web also are considered a secondary limiting factor for all populations.[24] These changes in the estuarine food web are caused primarily by increased microdetrital inputs from hydropower reservoirs and the loss of wetland habitats through diking and filling.

7.4.1.3 Hydropower Limiting Factors

Tributary hydropower development is one of the main limiting factors for Lower Columbia River spring Chinook salmon (see Table 7-5). In addition, flow management operations at large storage reservoirs in the interior of the Columbia Basin (Grand Coulee, Dworshak, etc.) affect all juvenile Lower Columbia River spring Chinook salmon in the lower mainstem and estuary, and potentially in the plume—primarily by altering flow volume and timing. These alterations impair sediment routing, influence habitat-forming processes, reduce access to peripheral habitat, and change the dynamics of the Columbia River plume and the estuarine food web (see Section 7.4.1.2).[25] Moreover, the large reservoirs associated with mainstem dams contribute to elevated water temperatures downstream in late summer and fall. Although the management unit plans identified temperature impacts of the hydropower system as a secondary limiting factor for all juvenile spring Chinook salmon, migration of juvenile spring Chinook salmon occurs from March through July and peaks in May (Dawley et al. 1986, McCabe et al. 1986, Roegner et al. 2004, Bottom et al. 2008, cited in Figure 2.2 of Carter et al. 2009). Thus, it is unlikely that elevated mainstem temperatures are having a

[23] Although the management plans identified temperature impacts as a secondary limiting factor for juveniles of all populations, the timing of juvenile spring Chinook salmon migration raises questions about the significance of this limiting factor; see Section 7.4.1.3.

[24] Although the Oregon management unit plan lists food web shifts as a primary limiting factor in the estuary, NMFS and the management unit planners agreed to consider such shifts secondary in this recovery plan to more closely reflect conclusions in the *Columbia River Estuary ESA Recovery Plan Module for Salmon and Steelhead* (NMFS 2011a). The extent to which food web shifts limit salmonid survival in the estuary is unclear.

[25] It is likely that flow impacts of the hydropower system affect Lower Columbia River ESUs more through changes in habitat-forming processes (including impacts to the plume) and food web impacts than through changes in migratory travel time.

significant impact on juvenile spring Chinook salmon. For the Hood and White Salmon populations, which spawn above Bonneville Dam, passage issues at Bonneville and inundation of historical spawning habitat by the Bonneville Reservoir are identified as secondary limiting factors.[26]

In the Cascade stratum, tributary hydropower is a primary limiting factor for the Upper Cowlitz, Cispus, Tilton, and North Fork Lewis populations, which historically were among the most productive populations but which have been extirpated or nearly so as a result of blocked passage. In addition, tributary dams have had adverse impacts on downstream habitat through reduced gravel recruitment and other effects. Tributary hydropower issues related to downstream passage of juveniles were identified as a secondary limiting factor for Sandy spring Chinook salmon, but the PGE Bull Run Hydroelectric Project (which consisted of Marmot and Little Sandy dams) was removed in 2007-2008, so this is no longer a factor. There are no tributary hydropower facilities in the Toutle or Kalama subbasins.[27]

In the Gorge stratum, the presence of Condit Dam was identified as a primary limiting factor for the White Salmon population because the dam blocked upstream passage to virtually all historical spring Chinook salmon spawning habitat. (Condit Dam was breached in October 2011 and complete removal is expected by August 2012, so this limiting factor is in the process of being addressed.) Passage issues related to adult passage at Powerdale Dam in the Hood subbasin were identified as a secondary limiting factor, but the dam was removed in 2010. In addition, passage issues at Bonneville Dam have impacts on the Hood and White Salmon populations.

7.4.1.4 Harvest Limiting Factors

Harvest-related mortality is identified as a primary limiting factor for all spring Chinook salmon populations within the ESU except the Sandy, for which harvest is identified as a secondary limiting factor (because ODFW considered it more resilient to the impacts of harvest [ODFW 2010]). About three-quarters of the harvest that affects spring Chinook salmon takes place in ocean fisheries from Oregon to Alaska. Some harvest also occurs in commercial and recreational fisheries in the mainstem Columbia River below Bonneville Dam, in tributary fisheries targeting hatchery fish, and in Zone 6 tribal fisheries for Lower Columbia River spring Chinook salmon spawning above Bonneville Dam (a tribal fishery also targets the Hood population in the tributary). From 1980 to 1993, harvest rates on spring Chinook salmon harvest averaged 51 percent, but during the period since listing (i.e., 1999 to 2006) they dropped to approximately 20 percent (ODFW 2010).

Although both the Washington and Oregon recovery plans discuss harvest as a limiting factor for Lower Columbia River spring Chinook salmon, they do not consider baseline

[26] The exact extent to which Bonneville Reservoir inundated habitats for any species is unknown. Some biologists have hypothesized impacts to spring Chinook salmon as a result of inundation. Based on spawning habitat preferences, it is likely that impacts of inundation were greatest on fall Chinook and chum salmon.

[27] However, the North Toutle sediment retention structure currently blocks access to as many as 50 miles of habitat for anadromous fish.

harvest rates as significant a limiting factor as dam passage constraints, tributary habitat degradation, and hatchery effects.

7.4.1.5 Hatchery-Related Limiting Factors

It is estimated that hatchery fish make up anywhere from 34 to 90 percent of spring Chinook salmon spawners, depending on the population in question (ODFW 2010, Table 4-8 and LCFRB 2010a, Table 3-8). Population-level effects resulting from stray hatchery fish interbreeding with natural-origin fish are identified as a primary limiting factor for all populations except the White Salmon. Hatchery straying, combined with past stock transfers, has likely altered the genetics of spring Chinook salmon populations and may have reduced diversity within the ESU. Productivity also has likely declined as a result of the influence of hatchery-origin fish. Notably, however, high proportions of hatchery-origin spawners are sometimes intentional because hatchery fish are being used to reintroduce spring Chinook salmon where they have been extirpated or nearly so (e.g., in the Hood, Cowlitz, and Lewis subbasins). In identifying hatchery-related limiting factors, the management unit plans evaluated only negative impacts of hatchery fish on productivity of natural fish and not the positive demographic benefits that such reintroduction programs can provide in the short term.

Some scientists suspect that closely spaced releases of hatchery fish from all Columbia Basin hatcheries may lead to increased competition with natural-origin fish for food and habitat space in the estuary. NMFS (2011a) and LCFRB (2010a) identified competition for food and space among hatchery and natural-origin juveniles in the estuary as a critical uncertainty. ODFW (2010) acknowledged that uncertainty but listed competition for food and space as a secondary limiting factor for juveniles of all populations. The NMFS Northwest Region and Northwest Fisheries Science Center are working to better define and describe the scientific uncertainty associated with ecological interactions between hatchery-origin and natural-origin salmon in freshwater, estuarine, and nearshore ocean habitats.

7.4.1.6 Predation

Direct mortality from predation is a secondary limiting factor for all spring Chinook salmon populations. Anthropogenic changes to the structure of habitat have increased predator abundance and effectiveness and led to increased predation by Caspian terns, double-crested cormorants and various other species of seabirds in the Columbia River estuary and plume. Gorge spring Chinook salmon also face secondary predation threats from non-salmonid fish (primarily pikeminnows above and below the dam but also walleye and smallmouth bass in the reservoir) and from marine mammals (primarily sea lions) at Bonneville Dam.

7.4.2 Spring Chinook Salmon Baseline Threat Impacts and Threat Reduction Targets

Table 7-6 shows the estimated impact on each Lower Columbia River spring Chinook salmon population resulting from potentially manageable threats, organized into six threat categories: tributary habitat degradation, estuary habitat degradation, hydropower, harvest, hatcheries, and predation. Both baseline and target impacts are shown, with the targets representing levels that would be consistent with long-term recovery goals. Impact values indicate the percentage reduction in abundance and productivity that is attributable to human activities related to a particular threat category. The value associated with any particular threat category can be interpreted as the percent reduction in abundance and productivity from historical conditions if that threat category were the only one affecting the population. The table also shows the overall percentage improvement that is needed to achieve the target impacts and corresponding population status.[28] These cumulative values across all threat categories (both baseline and target) are multiplicative rather than additive. Both the Oregon and Washington management unit plans use cumulative survivals across threat categories to illustrate the overall level of improvement needed. Each plan assumes that there is a direct proportional relationship between the projected changes in cumulative survival and the required changes in natural-origin spawner abundance and productivity. For populations where the survival improvement needed is larger than 500 percent, Table 7-6 does not report the exact value, in part because the value is highly uncertain.[29]

As an example, the baseline status of the Upper Cowlitz spring Chinook salmon population, circa 1999, has been severely reduced by the combined effects of multiple threats. The cumulative reduction in status was estimated at 99.8 percent from the multiplicative impacts of multiple threats acting across the salmon life cycle. Thus, current status is just 0.2 percent of the historical potential with no human impact. Tributary habitat, hydropower, harvest, and hatchery impacts each accounted for reductions in population productivity of 50 percent or more, with corresponding reductions in abundance, spatial structure, and diversity. The Washington management unit plan identifies a recovery strategy involving significant reductions in the impact of several threats. For instance, the plan targets tributary habitat impacts to be reduced from the estimated baseline level of 90 percent to 45 percent (i.e., an approximately 100 percent improvement relative to baseline conditions). With the targeted reductions in individual impacts, the cumulative effect of all impacts would drop from 99.8 percent at baseline to 86.1 percent at the target status. This change would translate into a more than 500 percent improvement in survival relative to the baseline. Although the population would still be experiencing abundance and productivity that are 74.7 percent lower than historical conditions, the extinction risk at this mortality level would be estimated sufficient to meet the targets for this plan.

Oregon and Washington recovery planners used somewhat different definitions or methods to quantify the estimated impacts of anthropogenic threats. Baseline impacts for Washington populations reflect conditions prevalent at the time of ESA listing (circa

[28] The percentage of survival improvement needed is the percentage change in net impacts, is derived from information in the Washington and Oregon management unit plans, and is calculated as follows: $[(1-\text{Cumulative}_{\text{Target}})-(1-\text{Cumulative}_{\text{Baseline}})]/[1-\text{Cumulative}_{\text{Baseline}}] \times 100$. These values generally correspond to population improvement targets identified for Washington populations in LCFRB (2010). Comparable numbers are not explicitly reported in ODFW (2010) but are implicit in the modeling approach that Oregon recovery planners used to derive target impacts.

[29] For some populations—many of them small—the survival improvement needed is very large and highly uncertain because various other factors also are uncertain (i.e., the population's baseline persistence probability, the exact degree of impact of human activities on tributary habitat, and whether the population's response to reductions in impacts will be linear). In addition, very small populations do not necessarily follow predictable patterns in their response to changing conditions.

1999), while the baseline impacts for Oregon populations reflect conditions through 2004. Dam impacts for Washington populations reflect passage mortality, habitat loss caused by inundation, and loss of access to historical production areas; for Oregon populations, the estimates of impacts in the "Dams" column of Table 7-6 reflect direct upstream and downstream passage mortality only, with other dam impacts accounted for in the habitat and predation threat categories. Hatchery impacts for Washington populations were limited to not more than 50 percent per population, in accordance with Hatchery Scientific Review Group (HSRG) assessments of the potential for genetic effects (Hatchery Scientific Review Group 2009); for Oregon populations, recovery planners used hatchery impact rates equivalent to one-half the rates at which hatchery fish were found on natural spawning grounds, based on analyzed relationships and reflecting concern about genetic and ecological effects. Washington recovery planners derived estimates of impacts to tributary habitat using the Ecosystem Diagnosis and Treatment (EDT) model. Oregon recovery planners estimated the mortality associated with estuary habitat degradation, hydropower, harvest, hatcheries, and predation and assigned all remaining mortality (relative to the difference between the current modeled abundance and estimated historical abundance) to tributary habitat. In general, the tributary habitat values in Table 7-6 have the highest degree of uncertainty relative to the other threat categories and, for Oregon populations, may include causes of mortality associated with the other threat categories but not directly captured in those mortality estimates. (See Section 5.5 for more on the methodologies used to estimate baseline impacts.)

Estimates of threat impacts are useful in showing the relative magnitude of impacts on each population. Given the differences in methodologies, some values in Table 7-6 for Oregon and Washington populations are not necessarily directly comparable. Thus, values for Oregon populations are most directly comparable to those for other Oregon populations, and values for Washington populations are most directly comparable to those for other Washington populations. Regardless of differences in specific threat impact definitions and methods, the net effect of changes from all threats is useful in understanding the magnitude of population improvement needed to achieve the target population status.

The target impacts in Table 7-6 represent one of several possible combinations of threat reductions that could conceivably close the conservation gap and lead to a population achieving its target status. The particular threat reductions shown in Table 7-6 reflect policy decisions and the methodologies and assumptions used by the different recovery planning teams. (For a description of how target impacts were developed, see Section 5.6.) In estimating impacts, management unit recovery planners evaluated each threat category independently (i.e., values in the table reflect the mortality of spring Chinook exposed to that particular category of threats, whether or not they are exposed to threats in the other categories). The estimates of baseline threat impacts have high levels of uncertainty and in many cases should be considered working hypotheses that are testable as part of recovery plan implementation. Despite this uncertainty, it is the expert judgment of NMFS and management unit scientists that, based on the best available information at this time, the estimates of baseline threat impacts provide a reasonable estimate of the relative magnitude of different sources of anthropogenic mortality and serve as an adequate basis for designing initial recovery actions.[30] As more and better information is collected, it will be applied to recovery efforts in an adaptive management framework.

As shown in Table 7-6, almost every spring Chinook salmon population is greatly affected by the loss and degradation of tributary habitat, and five populations—the Upper Cowlitz, Cispus, Tilton, Lewis, and White Salmon—have experienced impacts from tributary dams that are comparable to or even greater than those associated with other factors that affect tributary habitat. Accordingly, for most populations, the greatest gains in viability are expected from tributary habitat and dam passage improvements (combined with hatchery reintroduction programs). Exceptions are the Tilton—a stabilizing population that is expected to remain at its baseline status—and the Sandy and Hood populations, for which reductions in hatchery impacts are targeted to provide the greatest benefit.

Baseline hatchery and harvest impacts also are significant for most spring Chinook salmon populations. Although recent actions have substantially reduced harvest of spring Chinook salmon from baseline conditions, ancillary and precautionary actions are needed to ensure that harvest does not adversely affect conservation and recovery in the future. For all but the Tilton population, hatchery-related impacts are targeted to be reduced by half or more, with the largest reductions targeted in the Sandy and Hood populations.[31] Achieving recovery goals also will require improvements in predation management and estuary habitat impacts; however, net reductions in these threat categories are smaller than those for tributary habitat, hydropower, hatcheries, and harvest because the impacts of estuarine and predation threats are less.

Four of the nine spring Chinook salmon populations are targeted for significant reductions in every threat category, including hydropower (in the form of tributary dam removal or upstream and downstream passage improvements). These populations are the Upper Cowlitz, Cispus, Lewis, and White Salmon. Of these, only the White Salmon is not designated as primary.

More information on threat reduction scenarios, including methodologies used to determine baseline and target impacts, is available in the management unit plans (ODFW 2010, pp. 151-177 and LCFRB 2010a, pp. 4-30 through 4-33, and 6-49 through 6-52).

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[30] As implementation proceeds, research, monitoring, and evaluation and adaptive management will be key in helping to refine scientific understanding of the impact of threats on population persistence and of the extent to which management actions are reducing threats.

[31] See the discussion below, in Section 7.4.3.6, regarding use of out-of-ESU stock for reintroducing spring Chinook salmon in the Hood River.

Table 7-6

Impacts of Potentially Manageable Threats and Impact Reduction Targets Consistent with Recovery of LCR Spring Chinook Salmon Populations

	Impacts at Baseline[32]							Impacts at Target							% Survival Improvement Needed[40]
Population	T. Hab[33]	Est[34]	Dams[35]	Harv[36]	Hat[37]	Pred[38]	Cumulative[39]	T. Hab	Est	Dams	Harv	Hat	Pred	Cumulative	
Cascade Spring															
Upper Cowlitz (WA)	0.90	0.15	0.90	0.50	0.50	0.22	0.9983	0.45	0.08	0.45	0.25	0.25	0.11	0.8607	>500
Cispus (WA)	0.90	0.15	1.00	0.50	0.50	0.22	1.0000	0.45	0.08	0.50	0.25	0.25	0.11	0.8733	>500[41]

32 Impact figures represent a percentage reduction in abundance and productivity that is attributable to human activities related to a particular threat category. Methods used to estimate impacts differ for Oregon and Washington populations. For example, baseline impacts reflect conditions circa 1999 for Washington populations and through 2004 for Oregon populations. Given the methodological differences, impact figures are not necessarily directly comparable. See Sections 5.5 and 5.6 for more on methodologies.

33 Reduction in tributary habitat production potential relative to historical conditions. Oregon and Washington used different methods to estimate historical abundance. Oregon's approach, which incorporates safety margins and includes causes of mortality that are not captured in the other five threat categories, tends to indicate a higher potential impact from tributary habitat loss and degradation than does Washington's.

34 Reduction in juvenile survival in the Columbia River estuary as a result of habitat changes (relative to historical conditions); excludes predation.

35 Reflects passage mortality, habitat loss caused by inundation, and loss of access to historical production areas for Washington populations; for Oregon populations, dam impacts reflect direct passage mortality only.

36 Includes direct and indirect mortality.

37 Reflects only the negative impacts of hatchery-origin fish, such as high pHOS and low PNI (proportion of natural influence), not the benefits of conservation hatchery programs.

38 Includes the aggregate predation rate in the Columbia River mainstem and estuary by northern pikeminnow, marine mammals, Caspian terns, and cormorants.

39 Cumulative values (both baseline and target) are multiplicative rather than additive and are equal to $(1-[(1-M_{thab})(1-M_{est})(1-M_{dams})(1-M_{harv})(1-M_{hatch})(1-M_{pred})])$. Minor differences from numbers in ODFW 2010 are due to rounding.

40 Survival improvements indicate the percentage improvement (rounded to the nearest 10) in population survival needed to achieve target impacts and are derived from the cumulative values (baseline and target). For most populations this was calculated using the following equation: $[(1-\text{Cumulative}_{Target})-(1-\text{Cumulative}_{Baseline})]/[1-\text{Cumulative}_{Baseline}] \times 100$. These cumulative impact numbers are not explicitly reported in ODFW (2010) but are implicit in the modeling approach that Oregon recovery planners used to derive target impacts. For populations where the survival improvement needed is larger than 500 percent, this table does not report the exact value, for the reasons explained in Section 7.4.2

41 The Cispus population requires improvements in every threat category. However, given that hydropower impacts are 100 percent for this population, it will not benefit from improvements in other threat categories until some degree of passage is restored. Although passage improvements alone will not lead to recovery, how successful passage improvements are will greatly influence how much improvement is needed in the other threat categories. The Tilton population also has hydropower impacts of 100 percent but is a stabilizing population not targeted for improvements in any threat category. Because hydropower impacts are 100 percent for both these populations, the formula for percent survival improvement for these populations was modified to account for the 100 percent hydropower impacts (i.e., to avoid having to divide by zero).

Table 7-6

Impacts of Potentially Manageable Threats and Impact Reduction Targets Consistent with Recovery of LCR Spring Chinook Salmon Populations

	Impacts at Baseline[32]							Impacts at Target							% Survival Improvement Needed[40]
Population	**T. Hab[33]**	**Est[34]**	**Dams[35]**	**Harv[36]**	**Hat[37]**	**Pred[38]**	**Cumulative[39]**	**T. Hab**	**Est**	**Dams**	**Harv**	**Hat**	**Pred**	**Cumulative**	
Tilton (WA)	0.80	0.15	1.00	0.50	0.50	0.22	1.0000	0.80	0.15	1.00	0.50	0.50	0.22	1.0000	0
Toutle (WA)	0.90	0.15	0.00	0.50	0.50	0.22	0.9834	0.45	0.08	0.00	0.25	0.25	0.11	0.7467	>500
Kalama (WA)	0.90	0.15	0.00	0.50	0.50	0.22	0.9834	0.45	0.08	0.00	0.25	0.25	0.11	0.7467	>500
Lewis (WA)	0.40	0.15	0.95	0.50	0.50	0.22	0.9950	0.20	0.08	0.48	0.25	0.25	0.11	0.8084	>500
Sandy (OR)	0.94	0.10	0.08	0.25	0.27	0.12	0.9761	0.92	0.08	0.00	0.25	0.05	0.07	0.9512	100
Gorge Spring															
White Salmon (WA)[42]	0.70	0.14	0.96	0.50	0.50	0.27	0.9981	0.35	0.07	0.48	0.25	0.25	0.13	0.8462	>500
Hood (OR)	0.89	0.10	0.35	0.25	0.45	0.16	0.9777	0.82	0.08	0.12	0.25	0.05	0.07	0.9034	330

42 Baseline and target impacts for the Upper Gorge/White Salmon population are from LCFRB (2010a).

7.4.3 Spring Chinook Salmon Recovery Strategy

7.4.3.1 Strategy Summary

The recovery strategy for spring Chinook salmon is aimed at restoring the Cascade spring stratum to a high probability of persistence and improving the persistence probability of the two Gorge spring populations. Although the strategy involves threat reductions in all categories, the most crucial elements are as follows:

1. Protect and improve the Sandy spring Chinook salmon population, which is the best-performing population and the only Lower Columbia River spring Chinook salmon population with appreciable natural production. This will be accomplished by protecting high-quality, well-functioning spawning and rearing habitat, reducing the proportion of hatchery-origin spawners (pHOS), managing predation, and restoring tributary and estuarine habitat.[43]

2. Reestablish naturally spawning populations above dams on the Cowlitz and North Fork Lewis rivers, in areas that historically were highly productive, by improving adult and juvenile dam passage and developing hatchery reintroduction programs using broodstock from within-subbasin hatchery programs. Reestablishing populations in mid- to upper-elevation habitats is key to recovering the spring component of the Lower Columbia River Chinook salmon ESU.

3. Protect favorable tributary habitat and restore degraded but potentially productive habitat, particularly in the upper subbasins where spring Chinook salmon hold, spawn, and rear. Tributary habitat improvements are crucial for all populations.

4. Reestablish spring Chinook salmon in the White Salmon and Hood subbasins.

Very large improvements will be needed in the persistence probability of most spring Chinook salmon populations if the Lower Columbia River Chinook salmon ESU is to recover. (See Table 7-4 for the target persistence probability for each spring Chinook salmon population and Figure 7-6 for the gaps between baseline and target status.) Improving the status of the two Gorge populations will be difficult because of the challenges of reestablishing an extirpated population in the White Salmon subbasin after the removal of Condit Dam and of developing a locally adapted population in the Hood subbasin based on hatchery reintroduction. To compensate for limited prospects in the Gorge stratum, a goal of high persistence probability has been established for more than the minimum number of populations in the Cascade spring Chinook stratum.

The recovery strategy for spring Chinook salmon is a long-term, "all-H" approach in which plan implementers begin work on all of the elements described above immediately and implement actions associated with each of the six threat categories

[43] Some reduction in impacts on the Sandy population already have been achieved through removal of Marmot Dam and the Little Sandy River diversion in 2008 and protection of associated instream water rights for fish.

simultaneously.[44] As part of a series of 3- to 5-year implementation schedules, management unit planners will work with NMFS staff to prioritize individual actions within each threat category, rather than across threat categories (see Chapter 11 for more on implementation). Recovery will require improvements in every threat category, even those improvements in Table 7-6 that are relatively small. Although restoring effective passage into historical natural production areas in the upper Cowlitz and Lewis systems will be key in meeting recovery objectives for spring Chinook salmon, the full potential of dam passage improvements will be limited without significant habitat restoration and protection. Site-specific restoration is needed in upper subbasins immediately, along with implementation of tributary habitat protection and watershed-based restoration actions; these measures will ensure adequate habitat quantity and function for viable populations over the long term. Harvest rates will be maintained at their current relatively low level until actions in other threat categories have taken effect; once populations have been reestablished above tributary dams and natural production has increased, harvest rates can be reevaluated.

Key critical uncertainties that need to be addressed to support implementation of near-term actions relate to passage efficiencies past tributary dams, juvenile production in upper subbasins, the pace at which reintroduced populations become functional and self-sustaining, and the amount of pinniped predation on spring Chinook salmon in the Columbia River estuary (see Section 7.4.3.8).

The subsections below describe recovery strategies and near-term and long-term priorities for each threat category. For specific management actions in each threat category, linked to population and location, see the management unit plans (LCFRB 2010a, ODFW 2010, NMFS 2011b).

7.4.3.2 Tributary Habitat Strategy

Spring Chinook salmon will benefit from the regional tributary habitat strategy described in Section 4.1.2. The regional strategy is directed toward protecting and restoring high-quality, well-functioning spring Chinook salmon and steelhead habitat through a combination of (1) site-specific management actions that will protect habitat and provide benefits relatively quickly, (2) watershed-based actions that will repair habitat-forming processes and provide benefits over the long term, and (3) landscape-scale programmatic actions that affect a class of activities (such as stormwater management or forest practices) over multiple watersheds. Actions of particular benefit to spring Chinook salmon focus on protecting and restoring floodplain connectivity and function, access to side channels and off-channel habitats, and habitat complexity and diversity, especially in mid- to high-elevation habitat. Improving riparian cover and recruitment of large wood to streams also will be a priority. Headwater areas are targeted for protection and restoration to maintain sources of cool, clean water and normative hydrologic conditions; this includes protecting intact forests, managing forest lands to protect watershed processes and habitat conditions (LCFRB 2010a), and restoring upland processes that will reduce inputs of fine sediment to the spawning

[44] Implementation of recovery actions to reduce threats in each category is already under way, although the scale of effort is less than that called for in this recovery plan.

gravel of spring Chinook salmon. The subsections below summarize additional, stratum-specific tributary habitat strategies for spring Chinook salmon.

Cascade Spring Chinook Salmon Tributary Habitat Strategies

In implementing the Lower Columbia River spring Chinook salmon tributary habitat strategy in the Cascade stratum, considerations include the following:

- Generally, habitat conditions are favorable in the upper portions of the Cowlitz, Cispus, and North Fork Lewis subbasins, where populations are targeted for high or high-plus persistence probability but where access has been blocked by dams. In these areas, protecting high-quality habitat and restoring upslope processes, valley floodplain function, and stream habitat diversity will be priorities. Large portions of these areas are in Federal forest land, which highlights the importance of Northwest Forest Plan implementation to protect habitats in those areas.

- Particularly for the Washington populations, substantial restoration also will be needed in currently accessible areas. Because spring Chinook salmon use mid- to high-elevation valley habitats for spawning and rearing, restoration efforts will focus on such areas, both in historically highly productive watersheds as well as some where production potential is more limited. Actions will include those described above for spring Chinook salmon generally.

- Habitat conditions are generally favorable in the Sandy subbasin (this population is targeted for high persistence probability). Again, large portions of this subbasin are in federal forest land. Implementation of the City of Portland's Bull Run water supply habitat conservation plan will also play a key role in habitat restoration and protection in the Sandy subbasin. Under this plan, the city will implement habitat actions throughout the subbasin as mitigation for its water supply project on the Bull Run River.

- State or private forest land predominates in the upper portions of the Toutle, Kalama, and North Fork Lewis subbasins. These lands must be managed to protect and restore watershed processes.

Addressing passage barriers such as culverts will benefit Cascade spring Chinook salmon populations by restoring access to habitat in a number of locations, including the North Fork Lewis, Tilton, Cispus, and Upper Cowlitz subbasins. (In some cases, additional assessment is needed to inventory and prioritize these blockages.) For the Toutle population, addressing sedimentation and passage issues at the North Fork Toutle sediment retention structure will be key.

Assuming that the impacts of other threats are reduced to the levels shown in Table 7-6, the scale of habitat improvements needed for Cascade spring Chinook stratum populations is minimal in the case of the Sandy population and the Tilton population, which, as a stabilizing population, is expected to remain at its baseline status.[45] For the Upper Cowlitz, Cispus, Toutle, Kalama, and Lewis populations, baseline impacts to tributary habitat productivity are targeted to be reduced by 50 percent to meet recovery targets.

Gorge Spring Chinook Salmon Tributary Habitat Strategies

In implementing the Lower Columbia River spring Chinook salmon tributary habitat strategy in the Gorge stratum, considerations include the following:

- Gorge populations occur in watersheds that are largely Federal, state, and private forest land. These lands must be managed to protect and restore watershed processes.

The Oregon management unit plan identifies an approximately 8 percent reduction in tributary habitat impacts needed to achieve the target status for the Hood spring Chinook salmon population. Site-specific actions will focus on restoring or creating off-channel and side-channel habitat (alcoves, wetlands, floodplains, etc.), providing access to off-channel and side-channel habitat, and restoring riparian areas and instream habitat complexity, including recruitment of large wood to streams. Because water quantity issues associated with irrigation withdrawals are identified as a limiting factor for the Hood spring Chinook salmon population, the Oregon management unit plan identifies a number of actions to address flow issues (e.g., ensure that low-head hydropower projects do not adversely impact winter streamflows and work the Oregon Water Resources Department and others to keep water saved through publicly funded water conservation efforts instream for fish).

In the White Salmon subbasin, all historical spring Chinook salmon habitat is assumed to be located above Condit Dam. The breaching of Condit Dam in October 2011 (with full removal expected by August 2012) created near-term negative effects in the habitat below the dam and the habitat within the footprint of the former reservoir because of sediment release and scouring. Long-term effects are expected to be positive because of restored natural flow and sediment transport regimes. The White Salmon plan outlines four broad tributary habitat strategies: (1) gain information to identify and prioritize habitat actions, (2) when the dam is removed, restore mainstem habitat, (3) protect and conserve natural ecological processes, and (4) improve habitat in upriver reaches (NMFS 2011b). In the near term, evaluating the effects on of the dam breaching and removal on habitat and performing additional assessment of habitat limiting factors are high priorities.

7.4.3.3 Estuary Habitat Strategy

Improving Columbia River estuary habitat as described in the regional estuary habitat strategy will benefit all Columbia Basin ESUs, including Lower Columbia River spring Chinook salmon. (For a summary of the regional estuarine habitat strategy, see Section 4.2.2). The regional strategy reflects actions presented in the Oregon and Washington

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[45] Because of dam passage issues and relatively low habitat quality, the Tilton population is expected to remain at its baseline probability persistence of very low.

management unit plans to reduce estuarine habitat-related threats and is consistent with actions in the *Columbia River Estuary ESA Recovery Plan Module for Salmon and Steelhead* (NMFS 2011a).

The *Columbia River Estuary ESA Recovery Plan Module for Salmon and Steelhead* (NMFS 2011a) assumes that feasible estuarine habitat improvements and predation management measures could result in a maximum increase of 20 percent in the number of spring Chinook salmon leaving the Columbia River estuary. Oregon and Washington management recovery planners set targets of reducing anthropogenically enhanced mortality in the estuary for spring Chinook salmon populations based on the estuary module and their own approaches to threat reductions (ODFW 2010, Tables 6-24 and 6-25; LCFRB 2010a, Table 6-2).

7.4.3.4 Hydropower Strategy

The hydropower recovery strategy for Lower Columbia River spring Chinook salmon is to address the impacts of tributary hydropower dams through implementation of FERC relicensing agreements and thereby reestablish viable spring Chinook salmon populations in the Upper Cowlitz, Cispus, and North Fork Lewis subbasins; achieve survival gains in the Sandy, White Salmon, and Hood populations; and maintain the Tilton population at its baseline persistence probability of very low. Accomplishing these objectives will involve the removal of FERC-licensed dams (completed in the Sandy and Hood, and under way in the White Salmon) and development of adult and juvenile passage systems and hatchery reintroduction programs in the Cowlitz (Upper Cowlitz, Cispus populations) and Lewis subbasins.[46]

The strategy also includes measures to improve passage survival at Bonneville Dam for the Hood and White Salmon populations and implementation of mainstem flow management operations designed to benefit spring migrants from the interior of the Columbia Basin; NMFS expects that these flow management operations will also improve survival in the estuary and, potentially, the plume for all Lower Columbia River salmon and steelhead populations. NMFS estimates that survival of spring Chinook salmon passing Bonneville Dam was 95.1 percent for juveniles from 2002 to 2009 and 98.6 percent for adults from 2002 to 2007 (NMFS 2008a). NMFS expected that implementation of actions in the 2008 FCRPS Biological Opinion and its 2010 Supplement would improve juvenile spring Chinook salmon survival at Bonneville Dam by less than ½ percent, and that adult survival would be maintained at recent high levels (NMFS 2008a). Consequently, Oregon did not incorporate survival benefits from passage improvements at Bonneville into the hydropower threat reduction targets for Oregon populations above Bonneville.[47] The Washington management unit plan assumed that actions identified in the 2008 FCRPS Biological Opinion and its 2010 Supplement would aid adults and juveniles from all Lower Columbia River spring Chinook salmon populations originating above Bonneville Dam. However, preliminary information indicates that survival gains for yearling Chinook at Bonneville Dam are

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[46] Spring Chinook salmon will likely also be reintroduced into the Tilton subbasin eventually, but those efforts will be delayed to facilitate reintroduction into the Upper Cowlitz and Cispus subbasins.
[47] Hydropower-related threat reduction targets for Oregon populations above Bonneville Dam are associated with removal of Powerdale Dam on the Hood River.

higher than expected and are above 96 percent (U.S. Army Corps of Engineers 2011b). For more on actions to improve mainstem dam passage, see the regional hydropower strategy in Section 4.3.2.

In its management unit plan, Oregon incorporated several actions addressing impacts of the Columbia River hydropower system that are not included in the FCRPS Biological Opinion and its 2010 Supplement but that Oregon maintains are needed to benefit Lower Columbia River salmon and steelhead populations that spawn above Bonneville Dam. The state of Oregon's position is that the FCRPS action agencies should conduct operations in addition to those incorporated in the FCRPS Biological Opinion to address the needs of ESA-listed salmon and steelhead. Oregon is a plaintiff in litigation against various Federal agencies, including NMFS, challenging the adequacy of measures in the FCRPS Biological Opinion and its 2010 Supplement. NMFS does not agree with Oregon regarding the need for or likely efficacy of the additional actions Oregon proposed in that litigation, including the actions in the Oregon management unit plan that are not part of the FCRPS Biological Opinion and its 2010 Supplement. For more detail on these actions and NMFS' view of them, see the regional hydropower strategy in Section 4.3.2.

The subsections below summarize stratum-level hydropower strategies for spring Chinook salmon.

Cascade Spring Chinook Salmon Hydropower Strategy

The Cascade-stratum hydropower strategy is crucial to successful recovery of the spring life history component of the Lower Columbia River Chinook salmon ESU. The strategy involves creating or improving passage at projects on the Cowlitz and Lewis rivers and using hatchery reintroduction programs to reestablish viable populations in the Upper Cowlitz, Cispus, and North Fork Lewis subbasins (the Tilton population, in the Cowlitz system, is not expected to improve above its baseline persistence probability of very low). These changes are being implemented under the terms of FERC relicensing agreements completed with Tacoma Power for the Cowlitz River Project (Settlement Agreement completed in 2000) and with PacifiCorp and the Cowlitz PUD for the Lewis River Hydroelectric Projects (Settlement Agreement in 2004). Although there are many challenges to reestablishing natural spawning above the dams, the upper portions of the Cowlitz, Cispus, and North Fork Lewis subbasins still have relatively intact and well-functioning habitat that support spring Chinook salmon spawning and rearing.

In the Cowlitz subbasin, the hatchery Barrier Dam prevents all volitional passage of anadromous fish above RM 49.5. Currently, spring Chinook salmon are collected, natural-origin fish are separated from hatchery broodstock, and natural-origin fish are transported upstream of Barrier, Mayfield, and Mossyrock, and Cowlitz Falls dams and released into the Upper Cowlitz and Cispus rivers.[48] Spring Chinook salmon smolts are collected at Cowlitz Falls Dam, briefly held in stress-relief ponds, and released into the lower Cowlitz (LCFRB 2010a). Survival of juveniles through reservoirs and past dams is especially problematic in this system (LCFRB 2010a). Both upstream passage and downstream passage at these dams are expected to be improved as part of the 2002

[48] Spring Chinook salmon will likely also be reintroduced into the Tilton subbasin eventually, but those efforts will be delayed to facilitate reintroduction into the Upper Cowlitz and Cispus subbasins.

FERC relicensing order. Tacoma Power will evaluate fish returns and survival through the reservoirs and assess passage options. Adult passage at Mayfield Dam will be by trap and haul unless certain settlement agreement criteria (fish sorting, productivity, etc.) are met. If met, then passage at Mayfield Dam is likely to be provided through construction of a ladder, whereas passage at the much larger Mossyrock Dam would likely be provided by either trap and haul or a tramway.

In the North Fork Lewis subbasin, three dams—Merwin, Yale, and Swift—block passage to the upper North Fork Lewis, starting with Merwin Dam at RM 20. As part of the 2004 FERC relicensing agreement with PacifiCorp and the Cowlitz Public Utility District, spring Chinook salmon will be reintroduced into habitat upstream of the three dams. Almost all remaining historical spring Chinook salmon spawning habitat for the North Fork Lewis population is located in the upper North Fork Lewis watershed, above Swift Reservoir (LCFRB 2010a). The keys to successful reintroduction will be adequate passage of adults to and juveniles from the upper watershed, hatchery supplementation, and habitat improvements. In addition, because hydroregulation on the Lewis River has altered the natural flow regime below Merwin Dam, further adjustments in flow regime may be needed to provide adequate flows for habitat formation, fish migration, water quality, floodplain connectivity, habitat capacity, and sediment transport.[49] However, floodplain and channel alterations in the lower river will limit the ability of changes in flow regime to restore lower floodplain function, so flow modifications will need to take place in concert with restoration of lower river floodplain function.

Downstream passage of juveniles through tributary hydropower projects was identified as a secondary limiting factor for the Sandy spring Chinook salmon population, but the PGE Bull Run Hydroelectric Project (consisting of Marmot and Little Sandy dams) was removed in 2007-2008, so this is no longer a limiting factor.

Gorge Spring Chinook Salmon Hydropower Strategy

Tributary hydropower impacts for the White Salmon and Hood populations will be addressed by the removal of Condit and Powerdale dams, respectively. Condit Dam, operated on the White Salmon River by PacifiCorp, was breached in October 2011 and, under the terms of a 1999 decommissioning agreement and a 2006 Biological Opinion, is scheduled to be completely removed by August 2012,. Removal will reopen access to 12.8 miles of historical spring Chinook salmon habitat (NMFS 2011b). This represents virtually all the historical habitat for the White Salmon spring Chinook salmon population. Once dam removal is complete, natural escapement and production will be monitored for 4 to 5 years; if recolonization has not occurred adequately by that time, appropriate hatchery adults and/or juveniles may be released into the White Salmon River.

Powerdale Dam, on the Hood River, and also operated by PacifiCorp, was removed in 2010 under the terms of a settlement agreement reached in 2003. The dam acted as a partial barrier that delayed upstream migration of returning adults.[50] Removal of

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[49] Changes in flow regime will need to consider the needs of all listed species in the Lewis Basin.

[50] Downstream migrants were not entrained or delayed at Powerdale Dam once hydropower operations were suspended in late 2006.

Powerdale will eliminate this hydropower-related mortality for the Hood spring Chinook salmon population.

Actions in the 2008 FCRPS Biological Opinion and its 2010 Supplement will also provide slight improvements in juvenile survival for the two Gorge spring Chinook salmon populations (see the regional hydropower strategy in Section 4.3.2).

7.4.3.5 Harvest Strategy

Harvest impacts on natural-origin spring Chinook salmon averaged about 51 percent per year around the time of listing and currently are around 20 percent (about half of which occurs in mixed-stock ocean fisheries). The Oregon management unit plan considers a baseline harvest rate of 25 percent to be consistent with recovery of natural-origin spring Chinook salmon and does not include reductions in harvest in its population threat reduction scenarios for spring Chinook salmon (ODFW 2010); however, the Oregon management unit plan does include ancillary and precautionary actions to ensure that harvest does not adversely affect conservation and recovery in the future.

The Washington management unit plan also estimated that fishery impacts of 25 percent were consistent with long-term objectives. For harvest in general, the Washington management unit plan recommends a phased harvest strategy involving lower near-term rates to reduce population risks until habitat has improved. Modeling in the plan shows a scenario in which spring Chinook salmon harvest rates would be managed for benchmarks of 15 to 25 percent for three consecutive 12-year evaluation periods (i.e., from 1999-2010, 2011-2022, and 2023-2034). The 15 to 25 percent benchmark reflects the possible need for (1) rates lower than 25 percent in some years to reduce the risk of critically low escapements in years of low ocean survival, and (2) fishery restrictions within selected subbasins to protect local populations (LCFRB 2010a). Then, the modeling shows that, assuming that habitat improvements have been achieved and hatchery reintroductions have been successful in establishing natural production, harvest impacts on natural-origin fish could then be higher, in the range of 20 to 30 percent (LCFRB 2010a). These modeling results are planning targets and not predictions of future harvest rates; managers will establish future harvest rates based on observed indicators in Lower Columbia River spring Chinook salmon populations.

Although near-term harvest impact reduction benchmarks have been met (in the case of the Washington management unit plan) or are not needed (in the case of the Oregon management unit plan), the plans do contain some actions related to spring Chinook salmon that are consistent with the regional harvest strategy (see Section 4.5.2). Most of these actions have either already been implemented or involve the continuation of ongoing efforts, including the following:

- Supporting mark-selective ocean fisheries when the Pacific Salmon Treaty is renegotiated in 2018 (ODFW 2010).

- Employing time and area restrictions to address specific annual or population concerns (LCFRB 2010a, ODFW 2010).

Over the long term, as reintroduction and passage improvement efforts begin to yield more natural production, it will be necessary to reevaluate harvest impacts and determine an appropriate harvest strategy.

Cascade Spring Chinook Salmon Harvest Strategy

The Lower Columbia River spring Chinook salmon harvest strategy described in Section 7.4.3.5 will benefit populations in this stratum.

Gorge Spring Chinook Salmon Harvest Strategy

The ESU-level harvest strategies described in Section 7.4.3.5 will benefit populations in this stratum. In addition, because Lower Columbia River spring Chinook salmon spawning above Bonneville Dam (i.e., the Hood population at present, but once they are reestablished, the White Salmon population as well) are intercepted in Zone 6 tribal fisheries, the Oregon management unit plan includes an action to discuss with tribes potential actions to reduce those impacts. (Potential actions include extending sanctuaries from the mouths of tributaries and/or modifying season length or timing.)

7.4.3.6 Hatchery Strategy

The regional hatchery described in Section 4.4.2 summarizes goals and approaches relevant to Lower Columbia River spring Chinook salmon. Goals for spring Chinook salmon include using hatchery broodstocks to reestablish populations that have been extirpated (the Hood) or whose access to spawning and rearing habitat has been blocked by hydropower dams (the upper Cowlitz, North Fork Lewis, and Cispus populations and, potentially, the White Salmon). In general, reducing hatchery impacts on natural-origin spring Chinook salmon will be accomplished by (1) changing hatchery practices related to broodstock selection and management, numbers of releases, and locations and timing of acclimation and releases, and (2) physically excluding hatchery-origin fish from natural spawning areas by using weirs, traps, or other measures. For the Sandy and Hood populations, lessening the effects of hatchery-origin fish on naturally produced fish is expected to provide greater benefit than any other general category of action.

Details of how the hatchery strategy will be implemented in each spring Chinook salmon stratum will be developed as part of the transition schedules, but the subsections below provide some information.

Cascade Spring Chinook Salmon Hatchery Strategy

The hatchery strategy for the Cascade spring Chinook stratum centers on using hatchery spring Chinook salmon to reestablish the Upper Cowlitz and Cispus populations in historically accessible habitats in the Cowlitz subbasin and to reestablish the North Fork Lewis population in historically accessible habitats in the Lewis subbasin. (The Tilton population is targeted to be maintained at very low persistence probability, in part because of relatively poor habitat quality.) For the Kalama and Sandy populations, hatchery strategies will be targeted at reducing impacts on naturally spawning fish while continuing to produce spring Chinook salmon that provide fish for harvest. No hatchery spring Chinook salmon are released into the Toutle subbasin.

In the Cowlitz and Lewis systems, outplanting of hatchery-origin juveniles and adults is considered the initial stage of reintroduction. In this stage, broodstock choices are limited to existing hatchery stocks. In the Cowlitz, the Cowlitz hatchery broodstock has had negligible out-of-basin influence and is considered consistent with the original Cowlitz naturally spawning stock (LCFRB 2010a). Hatchery fish will be used to (1) reintroduce natural production in appropriate areas of the basin and adjacent tributary streams, (2) develop a local broodstock to reestablish historical diversity and life history characteristics, and (3) provide fishery mitigation in a manner that does not post significant risks to natural populations as they rebuild (LCFRB 2010a). The reintroduction program will include development of a biologically appropriate relationship and management strategy for hatchery and wild broodstock over time (LCFRB 2010a). Other considerations will include the timing of juvenile releases to minimize impacts to natural-origin fish (LCFRB 2010a).

In the North Fork Lewis subbasin, the Lewis River spring Chinook salmon program will be used to reintroduce spring Chinook salmon upstream of the hydrosystem. The Lewis hatchery spring Chinook salmon broodstock was developed from outside stocks, principally Cowlitz spring Chinook salmon, but currently is sustained without transfer from other hatcheries. As part of the reintroduction programs, facilities and operational strategies for these hatchery programs will address space, broodstock development, rearing methods, transfer of fish, marking strategies, and monitoring and evaluation (LCFRB 2010a).

In the near term, managing fisheries to meet hatchery escapement goals in the Cowlitz and Lewis systems is critical because recovery of spring Chinook salmon in those systems depends on the success of hatchery reintroduction programs, including the ability to collect enough fish at the hatcheries to meet the needs of the reintroduction program. Managing fisheries to meet hatchery escapement goals is therefore a key near-term strategy that integrates both harvest and hatchery objectives. As the reintroduction proceeds and natural production is established above the dams, the hatchery programs may shift to integrated supplementation to reduce risks to reestablished natural populations (as a first priority) and to improve the fitness of the hatchery stock (as a secondary priority). A matrix will be developed to manage naturally spawning fish in the broodstock, adult escapement to natural production areas and to the hatcheries, and hatchery fish on the spawning grounds (LCFRB 2010a).

To minimize potential predation on subyearling fall Chinook and chum salmon, the Washington management unit plan also calls for hatchery spring Chinook salmon release strategies that encourage rapid migration through the lower Cowlitz and Lewis; these strategies include volitional release, optimum release size, and release downstream of principal chum rearing areas (LCFRB 2010a).

In the Kalama and Sandy subbasins, hatchery programs will continue to produce fish for harvest concurrent with efforts to reduce impacts of hatchery fish on the natural populations. The spring Chinook salmon hatchery program in the Kalama is operated for fishery enhancement but with a dual supplementation objective: spring Chinook salmon that exceed broodstock needs are released above lower Kalama Falls to spawn naturally. Here, hatchery strategies will focus on (1) developing protocols regarding how many fish to pass upstream and (2) integrating hatchery and wild broodstock in the future after wild production is established. In the Sandy subbasin, ODFW will implement actions designed to meet the pHOS target of 10 percent or less established by ODFW for populations in Oregon targeted for high persistence probability. These actions will include acclimation practices to reduce straying, use of flows to attract more fish to the hatchery, and, potentially, the use of a trap to sort hatchery-origin fish within Cedar Creek and/or at the acclimation facilities. The Sandy spring Chinook salmon program formerly was an integrated hatchery program and now is being operated as a segregated program. ODFW intends to develop a matrix to govern take of natural-origin adults for inclusion in hatchery broodstock once the population has recovered to levels that can support an integrated hatchery program. Achieving the pHOS target for the Sandy spring Chinook salmon population is a high priority because the Sandy is one of the healthiest spring Chinook populations in the ESU. If the target has not been achieved by the year 2022, NMFS will urge other means of reducing pHOS, such as reducing hatchery smolt releases or moving production to another subbasin.

Gorge Spring Chinook Salmon Hatchery Strategy

The hatchery strategy for the Gorge spring Chinook stratum involves the continuation of hatchery reintroduction efforts in the Hood subbasin, and a potential hatchery reintroduction program in the White Salmon subbasin once Condit Dam is removed. (The dam was breached in October 2011, and complete removal is expected by August 2012.)

The historical spring Chinook salmon population in the Hood subbasin is considered extirpated, and Deschutes river stock (an out-of-ESU stock) is being used for a hatchery reintroduction program.[51] The recovery strategy calls for the program to continue and eventually be developed into an integrated hatchery/natural program. Specific strategies include moving toward in-basin rearing of hatchery spring Chinook salmon for better local adaptation of the Deschutes stock, working with the Confederated Tribes of Warm Springs to evaluate reintroduction and explore alternatives if the existing program is not successful, working with the Confederated Tribes of Warm Springs to develop a sliding scale for take of wild spring Chinook salmon broodstock for the integrated hatchery program, and installing an adult fish ladder and fish trap at Moving Falls to remove stray hatchery spring Chinook salmon from natural spawning areas.[52] The recovery strategy also includes reevaluation of the program at some point and exploration of alternatives (including alternative broodstock) if the current program is not successful.

The historical spring Chinook salmon population also is extirpated in the White Salmon subbasin because Condit Dam, which is operated by PacifiCorp, blocks access to virtually all historical spawning habitat. Under the terms of a 1999 FERC decommissioning agreement and a 2006 Biological Opinion, PacifiCorp breached Condit Dam in October 2011 and is expected to have completed removal by August 2012. The White Salmon Working Group, which is composed of Federal, state, and tribal fisheries

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[51] Some natural production is occurring in the Hood subbasin. At this time, the origin of that natural production is unknown.
[52] Note that ODFW 2010, p. 270, action ID 300 - HD, describes plans for a floating weir; subsequently, managers determined that a fish ladder and trap were more appropriate in this location.

managers as well as representatives of PacifiCorp, has recommended that once the dam is removed, natural escapement and production be monitored over a 4- to 5-year period, at which point the need and suitability for hatchery supplementation would be evaluated. If hatchery supplementation is needed, the working group has recommended that an integrated Klickitat hatchery spring Chinook salmon stock be developed and used as the brood source for juvenile release into the White Salmon subbasin.

The working group has noted that the 4- to 5-year monitoring period also will allow time to explore production capacity at the Klickitat Hatchery and develop the integrated spring Chinook salmon broodstock. The working group determined that the Klickitat Hatchery spring Chinook salmon program would be the best source of broodstock for reintroduction to the White Salmon, even though it is not part of the Lower Columbia River Chinook salmon ESU. Two other potential broodstock sources are the Lewis River hatchery spring Chinook salmon program in Washington and the Sandy River spring Chinook salmon program in Oregon. The Lewis River program was excluded from consideration for use in the White Salmon because it is needed for reintroduction efforts in the Lewis subbasin, and production in the Sandy River is constrained by broodstock collection and funding shortfalls (NMFS 2011b).

In both the Hood and White Salmon subbasins, managers are either using (in the Hood) or considering using (in the White Salmon) out-of-ESU broodstock for reintroduction efforts. In general, these subbasins are in a transition area between the Lower Columbia and Mid-Columbia ESUs. The Deschutes population appears more aligned with the Mid-Columbia ESU and the Hood population with the Lower Columbia ESU, although geographically these subbasins are clearly part of a transitional area. There has been discussion among NMFS scientists about whether to recommend assigning populations in the Klickitat and White Salmon subbasin to the Lower Columbia or Mid-Columbia ESU. In its most recent 5-year review, NMFS noted the transitional nature of this area and that it would be reasonable to assign the Klickitat spring Chinook population to either ESU but recommended maintaining the existing ESU boundaries (75 *Federal Register* 50448). In addition, options for broodstock in the White Salmon and Hood subbasins are limited by extirpations and other factors.

In the case of the Hood population, NMFS is supportive of efforts to reestablish natural production in the Hood subbasin. As noted above, the current hatchery program in the subbasin uses broodstock from the adjacent Deschutes River hatchery program, a Mid-Columbia ESU stock. The natural stock restoration strategy for the Hood River should include periodic genetic assessments to determine whether there are indications of local adaptation and/or contributions representative of the Lower Columbia fall Chinook lineage. NMFS will work with co-managers throughout the implementation and adaptive management process to consider options for incorporating fish from the Lower Columbia Chinook salmon ESU into the Hood River population and to evaluate the most appropriate ESU membership of this population.

NMFS also supports efforts to reestablish natural production in the White Salmon subbasin, either through recolonization or through hatchery reintroduction, as appropriate, after Condit Dam is removed. (The dam was breached in October 2011, with complete removal expected by August 2012.) Because NMFS noted in its most recent 5-year review (76 *Federal Register* 50448) that it would be reasonable to reassign the Klickitat population to either the Middle Columbia or the Lower Columbia River Chinook salmon ESU, the use of Klickitat stock for reintroduction in the White Salmon subbasin provides a more fluid situation in terms of ultimate ESU membership than does the use of Deschutes stock in the Hood subbasin. As in the Hood, NMFS expects that future 5-year reviews will reevaluate the most appropriate ESU membership for Klickitat and White Salmon populations.[53]

7.4.3.7 Predation Strategy

The regional predation strategy (see Section 4.6.2) involves reducing predation by birds, fish, and marine mammals and will benefit all Lower Columbia ESUs, including spring Chinook salmon.

7.4.3.8 Critical Uncertainties

Each aspect of the spring Chinook salmon recovery strategy has a number of critical uncertainties. For all ESUs, there are uncertainties regarding how habitat actions will translate into changes in productivity and capacity (Roni et al. 2011). Prioritizing and identifying next steps in resolving uncertainties is a near-term priority. Critical uncertainties specific to the Lower Columbia River spring Chinook salmon recovery strategy include the following:

- Effective methods of providing adequate downstream passage efficiency for juveniles migrating past tributary dams
- Effectiveness of natural recolonization (White Salmon) and hatchery reintroduction programs (Cowlitz, Lewis, Hood) and the pace at which these populations become functioning and self-sustaining; appropriate stock to use where reintroduction is necessary
- Productivity of reintroduced stocks in upper portions of subbasins
- Effectiveness of efforts to reduce straying in the Sandy and Hood subbasins now that Marmot and Powerdale dams have been removed
- Short-term and long-term survival benefits and risks at the population scale as a result of changes in hatchery production, changes in hatchery operation, and under various harvest rates
- How to reduce the risks of harvest of very small populations while still maintaining harvest opportunities on hatchery-origin fish

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[53] The NMFS Recovery Implementation Science Team is currently developing a two-part report on the subject of reintroductions in the Columbia River Basin. The first part will address general principles for planning and implementing a reintroduction effort for anadromous salmonids. The second part will evaluate the biological benefit of a reintroduction in Columbia Basin regions from which anadromous salmonids have been extirpated. The final report is expected in 2012.

- Adequacy of actions to protect and restore watershed processes in maintaining habitat quality in upper basins (where spring Chinook salmon spawn) in the face of climate change
- Degree of pinniped predation on spring Chinook salmon in the Columbia River estuary
- The historical role of the Gorge populations and the appropriate persistence probabilities for these populations
- Most appropriate boundary between the Mid-Columbia and Lower Columbia river Chinook salmon ESUs[54]

These critical uncertainties represent preliminary priorities identified by Oregon and Washington recovery planners and NMFS Northwest Regional Office and Northwest Fisheries Science Center staff during a November 2010 workshop. They are preliminary priorities only (and are not in ranked order); as described in Chapter 10 additional discussion among local recovery planners and NMFS staff will be needed to finalize future research priorities for Lower Columbia River steelhead.

The management unit plans identify more comprehensive critical uncertainties and research, monitoring, and evaluation needs that, along with the list above, will provide the basis for these future discussions. The White Salmon and Washington management unit plans have discrete sections on critical uncertainties for all of the ESUs in general (see Section 8.3 of NMFS 2011b, pp. 8-4 through 8-6, and Section 9.6 of LCFRB 2010a, pp. 9-68 through 9-73), while the Oregon management unit plan embeds relevant critical uncertainties within subsections on monitoring and evaluation needs related to the four VSP parameters and five ESA listing factors (see Sections 8.4 and 8.5, respectively, of ODFW 2010). In addition, in June 2010, the *Lower Columbia Fish Recovery Board completed the Research, Monitoring, and Evaluation Program for Lower Columbia Salmon and Steelhead* as a companion to its recovery plan (LCFRB 2010b). This document also describes critical uncertainties. The list above also does not include critical uncertainties that apply to multiple ESUs; these will be discussed and considered as decisions are made in implementation. In addition, the critical uncertainties above are of a technical nature; there are also many critical uncertainties related to social, political, and economic issues.

Critical uncertainties are one element of research, monitoring, and evaluation (RME) and adaptive management, which will be key components of the spring Chinook salmon recovery strategy (see Chapter 10 for more discussion of RME and adaptive management for this recovery plan).

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[54] In its 2011 5-year review (NMFS 2011c), NMFS discussed uncertainties regarding the most appropriate boundary between the Mid-Columbia and Lower Columbia River ESUs. NMFS stated that, given the transitional nature of the Klickitat River Chinook salmon population, it might be reasonable either to reassign that population from the Middle Columbia to the Lower Columbia River Chinook salmon ESU or to maintain the existing ESU boundary. NMFS recommended maintaining the existing boundary but will reexamine the issue in future 5-year reviews as new information becomes available.

7.5 Fall Chinook Salmon Analysis: Limiting Factors, Threat Reductions, and Recovery Strategies

7.5.1 Fall Chinook Salmon Limiting Factors

The tule fall Chinook salmon component of the Lower Columbia River Chinook salmon ESU is limited by a combination of factors: widespread habitat degradation in both tributaries and the Columbia River estuary; a history of high harvest rates and large-scale hatchery production, with associated population depletions, reductions in productivity, and loss of genetic diversity; the effects of tributary and mainstem dams on critical downstream habitat; and predation by native fish, birds, and marine mammals. In addition, the productivity and diversity of fall Chinook salmon continue to be affected by ongoing straying of hatchery fish, and harvest impacts continue to be significant. For some populations, spatial structure is constrained by dams; for many more populations, spatial structure is constrained by urban, agricultural, and transportation development in lowland areas; development also contributes to losses in abundance as habitat quality is reduced.

Table 7-7 and the text that follows summarize baseline limiting factors and threats for Lower Columbia River fall Chinook salmon strata based on population-specific limiting factors and threats identified in the management unit plans. In cases where conditions have changed significantly since the management unit plans' analyses of limiting factors and threats (e.g., if harvest rates have dropped or a dam is no longer present), this is noted in the text. Unless otherwise noted, NMFS agrees that the management unit plans' identification of limiting factors provide a credible hypothesis for understanding population performance and identifying management actions.

Because the individual management unit plans used somewhat different terms in identifying limiting factors, NMFS has translated those terms into standardized and more general terminology taken from a NMFS "data dictionary" of possible ecological concerns that could affect salmon and steelhead (Hamm 2012; see Section 5.4). In addition, in Table 7-7, NMFS has rolled up the population-specific limiting factors (see Appendix H) to the stratum level—a process that has resulted in some loss of specificity.

In addition, each management unit plan used a different approach for identifying limiting factors and threats (see Section 5.3). One difference relevant to the crosswalk is that while the Oregon management unit plan identified primary and secondary limiting factors for each population in each threat category,[55] the Washington management unit plan categorized limiting factors in this way only for habitat-related limiting factors, and the White Salmon plan and the estuary module did not use the primary and secondary terminology. For the crosswalk and this table, NMFS assigned primary and secondary status to non-habitat limiting factors for Washington populations (based on the Washington management unit plan's quantification of threat impacts, and the professional judgment of Lower Columbia Fish Recovery Board's staff and consultants). For populations that historically spawned in the White Salmon subbasin, NMFS staff inferred primary and secondary designations based on discussion in the Washington

[55] In the Oregon management unit plan, primary limiting factors are those that have the greatest impact and secondary limiting factors have a lesser but still significant impact.

and White Salmon management unit plans (LCFRB 2010a, NMFS 2011b). It is likely that some apparent distinctions in results between Washington and Oregon populations are artifacts of differences in limiting factor assessment methodologies and not an actual difference in conditions or their effects on salmon and steelhead populations. In addition, there is not necessarily a bright line between primary and secondary limiting factor designations. Nevertheless, NMFS believes that the designations are useful, particularly for looking across ESUs and populations and identifying patterns (see Chapter 4).

The management unit plans provide more detail on limiting factors and threats affecting Lower Columbia River fall Chinook salmon, including magnitude, spatial scale, and relative impact, see the management unit plans (LCFRB 2010a, Chapter 3 and various sections of Volume II; ODFW 2010, pp. 116 to 128; and NMFS 2011b, Chapter 5).[56] For a regional perspective on limiting factors and threats that affect multiple salmon and steelhead ESUs, see Chapter 4 of this recovery plan. For a description of the data dictionary and the "crosswalk" tables that NMFS used to correlate management unit terms for limiting factors with the standardized NMFS terminology at the population scale, and the approach for rolling up from the population to the stratum scale, see Section 5.4 and Appendix H.

Management unit recovery planners in Oregon and Washington recognized that six major categories of manageable threats—tributary habitat, estuary habitat, hydropower, harvest, hatcheries, and predation—were useful as an organizing construct for grouping limiting factors, quantifying impacts on population productivity, and determining how much different categories of threats would need to be reduced to close the gap between baseline and target population status. Planners in both Washington and Oregon quantified the impacts of each of these major threat categories on population status, along with a reduction in each impact that would be consistent with achieving population target status. The results of that analysis are presented in Section 7.5.2 and provide a related but slightly different perspective on limiting factors. The threat reduction targets also allow actions to be scaled to achieve a specific impact reduction, and to be linked to monitoring and performance benchmarks.

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[56] Limiting factors shown in the table for the White Salmon population reflect information from both the Washington (LCFRB 2010a) and White Salmon (NMFS 2011b) management unit plans.

Table 7-7

Baseline Limiting Factors and Threats Affecting LCR Fall Chinook Salmon: Stratum-Level Summary

Ecological Concern	Threat(s)	VSP Parameters Affected	Coast Fall	Cascade Fall	Gorge Fall
Tributary Habitat Limiting Factors					
Riparian Condition	Past and/or current land use practices	All	Secondary for Elochoman juveniles, primary for juveniles in all other populations	Secondary for Washougal juveniles, primary for juveniles in all other populations	Secondary for White Salmon juveniles, primary for juveniles in all other populations
Channel Structure and Form	Past and/or current land use practices/ transportation corridor	All	Secondary for Elochoman juveniles, primary for juveniles in all other populations	Secondary for Washougal juveniles, primary for juveniles in all other populations	Secondary for White Salmon juveniles, primary for juveniles in all other populations
Peripheral and Transitional Habitats: Side Channel and Wetland Conditions	Past and/or current land use practices/ transportation corridor	All	Secondary for Elochoman juveniles, primary for juveniles in all other populations	Secondary for Washougal juveniles, primary for juveniles in all other populations	Primary for Upper and Lower Gorge and Hood juveniles
Peripheral and Transitional Habitats: Floodplain Conditions	Past and/or current land use practices/ transportation corridor	All	Secondary for Elochoman juveniles, primary for juveniles in all other populations	Secondary for Washougal juveniles, primary for juveniles in all other populations	Primary for Upper and Lower Gorge and Hood juveniles
Sediment Conditions	Past and/or current land use practices/ transportation corridor	All	Primary for WA juveniles, secondary for juveniles in OR populations[57]	Secondary for OR and Washougal juveniles, primary for juveniles in all other WA populations	Secondary for Hood and White Salmon juveniles
Water Quality (Temperature)	Land uses that impair riparian function/decrease streamflow, dams	A,P,D	Primary for juveniles in WA populations	Primary for Toutle, Coweeman, Kalama, and Lewis juveniles, secondary for Clackamas (land use and dams), Sandy, Salmon Creek, and Washougal juveniles.	
Water Quantity (Flow)	Dams, land use, and water withdrawals for irrigation, municipal uses, and hatchery operations	All	Primary for Youngs Bay and Big Creek, and Scappoose juveniles, secondary for Grays adults, secondary for juveniles in all	Secondary for juveniles in all populations	Secondary for Upper and Lower Gorge and Hood juveniles (land use and dams); primary for Hood juveniles (irrigation withdrawals)

[57] This distinction is likely an artifact of differences in limiting factor assessment methodologies between the two states and not an actual difference in sediment conditions in tributary streams or their effects on fall Chinook populations.

Table 7-7

Baseline Limiting Factors and Threats Affecting LCR Fall Chinook Salmon: Stratum-Level Summary

Ecological Concern	Threat(s)	VSP Parameters Affected	Coast Fall	Cascade Fall	Gorge Fall
			other populations		
Estuary Habitat Limiting Factors[58]					
Toxic Contaminants	Agricultural chemicals, urban and industrial practices	A,P,D	Secondary for juveniles in all populations		
Food[59] (Shift from macrodetrital- to microdetrital-based food web)	Dam reservoirs	All	Secondary for juveniles in all populations		
Peripheral and Transitional Habitats: Estuary Condition	Past and/or current land use practices, transportation corridor, mainstem dams	All	Primary for juveniles in all populations		
Channel Structure and Form	Past and/or current land use practices/ transportation corridor	All	Primary for juveniles in all populations		
Sediment Conditions	Past and/or current land use practices/transportation corridor, dams	All	Primary for juveniles in all populations		
Water Quality (Temperature)	Land uses that impair riparian function/decrease streamflow, dam reservoirs	A,P,D	Secondary for juveniles in all populations		
Water Quantity (Flow)	Columbia River mainstem dams	All	Primary for juveniles in all populations		

58 The Washington and Oregon management unit plans both relied on the *Columbia River Estuary ESA Recovery Plan Module for Salmon and Steelhead* (NMFS 2011a) for information on estuary limiting factors, but there were some differences in how the plans translated the information into limiting factors experienced at the population level. The estuary module does not designate limiting factors as primary or secondary; instead, it ranks them in terms of assumed impact on ocean- and stream-type salmonids. Because the Oregon management unit plan integrated the module information with more specificity than did the Washington management unit plan, and because NMFS assumes that estuarine limiting factors affect all populations equally within the ESU, the estuarine limiting factors in this table and Section 7.4.1.2 reflect the determinations in the Oregon management unit plan, applied to all Lower Columbia River fall Chinook salmon populations, unless otherwise noted. As with other limiting factors, the designations of estuarine limiting factors as primary or secondary reflect working hypotheses that will need to be tested (and possibly revised) through adaptive management.

59 Although the Oregon management unit plan lists food web shifts as a primary limiting factor in the estuary, NMFS and the management unit planners agreed to consider such shifts secondary in this recovery plan to more closely reflect conclusions in the *Columbia River Estuary ESA Recovery Plan Module for Salmon and Steelhead* (NMFS 2011a). The extent to which food web shifts limit salmonid survival in the estuary is unclear.

Table 7-7

Baseline Limiting Factors and Threats Affecting LCR Fall Chinook Salmon: Stratum-Level Summary

Ecological Concern	Threat(s)	VSP Parameters Affected	Coast Fall	Cascade Fall	Gorge Fall
Hydropower Limiting Factors					
Habitat Quantity (Access)	Bonneville Dam	All			Secondary for adults and juveniles in all populations
Habitat Quantity (Inundation)	Bonneville Dam	All			Primary for Upper Gorge adults and juveniles, secondary for Hood juveniles and White Salmon adults
Habitat Quantity (Access)	Tributary Dams	All		Primary for Upper Cowlitz adults and juveniles, secondary for Sandy juveniles	Primary for White Salmon adults and juveniles, secondary for Hood adults and juveniles
Harvest Limiting Factors					
Direct Mortality	Fisheries	A,D	Primary for adults in all populations	Primary for adults in all populations	Primary for adults in all populations
Hatchery Limiting Factors					
Food[60]	Smolts from all Columbia Basin hatcheries competing for food and space in the estuary	All	Secondary for juveniles in all populations		
Population Diversity	Stray hatchery fish interbreeding with wild fish	A,P,D	Primary for adults in all populations	Secondary for Coweeman adults, primary for adults in all other populations	Secondary for White Salmon adults, primary for adults in all other populations
Predation Limiting Factors					
Direct Mortality	Land use	A,P,D	Secondary for juveniles in all populations		
Direct Mortality	Dams	A,P,D			Secondary for Upper Gorge and Hood juveniles (non-salmonid fish)

[60] Some scientists suspect that closely spaced releases of hatchery fish from all Columbia Basin hatcheries may lead to increased competition with natural-origin fish for food and habitat space in the estuary. NMFS 2011a and LCFRB (2010) identified competition for food and space among hatchery and natural-origin juveniles in the estuary as a critical uncertainty. ODFW (2010) acknowledged that uncertainty but listed competition for food and space as a secondary limiting factor for juveniles of all populations. The NMFS Northwest Region and Northwest Fisheries Science Center are working to better define and describe the scientific uncertainty associated with ecological interactions between hatchery-origin and natural-origin salmon in freshwater, estuarine, and nearshore ocean habitats.

7.5.1.1 Tributary Habitat Limiting Factors

Impaired side channel and wetland conditions, along with degraded floodplain habitat, have significant negative impacts on juvenile tule fall Chinook salmon throughout the ESU and are identified as primary limiting factors for all populations except the Elochoman/Skamokawa, Washougal, and White Salmon, where they are identified as secondary factors. Extensive channelization, diking, wetland conversion, stream clearing, and, in some subbasins, gravel extraction have barred tule Chinook salmon from historically productive habitats and simplified much of the remaining tributary habitats, weakening watershed processes that are essential to the maintenance of healthy ecosystems. Degraded riparian conditions and channel structure and form issues are also a primary limiting factor for all populations except the Elochoman/Skamokawa, Washougal, and White Salmon, where they are identified as secondary factors. The lack of large woody debris and appropriately sized gravel in the remaining accessible tributary habitat has significantly reduced the amount of suitable spawning and rearing habitat for tule fall Chinook salmon.

Sediment conditions are identified as a primary limiting factor for all Washington populations except the Washougal and White Salmon (for which they are considered a secondary limiting factor) and are identified as a secondary limiting factor for the Oregon portion of the ESU.[61] The high density of forest and rural roads throughout the area, as well as timber harvest practices and other land use patterns on unstable slopes adjacent to riparian habitat, contributes to an abundance of fine sediment in tributary streams. The resulting excess fine sediment covers spawning gravel, limiting egg development and incubation, and increases turbidity. In addition, water quality, specifically elevated water temperature brought about through land use, lack of functioning riparian habitat, and dam reservoirs, is a primary limiting factor for most Washington populations, along with the Clackamas and Sandy populations.

In the Coast fall Chinook stratum, tributary habitat limiting factors are largely the same as those described above for fall Chinook salmon as a whole. However, for the Youngs Bay, Big Creek, and Scappoose tule fall Chinook salmon populations, water quantity issues related to altered hydrology and flow timing also have been identified as a primary limiting factor. These water quantity issues are caused by land use practices on upland slopes that have reduced soil stability and vegetative cover, increased impermeable surfaces, and altered drainage systems, resulting in altered water storage and delivery to streams. Many stream systems have higher peak flows and lower base flows than they did historically (ODFW 2010). Past and current land uses in Coast ecozone watersheds have led to these conditions. Private and state forest land predominates in the upper reaches of these watersheds. Lower reaches are mostly in agricultural and rural residential use and have been extensively modified by bank stabilization, levees, and tide gates.

For the Cascade fall Chinook stratum, tributary habitat limiting factors are largely the same as those described above for fall Chinook salmon as a whole, except that spawning

[61] This distinction most likely is an artifact of differences in the limiting factor assessment methodologies used by Oregon and Washington and not an actual physical difference in sediment conditions in tributary streams or their effects on Chinook populations.

by the Clackamas, Sandy,[62] and Cowlitz fall Chinook salmon populations is also negatively by impaired gravel recruitment related to tributary dams. Land uses that have led to the conditions limiting habitat productivity in this stratum include forest management and timber harvest, agriculture, rural residential and urban development, and gravel extraction. A mix of private, state, and Federal forest land predominates in the upper mainstem and headwater tributaries of the Cascade subbasins, while the lower mainstem and tributary reaches of most subbasins are characterized by agricultural and rural residential land use, with some urban development, especially in the Salmon Creek and lower Clackamas subbasins. The Oregon management unit plan notes that in the Clackamas subbasin, high water temperatures are attributed in part to hydropower reservoirs.

A unique issue in the Cascade fall Chinook stratum is legacy effects in the Toutle subbasin of the 1980 Mount St. Helen's eruption. The North Fork Toutle in particular was heavily affected by sedimentation from the eruption. A sediment retention structure was constructed on the North Fork Toutle in an attempt to prevent continued severe sedimentation of stream channels and associated flood conveyance, transportation, and habitat degradation problems. The structure currently blocks access to as many as 50 miles of habitat for anadromous fish. Although fish are transported around the structure via a trap and haul system, the structure remains a source of chronic fine sediment to the lower river; this reduces habitat quality and has interfered with fish collection at the base of the structure.

In the Gorge fall Chinook stratum, tributary habitat limiting factors are largely the same as those described above for fall Chinook salmon as a whole, save for some unique water quantity and habitat issues. Water quantity problems caused by irrigation withdrawals and low-head hydro diversions have been identified as primary limiting factors for the Hood population. Degraded habitat quality resulting from transportation corridor development and maintenance is considered a primary threat for the Upper and Lower Gorge populations and for Hood juveniles. These limiting factors result from past and current land uses that include a mix of private, state, and Federal forest land in the upper mainstem and headwater reaches of the Gorge subbasins, and agricultural and rural residential land use, with some urban development, in lower mainstem and tributary reaches. Highway and transportation corridors run parallel to the Columbia River shoreline, traversing all creek drainages in ways that restrict access and disconnect upland and lowland habitat processes. Upper Gorge fall Chinook salmon also face habitat issues caused by inundation from Bonneville Reservoir.

Habitat within the White Salmon subbasin was altered by the breaching of Condit Dam (in October 2011, with full removal expected by August 2012). Alterations include near-term negative effects from sediment release and scouring. Scientists and managers expect long-term positive effects as the result of restoration of natural flow regimes and sediment transport, but monitoring is needed to evaluate habitat and fish response to

[62] Gravel recruitment may have improved since the removal of Marmot and Little Sandy dams in 2009; however, the Oregon management unit plan also identifies gravel recruitment as a result of the city of Portland's water supply system in the Bull Run watershed as a secondary limiting factor for the Sandy fall Chinook populations (ODFW 2010, p. 116).

dam removal, and additional assessment of habitat limiting factors will be needed to refine understanding of limiting factors.

7.5.1.2 Estuary Habitat Limiting Factors[63]

Estuary habitat conditions are important for juvenile fall Chinook salmon, which spend considerable time rearing in the estuary. Water quantity issues related to altered hydrology and flow timing are identified as a primary limiting factor for all populations, as is impaired sediment and sand routing; these limiting factors are associated with hydroregulation at large storage reservoirs in the interior of the Columbia Basin, and, in the case of sediment issues, land uses both past and present. Much of the land surrounding the Columbia River estuary is in agricultural or rural residential use and has been extensively modified via dikes, levees, bank stabilization, and tide gates. Altered hydrology and sediment routing influence habitat-forming processes, the quantity and accessibility of habitats such as side channels and wetlands, the dynamics of the Columbia River plume, and the estuarine food web. Channel structure issues, in the form of reduced habitat complexity and diversity, and reduced access to peripheral and transitional habitats such as side channels and wetlands also are identified as primary limiting factors for juveniles from all populations. Again, simplification of channel structure is related to conversion of land to other uses—agricultural, rural residential, and as a transportation corridor—while juveniles' access to side channels and wetlands is impaired by these same land uses but also by flow alterations caused by mainstem dams.

Secondary limiting factors in the estuary that affect tule fall Chinook salmon are exposure to toxic contaminants (from urban, agricultural, and industrial sources) and elevated late summer and fall water temperatures, which are related to (1) land use practices that impair riparian function or decrease streamflow, and (2) large hydropower reservoirs. Altered food web dynamics involving a transition from a macrodetrital-based food web to a microdetrital-based food web also are considered a secondary limiting factor for all populations.[64] These changes in the estuarine food web are caused primarily by increased microdetrital inputs from hydropower reservoirs and the loss of wetland habitats through diking and filling.

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[63] The Washington and Oregon management unit plans both relied on the *Columbia River Estuary ESA Recovery Plan Module for Salmon and Steelhead* (NMFS 2011a) for information on estuary limiting factors, but there were some differences in how the plans translated the information into limiting factors experienced at the population level. The estuary module does not designate limiting factors as primary or secondary; instead, it ranks them in terms of assumed impact on ocean- and stream-type salmonids. Because the Oregon management unit plan integrated the module information with more specificity than did the Washington management unit plan, and because NMFS assumes that estuarine limiting factors affect all populations equally within the ESU, the estuarine limiting factors in this section and in Table 7-7 reflect the determinations in the Oregon management unit plan, applied to all Lower Columbia River fall Chinook salmon populations, unless otherwise noted. As with other limiting factors, the designations of estuarine limiting factors as primary or secondary reflect working hypotheses that will need to be tested (and possibly revised) through adaptive management.

[64] Although the Oregon management unit plan lists food web shifts as a primary limiting factor in the estuary, NMFS and the management unit planners agreed to consider such shifts secondary in this recovery plan to more closely reflect conclusions in the *Columbia River Estuary ESA Recovery Plan Module for Salmon and Steelhead* (NMFS 2011a). The extent to which food web shifts limit salmonid survival in the estuary is unclear.

For the Coast stratum populations in particular, improvements to estuary habitat may be crucial. Habitat analysis indicates that populations in the Coast ecozone historically relied on wetland areas at the confluences of the tributaries and the mainstem Columbia (Northwest Fisheries Science Center 2010).

7.5.1.3 Hydropower Limiting Factors

Direct hydropower impacts are low on most Lower Columbia River fall Chinook salmon populations, with the exception of the Upper Cowlitz, the Sandy, and the Gorge stratum populations. Flow management operations at large storage reservoirs in the interior of the Columbia Basin (Grand Coulee, Dworshak, etc.) affect all juvenile Lower Columbia River fall Chinook salmon in the lower mainstem and estuary, and potentially in the plume—primarily by altering flow volume and timing. These alterations impair sediment routing, influence habitat-forming processes, reduce access to peripheral habitat, and change the dynamics of the Columbia River plume and the estuarine food web (see Section 7.5.1.2).[65] Moreover, the large reservoirs associated with mainstem dams contribute to elevated water temperatures downstream in late summer and fall. For the Upper Gorge, Hood, and White Salmon populations, which spawn above Bonneville Dam, passage issues at Bonneville and inundation of historical spawning habitat by Bonneville Reservoir are identified as secondary limiting factors.

There are no large tributary dams in the Coast ecozone, but tributary dams affect Cascade and Gorge fall Chinook salmon populations. In the Cascade fall Chinook stratum, impaired habitat access and passage caused by tributary hydropower are identified as a primary limiting factor for the Upper Cowlitz fall Chinook salmon population. The hatchery Barrier Dam in the Cowlitz subbasin prevents all volitional passage of anadromous fish above RM 49.5. Passage of downstream fry for the Sandy fall Chinook salmon population also was identified as a secondary limiting factor; however, the PGE Bull Run Hydroelectric Project (consisting of Marmot and Little Sandy dams) in the Sandy subbasin was removed in 2007-2008, so this limiting factor has been addressed for the Sandy fall Chinook population. There are no tributary hydropower facilities in the Coweeman, Toutle, Kalama, East Fork Lewis, Salmon Creek, or Washougal subbasins.[66] The Clackamas River Hydro Project was not identified as a hydropower threat for the Clackamas fall Chinook salmon population, but the project does affect downstream habitat; these impacts are accounted for under the tributary habitat limiting factor. In Washington, the Merwin, Yale, and Swift dams block passage to the Upper North Fork Lewis (beginning with Merwin Dam at RM 20). However, recovery efforts for the Lewis River fall Chinook salmon population are focused in the East Fork and lower North Fork Lewis subbasins, so the Merwin, Yale, and Swift dams are not identified as a limiting factor for fall Chinook salmon. Spawning and rearing habitats for the Lower Cowlitz and Lewis River fall Chinook salmon populations are adversely affected by flow regulation in the Cowlitz and Lewis river hydropower systems, respectively (LCFRB 2010a).

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[65] It is likely that flow impacts of the hydropower system affect Lower Columbia River ESUs more through changes in habitat-forming processes (including impacts to the plume) and food web impacts than through changes in migratory travel time.

[66] However, the North Fork Toutle sediment retention structure currently blocks access to as many as 50 miles of habitat for anadromous fish.

In the Gorge fall Chinook stratum, tributary hydropower impacts are identified as a primary limiting factor for the White Salmon fall Chinook salmon population (because Condit Dam has blocked all upstream passage on the White Salmon River) and a secondary limiting factor for the Hood population (because of impaired access to historical spawning habitat). Powerdale Dam on the Hood River was removed in 2010, so that limiting factor has been addressed. Condit Dam was breached in October 2012 and is scheduled to be completely removed by August 2012, so that limiting factor is in the process of being addressed. Tributary hydropower is not a limiting factor for the Lower Gorge or Upper Gorge populations. However, for the three tule fall Chinook salmon populations that spawn above Bonneville Dam (the Hood, White Salmon, and Upper Gorge), passage issues at the dam and inundation of historical habitat by Bonneville Reservoir are secondary limiting factors.

7.5.1.4 Harvest Limiting Factors

Harvest-related mortality is identified as a primary limiting factor for all tule fall Chinook salmon populations. Tule fall Chinook salmon harvest occurs primarily in Alaskan and Canadian ocean fisheries regulated under the U.S.-Canada Pacific Salmon Treaty. Additional harvest occurs in U.S. ocean commercial, tribal, and recreational fisheries off the Washington Coast and in mainstem Columbia River gillnet and recreational fisheries. Harvest impacts were as high as 69 percent during the years 1983 to 1993. Since then they have been lowered steadily and significantly. For example, from 1999 to 2006, harvest rate averaged 48 percent; tule fall Chinook salmon harvest rates recently have been further reduced—to 38 percent in 2009 and 2010 and 37 percent in 2011 (NMFS 2008c). Harvest impacts on the Youngs Bay and Big Creek populations are higher—estimated by ODFW to average 75 and 65 percent, respectively, from 1997 to 2007—as a result of terminal fisheries targeting hatchery-origin fish in those subbasins. The Upper Gorge, Hood, and White Salmon populations also are subject to slightly higher harvest rates than the average for the ESU because they are intercepted in Zone 6 tribal fisheries above Bonneville Dam.

7.5.1.5 Hatchery-Related Limiting Factors

Most fall Chinook salmon currently returning to lower Columbia tributaries are produced in hatcheries operated to produce fish for harvest. Hatchery production has been reduced from its peak in the late 1980s but continues to threaten the productivity of Lower Columbia River fall Chinook salmon. Population-level effects resulting from hatchery fish interbreeding with natural-origin fish are a primary limiting factor for all populations. Hatchery straying, combined with past stock transfers, has likely altered the genetics of fall Chinook salmon populations and may have reduced diversity within the ESU. Out-of-ESU Rogue River bright fall Chinook salmon released into Youngs Bay to support terminal harvest have been recovered in the Grays River, potentially affecting genetics and diversity within that population. Productivity also has likely declined as a result of the influence of hatchery-origin fish. In addition, many scientists suspect that competition with or predation by hatchery-origin fall Chinook salmon affects natural population productivity.

Some scientists suspect that closely spaced releases of hatchery fish from all Columbia Basin hatcheries may lead to increased competition with natural-origin fish for food and habitat space in the estuary. NMFS (2011a) and LCFRB (2010a) identified competition for food and space among hatchery and natural-origin juveniles in the estuary as a critical uncertainty. ODFW (2010) acknowledged that uncertainty but listed competition for food and space as a secondary limiting factor for juveniles of all populations. The NMFS Northwest Region and Northwest Fisheries Science Center are working to better define and describe the scientific uncertainty associated with ecological interactions between hatchery-origin and natural-origin salmon in freshwater, estuarine, and nearshore ocean habitats.

7.5.1.6 Predation Limiting Factors

Direct mortality from predation is a secondary limiting factor for all fall Chinook salmon populations. Anthropogenic changes to habitat structure have increased predator abundance and effectiveness and led to increased predation by Caspian terns, double-crested cormorants, and various other seabird species in the Columbia River estuary and plume. Predation by non-salmonid fish (primarily northern pikeminnows) throughout the freshwater portions of the lower Columbia mainstem, but primarily at Bonneville Dam and hatchery release locations, is a secondary limiting factor for Upper Gorge and Hood juvenile tule fall Chinook salmon populations.

7.5.2 Fall Chinook Salmon Baseline Threat Impacts and Threat Reduction Targets

Table 7-8 shows the estimated impact on each Lower Columbia River fall Chinook salmon population resulting from potentially manageable threats, organized into six threat categories: tributary habitat degradation, estuary habitat degradation, hydropower, harvest, hatcheries, and predation. Both baseline and target impacts are shown, with the targets representing mortality levels that would be consistent with long-term recovery goals. Impact values indicate the percentage reduction in abundance and productivity that is attributable to human activities related to a particular threat category. The value associated with any particular threat category can be interpreted as the percent reduction in abundance and productivity from historical conditions if that threat category were the only one affecting the population. Cumulative values (both baseline and target) are multiplicative rather than additive. The table also shows the percentage improvements in population productivity and abundance (i.e., the percentage improvement in survival) that is needed to achieve the target impacts and corresponding population status.[67] For populations where the survival improvement needed is larger than 500 percent, Table 7-8 does not report the exact value, in part because the value is highly uncertain.[68]

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[67] The percentage of survival improvement needed is the percentage change in net impacts, is derived from information in the Washington and Oregon management unit plans, and is calculated as follows: $[(1-\text{Cumulative}_{\text{Target}})-(1-\text{Cumulative}_{\text{Baseline}})]/[1-\text{Cumulative}_{\text{Baseline}}] \times 100$. These values generally correspond to population improvement targets identified for Washington populations in LCFRB (2010). Comparable numbers are not explicitly reported in ODFW (2010) but are implicit in the modeling approach that Oregon recovery planners used to derive target impacts.

[68] For some populations—many of them small—the survival improvement needed is very large and highly uncertain because various other factors also are uncertain (i.e., the population's baseline persistence probability, the exact degree of impact of human activities on tributary habitat, and whether the population's response to reductions in impacts will be linear). In addition, very small populations do not necessarily follow predictable patterns in their response to changing conditions.

As an example, the baseline status of the Grays/Chinook fall Chinook salmon population, circa 1999, has been severely reduced by the combined effects of multiple threats. The cumulative reduction in status was estimated at 92.6 percent from the multiplicative impacts of multiple threats acting across the salmon life cycle. Thus, current status is just 7.4 percent of the historical potential with no human impact. Tributary habitat, harvest, and hatchery impacts each accounted for reductions in population productivity of 40 percent or more, with corresponding reductions in abundance, spatial structure, and diversity. The Washington management unit plan identifies a recovery strategy involving significant reductions in the impact of several threats. For instance, the plan targets tributary habitat impacts to be reduced from the estimated baseline level of 40 percent to 16 percent (i.e., an approximately 120 percent improvement relative to baseline conditions). With the targeted reductions in individual impacts, the cumulative effect of all impacts would drop from 92.6 percent at baseline to 81.1 percent at the target status. This change would translate into a 150 percent improvement in survival relative to the baseline. Although the population would still be experiencing abundance and productivity that are 74.7 percent lower than historical conditions, the extinction risk at this mortality level would be estimated sufficient to meet the targets for this plan.

Oregon and Washington recovery planners used somewhat different definitions or methods to quantify the estimated impacts of anthropogenic threats. Baseline impacts for Washington populations reflect conditions prevalent at the time of ESA listing (circa 1999), while the baseline impacts for Oregon populations reflect conditions through 2004. Dam impacts for Washington populations reflect passage mortality, habitat loss caused by inundation, and loss of access to historical production areas; for Oregon populations, the estimates in the “Dams” column of Table 7-8 reflect direct upstream and downstream passage mortality only, with other dam impacts accounted for in the habitat and predation threat categories. Hatchery impacts for Washington populations were limited to not more than 50 percent per population, in accordance with Hatchery Scientific Review Group (HSRG) assessments of the potential for genetic effects (Hatchery Scientific Review Group 2009); Oregon recovery planners estimated that hatchery impacts were equivalent to one-half the rates at which hatchery fish were found on natural spawning grounds, based on analyzed relationships and reflecting concern about genetic and ecological effects. Washington recovery planners derived estimates of impacts to tributary habitat using the Ecosystem Diagnosis and Treatment (EDT) model. Oregon recovery planners estimated the mortality associated with estuary habitat degradation, hydropower, harvest, hatcheries, and predation and assigned all remaining mortality (relative to the difference between the current modeled abundance and estimated historical abundance) to tributary habitat. In general, the tributary habitat values in Table 7-8 have the highest degree of uncertainty relative to the other threat categories and, for Oregon populations, may include causes of mortality associated with the other threat categories but not directly captured in those mortality estimates. (See Section 5.5 for more on the methodologies used to estimate baseline impacts.)

Estimates of threat impacts are useful in showing the relative magnitude of impacts on each population. Given the differences in methodologies, some values in Table 7-8 for Oregon and Washington populations are not necessarily directly comparable. Thus, values for Oregon populations are most directly comparable to those for other Oregon populations, and values for Washington populations are most directly comparable to those for other Washington populations. Regardless of differences in specific threat impact definitions and methods, the net effect of changes from all threats is useful in understanding the magnitude of population improvement needed to achieve the target population status.

The target impacts in Table 7-8 represent one of several possible combinations of threat reductions that could conceivably close the conservation gap and lead to a population achieving its target status. The particular threat reductions shown in Table 7-8 reflect policy decisions and the methodologies and assumptions used by the different recovery planning teams. (For a description of how target impacts were developed, see Section 5.6.) In estimating impacts, management unit recovery planners evaluated each threat category independently (i.e., values in the table reflect the mortality of Chinook salmon exposed to that particular category of threats, whether or not they are exposed to threats in other categories). The estimates of baseline threat impacts have high levels of uncertainty and in many cases should be considered working hypotheses that are testable as part of recovery plan implementation. Despite this uncertainty, it is the expert judgment of NMFS and management unit scientists that, based on the best available information at this time, the estimates of baseline threat impacts provide a reasonable estimate of the relative magnitude of different sources of anthropogenic mortality and serve as an adequate basis for designing initial recovery actions.[69] As more and better information is collected, it will be applied to recovery efforts in an adaptive management framework.

As shown in Table 7-8, the baseline impacts from harvest, hatcheries, and loss and degradation of tributary habitat are significant for every fall Chinook salmon population. Only for the Upper Cowlitz, Upper Gorge, and White Salmon populations does another threat category (hydropower) rise to the level of harvest, hatchery, and tributary habitat impacts. Estuarine habitat impacts likewise consistently affect all populations, although to a lesser degree than tributary habitat impacts.

In the Coast and Cascade strata, much of the gains in fall Chinook salmon viability are targeted to be achieved through reductions in harvest, hatchery, and habitat impacts. This is the case for the Grays/Chinook, Elochoman/Skamokawa, Toutle, East Fork Lewis, Sandy, and Washougal populations. For the Scappoose population, target status is expected to be achieved primarily through reductions in hatchery and harvest impacts. In the Gorge stratum, some threat reductions are also targeted from hydropower actions, as the Upper Gorge, White Salmon, and Hood populations are affected by dam passage issues at Bonneville, Powerdale, and Condit dams. (Powerdale Dam, on the Hood River, was removed in 2010; Condit Dam was breached in October 2011 and is scheduled to be completely removed by August 2012).

Impacts from multiple threat categories will be needed for most populations if they are to achieve their target status. Exceptions are the Youngs Bay, Big Creek, Upper Cowlitz, and Salmon Creek populations. As stabilizing populations, the Youngs Bay, Upper Cowlitz, and Salmon Creek populations are not targeted for reductions in any threat

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[69] As implementation proceeds, research, monitoring, and evaluation and adaptive management will be key in helping to refine scientific understanding of the impact of threats on population persistence and of the extent to which management actions are reducing threats.

impacts. (However, recovery actions will still be needed for these populations to remain at their baseline status of low [for Youngs Bay] or very low.) Both the Youngs Bay and Big Creek populations will be used to provide harvest opportunity through terminal fisheries targeting hatchery fish; consequently, the proportion of hatchery-origin spawners (pHOS) and harvest impacts in these populations are expected to remain high. The Salmon Creek population is not targeted for threat reductions because of the highly urbanized nature of the subbasin and the extent of habitat degradation there. In the Upper Cowlitz subbasin, spring Chinook salmon recovery efforts are the focus of the recovery strategy, so the Upper Cowlitz fall Chinook population is not targeted for improvement in status (although as of 2010, fall Chinook are being transported and released into the Upper Cowlitz).

Four of the 21 fall Chinook salmon populations are targeted for significant reductions in every threat category, including hydropower (in the form of dam removal or improvements in upstream and downstream passage). These populations are the Toutle, Upper Gorge, White Salmon, and Hood. Of these, the Toutle and Hood are designated as primary and the Upper Gorge and White Salmon as contributing. The Hood population is targeted for dramatic and almost certainly unattainable threat reductions (i.e., reducing all threat categories except hydropower to zero).[70]

Reductions in predation are also targeted to contribute to achieving recovery goals for fall Chinook salmon; however, net reductions in predation impacts are smaller than those for the habitat, hatcheries, and harvest categories because the impact of predation threats is less.

More information on threat reduction scenarios, including methodologies used to determine baseline and target impacts, is available in the management unit plans (ODFW 2010, pp. 151-177 and LCFRB 2010a, pp. 4-30 through 4-33, and 6-49 through 6-52).

[70] This is a function of the Oregon recovery planning team setting target status to meet recovery criteria, even if the criteria are likely to be unattainable because of intractable anthropogenic impacts. In addition, Oregon believes that the historical population structure designated in the Gorge stratum should be reassessed. For a discussion of this and other issues related to the Gorge strata and delisting criteria, see Sections 3.2.1 and 7.7.

Table 7-8

Impacts of Potentially Manageable Threats and Impact Reduction Targets Consistent with Recovery of LCR Fall Chinook Salmon Populations

	Impacts at Baseline[71]							Impacts at Target							
Population	**T. Hab[72]**	**Est[73]**	**Dams[74]**	**Harv[75]**	**Hat[76]**	**Pred[77]**	**Cumu-lative[78]**	**T. Hab**	**Est**	**Dams**	**Harv**	**Hat**	**Pred**	**Cumul-ative**	**% Survival Improve-ment Needed[79]**
Coast Fall															
Youngs Bay (OR)	0.72	0.32	0.00	0.75	0.45	0.07	0.9757	0.72	0.26	0.00	0.70	0.45	0.04	0.9672	30
Grays/Chinook (WA)	0.40	0.23	0.00	0.65	0.50	0.09	0.9264	0.16	0.09	0.00	0.26	0.20	0.03	0.5611	>500
Big Creek (OR)	0.80	0.32	0.00	0.65	0.45	0.06	0.9754	0.58	0.26	0.00	0.60	0.45	0.04	0.9344	170
Eloch/Skam (WA)	0.30	0.23	0.00	0.65	0.50	0.09	0.9142	0.21	0.17	0.00	0.46	0.35	0.06	0.7837	150
Clatskanie (OR)	0.99	0.32	0.00	0.60	0.45	0.07	0.9986	0.80	0.26	0.00	0.35	0.05	0.05	0.9132	>500
Mill/Aber/Germ (WA)	0.40	0.23	0.00	0.65	0.49	0.10	0.9258	0.29	0.17	0.00	0.47	0.35	0.07	0.8112	150
Scappoose (OR)	0.80	0.32	0.00	0.60	0.45	0.07	0.9722	0.78	0.26	0.00	0.35	0.05	0.05	0.9045	240
Cascade Fall															
Lower Cowlitz (WA)	0.70	0.23	0.00	0.65	0.50	0.10	0.9636	0.64	0.21	0.00	0.60	0.46	0.09	0.9441	50

71 Impact figures represent a percentage reduction in abundance and productivity that is attributable to human activities related to a particular threat category. Methods used to estimate impacts differ for Oregon and Washington populations. For example, baseline impacts reflect conditions circa 1999 for Washington populations and through 2004 for Oregon populations. Given the methodological differences, impact figures are not necessarily directly comparable. See Sections 5.5 and 5.6 for more on methodologies.

72 Reduction in tributary habitat production potential relative to historical conditions. Oregon and Washington used different methods to estimate historical abundance. Oregon's approach, which incorporates safety margins and includes causes of mortality that are not captured in the other five threat categories, tends to indicate a higher potential impact from tributary habitat loss and degradation than does Washington's.

73 Reduction in juvenile survival in the Columbia River estuary as a result of habitat changes (relative to historical conditions); excludes predation.

74 Reflects passage mortality, habitat loss caused by inundation, and loss of access to historical production areas for Washington populations; for Oregon populations, dam impacts reflect direct passage mortality only.

75 Includes direct and indirect mortality.

76 Reflects only the negative impacts of hatchery-origin fish, such as high pHOS and low PNI (proportion of natural influence), not the benefits of conservation hatchery programs.

77 Includes the aggregate predation rate in the Columbia River mainstem and estuary by northern pikeminnow, marine mammals, Caspian terns, and cormorants.

78 Cumulative values (both baseline and target) are multiplicative rather than additive and are equal to $(1-[(1-M_{thab})(1-M_{est})(1-M_{dams})(1-M_{harv})(1-M_{hatch})(1-M_{pred})])$. Minor differences from numbers in ODFW 2010 and LCFRB 2010a are due to rounding.

79 Survival improvements indicate the percentage improvement (rounded to the nearest 10) in population survival needed to achieve target impacts and are derived from the cumulative values (baseline and target), using the following equation: $[(1\text{-Cumulative}_{Target})-(1\text{-Cumulative}_{Baseline})]/[1\text{-Cumulative}_{Baseline}] \times 100$. These cumulative impact numbers are not explicitly reported in ODFW (2010) but are implicit in the modeling approach that Oregon recovery planners used to derive target impacts. For populations where the survival improvement needed is larger than 500 percent, this table does not report the exact value, for the reasons explained in Section 7.5.2. For the Oregon population designated as stabilizing (Youngs Bay), a survival improvement is shown because of improvements that are expected in tributary habitat, estuary conditions, and predation.

Table 7-8

Impacts of Potentially Manageable Threats and Impact Reduction Targets Consistent with Recovery of LCR Fall Chinook Salmon Populations

	Impacts at Baseline[71]							Impacts at Target							
Population	T. Hab[72]	Est[73]	Dams[74]	Harv[75]	Hat[76]	Pred[77]	Cumu-lative[78]	T. Hab	Est	Dams	Harv	Hat	Pred	Cumul-ative	% Survival Improve-ment Needed[79]
Upper Cowlitz (WA)	0.80	0.23	1.00	0.65	0.50	0.10	1.0000	0.80	0.23	1.00	0.65	0.50	0.10	1.000	0[80]
Toutle (WA)	0.60	0.23	0.05	0.65	0.50	0.10	0.9539	0.41	0.16	0.03	0.44	0.34	0.07	0.8348	260
Coweeman (WA)	0.50	0.23	0.00	0.65	0.23	0.10	0.9066	0.41	0.19	0.00	0.53	0.19	0.08	0.8326	80
Kalama (WA)	0.40	0.23	0.00	0.65	0.50	0.10	0.9272	0.31	0.18	0.00	0.51	0.39	0.08	0.8444	110
Lewis (WA)	0.40	0.23	0.00	0.65	0.50	0.11	0.9280	0.23	0.13	0.00	0.38	0.29	0.06	0.7228	290
Salmon Creek (WA)	0.90	0.23	0.00	0.65	0.50	0.11	0.9881	0.90	0.23	0.00	0.65	0.50	0.11	0.9880	0
Clackamas (OR)	0.82	0.32	0.00	0.60	0.45	0.07	0.9750	0.82	0.26	0.00	0.35	0.15	0.06	0.9308	180
Sandy (OR)	0.83	0.32	0.03	0.60	0.45	0.07	0.9771	0.57	0.26	0.00	0.35	0.15	0.06	0.8347	>500
Washougal (WA)	0.30	0.23	0.00	0.65	0.50	0.11	0.9161	0.20	0.15	0.00	0.43	0.33	0.07	0.7585	190
Gorge Fall															
L. Gorge — WA portion	0.70	0.23	0.30	0.65	0.50	0.11	0.9748	0.35	0.11	0.15	0.33	0.25	0.06	0.7677	>500
L. Gorge — OR portion	0.82	0.32	0.00	0.60	0.45	0.07	0.9750	0.59	0.26	0.00	0.35	0.30	0.06	0.8702	420
U. Gorge — WA portion	0.70	0.22	0.54	0.65	0.50	0.14	0.9838	0.35	0.11	0.27	0.33	0.25	0.07	0.8026	>500
U. Gorge — OR portion	0.80	0.32	0.13	0.65	0.45	0.09	0.9793	0.58	0.26	0.13	0.40	0.30	0.07	0.8944	410
White Salmon (WA)[81]	0.70	0.22	0.54	0.65	0.50	0.14	0.9838	0.35	0.11	0.27	0.33	0.25	0.07	0.8026	>500
Hood (OR)[82]	0.71	0.32	0.19	0.70	0.45	0.09	0.9760	0.00	0.00	0.10	0.00	0.00	0.00	0.1000	>500

80 The Upper Cowlitz population is a stabilizing population not targeted for improvements in any threat category. Because hydropower impacts are 100 percent for this population, the formula for percent survival improvement for these populations was modified to account for the 100 percent hydropower impacts (i.e., to avoid having to divide by zero).

81 Baseline and target impacts for the White Salmon population are from LCFRB (2010a).

82 Oregon's analysis indicates a low probability of meeting the delisting objective of high viability persistence probability for this population.

7.5.3 Fall Chinook Salmon Recovery Strategy

7.5.3.1 Strategy Summary

The recovery strategy for the tule fall component of the Lower Columbia River Chinook salmon ESU is designed to restore the Coast and Cascade tule strata to a high probability of persistence and to improve the persistence probability of all four Gorge-stratum populations. The strategy involves transitioning from decades of management that allowed habitat degradation and emphasized hatchery production of fish for harvest (without adequate regard to effects on natural production) to management that supports a naturally self-sustaining ESU. This transition will be accomplished by addressing all threat categories and sharing the burden of recovery across categories. The most crucial elements are as follows:

1. Protect and improve the Coweeman and Lewis populations, which are currently performing the best, by ensuring that habitat is protected and restored, that the proportion of hatchery-origin spawners (pHOS) is reduced, and that harvest rates allow for gains in productivity to translate into continued progress toward recovery.

2. Fill information gaps regarding the extent of natural production and the extent of hatchery-origin spawners.

3. Focus recovery efforts on populations that have the greatest prospects for improvement; determine whether efforts to reestablish populations are needed.

4. Protect existing high-functioning habitat for all populations.

5. Implement aggressive efforts to improve the quality and quantity of both tributary and estuarine habitat.

6. Implement aggressive efforts to reduce the influence of hatchery fish on natural-origin fish.

7. Adjust harvest as needed to ensure appropriate increases in natural-origin abundance.

8. Assess habitat quantity, quality, and distribution.

Transition strategies will be developed for each primary population that specify (1) timelines and strategies for reducing hatchery-origin spawners, (2) benchmarks for habitat improvement, (3) expected population response, and (4) harvest adjustments as needed to ensure appropriate increases in natural-origin abundance. These strategies will include adaptive management that provides a pathway for addressing critical uncertainties and that establishes benchmarks and adaptive actions if benchmarks are not met.

Transition strategies for non-primary populations will be developed to protect them from deterioration while moving them from high pHOS, with little or no natural production, through a period that addresses short-term demographic risks and reduces hatchery fractions while improving habitat conditions. Monitoring and evaluation will be critical in validating and, as appropriate, updating current assumptions regarding what is currently limiting the most poorly performing populations (i.e., assumptions about pHOS rates, the degree of local adaptation, the causes of the poor performance, and how the poorly performing populations contribute to the overall genetic diversity of their stratum and the ESU).

Very large improvements are needed in the persistence probability of most fall Chinook salmon populations if this component of the Lower Columbia River Chinook salmon ESU is to achieve recovery (see Table 7-4 for the target persistence probability for each fall Chinook salmon population and Figure 7-7 for the gaps between baseline and target status). Recovery prospects for fall Chinook salmon populations in the Gorge are constrained by very low abundance, limited habitat availability, and inundation of historically productive habitat by Bonneville Reservoir (LCFRB 2010a). As indicated in the delisting criteria (see Section 3.2), the recovery scenario for fall Chinook salmon does not meet the criteria for a high probability of persistence as defined by the WLC TRT; in addition, whether the recovery scenario for Gorge fall Chinook salmon can even be achieved is highly uncertain because of questions about the historical role of the Gorge populations and constrained opportunities for habitat restoration. To compensate for these limited recovery prospects, additional populations in the Coast and Cascade strata are prioritized for high persistence probabilities.

The recovery strategy for tule fall Chinook salmon is a long-term, "all-H" approach in which plan implementers begin work on all of the elements described above immediately and implement actions associated with each of the six threat categories simultaneously.[83] As part of a series of 5-year implementation schedules, management unit planners will work with NMFS staff to prioritize individual actions within each threat category, rather than across threat categories (see Chapter 11 for more on implementation). Recovery will require improvements in every threat category, even those improvements in Table 7-8 that are relatively small. Substantial actions are needed to improve tributary and estuarine habitat and reduce the effects of hatcheries, harvest, and hydropower; without significant improvements in all of these threat categories, the benefits of actions in any individual sector are unlikely to be fully realized and the expected threat reductions will not be achieved. Hatchery actions in particular are needed immediately to reduce impacts on natural-origin populations; however, the exact type and extent of actions will depend on the results of early monitoring to determine more clearly the actual pHOS rates among different populations. (Populations-specific pHOS rates are a critical uncertainty for fall Chinook salmon; see Section 7.5.3.8.) Harvest strategies also will be influenced by the results of monitoring. As natural production, abundance, and diversity eventually improve in populations that currently are performing poorly, harvest rates may need to be reevaluated to avoid impacts on these newly emerging weak stocks.

Monitoring and evaluation are particularly important in the short term to address critical uncertainties about Lower Columbia River tule Chinook salmon. Specific needs include improving information on fall Chinook escapements in the Clatskanie and

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[83] Implementation of recovery actions to reduce threats in each category is already under way, although the scale of effort is less than that called for in this recovery plan.

Scappoose, identifying those habitat restoration strategies that have the most potential to improve production, and verifying assumptions about habitat conditions in key reaches in the priority populations (e.g., are we right to target fine sediment levels in spawning reaches as restoration priorities for poorly performing populations such as the Clatskanie and Elochoman/Skamokawa?).

The subsections below describe recovery strategies and near-term and long-term priorities for each threat category. For specific management actions in each threat category, linked to population and location, see the management unit plans (LCFRB 2010a, ODFW 2010, NMFS 2011b).

7.5.3.2 Tributary Habitat Strategy

An aggressive, strategic approach is needed to protect and restore tributary and Columbia River estuary habitat, both of which are severely limiting for Lower Columbia River tule fall Chinook salmon. Fall Chinook salmon will benefit from the regional tributary strategy described in Section 4.1.2. The regional strategy is directed toward protecting and restoring high-quality, well-functioning salmon and steelhead habitat through a combination of (1) site-specific management actions that will protect habitat and provide benefits relatively quickly, (2) watershed-based actions designed to protect or restore habitat-forming processes and provide benefits over the long term, and (3) landscape-scale programmatic actions that affect a class of activities (such as stormwater management or forest practices) over multiple watersheds.

For fall Chinook salmon, the management unit plans set a high priority on reducing the impacts of sediment on survival to emergence and on improving juvenile rearing habitats, including reconnecting or restoring side channels and marsh habitats that are particularly critical to juvenile rearing of tule Chinook salmon. Priority site-specific actions will focus on protecting, restoring, or creating lowland floodplain function, riparian function, and stream habitat complexity. Priority restoration projects will include those to create or improve access to off-channel and side-channel habitat (alcoves, wetlands, floodplains, etc.) and restore riparian areas and instream habitat complexity; this includes improving recruitment of large wood to streams. Estuary/tributary confluence areas may also be a focus of site-specific actions, as habitat analysis indicates that substantial numbers of naturally produced juvenile Lower Columbia River fall Chinook salmon spend considerable time in such habitats (Cooney and Holzer 2010).

Near-term habitat actions should focus on implementing high-priority tributary actions that have already been identified, completing recovery plan implementation schedules, developing a prioritization and sequencing framework for habitat actions, and completing additional assessment work as part of developing the aforementioned transition strategy. This assessment effort should include identification of the amount and distribution of extant marsh-type habitats that are currently inaccessible for juvenile rearing in the tributaries used by Lower Columbia River tule Chinook salmon, along with identification of milestones or expected trends in improved habitat conditions in high-priority tributary and intertidal areas. The subsections below summarize additional, stratum-specific tributary habitat strategies for tule fall Chinook salmon.

Ultimately, restoration of adequate habitat for tules will be challenging because of the high proportion of habitat in private ownership.

Coast Fall Chinook Salmon Tributary Habitat Strategies

In implementing the Lower Columbia River fall Chinook salmon habitat strategy in the Coast fall stratum, considerations include the following:

- Lowland areas are primarily in agricultural or rural residential use. These areas have been extensively modified by dikes, levees, bank stabilization, and tide gates; efforts to protect and restore habitat complexity will be priorities here. Actions will include breaching, lowering, or relocating dikes and levees where possible to improve access to off-channel habitats for juvenile fall Chinook salmon, particularly in the Clatskanie, Scappoose, Grays, and Elochoman/Skamokawa subbasins (ODFW 2010, LCFRB 2010a).

- Upland areas are predominantly state and private timber land; these lands must be managed to protect and restore watershed processes (for example, through implementation of Washington's habitat conservation plan for state-owned forest land).

- Sediment source analyses and implementation of actions to reduce sediment will be needed in most Coast-stratum tributaries.

In addition to the actions described as part of the regional strategy for tributary habitat, the Washington management unit plan calls for restoring passage at culverts and other artificial barriers in the Elochoman/Skamokawa subbasin (LCFRB 2010a). The Oregon plan identifies a need to investigate whether headwater springs in the Youngs Bay, Big Creek, Clatskanie, and Scappoose subbasins are drying up as a result of land management practices.

Assuming that the impacts of other threats are reduced to the levels shown in Table 7-8, the scale of habitat improvements needed for the Coast fall Chinook stratum ranges from minimal in the Youngs Bay and Scappoose subbasins to a 20 to 30 percent increase in the productive capacity of tributary habitat in most subbasins. In the Grays subbasin, habitat productivity is targeted to increase by just over 60 percent.

Cascade Fall Chinook Salmon Tributary Habitat Strategies

In implementing the Lower Columbia River fall Chinook salmon habitat strategy in the Cascade stratum, considerations include the following:

- In the lower reaches of most Cascade subbasins, including the Lower Cowlitz, Coweeman, North Fork Lewis, East Fork Lewis, Toutle, Salmon Creek, and Clackamas, floodplains have been drastically altered or disconnected as a result of channel modification to facilitate and protect development, agricultural land, and, in some cases, gravel mining. Restoration of these areas will need to be balanced with the need to protect existing infrastructure and control flood risk.

- Upper portions of the East Fork Lewis, Washougal, Clackamas, and Sandy subbasins are primarily Federal forest lands. Continued implementation of the Northwest Forest Plan will be crucial in protecting and restoring watershed processes in these areas.

- State or private forest land predominates in the upper portions of the Coweeman, Toutle, Kalama, North Fork Lewis, and Salmon Creek subbasins. These lands must be managed to protect and restore watershed processes (for example, through implementation of Washington's habitat conservation plan for state-owned forest land).

- The stratum includes the most heavily urbanized areas in the Columbia Basin. Managing the impacts of growth and development on watershed processes and habitat conditions will be key to the protection and improvement of habitat conditions for fall Chinook salmon in these areas.

In addition to the actions described as part of the regional strategy for tributary habitat, addressing passage barriers such as culverts will benefit fall Chinook salmon by restoring access to habitat in a number of locations, including the Lower Cowlitz, Kalama, and East Fork Lewis subbasins. (In some cases, additional assessment is needed to inventory and prioritize these blockages.) Addressing passage and sedimentation issues associated with the sediment retention structure on the North Fork Toutle River will be a key component for the Toutle population. Sediment issues in other watersheds will be addressed generally by restoring watershed processes and dealing with legacy road issues. In some cases (e.g., the Sandy), assessment to identify sediment sources is noted as a first step before additional actions can be taken. The Oregon management unit plan identifies a need to address flow issues in the Clackamas subbasin and incorporates a number of flow-related actions. In the Sandy subbasin, implementation of the city of Portland's Bull Run Water Supply habitat conservation plan will contribute significantly to the habitat improvements needed to achieve the recovery target.

Assuming that the impacts of other threats are reduced to the levels shown in Table 7-8, the scale of habitat improvements needed for Cascade fall Chinook stratum populations ranges from minimal (but with protection of well-functioning habitat) to just over 40 percent. The two stabilizing populations—Salmon Creek and Upper Cowlitz—are not targeted for improvements in habitat productivity, in the first case because production potential is low and in the second case because spring Chinook salmon recovery efforts in the Upper Cowlitz have been prioritized over fall Chinook salmon. The Lower Cowlitz is targeted for an 8 percent improvement in habitat productivity, and the Sandy, Toutle, Coweeman, Kalama, Washougal, and East Fork Lewis subbasins are targeted for habitat improvements on the order of 20 to 40 percent. Oregon estimated that, for the Clackamas population, existing habitat is adequate to achieve the targeted medium persistence probability, assuming that all other targeted threat reductions for that population are achieved. However, the Oregon plan notes that, because of multiple uncertainties, efforts should still be made to protect and restore habitat in the Clackamas subbasin.

Gorge Fall Chinook Salmon Tributary Habitat Strategies

In implementing the Lower Columbia River fall Chinook salmon habitat strategy in the Gorge stratum, considerations include the following:

- In the lower reaches of most Gorge tributary streams, floodplains have been drastically altered or disconnected as a result of channel modification to facilitate and protect development and agricultural land. For the Lower Gorge population, site-specific actions will include addressing or mitigating the impacts of the highway and railroad transportation corridors that run parallel to the Columbia River shoreline, traversing all creek drainages in ways that restrict access and disconnect upland and lowland habitat processes.

- Gorge populations occur in watersheds that are largely Federal, state, and private forest land. These lands must be managed to protect and restore watershed processes.

In addition to the actions described as part of the regional strategy for tributary habitat, the Oregon management unit plan identifies a number of actions to restore natural flows that have been disrupted by irrigation withdrawals in the Hood subbasin. Restoring floodplain connectivity and function is called for at locations below Bonneville Dam; however, there is little opportunity to implement floodplain measures above Bonneville Dam because much mainstem floodplain habitat was inundated by Bonneville Reservoir. For this reason, habitat efforts above the dam will rely on other strategies.

In the White Salmon subbasin, the breaching of Condit Dam in October 2011 (with full removal expected by August 2012) created near-term negative effects in the habitat below the dam and the habitat within the footprint of the former reservoir because of sediment release and scouring. Long-term effects are expected to be positive because of restored natural flow and sediment transport regimes. The White Salmon management unit plan outlines four broad tributary habitat strategies: (1) gain information to identify and prioritize habitat actions, (2) when the dam is removed, restore mainstem habitat, (3) protect and conserve natural ecological processes, and (4) improve habitat in upriver reaches (NMFS 2011b). In the near-term, evaluating the effects of the dam breaching and removal on habitat and performing additional assessment of habitat limiting factors are high priorities.

Assuming that the impacts of other threats are reduced to the levels shown in Table 7-8, reductions in baseline tributary habitat impacts needed to meet target statuses range from 50 percent for the Lower and Upper Gorge and the White Salmon subbasins to a complete elimination of anthropogenically enhanced tributary habitat-related mortality in the Hood subbasin. (The Oregon management unit plan acknowledges that this is unattainable.)

7.5.3.3 Estuary Habitat Strategy

Estuarine habitat improvements are critical for Lower Columbia River fall Chinook salmon, which are severely limited by a paucity of intertidal marshes and similar estuarine wetlands that tules rely on for spawning, refuge, and extended rearing.

Improvements to estuary habitat may be especially important for Coast-stratum fall Chinook populations; outmigrant trapping and habitat analyses indicate that populations in the Coast ecozone historically relied on wetland areas at the confluences of the tributaries and the mainstem Columbia as juvenile rearing areas (Northwest Fisheries Science Center 2010). In addition, substantial numbers of naturally produced juvenile Lower Columbia River fall Chinook salmon spend significant time in estuary/tributary confluence habitats (Cooney and Holzer 2010).

Improving Columbia River estuary habitat as described in the regional estuary habitat strategy will benefit all Columbia Basin ESUs, including Lower Columbia River fall Chinook salmon. (For a summary of the regional estuarine habitat strategy, see Section 4.2.2.) The regional strategy reflects actions presented in the Oregon and Washington management unit plans to reduce estuarine habitat-related threats and is consistent with actions in the *Columbia River Estuary ESA Recovery Plan Module for Salmon and Steelhead* (NMFS 2011a). For fall Chinook salmon, the assessment process described as part of the regional strategy should include assessment of the tidal portions of tributaries and their confluence with the mainstem Columbia. (Recent NMFS modeling for selected Lower Columbia River tule populations indicates that such confluence habitat may be especially important for Coast- and Cascade-stratum populations [Northwest Fisheries Science Center 2010].) Developing implementation priorities for estuarine habitat actions also should include establishment of milestones or expected trends in improved habitat conditions in high-priority intertidal areas.

The *Columbia River Estuary ESA Recovery Plan Module for Salmon and Steelhead* (NMFS 2011a) assumes that feasible estuarine habitat improvements and predation management measures could result in a maximum increase of 20 percent in the number of outmigrating juveniles leaving the Columbia River estuary. Oregon and Washington recovery planners set targets of reducing anthropogenically enhanced mortality in the estuary for fall Chinook salmon populations based on the estuary module and their own approaches to threat reductions (see ODFW 2010, Tables 6-13 and 6-21; LCFRB 2010a, Table 6-2).

Ultimately, restoring adequate habitat for tules in the Columbia River estuary will be challenging because of the high proportion of habitat in private ownership.

7.5.3.4 Hydropower Strategy

Because tule fall Chinook salmon are distributed low in tributary subbasins, reintroduction above tributary dam complexes is not critical to their recovery. However, the hydropower strategy includes actions to improve passage survival at tributary dams and reduce the effects of dam operation (e.g., flow management and water temperatures) on critical downstream habitats.

The strategy also includes measures to improve passage survival at Bonneville Dam for the Upper Gorge, Hood, and White Salmon populations and implementation of mainstem flow management operations designed to benefit spring migrants from the interior of the Columbia Basin; NMFS expects that these flow management operations will also improve survival in the estuary and, potentially, the plume for all Lower Columbia River salmon and steelhead populations. NMFS estimates that survival of

Lower Columbia River fall Chinook salmon passing Bonneville Dam was 95.1 percent for juveniles from 2002 to 2009 and 96.9 percent for adults from 2002 to 2007 (NMFS 2008a). NMFS expects that implementation of actions in the 2008 FCRPS Biological Opinion and its 2010 Supplement will improve juvenile fall Chinook salmon survival at Bonneville Dam by less than ½ percent, and that adult survival will be maintained at recent high levels (NMFS 2008a). Consequently, Oregon has not incorporated survival benefits from passage improvements at Bonneville into the hydropower threat reduction targets for Oregon populations above Bonneville.[84] The Washington management unit plan assumes that actions identified in the 2008 FCRPS Biological Opinion and its 2010 Supplement will aid adults and juveniles from all Lower Columbia River fall Chinook salmon populations originating above Bonneville Dam. For more on actions to improve mainstem dam passage, see the regional hydropower strategy in Section 4.3.2.

In its management unit plan, Oregon incorporated several actions addressing impacts of the Columbia River hydropower system that are not included in the FCRPS Biological Opinion and its 2010 Supplement but that Oregon maintains are needed to benefit Lower Columbia River salmon and steelhead populations that spawn above Bonneville Dam. The state of Oregon's position is that the FCRPS action agencies should conduct operations in addition to those incorporated in the FCRPS Biological Opinion to address the needs of ESA-listed salmon and steelhead. Oregon is a plaintiff in litigation against various Federal agencies, including NMFS, challenging the adequacy of measures in the FCRPS Biological Opinion and its 2010 Supplement. NMFS does not agree with Oregon regarding the need for or likely efficacy of the additional actions Oregon proposed in that litigation, including the actions in the Oregon management unit plan that are not part of the FCRPS Biological Opinion and its 2010 Supplement. For more detail on these actions and NMFS' view of them, see the regional hydropower strategy in Section 4.3.2.

The subsections below summarize stratum-level hydropower strategies for fall Chinook salmon.

Coast Fall Chinook Salmon Hydropower Strategies

There are no tributary dams in the Coast ecozone, so the hydropower strategy for the Coast stratum is to implement the FCRPS flow management operations for spring migrants from the interior of the Columbia Basin; these flow management operations will also improve survival in the estuary and, potentially, the plume for all Lower Columbia River fall Chinook salmon populations.

Cascade Fall Chinook Salmon Hydropower Strategies

The primary element of the hydropower strategy for Cascade fall Chinook salmon is to address downstream impacts of operation of hydropower facilities in the Cowlitz and Lewis subbasins. These changes will be implemented under the terms of FERC relicensing orders for Tacoma Power's Cowlitz River Project in 2004 and for PacifiCorp and the Cowlitz PUD's Lewis River Hydroelectric Projects in 2002. In addition, the removal of PGE's Bull Run Hydroelectric Project (which consisted of Marmot and Little

[84] Hydropower-related threat reduction targets for Oregon populations above Bonneville Dam are associated with removal of Powerdale Dam on the Hood River.

Sandy dams) in the Sandy subasin in 2009 addressed downstream passage impacts for fry of the Sandy fall Chinook salmon population.

Recovery efforts for Chinook salmon in the Upper Cowlitz subbasin are focused on spring Chinook salmon, [85] while fall Chinook salmon recovery efforts are focused on the Lower Cowlitz population (targeted for medium-plus persistence probability) rather than on the Upper Cowlitz population (targeted to be maintained at very low persistence probability). Flow regimes from Cowlitz River hydropower system operations affect spawning and rearing habitat for the Lower Cowlitz fall Chinook salmon population, so the recovery strategy includes actions to maintain a flow regime, including minimum flow requirements, to enhance fall Chinook salmon spawning and rearing habitats in the Lower Cowlitz (LCFRB 2010a). While passage for fall Chinook salmon through the Cowlitz subbasin dams is not a primary focus of the recovery strategy, fall Chinook salmon are (in 2010) passed above Mayfield Dam into the Tilton subbasin and above Cowlitz Falls Dam into the Upper Cowlitz subbasin. Although the primary habitat for fall Chinook salmon in the Upper Cowlitz has been inundated, efforts are being made to reestablish some fall Chinook salmon spawning in the Upper Cowlitz.

In the Lewis subbasin, tule fall Chinook salmon occur in both the lower North Fork Lewis and the East Fork Lewis (where there are no hydropower dams), but the East Fork Lewis supports most of the production and, along with the lower North Fork, is the focus of recovery efforts.[86] As in the Cowlitz, hydroregulation on the Lewis River has altered the natural flow regime below Merwin Dam, affecting the quantity and quality of fall Chinook salmon spawning and rearing habitat. The Washington management unit plan includes a measure to operate the Lewis hydrosystem to provide appropriate flows for salmon spawning and rearing habitat. The operational plan for the Lewis River dams, in conjunction with fish management plans, should include flow regimes—including minimum flow and ramping rate requirements—that enhance the lower river habitat for fall Chinook salmon (LCFRB 2010a). Passage at the Lewis River dams is not part of the recovery strategy for Lewis River fall Chinook salmon.

Gorge Fall Chinook Salmon Hydropower Strategies

Tributary hydropower impacts for the White Salmon and Hood populations will be addressed by removing Condit and Powerdale dams, respectively. Condit Dam, operated on the White Salmon River by PacifiCorp, was breached in October 2011 and is scheduled to be completely removed by August 2012, under the terms of a 1999 decommissioning agreement and a 2006 Biological Opinion. Removal will reopen access to four miles of historical fall Chinook salmon habitat (55 percent of historical spawning habitat is above the dam) (NMFS 2011b). Natural escapement and production will be monitored for 4 to 5 years; if adequate recolonization has not occurred by that time, appropriate hatchery adults and/or juveniles may be released into the White Salmon River. Powerdale Dam, on the Hood River and also operated by PacifiCorp, was

[85] Barrier Dam and Mayfield Dam in the Cowlitz Basin prevent all volitional passage of anadromous fish above RM 49.5.
[86] In the North Fork Lewis Basin, three dams (Merwin, Yale, and Swift), beginning with Merwin Dam at RM 20, block passage to the upper North Fork Lewis.

removed in 2010 under the terms of a settlement agreement reached in 2003. Benefits to fall Chinook salmon in the Hood River will include improved upstream and downstream migration; removal of the dam is expected to reduce hydropower-related impacts for the Hood fall Chinook salmon population from 18.7 percent to 13 percent (ODFW 2010). Tributary dams do not affect the Lower Gorge or Upper Gorge populations.

Actions in the 2008 FCRPS Biological Opinion and its 2010 Supplement will also provide slight improvements in juvenile survival for the three Gorge fall Chinook salmon populations that spawn above Bonneville Dam (see the regional hydropower strategy in Section 4.3.2).

7.5.3.5 Harvest Strategy

Consistent with the regional harvest strategy (see Section 4.5.2), the harvest strategy for Lower Columbia River fall Chinook salmon focuses on refining harvest management to further reduce impacts to naturally produced fish while maintaining harvest opportunities that target hatchery-produced fish. Harvest on Lower Columbia River tule Chinook salmon has been reduced from average highs of 69 percent during the years 1983 to 1993 to an average of 48 percent from 1999 to 2006, 38 percent in 2009 and 2010, and 37 percent in 2011 (NMFS 2008c). These changes have contributed to the harvest reductions called for in the Oregon and Washington management unit plans, both of which envision further reductions through a strategy of implementing mark-selective fisheries when feasible as a tool to sustain important fisheries, implementing abundance-based management when feasible, and applying weak-stock management principles.[87]

In terms of needed additional reductions, the Oregon management unit plan did not recommend specific harvest rates; instead, in its analyses it used 35 percent as a modeled, long-term average harvest rate and assumed that harvest actions such as abundance-based, weak-stock management and mark-selective commercial fisheries would be implemented. The Washington management unit plan recommends a phased harvest strategy involving lower near-term rates to reduce population risks until habitat improvements are achieved. Modeling in the Washington management unit plan shows a scenario in which harvest rates would be managed for benchmarks of 38 to 49 percent for the period between 1999 (the time of listing) and the year 2010, and rates of 33 to 38 percent from 2011 to 2022. (The benchmark range is a target to be met within the designated period and will be used to assess progress toward recovery. With respect to tule Chinook salmon, the 1999-2010 benchmark range of 38 to 49 percent was met by rates of 38 to 49 percent over most of the period.) The modeling also projects that harvest rates eventually would increase as the benefits of other recovery actions are realized and natural production improves. These modeling results are planning targets and not predictions of future harvest rates; managers will establish future harvest rates based on observed indicators in Lower Columbia River fall Chinook salmon populations.

NMFS' recent modeling (Northwest Fisheries Science Center 2010), which addressed all primary tule populations except the Toutle, indicates that, in the Cascade stratum, the

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[87] A critical question regarding weak stock management principles is how and when tule harvest will be based on the populations in the Coast stratum.

Lewis, Washougal, and Coweeman populations would benefit somewhat from additional harvest reductions but would be at low demographic risk at harvest rates of up to 38 percent. In the Coast stratum, the Clatskanie, Scappoose, and Elochoman/Skamokawa populations appear to be sustained by hatchery straying under current conditions and modeling indicates they would be at high risk in the absence of hatchery augmentation, even at very low harvest rates. The Mill/Abernathy/Germany population would be at intermediate risk at intermediate harvest levels. Because few population-specific landscape habitat maps are available, the NMFS analysis applied tributary habitat assumptions derived for the East Fork Lewis River to all populations. Under that assumption set, the Hood population appears to be self-sustaining at a harvest rate of around 20 percent; however, the Oregon management unit plan discusses the unique nature of the Hood River drainage, including the dynamic nature of sediment conditions caused by glacial inputs and other factors, and is more pessimistic about the status of that population (ODFW 2010). The uncertainty in all of these predictions is substantial. The Oregon and Washington management unit plans both highlight the need for improved estimates of current spawning levels and habitat conditions for Lower Columbia River fall Chinook salmon populations. The Oregon management unit plan identifies evaluating and potentially updating available data series for the Clatskanie, Scappoose, and Hood River fall Chinook salmon populations as high-priority technical tasks. Incorporating drainage-specific tributary habitat information may substantially alter model projections.

NMFS will ensure that best available science continues to be used to determine harvest rates that, when combined with other threat reduction strategies, are likely to achieve positive growth rates and move populations to their target status over the long term. Near-term actions will evaluate and describe options for employing mark-selective fishing strategies in order to sustain fisheries while reducing fishery impacts on naturally produced Lower Columbia River tule Chinook salmon populations. Near-term actions also will include investigation of one or more options for predicting the abundance of natural-origin Lower Columbia River tule Chinook salmon (including the use of prior year returns) and incorporating abundance-driven management principles into Lower Columbia River tule harvest management.

The current harvest strategy is based on the assumption (supported by the results of Northwest Fisheries Science Center 2010 modeling) that the productivity of the poorly performing populations in the Coast stratum is so low that their extinction risk would remain high regardless of harvest rates. The Hood tule population presents an additional challenge for several reasons. First, there is a relatively high degree of uncertainty associated with the specific assumptions regarding current tributary habitat conditions incorporated into NMFS' modeling for the Hood population. In addition, the population's baseline persistence probability in these model runs is very low, the population is targeted for high persistence probability, and—because of harvest impacts in Zone 6 fisheries above Bonneville Dam—the Hood population is subject to exploitation rates higher than those for the Coast and Cascade strata.[88] In the future, as productivity begins to improve in populations that currently are performing poorly, NMFS, co-managers, and the management unit leads will evaluate whether harvest

[88] Harvest management provisions in Zone 6 have been established through the year 2017 under the *US v. Oregon* process. Harvest in Zone 6 is limited primarily by constraints on upriver fall Chinook and steelhead.

needs to be adjusted. Additional information will be needed to understand how harvest and other threats are affecting the ability of tule populations to achieve their recovery targets and appropriate strategies will need to be developed.

In ESA evaluations of hatchery and harvest actions, NMFS expects to analyze the combinations of effects of multiple actions when appropriate. For example, where hatchery production clearly is intended to support harvest, the synergistic effects of artificial production and harvest will need to be analyzed at the juvenile and adult life stages. This should include ecological interactions as well as genetic and other considerations.

Coast Fall Chinook Salmon Harvest Strategies

The ESU-level harvest strategy described above is expected to reduce harvest impacts on most populations in this stratum. As part of the strategy to direct harvest impacts away from other Lower Columbia River fall Chinook salmon populations, terminal fisheries targeting hatchery fish in Youngs Bay and Big Creek will continue, and those populations will continue to be subject to higher harvest rates than other fall Chinook salmon populations. Still, implementation of the ESU-level harvest strategy is expected to reduce harvest impacts on the Youngs Bay and Big Creek populations from 75 and 65 percent, respectively, to 70 and 60 percent (ODFW 2010).

Cascade Fall Chinook Salmon Harvest Strategies

The ESU-level harvest strategy described above is expected to reduce harvest impacts on all populations in this stratum.

Gorge Fall Chinook Salmon Harvest Strategies

The ESU-level harvest strategy described above is expected to reduce harvest impacts on all populations in this stratum.

7.5.3.6 Hatchery Strategy

The regional hatchery strategy described in Section 4.4.2 summarizes goals and approaches relevant to Lower Columbia River fall Chinook salmon. In general, pHOS will be reduced through a combination of removal of excess hatchery-origin fish at weirs,[89] shifts in production levels or locations, changes in hatchery practices, and mark-selective harvest. Some programs will be shifted to formal integrated programs, in which genetic hatchery impacts are reduced through inclusion of natural-origin fish in the broodstock. Because pHOS and its impact on the productivity of naturally spawning fish are key uncertainties for fall Chinook salmon, the management unit recovery plans propose monitoring to determine with more certainty the actual pHOS, while simultaneously moving ahead with actions to reduce the influence of hatchery fish to levels appropriate to each population (i.e., populations with a higher target persistence probabilities will be targeted for lower levels of influence), using techniques tailored to

[89] The ecological risks of weirs will also be considered. The Recovery Implementation Science Team (RIST) discussed potential benefits and ecological risks associated with use of weirs (Recovery Implementation Science Team 2009).

the circumstances of each population.[90] Transition schedules will recognize the differences between populations such as the Washougal, where strays are largely from a within-population tributary hatchery program, and the Lewis, where hatchery strays are also from an adjacent facility but presumably are present at much lower numbers than in some populations. Near-term priorities include conducting more detailed assessments of current spawning escapements and hatchery proportions in the Clatskanie and Scappoose populations, both of which are designated as primary. The historical-to-current spawner data series for these two populations are highly uncertain. Near-term priorities also include continuing the efforts already under way to shift production and install and operate weirs. In addition, NMFS believes that there is a need for studies of the potential effects hatchery introgression on productivity (such studies are rare for fall Chinook salmon). Long-term priorities include achieving the recovery targets for each population and reducing reliance on hatchery production for harvest or risk reduction as natural productivity improves.

Details of how the hatchery strategy will be implemented in each fall Chinook salmon stratum will be developed as part of the transition schedules, but the subsections below provide some information.

Coast Fall Chinook Salmon Hatchery Strategies

The preliminary intent of the Coast-stratum hatchery strategy includes maintaining the Youngs Bay and Big Creek subbasins as areas of hatchery production to support terminal fisheries targeting hatchery fish; consequently, pHOS in the Youngs Bay and Big Creek populations is expected to remain high, and the populations are targeted to be maintained at low persistence probabilities. Some fall Chinook salmon hatchery production will be shifted from Big Creek to Youngs Bay in an effort to reduce hatchery-origin spawners in the Clatskanie and, to a lesser degree, Scappoose subbasins. Existing weirs in both Youngs Bay and Big Creek will be used to pass natural-origin fish into sanctuary areas. The Clatskanie and Scappoose subbasins will remain areas where no hatchery fish are released. If pHOS in the Clatskanie remains higher than 10 percent, a trap may be installed to sort hatchery fish within 15 years.[91]

The Grays/Chinook, Mill/Abernathy/Germany, and Elochoman/Skamokawa subbasins also are expected to be maintained as areas where no hatchery fall Chinook salmon are released. No hatchery fall Chinook salmon have been released in the Grays subbasin since 1998 and none from the Abernathy fall Chinook salmon program since 1995. The Elochoman hatchery was closed in 2009. The proportion of hatchery-origin spawners in each subbasin needs to be reduced; hatchery strays in the Grays subbasin are believed to come primarily from the Rogue River bright fall Chinook stock used to produce fish for the Select Area fishery in Youngs Bay. As of late 2011, weirs were in use in the Grays, Washougal, Elochoman, Coweeman, and Toutle rivers to separate hatchery- from natural-origin fish.

[90] For example, ODFW has established a target of 10 percent or less hatchery-origin spawners in natural spawning areas for populations targeted for high probability of persistence. WDFW will establish similar targets in its Conservation and Sustainable Fisheries Plan.

[91] The Oregon management unit plan did not incorporate an explicit contingency plan for the Scappoose basin.

Cascade Fall Chinook Salmon Hatchery Strategies

Currently, no hatchery fish are released into the Coweeman, Lewis, or Salmon Creek subbasins in Washington or into the Clackamas or Sandy subbasins in Oregon, although fall Chinook salmon populations in these watersheds are affected by hatchery-origin spawners that stray from other areas within the Lower Columbia subdomain. These areas are expected to be maintained as areas with no hatchery releases, and recovery actions will focus on reducing the proportion of hatchery-origin spawners (pHOS) to levels appropriate to each population depending on its target status.

As of 2010, fall Chinook salmon were being released into the Upper Cowlitz subbasin as part of a reintroduction strategy, although they are not the focus of the recovery effort in that subbasin. In the Lower Cowlitz, Toutle, Kalama, and Washougal, hatchery programs currently produce and release fall Chinook salmon that are intended to support harvest, in part as mitigation for fall Chinook salmon production lost as a result of multiple factors in the Columbia Basin. In these programs hatchery recovery efforts will focus initially on developing integrated hatchery programs through actions such as separate management of hatchery and natural subpopulations, control of hatchery-origin fish into natural spawning areas, incorporation of natural-origin fish into hatchery broodstock (LCFRB 2010a). Specific approaches to broodstock and targets for proportions of hatchery-origin spawners and natural-origin broodstock will be developed for each population depending on its target status.

In the Sandy subbasin, stray rates already have been reduced significantly from baseline levels and currently are lower than the 30 percent identified for recovery (ODFW 2010). Further reductions in pHOS may be difficult.

Gorge Fall Chinook Salmon Hatchery Strategies

Hatchery strategies for Gorge fall Chinook salmon will consist largely of changes in fishery enhancement programs to reduce hatchery impacts on natural-origin spawners. Actions may include separate management of hatchery and natural subpopulations and control of hatchery-origin fish into natural spawning areas. Specific targets for proportions of hatchery-origin spawners will be developed for each population depending on its target status.

For the Lower Gorge population, ODFW may install a weir and trap to reduce pHOS by separating natural- from hatchery-origin adults at Eagle Creek and Tanner Creek in Oregon. There are no hatcheries operating in the Washington Lower Gorge tributaries.

For the Upper Gorge population, Oregon will consider placing a trap at Herman Creek to sort hatchery fish. For the Washington portion of the Upper Gorge population and the White Salmon population, fall Chinook salmon from four Federal hatcheries will continue to be released to provide for fishery enhancement (LCFRB 2010a).

7.5.3.7 Predation Strategy

The regional predation strategy (see Section 4.6.2) involves reducing predation by birds, fish, and marine mammals and will benefit all Lower Columbia River ESUs, including tule fall Chinook salmon.

7.5.3.8 Critical Uncertainties

Each aspect of the fall Chinook salmon recovery strategy has a number of critical uncertainties. For all ESUs, there are uncertainties regarding how habitat actions will translate into changes in productivity and capacity (Roni et al. 2011). Prioritizing and identifying next steps in resolving uncertainties is a near-term priority. Critical uncertainties specific to Lower Columbia River fall Chinook salmon include the following:

- Current level of natural productivity, hatchery fractions, sources of hatchery strays, loss and gain of reproductive fitness, and ecological interactions between hatchery-origin fish and natural-origin fish
- Effects of hatchery-origin fish on natural productivity at the population level, and whether there are density-dependent and/or predation effects in the Columbia River estuary
- Response in natural productivity to reductions in pHOS, and the time frame of that response
- Effectiveness of integrated hatchery programs in restoring the productivity of natural populations; availability of sufficient numbers of naturally produced fish for incorporation in the hatchery broodstock; validity of assumptions concerning natural fitness of hatchery-origin fish produced using natural broodstock
- Historical role of the Gorge populations and appropriate persistence probabilities, and abundance and productivity targets, for these populations
- Most effective recovery strategy for populations whose genetic diversity is low and that may not be locally adapted
- Appropriate stock to use (especially in terms of run timing) if reintroduction is necessary
- Effect of the distribution of intertidal habitats on the life history strategies of fall Chinook salmon[92]
- Locations of priority habitats for restoration, especially with respect to the distribution of intertidal habitats

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[92] Recent modeling by NMFS (Northwest Fisheries Science Center 2010) for selected LCR tule populations indicates that "confluence habitat" (i.e., the tidal portions of tributaries and their confluence with the mainstem Columbia) may be especially important for coastal and Cascade populations.

These critical uncertainties represent preliminary priorities identified by Oregon and Washington recovery planners and NMFS Northwest Regional Office and Northwest Fisheries Science Center staff during a November 2010 workshop. They are preliminary priorities only (and are not in ranked order); as described in Chapter 10, additional discussion among recovery planners and NMFS staff will be needed to finalize future research priorities for Lower Columbia River fall Chinook salmon.

The management unit plans identify more comprehensive critical uncertainties and research, monitoring, and evaluation needs that, along with the list above, will provide the basis for these future discussions. The White Salmon and Washington management unit plans have discrete sections on critical uncertainties for all of the ESUs in general (see Section 8.3 of NMFS 2011b, pp. 8-4 through 8-6, and Section 9.6 of LCFRB 2010a, pp. 9-68 through 9-73), while the Oregon management unit plan embeds relevant critical uncertainties within subsections on monitoring and evaluation needs related to the four VSP parameters and five ESA listing factors (see Sections 8.4 and 8.5, respectively, of ODFW 2010). In addition, in June 2010, the *Lower Columbia Fish Recovery Board completed the Research, Monitoring, and Evaluation Program for Lower Columbia Salmon and Steelhead* as a companion to its recovery plan (LCFRB 2010b). This document also describes critical uncertainties. The list above also does not include critical uncertainties that apply to multiple ESUs; these will be discussed and considered as decisions are made in implementation. In addition, the critical uncertainties above are of a technical nature; there are also many critical uncertainties related to social, political, and economic issues.

Critical uncertainties are one element of research, monitoring, and evaluation (RME) and adaptive management, which will be key components of the fall Chinook salmon recovery strategy (see Chapter 10 for more discussion of RME and adaptive management for this recovery plan).

Monitoring and evaluation are particularly important in the short term to address critical uncertainties about Lower Columbia River tule Chinook salmon, identify those habitat restoration strategies that have the most potential to improve production, and verify assumptions about habitat conditions in key reaches in the priority populations (e.g., are we right to target fine sediment levels in spawning reaches as restoration priorities for poorly performing populations such as the Clatskanie and Elochoman/Skamokawa?).

7.6 Late-Fall Chinook Salmon Analysis: Limiting Factors, Threat Reductions, and Recovery Strategies

7.6.1 Late-Fall Chinook Salmon Limiting Factors

Table 7-9 and the text that follows summarize baseline limiting factors and threats for Lower Columbia River late-fall Chinook salmon strata based on population-specific limiting factors and threats identified in the management unit plans. In cases where conditions have changed significantly since the management unit plans' analyses of limiting factors and threats (e.g., if harvest rates have dropped or a dam is no longer present), this is noted in the text. Unless noted otherwise, NMFS agrees that the management unit plans' identification of limiting factors provide a credible hypothesis for understanding population performance and identifying management actions.

Because the individual management unit plans used somewhat different terms in identifying limiting factors, NMFS has translated those terms into standardized and more general terminology taken from a NMFS "data dictionary" of possible ecological concerns that could affect salmon and steelhead (Hamm 2012; see Section 5.4 and Appendix H). In addition, in Table 7-9 NMFS has rolled up the population-specific limiting factors to the stratum level—a process that also has resulted in some loss of specificity.

In addition, each management unit plan used a different approach for identifying limiting factors and threats (see Section 5.3). One difference relevant to the crosswalk is that while the Oregon management unit plan identified primary and secondary limiting factors for each population in each threat category,[93] the Washington management unit plan categorized limiting factors in this way only for habitat-related limiting factors, and the estuary module did not. For the crosswalk and this table, NMFS assigned primary and secondary status to non-habitat limiting factors for Washington populations (based on the Washington management unit plan's quantification of threat impacts and the professional judgment of Lower Columbia Fish Recovery Board's staff and consultants). It is likely that some apparent distinctions in results between Washington and Oregon populations are artifacts of differences in limiting factor assessment methodologies and not an actual difference in conditions or their effects on salmon and steelhead populations. In addition, there is not necessarily a bright line between primary and secondary limiting factor designations. Nevertheless, NMFS believes that the designations are useful, particularly for looking across ESUs and populations and identifying patterns (see Chapter 4).

The management unit plans provide more detail on limiting factors and threats affecting Lower Columbia River late-fall Chinook salmon, including magnitude, spatial scale, and relative impact, (see LCFRB 2010a, Chapter 3 and various sections of Volume II, and ODFW 2010, pp. 116-128). For a regional perspective on limiting factors and threats that affect multiple salmon and steelhead ESUs, see Chapter 4 of this recovery plan. For a description of the data dictionary, the approach NMFS used to correlate management unit terms for limiting factors with the standardized NMFS terminology at the population scale, and the approach for rolling up from the population to the stratum scale, see Section 5.4 and Appendix H.

Management unit recovery planners in Oregon and Washington recognized that six major categories of manageable threats—tributary habitat, estuary habitat, hydropower, harvest, hatcheries, and predation—were useful as an organizing construct for grouping limiting factors, quantifying impacts on population productivity, and determining how much different categories of threats would need to be reduced to close the gap between baseline and target population status. Planners in both Washington and Oregon quantified the impacts of each of these major threat categories on population status, along with a reduction in each impact that would be consistent with achieving population target status. The results of that analysis are presented in Section 7.6.2 and provide a related but slightly different perspective on limiting factors. The threat

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[93] In the Oregon management unit plan, primary limiting factors are those that have the greatest impact and secondary limiting factors have a lesser but still significant impact.

reduction targets also allow actions to be scaled to achieve a specific impact reduction, and to be linked to monitoring and performance benchmarks.

Table 7-9

Baseline Limiting Factors and Threats Affecting LCR Late-Fall Chinook Salmon: Stratum-Level Summary

Ecological Concern	Threat(s)	VSP Parameters Affected	Cascade Late Fall
Tributary Habitat Limiting Factors			
Riparian Condition	Past and/or current land use practices	All	Primary for Sandy juveniles, secondary for NF Lewis juveniles
Channel Structure and Form	Past and/or current land use practices/ transportation corridor	All	Primary for Sandy juveniles, secondary for NF Lewis juveniles
Peripheral and Transitional Habitats: Side Channel and Wetland Conditions	Past and/or current land use practices/ transportation corridor	All	Primary for Sandy juveniles, secondary for NF Lewis juveniles
Peripheral and Transitional Habitats: Floodplain Conditions	Past and/or current land use practices/ transportation corridor	All	Primary for Sandy juveniles, secondary for NF Lewis juveniles
Sediment Conditions	Past and/or current land use practices/ transportation corridor	All	Secondary for juveniles in both populations
Water Quality (Temperature)	Land uses that impair riparian function/decrease streamflow, dams	A,P,D	Secondary for juveniles in NF Lewis
Water Quantity (Flow)	Dams, land use, irrigation, municipal, and hatchery withdrawals	All	Secondary for juveniles in both populations
Estuary Habitat Limiting Factors[94]			
Toxic Contaminants	Agricultural chemicals, urban and industrial practices	A,P,D	Secondary for juveniles in both populations
Food[95] (Shift from macrodetrital- to microdetrital-based food web)	Dam reservoirs	All	Secondary for juveniles in both populations

94 The Washington and Oregon management unit plans both relied on the *Columbia River Estuary ESA Recovery Plan Module for Salmon and Steelhead* (NMFS 2011a) for information on estuary limiting factors, but there were some differences in how the plans translated the information into limiting factors experienced at the population level. The estuary module does not designate limiting factors as primary or secondary; instead, it ranks them in terms of assumed impact on ocean- and stream-type salmonids. Because the Oregon management unit plan integrated the module information with more specificity than did the Washington management unit plan, and because NMFS assumes that estuarine limiting factors affect all populations equally within the ESU, the estuarine limiting factors in this table and Section 7.5.1.2 reflect the determinations in the Oregon management unit plan, applied to all Lower Columbia River late-fall Chinook salmon populations, unless otherwise noted. As with other limiting factors, the designations of estuarine limiting factors as primary or secondary reflect working hypotheses that will need to be tested (and possibly revised) through adaptive management.

95 Although the Oregon management unit plan lists food web shifts as a primary limiting factor in the estuary, NMFS and the management unit planners agreed to consider such shifts secondary in this recovery plan to more closely reflect conclusions in the *Columbia River Estuary ESA Recovery Plan Module for Salmon and Steelhead* (NMFS 2011a). The extent to which food web shifts limit salmonid survival in the estuary is unclear.

Table 7-9

Baseline Limiting Factors and Threats Affecting LCR Late-Fall Chinook Salmon: Stratum-Level Summary

Ecological Concern	Threat(s)	VSP Parameters Affected	Cascade Late Fall
Peripheral and Transitional Habitats: Estuary Condition	Past and/or current land use practices/transportation corridor, mainstem dams	All	Secondary for juveniles in both populations
Channel Structure and Form	Past and/or current land use practices/ transportation corridor	All	Secondary for juveniles in both populations
Sediment Conditions	Past and/or current land use practices/transportation corridor , dams	All	Primary for juveniles in both populations
Water Quality (Temperature)	Land uses that impair riparian function/decrease streamflow, dam reservoirs	A,P,D	Secondary for juveniles in both populations
Water Quantity (Flow)	Columbia River mainstem dams	All	Primary for juveniles in both populations
Hydropower Limiting Factors			
Habitat Quantity (Access)	Bonneville Dam	All	
Habitat Quantity (Access)	Tributary dams	All	Secondary for Sandy juveniles
Harvest Limiting Factors			
Direct Mortality	Fisheries	A,D	Primary for adults in both populations
Hatchery Limiting Factors			
Food[96]	Smolts from all Columbia Basin hatcheries competing for food and space in the estuary	All	Secondary for juveniles in both populations
Population Diversity	Stray hatchery fish interbreeding with wild fish	A,P,D	Primary for Sandy adults
Predation Limiting Factors			
Direct Mortality	Land use	A,P,D	Secondary for juveniles in both populations
Direct Mortality	Dams	A,P,D	

7.6.1.1 Tributary Habitat Limiting Factors

Degraded riparian conditions caused by land uses past and present are a primary limiting factor for the Sandy late-fall Chinook salmon population and a secondary factor for the North Fork Lewis population. So, too, are channel structure and form issues, in the form of reductions in habitat complexity, diversity, and connectivity; changes in channel structure and form have resulted from past and current land uses, including the

[96] Some scientists suspect that closely spaced releases of hatchery fish from all Columbia Basin hatcheries may lead to increased competition with natural-origin fish for food and habitat space in the estuary. NMFS 2011a and LCFRB (2010) identified competition for food and space among hatchery and natural-origin juveniles in the estuary as a critical uncertainty. ODFW (2010) acknowledged that uncertainty but listed competition for food and space as a secondary limiting factor for juveniles of all populations. The NMFS Northwest Region and Northwest Fisheries Science Center are working to better define and describe the scientific uncertainty associated with ecological interactions between hatchery-origin and natural-origin salmon in freshwater, estuarine, and nearshore ocean habitats.

transportation corridor. Sediment conditions are a secondary limiting factor for both populations. The high density of forest and rural roads in the Lower Columbia subdomain contributes to an abundance of fine sediment in tributary streams used by late-fall Chinook salmon. The resulting excess fine sediment covers spawning gravel, limiting egg development and incubation.

Water quality—specifically elevated water temperature—is a secondary limiting factor for juveniles from the North Fork Lewis population of late-fall Chinook salmon. Water quantity issues related to altered hydrology and flow timing have been identified as secondary limiting factors for both populations. Impaired side channel and wetland conditions along with degraded floodplain habitat also have significant negative impacts on Lower Columbia River late-fall Chinook salmon, warranting mention as a primary limiting factor for the Sandy population and a secondary factor for the North Fork Lewis population.

7.6.1.2 *Estuary Habitat Limiting Factors*[97]

Estuary habitat conditions are important for juvenile late-fall Chinook salmon, which spend considerable time rearing in the estuary. Water quantity issues related to altered hydrology and flow timing are identified as a primary limiting factor for both late-fall populations, as is impaired sediment and sand routing; these limiting factors are associated with hydroregulation at large storage reservoirs in the interior of the Columbia Basin, and, in the case of sediment issues, land uses both past and present. Much of the land surrounding the Columbia River estuary is in agricultural or rural residential use and has been extensively modified via dikes, levees, bank stabilization, and tide gates. Altered hydrology and sediment routing influence habitat-forming processes, the quantity and accessibility of habitats such as side channels and wetlands, the dynamics of the Columbia River plume, and the estuarine food web.

Channel structure issues, in the form of reduced habitat complexity and diversity, are identified as a secondary limiting factor for juveniles from both populations, as is lack of access to peripheral and transitional habitats such as side channels and wetlands. Again, simplification of channel structure is related to conversion of land to other uses—agricultural, rural residential, and as a transportation corridor—while juveniles' access to side channels and wetlands is impaired by these same land uses but also by flow alterations caused by mainstem dams. Other secondary limiting factors in the estuary that affect both late-fall bright populations are exposure to toxic contaminants (from urban, industrial, and agricultural sources) and elevated late summer and fall water

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[97] The Washington and Oregon management unit plans both relied on the *Columbia River Estuary ESA Recovery Plan Module for Salmon and Steelhead* (NMFS 2011a) for information on estuary limiting factors, but there were some differences in how the plans translated the information into limiting factors experienced at the population level. The estuary module does not designate limiting factors as primary or secondary; instead, it ranks them in terms of assumed impact on ocean- and stream-type salmonids. Because the Oregon management unit plan integrated the module information with more specificity than did the Washington management unit plan, and because NMFS assumes that estuarine limiting factors affect all populations equally within the ESU, the estuarine limiting factors in this section and in Table 7-9 reflect the determinations in the Oregon management unit plan, applied to all Lower Columbia River late-fall Chinook salmon populations, unless otherwise noted. As with other limiting factors, the designations of estuarine limiting factors as primary or secondary reflect working hypotheses that will need to be tested (and possibly revised) through adaptive management.

temperatures, which are related to (1) land use practices that impair riparian function or decrease streamflow, and (2) large hydropower reservoirs. Altered food web dynamics involving a transition from a macrodetrital-based food web to a microdetrital-based food web also are considered a secondary limiting factor for both populations.[98] These changes in the estuarine food web are caused primarily by increased microdetrital inputs from hydropower reservoirs and the loss of wetland habitats through diking and filling.

7.6.1.3 Hydropower Limiting Factors

Flow management operations at large storage reservoirs in the interior of the Columbia Basin (Grand Coulee, Dworshak, etc.) affect all juvenile Lower Columbia River late-fall Chinook salmon in the lower mainstem and estuary, and potentially in the plume—primarily by altering flow volume and timing. These alterations impair sediment routing, influence habitat-forming processes, reduce access to peripheral habitat, and change the dynamics of the Columbia River plume and the estuarine food web (see Section 7.6.1.2).[99] Moreover, the large reservoirs associated with mainstem dams contribute to elevated water temperatures downstream in late summer and fall. Tributary hydropower impacts in the form of impaired habitat access and passage were identified as a secondary limiting factor for Sandy late-fall Chinook salmon, with downstream fry passage being impaired by PGE's Bull Run Hydroelectric Project (consisting of Marmot and Little Sandy dams). This project was removed in 2009, so this limiting factor has been addressed. In the Lewis subbasin, the Lewis River hydroelectric project's effects on flow, sediment transport, and large wood supply were identified as limiting factors.

7.6.1.4 Harvest Limiting Factors

Harvest-related mortality is identified as a primary limiting factor for both populations. Harvest rates historically were around 54 percent but have dropped to approximately 36 percent since listing. The majority of the harvest affecting late-fall Chinook salmon takes place in ocean fisheries, although there is some harvest in non-treaty fisheries in the mainstem Columbia River below Bonneville Dam, and in the North Fork Lewis River.

7.6.1.5 Hatchery-Related Limiting Factors

Population-level effects resulting from stray hatchery fish interbreeding with natural-origin fish are identified as a secondary limiting factor for the Sandy population, which has an average pHOS of 25 percent. The North Fork Lewis population is largely uninfluenced by hatchery effects.

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[98] Although the Oregon management unit plan lists food web shifts as a primary limiting factor in the estuary, NMFS and the management unit planners agreed to consider such shifts secondary in this recovery plan to more closely reflect conclusions in the *Columbia River Estuary ESA Recovery Plan Module for Salmon and Steelhead* (NMFS 2011a). The extent to which food web shifts limit salmonid survival in the estuary is unclear.

[99] It is likely that flow impacts of the hydropower system affect Lower Columbia River ESUs more through changes in habitat-forming processes (including impacts to the plume) and food web impacts than through changes in migratory travel time.

Some scientists suspect that closely spaced releases of hatchery fish from all Columbia Basin hatcheries may lead to increased competition with natural-origin fish for food and habitat space in the estuary. NMFS (2011a) and LCFRB (2010a) identified competition for food and space among hatchery and natural-origin juveniles in the estuary as a critical uncertainty. ODFW (2010) acknowledged that uncertainty but listed competition for food and space as a secondary limiting factor for juveniles of both populations. The NMFS Northwest Region and Northwest Fisheries Science Center are working to better define and describe the scientific uncertainty associated with ecological interactions between hatchery-origin and natural-origin salmon in freshwater, estuarine, and nearshore ocean habitats.

7.6.1.6 Predation Limiting Factors

Direct mortality from predation is a secondary limiting factor for all Cascade Chinook salmon populations, including late-fall Chinook salmon. Anthropogenic changes to the structure of habitat have increased predator abundance and effectiveness and led to increased predation by Caspian terns, double-crested cormorants, and various other seabird species in the Columbia River mainstem, estuary, and plume.

7.6.2 Late-Fall Chinook Salmon Baseline Threat Impacts and Threat Reduction Targets

Table 7-10 shows the estimated impact on each Lower Columbia River late-fall Chinook salmon population resulting from potentially manageable threats, organized into six threat categories: tributary habitat degradation, estuary habitat degradation, hydropower, harvest, hatcheries, and predation. Both baseline and target impacts are shown, with the targets representing mortality levels that would be consistent with long-term recovery goals. Impact values indicate the percentage reduction in abundance and productivity that is attributable to human activities related to a particular threat category. The value associated with any particular threat category can be interpreted as the percent reduction in abundance and productivity from historical conditions if that threat category were the only one affecting the population. Cumulative values (both baseline and target) are multiplicative rather than additive. The table also shows the percentage improvement in productivity and abundance (i.e., improvement in population survival) that is needed to achieve the target impacts and corresponding population status.[100]

As an example, the baseline status of the Sandy late-fall Chinook salmon population has been reduced by the combined effects of multiple threats. The cumulative reduction in status was estimated at 90.8 percent from the multiplicative impacts of multiple threats acting across the salmon life cycle. Thus, current status is just 9.2 percent of the historical potential with no human impact. Tributary and estuary habitat, harvest, and hatchery impacts each accounted for reductions in population productivity of 20 percent or more,

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[100] The percentage of survival improvement needed is the percentage change in net impacts, is derived from information in the Washington and Oregon management unit plans, and is calculated as follows: $[(1-\text{Cumulative}_{\text{Target}})-(1-\text{Cumulative}_{\text{Baseline}})]/[1-\text{Cumulative}_{\text{Baseline}}] \times 100$. These values generally correspond to population improvement targets identified for Washington populations in LCFRB (2010). Comparable numbers are not explicitly reported in ODFW (2010) but are implicit in the modeling approach that Oregon recovery planners used to derive target impacts.

with corresponding reductions in abundance, spatial structure, and diversity. The Oregon management unit plan identifies a recovery strategy involving significant reductions in the impact of several threats. For instance, the plan targets tributary habitat impacts to be reduced from the estimated baseline level of 23 percent to 17 percent (i.e., an approximately 8 percent improvement relative to baseline conditions). With the targeted reductions in individual impacts, the cumulative effect of all impacts would drop from 90.8 percent at baseline to 61.6 percent at the target status. This change would translate into a 310 percent improvement in survival relative to the baseline. Although the population would still be experiencing abundance and productivity that are 74.7 percent lower than historical conditions, the extinction risk at this mortality level would be estimated sufficient to meet the targets for this plan.

Oregon and Washington recovery planners used somewhat different definitions or methods to quantify the estimated impacts of anthropogenic threats. Baseline impacts for the Washington population reflect conditions prevalent at the time of ESA listing (circa 1999), while the baseline impacts for the Oregon population reflect conditions through 2004. Dam impacts for the Washington population reflect passage mortality, habitat loss caused by inundation, and loss of access to historical production areas; for the Oregon population, the estimate of impacts in the "Dams" column of the Table 7-10 reflects direct upstream and downstream passage mortality only, with other dam impacts accounted for in the habitat and predation threat categories. Hatchery impacts for the Washington population were limited to not more than 50 percent per population, in accordance with Hatchery Scientific Review Group (HSRG) assessments of the potential for genetic effects (Hatchery Scientific Review Group 2009); for the Oregon population, recovery planners used hatchery impact rates equivalent to one-half the rates at which hatchery fish were found on natural spawning grounds, based on analyzed relationships and reflecting concern about genetic and ecological effects. Washington recovery planners derived estimates of impacts to tributary habitat using the Ecosystem Diagnosis and Treatment (EDT) model. Oregon recovery planners estimated the mortality associated with estuary habitat degradation, hydropower, harvest, hatcheries, and predation and assigned all remaining mortality (relative to the difference between the current modeled abundance and estimated historical abundance) to tributary habitat. In general, the tributary habitat values in Table 7-10 have the highest degree of uncertainty relative to the other threat categories and, for Oregon populations, may include causes of mortality associated with the other threat categories but not directly captured in those mortality estimates. (See Section 5.5 for more on the methodologies used to estimate baseline impacts.)

Estimates of threat impacts are useful in showing the relative magnitude of impacts on each population. Given the differences in methodologies, some values in Table 7-10 for the Oregon and Washington populations are not necessarily directly comparable. Regardless of differences in specific threat impact definitions and methods, the net effect of changes from all threats is useful in understanding the magnitude of population improvement needed to achieve the target population status.

The target impacts in Table 7-10 represent one of several possible combinations of threat reductions that could conceivably close the conservation gap and lead to a population achieving its target status. The particular threat reductions shown in Table 7-10 reflect policy decisions and the methodologies and assumptions used by the different recovery planning teams. (For a description of how target impacts were developed, see Section 5.6.) In estimating impacts, management unit recovery planners evaluated each threat category independently (i.e., values in the table reflect the mortality of Chinook salmon exposed to that particular category of threats, whether or not they are exposed to threats in other categories). The estimates of baseline threat impacts have high levels of uncertainty and in many cases should be considered working hypotheses that are testable as part of recovery plan implementation. Despite this uncertainty, it is the expert judgment of NMFS and management unit scientists that, based on the best available information at this time, the estimates of baseline threat impacts provide a reasonable estimate of the relative magnitude of different sources of anthropogenic mortality and serve as an adequate basis for designing initial recovery actions.[101] As more and better information is collected, it will be applied to recovery efforts in an adaptive management framework.

Both the North Fork Lewis and Sandy populations are currently considered viable; however, the recovery scenario calls for the persistence probability of the Sandy population to be raised from high to very high. This will be accomplished primarily through reductions in harvest and hatchery impacts. As with spring and fall Chinook salmon, recent actions have substantially reduced harvest impacts on late-fall Chinook salmon over baseline conditions, but additional reductions in harvest impacts are called for to achieve the target status for the Sandy population. More modest reductions in the tributary and estuarine habitat, hydropower, and predation threat categories are expected to support the gains achieved through reductions in harvest and hatchery impacts.

[101] As implementation proceeds, research, monitoring, and evaluation and adaptive management will be key in helping to refine scientific understanding of the impact of threats on population persistence and of the extent to which management actions are reducing threats.

Table 7-10
Impacts of Potentially Manageable Threats and Impact Reduction Targets Consistent with Recovery of LCR Late-fall Chinook Salmon Populations

Population	Impacts at Baseline[102]							Impacts at Target							% Survival Improvement Needed[110]
	T. Hab[103]	Est[104]	Dams[105]	Harv[106]	Hat[107]	Pred[108]	Cumulative[109]	T. Hab	Est	Dams	Harv	Hat	Pred	Cumulative	
Cascade Late Fall															
NF Lewis (WA)	0.10	0.23	0.16	0.50	0.05	0.11	0.7539	0.10	0.23	0.16	0.50	0.05	0.11	0.7539	0
Sandy (OR)	0.23	0.31	0.03	0.50	0.25	0.07	0.9074	0.17	0.26	0.00	0.30	0.05	0.06	0.6161	310

102 Impact figures represent a percentage reduction in abundance and productivity that is attributable to human activities related to a particular threat category. Methods used to estimate impacts differ for Oregon and Washington populations. For example, baseline impacts reflect conditions circa 1999 for Washington populations and through 2004 for Oregon populations. Given the methodological differences, impact figures are not necessarily directly comparable. See Sections 5.5 and 5.6 for more on methodologies.

103 Reduction in tributary habitat production potential relative to historical conditions. Oregon and Washington used different methods to estimate historical abundance. Oregon's approach, which incorporates safety margins and includes causes of mortality that are not captured in the other five threat categories, tends to indicate a higher potential impact from tributary habitat loss and degradation than does Washington's.

104 Reduction in juvenile survival in the Columbia River estuary as a result of habitat changes (relative to historical conditions); excludes predation.

105 Reflects passage mortality, habitat loss caused by inundation, and loss of access to historical production areas for Washington populations; for Oregon populations, dam impacts reflect direct passage mortality only.

106 Includes direct and indirect mortality.

107 Reflects only the negative impacts of hatchery-origin fish, such as high pHOS and low PNI (proportion of natural influence), not the benefits of conservation hatchery programs.

108 Includes the aggregate predation rate in the Columbia River mainstem and estuary by northern pikeminnow, marine mammals, Caspian terns, and cormorants.

109 Cumulative values (both baseline and target) are multiplicative rather than additive and are equal to $(1-[(1-M_{thab})(1-M_{est})(1-M_{dams})(1-M_{harv})(1-M_{hatch})(1-M_{pred})])$. Minor differences from numbers in ODFW 2010 are due to rounding.

110 Survival improvements indicate the percentage improvement (rounded to the nearest 10) in population survival needed to achieve target impacts and are derived from the cumulative values (baseline and target), using the following equation: $[(1\text{-Cumulative}_{Target})-(1\text{-Cumulative}_{Baseline})]/[1\text{-Cumulative}_{Baseline}] \times 100$. These cumulative impact numbers are not explicitly reported in ODFW (2010) but are implicit in the modeling approach that Oregon recovery planners used to derive target impacts.

7.6.3 Late-Fall Chinook Salmon Recovery Strategy

7.6.3.1 Strategy Summary

The recovery strategy for the late-fall component of the Lower Columbia River Chinook salmon ESU is designed to maintain the two healthy populations (North Fork Lewis and Sandy) and raise the persistence probability of the Sandy population from high to very high. Key elements of the strategy are as follows:

1. Implement the regional hatchery strategy. Minimize the impacts of hatchery releases of steelhead, coho, and spring Chinook salmon on late-fall Chinook salmon. Continue the current practice of not releasing hatchery fall Chinook salmon into the North Fork Lewis River.

2. Reduce harvest impacts on the Sandy late-fall population by using the same harvest strategies identified for tule fall Chinook salmon. Continue to manage fisheries to meet the spawning escapement goal for the Lewis River late-fall population and consider reassessing the goal as new data are acquired.

3. Implement actions in the regional tributary and estuary habitat strategy designed to benefit tule fall Chinook salmon. Implement the stratum-level tributary habitat strategies designated for tule fall Chinook.

Improving the persistence of the Sandy population will be accomplished primarily through reductions in harvest and hatchery impacts. As with spring and tule fall Chinook salmon, recent actions have substantially reduced harvest impacts on late-fall Chinook salmon over baseline conditions, but additional reductions in harvest impacts are called for to achieve the target status for the Sandy population.

7.6.3.2 Late-Fall Chinook Salmon Tributary and Estuarine Habitat Strategy

In general, tributary and estuary habitat actions designed to benefit tule fall Chinook salmon will benefit the two late-fall Chinook salmon populations. Actions include those in the regional tributary and estuary habitat strategies (see Sections 4.1.2 and 4.2.2) and the stratum-level tributary habitat strategies described in Section 7.5.3.2.

7.6.3.3 Late-Fall Chinook Salmon Hydropower Strategy

Tributary hydropower impacts, which had baseline effects on the Sandy late-fall population, have been addressed by the removal of PGE's Marmot and Little Sandy dams (ODFW 2010). The hydropower strategy also includes implementation of mainstem flow management operations designed to benefit spring migrants from the interior of the Columbia Basin; NMFS expects that these flow management operations will also improve survival in the estuary and, potentially, the plume for all Lower Columbia River salmon and steelhead populations. (See the regional hydropower strategy in Section 4.3.2).

7.6.3.4 Late-Fall Chinook Salmon Harvest Strategy

Late-fall Chinook salmon are captured in many of the same ocean fisheries as their early fall run counterparts, although overall, inshore recreational and net harvest impacts are somewhat less for late-run fall Chinook salmon. Fisheries are managed to meet a spawning escapement goal for Lower Columbia River bright fall Chinook salmon that is based on the North Fork Lewis river population. In recent years, this escapement goal has been 5,700 natural adult late-fall Chinook salmon. Under the recovery strategy, ocean and freshwater fisheries would continue to employ escapement goal management for Lewis River late-fall Chinook salmon. The escapement goal may be reassessed as new data are acquired (LCFRB 2010a). Consistent with the regional harvest strategy (see Section 4.5.2), the Oregon management unit plan targets a reduction in harvest impacts for the Sandy late-fall Chinook salmon population from 50 percent to 30 percent and expects that this reduction would be achieved through the same harvest strategies identified for tule fall Chinook salmon.

7.6.3.5 Late-Fall Chinook Salmon Hatchery Strategy

The regional hatchery strategy described in Section 4.4.2 summarizes goals and approaches relevant to Lower Columbia River late-fall Chinook salmon. Lewis River naturally spawning late-fall Chinook salmon are the healthiest Chinook salmon population in the lower Columbia Basin and have been largely uninfluenced by hatchery production. Hatchery late-fall Chinook salmon are not released into the North Lewis River and releases should not be considered in the future. Hatchery releases of steelhead, coho, and spring Chinook salmon, either from the hatchery harvest program or from the upper Lewis natural reintroduction program, must include strategies to minimize impacts to rearing naturally produced fall and late-fall Chinook salmon. Hatchery strays have had a lesser, though still key, effect on the Sandy late-fall Chinook salmon population, with stray rates at one time averaging 24 percent but currently assumed to be less than 10 percent (lower than the hatchery threat reduction target for the Sandy late-fall population) (ODFW 2010).

7.6.3.6 Late-Fall Chinook Salmon Predation Strategy

The regional predation strategy (see Section 4.6.2) involves reducing predation by birds, fish, and marine mammals and will benefit all Lower Columbia River ESUs, including late-fall Chinook salmon.

7.6.3.7 Critical Uncertainties

For all ESUs, there are uncertainties regarding how habitat actions will translate into changes in productivity and capacity (Roni et al. 2011). In addition, the following are critical uncertainties specific to the Lower Columbia River late-fall Chinook salmon recovery strategy:

- Evaluate assumptions about harvest: are impacts on the Sandy late fall Chinook salmon population lower than those on the tules because of run timing differences?

- Adequacy of the spatial distribution of the North Fork Lewis population to maintain the population at a high probability of persistence

These critical uncertainties represent preliminary priorities identified by Oregon and Washington recovery planners and NMFS Northwest Regional Office and Northwest Fisheries Science Center staff during a 2010 workshop. They are preliminary priorities only; as described in Chapter 10, additional discussion among recovery planners and NMFS staff will be needed to finalize future research and monitoring priorities for Lower Columbia River Chinook salmon.

The management unit plans identify more comprehensive critical uncertainties and research, monitoring, and evaluation needs that, along with the list above, will provide the basis for these future discussions. The Washington management unit plan has a discrete section on critical uncertainties for all of the ESUs in general (see Section 9.6 of LCFRB 2010a, pp. 9-68 through 9-73), while the Oregon management unit plan embeds relevant critical uncertainties within subsections on the four VSP parameters and five ESA listing factors (see Sections 8.4 and 8.5, respectively, of ODFW 2010). In addition, in June 2010, the Lower Columbia Fish Recovery Board completed its *Research, Monitoring, and Evaluation Program for Lower Columbia Salmon and Steelhead* as a companion to its recovery plan (LCFRB 2010b). This document also describes critical uncertainties. The list above also does not include critical uncertainties that apply to multiple ESUs; these will be discussed and considered as decisions are made in implementation. In addition, the critical uncertainties above are of a technical nature; there are also many critical uncertainties related to social, political, and economic issues.

Critical uncertainties are one element of research, monitoring, and evaluation (RME) and adaptive management, which Chapter 10 discusses in depth. RME and adaptive management will be key components of the Lower Columbia River late-fall Chinook salmon recovery strategy.

7.7 Delisting Criteria Conclusion for LCR Chinook Salmon

The requirement for determining that a species no longer requires the protection of the ESA is that the species is no longer in danger of extinction or likely to become endangered within the foreseeable future, based on evaluation of the listing factors specified in ESA section 4(a)(1). To remove the Lower Columbia River Chinook salmon ESU from the Federal List of Endangered and Threatened Wildlife and Plants (that is, to delist the ESU or DPS), NMFS must determine that the ESU, as evaluated under the ESA listing factors, is no longer likely to become endangered.

The ESA requires that recovery plans, to the maximum extent practicable, incorporate objective, measurable criteria that, when met, would result in a determination in accordance with the provisions of the ESA that the species be removed from the Federal List of Endangered and Threatened Wildlife and Plants (50 CFR 17.11 and 17.12). The recovery criteria in this plan (both biological and threats criteria) meet this statutory requirement.

As described in Section 7.3, if the scenario in Table 7-4 were achieved, it would exceed the WLC TRT's stratum-level viability criteria in the Coast and Cascade fall strata, the

Cascade spring stratum, and the Cascade late-fall stratum. However, the scenario for the Gorge fall and Gorge spring strata does not meet WLC TRT criteria because, within each stratum, the scenario targets only one population (the Hood) for high persistence probability, instead of two (see Table 7-11).[111] Exceeding the WLC TRT criteria in the Cascade fall and spring Chinook strata was intentional on the part of local recovery planners to compensate for uncertainties about meeting the WLC TRT's criteria in the Gorge fall and spring strata. In addition, multiple spring Chinook salmon populations are prioritized for aggressive recovery efforts to balance risks associated with the uncertainty of success in reintroducing spring Chinook salmon populations above tributary dams in the Cowlitz and Lewis systems.

Table 7-11
LCR Chinook Salmon Recovery Scenario Scores Relative to WLC TRT Viability Criteria

Species	Number of Primary Populations					Stratum Average Criteria			
		Coast	Cascade	Gorge	Total		Coast	Cascade	Gorge
Fall Chinook	n ≥ high	4	4	1	9	Avg. score	2.36	2.35	2.25*
	TRT criterion (n ≥ 2) met?	Yes	Yes	No		TRT criterion (avg. ≥ 2.25) met?	Yes	Yes	*
Late-Fall Chinook	n ≥ high	--	2	--	2	Avg. score	--	4.00	--
	TRT criterion (n ≥ 2) met?	--	Yes	--		TRT criterion (avg. ≥ 2.25) met?	--	Yes	--
Spring Chinook	n ≥ high	--	4	1	5	Avg. score	--	2.36	2.75*
	TRT criterion (n ≥ 2) met?	--	Yes	No		TRT criterion (avg. ≥ 2.25) met?	--	Yes	*

*Stratum does not meet WLC TRT criterion for number of populations at high or higher probability of persistence.

Source: Based on LCFRB 2010a, Table 4-7

Recovery planners' uncertainty about meeting WLC TRT criteria in the Gorge fall and spring Chinook salmon strata is based on questions about available habitat and anthropogenic impacts that are unlikely to change in the near future (e.g., inundation of habitat by Bonneville Reservoir) and on questions regarding Gorge strata and population delineations and historical role (LCFRB 2010a, ODFW 2010). These questions include whether the Gorge populations were highly persistent historically, whether they functioned as independent populations within their stratum in the same way that the

[111] As discussed in Section 2.5.4, the TRT's criteria for high probability of stratum persistence require that two or more populations be viable and that the average score for all populations in the stratum be 2.25 or higher.

Coast and Cascade populations did, and whether the Gorge stratum itself should be considered a separate stratum from the Cascade stratum.

As discussed in Section 3.2, NMFS has considered the WLC TRT's viability criteria (from McElhany et al. 2003 and 2006 and summarized in Table 2-3), the additional recommendations in McElhany et al. (2007), the recovery scenarios and population-level abundance and productivity goals developed by the management unit planners, and the questions management unit planners raised regarding the historical role of the Gorge strata.

NMFS has concluded that the WLC TRT's criteria adequately describe the characteristics of an ESU that meet or exceed the requirement for determining that a species no longer needs the protection of the ESA. These criteria provide a framework within which to evaluate specific recovery scenarios. NMFS has evaluated the recovery scenario in the management unit plans for Lower Columbia River Chinook salmon (summarized in Table 3-1 of this recovery plan) and the associated population-level abundance and productivity goals (see Section 7.3).

Regarding the divergence of the scenario from the WLC TRT's criteria, the TRT noted in its revised viability criteria (McElhany et al. 2006) the need for case-by-case evaluations of the continuum of ESU-level risk associated with some strata not meeting their criteria. In commenting on the recovery scenarios presented in the interim Washington management unit plan[112]—and by extension the recovery scenarios presented in Table 3-1 of this plan—the WLC TRT stated that achieving the recovery scenarios would improve the status of the Gorge strata, even if the TRT's criteria for those strata were not met. The TRT also noted that targeting the Cascade strata for very high persistence (above the minimum TRT criteria) would help lower ESU extinction risk. In addition, the TRT noted that the Gorge and Cascade strata are relatively similar compared to the Cascade and Coast strata. Also significant in the TRT's view was that options for recovery of the Gorge stratum would be preserved, in case future conditions or analyses were to require high stratum persistence for ESU viability (McElhany et al. 2006, p. 9).

Based on the information provided by the WLC TRT and the management unit recovery planners, NMFS concludes that the recovery scenarios in Table 3-1 and the associated population-level abundance and productivity goals in Section 7.3 represent one of multiple possible scenarios that would meet biological criteria for delisting. The similarities between the Gorge and Cascade strata, coupled with compensation in the Cascade stratum for not meeting TRT criteria in the Gorge stratum, would provide an ESU no longer likely to become endangered. NMFS endorses the recovery scenario and population-level goals found in the management unit plans for Lower Columbia River Chinook salmon (summarized in Table 3-1 and Section 7.3) as one of multiple possible scenarios consistent with delisting.

NMFS also agrees with the management unit planners that the historical role of the Gorge populations and stratum merits further examination. The extent to which

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[112] In February 2006, NMFS approved the December 2004 version of the Washington management unit plan as an interim regional recovery plan for Lower Columbia River Chinook salmon and steelhead and Columbia River chum salmon. In May 2010, the LCFRB completed a revision of its 2004 plan (LCFRB 2010a), which is incorporated into this ESU-level recovery plan as Appendix B.

compensation in the Cascade stratum is ultimately considered necessary to achieve an acceptably low risk at the ESU level will depend on how questions regarding the historical role of the Gorge populations are resolved.

NMFS therefore proposes the following delisting criteria for the Lower Columbia River Chinook salmon ESU (NMFS has amended the WLC TRT's criteria to incorporate the concept that each stratum should have a probability of persistence consistent with its historical condition, thus allowing for resolution of questions regarding the Gorge strata):

1. All strata that historically existed have a high probability of persistence or have a probability of persistence consistent with their historical condition. High probability of stratum persistence is defined as:

    a. At least two populations in the stratum have at least a 95 percent probability of persistence over a 100-year time frame (i.e., two populations with a score of 3.0 or higher based on the TRT's scoring system).

    b. Other populations in the stratum have persistence probabilities consistent with a high probability of stratum persistence (i.e., the average of all stratum population scores is 2.25 or higher, based on the TRT's scoring system). (See Section 2.6 for a brief discussion of the TRT's scoring system.)

    c. Populations targeted for a high probability of persistence are distributed in a way that minimizes risk from catastrophic events, maintains migratory connections among populations, and protects within-stratum diversity.

    A probability of persistence consistent with historical condition refers to the concept that strata that historically were small or had complex population structures may not have met Criteria A through C, above, but could still be considered sufficiently viable if they provide a contribution to overall ESU viability similar to their historical contribution.

2. The threats criteria described in Section 3.2.2 have been met.

8. Columbia River Chum Salmon

8.1 Chum Salmon Biological Background

8.1.1 Chum Salmon Life History and Habitat

Columbia River chum salmon (*Oncorhynchus keta*) once were widely distributed throughout the lower Columbia Basin and spawned in the mainstem Columbia and the lower reaches of most lower Columbia River tributaries. Historically, spawning occurred as far upstream as the Umatilla and Walla Walla rivers, but it now is restricted largely to tributary and mainstem areas downstream of Bonneville Dam (LCFRB 2010a, NMFS 2011b). Although chum salmon are strong swimmers, they rarely pass river blockages and waterfalls that pose no hindrance to other salmon or steelhead (ODFW 2010); thus, they spawn in low-gradient, low-elevation reaches and side channels (LCFRB 2010a). Chum salmon enter fresh water close to the time of spawning. They need clean gravel for spawning, and spawning sites typically are associated with areas of upwelling water. For example, in 1999 chum salmon were discovered spawning along the Washington shoreline near the I-205 Glen Jackson Bridge, where upwelling occurs. In addition, a significant proportion of chum salmon returning to Hamilton Creek spawn in a spring-fed channel, and portions of the Grays River and Hardy Creek populations spawn in the area of springs (LCFRB 2010a).

Adult chum salmon returning to the Columbia River at the present time are virtually all fall-run fish, entering fresh water from mid-October through November and spawning from early November to late December (see Figure 8-1) (LCFRB 2010a). There is also evidence that a summer-run chum salmon population returned historically to the Cowlitz River, and fish displaying this life history are occasionally observed there (Ford 2011, Myers et al. 2006).

Various physical and biotic factors affect the time it takes for eggs to incubate, hatch, and emerge as alevins from the gravel, but water temperature is believed to have the most influence on embryonic development; lower water temperatures can prolong the time required from fertilization to hatching by 1.5 to 4.5 months (NMFS 2011b). Chum salmon fry emerge from March through May (LCFRB 2010a), typically at night (ODFW 2010), and are believed to migrate promptly downstream to the estuary for rearing. Chum salmon fry are capable of adapting to seawater soon after emergence from gravel (LCFRB 2010a). Their small size at emigration is thought to make chum salmon susceptible to predation mortality during at this life stage (LCFRB 2010a).

Given the minimal time chum salmon spend in their natal streams, the period of estuarine residency appears to be a critical phase in their life history and may play a major role in determining the size of returning adults (NMFS 2011b). Chum and ocean-type Chinook salmon usually spend more time in estuaries than do other anadromous salmonids (Dorcey et al. 1978 and Healey et al. 1982, as cited in NMFS 2011b)—weeks or months, rather than days or weeks (NMFS 2011a). Shallow, protected habitats such as salt marshes, tidal creeks, and intertidal flats serve as significant rearing areas for juvenile chum salmon during estuarine residency (LCFRB 2010a).

Juvenile chum salmon rear in the Columbia River estuary from February through June before beginning long-distance ocean migrations (LCFRB 2010a). Chum salmon remain in the North Pacific and Bering Sea for 2 to 6 years, with most adults returning to the Columbia River as 4-year-olds (ODFW 2010). All chum salmon die after spawning.

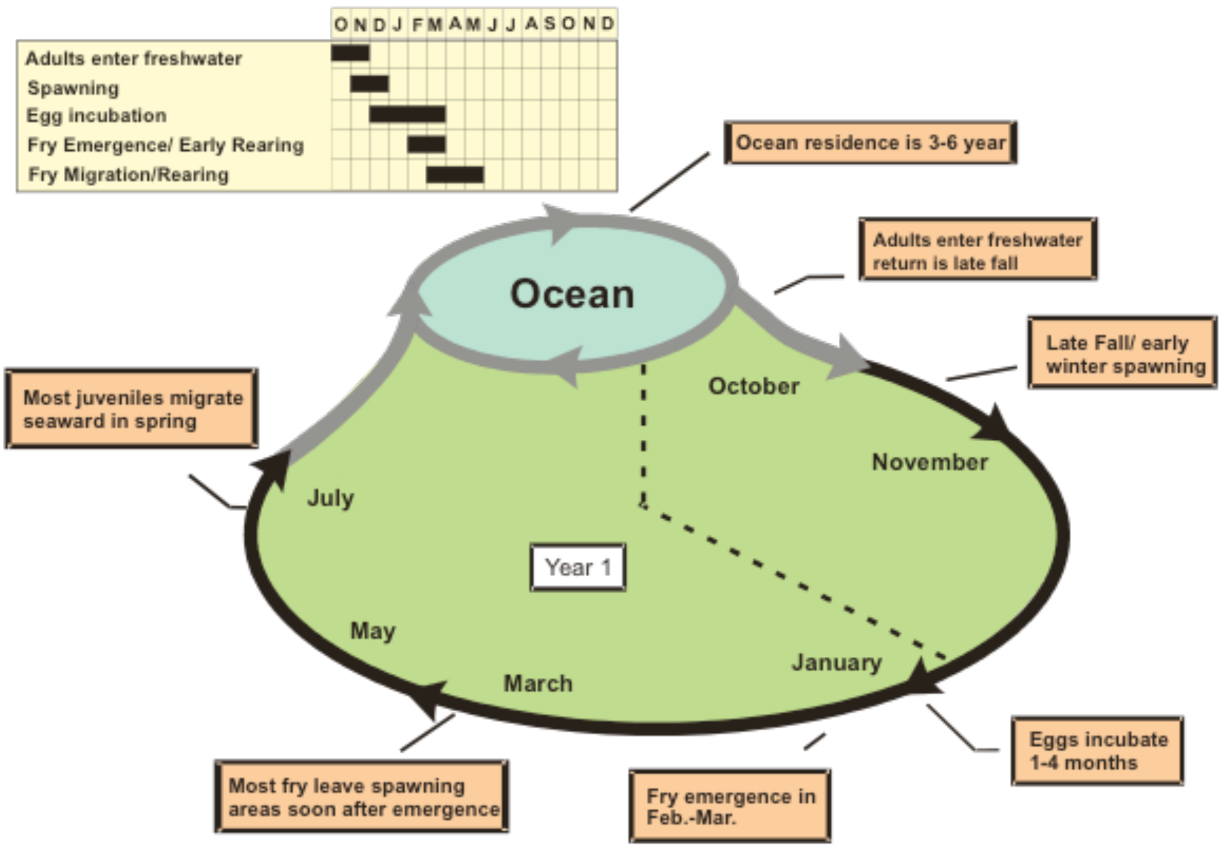

Figure 8-1. *Life Cycle of Columbia River Chum Salmon*

(Source: LCFRB 2010a)

8.1.2 Historical Distribution and Population Structure of Columbia River Chum Salmon

The Columbia River chum salmon ESU historically consisted of 17 independent populations. Of these, 16 were fall-run populations and one was a summer-run population that returned to the Cowlitz River.[1] Table 8-1 lists these populations and

[1] Recent genetic studies indicate the historical existence of a summer-run chum population in the Cowlitz subbasin (Ford 2011). Based on earlier information about the possible existence of this population (see Myers et al. 2006), the Washington management unit plan recognized the need to protect and restore the full

indicates core populations (which historically were highly productive) and genetic legacy populations (which represent important historical genetic diversity). Figure 8-2 shows the geographical distribution of Columbia River chum salmon strata and populations.

The Columbia River chum salmon ESU includes fish from three artificial propagation programs in Washington: the Chinook River (Sea Resources Hatchery), Grays River, and Washougal River/Duncan Creek chum salmon hatchery programs (70 *Federal Register* 37176). These programs produce fry for efforts to supplement natural populations (LCFRB 2010a). In 2010, the Oregon Department of Fish and Wildlife initiated a new chum salmon hatchery program, which NMFS has not yet evaluated for inclusion in the ESU, at Big Creek Hatchery to develop chum salmon for reintroduction into lower Columbia River tributaries in Oregon (76 *Federal Register* 50448, Jones 2011).

Table 8-1
Historical Columbia River Chum Salmon Populations

Stratum	Historical Populations	Core or Genetic Legacy Populations
Coast	Youngs Bay (OR)	Core
	Grays/Chinook (WA)	Core, genetic legacy
	Big Creek (OR)	Core
	Elochoman/Skamakowa (WA)	Core
	Clatskanie (OR)	
	Mill/Abernathy/Germany (WA)	
	Scappoose (OR)	
Cascade	Cowlitz - fall (WA)	Core
	Cowlitz - summer (WA)	Core
	Kalama (WA)	
	Lewis (WA)	Core
	Salmon Creek (WA)	
	Clackamas (OR)	Core
	Sandy (OR)	
	Washougal (WA)	
Gorge	Lower Gorge (WA & OR)	Core, genetic legacy
	Upper Gorge[2] (WA & OR)	

Source: Myers et al. (2006), McElhany et al. (2003).

range of diversity in this ESU, and incorporated actions to recover summer-run chum in the Cowlitz subbasin to a medium probability of persistence. The WLC TRT defines a stratum as a group of populations sharing major life history characteristics (e.g., run timing) and ecological zones and representing a major diversity component within an ESU (McElhany et al. 2003). It remains unclear whether summer-run chum salmon in the Cowlitz River represent a separate stratum from Cascade fall-run chum or the early component of broadly distributed run timing. In its 2011 5-year review, the NMFS Northwest Fisheries Science Center concluded that available information suggests adding the summer-run chum population to the Cascade stratum of the Columbia River chum ESU (Ford 2011). This approach is consistent with the Washington management unit plan's approach. Organizationally within this ESU-level recovery plan, Cowlitz summer chum are included in the Cascade chum stratum.

[2] Includes White Salmon population.

8.2 Baseline Population Status of Columbia River Chum Salmon

Over the last century, Columbia River chum salmon returns have collapsed from hundreds of thousands to just a few thousand per year. Of the 17 populations that historically made up this ESU, 15 of them (six in Oregon and nine in Washington) are so depleted that either their baseline probability of persistence is very low or they are extirpated or nearly so (LCFRB 2010a, ODFW 2010, Ford 2011).[3] All three strata in the ESU fall significantly short of the WLC TRT criteria for viability.

Currently almost all natural production occurs in just two populations: the Grays/Chinook and the Lower Gorge (see Figure 8-2).The Grays/Chinook population has a moderate persistence probability, and the Lower Gorge population has a high probability of persistence (LCFRB 2010a). The Lower Gorge population meets abundance and productivity criteria for very high levels of viability, but the distribution of spawning habitat (i.e., spatial structure) for the population has been significantly reduced (LCFRB 2010a); spatial structure may need to be improved, at least in part, through better performance from the Oregon portion of the population.

The very low persistence probabilities or possible extirpations of most chum salmon populations are due to low abundance, productivity, spatial structure, and diversity. Habitat loss has severely reduced the distribution of suitable chum salmon habitats, with accompanying reductions in abundance and productivity. Limited distribution also increases risk to the ESU from local disturbances. Although hatchery production of chum salmon has been limited and hatchery effects on diversity are thought to have been relatively small,[4] diversity has been greatly reduced at the ESU level because of presumed extirpations and the low abundance in the remaining populations (fewer than 100 spawners per year for most populations) (LCFRB 2010a). For additional discussion of Columbia River chum salmon population status, see the management unit plans (LCFRB 2010a, pp. 6-33 through 6-35; ODFW 2010, pp. 57-58; and NMFS 2011b, p. 4-3) and Ford (2011).

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[3] As described in Section 2.5 and 2.6, the WLC TRT recommended methods for evaluating the status of Lower Columbia River salmon and steelhead populations. The TRT's approach is based on evaluating the population parameters of abundance, productivity, spatial structure, and diversity and then integrating those assessments into an overall assessment of population persistence probability. As also described in Section 5.1, management unit recovery planners evaluated their respective populations' baseline status in a manner generally consistent with the WLC TRT's approach, with the baseline period being either circa 1999 (for Washington populations) or 2006-2008 (for Oregon populations). Unless otherwise noted, NMFS and the management unit planners believe that those assessments accurately the status of the population at that time; the assessments are the basis for the summaries presented here and are consistent with the conclusions of the Northwest Fisheries Science Center in its *Status Review Update for Pacific Salmon and Steelhead Listed under the Endangered Species Act* (Ford 2011). New information on population status will continue to accumulate over time and will be taken into account as needed to reflect the best available science regarding a population's status.

[4] LCFRB 2010a reports that the proportion of hatchery-origin spawners for most Washington populations is 3 percent or less. The exception is the Grays/Chinook population, which has a pHOS of 54 percent (LCFRB 2010a) because a conservation hatchery program is being used to supplement natural production in that population.

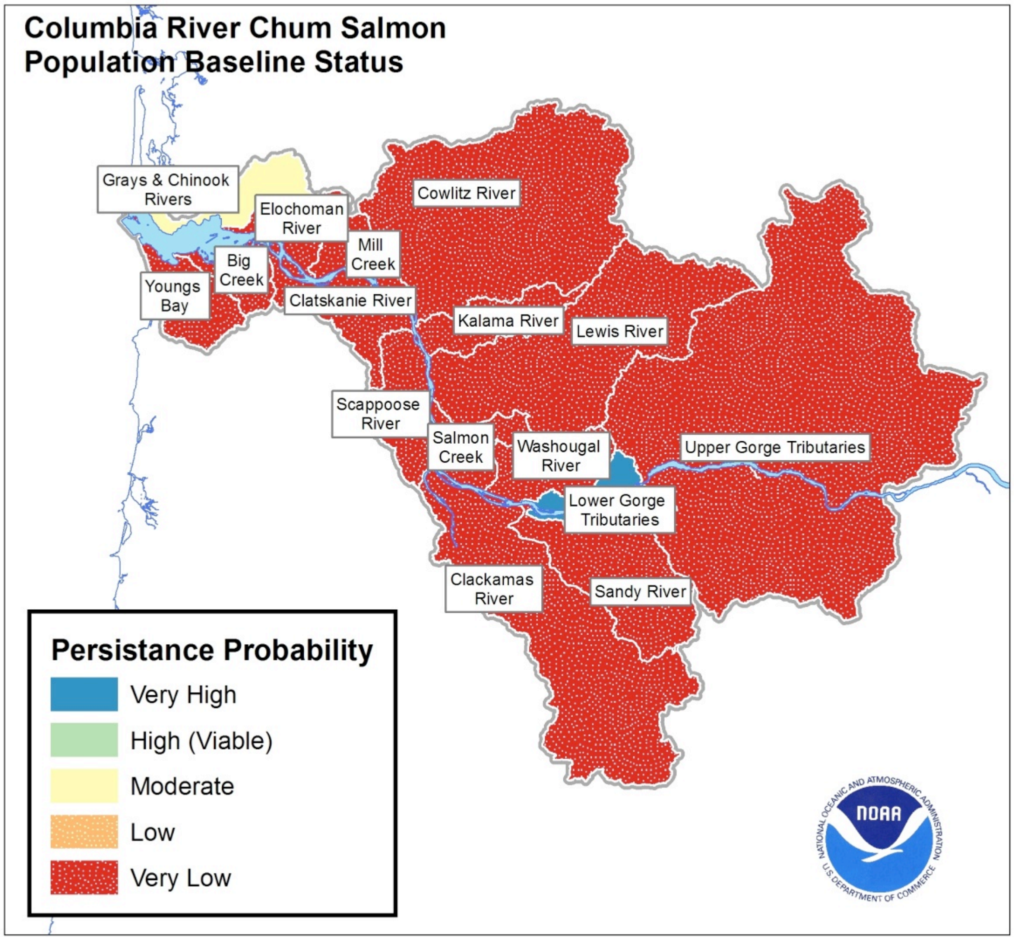

Figure 8-2. *Baseline Status of Historical Columbia River Chum Salmon Populations*

8.3 Target Status and Conservation Gaps for Chum Salmon Populations

Table 8-2 shows the baseline and target status and historical and target abundance for Washington Columbia River chum salmon population, along with target status and abundance for Oregon populations.[5] Local recovery planners coordinated with NMFS in making decisions about the target status for each population, taking into consideration opportunities for improvement in view of historical production, current habitat conditions and potential, and the desire to accommodate objectives such as maintaining harvest opportunities. Oregon did not identify abundance targets for chum salmon populations because quantitative data for use in calculating abundance targets and conservation gaps are not available. In Table 8-2, NMFS has included placeholder abundance targets for Oregon chum salmon populations based on the minimum abundance thresholds presented in McElhany et al. 2006 and 2007. The minimum

[5] Because quantitative data on the status of Oregon chum populations are lacking, ODFW (2010) variously refers to these populations as extirpated, nearly extirpated, functionally extirpated, or extremely depressed. It is often difficult to distinguish between a population that is truly extirpated and one that is not entirely extirpated but is at significant short-term risk. This ESU-level plan refers to Oregon chum salmon populations as very high risk or extirpated or nearly so.

abundance threshold (MAT) represents a lower bound estimate for average population size associated with a given persistence level. Minimum abundance thresholds take into account environmental variation, genetic issues, ecosystem functions, catastrophic risk, and other biological and ecological factors that affect the relationship between abundance and persistence probability and that may not be explicitly addressed in the viability curve analysis. McElhany et al. (2007) advised that, before a population is assigned to a particular risk category, the population should exceed the viability curve criterion, minimal abundance threshold, and any qualitative TRT criteria.[6] (Note: the target statuses in Table 8-2 are the same as the persistence probabilities in the recovery scenario presented in Table 3-1 in Section 3.1.3.)

Very large improvements are needed in the persistence probability of almost all chum salmon populations if the ESU is to achieve recovery (see Figure 8-3): nine of the eleven historical populations in Washington have very low baseline persistence probabilities, as do all six historical Oregon populations; it is possible that some populations are extirpated. Of the 17 historical populations, nine are targeted for high or better persistence probability. Some level of recovery effort will be needed for every population to arrest or reverse continuing long-tem declining trends; this is true for stabilizing populations, which are expected to remain at their baseline status, and for the ESU's two best-performing populations—the Grays/Chinook and Lower Gorge—which have baseline persistence probabilities of medium and high, respectively. For these latter two populations, meeting recovery objectives will require significant improvement in spatial structure. The Grays/Chinook will need improvements in diversity as well.

In the Coast stratum, five of seven populations are targeted for high or very high persistence probability. These include the Grays/Chinook and Elochoman/Skamakowa, which historically were among the most productive populations in the stratum. (The Grays/Chinook also is one of only two genetic legacy populations in the ESU.) However, two other Coast stratum populations that also historically were highly productive—Youngs Bay and Big Creek—are expected to remain at their baseline status of very low persistence probability to allow for incidental harvest of chum salmon that may occur in terminal fisheries that target hatchery coho and Chinook (ODFW 2010).

Of eight populations in the Cascade stratum, three—the Lewis, Sandy, and Washougal—are targeted for high or high-plus persistence probability; in the case of the Lewis, this is in part because it is a core population, meaning that historically it was one of the most productive in the stratum. Chum salmon in the Cowlitz and the Clackamas subbasins also are core populations.[7] However, extensive diking in the Longview/Kelso area limits the recovery prospects for chum salmon in the Cowlitz subbasin, and the Oregon chum recovery strategy does not require both the Clackamas and Sandy

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[6] Minimum abundance thresholds are also specific to historical population size. Estimates of historical watershed size available to chum salmon populations are not available at this time, so the minimum abundance thresholds in Table 8-2 reflect the upper end of the range of the minimum abundance threshold for the small size category of chum salmon populations.

[7] The WLC TRT also indicated that the Cowlitz, including fall and summer-run fish, was likely an important component of the genetic legacy of the ESU (McElhany et al. 2003). As discussed above, preserving the summer component of the Columbia River chum ESU is an important recovery objective.

populations to be viable.[8] Thus the target status for the Cowlitz and Clackamas populations is medium. The Salmon Creek population is expected to remain at its baseline persistence probability of very low because of severe habitat degradation in that subbasin and the historically small size of the population.

In the Gorge stratum, which contains two populations, the Lower Gorge population (a core and genetic legacy population) is targeted for high persistence probability, and the Upper Gorge population is targeted for medium probability of persistence. The management unit recovery planners did not consider it feasible to achieve a higher persistence probability for the latter population. Challenges include the small amount of historical and current habitat (and thus the limited options for restoration); anthropogenic impacts that are unlikely to change in the near future (e.g., inundation of historical spawning habitat by Bonneville Reservoir and roads that restrict access to habitat); high uncertainty in the data and analyses for small populations[9]; and the possibly inaccurate designation of population structure for this stratum. The Oregon management unit plan states that most of these issues are related to the population structure designation and suggests re-evaluating the Gorge stratum population structure for all species (ODFW 2010). As discussed in Section 3.2.1, NMFS agrees that such an evaluation is needed.

If the scenario in Table 8-2 were achieved, it would slightly exceed the WLC TRT's stratum-level viability criteria in the Coast and Cascade strata. However, the scenario would not meet criteria in the Gorge stratum because only one Gorge population (the Lower Gorge) would be viable, instead of two. Exceeding the criteria in the Coast and Cascade strata was intentional on the part of local recovery planners to compensate for high levels of uncertainty about recovery prospects in the Gorge stratum (LCFRB 2010a). (Delisting criteria for the Columbia River chum ESU are described in Section 3.2 and below in Section 8.7.)

Figure 8-3 displays the population-level conservation gaps for Columbia River chum salmon graphically. The conservation gap reflects the magnitude of improvement needed to move a population from its baseline status to the target status. For additional discussion of the status targets and conservation gaps for Columbia River chum salmon populations, see the management unit plans (LCFRB 2010a, pp. 6-33 through 6-37, ODFW 2010 pp. 148-150, and NMFS 2011b p. 3-12).

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[8] Oregon recovery planners set the desired status for chum salmon populations based on having half of the Oregon populations in a stratum reaching low extinction risk and the others improving significantly.

[9] In the method used by the WLC TRT and management unit planners to establish abundance goals, target abundance is based to some extent on the gap between current and historical abundance. If the historical abundance of Gorge chum salmon populations has been significantly overestimated, then the abundance needed to achieve their target status may also be overestimated (ODFW 2010).

Table 8-2

Baseline and Target Persistence Probability and Abundance of Columbia River Chum Salmon Populations

			Baseline Persistence Probability[10]					Abundance		
Stratum	**Population**	**Contribution**	**A&P**	**S**	**D**	**Net[11]**	**Target Persistence Probability**	**Historical**	**Baseline[12]**	**Target[13]**
Coast	Youngs Bay (OR) [C]	Stabilizing	--[14]	--	--	VL	VL	--	--	<500
	Grays/Chinook (WA) [C, GL]	Primary	VH	M	H	M	VH	10,000	1,600	1,600
	Big Creek (OR) [C]	Stabilizing	--	--	--	VL	VL	--	--	<500
	Elochoman/Skamakowa (WA) [C]	Primary	VL	H	L	VL	H	16,000	< 200	1,300
	Clatskanie (OR)	Primary	--	--	--	VL	H	--	--	1,000
	Mill/Abernathy/Germany (WA)	Primary	VL	H	L	VL	H	7,000	< 100	1,300
	Scappoose (OR)	Primary	--	--	--	VL	H	--	--	1,000
Cascade	Cowlitz - fall (WA) [C]	Contributing	VL	H	L	VL	M	195,000	< 300	900
	Cowlitz - Summer (WA) [C]	Contributing	VL	L	L	VL	M	--	--	900
	Kalama (WA)	Contributing	VL	H	L	VL	M	20,000	< 100	900

[10] A&P = Abundance and productivity, S = spatial structure, and D = genetic and life history diversity. Net = overall persistence probability of the population. VL = very low, L = low, M = moderate, H = high, VH = very high.

[11] All Oregon populations are considered to have a very low baseline persistence probability.

[12] Baseline abundance was estimated as described in Section 5.1 and does not equal observed natural-origin spawner counts. The baseline is a modeled abundance that represents 100-year forward projections under conditions representative of a recent baseline period using a population viability analysis that is functionally equivalent to the risk analyses in McElhany et al. (2007). Washington numbers reflect fishery impacts prevalent in the period immediately prior to listing in 1999.

[13] Oregon did not identify abundance targets for chum salmon populations because quantitative data for use in calculating abundance targets and conservation gaps are not available. In this table, NMFS has included placeholder abundance targets for Oregon chum salmon populations based on the minimum abundance thresholds presented in McElhany et al. 2006 and 2007. The minimum abundance threshold (MAT) represents a lower bound estimate for average population size associated with a given persistence level. Minimum abundance thresholds take into account environmental variation, genetic issues, ecosystem functions, catastrophic risk, and other biological and ecological factors that affect the relationship between abundance and persistence probability and that may not be explicitly addressed in the viability curve analysis. McElhany et al. (2007) advised that, before a population is assigned to a particular risk category, the population should exceed the viability curve criterion, minimal abundance threshold, and any qualitative TRT criteria.

[14] " –" indicates that no data are available from which to make a quantitative assessment.

Table 8-2

Baseline and Target Persistence Probability and Abundance of Columbia River Chum Salmon Populations

			Baseline Persistence Probability[10]					Abundance		
Stratum	**Population**	**Contribution**	**A&P**	**S**	**D**	**Net[11]**	**Target Persistence Probability**	**Historical**	**Baseline[12]**	**Target[13]**
	Lewis (WA) [C]	Primary	VL	H	L	VL	H	125,000	< 100	1,300
	Salmon Creek (WA)	Stabilizing	VL	L	L	VL	VL	--	< 100	--
	Clackamas (OR) [C]	Contributing	--	--	--	VL	M	--	--	500
	Sandy (OR)	Primary	--	--	--	VL	H	--	--	1,000
	Washougal (WA)	Primary	VL	H	L	VL	H+	18,000	< 100	1,300
Gorge	Lower Gorge (WA & OR) [C, GL]	Primary	VH	H	VH	H	VH	6,000	2,000	2,000
	Upper Gorge (WA & OR)	Contributing	VL	L	L	VL	M	11,000	< 50	900

C = Core populations, meaning those that historically were the most productive.

G = Genetic legacy populations, which best represent historical genetic diversity.

Source: LCFRB (2010a) and ODFW (2010).

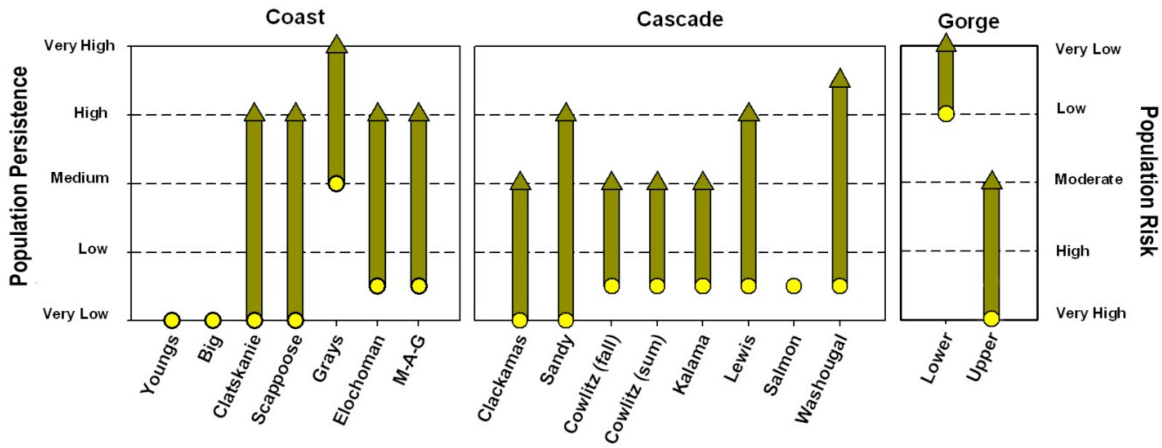

Figure 8-3. *Conservation Gaps for Columbia River Chum Salmon Populations: Difference between Baseline and Target Status*

Source: LCFRB 2010a.

8.4 Limiting Factors and Threats for Columbia River Chum Salmon

Columbia River chum salmon have been—and continue to be—affected by loss and degradation of spawning and rearing habitat, the impacts of mainstem hydropower dams on upstream access and downstream habitats, and the legacy effects of historical harvest; together, these factors have reduced the persistence probability of all populations. Under baseline conditions, constrained spatial structure at the ESU level (related to conversion, degradation, and inundation of habitat) contributes to very low abundance and low genetic diversity in most populations and increases risk to the ESU from local disturbances.

Table 8-3 and the text that follows summarize baseline limiting factors and threats for Columbia River chum salmon strata based on population-specific limiting factors and threats identified in the management unit plans. In cases where conditions have changed significantly since the management unit plans' analyses of limiting factors and threats (e.g., if harvest rates have dropped or a dam is no longer present), this is noted in the text. Unless otherwise noted, NMFS agrees that the management unit plans' identification of limiting factors provide a credible hypothesis for understanding population performance and indentifying management actions.

Because the individual management unit plans used somewhat different terms in identifying limiting factors, NMFS has translated those terms into standardized and more general terminology taken from a NMFS "data dictionary" of possible ecological concerns that could affect salmon and steelhead (Hamm 2012; see Section 5.4). In addition, in Table 8-3 NMFS has rolled up the population-specific limiting factors (see Appendix H) to the stratum level—a process that has resulted in some loss of specificity.

In addition, each management unit plan used a different approach for identifying limiting factors and threats (see Section 5.3). One difference relevant to the crosswalk is that while the Oregon management unit plan identified primary and secondary limiting factors for each population in each threat category,[15] the Washington management unit plan categorized limiting factors in this way only for habitat-related limiting factors, and the estuary module did not use the primary and secondary terminology. For the crosswalk and this table, NMFS assigned primary and secondary status to non-habitat limiting factors for Washington populations (based on the Washington management unit plan's quantification of threat impacts and the professional judgment of Lower Columbia Fish Recovery Board's staff and consultants). It is likely that some apparent distinctions in results between Washington and Oregon populations are artifacts of differences in limiting factor assessment methodologies and not an actual difference in conditions or their effects on salmon and steelhead populations. In addition, there is not necessarily a bright line between primary and secondary limiting factor designations. Nevertheless, NMFS believes that the designations are useful, particularly for looking across ESUs and populations and identifying patterns (see Chapter 4).

The management unit plans provide more detail on limiting factors and threats affecting each Columbia River chum salmon population, including magnitude, spatial scale, and relative impact (see LCFRB 2010a, Chapter 3 and various sections of Volume II; ODFW 2010, pp. 141-146; and NMFS 2011b, Chapter 5). For a regional perspective on limiting factors and threats that affect multiple salmon and steelhead ESUs, see Chapter 4 of this recovery plan. For a description of the data dictionary, the approach NMFS used to correlate management unit terms for limiting factors with the standardized NMFS terminology at the population scale, and the approach for rolling up from the population to the stratum scale, see Section 5.4 and Appendix H.

Management unit recovery planners in Oregon and Washington recognized that six major categories of manageable threats—tributary habitat, estuary habitat, hydropower, harvest, hatcheries, and predation—were useful as an organizing construct for grouping limiting factors, quantifying impacts on population productivity, and determining how much different categories of threats would need to be reduced to close the gap between baseline and target population status. Planners in both Washington and Oregon quantified the impacts of each of these major threat categories on population status, along with a reduction in each impact that would be consistent with achieving population target status. The results of that analysis are presented in Section 8.5 and provide a related but slightly different perspective on limiting factors. The threat reduction targets also allow actions to be scaled to achieve a specific impact reduction, and to be linked to monitoring and performance benchmarks.

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[15] In the Oregon management unit plan, primary limiting factors are those that have the greatest impact and secondary limiting factors have a lesser but still significant impact.

Table 8-3

Baseline Limiting Factors and Threats Affecting Columbia River Chum Salmon: Stratum-Level Summary

Ecological Concern	Threat(s)	VSP Parameters Affected	Coast	Cascade	Gorge
Tributary Habitat Limiting Factors[16]					
Riparian Condition	Past and/or current land use practices	All	Primary for WA juveniles	Primary for WA juveniles	Primary for Lower and Upper Gorge adults and juveniles
Channel Structure and Form	Past and/or current land use practices/ transportation corridor	All	Primary for WA juveniles	Primary for WA juveniles	Primary for Lower and Upper Gorge adults and juveniles
Peripheral and Transitional Habitats: Side Channel and Wetland Conditions	Past and/or current land use practices/ transportation corridor	All	Primary for WA juveniles	Primary for WA juveniles	Primary for Lower and Upper Gorge adults and juveniles
Peripheral and Transitional Habitats: Floodplain Conditions	Past and/or current land use practices/ transportation corridor	All	Primary for WA juveniles	Primary for WA juveniles	Primary for Lower and Upper Gorge adults and juveniles
Sediment Conditions	Past and/or current land use practices/ transportation corridor	All	Primary for WA juveniles; secondary for OR juveniles	Primary for Cowlitz, Kalama, and Washougal juveniles; secondary for OR juveniles	
Water Quality (Temperature)	Land uses that impair riparian function/decrease streamflow, dams	A,P,D		Primary for Kalama, Lewis, and Salmon Creek juveniles	
Water Quantity (Flow)	Dams, land use, and water withdrawals for irrigation, municipal uses, and hatchery operations	All	Secondary for juveniles in all populations	Primary for Cowlitz and Kalama juveniles; secondary for juveniles in all other populations	Secondary for Lower and Upper Gorge juveniles

16 Tributary habitat limiting factors in this table primarily reflect those identified in the Washington management unit plan. This is because chum salmon do not migrate far up tributaries and Oregon recovery planners categorized chum salmon limiting factors occurring in areas of tidal influence in the lower reaches of tributaries as estuarine. Thus, the relative paucity of tributary habitat limiting factors for Oregon chum salmon populations is an artifact of differences in limiting factor assessment methodologies between the two states and not an actual difference in the extent of tributary habitat limiting factors or their effects on chum salmon populations.

Table 8-3

Baseline Limiting Factors and Threats Affecting Columbia River Chum Salmon: Stratum-Level Summary

Ecological Concern	Threat(s)	VSP Parameters Affected	Coast	Cascade	Gorge
Estuary Habitat Limiting Factors[17]					
Toxic Contaminants	Agricultural chemicals, urban and industrial practices	A,P,D	Secondary for juveniles in all populations		
Food[18] (Shift from macrodetrital- to microdetrital-based food web)	Dam reservoirs	All	Secondary for juveniles in all populations		
Peripheral and Transitional Habitats: Estuary Condition	Past and/or current land use practices, transportation corridor, mainstem dams	All	Primary for juveniles in all populations		
Channel Structure and Form	Past and/or current land use practices/ transportation corridor	All	Primary for juveniles in all populations		
Sediment Conditions	Past and/or current land use practices/transportation corridor, dams	All	Primary for juveniles in all populations		
Water Quality (Temperature)	Land uses that impair riparian function/decrease streamflow, dam reservoirs	A,P,D	Secondary for juveniles in all populations		
Water Quantity (Flow)	Columbia River mainstem dams	All	Primary for juveniles in all populations		

[17] The Washington and Oregon management unit plans both relied on the *Columbia River Estuary ESA Recovery Plan Module for Salmon and Steelhead* (NMFS 2011a) for information on estuary limiting factors, but there were some differences in how the plans translated the information into limiting factors experienced at the population level. The estuary module does not designate limiting factors as primary or secondary; instead, it ranks them in terms of assumed impact on ocean- and stream-type salmonids. Because the Oregon management unit plan integrated the module information with more specificity than did the Washington management unit plan, and because NMFS assumes that estuarine limiting factors affect all populations equally within the ESU, the estuarine limiting factors in this table and Section 8.4.2 reflect the determinations in the Oregon management unit plan, applied to all Columbia River chum salmon populations, unless otherwise noted. As with other limiting factors, the designations of estuarine limiting factors as primary or secondary reflect working hypotheses that will need to be tested (and possibly revised) through adaptive management.

[18] Although the Oregon management unit plan lists food web shifts as a primary limiting factor in the estuary, NMFS and the management unit planners agreed to consider such shifts secondary in this recovery plan to more closely reflect conclusions in the *Columbia River Estuary ESA Recovery Plan Module for Salmon and Steelhead* (NMFS 2011a). The extent to which food web shifts limit salmonid survival in the estuary is unclear.

Table 8-3
Baseline Limiting Factors and Threats Affecting Columbia River Chum Salmon: Stratum-Level Summary

Ecological Concern	Threat(s)	VSP Parameters Affected	Coast	Cascade	Gorge
Hydropower Limiting Factors					
Habitat Quantity (Access)	Bonneville Dam	All			Primary for Upper Gorge adults and juveniles
Habitat Quantity (Inundation)	Bonneville Dam	All			Primary for Upper Gorge adults and juveniles
Hatchery Limiting Factors					
Food	Smolts from all Columbia Basin hatcheries competing for food and space in the estuary	All			
Population Diversity	Stray hatchery fish interbreeding with wild fish	A,P,D	Secondary for Grays adults		
Predation Limiting Factors					
Direct Mortality	Dams	A,P,D			Secondary for Upper Gorge juveniles
Direct Mortality	Hatchery fish	A,P,D	Secondary for juveniles in all populations[19]		

8.4.1 Tributary Habitat Limiting Factors

The pervasive loss of critical spawning, incubation, and rearing habitat is a primary limiting factor for chum salmon throughout the Lower Columbia subdomain. Chum salmon typically spawn in upwelling areas of clean gravel beds in mainstem and side-channel portions of low-gradient reaches above tidewater. These habitats have been practically eliminated in most systems through a combination of channel alteration and sedimentation that is attributable largely to past and current land uses; these include historical and current forest management, agriculture, rural residential uses, urban development, and gravel extraction. Low-elevation stream reaches have been directly affected by extensive channelization, diking, wetland conversion, stream clearing, and gravel extraction. Impaired watershed processes continue to limit chum salmon habitat through effects on floodplain and wetland habitat conditions and connectivity, riparian conditions and function, and channel structure.

Impaired side channel and wetland conditions, along with degraded floodplain habitat are identified as primary limiting factors for all Washington populations and the two Gorge populations. Channel structure and form issues and degraded riparian conditions also are considered primary limiting factors for juveniles in all Washington populations and for juveniles and adults in the two Gorge populations. Sediment conditions are

[19] Chum salmon fry from all populations may experience predation to varying degrees by hatchery-origin coho, steelhead, and Chinook smolts, although differences in life history patterns may moderate effects and the significance of these interactions is unknown.

identified as a primary limiting factor for all Washington populations in the Coast stratum and for the Cowlitz, Kalama, and Washougal populations in the Cascade stratum, and they are considered a secondary limiting factor for the Oregon portion of the Coast and Cascade strata.[20] In addition, water quality—specifically, elevated water temperature brought about through land use and hydropower reservoirs—is a primary factor for Kalama, Lewis, and Salmon Creek juveniles. Water quantity issues related to altered hydrology and flow timing have been identified as a primary limiting factor for juveniles in the Cowlitz and Kalama populations and as a secondary limiting factor for juveniles in all other chum populations.

In the Coast stratum, tributary habitat limiting factors are largely the same as those described above for the ESU as a whole and are attributable largely to past and current land uses. Lower reaches are mostly in agricultural and rural residential use and have been extensively modified by bank stabilization, levees, and tide gates. Private and state forest land predominates in the upper reaches of Coast ecozone subbasins. The high density of unimproved rural roads throughout the area leads to an abundance of fine sediment in tributary streams that covers spawning gravel and increases turbidity. In the Youngs Bay and Big Creek subbasins, hatchery weirs are identified as secondary limiting factors because they block access to historically productive spawning and rearing habitat for chum salmon.

In the Cascade stratum, tributary habitat limiting factors are largely the same as those described above for the ESU as a whole, with the addition of road crossings that impede chum salmon passage; this has been identified as a secondary limiting factor in the Clackamas and Sandy subbasins. Land uses that have limited the productivity of tributary habitat in this stratum include forest management and timber harvest, agriculture, rural residential and urban development, and gravel extraction. A mix of private, state, and Federal forest land predominates in the upper mainstem and headwater tributaries of the Cascade subbasins, while the lower mainstem and tributary reaches of most subbasins are characterized by agricultural and rural residential land use, with some urban development, especially in the Salmon Creek and lower Clackamas subbasins.

In the Gorge stratum, habitat-related limiting factors result from past and current land uses; these include a mix of private, state, and Federal forest land in the upper mainstem and headwater reaches of the Gorge subbasins, plus agricultural and rural residential land use, with some urban development, in lower mainstem and tributary reaches. Highway and transportation corridors run parallel to the Columbia River shoreline, traversing all creek drainages in ways that restrict access and disconnect upland and lowland habitat processes. The associated habitat degradation is considered a primary limiting factor for the Upper and Lower Gorge chum salmon populations. The Upper Gorge population also is affected by habitat loss caused by inundation from Bonneville

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[20] Tributary habitat limiting factors for chum salmon populations primarily reflect those identified in the Washington management unit plan. This is because chum salmon do not migrate far up tributaries and Oregon recovery planners categorized chum salmon limiting factors occurring in areas of tidal influence in the lower reaches of tributaries as estuarine. Thus, the apparent lack of tributary habitat limiting factors for Oregon populations is an artifact of differences in limiting factor assessment methodologies between the two states and not an actual difference in the extent of tributary habitat limiting factors or their effects on chum salmon populations.

Reservoir; it is likely that significant amounts of historical spawning and rearing habitat for this population have been inundated.

8.4.2 Estuary Habitat Limiting Factors[21]

Estuary habitat conditions are important for juvenile chum salmon, which leave their natal streams as fry and spend considerable time rearing in the estuary. Water quantity issues related to altered hydrology and flow timing are identified as a primary limiting factor for all populations, as is impaired sediment and sand routing; these limiting factors are associated with hydroregulation at large storage reservoirs in the interior of the Columbia Basin, and, in the case of sediment issues, land uses both past and present. Much of the land surrounding the Columbia River estuary is in agricultural or rural residential use and has been extensively modified via dikes, levees, bank stabilization, and tide gates. Altered hydrology and sediment routing influence habitat-forming processes, the quantity and accessibility of habitats such as side channels and wetlands, the dynamics of the Columbia River plume, and the estuarine food web. Channel structure issues, in the form of reduced habitat complexity and diversity, and reduced access to peripheral and transitional habitats such as side channels and wetlands also are identified as primary limiting factors for juveniles from all populations. Again, simplification of channel structure is related to conversion of land to other uses—agricultural, rural residential, and as a transportation corridor—while juveniles' access to side channels and wetlands is impaired by these same land uses but also by flow alterations caused by mainstem dams.

Secondary limiting factors in the estuary that affect chum salmon are exposure to toxic contaminants (from urban, agricultural, and industrial sources) and elevated late summer and fall water temperatures, which are related to (1) land use practices that impair riparian function or decrease streamflow, and (2) large hydropower reservoirs.[22] Altered food web dynamics involving a transition from a macrodetrital-based food web to a microdetrital-based food web also are considered a secondary limiting factor for all populations.[23] These changes in the estuarine food web are caused primarily by

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[21] The Washington and Oregon management unit plans both relied on the *Columbia River Estuary ESA Recovery Plan Module for Salmon and Steelhead* (NMFS 2011a) for information on estuary limiting factors, but there were some differences in how the plans translated the information into limiting factors experienced at the population level. The estuary module does not designate limiting factors as primary or secondary; instead, it ranks them in terms of assumed impact on ocean- and stream-type salmonids. Because the Oregon management unit plan integrated the module information with more specificity than did the Washington management unit plan, and because NMFS assumes that estuarine limiting factors affect all populations equally within the ESU, the estuarine limiting factors in this section and in Table 8-3 reflect the determinations in the Oregon management unit plan, applied to all Columbia River chum salmon populations, unless otherwise noted. As with other limiting factors, the designations of estuarine limiting factors as primary or secondary reflect working hypotheses that will need to be tested (and possibly revised) through adaptive management.

[22] Although the management unit plans identified temperature impacts as a secondary limiting factor for juveniles in all populations, the timing of juvenile chum salmon migration and rearing raises questions about the significance of this limiting factor; see Section 8.4.3.

[23] Although the Oregon management unit plan lists food web shifts as a primary limiting factor in the estuary, NMFS and the management unit planners agreed to consider such shifts secondary in this recovery plan to more closely reflect conclusions in the *Columbia River Estuary ESA Recovery Plan Module for Salmon and Steelhead* (NMFS 2011a). The extent to which food web shifts limit salmonid survival in the estuary is unclear.

increased microdetrital inputs from hydropower reservoirs and the loss of wetland habitats through diking and filling.

8.4.3 Hydropower Limiting Factors

Flow management operations at large storage reservoirs in the interior of the Columbia Basin (Grand Coulee, Dworshak, etc.) affect all juvenile Columbia River chum salmon in the lower mainstem and estuary, and potentially in the plume—primarily by altering flow volume and timing. These alterations impair sediment routing, influence habitat-forming processes, reduce access to peripheral habitat, and change the dynamics of the Columbia River plume and the estuarine food web (see Section 8.4.2).[24] Moreover, the large reservoirs associated with mainstem dams contribute to elevated water temperatures downstream in late summer and fall. Although the management unit recovery plans identified temperature impacts of the hydropower system as a secondary limiting factor for all juvenile chum salmon, juvenile chum salmon are rearing in and migrating through the mainstem in February through July, with peak presence in May(Dawley et al. 1986, McCabe et al. 1986, Roegner et al. 2004, Bottom et al. 2008, cited in Figure 2.2 of Carter et al. 2009). Thus, it is unlikely that elevated mainstem temperatures are having a significant impact on juvenile chum salmon.

For the Upper Gorge population, which spawns above Bonneville Dam, passage issues at Bonneville and inundation of historical spawning habitat by Bonneville Reservoir are identified as primary limiting factors.[25] For the Lower Gorge population, the availability of tailrace spawning habitat is affected by flows from the Columbia River hydropower system, with winter and early spring flows being critical to prevent dewatering of redds before emergence.

There are no large tributary dams in the Coast ecozone. In the Cascade and Gorge ecozones, tributary dams are not identified as a primary or secondary limiting factor. Large dam complexes in the Cowlitz and Lewis systems may be affecting chum salmon spawning and rearing conditions by altering habitat-forming processes downstream, but the significance of these effects is unknown (and LCFRB 2010a does not explicitly identify such effects as limiting factors).

8.4.4 Harvest Limiting Factors

Historical high harvest rates of chum salmon may have compounded the effects of habitat losses during the last century, but harvest mortality is not considered a baseline or current limiting factor for Columbia River chum salmon. Commercial chum salmon fisheries were closed or drastically reduced in the 1950s. Harvest impacts are limited to illegal harvest and incidental take in lower river commercial gillnet and recreational fisheries (LCFRB 2010a). Commercial fisheries for Chinook and coho salmon occur

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[24] It is likely that flow impacts of the hydropower system affect Lower Columbia River ESUs more through changes in habitat-forming processes (including impacts to the plume) and food web impacts than through changes in migratory travel time.

[25] In the 2008 FCRPS Biological Opinion and its 2010 Supplement, NMFS assumed that survival of adult chum passing Bonneville Dam is 96 to 97 percent, based on data for Snake River Fall Chinook salmon (NMFS 2008f and 2010a). It is likely that significant areas of historical chum spawning habitat were inundated by Bonneville Reservoir.

before adult chum salmon return in the late fall. Harvest-related mortality of chum salmon has been less than 5 percent per year since 1993 (LCFRB 2010a) and has averaged 1.6 percent annually since 1998 (ODFW 2010).

8.4.5 Hatchery-Related Limiting Factors

Chum salmon have never been subject to significant hatchery production in the Columbia River for fishery mitigation programs. Hatchery-related factors were not identified as limiting for any Oregon chum salmon population. ODFW began releasing chum salmon into the Big Creek subbasin in 2011 as part of a reintroduction program, using Grays River chum salmon as broodstock. In Washington, conservation hatchery programs are being used to supplement natural production in the Grays/Chinook and Lower Gorge populations. Population-level effects resulting from stray hatchery fish interbreeding with natural-origin fish were identified as a secondary limiting factor for the Grays/Chinook chum salmon, where analysis by the regional Hatchery Scientific Review Group estimated an 11 percent reduction in productivity; however, the HSRG analysis did not consider the positive demographic effects of increased natural spawning abundance through hatchery supplementation. Conservation hatchery programs are identified as a key component of reintroduction and recovery efforts for chum salmon populations in Oregon and Washington.

It is possible that juvenile chum salmon rearing in the estuary are affected by hatchery-origin Chinook, steelhead, and coho juveniles. Potentially detrimental interactions include competition for food and space. However, differences in life history patterns may moderate effects, and the significance of interactions is unknown. NMFS (2011a) and LCFRB (2010a) identified competition for food and space among hatchery and natural-origin juveniles in the estuary as a critical uncertainty. ODFW (2010) acknowledged that uncertainty but listed competition for food and space as a secondary limiting factor for juveniles of all populations. The NMFS Northwest Region and Northwest Fisheries Science Center are working to better define and describe the scientific uncertainty associated with ecological interactions between hatchery-origin and natural-origin salmon and steelhead in freshwater, estuarine, and nearshore ocean habitats.

8.4.6 Predation Limiting Factors

Predation by hatchery smolts in the estuary is identified as a secondary limiting factor for all Columbia River chum salmon. Chum salmon fry from all populations may experience predation by hatchery-origin coho, steelhead, and Chinook smolts, although differences in life history patterns may moderate effects, and the significance of interactions is unknown. In addition, predation by non-salmonid fish is identified as a secondary limiting factor for the Upper Gorge population. Although the extent of chum salmon production above Bonneville is unknown, fish spawning above the dam would experience predation by pikeminnow above and below Bonneville Dam and by walleye and smallmouth bass in the reservoir behind the dam.

8.5 Baseline Threat Impacts and Reduction Targets

Table 8-4 shows the estimated impact on each Washington Columbia River chum salmon population resulting from potentially manageable threats, organized into six threat categories: tributary habitat degradation, estuary habitat degradation, hydropower, harvest, hatcheries, and predation. Both baseline and target impacts are shown, with the targets representing levels that would be consistent with long-term recovery goals. Impact values indicate the percentage reduction in abundance and productivity that is attributable to human activities related to a particular threat category. The value associated with any particular threat category can be interpreted as the percent reduction in abundance and productivity from historical conditions if that threat category were the only one affecting the population. The table also shows the overall percentage improvement that is needed to achieve the target impacts and corresponding population status.[26] These cumulative values across all threat categories (both baseline and target) are multiplicative rather than additive. Both the Oregon and Washington management unit plans use cumulative survivals across threat categories to illustrate the overall level of improvement needed. Each plan assumes that there is a direct proportional relationship between the projected changes in cumulative survival and the required changes in natural-origin spawner abundance and productivity. For populations where the survival improvement needed is larger than 500 percent, Table 8-4 does not report the exact value, in part because the value is highly uncertain.[27]

As an example, the baseline status of the Elochoman/Skamakowa chum salmon population, circa 1999, has been severely reduced by the combined effects of multiple threats. The cumulative reduction in status was estimated at 93.3 percent from the multiplicative impacts of multiple threats acting across the salmon life cycle. Thus, current status is just 6.7 percent of the historical potential with no human impact. Tributary and estuary habitat impacts each accounted for reductions in population productivity of 25 percent or more, with corresponding reductions in abundance, spatial structure, and diversity. The Washington management unit plan identifies a recovery strategy involving significant reductions in the impact of habitat-related threats. For instance, the plan targets tributary habitat impacts to be reduced from the estimated baseline level of 90 percent to 45 percent (i.e., an approximately 100 percent improvement relative to baseline conditions). With the targeted reductions in individual impacts, the cumulative effect of all impacts would drop from 93.3 percent at baseline to 55 percent at the target status. This change would translate into a more than 500 percent improvement in survival relative to the baseline. Although the population would still be experiencing abundance and productivity that are 74.7 percent lower than historical conditions, the extinction risk at this mortality level would be estimated sufficient to meet the targets for this plan.

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[26] The percentage improvement (rounded to the nearest 10) in population survival needed to achieve target impacts is taken from Table 6-7 of LCFRB (2010a). For populations where the survival improvement needed is larger than 500 percent, this table does not report the exact value, for the reasons explained in Section 8.5.

[27] For some populations—many of them small—the survival improvement needed is very large and highly uncertain because various other factors also are uncertain (i.e., the population's baseline persistence probability, the exact degree of impact of human activities on tributary habitat, and whether the population's response to reductions in impacts will be linear). In addition, very small populations do not necessarily follow predictable patterns in their response to changing conditions.

Baseline impacts reflect conditions prevalent at the time of ESA listing (circa 1999). Dam impacts reflect passage mortality, habitat loss caused by inundation, and loss of access to historical production areas. Hatchery impacts were limited to not more than 50 percent per population, in accordance with Hatchery Scientific Review Group (HSRG) assessments of the potential for genetic effects (Hatchery Scientific Review Group 2009). Washington recovery planners derived estimates of impacts to tributary habitat using the Ecosystem Diagnosis and Treatment (EDT) model. In general, the tributary habitat values in Table 8-4 have the highest degree of uncertainty relative to the other threat categories. (See Section 5.5 for more on the methodologies used to estimate baseline impacts.)

Estimates of threat impacts are useful in showing the relative magnitude of impacts on each population. Given the differences in methodologies, some values in Table 8-4 for Oregon and Washington populations are not necessarily directly comparable. Thus, values for Oregon populations are most directly comparable to those for other Oregon populations, and values for Washington populations are most directly comparable to those for other Washington populations. Regardless of differences in specific threat impact definitions and methods, the net effect of changes from all threats is useful in understanding the magnitude of population improvement needed to achieve the target population status.

The target impacts in Table 8-4 represent one of several possible combinations of threat reductions that could conceivably close the conservation gap and lead to a population achieving its target status. The particular threat reductions shown in Table 8-4 reflect policy decisions and the methodologies and assumptions used by the management unit recovery planners. (For a description of how target impacts were developed, see Section 5.6.) In estimating impacts, management unit recovery planners evaluated each threat category independently (i.e., values in the table reflect the mortality of chum salmon exposed to that particular category of threats, whether or not they are exposed to threats in other categories). The estimates of baseline threat impacts have high levels of uncertainty and in many cases should be considered working hypotheses that are testable as part of recovery plan implementation. Despite this uncertainty, it is the expert judgment of NMFS and management unit scientists that, based on the best available information at this time, the estimates of baseline threat impacts provide a reasonable estimate of the relative magnitude of different sources of anthropogenic mortality and serve as an adequate basis for designing initial recovery actions.[28] As more and better information is collected, it will be applied to recovery efforts in an adaptive management framework.

As shown in Table 8-4, most of the gains in the viability of Washington chum salmon populations are targeted to be achieved by improving tributary and estuarine habitat. Because potentially manageable harvest, hatchery, and predation impacts on chum salmon already are relatively low, there is little opportunity to further reduce threats in these sectors. Hydropower actions also are projected to benefit the Upper Gorge population, which is affected by Bonneville Dam and its reservoir.

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[28] As implementation proceeds, research, monitoring, and evaluation and adaptive management will be key in helping to refine scientific understanding of the impact of threats on population persistence and of the extent to which management actions are reducing threats.

Oregon recovery planners did not develop current and target threat impacts for chum salmon populations because quantitative information for use in calculating baseline or target threat impacts or the likelihood of recovery goals being achieved was not available (ODFW 2010). Recovery planners developed a chum salmon recovery strategy that involves identifying specific habitat needs and proceeding with reintroduction, initially in the Coast stratum (see Appendix I of ODFW 2010).

More information on threat reduction scenarios, including methodologies to determine baseline and target impacts, is available in the management unit plans (ODFW 2010 p. 152 and LCFRB 2010a pp. 4-30 through 4-33 and 6-37 through 6-40).

Table 8-4

Impacts of Potentially Manageable Threat, and Impact Reduction Targets Consistent with Recovery of Columbia River Chum Salmon (Washington Populations Only[29])

Washington Population	Impacts at Baseline[30]							Impacts at Target							% Survival Improvement Needed[38]
	T. Hab[31]	Est[32]	Dams[33]	Harv[34]	Hat[35]	Pred[36]	Cumul-ative[37]	T. Hab	Est	Dams	Harv	Hat	Pred	Cumul-ative	
Coast															
Grays/Chinook	0.80	0.25	0.00	0.05	0.11	0.03	0.8770	0.80	0.25	0.00	0.05	0.11	0.03	0.8770	0%
Eloch/Skam	0.90	0.25	0.00	0.05	0.03	0.03	0.9330	0.45	0.13	0.00	0.03	0.01	0.02	0.5497	>500%
Mill/Ab/Germ	0.90	0.25	0.00	0.05	0.03	0.03	0.9330	0.45	0.13	0.00	0.03	0.01	0.02	0.7497	>500%
Cascade															
Cowlitz (Fall)	0.96	0.25	0.00	0.05	0.02	0.03	0.9729	0.48	0.13	0.00	0.03	0.01	0.02	0.5742	>500%
Cowlitz (Summer)	0.96	0.25	0.00	0.05	0.02	0.03	0.9729	0.48	0.13	0.00	0.03	0.01	0.02	0.5742	>500%
Kalama	0.90	0.25	0.00	0.05	0.01	0.03	0.9316	0.45	0.13	0.00	0.03	0.00	0.02	0.5451	>500%
Lewis	0.90	0.25	0.00	0.05	0.01	0.03	0.9316	0.45	0.13	0.00	0.03	0.01	0.02	0.5497	>500%
Salmon Creek	0.98	0.25	0.00	0.05	0.01	0.03	0.9863	0.98	0.25	0.00	0.05	0.01	0.03	0.9863	0%
Washougal	0.96	0.25	0.00	0.05	0.01	0.03	0.9863	0.48	0.13	0.00	0.03	0.01	0.02	0.5742	>500%

29 Oregon populations are not included in this table because data are not available to quantify the baseline or target threat impacts for these populations.
30 Impact figures represent a percentage reduction in abundance and productivity that is attributable to human activities related to a particular threat category. See Sections 5.5 and 5.6 for information on methodologies.
31 Reduction in tributary habitat production potential relative to historical conditions.
32 Reduction in juvenile survival in the Columbia River estuary as a result of habitat changes (relative to historical conditions); excludes predation.
33 Reflects passage mortality, habitat loss caused by inundation, and loss of access to historical production areas.
34 Includes direct and indirect mortality.
35 Reflects only the negative impacts of hatchery-origin fish, such as high pHOS and low PNI (proportion of natural influence), not the benefits of conservation hatchery programs.
36 Includes the aggregate predation rate in the Columbia River mainstem and estuary by northern pikeminnow, marine mammals, Caspian terns, and cormorants.
37 Cumulative values (both baseline and target) are multiplicative rather than additive and are equal to $(1-[(1-M_{thab})(1-M_{est})(1-M_{dams})(1-M_{harv})(1-M_{hatch})(1-M_{pred})])$.
38 Survival improvements indicate the percentage improvement (rounded to the nearest 10) in population survival needed to achieve target impacts and are taken from Table 6-7 of LCFRB (2010a). For populations where the survival improvement needed is larger than 500 percent, this table does not report the exact value, for the reasons explained in Section 8.5.

Table 8-4

Impacts of Potentially Manageable Threat, and Impact Reduction Targets Consistent with Recovery of Columbia River Chum Salmon (Washington Populations Only[29])

Washington Population	Impacts at Baseline[30]							Impacts at Target							% Survival Improvement Needed[38]
	T. Hab[31]	Est[32]	Dams[33]	Harv[34]	Hat[35]	Pred[36]	Cumul-ative[37]	T. Hab	Est	Dams	Harv	Hat	Pred	Cumul-ative	
Gorge															
Lower Gorge—WA portion	0.40	0.25	0.30	0.05	0.01	0.03	0.7126	0.40	0.25	0.30	0.05	0.01	0.03	0.7126	0%
Upper Gorge—WA portion	0.97	0.25	0.96	0.05	0.01	0.03	0.9992	0.49	0.13	0.48	0.03	0.00	0.02	0.7807	>500%

8.6 ESU Recovery Strategy for Columbia River Chum Salmon

This section describes the recovery strategy for Columbia River chum salmon. A general summary of the ESU-level strategy is presented first. This is followed by subsections on each of the threat categories and critical uncertainties that pertain to the strategy. Where appropriate, stratum-specific strategies are described for each threat category.

8.6.1 Strategy Summary

The ESU recovery strategy for Columbia River chum salmon focuses on improving tributary and estuarine habitat conditions, reducing or mitigating hydropower impacts, and reestablishing chum salmon populations where they may have been extirpated. The goal of the strategy is to increase the abundance, productivity, diversity, and spatial structure of chum salmon populations such that the Coast and Cascade chum salmon strata are restored to a high probability of persistence and the persistence probability of the two Gorge populations is improved (including achieving a high persistence probability for the Lower Gorge population). The ESU recovery strategy has the following main elements:

1. Protect and improve the Grays/Chinook and Lower Gorge populations, which together produce the majority of Columbia River chum salmon (LCFRB 2010a) and are the only populations in the ESU not currently at very high risk of extinction.

2. Identify, protect, and restore chum salmon spawning habitat in lower mainstem and off-channel areas of large rivers and streams that are fed by upwelling from intergravel flows or springs. Restore hydrologic, riparian, and sediment processes (e.g., large woody debris recruitment) that support the accumulation of spawning gravel and reduce inputs of fine sediment.

3. Restore off-channel and side-channel habitats (alcoves, wetlands, floodplains, etc.) in the Columbia River estuary, where chum salmon fry rely on peripheral and transitional habitats for extended estuarine rearing.

4. Use hatchery reintroduction as appropriate in reestablishing chum salmon populations and continue using supplementation to enhance the abundance of the Grays and Lower Gorge populations.

Restoring tributary spawning and estuary rearing habitat is essential in the recovery of Columbia River chum salmon. Although the recovery strategy includes other components, no other factor can effectively bring about recovery (LCFRB 2010a).

The Oregon management unit plan's description of a systematic, adaptive approach to chum salmon recovery can be viewed as a template for the ESU. The approach involves (1) identifying, assessing, and protecting existing chum salmon habitat, especially in currently productive areas, (2) restoring spawning and rearing habitat in all ecozones as needed to support recovered populations,[39] (3) reestablishing populations in selected subbasins, (4) monitoring to evaluate the program and allow for adaptive management, and (5) applying successful techniques elsewhere (see ODFW 2010, Appendix I). Oregon intends to focus initial efforts on the Clatskanie and Scappoose populations and then, based on results in those populations, expand efforts to populations in the Cascade and Gorge ecozones. Washington intends to focus initial efforts on the Elochoman-Skamokawa, Mill/Abernathy/Germany, Lewis, and Washougal populations.

Reestablishing chum salmon populations could occur through recolonization or hatchery reintroduction. Recolonization is the process of fish from other populations straying into a subbasin and spawning successfully; this may lead to the establishment of self-sustaining, locally adapted populations. If chum salmon abundances are so low that recolonization cannot occur, hatchery reintroduction may have a higher likelihood of success. For either method to be successful, the factors that led to extirpation will need to have been addressed—thus the emphasis on habitat assessment and restoration.

As part of a series of 3- to 5-year implementation schedules, management unit planners will work with NMFS staff to prioritize individual actions within each threat category, rather than across threat categories (see Chapter 11 for more on implementation).

Key critical uncertainties that need to be addressed to support implementation of near-term actions for chum salmon relate to current population status, estuarine habitat requirements, the extent and location of currently or potentially suitable habitat, and the effectiveness of hatchery reintroduction compared to natural recolonization (see Section 8.6.8).

The subsections below describe recovery strategies and near-term and long-term priorities for each threat category. For specific management actions in each threat category, linked to population and location, see the management unit plans (LCFRB 2010a, ODFW 2010, NMFS 2011b).

8.6.2 Tributary Habitat Strategy

Tributary habitat protection and improvement are essential to the recovery of Columbia River chum salmon, which will benefit from the regional tributary habitat strategy described in Section 4.1.2. The regional strategy is directed toward protecting and restoring high-quality, well-functioning salmon and steelhead habitat through a combination of (1) site-specific management actions that will protect habitat and provide benefits relatively quickly, (2) watershed-based actions that will repair habitat-forming processes and provide benefits over the long term, and (3) landscape-scale programmatic actions that affect a class of activities (such as stormwater management or forest practices) over multiple watersheds. The management unit plans set a high priority on identifying and improving chum salmon spawning habitat, reducing the impacts of sediment on survival to emergence, and improving juvenile rearing habitat.[40] Because of a lack of habitat data in Oregon specific to chum salmon, physical

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[39] Recovery plan implementers will look for opportunities to combine chum habitat restoration efforts with those for fall Chinook, to increase efficiency.

[40] Because chum salmon leave tributary habitat at a very early age, improving estuarine habitats will also be essential to improving juvenile rearing habitats for chum salmon.

assessments are needed to identify areas for reintroduction, estimate carrying capacity, and identify habitat in need of immediate restoration. Key habitats to be protected or restored for chum salmon include lower mainstem and off-channel areas of large rivers and streams fed by upwelling from intergravel flows or springs. Protecting key production areas in the Grays River and Columbia River mainstem will be critical.

Near-term habitat improvements will depend on implementation of high-priority tributary actions that are identified in the management unit plans, completion of recovery plan implementation schedules—including a prioritization and sequencing framework for additional habitat actions—and completion of additional assessment work. The Oregon management unit plan recommends that physical habitat surveys be initiated as soon as possible to determine the quality and quantity of chum salmon spawning habitat for the entire historical range of chum salmon in Oregon if funding is available but with priority given to areas of high intrinsic habitat potential in the Scappoose and Clatskanie subbasins if funds are limited (ODFW 2010, Appendix I).

Priority site-specific actions for chum salmon will focus on protecting, restoring, or creating lowland floodplain function, riparian function, and stream habitat complexity. Priority restoration projects will include those to create or improve access to off-channel and side-channel habitat (alcoves, wetlands, floodplains, etc.) and restore riparian areas and instream habitat complexity; this includes improving recruitment of large wood to streams. The Washington management unit plan also identifies the creation of chum salmon spawning channels as a priority short-term action. The subsections below summarize additional, stratum-specific tributary habitat strategies for Columbia River chum salmon.

Ultimately, restoration of adequate habitat for chum salmon will be challenging because of the high proportion of habitat in private ownership.

8.6.2.1 Coast-Stratum Tributary Habitat Strategies

In implementing the Columbia River chum salmon strategy in the Coast stratum, considerations include the following:

- Protecting the existing production areas in the Grays River will be key. The Grays/Chinook chum salmon population is a core and genetic legacy population and one of only two populations in the ESU with appreciable natural production.

- Lowland areas are primarily in agricultural or rural residential use. These areas have been extensively modified by dikes, levees, bank stabilization, and tide gates; efforts to protect and restore habitat complexity will be priorities here. Actions will include breaching, lowering, or relocating dikes and levees where possible to improve access to off-channel habitats for juvenile chum salmon, particularly in the Clatskanie, Scappoose, Grays, and Mill/Abernathy/Germany, and Elochoman/Skamokowa subbasins (ODFW 2010, LCFRB 2010a).

- Upland areas are predominantly state and private timber land; these lands must be managed to protect and restore watershed processes.

- Physical habitat surveys are needed to determine the quality and quantity of chum salmon spawning habitat within high intrinsic potential areas of the Scappoose and Clatskanie subbasins. Assessments should include evaluations of gravel quality, hyporheic flow, upwelling, and water quality conditions (temperature, suspended sediments dissolved oxygen, etc.).

- Sediment source analyses and implementation of actions to reduce sediment will be needed in most Coast-stratum tributaries.

In addition to the actions described as part of the regional strategy for tributary habitat, the Oregon plan identifies a need to investigate whether headwater springs in the Youngs Bay, Big Creek, Clatskanie, and Scappoose subbasins are drying up as a result of land management practices. The Oregon management unit plan also emphasizes the almost universal deficiency of large woody debris in the Coast ecozone as a contributing factor to the inability of individual stream systems to sort and store gravel suitable for use by chum salmon.

Assuming that the impacts of other threats are reduced to the levels shown in Table 8-4, habitat improvements of up to 50 percent will be needed for some Washington Coast-stratum chum salmon populations. Significant habitat actions will be needed in all areas to protect existing habitats. Habitat improvement targets for Oregon chum salmon populations were not quantified because of a lack of baseline habitat and population data for chum salmon.

8.6.2.2 Cascade-Stratum Tributary Habitat Strategies

In implementing the Columbia River chum salmon habitat strategy in the Cascade stratum, considerations include the following:

- In the lower reaches of most Cascade subbasins, including the Lower Cowlitz, North Fork Lewis, East Fork Lewis, Salmon Creek, and Clackamas, floodplains have been drastically altered or disconnected as a result of channel modification to facilitate and protect development, agricultural land, and, in some cases, gravel mining. Restoration of these areas will need to be balanced with the need to protect existing infrastructure and control flood risk. Restoring floodplain function and habitat complexity in these areas is crucial in restoring chum salmon spawning and rearing habitat.

- Upper portions of the East Fork Lewis, Washougal, Clackamas, and Sandy subbasins are primarily Federal forest lands. Continued implementation of the Northwest Forest Plan will be crucial in protecting and restoring watershed processes in these areas.

- State or private forest land predominates in the upper portions of the Kalama, North Fork Lewis, and Salmon Creek subbasins. These lands must be managed to protect and restore watershed processes.

- The stratum includes the most heavily urbanized areas in the Columbia Basin. Managing the impacts of growth and development on watershed processes and habitat conditions will be key to the protection and improvement of habitat conditions for chum salmon in these areas.

- Physical habitat surveys are needed to determine the quality and quantity of chum salmon spawning habitat within areas of high intrinsic potential. Assessments should include evaluations of gravel quality, hyporheic flow, upwelling, and water quality conditions (temperature, suspended sediments dissolved oxygen, etc.).

Sediment issues will be addressed generally by restoring watershed processes and dealing with legacy road issues. In some cases (e.g., the Sandy), assessment to identify sediment sources is noted as a first step before additional actions can be taken. The Oregon management unit plan also includes actions to address flow issues in the Clackamas subbasin and roadway-related passage issues in lower Sandy river tributaries. Implementation of the city of Portland's Bull Run Water Supply habitat conservation plan will include habitat restoration in the Sandy River delta and lower reaches that will improve habitat for chum salmon.

Assuming that the impacts of other threats are reduced to the levels shown in Table 8-4, the scale of habitat improvements needed for Washington Cascade chum salmon populations ranges from minimal for the Salmon Creek population to a 50 percent reduction in habitat impacts in other Washington populations. Habitat improvement targets for Oregon chum salmon populations were not quantified because of a lack of baseline habitat and population data for chum salmon.

8.6.2.3 Gorge-Stratum Tributary Habitat Strategies

In implementing the Columbia River chum salmon habitat strategy in the Gorge stratum, considerations include the following:

- It is likely that significant amounts of historical chum spawning habitat for the Upper Gorge population have been inundated by Bonneville Reservoir.

- In the lower reaches of most Gorge streams, floodplains have been drastically altered or disconnected as a result of channel modification to facilitate and protect development and agricultural land. For the Upper Gorge population, site-specific actions will include addressing or mitigating the impacts of the highway and railroad transportation corridors that run parallel to the Columbia River shoreline, traversing all creek drainages in ways that restrict access and disconnect upland and lowland habitat processes.

- Upper portions of some Gorge tributaries are largely Federal, state, and private forest land. These lands must be managed to protect and restore watershed processes.

- Physical habitat surveys are needed to determine the quality and quantity of chum salmon spawning habitat within areas of high intrinsic potential. Assessments should include evaluations of gravel quality, hyporheic flow, upwelling, and water quality conditions (temperature, suspended sediments dissolved oxygen, etc.).

Restoring floodplain connectivity and function is called for at locations below Bonneville Dam; however, there is little opportunity to implement these floodplain measures above Bonneville Dam because much floodplain habitat was inundated by Bonneville Reservoir. For this reason, habitat efforts above the dam will rely on other strategies.

Assuming that the impacts of other threats are reduced to the levels shown in Table 8-4, reductions in baseline tributary habitat impacts needed to meet target statuses range from minimal for the Upper Gorge population to a 50 percent reduction in habitat impacts for the Washington portion of the Lower Gorge population. Habitat improvement targets for Oregon chum salmon populations were not quantified because of a lack of baseline habitat and population data for chum salmon.

8.6.3 Estuary Habitat Strategy

Estuarine habitat improvements are likely to be critical for Columbia River chum salmon, which leave their natal tributaries at a very early age and are thought to be severely limited by a paucity of intertidal marshes and similar estuarine wetlands needed for refuge and extended rearing. Habitat analysis for fall Chinook salmon indicates that populations in the Coast ecozone historically relied on wetland areas at the confluences of the tributaries and the mainstem Columbia (Northwest Fisheries Science Center 2010); because the habitat needs of fall Chinook and chum salmon appear to overlap considerably, some NMFS scientists have suggested that these same confluence areas may also be significant for chum salmon.

Improving Columbia River estuary habitat as described in the regional estuary habitat strategy will benefit all Columbia Basin ESUs, including Columbia River chum salmon. (For a summary of the regional estuarine habitat strategy, see Section 4.2.2.) The regional strategy reflects actions presented in the Oregon and Washington management unit plans to reduce estuarine habitat-related threats and is consistent with actions in the *Columbia River Estuary ESA Recovery Plan Module for Salmon and Steelhead* (NMFS 2011a). For Columbia River chum salmon, the assessment process described as part of the regional strategy should include assessment of the tidal portions of tributaries and their confluence with the mainstem Columbia. Developing implementation priorities for estuarine habitat actions also should include establishment of milestones or expected trends in improved habitat conditions in high-priority intertidal areas.

The *Columbia River Estuary ESA Recovery Plan Module for Salmon and Steelhead* (NMFS 2011a) assumes that feasible estuarine habitat improvements and predation management measures could result in a maximum increase of 20 percent in the number of outmigrating juveniles leaving the Columbia River estuary. Washington recovery planners set targets of reducing anthropogenically enhanced mortality in the estuary for chum salmon populations based on the estuary module and their own approach to threat reductions (LCFRB 2010a, Table 6-7). Oregon did not quantify baseline and target threat impacts for chum salmon populations because data were inadequate to do so.

Ultimately, restoring adequate habitat for chum salmon in the Columbia River estuary will be challenging because of the high proportion of habitat in private ownership.

8.6.4 Hydropower Strategy

Chum salmon are expected to benefit from the regional hydropower strategy (see Section 4.3.2), which involves improving passage survival at Bonneville Dam for the Upper Gorge populations and, specifically for chum salmon, ensuring adequate flows in the Bonneville Dam tailrace and downstream throughout migration, spawning, incubation, and emergence. In addition, NMFS expects that implementation of mainstem flow management operations designed to benefit spring migrants from the interior of the Columbia Basin will also improve survival in the estuary and, potentially, the plume for all Lower Columbia River salmon and steelhead populations. Because Columbia River chum salmon are distributed low in tributary subbasins, reintroduction above tributary dam complexes is not part of the recovery strategy.

NMFS estimates that survival of Columbia River chum salmon passing Bonneville Dam was 95.1 percent for juveniles from 2002 to 2009 and 96.9 percent for adults from 2002 to 2007 (NMFS 2008a). NMFS expects that implementation of actions in the 2008 FCRPS Biological Opinion and its 2010 Supplement will improve juvenile chum salmon survival at Bonneville Dam by less than ½ percent, and that adult survival will be maintained at recent high levels (NMFS 2008a). Consequently, Oregon has not incorporated survival benefits from passage improvements at Bonneville into the hydropower threat reduction targets for Oregon populations above Bonneville.[41] The Washington management unit plan assumes that actions identified in the 2008 FCRPS Biological Opinion and its 2010 Supplement will aid adults and juveniles from all chum salmon populations originating above Bonneville Dam.

FCRPS Biological Opinion actions also will provide adequate conditions for chum salmon spawning in the mainstem Columbia River in the area of the Ives Island complex and/or access to the Hamilton and Hardy Creeks to protect spawning areas for the Lower Gorge population.

For information on how hydropower operations will improve the survival of chum salmon in the Columbia River estuary, see the regional hydropower strategy in Section 4.3.2.

In its management unit plan, Oregon incorporated several actions addressing impacts of the Columbia River hydropower system that are not included in the FCRPS Biological Opinion and its 2010 Supplement but that Oregon maintains are needed to benefit Lower Columbia River salmon and steelhead populations that spawn above Bonneville Dam. The state of Oregon's position is that the FCRPS action agencies should conduct operations in addition to those incorporated in the FCRPS Biological Opinion to address the needs of ESA-listed salmon and steelhead. Oregon is a plaintiff in litigation against various Federal agencies, including NMFS, challenging the adequacy of measures in the FCRPS Biological Opinion and its 2010 Supplement. NMFS does not agree with Oregon

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[41] Hydropower-related threat reduction targets for Oregon populations above Bonneville Dam are associated with removal of Powerdale Dam on the Hood River.

regarding the need for or likely efficacy of the additional actions Oregon proposed in that litigation, including the actions in the Oregon management unit plan that are not part of the FCRPS Biological Opinion and its 2010 Supplement. For more detail on these actions and NMFS' view of them, including their potential to benefit chum salmon, see the regional hydropower strategy in Section 4.3.2.

The subsections below summarize stratum-level hydropower strategies for chum salmon.

8.6.4.1 Coast-Stratum Hydropower Strategies

There are no tributary dams in the Coast ecozone, so the hydropower strategy for the Coast stratum is to implement the flow management operations designed to benefit spring migrants from the interior of the Columbia Basin; these flow management operations will also improve survival in the estuary and, potentially, the plume for all Lower Columbia River salmon and steelhead populations.

8.6.4.2 Cascade-Stratum Hydropower Strategies

Tributary dams in the Cascade ecozone are not identified as limiting factors for Cascade chum salmon populations, so the hydropower strategy for the Cascade stratum is to implement the mainstem hydropower actions that are expected to improve estuarine and, potentially, plume survival for all Columbia River chum salmon populations. The quantity and quality of spawning and rearing habitat for chum salmon in the North Fork Lewis and Cowlitz are affected by the rate at which water is discharged at Merwin and Mayfield dams, respectively. The operational plans for the Lewis and Cowlitz dams, in conjunction with fish management plans, should include flow regimes (minimum flow and ramping rate requirements, etc.) that enhance the lower river habitat for chum salmon.

8.6.4.3 Gorge-Stratum Hydropower Strategies

Tributary dams do not affect the Lower Gorge or Upper Gorge populations. Reductions in passage impacts at Bonneville Dam, as outlined in the 2008 FCRPS Biological Opinion and its 2010 Supplement (NMFS 2008f and 2010a), are expected to provide slight benefits to the Upper Gorge population, and the FCRPS will be operated to provide adequate conditions for chum salmon spawning in the mainstem Columbia River below Bonneville Dam (i.e., the Lower Gorge population). For more information, see the regional hydropower strategy in Section 4.3.2.

8.6.5 Harvest Strategy

The harvest strategy for chum salmon is to avoid significant increases in the current very low incidental fishery impacts by continuing to limit mainstem and tributary recreational fisheries for other species (primarily hatchery late-fall Chinook and coho) in times and areas where chum salmon are present. The Washington management unit plan identifies targets for reductions in impacts of all threat categories based on a strategy of equitable sharing of the recovery burden. Thus, the Washington plan describes fishery impact reductions from the 5 percent baseline rate for chum salmon at the time of listing. However, the current incidental fishery impact rate of 2 percent or less per year meets impact reduction targets identified in the Washington management unit plan (LCFRB 2010a).

8.6.6 Hatchery Strategy

The hatchery recovery strategy for Columbia River chum salmon is to use hatcheries to supplement and reduce risks to natural populations as appropriate, and to use hatchery reintroduction as appropriate to reestablish populations where they have been extirpated or nearly so. Reintroduction using hatchery chum salmon would be coordinated with habitat protection and restoration and triggered by a determination that natural chum salmon abundances are so low that recolonization would likely not be successful. Steps in the reintroduction strategy are to identify and obtain suitable broodstock, identify facilities for use in the conservation hatchery program, identify production goals and program duration, identify artificial production techniques, and identify release strategies for the reintroduction program. Experimental supplementation and reintroduction programs will be accompanied by aggressive monitoring and evaluation programs.

8.6.6.1 Coast-Stratum Hatchery Strategy

In the Coast stratum, the hatchery strategy is to continue the existing hatchery supplementation program and expand supplementation or reintroduction to other populations as deemed appropriate. The Grays River hatchery program produces chum salmon to augment natural production and reduce extinction risks to naturally spawning Grays River chum salmon. This program occurs in conjunction with habitat restoration efforts in the Grays subbasin. The program also is considered an important safety net for chum in the lower Columbia in general (LCFRB 2010a, Volume II).

Oregon also recently initiated a chum salmon hatchery program at its Big Creek hatchery, using Grays River fish as broodstock. Chum salmon from this program were first released into the Big Creek subbasin in 2011 as part of a reintroduction program. The Oregon management unit plan's chum salmon recovery strategy focuses initially on the Coast stratum. This is because the Coast-stratum subbasins are believed to have been less altered by human development than subbasins in other strata; thus Coast-stratum subbasins provide the best opportunity to test hypotheses regarding re-establishing self-sustaining chum salmon populations. (Oregon will use lessons learned from chum salmon recovery efforts in the Coast stratum to inform efforts to improve or create habitat and to reestablish chum salmon throughout the ESU.)

No hatchery chum salmon are currently released into other Coast-stratum subbasins, although other reintroduction or supplementation programs may be developed.

8.6.6.2 Cascade-Stratum Hatchery Strategy

In the Cascade stratum, the hatchery strategy is to develop supplementation or reintroduction programs for Cascade-stratum populations as deemed appropriate. Currently, no hatchery chum salmon are released in the Cascade stratum. (The Washougal hatchery produces chum salmon for an enhancement program to assist in rebuilding of the Lower Gorge chum salmon population). The Washington management unit plan notes that for the Cascade populations, one potential hatchery strategy is to develop a chum salmon broodstock using natural returns or some other appropriate population but does not lay out any timelines or decision points for that strategy. The Oregon management unit plan will focus efforts first in the Coast stratum and use lessons learned there to inform efforts to improve or create habitat and to reestablish chum salmon throughout the ESU.

8.6.6.3 Gorge-Stratum Hatchery Strategy

In the Gorge stratum, the hatchery strategy is to continue the existing hatchery supplementation program and expand supplementation or reintroduction as deemed appropriate. Currently, no hatchery chum salmon are produced in the Gorge stratum; however, the Washougal hatchery produces chum salmon for an enhancement program to assist in rebuilding the Lower Gorge population. This program uses chum salmon spawning in the Ives Island area for broodstock with a goal of enhancing chum salmon returns to Duncan Creek. The program occurs in conjunction with habitat restoration efforts in Duncan Creek. This program also acts as a safety net in the event that mainstem Columbia flow operations severely limit the natural spawning of chum salmon in Hamilton and Hardy creeks and in the Ives Island area below Bonneville Dam. The Washington management unit plan also notes the possibility of using a conservation hatchery program for the Upper Gorge population. The Oregon management unit plan will focus chum salmon recovery efforts first in the Coast stratum and use lessons learned there to inform efforts to improve or create habitat and to reestablish chum salmon throughout the ESU.

8.6.7 Predation Strategy

The regional predation strategy (see Section 4.6.2) involves reducing predation by birds, fish, and marine mammals and will benefit all Lower Columbia ESUs, including Columbia River chum salmon.

8.6.8 Critical Uncertainties

Each aspect of the chum salmon recovery strategy has a number of critical uncertainties, including the overarching questions of why some chum salmon populations are performing better than others and what the implications of these differences are with respect to recovery. To answer these questions, additional data are needed on chum salmon population characteristics, habitat usage and availability, interspecies predation on chum salmon juveniles, and hatchery reintroductions of chum salmon. In addition, for all ESUs there are uncertainties regarding how habitat actions will translate into changes in productivity and capacity (Roni et al. 2011). Prioritizing and identifying next steps in resolving uncertainties is a near-term priority. Critical uncertainties specific to the Columbia River chum salmon recovery strategy include the following:

- Historical role of the Gorge populations and appropriate target persistence probabilities, and abundance and productivity targets for them.

- Total adult spawning escapement, adult productivity, juvenile survival, and life history diversity of Columbia River chum salmon populations;
- Chum salmon's estuarine habitat requirements and how they overlap with those of fall Chinook
- Extent to which chum salmon use intertidal estuary-tributary "confluence" habitats and, if so, whether they are the same habitats used by fall Chinook
- Current extent of suitable or potentially suitable chum salmon habitat
- Best locations for restoration of chum salmon spawning habitat
- Effectiveness (both short term and long term) of constructed chum salmon spawning channels as a restoration strategy
- Relative effectiveness of hatchery reintroduction, hatchery supplementation, and natural recolonization in reestablishing and recovering chum salmon populations
- Significance of ecological interactions between hatchery- and natural-origin fish, such as predation by steelhead and coho on chum salmon (LCFRB 2010a)
- Potential for incidental harvest of chum salmon to increase in terminal fishing areas as chum salmon are reintroduced in Oregon and populations increase

These critical uncertainties represent preliminary priorities identified by Oregon and Washington recovery planners and NMFS Northwest Regional Office and Northwest Fisheries Science Center staff during a November 2010 workshop. They are preliminary priorities only (and are not in ranked order); as described in Chapter 10, additional discussion among local recovery planners and NMFS staff will be needed to finalize future research and monitoring priorities for chum salmon.

The management unit plans identify more comprehensive critical uncertainties and research, monitoring, and evaluation needs that, along with list above, will provide the basis for these future discussions. The White Salmon and Washington management unit plans have discrete sections on critical uncertainties for all of the ESUs in general (see Section 8.3 of NMFS 2011b, pp. 8-4 through 8-6, and Section 9.6 of LCFRB 2010a, pp. 9-68 through 9-73), while the Oregon management unit plan embeds relevant critical uncertainties within subsections on the four VSP parameters and five ESA listing factors (see Sections 8.4 and 8.5, respectively, of ODFW 2010). In addition, in June 2010, the Lower Columbia Fish Recovery Board completed the *Research, Monitoring, and Evaluation Program for Lower Columbia Salmon and Steelhead* as a companion to its recovery plan (LCFRB 2010b). This document also describes critical uncertainties—and Section 8.6.4 of ODFW (2010) lists research, monitoring, and evaluation needs to address uncertainties related to Oregon's chum salmon recovery strategy. The list above does not include critical uncertainties that apply to multiple ESUs; these will be discussed and considered as decisions are made in implementation. In addition, the critical uncertainties above are of a technical nature; there are also many critical uncertainties related to social, political, and economic issues.

Critical uncertainties are one element of research, monitoring, and evaluation (RME) and adaptive management, which will be key components of the chum salmon recovery strategy (see Chapter 10 for more discussion of RME and adaptive management for this recovery plan).

8.7 Delisting Criteria Conclusion for Columbia River Chum Salmon

The requirement for determining that a species no longer requires the protection of the ESA is that the species is no longer in danger of extinction or likely to become endangered within the foreseeable future, based on evaluation of the listing factors specified in ESA section 4(a)(1). To remove the Columbia River chum salmon ESU from the Federal List of Endangered and Threatened Wildlife and Plants (that is, to delist the ESU), NMFS must determine that the ESU, as evaluated under the ESA listing factors, is no longer likely to become endangered.

The ESA requires that recovery plans, to the maximum extent practicable, incorporate objective, measurable criteria that, when met, would result in a determination in accordance with the provisions of the ESA that the species be removed from the Federal List of Endangered and Threatened Wildlife and Plants (50 CFR 17.11 and 17.12). The biological and threats criteria in this plan, taken together, meet this statutory requirement.

As described in Section 8.3, if the scenario in Table 8-2 were achieved, it would slightly exceed the WLC TRT's viability criteria in the Coast and Cascade strata (in the latter case, the scenario would exceed the criterion for number of populations but just meet the scoring criterion) (see Table 8-5). However, the scenario would not meet criteria in the Gorge stratum because only one Gorge population (the Lower Gorge) would be viable, instead of two (see Table 8-5).[42] Exceeding the criteria in the Coast and Cascade strata was intentional on the part of local recovery planners to compensate for uncertainties about the feasibility of meeting the WLC TRT's criteria in the Gorge stratum.

[42] As discussed in Section 2.5.4, the TRT's criteria for high probability of stratum persistence require that two or more populations be viable and that the average score for all populations in the stratum be 2.25 or higher.

Table 8-5
Chum Salmon Recovery Scenario Scores Relative to WLC TRT's Viability Criteria

Species	Number of Primary Populations					Stratum Average Criteria			
Chum		Coast	Cascade	Gorge	Total		Coast	Cascade	Gorge
	n ≥ high	5	3	1	9	Avg. score	2.29	2.25	3
	TRT criterion (n ≥ 2) met?	Yes	Yes	No		TRT criterion (avg. ≥ 2.25) met?	Yes	Yes	Yes

Source: Based on LCFRB (2010a), Table 4-7.

Recovery planners' uncertainty about meeting WLC TRT criteria in the Gorge chum stratum is based on questions about available habitat and anthropogenic impacts that are unlikely to change in the near future (e.g., inundation of habitat by Bonneville Reservoir) and on questions regarding Gorge strata and population delineations and historical role (LCFRB 2010a, ODFW 2010). These questions include whether the Gorge populations were highly persistent historically, whether they functioned as independent populations within their stratum in the same way that the Coast and Cascade populations did, and whether the Gorge stratum itself should be considered a separate stratum from the Cascade stratum.

As discussed in Section 3.2, NMFS has considered the WLC TRT's viability criteria (from McElhany et al. 2003 and 2006 and summarized in Table 2-3), the additional recommendations in McElhany et al. (2007), the recovery scenarios and population-level goals in the management unit plans, and the questions management unit planners raised regarding the historical role of the Gorge stratum.

NMFS has concluded that the WLC TRT's criteria adequately describe the characteristics of an ESU that meet or exceed the requirement for determining that a species no longer needs the protection of the ESA. These criteria provide a framework within which to evaluate specific recovery scenarios. NMFS has evaluated the recovery scenario presented in the management unit plans for Columbia River chum salmon (summarized in Table 3-1 of this recovery plan) and the associated population-level abundance and productivity goals (see Section 8.3).

Regarding the divergence of the scenario from the WLC TRT's criteria, the TRT noted in its revised viability criteria (McElhany et al. 2006) the need for case-by-case evaluations of the continuum of ESU-level risk associated with some strata not meeting their criteria. In commenting on the recovery scenarios presented in the interim Washington management unit plan[43]—and by extension the recovery scenarios presented in Table 3-1 of this plan—the WLC TRT stated that achieving the recovery scenarios would improve the status of the Gorge strata, even if the TRT's criteria for those strata were not

[43] In February 2006, NMFS approved the December 2004 version of the Washington management unit plan as an interim regional recovery plan for Lower Columbia River Chinook salmon and steelhead and Columbia River chum salmon. In May 2010, the LCFRB completed a revision of its 2004 plan (LCFRB 2010a), which is incorporated into this ESU-level recovery plan as Appendix B.

met. The TRT also noted that targeting the Cascade stratum for above the minimum TRT criteria would help lower ESU extinction risk. In addition, the TRT noted that the Gorge and Cascade strata are relatively similar compared to the Cascade and Coast strata. Also significant in the TRT's view was that options for recovery of the Gorge stratum would be preserved, in case future conditions or analyses were to require high stratum persistence for ESU viability (McElhany et al. 2006, p. 9).

Based on the information provided by the WLC TRT and the management unit recovery planners, NMFS concludes that the recovery scenarios in Table 3-1 and the associated population-level abundance and productivity goals in Section 8.3 represent one of multiple possible scenarios that would meet biological criteria for delisting. The similarities between the Gorge and Cascade strata, coupled with compensation in the Cascade stratum for not meeting TRT criteria in the Gorge stratum, would provide an ESU no longer likely to become endangered. NMFS endorses the recovery scenario and population-level goals found in the management unit plans for Columbia River chum salmon (summarized in Table 3-1 and Section 8.3) as one of multiple possible scenarios consistent with delisting. As noted earlier in this chapter (see Section 8.3), Oregon did not identify abundance targets for chum salmon populations because data for use in calculating abundance targets and conservation gaps are not available. In this plan (see Table 8-2), NMFS has included placeholder abundance targets for Oregon chum salmon populations based on the minimum abundance thresholds presented in McElhany et al. (2006 and 2007). NMFS expects that these targets will be refined over time as more information becomes available.

NMFS also agrees with the management unit planners that the historical role of the Gorge populations and stratum merits further examination. The extent to which compensation in the Cascade stratum is ultimately considered necessary to achieve an acceptably low risk at the ESU level will depend on how questions regarding the historical role of the Gorge populations are resolved.

NMFS therefore proposes the following biological criteria for the Columbia River chum salmon ESU (NMFS has amended the WLC TRT's criteria to incorporate the concept that each stratum should have a probability of persistence consistent with its historical condition, thus allowing for resolution of questions regarding the Gorge stratum):

1. All strata that historically existed have a high probability of persistence or have a probability of persistence consistent with their historical condition. High probability of stratum persistence is defined as:

    a. At least two populations in the stratum have at least a 95 percent probability of persistence over a 100-year time frame (i.e., two populations with a score of 3.0 or higher based on the TRT's scoring system).

    b. Other populations in the stratum have persistence probabilities consistent with a high probability of stratum persistence (i.e., the average of all stratum population scores is 2.25 or higher, based on the TRT's scoring system). (See Section 2.6 for a brief discussion of the TRT's scoring system.)

c. Populations targeted for a high probability of persistence are distributed in a way that minimizes risk from catastrophic events, maintains migratory connections among populations, and protects within-stratum diversity.

A probability of persistence consistent with historical condition refers to the concept that strata that historically were small or had complex population structures may not have met Criteria A through C, above, but could still be considered sufficiently viable if they provide a contribution to overall ESU viability similar to their historical contribution.

2. The threats criteria described in Section 3.2.2 have been met.

9. Lower Columbia River Steelhead

9.1 Steelhead Biological Background

9.1.1 Steelhead Life History and Habitat

Lower Columbia River steelhead (*Oncorhynchus mykiss*) exhibit perhaps the most complex life history of any Pacific salmonid. These fish can be anadromous or freshwater residents (and under some circumstances, apparently yield offspring of the opposite form). Steelhead, the anadromous form of *O. mykiss*, are under the jurisdiction of NMFS, while the resident freshwater forms, usually called "rainbow" or "redband" trout, are under the jurisdiction of the U.S. Fish and Wildlife Service. Steelhead are iteroparous, meaning they can spawn more than once. Repeat spawners are called "kelts."

Two distinct life history types of steelhead—summer and winter runs—historically were and currently are found in the lower Columbia River. The two life history types differ in degree of sexual maturity at freshwater entry, spawning time, and frequency of repeat spawning. Most summer-run steelhead from the Lower Columbia River steelhead DPS re-enter freshwater between May and October and require several months to mature before spawning, generally between late February and early April. Most winter-run steelhead re-enter freshwater between December and May as sexually mature fish; peak spawning occurs later than for summer steelhead, in late April and early May. (See Figures 9-1 and 9-2.) Iteroparity (repeat spawning) rates for Columbia Basin steelhead have been reported as high as 2 to 6 percent for summer steelhead and 8 to 17 percent for winter steelhead populations (Leider et al. 1986, Hulett et al. 1993, and Busby et al. 1996).

Within the same watershed, winter and summer steelhead generally spawn in geographically distinct areas (Myers et al. 2006). Summer steelhead can often reach headwater areas above waterfalls that are impassable to winter steelhead during the high-velocity flows common during the winter-run migration. In basins where both winter and summer steelhead are present, the summer life history strategy appears to be able to persist only above the barrier falls that exclude winter steelhead. Although the summer steelhead's long duration of pre-spawning holding in freshwater enhances their opportunity to take advantage of periodically favorable passage conditions, it may also result in a higher pre-spawning mortality rate that puts summer steelhead at a competitive disadvantage relative to winter steelhead (Myers et al. 2006). Historically, winter steelhead may have been excluded from interior Columbia River subbasins by Celilo Falls.

Steelhead spawn in a wide range of conditions ranging from large streams and rivers to small streams and side channels (Myers et al. 2006). Productive steelhead habitat is characterized by suitable gravel size, depth, and water velocity, and by complexity, primarily in the form of large and small wood (Barnhart 1986). Steelhead may enter streams and arrive at spawning grounds weeks or even months before spawning and therefore are vulnerable to disturbance and predation. They need cover in the form of overhanging vegetation, undercut banks, submerged vegetation, submerged objects such as logs and rocks, floating debris, deep water, turbulence, and turbidity (Geiger 1973). Their spawning timing must optimize avoiding risks from gravel-bed scour during high flow and increasing water temperatures that can become lethal to eggs. Spawning generally occurs earlier in areas of lower elevation, where water temperature is warmer, than in areas of higher elevation, with cooler water temperature.

Depending on water temperature, steelhead eggs may incubate for 35 to 50 days before hatching, after which alevins remain in the gravel 2 to 3 weeks, until the yolk-sac is absorbed. Generally, emergence occurs from March into July, with peak emergence time generally in April and May. Fry emergence is principally determined by the time of egg deposition and the water temperature during the incubation period. In the Lower Columbia subdomain, emergence timing differs slightly between winter and summer life-history types and among subbasins. These differences may be a function of spawning location (and hence water temperature) or of genetic differences between life-history types.

Following emergence, fry usually move into shallow and slow-moving margins of the stream. As they grow, they inhabit areas with deeper water, a wider range of velocities, and larger substrate, and they may move downstream to rear in large tributaries or mainstem rivers. Young steelhead typically rear in streams for some time before migrating to the ocean as smolts. Steelhead smolts generally migrate at ages ranging from 1 to 4 years, but most steelhead smolt after 2 years in freshwater (Busby et al. 1996). In the lower Columbia River, outmigration of steelhead smolts (of both summer and winter life-history types) generally occurs from March to June, with peak migration usually in April or May.

Catch data suggest that juvenile steelhead migrate directly offshore during their first summer, rather than migrating nearer to the coast. Maturing Columbia River steelhead are found off the coast of Northern British Columbia and west into the North Pacific Ocean (Busby et al. 1996). Fin-mark and coded-wire tag data suggest that winter steelhead tend to migrate farther offshore but not as far north into the Gulf of Alaska as summer steelhead (Burgner et al. 1992). Most steelhead spend 2 years in the ocean (range 1 to 4 years) before migrating back to their natal streams (Shapovalov and Taft 1954, Narver 1969, Ward and Slaney 1988). Once in the river, adult steelhead apparently rarely eat and grow little, if at all.

The key freshwater habitat needs of Lower Columbia River steelhead at different life stages are shown in Table 9-1. Steelhead typically rear in a wider range of stream gradients and average velocities than do other salmon species.

Table 9-1
Key Habitat for Steelhead, by Life Stage

Life Stage	Key Habitat Descriptions
Spawning	Riffles, tailouts, and glides containing a mixture of gravel and cobble sizes with flow of sufficient depth for spawning activity
Incubation	As for spawning, but with sufficient flow for egg and alevin development
Fry Colonization	Shallow, slow-velocity areas within the stream channel, often associated with stream margins
Active Rearing	Gravel and cobble substrates with sufficient depth and velocity, and boulder/large cobble/wood obstruction to reduce flow and concentrate food
Inactive Rearing	Stable cobble/boulder substrates with interstitial spaces
Migrant	All habitat types having sufficient flow for free movement of juvenile migrants
Pre-Spawning Migrant	All habitat types having sufficient flow for free movement of sexually mature adult migrants
Pre-Spawning Holding	Relatively slow, deep-water habitat types (with cool temperatures), typically associated with (or immediately adjacent to) the main channel

Source: Adapted from Northwest Power and Conservation Council (2004b).

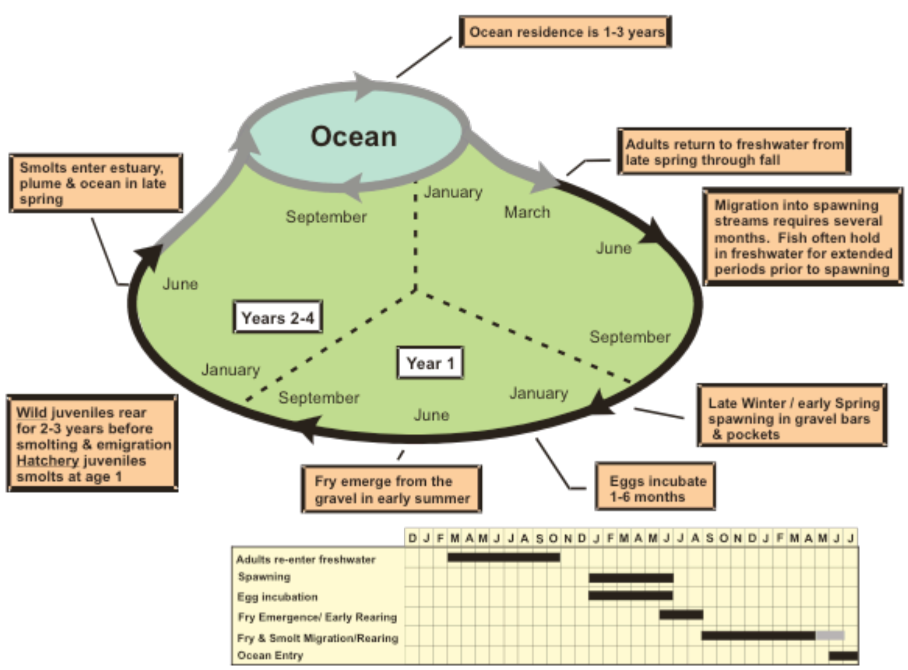

Figure 9-1. *Life Cycle of LCR Summer Steelhead*
(Source: LCFRB 2010a)

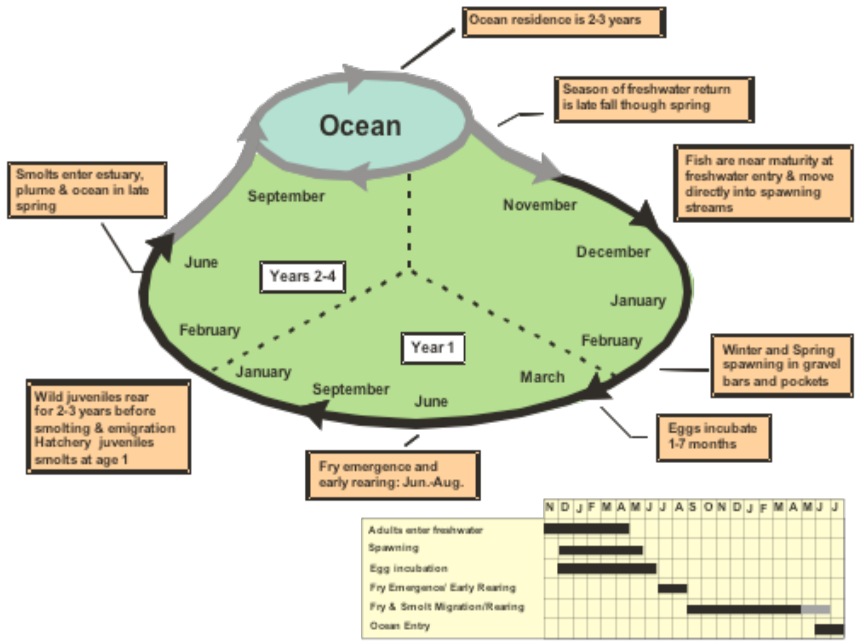

Figure 9-2. *Life Cycle of Winter Steelhead*
(Source: LCFRB 2010a)

9.1.2 Historical Distribution and Population Structure of LCR Steelhead

The WLC TRT identified 23 historical independent populations of Lower Columbia River steelhead: 17 winter-run populations and six summer-run populations, within the Cascade and Gorge ecozones. [1] Table 9-2 lists these populations and indicates core populations (which historically were highly productive) and genetic legacy populations (which represent important historical genetic diversity). Figures 9-3 and 9-4 show the geographical distribution of Lower Columbia River steelhead strata and populations.

[1] Steelhead populations within the Coast ecozone are part of a separate DPS—the unlisted Southwest Washington DPS—and are not addressed in this recovery plan; however, they are addressed in the Oregon and Washington management unit plans to address state planning needs. The White Salmon and Little White Salmon steelhead populations are part of the Middle Columbia steelhead DPS and are addressed in a separate species-level recovery plan, the *Middle Columbia River Steelhead Distinct Population Segment ESA Recovery Plan* (NMFS 2009a). However, recovery actions for the White Salmon population of Mid-Columbia steelhead are included in the White Salmon management unit plan (*Draft ESA Recovery Plan for the White Salmon River Watershed,* NMFS 2011b; see Appendix C of this recovery plan) because this population shares geography with Lower Columbia River coho and Chinook salmon and Columbia River chum in the White Salmon subbasin.

Table 9-2
Historical LCR Steelhead Populations

Stratum	Historical Populations	Core or Genetic Legacy Populations
Cascade summer	Kalama (WA)	Core
	NF Lewis (WA)	
	EF Lewis (WA)	Genetic legacy
	Washougal (WA)	Core, genetic legacy
Gorge summer	Wind (WA)	Core
	Hood (OR)	
Cascade winter	Lower Cowlitz (WA)	
	Upper Cowlitz (WA)	Core, genetic legacy
	Cispus (WA)	Core, genetic legacy
	Tilton (WA)	
	SF Toutle (WA)	
	NF Toutle (WA)	Core
	Coweeman (WA)	
	Kalama (WA)	
	NF Lewis (WA)	Core
	EF Lewis (WA)	
	Salmon Creek (WA)	
	Clackamas (OR)	Core
	Sandy (OR)	Core
	Washougal (WA)	
Gorge winter	Lower Gorge (WA and OR)	
	Upper Gorge (WA and OR)	
	Hood (OR)	Core, genetic legacy

Source: Myers et al. (2006), McElhany et al. (2003).

Up through 2006, ten artificial propagation programs produced steelhead considered to be part of this DPS (see Table 9-3). In 2007, the release of Cowlitz Hatchery winter steelhead into the Tilton River was discontinued; in 2009, the Hood River winter steelhead program was discontinued; and in 2010, the release of hatchery winter steelhead into the Upper Cowlitz and Cispus rivers was discontinued. In 2011, NMFS recommended removing these programs from the DPS. A Lewis River winter steelhead program was initiated in 2009, and in 2011, NMFS proposed that it be included in the DPS (76 *Federal Register* 50448). For a list of steelhead hatchery programs not included in the DPS, see Jones (2011).

Table 9-3
Artificial Propagation Programs for LCR Steelhead

Run Type	Washington Programs	Oregon Programs
Summer steelhead	Kalama River Wild	Hood River*
Winter steelhead	Cowlitz Trout Hatchery - Cispus* Cowlitz Trout Hatchery - Upper Cowlitz* Cowtliz Trout Hatchery - Lower Cowlitz Cowlitz Trout Hatchery - Tilton* Kalama River Wild	Clackamas Hatchery Sandy Hatchery Hood River

* Program has been discontinued and NMFS has recommended removing it from the DPS (76 *Federal Register* 50448).
Source: 71 *Federal Register* 8844.

9.2 Baseline Population Status of LCR Steelhead

Out of the 23 populations in this DPS, 16 are considered to have a low or very low probability of persisting over the next 100 years (see Table 9-4), and six populations have a moderate probability of persistence (LCFRB 2010a, ODFW 2010, Ford 2011).[2] Only the summer-run Wind population is considered viable. Although current Lower Columbia River steelhead populations are depressed compared to historical levels and long-term trends show declines, many populations are substantially healthier than their salmon counterparts, typically because of better habitat conditions in core steelhead production areas (LCFRB 2010a). However, all four strata in the DPS fall short of the WLC TRT criteria for viability.

The low to very low baseline persistence probabilities of most Lower Columbia River steelhead populations reflects low abundance and productivity. In addition, it is likely that genetic and life history diversity has been reduced as a result of pervasive hatchery effects and population bottlenecks. Spatial structure remains relatively high for most populations (LCFRB 2010a, ODFW 2010).

9.2.1 Baseline Status of LCR Summer Steelhead

Baseline persistence probabilities were estimated to be low or very low for three out of the six summer steelhead populations that are part of the Lower Columbia River DPS,

[2] As described in Section 2.6, the WLC TRT recommended methods for evaluating the status of Lower Columbia River salmon and steelhead populations. The TRT's approach is based on evaluating the population parameters of abundance, productivity, spatial structure, and diversity and then integrating those assessments into an overall assessment of population persistence probability. As described in Section 5.1, management unit recovery planners evaluated their respective populations' baseline status in a manner generally consistent with the WLC TRT's approach, with the baseline period being either circa 1999 (for Washington populations) or 2006-2018 (for Oregon populations). Unless otherwise noted, NMFS and the management unit planners believe that those assessments accurately reflect the status of the population at that time; the assessments are the basis for the summaries presented here and are consistent with the conclusions of the Northwest Fisheries Science Center in its *Status Review Update for Pacific Salmon and Steelhead Listed under the Endangered Species Act* (Ford 2011). New information on population status will continue to accumulate over time and will be taken into account as needed to reflect the best available science regarding a population's status.

moderate for two, and high for one—the Wind, which is considered viable (see Figure 9-3) (LCFRB 2010a, ODFW 2010).

Declines in persistence probability are attributable primarily to low abundance and productivity. Except in the North Fork Lewis subbasin, where dams have impeded access to historical spawning habitat, most summer steelhead populations continue to have access to historical production areas in forested, mid- to-high-elevation subbasins that remain largely intact. It is likely that historical hatchery effects have reduced the genetic diversity of many summer steelhead populations and caused declines in productivity (LCFRB 2010a). The Hood population has the highest proportion of hatchery spawners, at 53 percent (ODFW 2010). The highest pHOS rate among the Washington populations is 35 percent, for the East Fork Lewis (LCFRB 2010a).

9.2.2 Baseline Status of LCR Winter Steelhead

Thirteen of the 17 Lower Columbia River winter steelhead populations have low or very low baseline probabilities of persistence, and the remaining four are at moderate probability of persistence (see Figure 9-4) (LCFRB 2010a, ODFW 2010).

Declines in persistence probability are related primarily to low abundance and productivity. In addition, it is likely that historical hatchery effects have reduced the genetic diversity of most winter steelhead populations and caused declines in productivity. Most populations have maintained their spatial structure, meaning that returning adults can access most areas of significant historical habitat (although many of these habitats no longer support significant production) (LCFRB 2010a, ODFW 2010). For the Upper Cowlitz, Cispus, Tilton, North Fork Lewis, and Sandy populations, passage to upper basin habitat is partially or entirely blocked by dams (LCFRB 2010a; ODFW 2010); the Upper Gorge population is constrained by hatchery weirs, and the Hood population is constrained by the presence and operation of an irrigation dam. Steelhead distribution has been partially restored in the Upper Cowlitz, Cispus, and Tilton subbasin by trapping and transferring adults and juveniles around impassable dams.

For additional discussion of Lower Columbia River steelhead population status, see the management unit plans (LCFRB 2010a, pp. 6-57 through 6-52, and ODFW 2010, pp. 55-56) and Ford (2011).

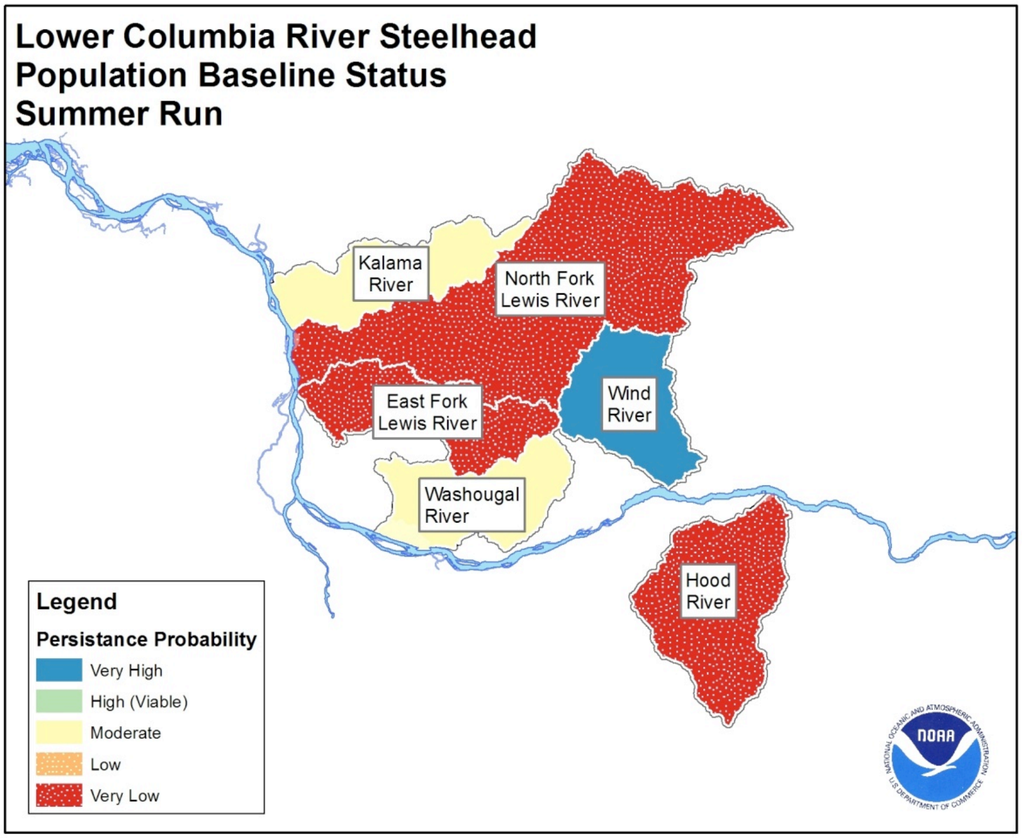

Figure 9-3. *Baseline Status of LCR Summer Steelhead Populations*

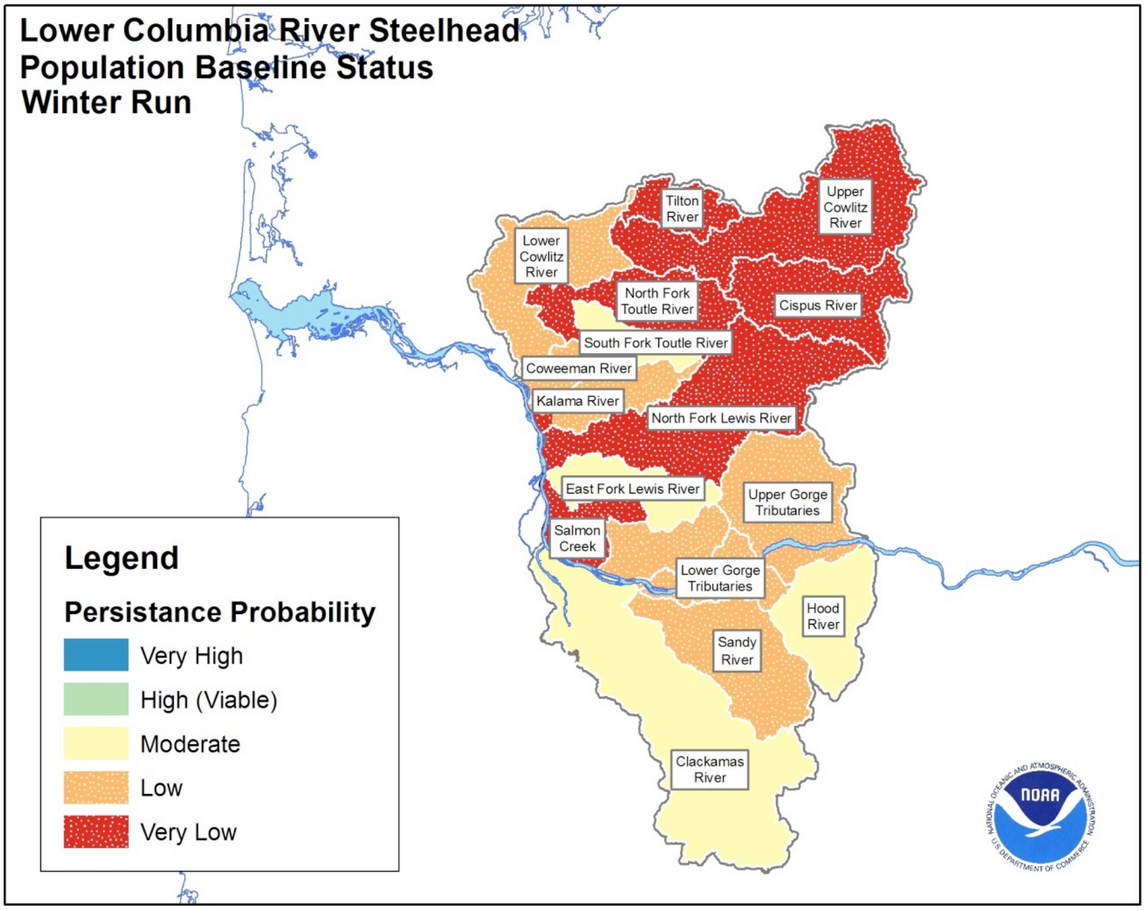

Figure 9-4. *Baseline Status of LCR Winter Steelhead Populations*

9.3 Target Status and Conservation Gaps for Steelhead Populations

Table 9-4 shows the baseline and target status for each Lower Columbia River steelhead population, along with historical abundance and target abundance. Local recovery planners coordinated with NMFS in making decisions about the target status for each population, taking into consideration opportunities for improvement in view of historical production, current habitat conditions and potential, and the desire to accommodate objectives such as maintaining harvest opportunities. (Note: the target statuses in Table 9-4 are the same as the persistence probabilities in the recovery scenario presented in Table 3-1 in Section 3.13.) As described in Section 5.1, although Oregon and Washington recovery planners used somewhat different methodologies to estimate baseline status and target abundance and productivity NMFS and the management unit planners agree that the methodologies led to similar conclusions regarding the baseline status for Lower Columbia River steelhead populations.

Substantial improvements are needed in the persistence probability of most steelhead populations if the DPS is to achieve recovery (see Figures 9-5 and 9-6). For example, 16 (11 winter and five summer) of 23 historical populations are targeted for high persistence probability or better. Of these, seven of the 17 historical winter-run populations and two of the six historical summer-run populations have very low or low baseline persistence probabilities. Some level of recovery effort will be needed for every population—even stabilizing populations that are expected to remain at their baseline status—to arrest or reverse continuing long-term declining trends. For most populations, meeting recovery objectives will require improvement in abundance, productivity, and diversity; several populations will also require improvements in spatial structure.

In the Cascade summer steelhead stratum, three of four populations are targeted for high persistence probability. These include the Kalama and Washougal, both large, productive populations historically. Today abundance and productivity in the Kalama population are high, but improvements are needed in spatial structure and diversity. Only one summer steelhead population—the North Fork Lewis—is expected to remain at its baseline status of very low persistence probability; this is because of loss of habitat access related to Merwin Dam, ongoing hatchery programs that produce summer steelhead for harvest, and the desire not to interfere with winter steelhead recovery efforts in the upper North Fork Lewis.

Both populations in the Gorge summer steelhead stratum are designated primary. The Wind population has a high baseline persistence probability and is targeted for very high persistence. The Hood population is targeted to move from very low to high probability of persistence; however, Oregon notes that achieving this target is unlikely (ODFW 2010). Challenges include the small amount of historical and current habitat (and thus the limited options for restoration), anthropogenic impacts that are unlikely to change in the near future (e.g., inundation of historical habitat by Bonneville Reservoir and roads that restrict access to habitat), and high uncertainty in the data and analyses for small populations.[3] The Oregon management unit plan states that most of these issues are related to the population structure designation and suggests re-evaluating the Gorge stratum population structure for all species (ODFW 2010). As discussed in Chapter 3, NMFS agrees that such an evaluation is needed.

In the Cascade winter steelhead stratum, nine of 14 historical populations are targeted for high or better persistence probability. These include the two genetic legacy populations and five of six core populations (those that were historically the most productive). One of these, the Clackamas population, is targeted to move from medium to high persistence probability, but Oregon notes that achieving this target status is unlikely because the level of tributary habitat improvement needed is considered infeasible (ODFW 2010). The sixth core population in this stratum, the North Fork Lewis, is targeted for medium persistence probability. In this stratum, only Salmon Creek, in a highly urbanized subbasin, is expected to remain at its baseline persistence probability of very low.

Of the three populations in the Gorge winter steelhead stratum, two—the Lower Gorge and the Hood (which is both a core and a genetic legacy population)—are targeted for

[3] In the method used by the WLC TRT and management unit planners to establish abundance goals, target abundance is based to some extent on the gap between current and historical abundance. If the historical abundance of Gorge stratum steelhead populations has been significantly overestimated, then the abundance needed to achieve their target status may also be overestimated (ODFW 2010).

high persistence probability. The third, the Upper Gorge, is designated as stabilizing and is expected to remain at its low baseline status because of questions about the historical role of the population and current habitat potential.

If the scenario in Table 9-4 were achieved, it would meet or exceed the WLC TRT's viability criteria, particularly in the Cascade winter stratum but also in the Cascade summer stratum.[4] Exceeding the criteria in the Cascade strata was intentional on the part of local recovery planners to compensate for uncertainties about the feasibility of meeting the WLC TRT's criteria in the Gorge summer stratum.[5] (Delisting criteria for the Lower Columbia River steelhead DPS are described in Sections 3.2 and Section 9.7.)

Figures 9-5 and 9-6 display the population-level conservation gaps for Lower Columbia River steelhead graphically. The conservation gap reflects the magnitude of improvement needed to move a population from its baseline status to the target status. For additional discussion of status targets and conservation gaps for Lower Columbia River steelhead populations, see the management unit plans (LCFRB 2010a, pp. 6-62 through 6-64 and ODFW 2010 pp. 148-150).

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[4] As discussed in Section 2.5.4, the TRT's criteria for high probability of stratum persistence require that two or more populations be viable and that the average score for all populations in the stratum be 2.25 or higher. In the Cascade winter stratum, nine populations are targeted for high or very high persistence probability, and, using the WLC TRT's scoring system, the average viability score for all populations in the stratum would be 2.61.

[5] As noted in the discussion above, the Oregon management unit plan stated that achieving the target of high persistence probability for the Clackamas winter population is unlikely because the level of tributary habitat improvement needed is unfeasible. Even if the Clackamas population remained at its baseline status of medium probability of persistence, the Cascade winter steelhead stratum could still meet the WLC TRT's viability criteria for high probability of persistence, assuming adequate improvements in the persistence probability of the other populations in the stratum.

Table 9-4

Baseline and Target Persistence Probability and Abundance of LCR Steelhead Populations

			Baseline Persistence Probability[6]					Abundance		
Stratum	**Population**	**Contribution**	**A&P**	**S**	**D**	**Net**	**Target Persistence Probability**	**Historical**	**Baseline[7]**	**Target**
Cascade summer	Kalama (WA) [C]	Primary	H	VH	M	M	H	1,000	500	500
	NF Lewis (WA)	Stabilizing	VL	VL	VL	VL	VL	--[8]	150	--
	EF Lewis (WA)	Primary	VL	VH	M	VL	H	600	< 50	500
	Washougal (WA) [C]	Primary	M	VH	M	M	H	2,200	400	500
Gorge summer	Wind (WA) [C]	Primary	VH	VH	H	H	VH	--	1,000	1,000
	Hood (OR)	Primary	VL	VH	L	VL	H*	3,822	35	2,008
Cascade winter	Lower Cowlitz (WA)	Contributing	L	M	M	L	M	1,400	350	400
	Upper Cowlitz (WA) [C, GL]	Primary	VL	M	M	VL	H	1,400	< 50	500
	Cispus (WA) [C, GL]	Primary	VL	M	M	VL	H	1,500	< 50	500
	Tilton (WA)	Contributing	VL	M	M	VL	L	1,700	< 50	200
	SF Toutle (WA)	Primary	M	VH	H	M	H+	3,600	350	600
	NF Toutle (WA) [C]	Primary	VL	H	H	VL	H		120	600
	Coweeman (WA)	Primary	L	VH	VH	L	H	900	350	500
	Kalama (WA)	Primary	L	VH	H	L	H+	800	300	600
	NF Lewis (WA) [C]	Contributing	VL	M	M	VL	M	8,800	150	400
	EF Lewis (WA)	Primary	M	VH	M	M	H	900	350	500

[6] A&P = Abundance and productivity, S = spatial structure, and D = genetic and life history diversity. Net = overall persistence probability of the population. VL = very low, L = low, M = moderate, H = high, VH = very high.

[7] Baseline abundance was estimated as described in Section 5.1 and does not equal observed natural-origin spawner counts. The baseline is a modeled abundance that represents 100-year forward projections under conditions representative of a recent baseline period using a population viability analysis that is functionally equivalent to the risk analyses in McElhany et al. (2007). Projections generally assume conditions similar to those from 1974 to 2004. Oregon numbers reflect fishery reductions between the 1990s and about 2004, while Washington numbers reflect fishery impacts prevalent in the period immediately prior to listing in 1999.

[8] " — " indicates that no data are available from which to make a quantitative assessment.

Table 9-4
Baseline and Target Persistence Probability and Abundance of LCR Steelhead Populations

			Baseline Persistence Probability[6]					Abundance		
Stratum	**Population**	**Contribution**	**A&P**	**S**	**D**	**Net**	**Target Persistence Probability**	**Historical**	**Baseline[7]**	**Target**
	Salmon Creek (WA)	Stabilizing	VL	H	M	VL	VL	--	< 50	--
	Clackamas (OR) [C]	Primary	M	VH	M	M	H*	21,186	3,897	10,671
	Sandy (OR) [C]	Primary	L	M	M	L	VH	11,687	674	1,519
	Washougal (WA)	Contributing	L	VH	M	L	M	800	300	350
Gorge winter	L. Gorge (OR & WA)	Primary	L	VH	M	L	H	--	200	300
	U. Gorge (OR & WA)	Stabilizing	L	M	M	L	L	--	200	--
	Hood (OR) [C, GL]	Primary	M	VH	M	M	H	3,822	1,127	2,079

C = Core populations, meaning those that historically were the most productive.
G = Genetic legacy populations, which best represent historical genetic diversity.
*Oregon's analysis indicates a low probability of meeting the delisting objective of high persistence probability for this population.
Source: LCFRB (2010a) and ODFW (2010).

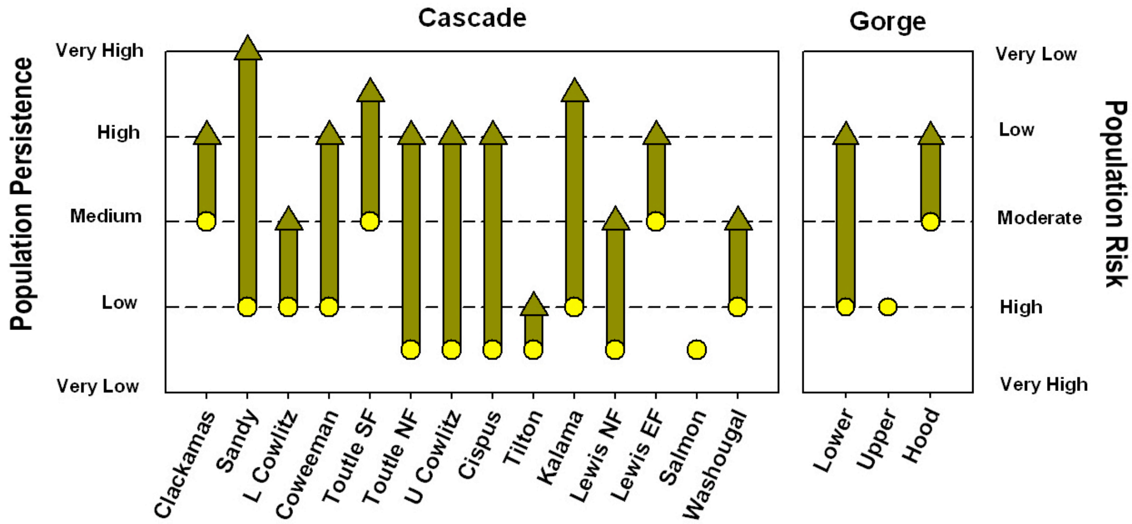

Figure 9-5. *Conservation Gaps for LCR Winter Steelhead Populations: Difference between Baseline and Target Status*

Source: LCFRB 2010a.

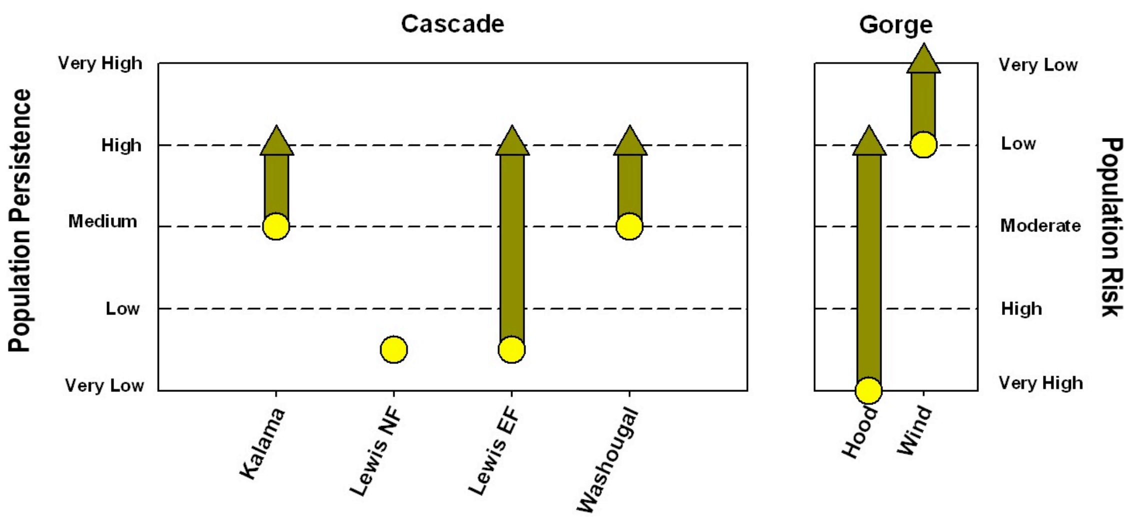

Figure 9-6. *Conservation Gaps for LCR Summer Steelhead Populations: Difference between Baseline and Target Status*

Source: LCFRB 2010a.

9.4 Limiting Factors and Threats for LCR Steelhead

Lower Columbia River steelhead are affected by a legacy of habitat degradation, harvest, hatchery production, and hydropower development that together have reduced the persistence probability of almost every population. Historically, high harvest rates contributed to population depletions, while stock transfers and straying of hatchery-origin fish reduced productivity and genetic and life history diversity. Construction of tributary and mainstem dams has constrained the spatial structure of some steelhead populations by blocking or impairing access to historical spawning areas. Over time, population abundance and productivity have been reduced through habitat alterations. Habitat alterations in the Columbia River estuary also have contributed to increased predation on steelhead juveniles. Today, widespread habitat degradation, predation, and the lingering effects of hatchery-origin fish continue to be significant limiting factors for most steelhead populations.

Tables 9-5 and 9-6 and the text that follows summarize baseline limiting factors and threats for Lower Columbia River steelhead strata based on population-specific limiting factors and threats identified in the management unit plans. In cases where conditions have changed significantly since the management unit plans' analyses of limiting factors and threats (e.g., if harvest rates have dropped or a dam is no longer present), this is noted in the text. Unless otherwise noted, NMFS agrees that the management unit plans' identification of limiting factors provide a credible hypothesis for understanding population performance and identifying management actions.

Because the individual management unit plans used somewhat different terms in identifying limiting factors, NMFS has translated those terms into standardized and more general terminology taken from a NMFS "data dictionary" of possible ecological concerns that could affect salmon and steelhead (Hamm 2012; see Section 5.4). In addition, in Tables 9-5 and 9-6, NMFS has rolled up the population-specific limiting factors (see Appendix H) to the stratum level—a process that has resulted in some loss of specificity.

In addition, each management unit plan used a different approach for identifying limiting factors and threats (see Section 5.3). One difference relevant to the crosswalk is that while the Oregon management unit plan identified primary and secondary limiting factors for each population in each threat category,[9] the Washington management unit plan categorized limiting factors in this way only for habitat-related limiting factors, and the estuary module did not use the primary and secondary terminology. For the crosswalk and this table, NMFS assigned primary and secondary status to non-habitat limiting factors for Washington populations (based on the Washington management unit plan's quantification of threat impacts and the professional judgment of Lower Columbia Fish Recovery Board's staff and consultants). It is likely that some apparent distinctions in results between Washington and Oregon populations are artifacts of differences in limiting factor assessment methodologies and not an actual difference in conditions or their effects on salmon and steelhead populations. In addition, there is not necessarily a bright line between primary and secondary limiting factor designations.

[9] In the Oregon management unit plan, primary limiting factors are those that have the greatest impact and secondary limiting factors have a lesser but still significant impact.

Nevertheless, NMFS believes that the designations are useful, particularly for looking across ESUs and populations and identifying patterns (see Chapter 4).

The management unit plans provide more detail on limiting factors and threats affecting each Lower Columbia River steelhead population, including magnitude, spatial scale, and relative impact (see LCFRB 2010a, Chapter 3 and various sections of Volume II, and ODFW 2010, pp. 129-140). For a regional perspective on limiting factors and threats that affect multiple salmon and steelhead ESUs, see Chapter 4 of this recovery plan. For a description of the data dictionary, the approach NMFS used to correlate management unit terms for limiting factors with the standardized NMFS terminology at the population scale, and the approach for rolling up from the population to the stratum scale, see Section 5.4 and Appendix H.

Management unit recovery planners in Oregon and Washington recognized that six major categories of manageable threats—tributary habitat, estuary habitat, hydropower, harvest, hatcheries, and predation—were useful as an organizing construct for grouping limiting factors, quantifying impacts on population productivity, and determining how much different categories of threats would need to be reduced to close the gap between baseline and target population status. Planners in both Washington and Oregon quantified the impacts of each of these major threat categories on population status, along with a reduction in each impact that would be consistent with achieving population target status. The results of that analysis are presented in Section 9.5 and provide a related but slightly different perspective on limiting factors. The threat reduction targets also allow actions to be scaled to achieve a specific impact reduction, and to be linked to monitoring and performance benchmarks.

Table 9-5

Baseline Limiting Factors and Threats Affecting LCR Winter Steelhead: Stratum-Level Summary

Ecological Concern	Threat(s)	VSP Parameters Affected	Cascade Winter	Gorge Winter
Tributary Habitat Limiting Factors				
Riparian Condition	Past and/or current land use practices	All	Secondary for North Fork Lewis juveniles; primary for juveniles in all other populations	Primary for Upper and Lower Gorge adults and juveniles; secondary for Hood juveniles
Channel Structure and Form	Past and/or current land use practices/ transportation corridor	All	Secondary for North Fork Lewis juveniles; primary for juveniles in all remaining populations	Primary for Upper and Lower Gorge adults and juveniles; secondary for Hood juveniles
Peripheral and Transitional Habitats: Side Channel and Wetland Conditions	Past and/or current land use practices/ transportation corridor	All	Secondary for North Fork Lewis juveniles; primary for juveniles in all other populations	Primary for Upper and Lower Gorge adults and juveniles; secondary for Hood juveniles

Table 9-5

Baseline Limiting Factors and Threats Affecting LCR Winter Steelhead: Stratum-Level Summary

Ecological Concern	Threat(s)	VSP Parameters Affected	Cascade Winter	Gorge Winter
Peripheral and Transitional Habitats: Floodplain Conditions	Past and/or current land use practices/ transportation corridor	All	Secondary for North Fork Lewis juveniles; primary for juveniles in all remaining populations	Primary for Upper and Lower Gorge adults and juveniles; secondary for Hood juveniles
Sediment Conditions	Past and/or current land use practices/ transportation corridor	All	Secondary for Clackamas, Upper Cowlitz and Cispus juveniles; secondary for Sandy adults and juveniles; primary for juveniles in all other WA populations	Secondary for Hood juveniles
Water Quality (Temperature)	Land uses that impair riparian function/decrease streamflow, dams	A,P,D	Secondary for OR, Upper Cowlitz and Cispus juveniles; primary for juveniles in all other WA populations	Secondary for Hood juveniles
Water Quantity (Flow)	Dams, land use, water withdrawals for irrigation, municipal uses, and hatchery operations	All	Secondary for juveniles in all populations	Secondary for juveniles in all populations, primary for Hood juveniles (irrigation withdrawals)
Toxic Contaminants	Agricultural chemicals, urban and industrial practices	A,P,D		Secondary for Hood juveniles
Estuary Habitat Limiting Factors[10]				
Toxic Contaminants	Agricultural chemicals, urban and industrial practices	A,P,D	Secondary for juveniles in all populations	

[10] The Washington and Oregon management unit plans both relied on the *Columbia River Estuary ESA Recovery Plan Module for Salmon and Steelhead* (NMFS 2011a) for information on estuary limiting factors, but there were some differences in how the plans translated the information into limiting factors experienced at the population level. The estuary module does not designate limiting factors as primary or secondary; instead, it ranks them in terms of assumed impact on ocean- and stream-type salmonids. Because the Oregon management unit plan integrated the module information with more specificity than did the Washington management unit plan, and because NMFS assumes that estuarine limiting factors affect all populations equally within the DPS, the estuarine limiting factors in this table and Section 9.4.2 reflect the determinations in the Oregon management unit plan, applied to all Lower Columbia River steelhead populations, unless otherwise noted. As with other limiting factors, the designations of estuarine limiting factors as primary or secondary reflect working hypotheses that will need to be tested (and possibly revised) through adaptive management.

Table 9-5

Baseline Limiting Factors and Threats Affecting LCR Winter Steelhead: Stratum-Level Summary

Ecological Concern	Threat(s)	VSP Parameters Affected	Cascade Winter	Gorge Winter
Food[11] (Shift from macrodetrital- to microdetrital-based food web)	Dam reservoirs	All	Secondary for juveniles in all populations	
Peripheral and Transitional Habitats: Estuary Condition	Past and/or current land use practices, transportation corridor, mainstem dams	All	Secondary for juveniles in all populations	
Channel Structure and Form	Past and/or current land use practices/ transportation corridor	All	Primary for juveniles in all populations	
Sediment Conditions	Past and/or current land use practices/transportation corridor, dams	All	Primary for juveniles in all populations	
Water Quality (Temperature)	Land uses that impair riparian function/decrease streamflow, dam reservoirs	A,P,D	Secondary for juveniles in all populations	
Water Quantity (Flow)	Columbia River mainstem dams	All	Primary for juveniles in all populations	
Hydropower Limiting Factors				
Habitat Quantity (Access)	Bonneville Dam	All		Secondary for Upper Gorge and Hood adults and juveniles
Habitat Quantity (Inundation)	Bonneville Dam	All		Secondary for Upper Gorge and Hood juveniles[12]
Habitat Quantity (Access)	Tributary Dams	All	Primary for Upper Cowlitz, North Fork Lewis, Cispus, and Tilton adults and juveniles; secondary for Clackamas juveniles; secondary for Sandy adults	Secondary for Hood juveniles
Harvest Limiting Factors				
Direct Mortality	Fisheries	A,D	Secondary for adults in all populations	

[11] Although the Oregon management unit plan lists food web shifts as a primary limiting factor in the estuary, NMFS and the management unit planners agreed to consider such shifts secondary in this recovery plan to more closely reflect conclusions in the *Columbia River Estuary ESA Recovery Plan Module for Salmon and Steelhead* (NMFS 2011a). The extent to which food web shifts limit salmonid survival in the estuary is unclear.

[12] The exact extent to which Bonneville Reservoir inundated habitats for any species is unknown. Some biologists have hypothesized impacts to spring Chinook salmon as a result of inundation. Based on spawning habitat preferences, it is likely that impacts of inundation were greatest on fall Chinook and chum salmon.

Table 9-5

Baseline Limiting Factors and Threats Affecting LCR Winter Steelhead: Stratum-Level Summary

Ecological Concern	Threat(s)	VSP Parameters Affected	Cascade Winter	Gorge Winter
Hatchery Limiting Factors				
Food[13]	Smolts from all Columbia Basin hatcheries competing for food and space in the estuary	All	Secondary for juveniles in all populations	
Population Diversity	Stray hatchery fish interbreeding with wild fish	A,P,D	Primary for Upper and Lower Cowlitz, Cispus, Tilton, Lewis, Salmon Creek, and Sandy adults; secondary for adults in all other populations	Secondary for adults in all populations
Predation Limiting Factors				
Direct Mortality	Land use	A,P,D	Secondary for juveniles in all populations	
Direct Mortality	Dams	A,P,D		Secondary for Upper Gorge and Hood adults and juveniles

Table 9-6

Baseline Limiting Factors and Threats Affecting LCR Summer Steelhead: Stratum-Level Summary

Ecological Concern	Threat(s)	VSP Parameters Affected	Cascade Summer	Gorge Summer
Tributary Habitat Limiting Factors				
Riparian Condition	Past and/or current land use practices	All	Primary for juveniles in all populations	
Channel Structure and Form	Past and/or current land use practices/ transportation corridor	All	Primary for juveniles in all populations	
Peripheral and Transitional Habitats: Side Channel and Wetland Conditions	Past and/or current land use practices/ transportation corridor	All	Primary for juveniles in all populations	

[13] Some scientists suspect that closely spaced releases of hatchery fish from all Columbia Basin hatcheries may lead to increased competition with natural-origin fish for food and habitat space in the estuary. NMFS (2011b) and LCFRB (2010) identified competition for food and space among hatchery and natural-origin juveniles in the estuary as a critical uncertainty. ODFW (2010) acknowledged that uncertainty but listed competition for food and space as a secondary limiting factor for juveniles of all populations. The NMFS Northwest Region and Northwest Fisheries Science Center are working to better define and describe the scientific uncertainty associated with ecological interactions between hatchery-origin and natural-origin salmon and steelhead in freshwater, estuarine, and nearshore ocean habitats.

Table 9-6

Baseline Limiting Factors and Threats Affecting LCR Summer Steelhead: Stratum-Level Summary

Ecological Concern	Threat(s)	VSP Parameters Affected	Cascade Summer	Gorge Summer
Peripheral and Transitional Habitats: Floodplain Conditions	Past and/or current land use practices/ transportation corridor	All	Primary for juveniles in all populations	
Sediment Conditions	Past and/or current land use practices/ transportation corridor	All	Primary for Kalama, Washougal, and East Fork Lewis juveniles	Primary for Wind juveniles; secondary for Hood juveniles
Water Quality (Temperature)	Land uses that impair riparian function/decrease streamflow, dams	A,P,D	Primary for Washougal and East Fork Lewis juveniles	Primary for Wind juveniles; secondary for Hood juveniles
Water Quantity (Flow)	Dams, land use, irrigation, municipal, and hatchery withdrawals	All	Secondary for juveniles in all populations except North Fork Lewis	
Toxic Contaminants	Agricultural chemicals, urban and industrial practices	A,P,D		Secondary for Hood juveniles
Estuary Habitat Limiting Factors[14]				
Toxic Contaminants	Agricultural chemicals, urban and industrial practices	A,P,D	Secondary for juveniles in all populations	
Food[15] (Shift from macrodetrital- to microdetrital-based food web)	Dam reservoirs	All	Secondary for juveniles in all populations	
Peripheral and Transitional Habitats: Estuary Condition	Past and/or current land use practices/transportatio n corridor, mainstem dams	All	Secondary for juveniles in all populations	
Channel Structure and Form	Past and/or current land use practices/ transportation corridor	All	Secondary for juveniles in all populations	

14 The Washington and Oregon management unit plans both relied on the *Columbia River Estuary ESA Recovery Plan Module for Salmon and Steelhead* (NMFS 2011a) for information on estuary limiting factors, but there were some differences in how the plans translated the information into limiting factors experienced at the population level. The estuary module does not designate limiting factors as primary or secondary; instead, it ranks them in terms of assumed impact on ocean- and stream-type salmonids. Because the Oregon management unit plan integrated the module information with more specificity than did the Washington management unit plan, and because NMFS assumes that estuarine limiting factors affect all populations equally within the DPS, the estuarine limiting factors in this table and Section 9.4.2 reflect the determinations in the Oregon management unit plan, applied to all Lower Columbia River steelhead populations, unless otherwise noted. As with other limiting factors, the designations of estuarine limiting factors as primary or secondary reflect working hypotheses that will need to be tested (and possibly revised) through adaptive management.

15 Although the Oregon management unit plan lists food web shifts as a primary limiting factor in the estuary, NMFS and the management unit planners agreed to consider such shifts secondary in this recovery plan to more closely reflect conclusions in the *Columbia River Estuary ESA Recovery Plan Module for Salmon and Steelhead* (NMFS 2011a). The extent to which food web shifts limit salmonid survival in the estuary is unclear.

Table 9-6
Baseline Limiting Factors and Threats Affecting LCR Summer Steelhead: Stratum-Level Summary

Ecological Concern	Threat(s)	VSP Parameters Affected	Cascade Summer	Gorge Summer
Sediment Conditions	Past and/or current land use practices/transportation corridor, dams	All	Primary for juveniles in all populations	
Water Quality (Temperature)	Land uses that impair riparian function/decrease streamflow, dam reservoirs	A,P,D	Secondary for juveniles in all populations	
Water Quantity (Flow)	Columbia River mainstem dams	All	Primary for juveniles in all populations	
Hydropower Limiting Factors				
Habitat Quantity (Access)	Bonneville Dam	All		Secondary for Wind and Hood adults and juveniles
Habitat Quantity (Inundation)	Bonneville Dam	All		Secondary for Hood and Wind juveniles[16]
Habitat Quantity (Access)	Tributary dams	All	Primary for North Fork Lewis adults and juveniles	Secondary for Hood adults and juveniles
Harvest Limiting Factors				
Direct Mortality	Fisheries	A,D	Secondary for adults in all populations	
Hatchery Limiting Factors				
Food[17]	Smolts from all Columbia Basin hatcheries	All	Secondary for juveniles in all populations	
Population Diversity	Stray hatchery fish interbreeding with wild fish	A,P,D	Primary for North Fork Lewis adults; secondary for East Fork Lewis and Washougal adults	Primary for Hood adults
Predation Limiting Factors				
Direct Mortality	Land use	A,P,D	Secondary for juveniles in all populations	Secondary for Hood juveniles
Direct Mortality	Dams	A,P,D		Secondary for Hood adults and juveniles

[16] The exact extent to which Bonneville Reservoir inundated habitats for any species is unknown. Some biologists have hypothesized impacts to spring Chinook salmon as a result of inundation. Based on spawning habitat preferences, it is likely that impacts of inundation were greatest on fall Chinook and chum salmon.

[17] Some scientists suspect that closely spaced releases of hatchery fish from all Columbia Basin hatcheries may lead to increased competition with natural-origin fish for food and habitat space in the estuary. NMFS (2011a) and LCFRB (2010a) identified competition for food and space among hatchery and natural-origin juveniles in the estuary as a critical uncertainty. ODFW (2010) acknowledged that uncertainty but listed competition for food and space as a secondary limiting factor for juveniles of all populations. The NMFS Northwest Region and Northwest Fisheries Science Center are working to better define and describe the scientific uncertainty associated with ecological interactions between hatchery-origin and natural-origin salmon and steelhead in freshwater, estuarine, and nearshore ocean habitats.

9.4.1 Tributary Habitat Limiting Factors

Because steelhead are stream-type fish that typically rear in tributary reaches for a year or more, they depend heavily on tributary habitat conditions for their early survival (LCFRB 2010a). Loss and degradation of tributary habitat is one of the main limiting factors for Lower Columbia River steelhead (see Tables 9-5 and 9-6).

Impaired side channel and wetland conditions along with degraded floodplain habitat have significant negative impacts on juvenile steelhead throughout the DPS and are identified as primary limiting factors for all summer populations and all winter steelhead populations except the North Fork Lewis and Hood, where they are identified as secondary factors. In most cases, these limiting factors have resulted from extensive channelization, diking, wetland conversion, stream clearing, and gravel extraction, which have barred steelhead from historically productive habitats and simplified remaining habitats, weakening watershed processes that are essential to the maintenance of healthy ecosystems and reducing refugia and resting places. Degraded riparian conditions and channel structure and form issues are also primary limiting factors for juveniles of all summer steelhead populations and all winter populations except the North Fork Lewis and Hood, where these conditions are identified as secondary factors. A lack of large woody debris and appropriately sized gravel in the remaining accessible tributary habitat has significantly reduced the amount of suitable spawning and rearing habitat for winter steelhead.

Sediment conditions are identified as a limiting factor for juveniles in all Cascade winter populations; for Kalama, Washougal, East Fork Lewis, Wind, and Hood summer steelhead juveniles; and for juveniles from the Hood winter population. The high density of unimproved rural roads throughout the area, as well as timber harvest practices and other land use patterns on unstable slopes adjacent to riparian habitat, contributes to an abundance of fine sediment in tributary streams. The resulting excess fine sediment increases turbidity and covers spawning gravel, limiting egg development and incubation. In addition, water quality—specifically, elevated water temperature brought about through land use practices and dam reservoirs—is a primary limiting factor for juveniles in the East Fork Lewis, Washougal, and Wind summer populations and juveniles in all Washington Cascade winter populations except the Upper Cowlitz and Cispus. Water temperature is a secondary factor for juveniles from the Clackamas and Sandy winter steelhead populations and Hood summer steelhead juveniles. The influence of dams, land use, low-head hydro diversions, and irrigation withdrawals has led to water quantity issues being identified as a secondary limiting factor for all populations except the North Fork Lewis. These water quantity issues are related to altered hydrology and flow timing.

In the Cascade ecozone, land uses that have led to the conditions that limit tributary habitat productivity include forest management and timber harvest, agriculture, rural residential and urban development, and gravel extraction. A mix of private, state, and Federal forest land predominates in the upper mainstem and headwater tributaries of the Cascade subbasins, while the lower mainstem and tributary reaches of most subbasins are characterized by agricultural and rural residential land use, with some urban development, especially in the Salmon Creek and Clackamas subbasins.

A unique issue in the Cascade stratum is legacy effects in the Toutle subbasin of the 1980 Mount St. Helens eruption. The North Fork Toutle in particular was heavily affected by sedimentation from the eruption. A sediment retention structure was constructed on the North Fork Toutle in an attempt to prevent continued severe sedimentation of stream channels and associated flood conveyance, transportation, and habitat degradation problems. The structure currently blocks access to as many as 50 miles of habitat for anadromous fish. Although fish are transported around the structure via a trap and haul system, it remains a source of chronic fine sediment to the lower river; this reduces habitat quality and has interfered with fish collection at its base.

In the Gorge ecozone, habitat limiting factors are generally the same as those described for the DPS as a whole, with some exceptions. For example, sediment conditions and water quality were not identified as limiting factors for the Upper and Lower Gorge winter steelhead populations. In addition, the primary cause of impaired side channel, wetland, and floodplain conditions for these populations is transportation corridor development. Highway and transportation corridors run parallel to the Columbia River shoreline, traversing all creek drainages in ways that restrict access and disconnect upland and lowland habitat processes. For the Hood winter steelhead population, all tributary habitat limiting factors were secondary with the exception of reduced instream flow caused by irrigation withdrawals, which was identified as a primary limiting factor. For the Hood summer population, riparian conditions and impaired side channel, wetland, and floodplain habitat were identified as primary tributary limiting factors.

Also unique to the Hood populations, both winter and summer, was the identification of organophosphates, insecticides, and other agricultural chemicals as a secondary limiting factor for juveniles. In addition, inundation of historical habitat by Bonneville Reservoir is identified as a secondary limiting factor for Upper Gorge winter steelhead and both winter and summer Hood populations.

9.4.2 Estuary Habitat Limiting Factors[18]

As stream-type fish, steelhead spend less time in the Columbia River estuary and plume than do ocean-type salmon such as fall Chinook, yet estuary habitat conditions nevertheless play an important role in the survival of steelhead juveniles, particularly those displaying less dominant life history strategies. Water quantity issues related to altered hydrology and flow timing are identified as a primary limiting factor for all populations, as is impaired sediment and sand routing; these limiting factors are associated with hydroregulation at large storage reservoirs in the interior of the

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[18] The Washington and Oregon management unit plans both relied on the *Columbia River Estuary ESA Recovery Plan Module for Salmon and Steelhead* (NMFS 2011a) for information on estuary limiting factors, but there were some differences in how the plans translated the information into limiting factors experienced at the population level. The estuary module does not designate limiting factors as primary or secondary; instead, it ranks them in terms of assumed impact on ocean- and stream-type salmonids. Because the Oregon management unit plan integrated the module information with more specificity than did the Washington management unit plan, and because NMFS assumes that estuarine limiting factors affect all populations equally within the DPS, the estuarine limiting factors in this section and Tables 9-5 and 9-6 reflect the determinations in the Oregon management unit plan, applied to all Lower Columbia River steelhead populations, unless otherwise noted. As with other limiting factors, the designations of estuarine limiting factors as primary or secondary reflect working hypotheses that will need to be tested (and possibly revised) through adaptive management.

Columbia Basin, and, in the case of sediment issues, land uses both past and present. Much of the land surrounding the Columbia River estuary is in agricultural or rural residential use and has been extensively modified via dikes, levees, bank stabilization, and tide gates. Altered hydrology and sediment routing influence habitat-forming processes, the quantity and accessibility of habitats such as side channels and wetlands, the dynamics of the Columbia River plume, and the estuarine food web. Channel structure issues, in the form of reduced habitat complexity and diversity, also are a primary limiting factor for juveniles from all populations. Again, simplification of channel structure is related to conversion of land to other uses—agricultural, rural residential, and as a transportation corridor.

Lack of access to peripheral and transitional habitats, such as side channels and wetlands is a secondary limiting factor for all populations, with access being impaired by the land uses—including the transportation corridor—and by flow alterations caused by mainstem dams. Other secondary limiting factors in the estuary that affect all steelhead populations are exposure to toxic contaminants (from urban, industrial, and agricultural sources) and elevated late summer and fall water temperatures, which are related to (1) land use practices that impair riparian function or decrease streamflow, and (2) large hydropower reservoirs.[19] Altered food web dynamics involving a transition from a macrodetrital-based food web to a microdetrital-based food web also are considered a secondary limiting factor for all populations.[20] These changes in the estuarine food web are caused primarily by increased microdetrital inputs from hydropower reservoirs and the loss of wetland habitats through diking and filling.

9.4.3 Hydropower Limiting Factors

The severity of dam-related impacts on winter steelhead populations varies throughout the DPS. Flow management operations at large storage reservoirs in the interior of the Columbia Basin (Grand Coulee, Dworshak, etc.) affect all juvenile Lower Columbia River steelhead in the lower mainstem and estuary, and potentially in the plume—primarily by altering flow volume and timing. These alterations impair sediment routing, influence habitat-forming processes, reduce access to peripheral habitat, and change the dynamics of the Columbia River plume and estuarine food web (see Section 9.4.2).[21] Moreover, the large reservoirs associated with mainstem dams contribute to elevated water temperatures downstream in late summer and fall. Although the management unit plans identified temperature impacts of the hydropower system as a secondary limiting factor for all juvenile steelhead, migration of juvenile steelhead occurs primarily in April through June (Dawley et al. 1986, McCabe et al. 1986, Roegner et al. 2004, Bottom et al. 2008, cited in Figure 2.2 of Carter et al. 2009), when elevated

[19] Although the management unit plans identified temperature impacts as a secondary limiting factor for juveniles in all populations, the timing of juvenile steelhead migration raises questions about the significance of this limiting factor; see Section 9.4.3.

[20] Although the Oregon management unit plan lists food web shifts as a primary limiting factor in the estuary, NMFS and the management unit planners agreed to consider such shifts secondary in this recovery plan to more closely reflect conclusions in the *Columbia River Estuary ESA Recovery Plan Module for Salmon and Steelhead* (NMFS 2011a). The extent to which food web shifts limit salmonid survival in the estuary is unclear.

[21] It is likely that flow impacts of the hydropower system affect the Lower Columbia River steelhead DPS more through changes in habitat-forming processes (including impacts to the plume) and food web impacts than through changes in migratory travel time.

mainstem temperatures are unlikely to be having a significant impact. The impacts of Bonneville Dam on passage and habitat quantity have been identified as a secondary limiting factor for Upper Gorge winter steelhead, Wind summer steelhead, and both populations of Hood steelhead.[22]

The effects of tributary dams vary among steelhead populations. In the Cascade winter steelhead stratum, tributary hydropower development is a primary limiting factor for adults and juveniles in the Upper Cowlitz, Cispus, and North Fork Lewis populations, which historically were among the most productive winter steelhead populations, and for the Tilton population; access to significant amounts of historical habitat in these river systems has been blocked by tributary dams, which also have had adverse impacts on downstream habitat through reduced gravel recruitment and other effects. Tributary hydropower issues related to upstream passage of adult winter steelhead past the Bull Run water system dams in the Sandy subbasin and downstream passage of juvenile winter steelhead through the PGE Clackamas River Project were identified as secondary limiting factors. There are no tributary hydropower facilities in the Coweeman, Toutle, Kalama, Salmon Creek, or Washougal subbasins.[23]

In the Cascade summer steelhead stratum, impaired habitat access and passage has been identified as a primary limiting factor for North Fork Lewis summer steelhead; tributary dams have blocked access to or inundated about 50 percent of the historical habitat for that population (LCFRB 2010a). In addition, tributary dams have adverse effects on downstream habitat through reduced gravel recruitment and other impacts. There are no tributary hydropower facilities in the Kalama and Washougal subbasins.

In the Gorge winter steelhead stratum, impaired adult passage is considered a secondary limiting factor for the Hood River population because of Laurence Lake Dam and Powerdale Dam (removed in 2010). The impacts of Bonneville Dam on adult and juvenile passage are identified as a secondary factor for both the Upper Gorge and Hood winter steelhead populations. Upstream passage to potential spawning grounds is limited by Bonneville Dam, and inundation of historical habitat has reduced habitat quantity for juveniles.

In the Gorge summer steelhead stratum, Powerdale Dam on the Hood River hindered access of adult steelhead to historical spawning areas until its removal in 2010. Inundation from the Bonneville Dam and the concomitant loss of historical riparian ecosystems has also reduced habitat quality for juvenile summer steelhead in the Hood River population.

9.4.4 Harvest Limiting Factors

Harvest-related mortality is identified as a secondary limiting factor for all populations within the DPS. Currently, harvest-related mortality on steelhead is limited to incidental mortality in Columbia River mainstem commercial gillnet fisheries, incidental mortality

[22] The exact extent to which Bonneville Dam inundated habitats for any species is unknown. Some biologists have hypothesized impacts to steelhead as a result of inundation. Based on spawning habitat preferences, it is likely that impacts of inundation were greatest on fall Chinook and chum salmon.
[23] However, the North Fork Toutle sediment retention structure currently blocks access to as many as 50 miles of habitat for anadromous fish.

in tributary recreational fisheries, and small levels of directed harvest in tribal fisheries above Bonneville Dam in Zone 6. Before the mid-1970s, harvest levels on natural-origin steelhead regularly exceeded 70 percent. However, implementation of mark-selective fisheries for hatchery steelhead has reduced recent impacts to 10 percent or less for most populations. Summer steelhead populations originating above Bonneville Dam are subject to somewhat higher rates—on the order of 15 percent or less— as a result of the combined effects tribal and non-tribal fisheries. Although the management unit plans identify steelhead harvest as a limiting factor, they also determine that the significant reduction in the harvest of steelhead over the last 20 or 30 years has resulted in harvest levels that appear to be consistent with achieving recovery objectives (ODFW 2010, LCFRB 2010a).

9.4.5 Hatchery-Related Limiting Factors

More than 2 million winter steelhead and 1.4 million summer steelhead were released from Lower Columbia River hatchery programs in 2008 (ODFW 2010). Many Lower Columbia River steelhead populations have large proportions of hatchery-origin spawners. Population-level effects resulting from stray hatchery fish interbreeding with natural-origin fish are identified as a primary limiting factor for the Upper and Lower Cowlitz, Cispus, Tilton, Lewis, Salmon Creek, and Sandy winter populations and the North Fork Lewis and Hood summer populations, and as a secondary limiting factor for the East Fork Lewis and Washougal summer populations and all other winter populations.[24] Hatchery straying, combined with past stock transfers, is believed to have reduced genetic diversity within and among Lower Columbia River steelhead populations. Productivity likewise has declined as a result of the influence of hatchery-origin fish. High proportions of hatchery-origin spawners are sometimes intentional, however, because hatchery fish are being used to reintroduce steelhead where they have been extirpated or nearly so (e.g., in the Cowlitz, and Lewis subbasins). In identifying hatchery-related limiting factors, the management unit plans evaluated only negative impacts of hatchery fish on productivity of natural fish and not the positive demographic benefits that such reintroduction programs can provide in the short term.

Some scientists suspect that closely spaced releases of hatchery fish from all Columbia Basin hatcheries may lead to increased competition with natural-origin fish for food and habitat space in the estuary. NMFS (2011a) and LCFRB (2010a) identified competition for food and space among hatchery and natural-origin juveniles in the estuary as a critical uncertainty. ODFW (2010) acknowledged that uncertainty but listed competition for food and space as a secondary limiting factor for juveniles of all populations. The NMFS Northwest Region and Northwest Fisheries Science Center are working to better define and describe the scientific uncertainty associated with ecological interactions between hatchery-origin and natural-origin salmon and steelhead in freshwater, estuarine, and nearshore ocean habitats.

[24] The nature and extent of risk to natural populations posed by hatchery programs affecting these populations will be the focus of future ESA section 7 consultations.

9.4.6 Predation

Direct mortality from predation is a secondary limiting factor that affects all Lower Columbia River steelhead populations. Anthropogenic changes to habitat structure have led to increased predation by Caspian terns, double-crested cormorants, and various other seabird species in the Columbia River estuary and plume. Steelhead spawning above Bonneville Dam also are subject to predation by non-salmonid fish (primarily pikeminnows above and below the dam but also walleye and smallmouth bass in the reservoir). Winter steelhead spawning above Bonneville Dam are also subject to predation by marine mammals (primarily sea lions) at Bonneville Dam.

9.5 Baseline Threat Impacts and Threat Reduction Targets

Table 9-7 shows the estimated impact on each Lower Columbia River steelhead population of potentially manageable threats, organized into six threat categories: tributary habitat degradation, estuary habitat degradation, hydropower, harvest, hatcheries, and predation. Both baseline and target impacts are shown, with the targets representing levels that would be consistent with long-term recovery goals. Impact values indicate the percentage reduction in abundance and productivity that is attributable to human activities related to a particular threat category. The value associated with any particular threat category can be interpreted as the percent reduction in abundance and productivity from historical conditions if that threat category were the only one affecting the population. The table also shows the overall percentage improvement that is needed to achieve the target impacts and corresponding population status.[25] These cumulative values across all threat categories (both baseline and target) are multiplicative rather than additive. Both the Oregon and Washington management unit plans use cumulative survivals across threat categories to illustrate the overall level of improvement needed. Each plan assumes that there is a direct proportional relationship between the projected changes in cumulative survival and the required changes in natural-origin spawner abundance and productivity. For populations where the survival improvement needed is larger than 500 percent, Table 9-7 does not report the exact value, in part because the value is highly uncertain.[26]

As an example, the baseline status of the Clackamas winter steelhead population has been severely reduced by the combined effects of multiple threats. The cumulative reduction in status was estimated at 81.8 percent from the multiplicative impacts of multiple threats acting across the salmon life cycle. Thus, current status is just 18.2 percent of the historical potential with no human impact. Tributary habitat and hatchery

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[25] The percentage of survival improvement needed is the percentage change in net impacts, is derived from information in the Washington and Oregon management unit plans, and is calculated as follows: $[(1-\text{Cumulative}_{\text{Target}})-(1-\text{Cumulative}_{\text{Baseline}})]/[1-\text{Cumulative}_{\text{Baseline}}] \times 100$. These values generally correspond to population improvement targets identified for Washington populations in LCFRB (2010a). Comparable numbers are not explicitly reported in ODFW (2010) but are implicit in the modeling approach that Oregon recovery planners used to derive target impacts.

[26] For some populations—many of them small—the survival improvement needed is very large and highly uncertain because various other factors also are uncertain (i.e., the population's baseline persistence probability, the exact degree of impact of human activities on tributary habitat, and whether the population's response to reductions in impacts will be linear). In addition, very small populations do not necessarily follow predictable patterns in their response to changing conditions.

impacts are the largest, accounting independently for reductions of 65 and 23 percent, respectively, in population productivity, with corresponding reductions in abundance, spatial structure, and diversity. The Oregon management unit plan identifies a recovery strategy for this population that involves significant reductions in the impact of habitat and hatcheries and smaller reductions in the impacts of estuarine habitat and predation. For instance, the plan targets tributary habitat impacts to be reduced from the estimated baseline level of 65 percent to 24 percent (i.e., an approximately 117 percent improvement relative to baseline conditions). With the targeted reductions in individual impacts, the cumulative effect of all impacts would drop from 81.8 percent at baseline to 50 percent at the target status. This change would translate into a 170 percent improvement in survival relative to the baseline. Although the population would still be experiencing abundance and productivity that are 74.7 percent lower than historical conditions, the extinction risk at this mortality level would be estimated sufficient to meet the targets for this plan.

Oregon and Washington recovery planners used somewhat different definitions or methods to quantify the estimated impacts of anthropogenic threats. Baseline impacts for Washington populations reflect conditions prevalent at the time of ESA listing (circa 1999), while the baseline impacts for Oregon populations reflect conditions through 2004. Dam impacts for Washington populations reflect passage mortality, habitat loss caused by inundation, and loss of access to historical production areas; for Oregon populations, the estimates in the "Dams" column of Table 9-7 reflect direct upstream and downstream passage mortality only, with other dam impacts accounted for in the habitat and predation threat categories. Hatchery impacts for Washington populations were limited to not more than 50 percent per population, in accordance with Hatchery Scientific Review Group (HSRG) assessments of the potential for genetic effects (Hatchery Scientific Review Group 2009); Oregon recovery planners estimated that hatchery impacts were equivalent to the rates at which hatchery fish were found on natural spawning grounds, based on analyzed relationships and reflecting a concern for both genetic and ecological effects. Washington recovery planners derived estimates of impacts to tributary habitat using the Ecosystem Diagnosis and Treatment (EDT) model. Oregon recovery planners estimated the mortality associated with estuary habitat degradation, hydropower, harvest, hatcheries, and predation and assigned all remaining mortality (relative to the difference between the current modeled abundance and estimated historical abundance) to tributary habitat. In general, the tributary habitat values in Table 9-7 have the highest degree of uncertainty relative to the other threat categories and, for Oregon populations, may include causes of mortality associated with the other threat categories but not directly captured in those mortality estimates. (See Section 5.5 for more on the methodologies used to estimate baseline impacts.)

Estimates of threat impacts are useful in showing the relative magnitude of impacts on each population. Given the differences in methodologies, some values in Table 9-7 for Oregon and Washington populations are not necessarily directly comparable. Thus, values for Oregon populations are most directly comparable to those for other Oregon populations, and values for Washington populations are most directly comparable to those for other Washington populations. Regardless of differences in specific threat impact definitions and methods, the net effect of changes from all threats is useful in understanding the magnitude of population improvement needed to achieve the target population status.

The target impacts represent one of several possible combinations of threat reductions that could conceivably close the conservation gap and lead to a population achieving its target status. The particular threat reductions shown in Table 9-7 reflect policy decisions and the methodologies and assumptions used by the different recovery planning teams. (For a description of how target impacts were developed, see Section 5.6.) In estimating impacts, management unit recovery planners evaluated each threat category independently (i.e., values in the table reflect the mortality of steelhead exposed to that particular category of threats, whether or not they are exposed to threats in other categories). The estimates of baseline threat impacts have high levels of uncertainty and in many cases should be considered working hypotheses that are testable as part of recovery plan implementation. Despite this uncertainty, it is the expert judgment of NMFS and management unit scientists that, based on the best available information at this time, the estimates of baseline threat impacts provide a reasonable estimate of the relative magnitude of different sources of anthropogenic mortality and serve as an adequate basis for designing initial recovery actions.[27] As more and better information is collected, it will be applied to recovery efforts in an adaptive management framework.

As shown in Table 9-7, loss and degradation of tributary habitat, hatchery effects, and predation are pervasive threats that affect most steelhead populations. However, expected threat reductions vary by population.

In the Cascade ecozone, the Upper Cowlitz, Cispus, Tilton, and North Fork Lewis winter populations and the East Fork Lewis summer population are targeted for the largest improvements, with sizeable reductions needed in all or most threat categories, including predation. For the Upper Cowlitz, Cispus, Tilton, and North Fork Lewis winter populations, the greatest gains in persistence probability are expected to be achieved by reestablishing natural populations above tributary dams; however, reductions in hatchery- and tributary habitat-related threats are also targeted to contribute significantly to gains in persistence probability. For the East Fork Lewis summer population, improvements in tributary habitat are projected to provide the greatest benefit. All of these populations are designated primary except the Tilton and North Fork Lewis winter populations, which are designated as contributing.

Other Cascade populations targeted for large threat reductions are the Clackamas and Sandy winter steelhead populations. For Sandy winter steelhead, the most significant threat reductions are targeted to be achieved through reductions in hatchery-related threats.[28] For Clackamas winter steelhead, sizeable reductions in both hatchery- and tributary habitat-related threats are called for.[29] The threat reductions needed to achieve targets for other primary and contributing populations within the Cascade strata are relatively small, with improvements in tributary habitat figuring most prominently. This is the case for the Lower Cowlitz, North and South Fork Toutle, Coweeman, Kalama,

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[27] As implementation proceeds, research, monitoring, and evaluation and adaptive management will be key in helping to refine scientific understanding of the impact of threats on population persistence and of the extent to which management actions are reducing threats.

[28] The Oregon management unit plan states that, because of fairly recent changes in the management of the hatchery steelhead program, current stray rates in the Sandy winter steelhead population already are lower than the 10 percent called for delisting (ODFW 2010).

[29] However, the Oregon management unit plan describes the targeted level of tributary habitat improvements for the Clackamas winter steelhead population as infeasible (see ODFW 2010).

East Fork Lewis, and Washougal winter populations and the Kalama and Washougal summer populations. For the Kalama summer steelhead population, Table 9-7 does not show threat reductions because the baseline abundance and productivity of the population are high; however, improvements in diversity will be needed in the Kalama summer population to meet recovery objectives.

The Salmon Creek winter and North Fork Lewis summer steelhead populations are not targeted for threat reductions, although they are expected to benefit from actions to reduce threats to other species and populations. These populations are designated as stabilizing because of habitat degradation in the highly urbanized Salmon Creek subbasin and because access to most of the North Fork summer population's historical spawning habitat has been blocked by Merwin Dam.

In the Gorge strata, all populations are designated as primary except the Upper Gorge winter population, which is considered contributing. For the Lower and Upper Gorge winter populations, target status is targeted to be achieved mostly by reducing tributary habitat-related threats, especially in Oregon. For the Hood winter population, no tributary habitat threat reductions are called for. Instead, the greatest gains in persistence probability are targeted from reductions in hatchery- and hydropower-related threats. The Hood summer steelhead population is targeted for significant reductions in multiple threat categories, with particularly large reductions in tributary habitat- and hydropower-related threats and a complete elimination of hatchery threats (summer steelhead will no longer be released in the Hood subbasin).[30] For the Wind summer steelhead population, Table 9-7 does not show threat reductions because the baseline abundance and productivity of the population are very high; however, improvements in diversity will be needed in the Wind summer population to meet recovery objectives.

With harvest impacts on natural-origin winter steelhead having dropped substantially from historical highs, further reductions in harvest impacts do not figure prominently in the threat reduction scenarios for most steelhead populations. The recovery strategy involves continued management of fisheries to limit impacts to baseline levels.

Threat reductions associated with estuary habitat improvements are needed for recovery and will benefit every steelhead population; however, net reductions in this threat category are smaller than those for tributary habitat-related threats, hatcheries, predation, and, in some cases, hydropower and harvest because for most populations the impacts of estuarine habitat-related threats are less.

More information on threat reductions, including methodologies used to determine baseline and target impacts, is available in the management unit plans (ODFW 2010, pp. 151-168 and 195-200; LCFRB 2010a, pp. 4-30 through 4-33 and 6-65 through 6-70).

[30] The targeted level of tributary habitat improvements for the Hood summer steelhead population is described in the Oregon management unit plan as infeasible (see ODFW 2010).

Table 9-7

Impacts of Potentially Manageable Impacts of Threats and Impact Reduction Targets Consistent with Recovery of LCR Steelhead Populations

Population	Impacts at Baseline[31]							Impacts at Target							% Survival Improvement Needed[32]
	T. Hab[33]	Est[34]	Dams[35]	Har[36]	Hat[37]	Pred[38]	Cumulative[39]	T. Hab	Est	Dams	Harv	Hat	Pred	Cumulative	
Cascade Summer															
Kalama (WA)	0.43	0.15	0.00	0.10	0.01	0.24	0.6719	0.43	0.15	0.00	0.10	0.01	0.24	0.6719	0
NF Lewis (WA)	0.40	0.15	0.50	0.10	0.47	0.24	0.9076	0.40	0.15	0.50	0.10	0.47	0.24	0.9076	0
EF Lewis (WA)	0.70	0.15	0.00	0.10	0.26	0.24	0.8709	0.35	0.08	0.00	0.05	0.13	0.12	0.5651	>500

31 Impact figures represent a percentage reduction in abundance and productivity that is attributable to human activities related to a particular threat category. Methods used to estimate impacts differ for Oregon and Washington populations. For example, baseline impacts reflect conditions circa 1999 for Washington populations and through 2004 for Oregon populations. Given the methodological differences, impact figures are not necessarily directly comparable. See Sections 5.5 and 5.6 for more on methodologies.

32 Survival improvements indicate the percentage improvement (rounded to the nearest 10) in population survival needed to achieve target impacts and are derived from the cumulative values (baseline and target). For most populations this was calculated using the following equation: $[(1\text{-Cumulative}_{Target})\text{-}(1\text{-Cumulative}_{Baseline})]/[1\text{-Cumulative}_{Baseline}] \times 100$. For the East Fork Lewis population , this equation yields a different result than that reported in LCFRB (2010a) because, for populations that have a very low probability of persistence and require very large improvements, the Washington management unit plan limited threat-specific reductions to 50 percent of the current impact as interim targets until the population response to improvements can be accurately gauged. For the East Fork Lewis, the numbers reported in this table are consistent with LCFRB (2010a) rather than with the aforementioned equation. In addition, these cumulative impact numbers are not explicitly reported in ODFW (2010) but are implicit in the modeling approach that Oregon recovery planners used to derive target impacts. For populations where the survival improvement needed is larger than 500 percent, this table does not report the exact value, for the reasons explained in Section 9.5.

33 Reduction in tributary habitat production potential relative to historical conditions. Oregon and Washington used different methods to estimate historical abundance. Oregon's approach, which incorporates safety margins and includes causes of mortality that are not captured in the other five threat categories, tends to indicate a higher potential impact from tributary habitat loss and degradation than does Washington's.

34 Reduction in juvenile survival in the Columbia River estuary as a result of habitat changes (relative to historical conditions); excludes predation.

35 Reflects passage mortality, habitat loss caused by inundation, and loss of access to historical production areas for Washington populations; for Oregon populations, dam impacts reflect direct passage mortality only.

36 Includes direct and indirect mortality.

37 Reflects only the negative impacts of hatchery-origin fish, such as high pHOS and low PNI (proportion of natural influence), not the benefits of conservation hatchery programs.

38 Includes the aggregate predation rate in the Columbia River mainstem and estuary by northern pikeminnow, marine mammals, Caspian terns, and cormorants.

39 Cumulative values (both baseline and target) are multiplicative rather than additive and are equal to $(1-[(1-M_{thab})(1-M_{est})(1-M_{dams})(1-M_{harv})(1-M_{hatch})(1-M_{pred})])$. Minor differences from numbers in ODFW 2010 and LCFRB 2010a are due to rounding.

Table 9-7

Impacts of Potentially Manageable Impacts of Threats and Impact Reduction Targets Consistent with Recovery of LCR Steelhead Populations

Population	Impacts at Baseline[31]							Impacts at Target							% Survival Improvement Needed[32]
	T. Hab[33]	Est[34]	Dams[35]	Har[36]	Hat[37]	Pred[38]	Cumulative[39]	T. Hab	Est	Dams	Harv	Hat	Pred	Cumulative	
Washougal (WA)	0.40	0.15	0.00	0.10	0.30	0.24	0.7558	0.32	0.12	0.00	0.08	0.24	0.19	0.6611	40
Gorge Summer															
Wind (WA)	0.50	0.14	0.11	0.17	0.01	0.27	0.7704	0.50	0.14	0.11	0.17	0.01	0.27	0.7704	0
Hood (OR)[40]	0.95	0.07	0.36	0.15	0.53	0.15	0.9899	0.14	0.07	0.16	0.15	0.00	0.08	0.4746	>500
Cascade Winter															
Lower Cowlitz (WA)	0.70	0.15	0.00	0.10	0.49	0.24	0.9110	0.69	0.15	0.00	0.10	0.48	0.23	0.9053	10
Upper Cowlitz (WA)	0.40	0.15	1.00	0.10	0.49	0.24	1.00	0.20	0.08	0.50	0.05	0.25	0.12	0.7693	>500[41]
Cispus (WA)	0.60	0.15	1.00	0.10	0.49	0.24	1.00	0.30	0.08	0.50	0.05	0.25	0.12	0.7981	>500
Tilton (WA)	0.90	0.15	1.00	0.10	0.49	0.24	1.00	0.45	0.08	0.50	0.05	0.25	0.12	0.8414	>500
SF Toutle (WA)	0.80	0.15	0.00	0.10	0.24	0.24	0.9116	0.74	0.14	0.00	0.09	0.22	0.22	0.8762	40
NF Toutle (WA)	0.80	0.15	0.00	0.10	0.33	0.24	0.9221	0.64	0.12	0.00	0.08	0.26	0.19	0.8253	120
Coweeman (WA)	0.50	0.15	0.00	0.10	0.12	0.24	0.7442	0.43	0.13	0.00	0.09	0.10	0.20	0.6751	30
Kalama (WA)	0.50	0.15	0.00	0.10	0.02	0.24	0.7151	0.37	0.11	0.00	0.07	0.02	0.18	0.5810	50
NF Lewis (WA)	0.10	0.15	0.92	0.10	0.49	0.24	0.9787	0.05	0.08	0.46	0.05	0.25	0.12	0.7041	>500
EF Lewis (WA)	0.50	0.15	0.00	0.10	0.48	0.24	0.8488	0.45	0.14	0.00	0.09	0.44	0.22	0.8120	20
Salmon Creek (WA)	0.80	0.15	0.00	0.10	0.50	0.24	0.9419	0.80	0.15	0.00	0.10	0.50	0.24	0.9419	0

40 Oregon's analysis indicates a low probability of meeting the delisting objective of high viability persistence probability for this population.

41 The Upper Cowlitz, Cispus, and Tilton populations require improvements in every threat category. However, given that hydropower impacts are 100 percent for these populations, they will not benefit from improvements in the other threat categories until some degree of passage is restored. Although passage improvements alone will not lead to recovery, how successful passage improvements are will greatly influence how much improvement is needed in the other threat categories. In addition the formula for percent survival improvement for these populations was modified to account for the 100 percent hydropower impacts (i.e., to avoid having to divide by zero).

Table 9-7

Impacts of Potentially Manageable Impacts of Threats and Impact Reduction Targets Consistent with Recovery of LCR Steelhead Populations

Population	Impacts at Baseline[31]							Impacts at Target							% Survival Improvement Needed[32]
	T. Hab[33]	Est[34]	Dams[35]	Har[36]	Hat[37]	Pred[38]	Cumulative[39]	T. Hab	Est	Dams	Harv	Hat	Pred	Cumulative	
Clackamas (OR)[42]	0.65	0.10	0.05	0.10	0.23	0.12	0.8175	0.24	0.08	0.05	0.10	0.10	0.07	0.4996	170
Sandy (OR)	0.82	0.10	0.04	0.10	0.52	0.12	0.9409	0.81	0.08	0.00	0.10	0.10	0.07	0.8683	120
Washougal (WA)	0.50	0.15	0.00	0.10	0.08	0.24	0.7326	0.46	0.14	0.00	0.09	0.08	0.22	0.6967	10
Gorge Winter															
L. Gorge —WA portion	0.60	0.15	0.00	0.10	0.01	0.22	0.7637	0.48	0.12	0.00	0.08	0.00	0.18	0.6548	50
L. Gorge—OR portion	0.60	0.10	0.00	0.10	0.10	0.12	0.7434	0.40	0.08	0.00	0.10	0.10	0.07	0.5842	60
U. Gorge—WA portion	0.60	0.14	0.11	0.10	0.01	0.30	0.8090	0.60	0.14	0.11	0.10	0.01	0.30	0.8090	0
U. Gorge—OR portion	0.51	0.07	0.16	0.15	0.10	0.16	0.7540	0.30	0.07	0.16	0.15	0.10	0.10	0.6235	50
Hood (OR)	-0.01	0.07	0.36	0.15	0.30	0.16	0.6995	-0.01	0.07	0.16	0.15	0.10	0.10	0.4675	80

42 Oregon's analysis indicates a low probability of meeting the delisting objective of high viability persistence probability for this population.

9.6 DPS Recovery Strategy for LCR Steelhead

This section describes the recovery strategy for Lower Columbia River steelhead. A general summary of the DPS-level strategy is presented first. This is followed by subsections on each of the threat categories and critical uncertainties that pertain to the strategy. Where appropriate, stratum-specific strategies are described for each threat category.

9.6.1 Strategy Summary

The recovery strategy for the Lower Columbia River steelhead DPS is aimed at restoring the Cascade and Gorge winter and summer strata to a high probability of persistence.[43] Although the strategy involves threat reductions in all categories, the most crucial elements are as follows:

1. Protect favorable tributary habitat and restore degraded but potentially productive habitat, especially in subbasins where large improvements in population abundance and productivity are needed to achieve recovery goals. This is the case in the Upper Cowlitz, Cispus, North Fork Toutle, Kalama, and Sandy subbasins for winter steelhead and in the East Fork Lewis and Hood subbasins for summer steelhead.

2. Protect and improve the South Fork Toutle, East Fork Lewis, Clackamas, and Hood winter steelhead populations, which currently are the best-performing winter populations, to a high probability of persistence. This will be accomplished through population-specific combinations of threat reductions, to include protection and restoration of tributary habitat (crucial for all except the Hood population), reductions in pHOS, and—for the Hood population—removal of Powerdale Dam (this was completed in 2010).

3. Significantly reduce hatchery impacts on the Hood summer steelhead population[44] and, to a lesser degree, on many other populations, especially the Upper Cowlitz, Cispus, Tilton, North Fork Lewis, and Clackamas winter populations and the East Fork summer population. Continue to limit hatchery impacts on the Kalama and Wind summer steelhead populations to improve population diversity. (The baseline abundance and productivity of these two populations are high and very high, respectively.)

4. Reestablish naturally spawning winter steelhead populations above tributary dams in the Cowlitz system (Upper Cowlitz and Cispus populations) and improve the status of the Tilton winter steelhead population through hatchery

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[43] Steelhead populations in the Coast ecozone are part of the Southwest Washington steelhead DPS and are not listed under the Federal ESA; thus, they are not addressed in this recovery plan.

[44] The Sandy winter steelhead population was also targeted for a significant reduction in hatchery impacts (i.e., 80 percent). However, the Oregon management unit plan states that, because of fairly recent changes in the management of the hatchery steelhead program, current stray rates in the Sandy winter steelhead population already are lower than the 10 percent called for in the threat reduction targets (ODFW 2010 p. 196).

reintroductions and comprehensive threat reductions; reintroduce winter steelhead above dams on the North Fork Lewis River.

5. Reduce predation by birds, non-salmonid fish, and marine mammals.

If the DPS is to achieve recovery, improvements are needed in the persistence probability of most populations, and very large improvements are needed in the status of some populations (the Upper Cowlitz, Cispus, North Fork Toutle, Kalama, and Sandy winter populations and the East Fork Lewis and Hood summer populations). (See Table 9-4 for the target status for each steelhead population and Figures 9-5 and 9-6 for the gaps between baseline and target status.)

The recovery strategy for Lower Columbia River steelhead is a long-term, "all-H" approach in which plan implementers begin work on all of the elements described above immediately and implement actions associated with each of the six threat categories simultaneously.[45] As part of a series of 3- to 5-year implementation schedules, management unit planners will work with NMFS staff to prioritize individual actions within each threat category, rather than across threat categories (see Chapter 11 for more on implementation). Recovery will require improvements in every threat category, even those improvements in Table 9-7 that are relatively small. Substantial actions are needed to improve tributary habitat, reduce the effects of hatcheries on natural populations, manage predation, and, for some populations, address hydropower passage issues. Without improvements in all of these threat categories, the full benefits of actions in any individual sector, such as improved passage at tributary dams, are unlikely to be realized and the expected threat reductions will not be achieved. Recovery also will require contributions from estuary habitat actions; however, for stream-type fish such as steelhead, these gains are expected to be less than those from coordinated efforts to address tributary habitat, hatchery, and predation impacts.

Immediate implementation of certain actions is expected to reduce short-term population risk relatively quickly; examples include site-specific projects to (1) protect and restore habitat complexity and diversity, (2) provide access to side channels and off-channel habitats, and (3) protect or restore floodplain connectivity and function. The benefits of other actions, such as restoring riparian conditions to improve watershed function, will not be felt for years or decades after implementation. For many populations, actions are needed soon to start reducing the impact of hatchery-origin fish so that populations can become self-sustaining as habitat conditions improve. A first step in this process is to develop population-specific transition strategies that specify how and when hatchery strategies described in the management unit plans will be implemented.

Key uncertainties that need to be addressed to support implementation of near-term actions for Lower Columbia River steelhead relate to techniques for reducing pHOS and increasing passage efficiencies past tributary dams, and the pace at which reintroduced populations become functional and self-sustaining (see Section 9.6.7).

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[45] Implementation of recovery actions to reduce threats in each category is already under way, although the scale of effort is less than that called for in this recovery plan.

The subsections below describe recovery strategies and near-term and long-term priorities for each threat category. For specific management actions in each threat category, linked to population and location, see the management unit plans (LCFRB 2010a and ODFW 2010).

9.6.2 Tributary Habitat Strategy

Lower Columbia River steelhead will benefit from the regional tributary strategy described in Section 4.1.2. The regional strategy is directed toward protecting and restoring high-quality, well-functioning salmon and steelhead habitat through a combination of (1) site-specific management actions that will protect habitat and provide benefits relatively quickly, (2) watershed-based actions designed to protect or restore habitat-forming processes and provide benefits over the long term, and (3) landscape-scale programmatic actions that affect a class of activities (such as stormwater management or forest practices) over multiple watersheds. Actions of particular benefit to steelhead focus on protecting and restoring habitat complexity and diversity, access to side channels and off-channel habitats, and floodplain connectivity and function in high-priority stream reaches. Improving riparian cover and recruitment of large wood to streams also will be a priority. The subsections below summarize additional, stratum-specific tributary habitat strategies for steelhead.

9.6.2.1 Cascade Winter and Summer Steelhead Tributary Habitat Strategies

In implementing the tributary habitat strategy for the Cascade strata, considerations include the following:

- Generally, habitat conditions are favorable in the upper portions of the Cowlitz, Cispus, and North Fork Lewis subbasins, where winter steelhead populations are targeted for viability but where access has been blocked by dams. In these areas, protecting high-quality habitat and restoring upslope processes that improve and maintain habitat quality will be priorities. Large portions of these areas are in Federal forest land; this highlights the importance of implementing the Northwest Forest Plan to protect habitats in those areas.

- Habitat conditions are also generally favorable in the Sandy subbasin (the Sandy winter steelhead population is targeted for very high persistence probability). Again, large portions of this subbasin are in Federal forest land. Implementation of the City of Portland's Bull Run water supply habitat conservation plan also will improve habitat quality and increase the amount of habitat available to Sandy winter steelhead.

- Substantial restoration effort will be needed in areas currently accessible to Lower Columbia River steelhead. Because steelhead use mid- to upper-basin habitats for spawning and rearing, restoration efforts will focus on such areas, both in historically highly productive watersheds and in areas where production potential is more limited. Specific actions will include those described above for Lower Columbia River steelhead generally.

- State or private forest land predominates in the upper portions of the Toutle, Kalama, and North Fork Lewis subbasins, and the upper portions of the East Fork Lewis and Washougal subbasins also are forested, with state/Federal and private/Federal ownership, respectively. These forest lands must be managed to protect and restore watershed processes (such as by implementing the Northwest Forest Plan and Washington's habitat conservation plan for state-owned forest land and Forest Practices Rules for private forest land).

- Managing the impacts of growth and development will be important in all subbasin but particularly in the Washougal, where human population growth is expected to be large.

- In all subbasins, but particularly in the East Fork Lewis, restoring lowland floodplain function, riparian function, and stream habitat diversity will be important. The historically active floodplain and channel migration zone in the lower mainstem East Fork Lewis has been drastically altered by modifications to protect rural residential development, agricultural land, and gravel mining operations.

In addition to the actions described as part of the regional strategy for tributary habitat, addressing passage barriers such as culverts will benefit steelhead by restoring access to habitat in a number of locations; in some cases, additional assessment is needed to inventory passage barriers and prioritize them for removal or improvement. For the North Fork Toutle winter steelhead population, addressing sedimentation and passage issues at the North Fork Toutle sediment retention structure will be key. In the Sandy subbasin, municipal water withdrawals by the City of Portland have adverse effects on instream flows and are being addressed by implementation of the city of Portland's Bull Run Water Supply habitat conservation plan.

Assuming that the impacts of other threats are reduced to the levels shown in Table 9-7, the scale of habitat improvements that will be needed for Cascade winter steelhead populations ranges from minimal in the case of the Salmon Creek and Sandy populations (the Salmon Creek population is targeted to be maintained at its baseline status, and habitat conditions in the Sandy subbasin are generally good) to reductions of 50 percent (Upper Cowlitz, Cispus, Tilton) or more (Clackamas) in baseline habitat impacts to tributary habitat productivity.[46]

The scale of habitat improvements needed for Cascade summer steelhead populations ranges from minimal in the case of the Kalama and North Fork Lewis populations (which are targeted for high and very low persistence probabilities, respectively) to a 20 percent reduction in baseline tributary habitat impacts in the Washougal and a 50 percent reduction in the East Fork Lewis.

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[46] The Oregon management unit plan notes that achieving the level of habitat improvement identified to meet the target status of high persistence probability for the Clackamas winter steelhead population is not feasible (ODFW 2010, p. 195). It is possible that the Cascade winter steelhead stratum would meet the WLC TRT's viability criteria for high probability of stratum persistence even if the Clackamas population were maintained at its baseline status, depending on the outcome of recovery efforts for other populations in the stratum.

9.6.2.2 Gorge Winter and Summer Steelhead Tributary Habitat Strategies

In implementing the tributary habitat strategy for the Gorge strata, considerations include the following:

- Gorge populations occur in watersheds that are largely Federal, state, and private forest land. These lands must be managed to protect and restore watershed processes.
- In the lower reaches of most Gorge tributary streams, floodplains have been drastically altered or disconnected as a result of channel modification to facilitate and protect development and agricultural land.
- Water quality and flow in the Hood subbasin are adversely affected by water withdrawals for irrigation, low-head hydropower, and the use of agricultural chemicals.
- For the Lower and Upper Gorge winter steelhead populations, site-specific actions will include addressing or mitigating the impacts of the highway and railroad transportation corridors that run parallel to the Columbia River shoreline, traversing all creek drainages in ways that restrict access and disconnect upland and lowland habitat processes.

In addition to the actions described as part of the regional strategy for tributary habitat, for the Hood summer population, reduced instream flow from irrigation withdrawals is a primary threat, so actions to identify and implement flow improvements will be important.

Assuming that the impacts of other threats are reduced to the levels shown in Table 9-7, reductions in baseline tributary habitat impacts needed to meet target statuses for Gorge winter steelhead populations are on the order of 20 to 40 percent for the Upper and Lower Gorge winter steelhead populations. For the Hood population, although existing habitat appears to be adequate, the Oregon management unit plan expects that habitat actions benefitting other species will also benefit winter steelhead.

Assuming that the impacts of other threats are reduced to the levels shown in Table 9-7, the scale of habitat improvements needed to meet targets for Gorge summer steelhead populations ranges from minimal, for the currently viable Wind summer population,[47] to an 85 percent reduction in baseline tributary habitat impacts for the Hood population. The Oregon management unit plan notes that tributary habitat improvements of this magnitude are not feasible in the Hood subbasin and that the Hood population is unlikely to achieve a high persistence probability (ODFW 2010).

[47] Although the Wind summer steelhead population currently is viable and is not targeted for improvements in abundance and productivity, increases in the diversity of this population are needed for it to achieve recovery goals.

9.6.3 Estuary Habitat Strategy

Improving Columbia River estuary habitat as described in the regional estuary habitat strategy will benefit all Columbia Basin ESUs, including Lower Columbia River steelhead. (For a summary of the regional estuarine habitat strategy, see Section 4.2.2.) The regional strategy reflects actions presented in the Oregon and Washington management unit plans to reduce estuarine habitat-related threats and is consistent with actions in the *Columbia River Estuary ESA Recovery Plan Module for Salmon and Steelhead* (NMFS 2011a).

The *Columbia River Estuary ESA Recovery Plan Module for Salmon and Steelhead* (NMFS 2011a) assumes that feasible estuarine habitat improvements and predation management measures could result in a maximum increase of 20 percent in the number of outmigrating juveniles leaving the Columbia River estuary. Oregon and Washington recovery planners set targets of reducing anthropogenically enhanced mortality in the estuary for winter steelhead populations based on the estuary module and their own approaches to threat reductions (ODFW 2010 195-199, Tables 6-30 through 6-35; LCFRB 2010a p. 6-66, Table 6-13).

9.6.4 Hydropower Strategy

The hydropower recovery strategy for Lower Columbia River steelhead is to address impacts of tributary hydropower dams through implementation of FERC relicensing agreements and thereby reestablish viable winter-run populations in the Upper Cowlitz and Cispus subbasins and achieve survival gains in other populations affected by tributary hydropower facilities.

The strategy also includes measures to improve passage survival at Bonneville Dam for the populations that spawn above Bonneville Dam and implementation of mainstem flow management operations designed to benefit spring migrants from the interior of the Columbia Basin; NMFS expects that these flow management operations will also improve survival in the estuary and, potentially, the plume for all Lower Columbia River salmon and steelhead populations. NMFS estimates that survival of Lower Columbia River steelhead passing Bonneville Dam was 90.6 percent for juveniles from 2002 to 2009 and 98.5 percent for adults from 2002 to 2007 (NMFS 2008a). NMFS expects that implementation of actions in the 2008 FCRPS Biological Opinion and its 2010 Supplement will improve juvenile steelhead salmon survival at Bonneville Dam by less than ½ percent, and that adult survival will be maintained at recent high levels (NMFS 2008a). Consequently, Oregon has not incorporated survival benefits from passage improvements at Bonneville into the hydropower threat reduction targets for Oregon populations above Bonneville.[48] The Washington management unit plan assumes that actions identified in the 2008 FCRPS Biological Opinion and its 2010 Supplement will aid adults and juveniles from all steelhead populations originating above Bonneville Dam. For more on actions to improve mainstem dam passage, see the regional hydropower strategy in Section 4.3.2.

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[48] Hydropower-related threat reduction targets for Oregon populations above Bonneville Dam are associated with removal of Powerdale Dam on the Hood River.

In its management unit plan, Oregon incorporated several actions addressing impacts of the Columbia River hydropower system that are not included in the FCRPS Biological Opinion and its 2010 Supplement but that Oregon maintains are needed to benefit Lower Columbia River salmon and steelhead populations that spawn above Bonneville Dam. The state of Oregon's position is that the FCRPS action agencies should conduct operations in addition to those incorporated in the FCRPS Biological Opinion to address the needs of ESA-listed salmon and steelhead. Oregon is a plaintiff in litigation against various Federal agencies, including NMFS, challenging the adequacy of measures in the FCRPS Biological Opinion and its 2010 Supplement. NMFS does not agree with Oregon regarding the need for or likely efficacy of the additional actions Oregon proposed in that litigation, including the actions in the Oregon management unit plan that are not part of the FCRPS Biological Opinion and its 2010 Supplement. For more detail on these actions and NMFS' view of them, see the regional hydropower strategy in Section 4.3.2.

The subsections below summarize stratum-level hydropower strategies for Lower Columbia River steelhead.

9.6.4.1 Cascade Winter Steelhead Hydropower Strategy

Passage improvements and hatchery reintroduction programs are the main elements of the hydropower strategy for Cascade winter steelhead. Passage will be created or improved at projects on the Cowlitz (Upper Cowlitz, Cispus, and Tilton populations) and Lewis (North Fork Lewis population) rivers, while hatchery reintroduction programs will be used to reestablish viable winter steelhead populations in the Upper Cowlitz and Cispus subbasins and to improve the persistence probability of the Tilton population (from very low to low) and North Fork Lewis (from very low to medium) population. These changes will be implemented under the terms of FERC relicensing agreements completed with (1) Tacoma Power for the Cowlitz River Project in 2000, and (2) PacifiCorp and the Cowlitz PUD for the Lewis River Hydroelectric Projects in 2004. Habitat above the dams in these systems is relatively intact, with well-functioning watershed processes and a high percentage of Federal land ownership.

In the Cowlitz subbasin, Mayfield Dam blocks winter steelhead access to the upper watershed; approximately 40 percent of the spawning and rearing habitat in the Cowlitz subbasin is not accessible. Under a trap and haul program begun in 1994, adult winter steelhead are collected at the Cowlitz hatcheries and released into the Upper Cowlitz, Cispus, and Tilton subbasins. The resulting naturally produced smolts are collected at the Cowlitz Falls Fish Collection Facility, acclimated at the Cowlitz Salmon Hatchery, and released in the mainstem Cowlitz (LCFRB 2010a). Passage at these dams is expected to be improved at some point as part of the 2000 FERC relicensing agreement.[49] Tacoma Power will evaluate fish returns and survival through the reservoirs and assess passage options. Adult passage will be by trap and haul unless certain settlement agreement criteria (fish sorting, productivity, etc.) are met. If they are met, passage at Mayfield Dam is likely to be provided via a new fish ladder, whereas passage at the much larger Mossyrock Dam likely will be provided by either trap and haul or a tramway.

[49] As of fall 2010, Tacoma Power had improved downstream passage survival at Mayfield Dam for juvenile steelhead from the Tilton winter-run population.

In the North Fork Lewis subbasin, three dams (Merwin, Yale, and Swift) block passage to the upper North Fork Lewis, beginning with Merwin Dam at RM 20. As part of the 2004 FERC relicensing agreement for these dams, reintroduction of winter steelhead into habitat upstream of the three dams is being evaluated and is likely to begin in 2012-2013. The keys to successful reintroduction will be adequate passage of juveniles and adults to and from the upper watershed, hatchery supplementation, and habitat improvements. In addition, hydroregulation on the Lewis River has altered the natural flow regime below Merwin Dam, and the flow regime will be need to be adjusted to provide adequate flows for habitat formation, fish migration, water quality, floodplain connectivity, habitat capacity, and sediment transport. However, floodplain and channel alterations in the lower river will limit the ability to restore the natural flow regime, and flow modifications will need to take place in concert with restoration of lower river floodplain function. (LCFRB 2010a)

Maintaining access to headwater spawning areas in the Cowlitz and Lewis systems may become increasingly important because the effects of climate change on stream temperatures may not be as pronounced there (LCFRB 2010a).

In the Clackamas subbasin, PGE's River Mill-Faraday-North Fork Dam complex, which has both upstream and downstream passage facilities, impairs downstream steelhead passage and may also delay adult upstream passage and reduce spawner distribution and success. As part of the 2006 FERC relicensing agreement, PGE agreed to improve downstream juvenile mortality through the dam complex to 3 percent or less and has already rebuilt the ladder and trap at North Fork Dam.

9.6.4.2 Cascade Summer Steelhead Hydropower Strategy

There are no tributary hydropower dams in the Kalama, East Fork Lewis, or Washougal subbasins. In the North Fork Lewis subbasin, summer steelhead recovery efforts will be focused below Merwin Dam.

9.6.4.3 Gorge Winter and Summer Steelhead Hydropower Strategy

Tributary hydropower impacts for the Hood winter and summer steelhead populations will be addressed by the removal of Powerdale Dam. The dam, which was operated by PacifiCorp, was removed in 2010 under the terms of a settlement agreement reached in 2003. The dam had passage systems in place; nevertheless, removal is expected to improve upstream and downstream survival, increase access to historical spawning and rearing habitat, and reduce hydropower impacts on Hood winter and summer populations by 55 percent. There are no tributary dams in the Wind subbasin.

Actions in the 2008 FCRPS Biological Opinion and its 2010 Supplement will also provide slight improvements in juvenile survival at Bonneville Dam for the Upper Gorge winter and Hood winter and summer populations (see the regional hydropower strategy in Section 4.3.2).

9.6.5 Harvest Strategy

Before the mid-1970s, steelhead harvest impacts were on the order of 70 percent or more. Harvest impacts were reduced in 1975 when the commercial harvest of steelhead in non-treaty fisheries was prohibited, and reduced further in the late 1980s and early 1990s through the implementation of mass marking and hatchery-fish-only retention requirements. For most populations harvest impacts are now 10 percent or less. Harvest impacts to populations above Bonneville Dam are somewhat higher, on the order of 15 percent or less, as a result of the additional impacts that occur in tribal fisheries.

As discussed in Section 9.4.4, although harvest-related mortality is identified as a secondary limiting factor for all populations within the DPS, substantial actions already have been implemented to reduce harvest impacts on natural-origin steelhead. Analysis in the Oregon and Washington management unit plans determined that maintaining steelhead harvest at current levels is consistent with achieving recovery objectives (ODFW 2010, LCFRB 2010a). The harvest strategy is to ensure continued regulation of fisheries to limit impacts to current levels, using ancillary and precautionary actions as described in Section 4.5.2 (the regional harvest strategy).

The Washington plan recommends maintaining harvest impacts on Cascade winter and summer steelhead of between 5 and 10 percent for the 50-year implementation period; this will be accomplished through improved monitoring and application of regulations in mainstem and tributary fisheries. Oregon did not incorporate any reduction to the 10 percent baseline harvest impact rate into its threat reductions for winter steelhead populations. In addition to maintaining current harvest regulations and impacts, the Washington management unit plan recommends (1) continuing to improve gear and regulations to minimize incidental impacts to naturally spawning steelhead, (2) establishing specific triggers for in-season Columbia River fishery adjustments as needed to support lower Columbia River winter steelhead recovery goals and strategies, (3) managing Columbia River commercial fisheries by time, area, and gear to target hatchery fish and minimize impacts to naturally spawning steelhead, and (4) monitoring naturally spawning steelhead encounter rates in tributary recreational fisheries, particularly in populations targeted for viability or high persistence probability.

9.6.5.1 Cascade Winter and Summer Steelhead Harvest Strategy

The DPS-level harvest strategies will benefit populations in the Cascade winter and summer strata.

9.6.5.2 Gorge Winter and Summer Steelhead Harvest Strategy

The DPS-level harvest strategies will benefit populations in this stratum. In addition, for the Upper Gorge, Wind, and Hood populations, Oregon proposes discussing Zone 6 fishery impacts with tribes to reduce potential additional impacts. Potential actions include extending harvest sanctuaries from tributary mouths and modifying season length or timing (ODFW 2010).

9.6.6 Hatchery Strategy

The regional hatchery strategy described in Section 4.4.2 summarizes goals and approaches relevant to Lower Columbia River steelhead. Details of how the hatchery strategy will be implemented in each steelhead stratum will be developed as part of the transition schedules, but the subsections below provide some information.

9.6.6.1 Cascade Winter Steelhead Hatchery Strategy

Hatcheries will be used in reintroducing winter steelhead in the Upper Cowlitz (Upper Cowlitz, Cispus, and Tilton populations) and North Fork Lewis subbasins. Hatchery-origin adult winter steelhead already are being released upstream of dams to spawn naturally in the Upper Cowlitz, Cispus, and Tilton rivers; these fish come from hatchery programs that were founded with local stock and have not been augmented with non-local stocks. Local stocks will also be used to develop hatchery programs that will be used to reintroduce winter steelhead to the upper Lewis subbasin. WDFW may also consider supplementation programs in some other Cascade populations to bolster natural fish numbers above critical levels in selected areas until habitat is restored to levels where a population can be self-sustaining.

The hatchery strategy involves continued hatchery production as mitigation and for fishery enhancement of winter steelhead in the Lower Cowlitz, Kalama, East Fork Lewis, Salmon Creek, Washougal, Clackamas, and Sandy[50] subbasins. Effective control of reproductive and competitive interactions between hatchery-origin fish and natural populations will be particularly important in these cases, with details varying depending on the population's target status. In addition, although there are no hatchery programs located in the Coweeman, hatchery-produced winter steelhead are released there for fishery enhancement.

For the Clackamas population, a pHOS target of 10 percent will be met by reducing Eagle Creek winter steelhead hatchery releases (from 150,000 to 100,000 beginning in 2009). The Clackamas will be managed initially as an integrated program, with a sliding scale developed for take of wild winter steelhead broodstock.[51] The Sandy subbasin winter steelhead program will also be managed as an integrated program, with a sliding scale developed for take of wild winter steelhead broodstock.

The Clackamas subbasin above North Fork Dam will be maintained as a wild fish sanctuary. No hatchery winter steelhead are currently released, nor are the expected to be released, into the North and South Fork Toutle subbasins.

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[50] The Sandy winter steelhead population was targeted for an 80 percent reduction in hatchery impacts. The Oregon management unit plan states that, because of fairly recent changes in the management of the hatchery steelhead program, that target has been met, and current stray rates are lower than the 10 percent objective for this population (ODFW 2010).

[51] ODFW will also explore the feasibility of shifting the Clackamas hatchery winter steelhead program to one that holds and rears fish for an extra year to better mimic their natural life cycle (ODFW 2010).

9.6.6.2 Gorge Winter Steelhead Hatchery Strategy

In the Hood subbasin, Oregon proposes to install a floating weir to remove stray hatchery winter steelhead and to implement a sliding scale for take of wild winter steelhead broodstock for an integrated hatchery program. There are no hatcheries and no releases of hatchery-origin steelhead at present in the Upper Gorge tributaries, and the Washington plan proposes that this area be maintained as a refuge area for winter steelhead (LCFRB Vol. II). In the Lower Gorge, Oregon proposes to investigate placing a new weir and trap to sort hatchery-origin winter steelhead from natural-origin winter steelhead migrating upstream on Eagle Creek, Tanner Creek, or both. There are no hatcheries or winter steelhead releases in the Washington lower Gorge tributaries.

9.6.6.3 Cascade Summer Hatchery Strategy

Fishery enhancement programs are expected to continue in the North Fork Lewis, Kalama, East Fork Lewis, and Washougal subbasins. Washington will develop either integrated or segregated programs in each of these subbasins to meet criteria appropriate to the target status of these populations.

9.6.6.4 Gorge Summer Hatchery Strategy

The Wind subbasin is expected to be maintained as a refuge area for natural-origin fish. The summer steelhead hatchery program in the Hood subbasin was discontinued in 2009.

9.6.7 Predation Strategy

The regional predation strategy (see Section 4.6.2) involves reducing predation by birds, fish, and marine mammals and will benefit all Lower Columbia River ESUs, including summer and winter steelhead.

9.6.8 Critical Uncertainties

Each aspect of the steelhead recovery strategy has a number of critical uncertainties. For all ESUs, there are uncertainties regarding how habitat actions will translate into changes in productivity and capacity (Roni et al. 2011). Prioritizing and identifying next steps in resolving uncertainties is a near-term priority. Critical uncertainties specific to the Lower Columbia River steelhead recovery strategy include the following:

- Effectiveness of weirs, shifts in production, and other techniques in achieving pHOS targets
- Effectiveness of various approaches to developing integrated hatchery/natural populations, especially for populations with very low natural-origin abundance
- Effective methods of providing adequate downstream passage efficiency for juveniles migrating past tributary dams
- Effectiveness of hatchery reintroduction programs and the pace of local adaptation of reintroduced stocks above tributary dams

- Most appropriate boundary between Mid-Columbia and Lower Columbia River steelhead DPSs[52]

These critical uncertainties represent preliminary priorities identified by Oregon and Washington recovery planners and NMFS Northwest Regional Office and Northwest Fisheries Science Center staff during a November 2010 workshop. They are preliminary priorities only (and are not in ranked order); as described in Chapter 10, additional discussion among local recovery planners and NMFS staff will be needed to finalize future research priorities for Lower Columbia River steelhead.

The management unit plans identify more comprehensive critical uncertainties and research, monitoring, and evaluation needs that, along with the list above, will provide the basis for these future discussions. The Washington management unit plan has a discrete section on critical uncertainties for all of the ESUs in general (see Section 9.6 of LCFRB 2010a, pp. 9-68 through 9-73), while the Oregon management unit plan embeds relevant critical uncertainties within subsections on monitoring and evaluation needs related to the four VSP parameters and five ESA listing factors (see Sections 8.4 and 8.5, respectively, of ODFW 2010). In addition, in June 2010, the *Lower Columbia Fish Recovery Board completed the Research, Monitoring, and Evaluation Program for Lower Columbia Salmon and Steelhead* as a companion to its recovery plan (LCFRB 2010b). This document also describes critical uncertainties. The list above does not include critical uncertainties that apply to multiple ESUs; these will be discussed and considered as decisions are made in implementation. In addition, the critical uncertainties above are of a technical nature; there are also many critical uncertainties related to social, political, and economic issues.

Critical uncertainties are one element of research, monitoring, and evaluation (RME) and adaptive management, which will be key components of the steelhead recovery strategy (see Chapter 10 for more discussion of RME and adaptive management for this recovery plan).

9.7 Delisting Criteria Conclusion for LCR Steelhead

The requirement for determining that a species no longer requires the protection of the ESA is that the species is no longer in danger of extinction or likely to become endangered within the foreseeable future, based on evaluation of the listing factors specified in ESA section 4(a)(1). To remove the Lower Columbia River steelhead DPS from the Federal List of Endangered and Threatened Wildlife and Plants (that is, to delist the DPS), NMFS must determine that the DPS, as evaluated under the ESA listing factors, is no longer likely to become endangered.

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[52] In its 2011 5-year review (76 *Federal Register* 50448), NMFS discussed uncertainties regarding the most appropriate boundary between the Mid-Columbia and Lower Columbia River steelhead DPSs. New information, primarily DNA microsatellite variation, underscores the transitional nature of populations in this area and the uncertainty associated with the ESU and DPS boundaries there. Given all this information, it might be reasonable either to reassign the White Salmon and Klickitat River steelhead from the Middle Columbia River DPS to the Lower Columbia River DPS or to maintain the existing DPS boundary. NMFS recommended maintaining the existing boundary but will reexamine the issue in future 5-year reviews as new information becomes available.

The ESA requires that recovery plans, to the maximum extent practicable, incorporate objective, measurable criteria that, when met, would result in a determination in accordance with the provisions of the ESA that the species be removed from the Federal List of Endangered and Threatened Wildlife and Plants (50 CFR 17.11 and 17.12). The recovery criteria in this plan (both biological and threats criteria) meet this statutory requirement.

As described in Section 9.3, if the scenario in Table 9-4 were achieved, it would meet or exceed the WLC TRT's viability criteria, particularly in the Cascade winter stratum but also in the Cascade summer stratum (see Table 9-8).[53] Exceeding the criteria in the Cascade stratum was intentional on the part of local recovery planners to compensate for uncertainties about the feasibility of meeting the WLC TRT's criteria in the Gorge stratum, in particular the questions raised by Oregon about the feasibility of meeting the target status for the Hood summer population.

Table 9-8
Steelhead Recovery Scenario Scores Relative to WLC TRT Viability Criteria

Species	Number of Primary Populations				Stratum Average Criteria		
		Cascade	Gorge	Total		Cascade	Gorge
Winter Steelhead	n ≥ high	9	2	11	Avg. score	2.61	2.33
	TRT criterion (n ≥ 2) met?	Yes	Yes		TRT criterion (avg. ≥ 2.25) met?	Yes	Yes
Summer Steelhead	n ≥ high	3	2	5	Avg. score	2.38	3.50
	TRT criterion (n ≥ 2) met?	Yes	Yes		TRT criterion (avg. ≥ 2.25) met?	Yes	Yes

Source: Based on LCFRB (2010a), Table 4-7.

Oregon recovery planners raised questions about the feasibility of meeting the recovery target of high persistence probability for both the Clackamas winter and Hood summer steelhead populations (ODFW 2010, Table 6-36). The Oregon management unit plan states that achieving a high probability of persistence for the Clackamas population would require more tributary habitat improvements than are believe feasible (ODFW 2010, Table 3-30). Because the recovery scenario targets nine steelhead populations for high persistence probability in the Cascade stratum, the WLC TRT criteria would likely be met even without achieving high persistence probability for the Cascade winter population.

[53] As discussed in Section 2.5.4, the TRT's criteria for high probability of stratum persistence require that two or more populations be viable and that the average score for all populations in the stratum be 2.25 or higher. In the Cascade winter stratum, nine populations are targeted for high or very high persistence probability, and, using the WLC TRT's scoring system, the average viability score for all populations in the stratum would be 2.61.

Oregon recovery planners' uncertainty regarding the Hood summer steelhead population is based in part on questions about the feasibility of meeting the habitat and hatchery threat reduction targets for this population (ODFW 2010) and in part on questions raised by both Oregon and Washington management unit planners regarding Gorge stratum and population delineations and the historical role of the Gorge populations (LCFRB 2010a, ODFW 2010). These questions include whether the Gorge populations were highly persistent historically, whether they functioned as independent populations within their stratum in the same way that the Coast and Cascade populations did, and whether the Gorge stratum itself should be considered a separate stratum from the Cascade stratum.

As discussed in Section 3.2, NMFS has considered the WLC TRT's viability criteria (from McElhany et al. 2003 and 2006 and summarized in Table 2-3), the additional recommendations in McElhany et al. (2007), the recovery scenarios and population-level goals in the management unit plans, and the questions raised regarding the historical role of the Gorge strata.

NMFS has concluded that the WLC TRT's criteria adequately describe the characteristics of a DPS that meet or exceed the requirement for determining that a species no longer needs the protection of the ESA. These criteria provide a framework within which to evaluate specific recovery scenarios. NMFS has evaluated the recovery scenario presented in the management unit plans for Lower Columbia River steelhead (summarized in Table 3-1 of this recovery plan) and the associated population-level abundance and productivity goals (see Section 9.3) and has concluded that they also adequately describe the characteristics of a DPS that no longer needs the protections of the ESA. NMFS endorses the Lower Columbia River steelhead recovery scenario and the associated population-level goals in the management unit plans (summarized in Table 3-1 and Section 9.3) as one of multiple possible scenarios consistent with delisting.

NMFS also agrees with the management unit planners that the historical role of the Gorge populations and strata merits further examination. The extent to which compensation in the Cascade stratum is ultimately considered necessary to achieve an acceptably low risk at the DPS level will depend on how questions regarding the historical role of the Gorge populations are resolved.

NMFS therefore proposes the following delisting criteria for the Lower Columbia River steelhead DPS. (NMFS has amended the WLC TRT's criteria to incorporate the concept that each stratum should have a probability of persistence consistent with its historical condition, thus allowing for resolution of questions regarding the Gorge strata):

1. All strata that historically existed have a high probability of persistence or have a probability of persistence consistent with their historical condition. High probability of stratum persistence is defined as:

    a. At least two populations in the stratum have at least a 95 percent probability of persistence over a 100-year time frame (i.e., two populations with a score of 3.0 or higher based on the TRT's scoring system).

b. Other populations in the stratum have persistence probabilities consistent with a high probability of stratum persistence (i.e., the average of all stratum population scores is 2.25 or higher, based on the TRT's scoring system). (See Section 2.6 for a brief discussion of the TRT's scoring system.)

c. Populations targeted for a high probability of persistence are distributed in a way that minimizes risk from catastrophic events, maintains migratory connections among populations, and protects within-stratum diversity.

A probability of persistence consistent with historical condition refers to the concept that strata that historically were small or had complex population structures may not have met Criteria A through C, above, but could still be considered sufficiently viable if they provide a contribution to overall ESU viability similar to their historical contribution.

2. The threats criteria described in Section 3.2.2 have been met.

10. Adaptive Management and Research, Monitoring, and Evaluation

The long-term success of recovery efforts for Lower Columbia River salmon and steelhead will depend on the strategic use of research, monitoring, and evaluation (RME) to provide useful information to decision makers within an adaptive management framework. Research, monitoring, and evaluation programs associated with recovery plans need to gather the information that will be most useful in tracking and evaluating implementation and action effectiveness and assessing the status of listed species. Planners and managers then need to use the information collected to guide and refine recovery strategies and actions. These elements of recovery plans are crucial for salmon and steelhead because of the complexity of the species' life cycles, the range of factors affecting survival, and the limits on our understanding of how specific actions affect species' characteristics and survival.

Research, monitoring, and evaluation for salmon and steelhead are complicated by the existence of multiple entities in the region conducting relevant monitoring. Within the Columbia Basin and the Lower Columbia recovery subdomain, many organizations, including Federal, state, tribal, local, and private entities, conduct various kinds of monitoring. Developing regional coordination for these efforts is essential if we are to design and implement sound monitoring programs that provide relevant, valid, and accessible data and use limited resources most effectively.

The management unit recovery plans contain or will contain specific RME plans for their areas. These RME plans are based on regional guidance for adaptive management and RME and will guide recovery planning RME efforts and funding in their respective areas, within a context of ongoing regional guidance and coordination.

This chapter provides the following information:

- A brief description of the concept of adaptive management and a brief overview of salmon and steelhead recovery plan RME needs
- A summary of regional guidance for adaptive management and RME
- An overview of the RME components of each management unit plan and the *Columbia River Estuary ESA Recovery Plan Module for Salmon and Steelhead* (NMFS 2011a)
- An overview of RME regional coordination efforts and needs[1]

10.1 Overview of Adaptive Management and RME Needs

Adaptive management is the process of adjusting management actions and/or overall approach based on new information. Adaptive management works by coupling decision

[1] For a list of preliminary critical uncertainties for each ESU, see Sections 6.6.8, 7.4.3.8, 7.5.3.8, 7.6.3.6, 8.6.8, and 9.6.7.

making with data collection and evaluation. Most importantly, it works by offering an explicit process through which alternative approaches and actions can be proposed, prioritized, implemented, and evaluated (NMFS 2007). Successful adaptive management requires that monitoring and evaluation plans be incorporated into overall implementation plans for recovery actions. These plans should link monitoring and evaluation results explicitly to feedback on the design and implementation of actions. In adaptive management, recovery strategies are treated like working hypotheses that can be acted upon, tested, and revised (Lee 1999). Figure 10-1 illustrates the adaptive management process.

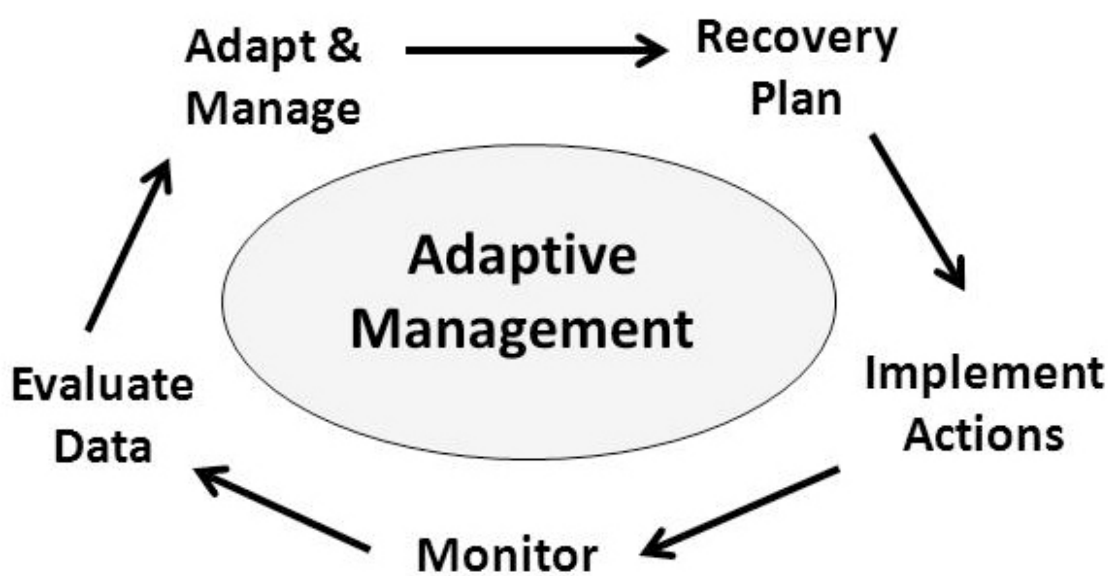

Figure 10-1. *The Adaptive Management Cycle*

Several types of monitoring are needed to support adaptive management (NMFS 2007):

- Implementation monitoring and compliance monitoring, which are used to evaluate whether recovery plan actions are being implemented as directed.
- Status and trend monitoring, which assesses changes in the status of an ESU and its component populations, and changes in the status or significance of the threats to an ESU.
- Effectiveness monitoring, which tests hypotheses about cause-and-effect relationships and determines via research whether an action is effective and should be continued.

It is also important to explicitly address the many unknowns in salmon recovery—the "critical uncertainties" that make management decisions much harder. Doing so will involve prioritizing critical uncertainties and ensuring that appropriate research is conducted that can inform managers on the questions (NMFS 2007).

Finally, given the wide array of organizations involved in salmon recovery in the Columbia Basin, including groups from Federal agencies, states, and tribes, the task of coordinating all the information being gathered and making it available to decision makers throughout the region is daunting. During the last decade, substantial progress has been made in standardizing fisheries data collection and storage methods.

10.2 Guidance for Adaptive Management and RME

NMFS and other entities have developed documents to guide and coordinate salmon and steelhead RME efforts throughout the Columbia Basin and the Pacific Northwest. Overall, the goal of these guidance documents is to ensure that monitoring programs are designed to provide the information NMFS and others need to understand the effects of recovery actions and evaluate the status of salmon and steelhead populations and the threats they face. Another objective of the guidance documents has been to ensure that data is managed, shared, and integrated in a cost-effective manner. The primary guidance documents are described briefly below.

10.2.1 Adaptive Management for ESA-Listed Salmon and Steelhead Recovery: Decision Framework and Monitoring Guidance

In 2007, the NMFS Northwest Region released *Adaptive Management for ESA-Listed Salmon and Steelhead Recovery: Decision Framework and Monitoring Guidance* (NMFS 2007). This document describes the questions NMFS asks in evaluating species status and making listing and delisting decisions. It offers conceptual-level guidance, not specific instructions, on gathering the information that will be most useful in tracking progress and assessing the status of listed species.

As outlined in the document, a delisting decision is based on evaluation of both the ESU's biological status and the extent to which the threats facing the ESU have been addressed. The document spells out the questions that need to be answered through RME to satisfy the requirements for each component of such a decision. These components are displayed graphically in the form of a "listing status decision framework" (Figure 10-2).

The document emphasizes that adaptive management is an experimental approach in which the assumptions underlying recovery strategies and actions are clearly stated and subject to evaluation (NMFS 2007). It further states that a monitoring and evaluation plan to support adaptive management should provide (1) a clear statement of the metrics and indicators by which progress toward achieving goals can be tracked, (2) a plan for tracking such metrics and indicators, and (3) a decision framework through which new information from monitoring and evaluation can be used to adjust strategies or actions aimed at achieving the plan's goals.

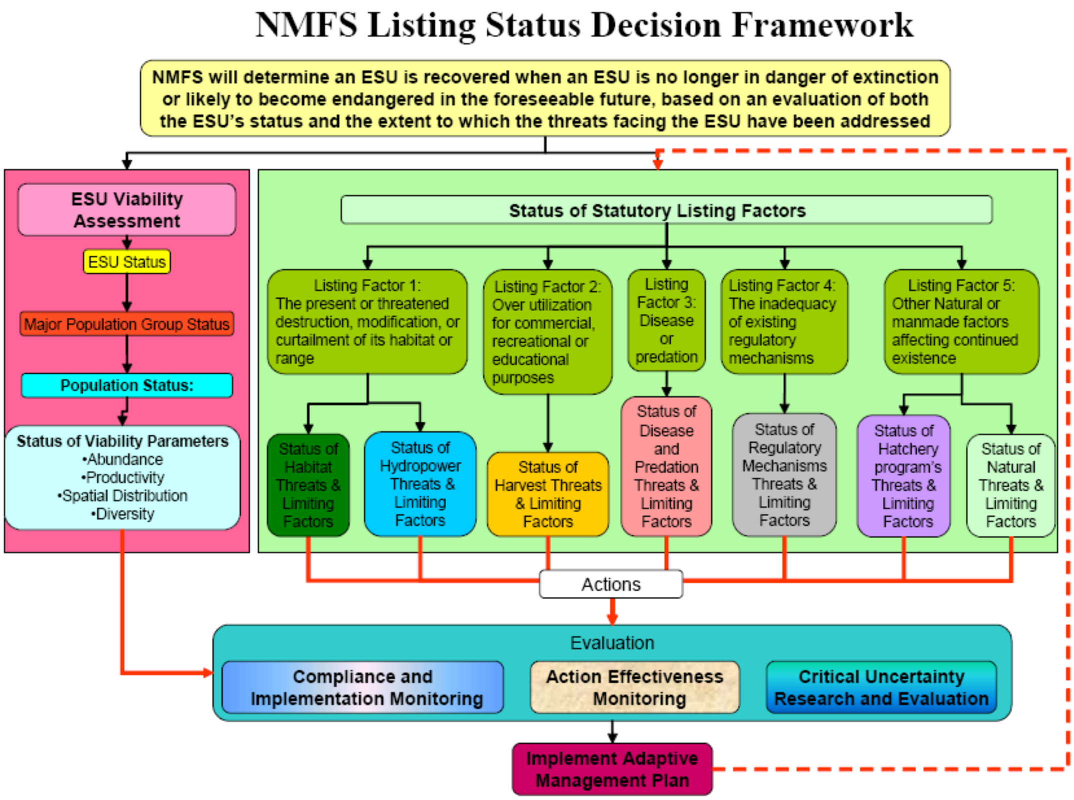

Figure 10-2. *NMFS Listing Status Decision Framework*

The document also discusses the various types of monitoring needed for salmon recovery, categorized as status and trend monitoring, effectiveness monitoring, validation monitoring, implementation monitoring, and research on critical uncertainties.

- **Status and trend monitoring**. Status monitoring is used to characterize existing conditions and establish a baseline for future comparisons. For monitoring of salmon and steelhead population status, the parameters of interest are abundance, productivity, diversity, and spatial structure. Parameters also need to be established to monitor the status of threats to salmon and steelhead (e.g., habitat, hydropower, hatcheries, and harvest). Trend monitoring involves measurements taken at regular time or space intervals to assess the long-term or large-scale trend in a particular parameter (NMFS 2007).

- **Effectiveness monitoring.** Effectiveness monitoring evaluates the direct effect of management actions. Success can be measured against reference areas, baseline conditions, or desired future conditions. Effectiveness monitoring can be implemented at the scale of individual actions, suites of actions across space, or for an entire strategy consisting of multiple actions at a single location.

- **Validation monitoring.** Validation monitoring answers the question: Did the management actions create the intended outcome? This question often involves evaluating the effects of numerous projects on a watershed or species. An example would be evaluating whether the cumulative effects of habitat restoration actions in a specific river basin resulted in increased production of juvenile salmon.

- **Implementation monitoring.** Implementation monitoring determines whether activities were carried out as planned and is generally conducted as an administrative review or site visit. This type of monitoring cannot directly link restoration actions to physical, chemical, or biological responses because none of these parameters are measured (NMFS 2007).
- **Research on critical uncertainties.** The adaptive management guidance notes that research on critical uncertainties may seem expensive or unnecessary but in the long run will reduce monitoring and implementation costs (NMFS 2007).

Finally, the adaptive management guidance (NMFS 2007) discusses considerations for prioritizing monitoring and examines the consequences of different sorts of incomplete data. Management and delisting decisions often must be made with incomplete information. Different types of incomplete information pose correspondingly different types of risks for delisting decisions. This discussion is intended to help planners consider how their own implementation and monitoring decisions may affect NMFS' assessment of ESU status.

10.2.2 Guidance for Monitoring Recovery of Pacific Northwest Salmon and Steelhead

Another document from the NMFS Northwest Region, *Guidance for Monitoring Recovery of Pacific Northwest Salmon and Steelhead* (Crawford and Rumsey 2011), builds on the 2007 adaptive management guidance document with specific recommendations for monitoring, data collection, and reporting ESA information (Crawford and Rumsey 2011). NMFS intends this document to assist those involved with salmon recovery in understanding the desired level of monitoring and the associated level of certainty needed at the regional, local, and project levels to support ESA status evaluations and listing and delisting decisions. NMFS also intends the guidance to assist in the development and implementation of a regional monitoring strategy that will provide the necessary monitoring information in the most cost-effective way for the region. The document does not establish new requirements or modify any existing requirements.

The recommendations included are for Federal and state agencies, tribes, local governments, and watershed organizations. Recommendations include monitoring that addresses all of the viable salmonid population (VSP) criteria and the threats to salmon and steelhead (organized under the five ESA listing factors). The guidance also makes recommendations for setting up regional databases and coordinating regional data collection so that the various agencies and tribes involved in salmon recovery can share data as well as report it efficiently to NMFS.

Recommendations for VSP monitoring address adult spawner abundance, productivity, spatial distribution, and diversity. Abundance considerations include use of a sampling design that has known precision and accuracy, monitoring of hatchery contributions, and a goal of a coefficient of variation of 15 percent or less for all populations. Productivity considerations include (1) developing at least 12 brood years of spawner information to allow use of the geometric mean of recruits per spawner to develop productivity estimates, and (2) obtaining estimates of juvenile migrants for at least one significant population within each stratum. The guidance recommends certainty levels for detecting changes in spatial distribution and, for diversity, suggests short-term strategies (use of spawn timing, age distribution, and other observations) and long-term strategies (genetic baseline information for each population).

Habitat-related recommendations include use of a generalized random tessellation stratified (GRTS) sampling program coupled with remote sensing of land use and land cover and coordinated with fish-in/fish-out monitoring where possible. Implementation of habitat restoration efforts should be capable of being reported (e.g., using the data fields in the Pacific Coastal Salmon Recovery Fund [PCSRF] project tracking database) and correlated with limiting factors as defined in the NMFS data dictionary (Hamm 2012). Reach-scale effectiveness monitoring should be conducted for various habitat improvement categories using a Before and After Control Impact (BACI) design wherever possible. There should also be at least one intensively monitored watershed (IMW) in each recovery subdomain. The U.S. Environmental Protection Agency, state agencies, and local governments should monitor stormwater and cropland runoff for concentrations of toxic contaminants and to identify their sources. For monitoring of hydropower-related threats, the guidance largely refers to specific requirements that have been written into FERC licenses.

For monitoring of harvest status and trends, the NMFS monitoring guidance notes the need for improved estimates of population-level harvest impacts, improved models for predicting harvest impacts to populations, and improved monitoring of incidental take and exploitation rate management.

For disease and predation, the guidance suggests that the status of existing invasive species should be compiled for each ESU/DPS and that watershed-level assessments should be conducted for species known to affect salmon and steelhead.

For threats related to hatchery production, the guidance recommends that states and tribes be able to determine annually and with known precision the proportion of hatchery origin spawners (pHOS) for each population. The proportion of natural influence (PNI) for primary populations with supplementation programs should be calculated periodically. Hatchery operators should complete Hatchery and Genetics Management Plans (HGMPs), submit them to NMFS for approval, and track and report on their implementation. Hatchery action effectiveness monitoring should include development of large-scale treatment/reference design to evaluate long-term trends in abundance and productivity of supplemented populations.

To evaluate the adequacy of regulatory actions, the guidance notes the need for a recovery action tracking system capable of recording whether entities have implemented regulatory actions proposed in recovery plans. It also suggests development of a randomized sampling program to test whether permits issued under regulatory programs designed to protect riparian and instream habitat are in compliance and adequately enforced.

Noting the regional needs to coordinate data collection, evaluation, and reporting, the guidance also makes the following recommendations: (1) regional environmental databases should be coordinated such that information can be readily reported to NMFS and shared among participants, (2) methods and calculations used to assess and evaluate data should be transparent and repeatable, (3) all project tracking should be consistent with the PCSRF project tracking database and the NMFS data dictionary, (4) regional salmon recovery partners should build a distributed data system that can communicate among agencies and report to the public, (5) sampling programs for habitat, water quality, and fish VSP criteria should be coordinated to fit within an integrated master sample program.

10.2.3 Other RME Guidance

A number of other regional efforts provide guidance relevant to developing RME and adaptive management programs for Lower Columbia River salmon and steelhead. These include Columbia River Basin Fish and Wildlife Program 2009 amendments and recommendations for implementing RME for the 2008 NOAA Fisheries FCRPS Biological Opinion and its 2010 Supplement (NMFS 2008f and 2010a).

10.2.3.1 Columbia River Basin Fish and Wildlife Program 2009 Amendments

The Northwest Power and Conservation Council's Fish and Wildlife Program emphasizes implementation of fish and wildlife projects based on needs identified in subbasin plans, Federal biological opinions, ESA recovery plans, and the 2008 Fish Accords signed by Federal agencies, Indian tribes, and the states of Idaho and Montana. The program amendments also establish reporting guidelines and the use of adaptive management to guide decision making and emphasize a more focused monitoring and evaluation framework coupled with a commitment to use the information obtained to make better decisions. The program includes general guidelines for monitoring and adaptive management in the Columbia Basin as well as a discussion of the need to develop a monitoring, evaluation, research, and reporting plan. A description of the program is available at http://www.nwCouncil.org/library/2009/2009-09/Default.asp.

10.2.3.2 Recommendations for Implementing Research, Monitoring and Evaluation for the 2008 NOAA Fisheries FCRPS Biological Opinion (AA/NOAA/NPCC RM&E Workgroups, June 2009 and May 2010)

Completion of the 2008 Biological Opinion on the operation of the Federal Columbia River Power System (FCRPS) stimulated collaboration related to RME in the mainstem lower Columbia River and estuary. The 2008 FCRPS Biological Opinion and its 2010 Supplement recommended a complex suite of actions to improve survival of salmonids through the migratory corridor of the Columbia River and to improve habitat below Bonneville Dam used for resting, feeding, the physiological transition for fresh to salt water, and migration. Subsequently, Federal, state, and tribal entities organized technical work groups to determine how best to implement the recommendations in the Biological Opinion and its Supplement and how to conduct RME to support them. Various guidance documents have been produced through this process and are available at http://www.salmonrecovery.gov/ResearchReportsPublications.aspx.

10.2.3.3 Salmon Monitoring Advisor

The Salmon Monitoring Advisor is a website developed by the Pacific Northwest monitoring community to provide a comprehensive, technically rigorous framework to help practitioners, decision makers, and funders design monitoring programs. The monitoring advisor is a web-based system that synthesizes a wide array of information into a systematic framework that offers an organized, structured procedure to help users efficiently design and implement reliable, informative, and cost-effective salmon monitoring programs. It provides advice and guidelines to help users systematically work through the numerous steps involved in designing, implementing, and analyzing results from monitoring programs to meet particular monitoring objectives. The address for this site is https://salmonmonitoringadvisor.org/.

10.3 RME Plans for the Washington, Oregon, and White Salmon Management Unit Plans

Within the framework of the guidance described above, local recovery planners have or will develop RME programs for their management unit recovery plans. These plans will provide conceptual-level guidance to RME implementation efforts at the local and regional scale. Implementation of these RME plans will also be influenced by the regional coordination efforts described below. Management unit RME plans are briefly summarized below; readers should consult the management unit plans themselves for detail.

10.3.1 Washington Management Unit

The Washington management unit plan (LCFRB 2010a) contains a monitoring and research chapter (see LCFRB 2010a, Chapter 9), which is supplemented by the *Research, Monitoring, & Evaluation Program for Lower Columbia Salmon & Steelhead* (LCFRB 2010b). Together these documents provide the framework for a systematic approach to RME in the LCFRB planning area.

Both documents describe general RME strategies for (1) biological status and trend monitoring, (2) habitat status and trend monitoring, (3) implementation/compliance monitoring, (4) action effectiveness monitoring, and (5) uncertainty and validation research. For each of these monitoring elements, the documents identify objectives, strategies, indicators, sampling and analytical design, and implementation actions needed for the RME program. In addition, the RME program document (LCFRB 2010b) contains inventories of available information and data and identifies critical information needs and priorities.[2] Both documents also address information reporting strategies. Because there is significant overlap between the two documents, they are referred to collectively here as the LCFRB RME program. In general, the LCFRB RME program identifies what needs to be done and how to do it but does not address specific implementation details such as desired confidence levels, statistical power, data collection protocols, and sample sizes. (For biological status and trends and habitat status and trends, such implementation details are being developed through the Pacific

[2] In particular, see Appendix B, "Detailed Inventory of Ongoing Monitoring Activities," and Appendix D, "Gap Analysis of Biological Monitoring Programs."

Northwest Aquatic Monitoring Partnership's Integrated Status and Trend Monitoring process, described below in Section 10.6.2).

The LCFRB RME program is intended to integrate with and complement other state and regional RME efforts for salmon and steelhead. Its goal is to provide a template for action and overall guidance to the extensive group of participants involved in implementation of the LCFRB plan. Specific elements are described briefly below.

10.3.1.1 Biological Status Monitoring

The LCFRB RME program's strategic approach for biological status monitoring is that while the status of every population needs to be assessed, all populations do not need to be monitored. The program advocates assigning the highest priorities for monitoring to populations targeted for high persistence probability and large improvements, and ensuring that populations selected for intensive monitoring represent all strata. For sampling and analytical design, the program recommends a stratified, representative, multi-level sampling framework. Such a sampling design would provide information on every population but sample different populations at different intensities and be designed to ensure representative coverage of all ESUs.

The program also identifies specific needs for a comprehensive natural coho sampling program, expanded adult and juvenile chum sampling efforts, and augmented sampling for adult and juvenile fall Chinook and winter steelhead.

10.3.1.2 Habitat Status Monitoring

The LCFRB RME program recommends monitoring stream corridor and landscape-scale habitat status as well as water quantity and quality. For stream habitat the strategic approach is to use a rotating panel of habitat samples to produce evaluations relative to baseline conditions every 12 years. The program also calls for assessing landscape condition at 12-year intervals, with landscape-scale information to be compiled uniformly across the entire study area. The primary focus of the LCFRB water quantity and water quality RME program is to characterize conditions for salmon and watershed health relative to a baseline at listing. The plan calls for comprehensive assessments of water quality and quantity status and trends at 12-year intervals.

10.3.1.3 Implementation and Compliance Monitoring

The LCFRB RME program identifies the need for implementation and compliance monitoring to determine whether recovery actions have been implemented as planned. The program proposes that this be accomplished by having implementing partners evaluate and report on progress in implementation through a centralized database system, called SalmonPORT, to be developed and maintained by LCFRB.

10.3.1.4 Action Effectiveness Monitoring

The LCFRB RME program addresses action effectiveness monitoring for actions in the categories of stream habitat, hydropower, fisheries, hatcheries, ecological interactions, and mainstem/estuary habitat.

- **Stream Habitat.** For stream habitat, the overall approach is to complete comprehensive assessments of habitat action effectiveness every 6 years. The strategy includes monitoring the effectiveness of specific types of habitat actions, developing and maintaining an inventory of habitat-related actions, and intensively monitoring a subset of habitat actions using formal statistical research design methods. For sampling and analytical design, the plan generally adopts monitoring designs and protocols developed by the Washington Salmon Recovery Funding Board.

- **Hydropower.** For hydropower actions, effectiveness monitoring is intended to determine whether hydropower actions for fish protection, restoration, and mitigation reduce or limit effects on natural-origin fish to levels consistent with conservation and recovery. The strategy calls for evaluating action effectiveness for passage, habitat protection and restoration, reintroduction, and other mitigation actions at all significant tributary and mainstem facilities every 6 years, using criteria as established in FERC licenses, biological opinions, and settlement agreements.

- **Harvest.** The overall objectives for fisheries action effectiveness monitoring include determining whether impacts are limited to prescribed levels and consistent with long-term recovery goals. The strategic approach is to monitor annual impacts and complete comprehensive assessments at 6-year intervals.

- **Hatcheries.** Overall objectives for hatchery action effectiveness monitoring include monitoring to determine whether hatchery impacts on each population are limited to prescribed levels and whether hatchery performance is consistent with goals for each hatchery program. The overall strategy is to monitor each hatchery program as well as the annual incidence of natural spawning by hatchery-origin fish and to complete comprehensive assessments of hatchery action effectiveness at 6-year intervals. Specific criteria for each program are to be developed in Hatchery and Genetic Management Plans.

- **Ecological Interactions**. The strategy for ecological interactions includes monitoring the effectiveness of actions addressing non-native species and predation by northern pikeminnow, marine mammals, and birds and developing 6-year summary evaluations.

- **Mainstem/Estuary.** The LCFRB RME program cites the estuary RME program developed by Johnson et al. to provide status monitoring, action effectiveness monitoring, and uncertainties research.

10.3.1.5 Research Needs

The LCFRB RME program identifies specific research needs for salmon population status, stream habitat and watershed health, hydropower, fisheries, hatcheries, ecological interactions, and the mainstem/estuary.

10.3.1.6 Data Management

The LCFRB RME program identifies a need for a data management needs assessment. It also notes the need to develop and maintain regionally standardized datasets and a data storage and management system, along with a need to produce and distribute regular progress reports and coordinate with other Columbia Basin efforts.

10.3.1.7 Programmatic Evaluation

The LCFRB RME program makes recommendations for programmatic evaluation, or adaptive management.

10.3.2 Oregon Management Unit

The Oregon management unit plan also contains a chapter devoted to research, monitoring, and evaluation (see ODFW 2010, Chapter 8). This chapter outlines the research, monitoring, and evaluation needs of the plan as they pertain to biological criteria (i.e., population VSP parameters) and threats (as organized under the ESA listing factors). It also describes how Oregon will incorporate RME into an adaptive management framework. The ODFW monitoring plan is based closely on the NMFS (2007) guidance document. It is organized around the key questions, as identified in the NMFS document, that must be answered for delisting decisions. It also includes the analytical framework Oregon intends to use to answer those key questions, along with measurable criteria against which the state intends to measure progress toward those goals. Like the LCFRB plan, the ODFW plan addresses status and trend monitoring, implementation monitoring, effectiveness monitoring, and critical uncertainty research.

10.3.2.1 Biological Status Monitoring

The Oregon management unit plan describes biological status monitoring needs for population abundance, productivity, spatial structure, and diversity. Included are decisions and key questions for evaluating population status as it pertains to each of the four VSP parameters, as well as analytical guidelines and measurable criteria. In general, decisions and key questions are derived from TRT documents and the Oregon management unit plan. The plan identifies a need for annual benchmarks of abundance and productivity based on annual, scaled estimates of spawner abundance, harvest of natural-origin fish, age at return, and an index of climate impact. The plan proposes to develop these annual estimates through spatially balanced, random surveys based on the generalized random tessellation stratified (GRTS) technique and using field protocols developed by ODFW.

For spatial structure, the plan identifies a need for annual estimates of the distribution and density of natural-origin spawning adults for each population (and for annual monitoring of juveniles at the stratum scale), as well as for 5-year assessments of habitat conditions throughout the accessible distribution of each population. The plan proposes spatially balanced, random surveys based on the GRTS technique and using ODFW protocols to obtain these estimates. In addition, the plan identifies a need for annual monitoring of streamflow.

For diversity, the plan identifies a need for periodic monitoring of key life history characteristics of each population; annual monitoring of spatial distribution, abundance, and origin of adult spawners in each population; hatchery monitoring; genetic marker monitoring; and periodic assessment of habitat diversity, occupancy, and anthropogenic changes to habitat and the environment.

The plan also calls for fish-in/fish-out (i.e., life-cycle) monitoring in at least one subwatershed in each stratum to provide marine survival estimates and another view of freshwater survival and productivity.

The plan describes a strategic approach to biological status monitoring that includes: (1) documenting the precision and bias associated with various monitoring protocols, (2) implementing GRTS or census-based spawning surveys where possible and using adult trapping facilities where necessary to provide population-level information on VSP parameters, and (3) using GRTS surveys to provide stratum-level information on juvenile abundance and, in at least one subwatershed, monitoring (via traps) adults in/juveniles out to provide an estimate of freshwater productivity. The chapter also describes how ODFW will prioritize resources under limited or fluctuating funding scenarios, including populations that will be cut from RME when resources are inadequate.

10.3.2.2 Monitoring Related to Listing Factors

The Oregon management unit plan discusses monitoring needs related to threats as organized under the five ESA listing factors. For each listing factor, the plan identifies the decision and key questions for delisting and status assessment (based on the NMFS 2007 guidance document) and discusses monitoring needs for status and trends, action effectiveness, and implementation. Discussion of status and trend monitoring includes identification of measurable criteria (metrics and evaluation thresholds), analytical procedures, and specific RME needs.

- **Habitat.** For habitat status and trend monitoring, the plan identifies a need for 5-year estimates of the spatial pattern and status of specific habitat attributes for each population as well as annual assessments of the status and spatial pattern of water quality for each population. The plan calls for these to be determined using spatially balanced, random surveys based on the GRTS technique and using ODFW or Oregon Department of Environmental Quality protocols. The plan also identifies the need for annual assessments of the status and spatial pattern of streamflow for each population.

  In addition to this 5-year monitoring, the plan calls for annual assessments at the stratum scale. Annual assessments are conducted during the summer; after 5 years, they provide a dense enough sample to characterize summer habitat conditions by population. This information complements the 5-year surveys, which are conducted in winter to characterize conditions during that season.

  For habitat implementation and compliance monitoring, the plan notes the needs for annual assessments of (1) compliance with existing habitat protection rules and regulations, (2) implementation of habitat best management practices, and

(3) implementation of habitat recovery actions. For habitat action effectiveness monitoring, the plan advocates use of intensively monitored watersheds (IMWs) as well as site-specific monitoring of habitat protection and BMPs and habitat restoration actions.

- **Hydropower.** For hydropower-related monitoring, the plan generally defers to the Clackamas River Hydroelectric Project Fish Passage and Protection Plan (Portland General Electric Company, 2006). Analytical procedures and RME needs for Laurance Lake Dam are to be determined.[3]

- **Harvest.** For monitoring related to the impacts of harvest, the plan identifies the need for annual estimates of mortality that is due to harvest for each population and annual estimates of the marine survival rates of natural-origin coho salmon (by monitoring adults in and smolts out of one intensively monitored watershed per stratum). For harvest implementation and compliance monitoring, the plan identifies a need for annual estimates of mortality, and for evaluation of whether managers meet targets for implementing mark-selective Chinook salmon fisheries and for shifting spring Chinook salmon commercial and tribal harvest to terminal areas during low-return years. For effectiveness monitoring related to harvest, the plan identifies a need to conduct studies to assess the effectiveness of harvest management actions needed to achieve harvest impact goals.

- **Hatcheries.** For status and trend monitoring related to hatcheries, the plan identifies the need for annual assessments of the abundance, distribution, and origin of hatchery fish spawning in each population, annual monitoring of the spatial and temporal distribution of juvenile fish released by hatchery programs, and all of the status and trend monitoring described for fish abundance and productivity. The plan also describes the need for monitoring and documentation that demonstrate that HGMPs have been implemented and effective.

- **Disease/predation**. For status and trends related to predation (by Caspian terns, double-crested cormorants, marine mammals, and northern pikeminnow), the plan identifies a need for monitoring of predation associated with anthropogenic alterations in the Columbia River estuary, at Bonneville Dam, and in Bonneville Reservoir. For issues related to disease, the plan calls for sampling of natural populations in and near hatcheries to determine occurrence of pathogens that may cause disease. The plan also calls for watershed-scale sampling for the occurrence of invasive aquatic species known to affect salmon and steelhead. Implementation and compliance monitoring and effectiveness monitoring needs for predation and disease are to be determined.

- **Regulatory mechanisms.** For monitoring related to regulatory mechanisms, the plan describes the need for a system that tracks whether regulatory actions called for in the plan are being implemented. It also identifies a need for a randomized sampling program to test whether permits issued under regulatory programs

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[3] Monitoring of hydropower-related facilities in the Sandy and Hood subbasins was not addressed because the dams have been removed.

designed to protect riparian and instream habitat are being issued as designed and being enforced.

The plan also identifies specific critical uncertainties for each of the VSP parameters and for each of the listing factors and includes an appendix describing existing monitoring programs (see ODFW 2010, Appendix J).

Like the LCFRB plan, the Oregon management unit plan discusses the need for and benefits of integrating monitoring plans throughout the region. As a step toward such integration, the plan advocates development of a survey design process that promotes data sharing, agreement on a core set of monitoring questions, coordination of monitoring activities, and development either of common protocols and methods or of ways to “crosswalk” data derived from different protocols. The plan also notes the need for improved data management and access through development of distributed data systems and data management infrastructure.

10.3.3 White Salmon Management Unit

The White Salmon management unit plan (NMFS 2011b) contains a brief discussion of monitoring, intended to provide a framework for the development of a detailed RME plan for the White Salmon, and identifies several critical uncertainties and actions needed to address them.[4] The management unit plan also notes that various monitoring efforts are under way and that there is a need for a coordinated monitoring program, and it includes some notes on initial steps in designing such a program. It also discusses adaptive management in general, identifies in-basin and out-of-subbasin research needs, discusses the various types of monitoring needed (implementation, status/trend, effectiveness), and the need for consistency/coordination with other monitoring programs. The plan also notes that the reintroduction plan for White Salmon River salmon will rely heavily on results of research and be guided by ongoing monitoring and evaluation.

10.4 Estuary Module RME

The *Columbia River Estuary ESA Recovery Plan Module for Salmon and Steelhead* (NMFS 2011a) also includes a chapter that describes RME needed to assess juvenile salmonid performance in the estuary and to evaluate the effectiveness of the 23 management actions described in the module. Like the management unit RME plans, this chapter notes the need for various types of monitoring (status and trends, action effectiveness research, critical uncertainties research, implementation and compliance monitoring) and for an adaptive management approach. It also discusses the need for coordination of monitoring efforts and for data and information management, synthesis, reporting, and evaluation. The estuary module RME chapter identifies RME needs associated with each management action in the module; describes existing monitoring plans, programs, and projects that relate to those needs; and identifies gaps and potential projects to fill those gaps.

[4] PacifiCorp breached Condit Dam in October 2011 and is expected to completely remove the dam by August 2012. Specific actions to improve habitat and monitor results will be determined once post-removal habitat conditions have been evaluated.

Monitoring for the estuary module will build on ongoing efforts, particularly efforts established under the *Research, Monitoring, and Evaluation for the Federal Columbia River Estuary Program* (ERME) (Johnson et al. 2008). The ERME monitoring plan forms the basis for estuary RME in the 2008 Federal Columbia River Power System Biological Opinion (NMFS 2008f) and the 2010 FCRPS Supplemental Biological Opinion (NMFS 2010a).

In addition to the ERME plan, other monitoring plans and guidance documents applicable to estuary RME are listed in the module. To implement these existing monitoring plans, a number of monitoring programs and projects are already under way in the estuary. The module identifies these programs and projects and relates them to the RME needs for each of the 23 management actions in the module, identifies a number of gaps, and suggests projects to fill those gaps. For each monitoring need, the module also recommends sampling design, spatial and temporal scale, variables to be measured, measurement protocols, variables to be derived, analyses needed, and possible implementing and funding entities.

As implementation of monitoring programs proceeds in the estuary and tributaries, there will be a need to ensure appropriate integration. For example, are monitoring designs compatible and/or comparable, are methods compatible or comparable, and are RME efforts addressing recovery plan questions?

10.5 RME in Biological Opinions and Records of Decision

Several Federal agencies have natural resource responsibilities related to the ESA and rely on biological opinions and issue records of decision that include RME that may be relevant to salmon recovery. Efforts to develop and coordinate recovery plan monitoring in the Lower Columbia subdomain should consider how RME needs and recommendations outlined in such documents could help fulfill recovery plan monitoring needs. Similarly, in proposing RME activities in biological assessments and records of decision, Federal agencies should consider the context of recovery plan monitoring needs.

Examples of relevant biological opinions include those for Federal Energy Regulatory Commission relicensing settlement agreements, harvest management decisions, and habitat actions, particularly large-scale actions. The 2008 Federal Columbia River Power System Biological Opinion and its 2010 Supplement, including the FCRPS Adaptive Management Implementation Plan (AMIP) (NMFS 2009c), along with associated RME work groups, are also relevant in the Lower Columbia, although less so than in the interior of the Columbia Basin.

10.6 Regional Coordination Efforts

Described briefly below are some of the regional entities that serve as a catalyst or provide forums for regional coordination of monitoring efforts. Such coordination efforts take place within the context of the RME guidance documents described above, in Section 10.2, and the management unit RME plans described above, in Section 10.3:

- **The Bonneville Power Administration and Northwest Power and Conservation Council**. The Bonneville Power Administration (BPA) is a major funding source for salmon recovery projects in the Columbia Basin as part of its obligation to mitigate the effects of the operation of the FCRPS on fish and wildlife. The Northwest Power and Conservation Council (NPCC) plays an important role in deciding which projects BPA should fund. As such, these two organizations function as coordinators of RME, both in terms of the RME actions they fund and the information-sharing processes they initiate or approve. For more information, see http://efw.bpa.gov/IntegratedFWP/anadfishresearch.aspx and http://www.nwcouncil.org/fw/.

- **The Columbia Basin Fish and Wildlife Authority**. The Columbia Basin Fish and Wildlife Authority (CBFWA) provides a venue for representatives of the states and tribes to work toward comprehensive and effective planning and implementation of fish and wildlife programs in the Columbia Basin. CBFWA's role includes evaluating monitoring needs and making recommendations to the NPCC and BPA on project funding. CBFWA is also a central source for information and news on status and trends of fish and wildlife in the Columbia Basin. For more information, see http://www.cbfwa.org/index.cfm.

- **The Pacific Northwest Aquatic Monitoring Partnership**. The Pacific Northwest Aquatic Monitoring Partnership (PNAMP) is a coordinating forum whose primary mission is to encourage standardization of monitoring methods among state, Federal, and tribal aquatic habitat and salmonid monitoring programs. PNAMP partners strive to improve communication and sharing of resources and data, and they work toward compatible monitoring efforts that will ultimately provide increased scientific credibility, cost-effective use of limited funds, and greater accountability to stakeholders. They develop and advance recommendations for consideration and potential adoption by participating agencies. The PNAMP effort is funded by in-kind services and modest funding from various agencies. A PNAMP demonstration project on Integrated Status and Trends Monitoring is under way in the Lower Columbia subdomain. For more information, see http://www.pnamp.org/.

- **Integrated Status and Effectiveness Monitoring Program**. The Integrated Status and Effectiveness Monitoring Program (ISEMP) is a scientific group working on four intensively monitored watersheds to test and evaluate methods for status and trends monitoring and effectiveness monitoring. It is hoped that the group's results will help others choose and design monitoring programs more effectively. For more information, see http://www.nwfsc.noaa.gov/research/divisions/cbd/mathbio/isemp/index.cfm.

- **FCRPS Biological Opinion Work Groups**. As noted above (in Section 10.2.3.2), completion of the 2008 Biological Opinion on the operation of the Federal Columbia River Power System (FCRPS) stimulated collaboration related to RME in the Columbia Basin, including the mainstem lower Columbia River and estuary. FCRPS Biological Opinion work groups were formed and tasked with determining how best to implement the recommendations in the Biological Opinion and how to conduct related RME. These groups provide wide-reaching catalysts for RME coordination. Because these work groups are ongoing and are evaluating agency proposals for funding, they may create the impetus for future coordination of activities for the Lower Columbia subdomain.

One effort that grew out of this coordination was the Anadromous Salmonid Monitoring Strategy (ASMS). The ASMS was a collaborative process in which Columbia Basin fish management agencies and tribes had an opportunity to react to work group recommendations from the Bonneville Power Administration, U.S. Army Corps of Engineers, U.S. Bureau of Reclamation, and other state and Federal agencies that monitor anadromous salmonids and/or their habitat. This interaction led to consensus on monitoring approaches.

Of the above coordination efforts, the Anadromous Salmonid Monitoring Strategy and PNAMP Integrated Status and Trends Monitoring Demonstration Project are particularly relevant in the Lower Columbia recovery subdomain. They are described in more detail below.

10.6.1 Anadromous Salmonid Monitoring Strategy (ASMS)

The Anadromous Salmonid Monitoring Strategy (ASMS) grew out of the Columbia Basin Coordinated Anadromous Monitoring Workshop, which BPA, CBFWA, NMFS, and the NPCC convened in Skamania, Washington, in October and November 2009. The purposes of the workshop were to develop a coordinated anadromous fish monitoring strategy for the Columbia Basin, to reach agreement among participants on an efficient and effective framework for monitoring, and to outline a specific implementation strategy.

The focus of the workshop was the monitoring of population status and trends using VSP criteria, of habitat action effectiveness, and of salmon hatchery effectiveness. Attendees used general guidelines for monitoring study design and for quality standards in each of these topics (primarily these guidelines were drawn from the Crawford and Rumsey [2011] RME guidance document) and collaborated to develop a monitoring strategy for each of four regions within the Columbia Basin, including the Lower Columbia region. In developing the strategies, participants evaluated inventories of all current monitoring work and identified overlaps and gaps for VSP, habitat effectiveness, and hatchery effectiveness data. From these inventories and evaluations, they developed a final, prioritized strategy. The framework and strategy are intended to address the needs of the NPCC's Fish and Wildlife Program and the 2008 FCRPS Biological Opinion and its 2010 Supplement and to contribute to ESA recovery plan and other regional fisheries management monitoring needs.

The ASMS (available at http://www.cbfwa.org/AMS/FinalDocs.cfm) contains the following elements relevant to the Lower Columbia subdomain:

- Lower Columbia subregion monitoring strategy
- Populations targeted for habitat status and trend and fish-in/fish-out monitoring, which will be used to assess habitat action effectiveness

- Critical monitoring projects, monitoring strategy, prioritized monitoring gaps, recommendations for addressing monitoring gaps under the FCRPS Reasonable and Prudent Alternative (RPA), prioritized projects (as of 2009) to be continued as-is or with modifications, and new funding proposals and estimated costs to address monitoring gaps

Co-managers subscribing to this strategy include the Oregon Department of Fish and Wildlife and the Washington Department of Fish and Wildlife. The Lower Columbia Fish Recovery Board also participated in the discussions and subscribes to the strategy. The ASMS products helped to identify gaps in population-scale adult abundance and smolt monitoring in the Lower Columbia subdomain and to obtain funding to fill those gaps. Additional effort, coordination, and funding will be needed to complete a comprehensive monitoring program for the Lower Columbia subdomain that includes the full range of monitoring needed for this recovery plan (e.g., monitoring of population-level spatial structure and diversity, monitoring of habitat status and trends at various scales, and action effectiveness monitoring).

The general ASMS approach for the Lower Columbia subdomain is as follows:

- **Viable salmonid population criteria:** Conduct annual surveys of natural- and hatchery-origin spawner abundance at the population scale to facilitate assessment of productivity, diversity, and distribution. Conduct annual surveys of juvenile density and distribution at the stratum scale; conduct life cycle (fish-in/fish-out) monitoring in at least one subwatershed per stratum.

- **Habitat:** Conduct annual generalized random tessellation stratified (GRTS)-based habitat surveys at the stratum scale; do pre- and post monitoring at habitat restoration sites, and use intensively monitored watersheds. (An intensively monitored watershed was initiated in the Mill/Abernathy/Germany subbasin of the Lower Columbia subdomain in 2003 with funds from NMFS and the Washington Salmon Recovery Funding Board. For the IMW to be effective in meeting its goals, funding should be maintained for monitoring and for implementation of restoration treatments of sufficient scope and intensity to provide detectable fish and habitat responses.

- **Hatchery effectiveness:** Monitor the effects of segregated and integrated hatchery programs, the coded-wire tag program, relative reproductive success, natural- and hatchery-origin spawner abundance, and residualism/ecological interactions.

WDFW and ODFW currently use slightly different approaches to monitor VSP criteria, particularly adult abundance. WDFW estimates of adult abundance have been based on expansions from fish surveys or redd counts combined with mark-recapture studies or from monitoring at weirs. In most cases ODFW's current redd surveys are GRTS-based, which facilitates evaluation of the precision and certainty of the adult abundance estimates. Both agencies are working through the PNAMP Integrated Status and Trends Monitoring program (see below) to improve integration of existing and new monitoring efforts for status and trends.

10.6.2 PNAMP Integrated Status and Trend Monitoring Demonstration Project

The Pacific Northwest Aquatic Monitoring Partnership's (PNAMP) Integrated Status and Trend Monitoring (ISTM) project is intended to demonstrate approaches for and the utility of integrating the collection of information to address multi-scale questions about the status and trends of fish (ESA-listed salmon, steelhead, and, potentially, bull trout), and physical, chemical, and biological attributes in stream networks. The overall intent is to assist PNAMP's participating members in developing strategic action plans for monitoring in the bi-state lower Columbia River demonstration area, as well as to demonstrate the general approach to developing such plans for other areas in the Pacific Northwest. The ISTM effort will provide entities tasked with monitoring fish populations and aquatic habitat in the Pacific Northwest with a roadmap for integration of scientifically sound monitoring programs intended to meet the needs of decision makers and managers. Specifically, the ISTM project will apply this approach and develop recommendations for integrated monitoring plans for ESA-listed salmon and steelhead and their habitats in the Lower Columbia subdomain.

A major objective of the ISTM project is to apply a "master sample" concept to the selection of sampling locations in the Lower Columbia subdomain. The project is being accomplished using a collaborative approach that involves PNAMP members and other local partners, including LCFRB, WDFW, and ODFW, who plan to use the resulting monitoring designs in the implementation of their RME plans. The master sample concept, along with other monitoring and monitoring design tools, has broad applicability to address status and trends questions in the estuarine and near-shore marine areas (area-based master sample), in addition to the status and trends of attributes along linear stream networks.

Other goals of the program include the following:

- Develop a coordinated VSP monitoring program that addresses key regional monitoring questions in a study design of sufficient quality and quantity to determine the status of Lower Columbia River salmon and steelhead.
- Develop a habitat status and trends monitoring design for the Lower Columbia subdomain.
- Identify and prioritize decisions, questions, and objectives.
- Evaluate the extent to which existing programs align with these decisions, questions, and objectives.
- Identify the most appropriate monitoring design to inform priority decisions.
- Use trade-off analysis to develop specific recommendations for monitoring.
- Recommend implementation and reporting mechanisms.

10.7 Additional Needs for RME in the Lower Columbia

Continued challenges in the Lower Columbia subdomain relate to efforts to develop an integrated, comprehensive RME system for the subdomain that is consistent with recovery plan needs and efforts to design data management and integration systems. There is also a need for funding to adequately implement the RME recommendations of the management unit recovery plans.

10.7.1 Integrated RME Program

The overall challenge in the Lower Columbia subdomain is to continue the process begun by CBFWA and NMFS in 2009 to integrate and coordinate the many RME efforts under way and to develop a systematically designed regional RME program. Such a program will help ensure that we have the information needed to assess salmon and steelhead status and the status of habitat and other threats and to ensure that we are using resources appropriately and efficiently. Such integration and coordination efforts should occur within the context of the full range of monitoring needs identified in recovery plans.

10.7.2 Data Management and Integration

Data management and integration also continue to pose challenges in the Lower Columbia subdomain and entire Columbia Basin. Through CBFWA, a collaborative effort is under way to develop assessment and data sharing strategies for meeting regional reporting requirements within each subregion of the ASMS. This effort will also identify gaps in data management and sharing capacities and establish strategies to close those gaps. This effort will address key questions such as how data will be shared, which data dictionary will be used, and what mechanisms will be developed to ensure that consistent evaluations, calculations, and metadata are used and documented (Columbia Basin Fish and Wildlife Authority 2010).

Such a strategy is needed to ensure effective evaluation of the FCRPS Biological Opinion, effective evaluation of recovery plan implementation and progress toward the recovery of ESA-listed salmon and steelhead, and effective implementation of the anadromous salmonid elements of the Columbia River Basin Fish and Wildlife Program. If successful, this data sharing strategy will provide the framework and technical tools to allow data sharing across disparate systems from the local level to the regional level; it also will ensure that comparable data from different sources can be combined to facilitate assessment at the regional scale.

10.8 Research on Critical Uncertainties

As noted in Section 10.3, the management unit recovery plans have identified comprehensive lists of critical uncertainties and research, monitoring, and evaluation needs. The White Salmon and Washington management unit plans have discrete sections on critical uncertainties for all of the ESUs in general (see Section 8.3 of NMFS 2011b, pp. 8-4 through 8-6, and Section 9.6 of LCFRB 2010a, pp. 9-68 through 9-73), while the Oregon management unit plan embeds relevant critical uncertainties within subsections on monitoring and evaluation needs related to the four VSP parameters and five ESA listing factors (see Sections 8.4 and 8.5, respectively, of ODFW 2010). In addition, in June 2010, the Lower Columbia Fish Recovery Board completed the *Research, Monitoring, and Evaluation Program for Lower Columbia Salmon and Steelhead* as a companion to its recovery plan (LCFRB 2010b). This document also describes critical uncertainties.

The species chapters of this recovery plan contain preliminary lists of priority critical uncertainties for each species (see Sections 6.6.8, 7.4.3.8, 7.5.3.8, 7.6.3.6, 8.6.8, and 9.6.7). These preliminary priorities were identified by Oregon and Washington recovery planners and NMFS Northwest Regional Office and Northwest Fisheries Science Center staff during a November 2010 workshop. They are preliminary priorities only (and are not in ranked order); additional discussion among local recovery planners and NMFS staff will be needed to finalize future research and monitoring priorities for Lower Columbia River salmon and steelhead. NMFS expects to work with management unit recovery planners to finalize research and monitoring priorities and to ensure that results are incorporated into future 5-year reviews (see Section 10.9).

The work in the management unit plans and the preliminary priorities identified in this recovery plan will provide the basis for continuing discussion of how to prioritize funds and activities for monitoring and research in the lower Columbia Basin.

10.9 RME and ESA 5-Year Reviews

The ESA requires NMFS to assess the status of listed species every 5 years. NMFS completed the most recent 5-year review in 2011 (76 *Federal Register* 50448, NMFS 2011c). NMFS will work with recovery plan implementers and other entities to link prioritization of RME efforts to products that will inform these 5-year reviews in the future.

The Oregon, Washington, and White Salmon management unit plans identify initial monitoring and evaluation actions intended to produce information needed to further refine particular strategies or to validate key assumptions behind recovery objectives. For example, the Oregon management unit plan (ODFW 2010) highlights key uncertainties regarding historical and current population structure in the Gorge strata and calls for additional analysis to refine the identification of historical population structure by the WLC TRT. The White Salmon management unit plan (NMFS 2011b) highlights the need for an immediate monitoring effort to evaluate fish recolonization above the former Condit Dam site. Both the Oregon and Washington management unit plans call for a review of methods for assessing population status with the intent of improving the methods to ensure that progress toward recovery objectives can be effectively evaluated. The Oregon and Washington management unit plans also both call for developing—and periodically reviewing and updating—implementation plans for recovery actions (including RME). NMFS anticipates working with the parties involved in these efforts to prioritize and set timelines for these RME tasks to ensure that information is developed and made available for consideration during future 5-year reviews.

11. Implementation and Coordination

Recovery plan implementation involves many entities and stakeholders, and the needs for coordination are complex and occur at multiple levels. For instance, implementation and coordination needs exist at the management unit and subdomain levels and involve government entities at the Federal, state, tribal, and local levels and also non-governmental entities. Coordination at the subdomain level is further complicated by the bi-state nature of the Lower Columbia subdomain, the need for coordination on issues of regional scope, and the need for close coordination with implementers of estuary recovery actions.

Coordination needs may differ depending on the type and scale of action in question. For instance, habitat actions require extensive local coordination but also coordination at the ESU or DPS level to ensure that overall recovery needs are being met. Similarly, although many funding decisions are made locally, there is a need for coordination of funding sources at the subdomain scale to ensure the most effective use of limited funds. Recovery strategies and actions related to harvest and hatcheries are another example of actions that require coordination at both state and subdomain scales and with NMFS and other entities.

In general, the management unit plans are the primary documents guiding implementation in the Lower Columbia subdomain. Coordination at the subdomain scale will occur as needed and will be achieved primarily through the Lower Columbia Recovery Plan Implementation Steering Committee, which will be the successor to the Lower Columbia Recovery Planning Steering Committee, which NMFS convened to guide development of this recovery plan and which will continue on to coordinate implementation.

This chapter presents NMFS' vision for recovery plan implementation, defines implementation responsibilities for NMFS and the management units, and describes how implementation of this recovery plan will be structured and coordinated.

11.1 NMFS' Vision for Recovery Implementation

In general, NMFS' vision for recovery implementation is that recovery plan actions are carried out in a cooperative and collaborative manner so that recovery and delisting occur (NMFS 2008d). NMFS' strategic goals to achieve that vision are as follows:

- Sustain local support and momentum for recovery implementation.
- Implement recovery plan actions within the time periods specified in each plan.
- Encourage others to use their authorities to implement recovery plan actions.
- Ensure that the implemented actions contribute to recovery.
- Provide accurate assessments of species status and trends, limiting factors, and threats.

NMFS' approach to achieving these goals is as follows:

- Support local efforts by using domain teams to coordinate internally and externally and encourage recovery plan implementation.[1]
- Use recovery plans to guide regulatory decision making.
- Provide leadership in regional forums to develop research, monitoring, and evaluation processes that track recovery action effectiveness and status and trends at the population and ESU levels.
- Provide periodic reports on species status and trends, limiting factors, threats, and plan implementation status.
- Staff and support the Lower Columbia Recovery Plan Implementation Steering Committee

NMFS will carry out its vision, goals, and strategic approach to recovery for the Lower Columbia River ESUs and DPS by working in partnership with the Lower Columbia Recovery Plan Implementation Steering Committee and the management units.

11.2 Prioritizing Recovery Actions

Prioritizing recovery actions is an important part of implementation of this recovery plan. Although the management unit plans establish population priorities and in some cases identify specific sites or reaches for implementation of tributary habitat actions, additional prioritization work is needed at both the management unit and subdomain levels, both within and among threat categories. The sections below describe how the management unit plans approached questions of prioritization and offer perspectives for potential consideration during implementation of the recovery plan.

11.2.1 Prioritizing Populations

As described in Section 3.1.3, management unit recovery planners developed a recovery scenario for each ESU that designates individual population goals at three levels of contribution to recovery: primary, contributing, and stabilizing. Populations designated as primary need to be restored to viability and are in many ways the foundation for ESU recovery. It is likely that primary populations will be prioritized for implementation of recovery actions, and actions benefitting multiple primary populations may be given highest priority. However, the management unit plans are clear that no population is unimportant to recovery. Regardless of whether a population is designated as primary, contributing, or stabilizing, it must achieve the status designated in the recovery scenario if the ESU as a whole is to recover. Recovery actions will be needed even for those populations designated as stabilizing, to maintain them at their baseline persistence probability.

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[1] Domain teams are an organizational structure internal to NMFS whose purpose is to coordinate recovery plan completion and implementation. The teams promote consistency in internal decision making and work with Federal, state, tribal, and local recovery parties to achieve recovery plan objectives.

11.2.2 Geographic Priorities

Establishing priorities at the stream reach scale is useful in identifying and sequencing habitat protection and restoration measures. All of the management unit plans identify site-specific tributary habitat actions for recovery. The Washington management unit plan prioritized tributary habitat actions by stream reach based on the needs of all salmon and steelhead populations, collectively, within a particular subbasin. The Oregon management unit plan did some population-specific prioritization based on where an action will have the greatest beneficial effect and where implementation is most feasible, but for many Oregon subbasin additional assessment is needed to determine protection and restoration priorities at a meaningful spatial scale (ODFW 2010). The White Salmon also identifies areas as a high priority for habitat actions but points to the need for additional information to identify and prioritize specific habitat actions (NMFS 2011b). In each case, the priority sites or reaches within each subbasin are not ranked against each other; rather, the management unit plans considered them to together be the highest priority areas for implementation of tributary habitat actions within each subbasin.

Oregon recovery planners determined locations for tributary habitat actions based on reach-scale habitat assessments or, when assessments were unavailable, professional judgment (ODFW 2010). For salmon and steelhead populations in subbasins that lack a reach-scale habitat assessment, the Oregon management unit plan recommends that an assessment be conducted to better define the highest priority areas for implementation of recovery actions (ODFW 2010).

Washington recovery planners used habitat assessment and modeling tools to assess the significance of each stream reach to net production of an individual species within a subbasin.[2] From this assessment, recovery planners identified high-, medium-, and low-priority reaches for each species and then placed reaches into one of four tiers, taking into consideration both the relative importance of a reach within a population and each fish population's importance relative to regional recovery objectives (LCFRB 2010a). This process yielded a four-tier, multi-species prioritization of stream reaches within each subbasin.

The White Salmon management unit plan identifies specific areas as high-priority reaches for habitat protection and restoration based on the expected distribution of salmon and steelhead species within the subbasin. Priority reaches were determined using information from current literature (NMFS 2011b).

The *Columbia River Estuary ESA Recovery Plan Module for Salmon and Steelhead* (NMFS 2011a) identifies priority reaches for each management action it analyzes (see Table 5-6 of NMFS 2011a). However, the estuary module refrains from explicitly prioritizing actions because it considers all of the management actions it identifies as important in improving the survival of juvenile salmonids in the Columbia River estuary and plume. The module does identify actions likely to be most beneficial to stream-type and ocean-type salmonids and actions that are most cost-effective (see Tables 7-2, 7-3, and 7-5 of NMFS 2011a); these analyses take into account the probable implementation constraints

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[2] For more detail, see p. 3-30 of LCFRB (2010a).

for each action. The module also notes that a logical first step in implementation would be a conversation among all relevant entities and stakeholders to discuss near-term implementation priorities, with a goal of developing a 5-year implementation plan that provides specificity and certainty regarding near-term actions and that identifies lead entities for implementation of specific actions or projects.

11.2.3 Prioritizing Actions

Because the Oregon and Washington management unit plans consider all of the actions they identify as significant for recovery and thus a high priority,[3] they defer detailed prioritization of actions to the implementation phase of recovery. Many decisions about prioritization will be made in the process of developing implementation schedules (see Section 11.3.2). For Oregon populations, an implementation team is expected to develop 3-year implementation schedules that outline priorities for the upcoming years; implementing entities then will use the action priorities outlined in the implementation schedules to identify projects for implementation and seek funding for those projects (ODFW 2010). Similarly, high-priority actions for Washington populations will be identified in a series of 6-year implementation work schedules that will include schedules, costs, and constraints and identify responsibilities. The Lower Columbia Fish Recovery Board, working with a steering committee, will facilitate and coordinate efforts among oversight and implementing partners; this will include setting priorities (LCFRB 2010a). The Washington management unit plan notes that priorities are expected to evolve over time based on new information, progress in implementation, and the adaptive management process.

Both the Oregon and White Salmon management unit plans offer some guidance on how actions might be prioritized, either during the implementation phase or as an aid in identifying actions that need to be implemented immediately to reduce near-term risks. The White Salmon management unit plan recommends that projects be prioritized for funding based on a balance of biological benefit, cost, and feasibility of implementation, with the highest funding priority given to projects that address primary limiting factors, have high biological benefit, are relatively inexpensive, and are feasible (NMFS 2011b). The Oregon management unit plan suggests that the following be considered high priorities as actions are identified for implementation and funding:

- Actions for populations that must achieve viability status (i.e., primary populations, which are targeted for high or very high persistence priority)
- Actions that address a threat reduction need
- Actions that address a primary limiting factor
- Actions that address a relatively large gap between baseline and target status, or that address a relatively large threat reduction need
- Actions in locations that will result in or protect accessible and connected high-quality habitat

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[3] See p. 388 of ODFW (2010) and p. 69 of the overview to LCFRB (2010).

- Restoration actions in high intrinsic potential (IP) locations[4]
- Actions intended to protect threatened high-quality or highly productive habitat
- Actions that provide resiliency against climate change
- Actions in areas that are believed to result in a significant improvement in survival
- Actions that address those threat categories that require the most improvement[5]

For more discussion of prioritization of actions, see p. 387 of ODFW (2010).

The Washington management unit plan does not explicitly address prioritization of actions across threat categories.

11.3 Organizational Structure and Implementation Roles and Responsibilities

Effectively implementing recovery actions for Lower Columbia River Chinook and coho salmon, Lower Columbia River steelhead, and Columbia River chum salmon will require coordinating the actions of diverse private, local, state, tribal, and Federal parties across two states. Coordination needs within the Lower Columbia subdomain exist at multiple levels. At the subdomain level, the Lower Columbia Recovery Plan Implementation Steering Committee (LC Steering Committee) will lead efforts to coordinate the actions of these many players, working with subcommittees and other regional forums as needed. At the management unit level, Washington's Lower Columbia Fish Recovery Board will lead implementation in the Washington management unit and the Oregon Department of Fish and Wildlife implementation coordinator and stakeholder team will lead recovery plan implementation in Oregon, supported by the governance structure of the Oregon Plan for Salmon and Watersheds. In the White Salmon subbasin, the Washington Gorge Implementation Team, coordinated by NMFS, currently is tracking progress on implementation of the White Salmon management unit plan (NMFS 2011b) and will also coordinate among the multiple entities involved in implementation there. Members of the Washington Gorge Implementation Team include the Yakama Nation, state and local agencies, local conservation districts, and other entities.

Because the planning areas of the Washington and Oregon management units overlap in tidal portions of tributaries with the planning area of the *Columbia River Estuary ESA Recovery Plan Module for Salmon and Steelhead* (NMFS 2011a), there is also a need for coordination between the management units and entities implementing estuary recovery actions. Finally, NMFS has a unique role in recovery plan implementation. These various coordinating forums and roles are described below.

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[4] See ODFW (2010) p. 205, Table 6-39, for a description of high intrinsic potential areas.
[5] This is the only specific guidance in the management unit plans regarding prioritization of actions across the threat categories.

11.3.1 Subdomain Level: Lower Columbia Recovery Plan Implementation Steering Committee

The Lower Columbia Recovery Plan Implementation Steering Committee (LC Steering Committee) will serve as a forum for communication and coordination on a bi-state level, among management units, with entities implementing estuary recovery actions, and with other regional forums. Figure 11-1 shows the makeup of the steering committee and its relationship to other regional entities.

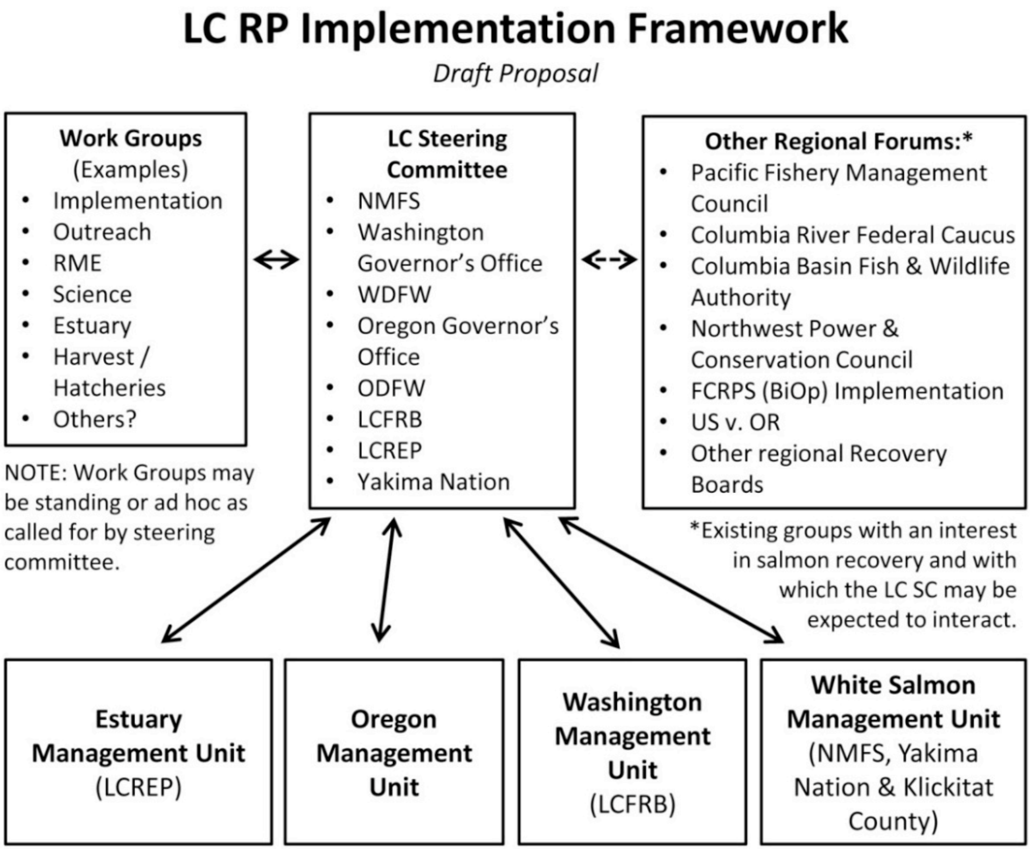

Figure 11-1. *Lower Columbia Recovery Plan Implementation Organizational Structure*

Functions of the steering committee include the following:

- Facilitating communication and coordination between states and among management units on issues related to implementation of recovery actions
- Facilitating communication and coordination with other regional entities and forums on issues related to implementation of recovery actions
- Increasing awareness of the recovery plan and advocating for implementation of recovery actions
- Providing recommendations for prioritization of recovery efforts and the use of resources

- Advancing the application of adaptive management to recovery efforts and the coordination of RME efforts
- Identifying and coordinating funding opportunities for recovery actions and RME
- Convening and overseeing issue-specific work groups as needed
- Providing an interface with the Recovery Implementation Science Team convened by NMFS

The committee will also serve as a link to other regional forums that have an interest in salmon recovery, such as the Northwest Power and Conservation Council, Columbia Basin Federal Caucus, Pacific Fisheries Management Council, and Columbia Basin Fish and Wildlife Authority.

A key related program is implementation of the Northwest Power and Conservation Council's Fish and Wildlife Program subbasin management plans. NMFS, in full coordination with management unit leads, fishery management agencies, and tribes, should ensure that the project selection process for the NPCC's subbasin plans within the management unit is consistent with the ESA priority actions in this recovery plan and the implementation schedules. The steering committee may serve as a coordinating forum for this effort.

11.3.1.1 Organization/Membership

Members of the LC Steering Committee will include, but not be limited to, NMFS, the Lower Columbia Fish Recovery Board, the Washington Governor's Salmon Recovery Office, the Washington Department of Fish and Wildlife, the Oregon Department of Fish and Wildlife, the Oregon Governor's Office, the Lower Columbia River Estuary Partnership, and the Yakama Nation. Representatives of these entities constituted the steering committee during recovery plan development. As appropriate, these members may decide to include additional entities.

11.3.1.2 Operations

The LC Steering Committee will meet semi-annually or as needed. Policy issues will be resolved at the appropriate level, be it within the steering committee or within respective local, state, Federal, and tribal authorities and agencies.

NMFS will serve as the convening partner and provide facilitation, venues, and other needs associated with convening meetings. Participating agencies and parties will fund their staff's involvement.

11.3.1.3 Areas of Focus

The LC Steering Committee will focus on four functional areas: (1) policy, (2) implementation, (3) research, monitoring, and evaluation, and (4) outreach. For these topic areas, the committee may establish work groups either as standing subcommittees or on an ad hoc basis. The decision to establish such subgroups will be determined based on the anticipated scope of work for each topic, LC Steering Committee members' available staffing and funding, and other considerations, as the LC Steering Committee considers appropriate. The intent of these efforts is to support coordinated and effective implementation of this recovery plan. More detail on each functional area is provided below.

Policy

The LC Steering Committee will serve as a forum for coordinating and discussing policy issues at the subdomain level. The committee may elect to organize subgroups for specific issues. Focus areas could include identifying issues where joint advocacy would support implementation or effectiveness of Lower Columbia recovery actions; providing recovery-plan perspective and input on regulatory and management decisions that affect the Lower Columbia River ESUs and DPS; tracking the status of Lower Columbia-related activities in the NPCC, Federal Caucus, FCRPS litigation, Pacific Fisheries Management Council, and other regional forums; and, as appropriate, developing policy recommendations on specific issues. Subgroups on specific issues will be convened as appropriate.

Implementation

Implementation focus areas for the LC Steering Committee will include discussing the progress of implementation progress and coordinating and resolving issues related to implementation of actions that are regional in scope. Specific implementation-related activities could include tracking the status of implementation schedules for each management unit, helping to resolve issues related to Lower Columbia River harvest and hatchery actions, sharing significant accomplishments, promoting information and technology transfer, communicating priorities for future action, and identifying opportunities where shared advocacy and coordination would help implement key recovery actions. Subgroups may be convened and will consist of staff from management unit recovery planning entities and representatives from partners in funding programs and recovery efforts.

Research, Monitoring, and Evaluation

The LC Steering Committee will ensure that RME activities are appropriately coordinated throughout the subdomain. RME activities in which the committee engages could include ensuring that new information on VSP parameters is adequately reviewed and compiled and that population status summaries are updated accordingly, identifying high-priority knowledge gaps across ESUs and coordinating efforts to address them, identifying how to track threats criteria and providing annual summaries of applicable data, and seeking efficiencies across the subdomain. The LC Steering Committee will convene subgroups on these matters as needed and appropriate.

Outreach

Activities in this focus area will include developing and/or supporting outreach related to recovery of the Lower Columbia River ESUs and DP, such as drafting or reviewing NMFS' biennial reports to Congress and updates to key decision makers (elected officials, agency heads, etc). Subgroups consisting of representatives from state governors' staffs, co-manager policy leads, management unit representatives, and/or partner agency policy staff may be convened.

11.3.2 Management Unit Level

Each management unit planning lead has proposed an organizational structure for plan implementation at the management unit level. In Oregon and Washington, this structure is based on the structure used for development of the respective management unit recovery plans. These approaches differed somewhat and will continue to differ slightly. In Oregon, the Oregon Department of Fish and Wildlife led recovery plan development with assistance from the Oregon Governor's Natural Resources Office and the Lower Columbia River Recovery Planning Stakeholder Team. During implementation, an ODFW implementation coordinator will be the lead staff person for facilitating implementation of the recovery plan. In Washington, the Lower Columbia Fish Recovery Board developed the management unit plan and will coordinate implementation with guidance and support from the Washington Governor's Salmon Recovery Office. In the White Salmon management unit, NMFS, in coordination with the Washington Gorge Implementation Team (WAGIT), has taken the lead in coordinating implementation. NMFS encourages the formation of a Washington Gorge Area Regional Board to coordinate implementation in the White Salmon management unit, if local stakeholders determine that this is appropriate.[6]

For the purposes of implementation, the term "management unit leads" (MU leads) refers to the LCFRB, ODFW (through its Lower Columbia implementation coordinator, who will work in conjunction with Oregon's recovery implementation team) and, for the White Salmon, NMFS (through the Washington Gorge Implementation Team). The MU leads have three primary responsibilities with respect to implementation:

1. Developing implementation schedules. Each MU lead is responsible for developing an implementation schedule for that MU plan and updating the schedule as needed. Implementation schedules identify the following:

    - Recovery projects specific to plan actions for populations within the management units
    - Limiting factor(s) addressed by each project
    - Priority for completing the projects
    - Duration of and schedule for projects
    - Benefits of each project
    - Lead agency/entity to implement each population-specific project
    - Estimated cost for each project over a period of time

2. Coordinating implementation. Management unit leads are responsible for coordinating implementation of recovery actions identified in the management unit plan and implementation schedule. In this capacity, they serve to facilitate communication vertically (i.e., at different spatial scales related to recovery plan

[6] The Washington Gorge Area Regional Board could consist of representatives from Klickitat, Skamania, Yakima, and Benton counties, local landowners, the Yakama Nation, and possibly others. Such a board could also coordinate with the LCFRB.

governance) and horizontally (i.e., among related programs and interests and outside of the recovery plan governance structure) within their respective inter- and intra-agency organizational structures. Specific responsibilities include the following:

- Coordinating with Federal and state agencies, tribes, local governments, and other stakeholders
- Developing implementation strategies for and facilitating implementation of actions that require coordination among various entities. Potential activities include local outreach; provision of incentives, technical assistance, and project funding; project management; and monitoring/reporting.

3. Tracking and reporting. Management unit leads are responsible for tracking and reporting on the progress of implementation of their plan actions. Specific responsibilities include:
   - Coordinating plan monitoring within the management unit and ensuring appropriate tracking and reporting of recovery actions
   - Coordinating plan research within the management unit, reporting results, and incorporating them into adaptive management.
   - Reporting on plan progress in relation to goals, strategies, and actions, using mechanisms and processes established for tracking progress, and highlighting plan successes and needs
   - Reviewing and revising the management unit plan implementation schedule as necessary, using monitoring and research to guide actions and incorporating adaptive management as needed
   - Representing the management unit in the LC Steering Committee and relevant subgroups as necessary

Performance of these responsibilities will be influenced by the capacity, authority, and priorities of the management unit leads. Full accomplishment will likely require other support structures or processes. Not all of these duties can be accomplished initially with the resources currently available. Prioritization of initial duties will be guided by the statutory requirements of the ESA and relevant state guidance.

11.3.2.1 Oregon

Oregon's recovery plan implementation framework is intended to provide a collaborative approach to implementation, along with scientific guidance, policy direction, information exchange and coordination, and linkage to state, ESU, and regional forums. Existing forums, groups, and partnerships will serve as the basis of Oregon's implementation framework, but additional resources and funding will be needed to make it work effectively and successfully. The basic components of Oregon's implementation structure include a recovery team, an implementation coordinator, an implementation team, a technical team, and stratum teams. The implementation framework will adapt and change as necessary to adjust to funding, available resources, and implementation needs (ODFW 2010). Oregon's implementation structure is illustrated in Figure 11-2 and described below.

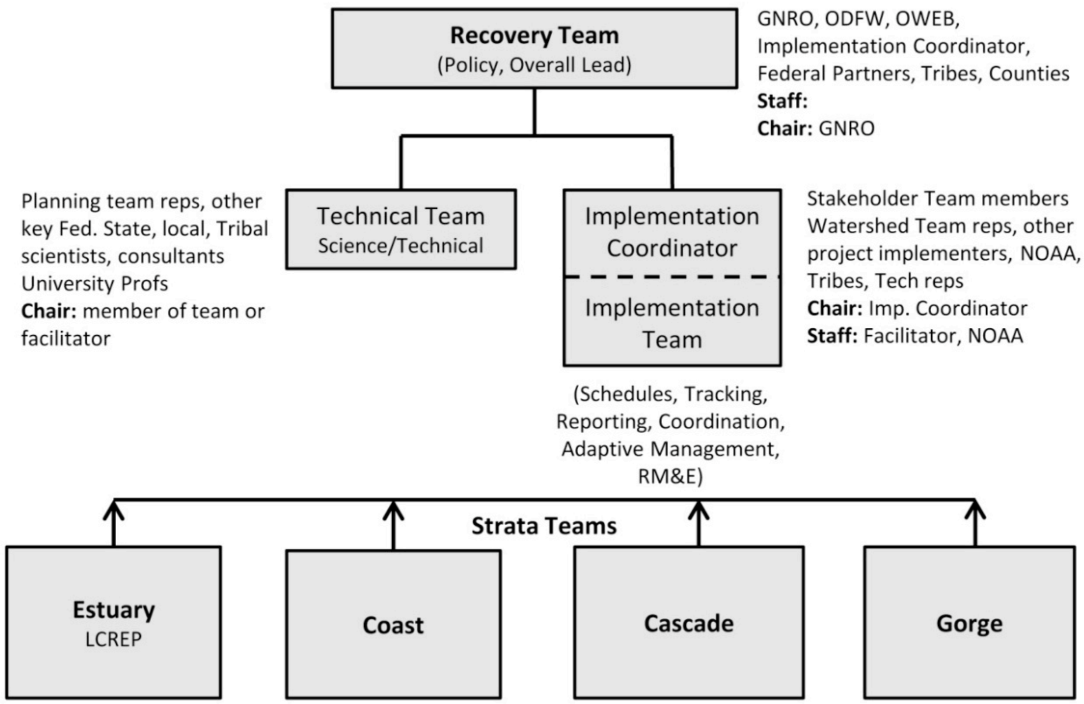

Figure 11-2. *Oregon's Organizational Implementation Structure*

Recovery Team

The recovery team provides oversight and vision for recovery plan implementation. This team is responsible for reporting to NMFS and shares accountability for species recovery in the Oregon management unit. The recovery team provides overall coordination and guidance to the technical and implementation teams, coordinates with other domain teams and the Oregon Plan core team, and serves as the state's representative to the LC Steering Committee. Members of the recovery team include the ODFW implementation coordinator and representatives from the Oregon Governor's Natural Resources Office, ODFW, the Oregon Watershed Enhancement Board, Federal agencies, and local and tribal governments. Additional membership will include interested parties from counties, Federal agencies, and non-governmental organizations. Although the recovery team serves a unique purpose and function, its members will also be on the implementation team (ODFW 2010).

Implementation Coordinator

An ODFW implementation coordinator will serve as Oregon's management unit lead for recovery plan implementation, acting under the advice and guidance of the recovery team. The implementation coordinator will work in conjunction with the implementation and stratum teams to plan, schedule, track, and report on action implementation, and—in coordination with technical teams—to develop, track, and report on RME activities. The implementation coordinator will also be a member of the recovery team. The implementation coordinator will lead the implementation team in its deliberations and actions, coordinate and lead development of 3-year implementation schedules and adaptive management processes, coordinate and communicate with watershed teams (or individual implementation entities) and the Oregon Plan regional management teams (interagency regional manager forum), and coordinate implementation of actions for which ODFW is responsible. The coordinator will also ensure that ODFW staff engaged in regional forums for hydropower, harvest, and hatchery issues (including the FCRPS Biological Opinion, *U.S. v. Oregon*, Northwest Planning and Conservation Council, and Columbia Basin Fish and Wildlife Authority) understand the content and priorities of the recovery plan so they can advocate for and use it in those forums. Actions and decisions within these forums are important in successfully implementing the recovery plan and achieving recovery of Lower Columbia River salmon and steelhead (ODFW 2010).

Implementation Team

The implementation team provides advice, recommendations, and support to the implementation coordinator, who chairs the team. The team assists in communicating and coordinating with the stratum teams or local implementation groups; developing, tracking, and reporting on 3-year implementation plans; and tracking and reporting on research and monitoring. The implementation team also facilitates the collection and exchange of information, identifies and pursues funding sources, and provides for public participation, education, and outreach.

Implementation team members include members of the LCR Stakeholder Team (i.e., cities, utilities, private forest and agriculture representatives, conservation groups, Federal representatives, watershed councils, and soil and water conservation districts), other local stakeholders, interest groups, and tribes and other governments. This diverse group represents differing perspectives, missions, and geographic areas, with the overall objective of collectively and synergistically working to achieve and advance recovery plan goals. NMFS will also participate on the implementation team (ODFW 2010).

Technical Team

The Oregon Technical Team will provide advice and guidance on technical and scientific issues related to RME, data analysis, and adaptive management that support and strengthen effective implementation of recovery plan actions. The technical team will be ad hoc and provide advice and guidance supplemental to that provided by the Oregon Plan Monitoring Team, which is an interagency monitoring forum. The technical team may include members of Oregon's recovery planning team and expert panel, as well as other key state, Federal, tribal, utility, and private scientists and biologists, consultants, and university staff as appropriate for the particular issue needing their advice and guidance. A voluntary chair will facilitate team operations (ODFW 2010).

Stratum Teams

Stratum teams will be composed of the various local entities that implement local restoration and conservation actions via their respective authorities, mandates, missions, and work plans and will include watershed councils, soil and water conservation districts, Federal and state agencies, local governments, tribes, conservation groups, and utilities. Stratum teams will be encouraged to form on a voluntary basis for a specific stratum or may already exist. In many cases, watershed councils currently serve this function, with representation from a diversity of interest and action groups. Team chairs will be voluntary, and teams will be self-directed. Collaborative teams will facilitate coordination and prioritization of actions and the exchange of information within the stratum. They will provide project information to the implementation coordinator (or members of the implementation team) to support development of 3-year implementation schedules, plans, and reports. Collectively or individually, stratum teams will promote public involvement through outreach, education, and volunteer opportunities (ODFW 2010).

11.3.2.2 Washington

The Lower Columbia Fish Recovery Board will be the lead for implementation of the Washington management unit plan, which notes that achieving recovery will require the combined and coordinated actions of other Federal and state agencies, tribal governments, and local governments, along with participation of nonprofit organizations, the business sector, and citizens. Collectively, these parties are referred to as implementing partners (LCFRB 2010a). The LCFRB organizational structure for implementation focuses on fulfilling three main functions: oversight, facilitation/coordination, and implementation. This structure is described below and illustrated in Figure 11-3.

Oversight Authorities and Functions

Key oversight bodies are entities with specific authority or responsibilities for managing the region's fish and wildlife resources. These include NMFS, the U.S. Fish and Wildlife Service, the state of Washington, the Cowlitz Tribe, the Yakama Nation, and the Northwest Power and Conservation Council.[7]

- NMFS has the primary Federal authority for the Endangered Species Act, Sustainable Fisheries Act, and Mitchell Act as they apply to salmon and steelhead.
- The Washington Governor's Office has the authority to direct and coordinate state agency actions in support of recovery. The Washington Department of Fish and Wildlife has management authority for the state's fish and wildlife resources.
- The Yakama Nation is a co-manager of fish resources with the state and Federal agencies.

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[7] Because the scope of the Washington management unit plan is broader than just salmon and steelhead and includes bull trout, among other species for which the U.S. Fish and Wildlife Service has jurisdiction, that agency is included among the implementing and oversight entities for the Washington management unit plan.

- The Northwest Power and Conservation Council oversees implementation of the program to address the effects of the Federal Columbia River Power System on fish and wildlife.

Other Federal, state, and local agencies have oversight responsibilities for water, natural resources, land management, and land use. These agencies are considered implementation partners because their responsibilities are not specific to fish management.

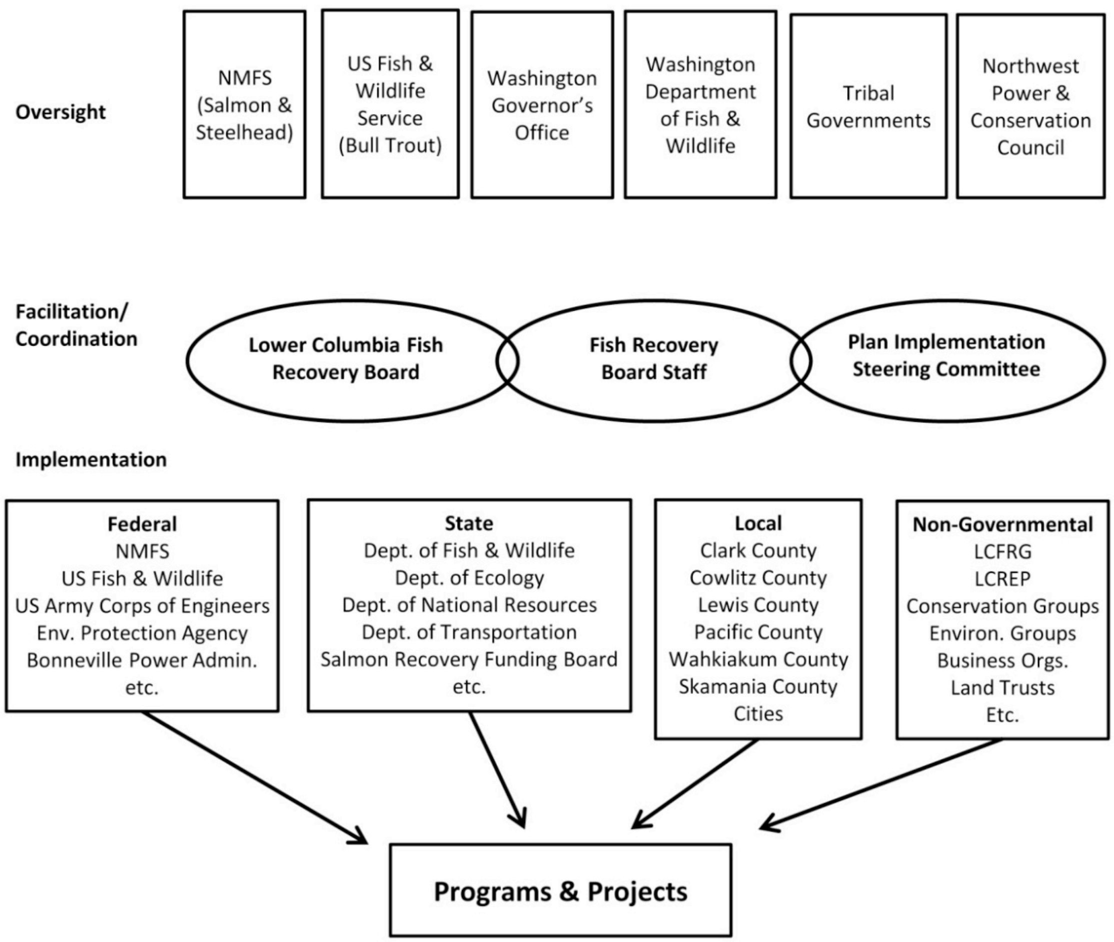

Figure 11-3. *Institutional Structure for Implementing Salmon Recovery in Washington Lower Columbia River Subbasins*

Implementation Steering Committee and Functions

The Lower Columbia Fish Recovery Board, working with a plan implementation steering committee, will facilitate and coordinate efforts of the oversight bodies and implementing partners. NMFS and the U.S. Fish and Wildlife Service, Northwest Power and Conservation Council, Lower Columbia River Estuary Partnership, Washington Department of Fish and Wildlife, Governor's Salmon Recovery Office, Washington Department of Ecology, U.S. Forest Service, counties, Cowlitz Indian Tribe, Yakama Nation, Chinook Tribe, and others will be invited to participate on the committee. The steering committee will assist the LCFRB in guiding implementation of the plan.

The steering committee will include representatives of the oversight bodies and a cross-section of implementing partners. Working groups consisting of steering committee members and other implementing partners will be established as needed to address policy or technical issues or to coordinate implementation efforts.

Key functions of the LCFRB and steering committee are as follows:

- Develop and revise a 6-year regional implementation plan.
- Assist implementation partners in developing and implementing their individual 6-year implementation plans.
- Prepare and issue clarifications or interpretations of recovery plan provisions when needed.
- Prepare and issue revisions or updates to the Washington management unit plan.[8]
- Develop and implement the regional public education and outreach program.
- Conduct implementation and biological evaluations in accordance with the adaptive management provisions and benchmarks set forth in this plan.
- Track implementation of measures, actions, programs, and projects and issue annual progress reports.
- Facilitate and assist partners in resolving technical and policy issues that arise during implementation.
- Facilitate communications and the exchange of information and data among implementation and oversight partners.
- Coordinate the collection, management, synthesis, and evaluation of fish and habitat monitoring results collected by the partners.
- Develop implementation partnerships and agreements.

Implementing Partners

Recovery actions will be implemented through the programs and projects of numerous implementing parties, some of which are shown in Figure 11-3. The functions of the implementing partners are as follows:

- Develop and implement a 6-year plan for their recovery actions.
- Monitor and report on their implementation progress to the LCFRB/steering committee.
- Advise the LCFRB/steering committee of issues or developments that affect progress.

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[8] NMFS would need to formally incorporate any substantial revisions to a management unit plan into this ESU-level recovery plan.

Each partner will set forth the tasks and schedule addressing assigned recovery actions and will document the partner's commitment to fulfilling its implementation responsibilities in 6-year implementation work schedules (see Section 11.4, "Implementation Time Frames").

The actions identified for each partner are based on the partner's mission, capabilities, responsibilities, authority, and jurisdiction. Each partner is responsible for developing and fully implementing programs to address its assigned actions. Programs are expected to be technically sound and adequately funded and staffed. In the case of regulatory programs, agencies must be committed to taking enforcement actions when necessary to achieve the desired outcome.

In some instances an implementing partner may not have the full or exclusive authority to implement a recovery action. A case in point is the setting of harvest quotas pursuant to international treaty provisions. In such instances, implementing partners will share an implementation responsibility to cooperate in working to achieve the desired outcome.

If needed for coordination, the implementation steering committee may designate a lead agency in carrying out an implementation action shared by two or more partners. Even where a single implementing partner possesses the authority to fully implement a recovery action, the action is likely to be more effectively implemented with the involvement, agreement, and support of other partners.

To achieve this level of cooperation and coordination, implementing partners are requested to identify in their 6-year implementation work schedules interrelationships with other partners that will facilitate, affect, or complement implementation of their recovery actions.

11.3.2.3 White Salmon

NMFS, in conjunction with the Washington Gorge Implementation Team (WAGIT), is coordinating recovery plan implementation in the White Salmon subbasin. Implementation is being facilitated through the various existing programs, including harvest management programs, the Yakama Nation Fish Habitat Program, Washington's Lead Entity Process, watershed planning and implementation processes initiated under state regulations and coordinated through Klickitat County, various state and local habitat and watershed programs, and the various programs administered by the conservation districts. The WAGIT draws upon and works within the many existing programs rather than developing a parallel and potentially conflicting recovery implementation process.

11.3.3 NMFS' Role

NMFS' role in the recovery of Lower Columbia River ESUs is twofold. The first is to ensure that the agency's statutory responsibilities for recovery under the ESA are met. The second is to serve as the convening partner for the LC Steering Committee, provide leadership in coordinating among management units, provide NMFS' perspective regarding recovery plan implementation, and update steering committee members on issues relevant to recovery strategies.

11.3.3.1 ESA Responsibilities

NMFS is required to see that the agency's statutory responsibilities for recovery under the ESA are met. In this capacity, NMFS is responsible for the following:

- Ensuring that the recovery plan meets ESA statutory requirements, tribal trust and treaty obligations, and agency policy guidelines
- Developing ESU-wide performance measures consistent with the recovery strategies outlined in Chapters 6 through 9
- Conducting 5-year reviews
- Making delisting determinations
- Coordinating with other Federal agencies to ensure compliance under the ESA
- Implementing recovery plans

11.3.3.2 LC Steering Committee Convening Partner

As the convener of the LC Steering Committee, the NMFS Northwest Regional Office, working through its Lower Columbia Recovery Coordinator and Domain Team, will do the following:

- Convene steering committee meetings on a regular basis (at least twice a year) and convene additional meetings as needed.
- Provide meeting facilitation services and manage the meeting process.
- Provide meeting venues.
- Prepare and distribute meeting notes and follow up on tasks agreed to by the steering committee.
- Serve as a central clearinghouse for information, to include ESU- or DPS-wide stock status, relevant Federal scientific research, and gaps in recovery efforts for each ESU or DPS.
- As requested by the LC Steering Committee, establish and facilitate state, Federal and tribal meetings necessary for the coordination of recovery activities.

11.3.4 Columbia River Estuary

The planning areas of the *Columbia River Estuary ESA Recovery Plan Module for Salmon and Steelhead* (NMFS 2011a) and the Oregon and Washington management unit plans overlap in the tidal reaches of the lower Columbia tributaries. The geographic overlap and the importance of improvements in intertidal rearing habitats for the recovery of some Lower Columbia River salmon and steelhead populations create a need in this subdomain for close coordination of estuary module implementation with implementation of the management unit plans.

Although not an officially designated management unit, the Columbia River estuary and plume, for implementation purposes, will be treated like a management unit. The Lower

Columbia River Estuary Partnership and PC Trask and Associates, Inc., developed the estuary module under contract to NMFS.

Implementation of the 23 management actions in the module will require the efforts of a variety of Federal, state, and local agencies, nonprofit organizations (such as watershed councils), private enterprises, and citizens. (Some potential implementers have been identified in Table 5-6 of the estuary module.) Although many of these entities have already been working to identify, prioritize, and implement salmon and steelhead recovery actions in the estuary and plume, effective implementation of all module actions will require additional coordination.

The first step in coordinated implementation of the module will be a conversation among all relevant entities and stakeholders to discuss near-term implementation priorities, with a goal of developing a 5-year implementation plan that provides specificity and certainty regarding near-term actions and that identifies lead entities for implementation of specific actions or projects. Given the complexities involved in implementing the full suite of module actions, this conversation also will be an opportunity to explore options for and recommend an organizational structure for coordinating and overseeing implementation of the estuary module. The Lower Columbia River Estuary Partnership, a National Estuary Program established to bring about collaboration, would be an appropriate convener of this discussion.

11.4 Implementation Time Frames

The Oregon and Washington management unit plans are 25-year plans that schedule actions throughout that time frame. The estuary recovery plan also uses a 25-year time frame for implementing its 23 management actions. The White Salmon management unit plan uses a 10-year implementation time frame for planning purposes; however, the rate of change in the river now that PacifiCorp breached Condit Dam may affect this timeline.

11.4.1 Oregon Management Unit Plan

In the Oregon management unit plan, many recovery actions are on 5-, 10-, 15-, 20-, and 25-year schedules. For priority actions, the plan requires 3-year implementation schedules with review and modifications, if needed, every 3 years. Members of the implementation team, watershed councils, and other implementing groups are encouraged to commit to the 3-year implementation schedule. Stratum teams, watershed councils, soil and water conservation districts, cities, counties, land managers and other implementers will use the action priorities outlined in the 3-year schedules to identify projects for implementation and to seek funding.

An implementation coordinator will develop a reporting process for gathering information from implementers, including government and funding entities, to develop annual reports on plan implementation that will be shared with implementers; funding entities; the implementation, recovery, and Oregon Plan teams; and the public. Annual reports will be used to assess the effectiveness of implementation at the population and ESU level. The implementation team will periodically (i.e., quarterly or annually) review progress toward implementation of priority actions and address local needs for more effective implementation. A major revision of the Oregon plan is called for after 12 years.

11.4.2 Washington Management Unit Plan

The Washington management unit plan calls for new implementation schedules to be prepared at 6-year intervals. This cycle will coincide with the 6-year adaptive management checkpoints and allow the schedules to incorporate needed modifications. Six-year schedules may be revised every 2 years based on the adaptive management implementation evaluation checkpoint.

Entities or partners already carrying out recovery actions will be asked to prepare an implementation schedule for their actions. These individual implementation work schedules will be melded into a regional implementation schedule. The LCFRB, in consultation with its steering committee, will develop a detailed template for 6-year implementation work schedules and will assist and advise partners in developing their schedule. The 6-year implementation work schedules submitted by each partner will set out tasks and schedules for addressing assigned recovery actions and document the partner's commitment to fulfilling its implementation responsibilities.

11.4.3 White Salmon Management Unit Plan

In the White Salmon management unit, the Washington Gorge Implementation Team (WAGIT) has developed a detailed implementation plan. The WAGIT meets annually to update information on ongoing actions and make recommendations regarding next steps. The annual meeting includes discussion of information gained through research, monitoring, and evaluation that will help in identifying priority recovery projects, facilitating efficient implementation of the White Salmon management unit plan, or identifying needed modifications in the plan. The implementation plan will be updated annually to reflect changes in understanding of within-subbasin processes affecting salmonid production and of the extent to which recolonization is occurring. The plan also will be updated to reflect actions initiated or completed in the prior year. Klickitat County maintains a database that tracks projects in the White Salmon subbasin.

11.4.4 Columbia River Estuary Recovery Plan Module

The *Columbia River Estuary ESA Recovery Plan Module for Salmon and Steelhead* (NMFS 2011a) includes a schedule for implementing the 23 management actions and each action's component projects. Schedule considerations are based primarily on the specific actions and the timing of component projects that depend on other projects. According to the estuary module, "developing a critical path for implementation of actions collectively is premature." A more comprehensive schedule will require knowing the level of effort and funding that will be committed to carrying out the proposed actions. The plan also notes the difficulties associated with establishing time frames when some of the actions in the 25-year plan may take decades to produce measurable effects.

11.4.5 NMFS Time Frames

NMFS is required to review the status of listed species every 5 years, prepare biennial reports to Congress, and update key decision makers, such as elected officials and agency heads.

12. Site-Specific Management Actions and Cost Estimates

ESA section 4(f)(1)(B) directs that recovery plans, to the maximum extent practicable, incorporate "a description of such site-specific management actions as may be necessary to achieve the plan's goal for the conservation and survival of the species" and "estimates of the time required and the cost to carry out those measures needed to achieve the plan's goal and to achieve intermediate steps toward that goal."

Detailed information on management actions, schedules, and cost estimates are presented in the Washington, Oregon, and White Salmon management unit plans and the *Columbia River Estuary ESA Recovery Plan Module for Salmon and Steelhead* (LCFRB 2010a, ODFW 2010, NMFS 2011b, and NMFS 2011a; see Appendixes A through D). This chapter summarizes the information contained in those documents.

12.1 Site-Specific Management Actions

The management actions presented in the management unit plans are designed to address the limiting factors and threats to species and populations found in each management unit's respective geographic area of responsibility. Site-specific management actions are discussed in detail in the appended management unit plans. Site-specific actions with respect to the Columbia River estuary and plume, passage at Bonneville Dam, predation, and flow affecting conditions in the lower Columbia River, estuary, and plume are described in the 2008 FCRPS Biological Opinion (NMFS 2008f), its 2010 Supplement (NMFS 2010a), the recovery plan hydropower module (NMFS 2008a), and the estuary module (NFMS 2011a). The management actions presented in each management unit plan and the estuary module are summarized in the subsections below. In addition, Table 12-1 presents actions that are representative of the types of site-specific actions in the management unit plans (i.e., in Chapters 7, 8, and 9 of ODFW 2010, Chapters 5 and 10 of LCFRB 2010a, and Chapter 6 of NMFS 2011b). The management unit leads will develop more detail on management actions during preparation of the implementation schedules described in Chapter 11 of this recovery plan.

Table 12-1
Representative Recovery Actions

Threat Category	Representative Actions	Limiting Factors Addressed
Tributary Habitat	• Restore degraded off-channel habitats • Streamline delivery of large wood to restoration sites • Restore degraded riparian areas through planting or fencing	Channel structure and form: Bed channel and form
	• Restore riparian areas to improve water quality, provide long-term supply of large wood to streams, and reduce impacts that alter other natural processes	Channel structure and form: Instream structural complexity
	• Place gravel for spawning (below dams) • Remove the Little Sandy River diversion (completed)	Sediment conditions and water quality[1]: Decreased sediment quantity (impaired sediment/sand routing and gravel recruitment)
	• Conduct sediment source analyses and reduce inputs • Develop/implement stormwater management plans for urban areas and roads • Identify and rectify problem legacy roads	Sediment conditions and water quality: Increased sediment quantity (turbidity from excessive fine sediment)
	• Protect intact riparian areas via easements and acquisition • Explore cooperative water conservation measures • Restore connectivity to small tributaries • Restore degraded off-channel and riparian habitat • Establish minimum ecosystem-based instream flows • Identify and halt illegal water withdrawals	Water quantity: Altered hydrology Water quantity: Decreased water quantity/downstream flows Water quantity: Altered flow timing
Estuary habitat	• Protect intact riparian areas in the estuary and restore riparian areas that are degraded • Protect remaining high-quality off-channel habitat from degradation and restore degraded areas with high intrinsic potential for high-quality habitat • Breach, lower, or relocate dikes and levees to establish or improve access to off-channel habitats • Reduce the export of sand and gravels via dredge operations by using dredged materials beneficially • Reduce entrainment and habitat effects resulting from main- and side-channel dredge activities and ship ballast intake in the estuary	Peripheral and transitional habitats: Estuary habitat quality (complexity and diversity) Peripheral and transitional habitats: Reduced macrodetrital inputs

[1] The data dictionary and limiting factors crosswalk consider turbidity as a subcategory of the water quality limiting factor and thus separately from sediment conditions, but the two limiting factors are presented together in this table because their mechanisms, causes, and effects in the lower Columbia River basin are so similar.

Threat Category	Representative Actions	Limiting Factors Addressed
	• Operate the hydrosystem to reduce the effects of reservoir surface heating, or conduct mitigation measures	Peripheral and transitional habitats: Estuary habitat quality (complexity and diversity) Peripheral and transitional habitats: Increased microdetrital inputs Water quality: Temperature
	• Protect or enhance estuary instream flows influenced by Columbia River tributary/mainstem water withdrawals and other water management actions in tributaries • Adjust the timing, magnitude, and frequency of flows (especially spring freshets) entering the estuary and plume to better reflect the natural hydrologic cycle, improve access to habitats, and provide better transport of coarse sediments and nutrients in the estuary and plume	Water quantity: Altered hydrology Habitat quantity: Anthropogenic barriers
	• Study and mitigate the effects of entrapment of fine sediment in reservoirs, to improve nourishment of the estuary and plume	Sediment conditions: Decreased sediment quantity
	• Reduce the square footage of over-water structures in the estuary • Reduce the effects of vessel wake stranding in the estuary	Peripheral and transitional habitats: Estuary habitat quality (complexity and diversity)
	• Implement pesticide and fertilizer best management practices to reduce estuarine and upstream sources of nutrients and toxic contaminants entering the estuary • Identify and reduce terrestrially and marine-based industrial, commercial, and public sources of pollutants • Restore or mitigate contaminated sites • Implement stormwater best management practices in cities and towns	Toxic contaminants in water and biota Water quality: Temperature
Hydropower	• Remove the Little Sandy water diversion (completed), Powerdale Dam on the Hood River (completed), and Condit Dam on the White Salmon River (in process) • Implement measures in the 2008 FRCRPS BiOp and its 2010 Supplement to improve adult and juvenile passage at Bonneville Dam • Maintain screens and fish passage structures • Reintroduce coho and spring Chinook salmon and winter steelhead upstream of tributary dams in the upper Cowlitz and North Fork Lewis subbasins (per FERC relicensing agreements) • Develop, maintain, and operate effective juvenile and adult passage facilities in the Cowlitz and Lewis subbasins	Habitat quantity: Access (anthropogenic barrier)

Threat Category	Representative Actions	Limiting Factors Addressed
	• Operate the hydro system in the North Fork Lewis and Cowlitz subbasins to provide appropriate flows for spawning and rearing habitat in areas downstream of the hydro system (i.e., maintain a flow regime that includes minimum flow requirements) • Maintain adequate water flows in Bonneville Dam tailrace and downstream habitats throughout salmon migration, incubation, and rearing periods	Water quantity: Altered hydrology
	• Implement PGE's FERC agreement for the Clackamas River Hydroelectric Project (includes downstream passage measures, placement of spawning gravel below River Mill Dam, and habitat mitigation and enhancement)	Habitat quantity: Access (anthropogenic barrier) Sediment conditions: Decreased sediment quantity Channel structure and form: Bed and channel form Channel structure and form: Instream structural complexity
	• Restore or create off-channel habitat or access to off-channel habitat (includes revegetation)	Water quantity: Altered hydrology Peripheral and transitional habitats: Side channel and wetland conditions Peripheral and transitional habitats: Floodplain condition Peripheral and transitional habitats: Estuary conditions Riparian condition, including large wood recruitment Water quality: Water temperature Toxic contaminants
	• Restore instream habitat complexity, including large wood placement	Channel structure and form: Bed and channel form Channel structure and form: Instream structural complexity
Hatcheries	• Maintain existing wild fish sanctuaries and limit hatchery-origin spawners to levels consistent with the target status of each population • Coded-wire tag enough fish from each hatchery to allow identification of the hatchery program of origin • Mark all hatchery-origin steelhead and coho and Chinook salmon (to facilitate mark-selective fishing) • Change acclimation or release strategies to reduce straying • Reduce or eliminate some hatchery releases • Shift some hatchery production to programs further downstream • Make use of conservation hatchery programs for reintroduction or supplementation; identify appropriate time period, stock, timing, and strategies • Integrate wild broodstock into hatchery programs • Provide or improve fish passage at hatcheries (and at road, railroad and I-84 crossings)	Population diversity: Impaired productivity and diversity

Threat Category	Representative Actions	Limiting Factors Addressed
Harvest	• Broaden the use of mark-selective fishing methods (e.g., develop new gear and methods for commercial fishing) • Refine the coho harvest matrix to ensure that it adequately accounts for weaker components of the ESU • Develop an abundance-based harvest approach for fall Chinook • Continue to review harvest rates and base future rates on observed indicators in populations • Manage Columbia River fisheries by time, area, and gear to target hatchery fish • Fill information gaps regarding hatchery-origin spawner escapement, natural productivity, and harvest impact rates	Direct mortality: Harvest
Ecological Interactions	• Redistribute nesting tern colonies in the Columbia River estuary • Reduce double-crested cormorant habitat in the Columbia River estuary and encourage dispersal to other locations • Reduce pinniped predation on salmon and steelhead • Manage pikeminnow and other piscivorous fish to reduce predation on salmonids (e.g., modify habitat, increase pikeminnow bounty program) • Evaluate ecological interactions between hatchery-origin and natural-origin salmon and steelhead in the Columbia River estuary	Direct mortality: Predation
	• Implement regulatory, control, and education measures to control introduced, invasive, or exotic species and prevent new invasions	Direct mortality: Predation, pathogens Food: Competition Food: Altered prey composition and diversity

12.1.1 Washington Management Unit Plan

The Washington management unit plan identifies 117 strategies (see Chapter 5, "Strategies and Measures," of LCFRB 2010a) and 365 actions (see the table in Chapter 10, "Implementation," Section 10.9, of LCFRB 2010a) that address threats in the following general categories:

- Tributary habitat
- Estuary/mainstem habitat
- Hydropower
- Harvest
- Hatcheries
- Ecological interactions (including predation)
- Climate and ocean conditions

These include the 23 actions called for in the *Columbia River Estuary ESA Recovery Plan Module* (NMFS 2011a). All actions are expected to be completed within 25 years, although the effects of the actions may not be realized for some time thereafter.

Management actions in the Lower Columbia Fish Recovery Board's geographic area of responsibility are discussed further in Chapters 5 and 10 ("Strategies and Measures" and "Implementation") of LCFRB (2010a).

12.1.2 Oregon Management Unit Plan

Like the Washington management unit plan, the Oregon management unit plan (ODFW 2010) orients its actions around threat categories. Actions are identified in the management unit plan—and costs estimated—for the following general categories of threats:

- Tributary habitat, including habitat protection and restoration
- Harvest
- Hatchery effects
- Predation

The Oregon management unit plan identifies 14 strategies and 308 management actions (see Tables 7-1, 7-3, and 9-3 in ODFW 2010). Of the 308 actions, 23 are actions called for in the estuary module (NMFS 2011a), and 18 are reasonable and prudent alternative actions brought forward from the 2008 FCRPS Biological Opinion (NMFS 2008f). All actions are expected to be completed within 25 years, although the effects of the actions may not be realized for some time thereafter.

Management actions in Oregon are discussed further in Chapters 7, 8, and 9 ("Strategies and Actions" "Research, Monitoring, and Evaluation," and "Implementation") of ODFW (2010).

12.1.3 White Salmon Management Unit Plan

The strategy for recovery actions in the White Salmon River consists of seven fundamental components:

- Assessment of pre-dam removal fish populations and habitat conditions
- Removal of Condit Dam
- Reintroduction of fish into the reaches formerly blocked by Condit Dam
- Assessment of actions needed for recovery once the dam is removed
- Habitat restoration of the reaches located under the current reservoir (Northwestern Lake) and below Condit Dam
- Habitat restoration in the reaches above Northwestern Lake to support reintroduced fish
- Assessments and monitoring of conditions to determine whether implemented actions are working and sufficient

The removal of Condit Dam is central and essential to the White Salmon recovery strategy. The decision to decommission the dam was made by the dam's owner (PacifiCorp) after comparing the benefits of continued operation with the cost to install fish ladders as proposed during relicensing negotiations with the Federal Energy Regulatory Commission. The dam's removal is considered a baseline action because it is not an action called for under the recovery plan and would occur regardless. Its removal presents an opportunity to reintroduce salmon into historical habitat blocked by the dam's original construction. The White Salmon plan's strategy and recovery management actions cannot succeed without the dam being removed.

The White Salmon management unit plan (NMFS 2011b) identifies 14 strategies (see Table 6-1 of NMFS 2011b) and 52 management actions (see Table 7-2 of NMFS 2011b). Assessments will further inform actions needed for recovery. The majority of actions will be implemented within 5 years of removal of Condit Dam. Additional actions may be identified after that time period, depending on the results of monitoring and evaluation activities. Recovery of the species in the White Salmon subbasin is expected to occur over decades. Natural recolonization is the preferred reintroduction option for spring Chinook, coho, and chum, while reintroduction using hatchery-origin adults is the preferred option for fall Chinook.

Management actions for the White Salmon subbasin are discussed further in Chapters 6 and 7 ("Recovery Actions and Strategies" and "Implementation and Cost Estimates") of the White Salmon management unit plan (NMFS 2011b).

12.1.4 Estuary Module

The *Columbia River Estuary ESA Recovery Plan Module for Salmon and Steelhead* (NMFS 2011a) presents 23 management actions or strategies, each supported by two to five programmatic "conceptual-level projects" (see Table 5-1 of NMFS 2011a). All actions are expected to be completed within 25 years, although the effects of the actions may not be realized for some time thereafter. Many of these actions and strategies call for a methodical approach of data collection, study, and careful design before projects are implemented on the ground so as to provide the maximum assurance that the actions implemented will be biologically effective. Consequently, the scope and nature of a project could change as better information is collected.

Because the actions in the estuary module have basinwide scope and are expected to benefit all 13 listed ESUs and DPSs in the Columbia Basin, the estuary module is incorporated by reference into all Columbia Basin salmon and steelhead recovery plans. For more information on management actions in the Columbia River estuary and plume, see Chapter 5 of the estuary module (NMFS 2011a).

12.2 Cost Estimates

This section provides 5-year and total cost estimates as called for under ESA and NOAA Interim Recovery Planning Guidance, version 1.3, dated June 2010.

Cost estimates for recovery projects were provided by the management unit planners where information was sufficient to allow reasonable estimates to be made. In some cases this was done in coordination with a NMFS economist at the Northwest Fisheries Science Center in Seattle and with input and review from in-house and/or regional experts.

Recovery planners developed cost estimates for proposed actions using the methods described in each management unit plan and summarized below. Although some management unit plans display the cost of baseline actions because they are necessary for recovery,[2] the costs of baseline actions are not included in the cost estimates.

Administrative costs are treated differently in each management unit plan. The administrative costs for actions identified in the *Columbia River Estuary ESA Recovery Plan Module for Salmon and Steelhead* (NMFS 2011a) are embedded in the action cost estimate. The Washington management unit plan addresses administrative coordination, direction, and tracking as line-item costs. The Oregon and White Salmon management unit plans use mixed approaches, with some administrative costs specifically identified while others are embedded in action cost estimates.

Research, monitoring, and evaluation costs also vary among the management unit plans. In many cases, RME costs have yet to be determined. Those that can be estimated at this

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[2] "Baseline actions" are those programs that are already in existence or that would occur regardless of recovery plans.

point are included in the management unit plans and incorporated into the estimates shown below.

All yearly costs identified in the management unit plans are presented in present-year dollars (that is, without adjusting for inflation). The total costs are the sum of the yearly costs without applying a discount rate.

The total estimated cost of recovery actions for the four threatened species found in the lower Columbia River over the next 25 years is about $2.1 billion, of which about $614 million is anticipated to be needed in the first 5 years (see Table 12-2). These estimates include expenditures by local, tribal, state, and Federal governments, private business, and individuals in implementing capital projects and non-capital work, as well as administrative costs for supervision and coordination. The total costs in Table 12-2 include $592 million ($164 in the first 5 years) for implementation of actions in the estuary module (NMFS 2011a); these actions have basinwide scope and are expected to benefit all 13 listed ESUs and DPSs in the Columbia Basin but are included in Table 12-2 because of their shared geography with the Lower Columbia River ESUs. Not included in Table 12-2 are expenses associated with implementing the 2008 FCRPS Biological Opinion and its 2010 Supplement (NMFS 2008f and 2010a).

Note that all estimates in Table 12-2 and the subsequent discussion are rounded to the nearest million.

Table 12-2
Summary of Cost Estimates

Management Unit	5-Year Cost Estimate (millions)	25-Year Cost Estimate (millions)
Washington (LCFRB 2010a)[3]	$245	$738
Oregon (ODFW 2010)[4,5]	$189	$758
White Salmon (NMFS 2011b)[6]	$16	$16
Estuary Module (NMFS 2011a)[7]	$164	$592
TOTAL	$614	$2,104

These estimates are based on the best available information at the time the management unit plans were completed and are expected to change as implementation plans are developed and actions are more clearly scoped and planned. It is therefore likely that estimated costs will increase substantially given the significant number of actions for which no costs could be estimated at the time of plan completion.

The cost estimates in each management unit plan are summarized below.

12.2.1 Washington Management Unit Plan

The Washington management unit plan (LCFRB 2010a) provides estimated costs for actions undertaken solely to address salmon recovery. The plan does not estimate baseline costs, i.e., costs for actions that may be critical to recovery efforts but are mandated by laws, regulations, or policy directives other than Endangered Species Act recovery plans and would thus occur irrespective of recovery planning efforts.

[3] The Washington management unit plan estimated costs for a short-term (10-year) and long-term (25-year) period. The 5-year estimate shown in Table 12-2 is extrapolated by dividing the 10-year estimate in half. NMFS worked with Washington recovery planners to add a 2 percent operations and maintenance cost factor to capital projects, beginning with the estimated project completion date. This addition made the Washington management unit plan consistent with the other management unit plans.

[4] The 5-year estimate was extrapolated from Table 9-3 of ODFW (2010). The estimate for the 25-year period includes a 2 percent maintenance cost factor added to capital projects, beginning with the estimated project completion date.

[5] Table 9-3 of ODFW (2010) indicates a number of actions scheduled to begin within the next 5, 10, 15, or 25 years. For the purposes of this table, unless otherwise specified, all are assumed to begin the first year the plan is put into effect.

[6] Most actions in the White Salmon management unit plan will occur within 5 years of removal of Condit Dam. This table assumes that all actions, including the dam's removal, will occur within the first 5 years of plan implementation. Additional actions may be added pending the results of RME and assessment efforts.

[7] The 5-year estimate is extrapolated from Tables 5-6 and 6-7 of the estuary module (NMFS 2011a).

Dam operational improvements and predation management actions are addressed in the 2008 FCRPS Biological Opinion and its 2010 Supplement (NMFS 2008f and 2010a), NMFS hydropower module, and FERC licensing agreements and are considered baseline costs. Estuary costs are quoted from the estuary module cost estimates for informational purposes only; they are not included in the management unit plan totals indicated below or in the Washington management unit costs in Table 12-2.

Research and monitoring needs are expected to be met largely through a combination of new and ongoing efforts by Federal and state agencies, local governments, and research organizations, the outlays for which are considered baseline costs. Additional research and monitoring are anticipated to fill information gaps not addressed by existing programs. The costs for this additional effort will be estimated once more complete information is available. (LCFRB 2010a, Volume I, Section 11.7)

The costs for stream habitat restoration are estimated on a cost-per-mile basis developed from habitat project assessments conducted for selected subbasins in the region (the Lower Cowlitz River [Lower Columbia Fish Recovery Board 2007], Lower East Fork Lewis River [Lower Columbia Fish Recovery Board 2009b], Abernathy and Germany Creeks [Lower Columbia Fish Recovery Board 2009a], and Grays River [Lower Columbia Fish Recovery Board 2009c]). For each subbasin, habitat improvement targets identified for each species were used to estimate miles of stream treatment consistent with recovery. Estimates included initial project implementation and long-term maintenance costs. Costs for fishery- and hatchery-related recovery costs were estimated for those actions outside of baseline fishery and hatchery management programs from data provided by the Washington Department of Fish and Wildlife and its draft Conservation and Sustainable Fishery Plan. Estimates for implementation coordination and administration are provided.

The Washington management unit plan envisions a 25-year implementation period and provides cost estimates for the near term (the first 10 years) and long term (years 11 through 25). The total estimated cost for the 25-year implementation period for recovery-related habitat, fishery, and hatchery actions and associated coordination and administration is $703 million (LCFRB 2010a, Volume I, Section 11.8). For this roll-up plan, NMFS added post-construction maintenance costs, estimated at 2 percent per year for 15 years, to the costs for habitat restoration, for a total of $738 million.[8] The estimated cost for the 2010-2014 period is $245 million.

Cost estimates are discussed further in Chapter 11, “Costs,” of LCFRB (2010a).

12.2.2 Oregon Management Unit Plan

The Oregon management unit plan envisions a 25-year time frame for recovery and conservation action implementation, with a formal assessment planned at the 12-year point. Action implementation is presented as occurring currently (i.e., “ongoing”); immediately after plan adoption; in 5-, 10-, 15-, and 25-year time frames; or in a specific

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[8] These maintenance costs were added to achieve consistency among management unit plans and were developed in coordination with Washington recovery planners.

year (such as 2010). Cost estimates are provided for new actions or current program expansions that are called for in the recovery plan, unless there is not enough information for an estimate. Actions required under other statutes or programs are considered baseline costs and not included, although their successful implementation is considered necessary for the overall recovery effort.

Actions called for in the 2008 FCRPS Biological Opinion and its 2010 Supplement (NMFS 2008f and 2010a) are included in the management unit plan for informational purposes but not included in the management plan costs, which are indicated in Table 12-2 above or in Table 9-3 of ODFW (2010). Actions from the estuary module (NMFS 2011a) are presented in the Oregon management unit plan, but their costs are not included in the management unit plan totals below or in the Oregon management unit costs in Table 12-2..

The cost estimating methodologies for tributary habitat actions consisted of either (a) calculation of the quantity of actions necessary and determination of unit costs, (b) expert opinion, or (c) applicable estimates from other plans. Costs for harvest, hatchery, and predation actions were based on the expert opinion and professional judgment of the Oregon Department of Fish and Wildlife. The cost estimate includes a 2 percent maintenance cost for capital projects for 20 years.

The total cost for the 25-year implementation period, not including baseline estuary or hydropower actions, is estimated to be $758 million. The estimated cost for the first 5 years is $189 million.

For further discussion of Oregon management unit plan cost estimates, see Chapter 9 ("Implementation") of ODFW (2010), including, Section 9.1 ("Action Details: Locations, Schedule, Costs, and Potential Implementers") and Table 9-3.

12.2.3 White Salmon Management Unit Plan

The decommissioning and removal of Condit Dam is central to the White Salmon recovery strategy. The costs of dam removal are being born by the PacifiCorp power company.

Removal of Condit Dam and associated reintroduction and habitat improvement actions are estimated to cost between $12 and $15 million. Additional habitat restoration and harvest and hatchery management actions are estimated to cost about $14 million.

Numerous RME actions are identified in the White Salmon management unit plan. The results of studies will help with prioritization of actions within the subbasin. It is estimated that the RME actions will cost roughly $2 million over a 5-year period.

Because dam removal is considered a baseline action, Table 12-2 includes only the additional habitat restoration and harvest and hatchery management action and RME cost estimates. The total estimated cost for the first 5-year period for restoring anadromous populations in the White Salmon River, not counting the baseline action of Condit Dam removal, is estimated to be about $16 million.[9]

Additional costs for recovery are likely to be incurred beyond the initial 5-year period. These costs cannot be estimated until the RME has been completed.

For further discussion of cost estimates for the White Salmon subbasin, see Chapter 7 of NMFS (2011b), specifically Section 7.2 ("Costs") and Tables 7-1 and 7-2.

12.2.4 Estuary Module

Cost estimates in the *Columbia River Estuary ESA Recovery Plan Module for Salmon and Steelhead* (NMFS 2011a) address direct, incremental costs of actions over and above baseline activities. Most of the estimates provided were developed by the consulting firm PC Trask & Associates, Inc., and members of the Lower Columbia River Estuary Partnership, based on action implementation experience and historical records. Other estimates were provided by Federal agency experts, most notably NMFS and the U.S. Army Corps of Engineers.

Total costs for actions in the estuary module are estimated at $528 million over the module's 25-year planning horizon. This estimate includes the costs of actions that are currently being implemented or that have already been completed, with implementation having begun in 2006. The cost estimate for the 5-year period 2010 to 2014, extrapolated from Table 5-6 of the estuary module, is $149 million.

Some of the module actions identified above include RME projects and associated cost estimates that are included in the estuary action cost estimates identified above. Table 6-6 of the estuary module identifies additional monitoring needs not directly associated with other actions. The estimated cost of these additional RME actions is $64 million over the module's 25-year planning horizon. The portion of this cost occurring over the period 2010 to 2014, as extrapolated from Table 6-7 of the estuary module, is about $15 million.

The total estimate for estuary actions and RME is $592 over the module's 25-year planning horizon, with $164 million estimated for the period 2010 to 2014. Although costs of implementing estuary module actions are included in this recovery plan for Lower Columbia River ESUs, the actions in the estuary module are expected to benefit all 13 listed ESUs and DPSs in the Columbia Basin and the estuary module is incorporated by reference into all Columbia Basin salmon and steelhead recovery plans.

For further discussion of the estuary module's cost estimates, see Table 5-6 of the module (NMFS 2011a).

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[9] Totals do not sum because of rounding.

12.3 Time Estimate

There are unique characteristics and challenges in estimating the time required for salmon and steelhead recovery given the complex relationship of these fish to their environment and to human activities in the water and on land. Examples of the uncertainties that preclude a more precise estimate of time include biological and ecosystem responses to recovery actions and the unknown impacts of future economic, demographic, and social developments.

Consequently, the management unit plans provide a 25-year period for action implementation. The management unit authors believe, and NMFS concurs, that it may take longer than 25 years for the biological effects of management actions to be fully realized and for recovery of Lower Columbia River salmonid species to occur. Rather than speculate on conditions that may or may not exist that far into the future, this recovery plan relies on ongoing monitoring and periodic plan review regimes to add, eliminate, or modify actions through adaptive management as information becomes available and until such time as the protection of the Endangered Species Act is no longer required.

NMFS believes it most appropriate to focus on the first 5 years of implementation and in 5-year intervals thereafter, with the understanding that before the end of each 5-year implementation period, specific actions and costs will be estimated for subsequent years.

13. References

Allee, B. 2011. Cumulative Impact of Hatchery Origin Fish on Natural Origin Fish in the Columbia River Estuary. National Marine Fisheries Service Northwest Region, Portland OR.

Barnhart, R.A. 1986. Species Profiles: Life Histories and Environmental Requirements of Coastal Fishes and Invertebrates (Pacific Southwest) — Steelhead. U.S. Army Corps of Engineers, TR EL-B2-4. USFWS Biological Report 82(11.60), 21 pp.

Beacham, T.D., and C.B. Murray. 1987. Adaptive Variation in Body Size, Age, Morphology, Egg Size, and Developmental Biology of Chum Salmon (*Oncorhynchus keta*) in British Columbia. Canadian Journal of Fisheries and Aquatic Sciences 44:244-261.

Beamer, E., A. McBride, C. Greene, R. Henderson, G. Hood, K. Wolf, K. Larsen, C. Rice, and K. Fresh. 2005. Delta and Nearshore Restoration for the Recovery of Wild Skagit River Chinook Salmon: Linking Estuary Restoration to Wild Chinook Salmon Populations. Skagit River System Cooperative, LaConner, Washington.

Beamesderfer, R.C., D.L. Ward, and A.A. Nigro. 1996. Evaluation of the Biological Basis for a Predator Control Program on Northern Pikeminnow (*Ptychochelius oregonensis*) in the Columbia and Snake Rivers. Canadian Journal of Fisheries and Aquatic Sciences 53:2898-2908.

Beechie, T.J., M. Ruckelshaus, E. Buhle, A. Fullerton, and L. Holsinger. 2006. Hydrologic Regime and the Conservation of Salmon Life History Diversity. Biological Conservation 130(4):560-572.

Behnke, R.J. 1992. Native Trout of Western North America. American Fisheries Society Monograph. 6, 275 p. American Fisheries Society, Bethesda, Maryland.

Berejikian, B.A., and M.J. Ford. 2004. Review of Relative Fitness of Hatchery and Natural Salmon. NOAA Technical Memorandum NMFS-NWFSC-61, 28 pp.

Berejikian, B.A., Tatara, C.P., and Lee, J.S.F. 2009. Status of Science of Ecological Interactions between Hatchery and Natural Origin Anadromous Pacific Salmonids: Mechanisms, Spatial Scales and Information Gaps. 14 p.

Bilby, R.E., B.R Fransen, and P.A. Bisson. 1996. Incorporation of Nitrogen and Carbon from Spawning Coho Salmon into the Trophic System of Small Streams. Canadian Journal of Fisheries and Aquatic Sciences 53: 164-173.

Bonneville Power Administration, U.S. Bureau of Reclamation, and U.S. Army Corps of Engineers. 2004. Final Updated Proposed Action for the FCRPS Biological Opinion Remand. Portland, OR.

Bottom, D.L., C.A. Simenstad, J. Burke, A.M Baptista, D.A. Jay, K.K. Jones, E. Casillas, and M.H. Schiewe. 2005. Salmon at River's End: The Role of the Estuary in Decline and

Recovery of Columbia River Salmon. U.S. Dept. Commerce, NOAA technical memorandum. NMFS-NWFSC-68, 246p.

Bottom, D.L., G. Anderson, A. Baptista, J. Burke, M. Burla, M. Bhuthimethee, L. Campbell, E. Casillas, S. Hinton, K. Jacobson, D. Jay, R. McNatt, P. Moran, G.C. Roegner, C.A. Simenstad, V. Stamatiou, D. Teel, and J. E. Zamon. 2008. Salmon Life Histories, Habitat, and Food Webs in the Columbia River Estuary: An Overview of Research Results, 2002-2006. Northwest Fisheries Science Center, National Marine Fisheries Service, Seattle, WA.

Burgner, R.L., J.T. Light, L. Margolis, T. Okazaki, A. Tautz, and S. Ito. 1992. Distribution and Origins of Steelhead Trout (*Oncorhynchus mykiss*) in Offshore Waters of the North Pacific Ocean. Bulletin No. 51, International North Pacific Fisheries Commission, Vancouver, British Columbia, Canada.

Busack, C., and K. P. Currens. 1995. Genetic Risks and Hazards in Hatchery Operations: Fundamental Concepts and Issues. American Fisheries Society Symposium 15:71-80.

Busby, P.J., T.C. Wainwright, E.J. Bryant, L.J. Lierheimer, R.S. Waples, F.W. Waknitz, and I.V. Lagomarsino. 1996. Status Review of West Coast Steelhead from Washington, Idaho, Oregon, and California. NOAA Technical Memorandum 27.

Busch, D. S., M. Sheer, K. Burnett, P. McElhany, and T. Cooney. 2011. Landscape-Level Model to Predict Spawning Habitat for Lower Columbia River Fall Chinook Salmon (*Oncorhynchus tshawytscha).* River Research and Applications. Published online in Wiley Online Library (wileyonlinelibrary.com) DOI: 10.1002/rra.1597.

Carter, J.A., G.A. McMichael, I.D. Welch, R.A. Harnish, and B.J. Bellgraph. 2009. Seasonal Juvenile Salmonid Presence and Migratory Behavior in the Lower Columbia River. PNNL 18246, Pacific Northwest National Laboratory, Richland, WA. Prepared for the U.S. Army Corps of Engineers, Portland District.

Cederholm, C.J., M.D. Kunze, T. Murota, and A. Sibatani. 1999. Pacific Salmon Carcasses: Essential Contributions of Nutrients and Energy for Aquatic and Terrestrial Ecosystems. Fisheries 24 (10): 6-15.

Center for Whale Research. Photo-identification of Southern Resident Killer Whales. www.whaleresearch.com/research.html. Viewed January 27, 2012.

Chang, H., and J. Jones. 2010. Climate Change and Freshwater Resources in Oregon. Pages 69-149 in Oregon Climate Assessment Report, Oregon Climate Change Research Institute, K.D. Dello and P.W. Mote, editors. College of Oceanic and Atmospheric Sciences, www.occri.net/OCAR.

Chilcote, M.W. 1999. Conservation Status of Lower Columbia River Coho Salmon. Oregon Department of Fish and Wildlife, Fish Division Information Report 99-3, 41p. Department of Fish and Wildlife, Salem, Oregon.

Chilcote, M.W., K.W. Goodson, and M.R. Falcy. 2011. Reduced Recruitment Performance in Natural Populations of Anadromous Salmonids Associated with Hatchery-reared Fish. Canadian Journal of Fisheries and Aquatic Sciences 68:511-522.

Climate Impacts Group. 2004. Overview of Climate Change Impacts in the U.S. Pacific Northwest. University of Washington. Seattle, WA www.cses.washington/edu/cig.

Climate Impacts Group. 2009. The Washington Climate Change Impacts Assessment. M. Elsner, J. Littell, and L. Whitely Binder (eds). Center for Science in the Earth System, Joint Institute for the Study of the Atmosphere and Oceans, University of Washington, Seattle, Washington. Available at: http://www.cses.washington.edu/db/pdf/wacciareport681.pdf.

Collis, K., and D.D. Roby. 2006. Research, Monitoring, and Evaluation of Avian Predation on Salmonid Smolts in the Lower and Mid-Columbia River. Bonneville Power Administration and U.S. Army Corps of Engineers. Draft 2005 season summary.

Columbia Basin Fish and Wildlife Authority. 1990. Review of the History, Development, and Management of Anadromous Fish Production Facilities in the Columbia River Basin. Unpublished manuscript, 52 p., U.S. Fish & Wildlife Service.

Columbia Basin Fish and Wildlife Authority. 2010. Revised Work Plan for Coordinated Assessments for Salmon and Steelhead. June 17, 2010.

Cooney, T.D., and D. Holzer. 2011. Lower Columbia Tule Chinook Populations: Estimating Intertidal Rearing Capacities and Survival Rates. March 4, 2011. NMFS Northwest Fisheries Science Center.

Cramer, D.P., and S.P. Cramer. 1994. Status and Population Dynamics of Coho Salmon in the Clackamas River. Technical Report, Portland General Electric Company, Portland, Oregon.

Crawford, B.A., and S.M. Rumsey. 2011. Guidance for Monitoring Recovery of Pacific Northwest Salmon & Steelhead listed under the Federal Endangered Species Act. National Marine Fisheries Service, Northwest Region. January 2011. Available at http://www.nwr.noaa.gov/Salmon-Recovery-Planning/upload/RME-Guidance.pdf.

Crozier, L. 2011. Literature Review for 2010 Citations for BIOP: Biological Effects of Climate Change. Attachment 1 of FCRPS Biological Opinion 2010 Annual Progress Report (p. 148-203). Available at: http://www.salmonrecovery.gov/Files/BiologicalOpinions/2010/2010_FCRPS_APR_Section_2_Final.pdf.

Currens, K. P., A.R. Hemmingsen, R.A. French, D.V. Buchanan, C.R. Schreck, and H.W. Li. 1997. Introgression and Susceptibility to Disease in a Wild Population of Rainbow Trout. North American Journal of Fisheries Management 17:1065-1078.

Dawley, E.M., R.D. Ledgerwood, T.H. Blahm, C.W. Sims, J.T. Durkin, R.A. Kim, A.E. Rankin, G.E. Monan, and F.J. Ossiander. 1986. Migrational Characteristics, Biological Observations, and Relative Survival of Juvenile Salmonids Entering the Columbia River

Estuary, 1966-1983. Northwest Fisheries Science Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, Seattle, WA.

Dorcey, A.H.J., T.G. Northcote, and D.V. Ward. 1978. Are the Fraser River Marshes Essential to Salmon? University of British Columbia Press, Vancouver, Canada.

Elsner, M.M., L. Cuo, N. Voisin, J.S. Deems, A.F. Hamlet, J.A Vano, K.E.B. Michelson, S. Lee, and D.P. Lettenmaier. 2009. Implications of 21st Century Climate change for the Hydrology of Washington State. Pages 69–106 in M.M. Elsner, J. Littell, and L.W. Binder (editors). The Washington Climate Change Impacts Assessment. Center for Science in the Earth System, Joint Institute for the Study of the Atmosphere and Oceans, University of Washington, Seattle.

Emmett, R. L., R. D. Brodeur, and P. M. Orton. 2004. The Vertical Distribution of Juvenile Salmon (Oncorhynchus spp.) and Associated Fishes in the Columbia River Plume. Fisheries Oceanography. 13:392–402.

Feely, R., C. Sabine, J. Hernandez-Ayon, D. Ianson, and B. Hales. 2008. Evidence for Upwelling of Corrosive "Acidified" Water onto the Continental Shelf. Science 320: 1490-1492.

Flagg, T.A., B.A. Berejikian, J.E. Colt, W.W. Dickhoff, L.W. Harrell, D.J. Maynard, C.E. Nash, M.S. Strom, R.N Iwamoto, and C.V.W. Mahnken. 2000. Ecological and Behavioral Impacts of Artificial Production Strategies on the Abundance of Wild Salmon Populations. U.S. Dept. Commer., NOAA Tech. Memo. NMFS-NWFSC- 41, 92 pp. http://www.nwfsc.noaa.gov/publications/techmemos/tm41/tm41.htm.

Flagg, T.A., F.W. Waknitz, D.J. Maynard, G.B. Milner, and C.V. Mahnken. 1995. The Effect of Hatcheries on Native Coho Salmon Populations in the Lower Columbia River. In: Schramm, H.I. and Piper, R.G., eds. Uses and Effects of Cultured Fishes in Aquatic Ecosystems. American Fisheries Society Symposium 15. Bethesda, Maryland.

Ford, J.K., G.M. Ellis., P. F. Olesiuk, and K.C. Balcomb III. 2009. Linking Killer Whale Survival and Prey Abundance: Food Limitation in the Oceans' Apex Predator? Biology Letters doi:10.1098/rsbl.2009.0468.

Ford, J.K.B., and G.M. Ellis. 2006. Selective Foraging by Fish-eating Killer Whales *Orcinus orca* in British Columbia. Marine Ecology Progress Series. Volume 316, pages 185 to 199.

Ford, J.K.B., G.M. Ellis, and K.C. Balcomb. 2000. Killer Whales: The Natural History and Genealogy of *Orcinus orca* in British Columbia and Washington State. 2nd ed. UBC Press, Vancouver, British Columbia.

Ford, M., N. Sands, P. McElhany, R. Kope, D. Simmons, P. Dygert. 2007. Analyses to Support a Review of an ESA Jeopardy Consultation on Fisheries Impacting Lower Columbia River Tule Chinook Salmon. National Marine Fisheries Service. October 5.

Ford, M.J. (Ed.). 2011. Status Review Update for Pacific Salmon and Steelhead Listed Under the Endangered Species Act: Pacific Northwest. U.S. Department of Commerce, NOAA Technical Memorandum NOAA-NWFSC-113, 281 pp. November 2011.

Fresh, K. L., and S. L. Schroder. 1987. Influence of the Abundance, Size, and Yolk Reserves of Juvenile Chum Salmon (*Oncorhynchus keta*) on Predation by Freshwater Fishes in a Small Coastal Stream. Canadian Journal of Fisheries and Aquatic Sciences 44.

Fresh, K.L. 1997. The Role of Competition and Predation in the Decline of Pacific Salmon and Steelhead. In D.J. Stouder, P.A. Bisson, and R.J. Naiman (editors), Pacific Salmon and Their Ecosystems: Status and Future Options, pp. 245-275. Chapman Hall, New York.

Fresh, K.L., E. Casillas, L.L. Johnson, and D.L. Bottom. 2005. Role of the Estuary in the Recovery of Columbia River Basin Salmon and Steelhead: An Evaluation of the Effects of Selected Factors on Salmonid Population Viability. NOAA technical memorandum, Northwest Fisheries Science Center, National Marine Fisheries Service. Seattle, WA. 136 pp.

Friesen, T.A., and D.L. Ward. 1999. Management of Northern Pikeminnow and Implications for Juvenile Salmonid Survival in the Lower Columbia and Snake Rivers. North American Journal of Fisheries Management 19:406-420.

Fritts, A., and T. Pearsons. 2008. Can Non-native Smallmouth Bass, *Micropterus dolomieu*, Be Swamped by Hatchery Fish Releases to Increase Juvenile Chinook Salmon, *Oncorhynchus tshawytscha*, Survival? Environmental Biology of Fishes 83(4):485-494.

Garrison, R.C., and M.M. Rosentreter. 1981. Stock Assessment and Genetic Studies of Anadromous Salmonids. Pages 66. Federal Aid Progress Rpts Fisheries, 1980. Oregon Dept. Fish and Wildlife, Fish Div, Portland.

Geiger, R.D. 1973. Streamflow Requirements for Salmonids. OR Wildl. Comm., Job. Final Rep. Proj. AFS 62-1, Portland, Oregon. 117p.

Genovese, P.V., and R.L. Emmett. 1997. Desktop Geographic Information System for Salmonid Resources in the Columbia River Basin. U.S. Dept. Commer., NOAA Tech. Memo. NMFS-NWFSC-34.

Gilbreath, L., and E. Prentice. 1999. Post Construction Evaluation of the Modified Bonneville Dam Second Powerhouse Juvenile Bypass System. In Abstracts, Anadromous Fish Evaluations Program 1999 Annual Research Review, November 1999. (Available from U.S. Army Corps of Engineers, Walla Walla District, Walla Walla, WA.)

Glick, P., J. Clough, and B. Nunley. 2007. Sea-level Rise and Coastal Habitats in the Pacific Northwest: An Analysis for Puget Sound, Southwestern Washington, and Northwestern Oregon. National Wildlife Federation, Western Natural Resource Center 6 Nickerson Street, Suite 200 Seattle, Washington 98109. Available at: http://www.nwf.org/~/media/PDFs/Water/200707_PacificNWSeaLevelRise_Report.ashx.

Goede, R.W. 1986. Management Considerations in Stocking of Diseased or Carrier Fish. Pages 349-355 in R. H. Stroud, ed. Fish Culture in Fisheries Management. American Fisheries Society, Bethesda, MD.

Hamm, D.E. 2012. Development and Evaluation of a Data Dictionary to Standardize Salmonid Habitat Assessments in the Pacific Northwest. Fisheries. Volume 37, Issue 1, 2012.

Hanson, B., J. Hempelmann-Halos, and D. Van Doornik. 2010b. Species and Stock Identification of Scale/Tissue Samples from Southern Resident Killer Whale Predation Events Collected off the Washington Coast during PODs 2009 Cruise on the McArthur II. Unpublished memorandum. March 16, 2010.

Hanson, M.B., R.W. Baird, C. Emmons, J. Hempelmann, G.S. Schorr, J. Sneva, and D.Van Doornik. 2007. Summer Diet and Prey Stock Identification of the Fisheating "Southern Resident" Killer Whales: Addressing a Key Recovery Need Using Fish Scales, Fecal Samples, and Genetic Techniques. Abstract from the 17th Biennial Conference on the Biology of Marine Mammals, Capetown, South Africa.

Hanson, M.B., R.W. Baird, J.K.B. Ford, J. Hempelmann-Halos, D.M. Van Doornik, J.R. Candy, C. K. Emmons, G.S. Schorr, B. Gisborne, K.L. Ayres, S.K. Wasser, K.C. Balcomb, K. Balcomb-Bartok, J.G. Sneva, and M.J. Ford. 2010a. Species and Stock Identification of Prey Consumed by Endangered Southern Resident Killer Whales in Their Summer Range. Endangered Species Research. Volume 11, pages 69 to 82.

Hatchery Scientific Review Group. 2006. Columbia River Hatchery Reform Project Progress Report. April 17, 2006.

Hatchery Scientific Review Group. 2007. Preview of Key Findings for Lower Columbia River Hatchery Programs. Memo prepared by the Hatchery Scientific Review Group for the Columbia River Hatchery Reform Steering Committee. July 18, 2007.

Hatchery Scientific Review Group. 2009. Columbia River Hatchery Reform System-wide Report. February 2009. Available at: http://www.hatcheryreform.us/hrp/reports/system/welcome_show.action.

Healey, M.C. 1982. Juvenile Pacific Salmon in the Estuaries: The Life Support System. In Estuarine Comparisons. Academic Press, Inc., New York.

Hixon, M.A., S. Gregory, and W. Robinson. 2010. Oregon's Fish and Wildlife in a Changing Climate. Pages 256-358 in K.D. Dello and P.W. Mote (editors). Oregon Climate Assessment Report. Oregon Climate Change Research Institute, College of Oceanic and Atmospheric Sciences, Oregon State University, Corvallis, OR. www. occri.net/OCAR.

Hulett, P.L., R.H. Bradford, C.W. Wagemann, and S.A. Leider. 1993. Studies of Hatchery and Wild Steelhead in the Lower Columbia Region. Washington Department of Fish and Wildlife Management Division 93-12. (Available from WDFW, 600 Capital Way N., Olympia, WA 98501).

Huppert, D., A. Moore, and K. Dyson. 2009. Impacts of Climate Change on the Coasts of Washington State. P. 285-309. In: M. Elsner, J. Littell, and L. Whitely Binder (eds). The Washington Climate Change Impacts Assessment. Center for Science in the Earth System, Joint Institute for the Study of the Atmosphere and Oceans, University of Washington, Seattle, Washington. Available at: http://www.cses.washington.edu/db/pdf/wacciareport681.pdf.

Independent Scientific Advisory Board. 2007a. Climate Change Impacts on Columbia River Basin Fish and Wildlife. ISAB Climate Change Report, ISAB 2007-2. Prepared by the Independent Scientific Advisory Board for the Northwest Power and Conservation Council, Columbia River Basin Indian Tribes, and National Marine Fisheries Service. May 11, 2007.

Independent Scientific Advisory Board. 2007b. Human Population Impacts on Columbia Basin Fish and Wildlife. ISAB Report 2007-3. Prepared by the Independent Scientific Advisory Board for the Northwest Power and Conservation Council, Columbia River Basin Indian Tribes, and National Marine Fisheries Service. June 8, 2007.

Integrated Hatchery Operations Team. 1995. Policy and Procedures for Columbia Basin Anadromous Salmonid Hatcheries. Annual report 1994 to the Bonneville Power Administration, Portland, Oregon. Project # 93-043.

Intergovernmental Panel on Climate Change. 2007a. Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (S. Solomon, D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller [eds.]). Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 996 pp. Available at: http://www.ipcc.ch/publications_and_data/publications_ipcc_fourth_assessment_report_wg1_report_the_physical_science_basis.htm.

Intergovernmental Panel on Climate Change. 2007b. Glossary. Annex 1 In: B. Metz, O.R. Davidson, P.R. Bosch, R. Dave, L.A. Meyer (eds). Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom, and New York, NY, USA.

Intergovernmental Panel on Climate Change. 2007c. Glossary. Appendix I In: M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson (eds). Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, UK, 976 pp.

Interior Columbia TRT. 2005. Viability Criteria for Application to Interior Columbia Basin Salmonid ESUs. Interior Columbia Technical Recovery Team NOAA-NWFSC, Seattle, WA.

Iwamoto, R.N., and J.G. Williams. 1993. Juvenile Salmonids Passage and Survival Through Turbines. Report to U.S. Army Corps of Engineers, Portland, OR, Contract E86920049, 27 p. (Available from Northwest Fisheries Science Center, 2725 Montlake Blvd. E., Seattle, WA 98112-2097.)

Jay, D.A., and P. Naik. 2002. Separating Human and Climate Impacts on Columbia River Hydrology and Sediment Transport. Pp. 38-48 in G. Gelfenbaum and G. Kaminsky, eds., Southwest Washington Coastal Erosion Workshop Report 2000, U.S. Geological Survey Open File Report, 02-229. 308 pp.

Jay, D.A., and T. Kukulka. 2003. Impacts of Columbia River Discharge on Salmonid Habitat. Manuscript submitted to the Journal of Geophysical Research. Revised 2003.

Jeffries, S.J. 1984. Marine Mammals of the Columbia River Estuary. Final report on the marine mammals work unit of the Columbia River estuary data development program. Washington Department of Game. Olympia, WA.

Jeffries, S.J., P.J. Gearin, H.R. Huber, D.L. Saul, and D.A. Pruett. 2000. Atlas of Seal and Sea Lion Haulout Sites in Washington. Washington Department of Fish and Wildlife, Olympia, Washington.

Johnson, G.E., H.L. Diefenderfer, B.D. Ebberts, C. Tortorici. T. Yerxa, J. Leary, and J.R. Skalski. 2008. Research, Monitoring, and Evaluation for the Federal Columbia River Estuary Program Prepared for the Bonneville Power Administration by the Pacific Northwest National Laboratory under a Related Services Agreement with the U.S. Department of Energy Contract DE-AC05-76RL01830 in conjunction with NOAA Fisheries and the U.S. Army Corps of Engineers, Portland District with the collaboration of the Lower Columbia River Estuary Partnership. January 31, 2008.

Johnson, G.E., R.M. Thom, A.H. Whiting, G.B. Sutherland, T. Berquam, B.D. Ebberts, M. Ricci, J.A. Southard, and J.D. Wilcox. 2003. An Ecosystem-based Approach to Habitat Restoration Projects with Emphasis on Salmonids in the Columbia River Estuary. Final draft prepared by the Pacific Northwest National Laboratory, Columbia River Estuary Study Taskforce, Lower Columbia River Estuary Partnership, Bonneville Power Administration, and U.S. Army Corps of Engineers.

Joint Columbia River Management Staff (Washington Department of Fish and Wildlife and Oregon Department of Fish and Wildlife). 2011. 2011 Joint Status Report: Stock Status and Fisheries for Fall Chinook Salmon, Coho Salmon, Chum Salmon, Summer Steelhead and White Sturgeon. Oregon Department of Fish and Wildlife and Washington Department of Fish and Wildlife. July 13, 2011.

Jones, Rob. 2011. 2010 5-Year Reviews: Updated Evaluation of the Relatedness of Pacific Northwest Hatchery Programs to 18 Salmon Evolutionarily Significant Units and Steelhead Distinct Population Segments Listed Under the Endangered Species Act. Memo to Donna Darm. June 29, 2011.

Karl, T.R., J.M. Melillo, and T.C. Peterson (eds.). 2009. Global Climate Change Impacts in the United States. Cambridge University Press. Available at: http://www.globalchange.gov/publications/reports/scientific-assessments/us-impacts.

Knudsen, E.E. 2002. Ecological Perspectives on Pacific Salmon: Can We Sustain Biodiversity and Fisheries? Pages 277-320 In K.D. Lynch, M.L. Jones, and W.W. Taylor, editors. Sustaining North American Salmon: Perspectives across Regions and Disciplines. American Fisheries Society, Bethesda, Maryland.

Krahn, M.M., et al. 2002. Status Review of Southern Resident Killer Whales (*Orcinus orca*) under the Endangered Species Act. NOAA Technical Memorandum. NMFS-NWFSC-54.

Krahn, M.M., J.J. Ford, W.F. Perrin, P.R. Wade, R.P. Angliss, M.B. Hanson, B.L. Taylor, G.M. Ylitalo, M.E. Dahlheim, J.E. Stein, and R.S. Waples. 2004. 2004 Status Review of Southern Resident Killer Whales (*Orcinus orca*) under the Endangered Species Act. NOAA Technical Memorandum NMFS-NWF-SC-62, National Marine Fisheries Service, Northwest Region, Seattle, Washington.

Krahn, M.M., M.B. Hanson, R.W. Baird, R.H. Boyer, D.G. Burrows, C.E. Emmons, J.K.B. Ford, L.L. Jones, D.P. Noren, P.S. Ross, G.S. Schorr, and T.K. Collier. 2007. Persistent Organic Pollutants and Stable Isotopes in Biopsy Samples (2005/2006) from Southern Resident Killer Whales. Marine Pollution Bulletin. Volume 54, pages 1903 to 1911.

Lampman, B. 1946. The Coming of the Pond Fishes. Benford and Mart, Portland, OR.

Lee, K.N. 1993. Compass and Gyroscope: Integrating Science and Politics for the Environment. Island Press, Washington, D.C

Lee, K.N. 1999. Appraising Adaptive Management. Conservation Ecology 3(2): 3. Available at http://www.consecol.org/vol3/iss2/art3/

Leider, S.A., M.W. Chilcote, and J L. Loch. 1986. Comparative Life History Characteristics of Hatchery and Wild Steelhead Trout (*Salmo gairdneri*) of Summer and Winter Races in the Mid-Columbia Kalama River, Washington. Canadian Journal of Fisheries and Aquatic Sciences 43:1398–1409.

Loge, F.J, M.R. Arkoosh, T.R. Ginn, L.L. Johnson, and T.K. Collier. 2005. Impact of Environmental Stressors on the Dynamics of Disease Transmission. Environmental Science and Technology. 39:7329-7336.

Lohn, D. Robert. 2003. Testimony of D. Robert Lohn, Regional Administrator, Northwest Region, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, before the Committee on Indian Affairs, United States Senate, on Tribal Fish and Wildlife Management Programs in the Pacific Northwest. June 4, 2003.

Lohn, D. Robert. 2006. Personal communication. Letter from D. Robert Lohn, NMFS Regional Administrator, to Governor Christine Gregoire, Jeff Koennings, and George Trott regarding approval of the Lower Columbia Fish Recovery Board plan. February 3, 2006.

Lower Columbia Fish Recovery Board. 2007. Lower Cowlitz River and Floodplain Habitat Restoration Project Siting and Design. Final revised report. Prepared for the Lower Columbia Fish Enhancement Group and Lower Columbia Fish Recovery Board by Tetra Tech, Inc. December 2007. Available at http://www.lcfrb.gen.wa.us/document_library_studies.htm.

Lower Columbia Fish Recovery Board. 2009a. Abernathy and Germany Creeks Intensively Monitored Treatment Plan. Prepared for the Lower Columbia Fish Recovery Board, Longview, Washington, by HDR, Inc., and Cramer Fish Sciences. January 2009. Available at http://www.lcfrb.gen.wa.us/document_library_studies.htm.

Lower Columbia Fish Recovery Board. 2009b. Lower East Fork Lewis River Habitat Restoration Plan. Prepared by the East Fork Lewis Working Group. April 2009.

Lower Columbia Fish Recovery Board. 2009c. Grays River Habitat Restoration Technical Report. Prepared by Tetra Tech, Inc., ENTRIX, Inc., and Waterfall Engineering, LLC. December 2009. Available at http://www.lcfrb.gen.wa.us/document_library_studies.htm.

Lower Columbia Fish Recovery Board. 2010a. Washington Lower Columbia Salmon Recovery and Fish & Wildlife Subbasin Plan. Lower Columbia Fish Recovery Board, Washington. May 28, 2010.

Lower Columbia Fish Recovery Board. 2010b. Research, Monitoring, and Evaluation Program for Lower Columbia Salmon and Steelhead. June 2010.

Lower Columbia River Estuary Partnership. 2007. Lower Columbia River and Estuary Ecosystem Monitoring: Water Quality and Salmon Sampling Report.

Mantua, N., I. Tohver, and A. F. Hamlet. 2009. Impacts of Climate Change on Key Aspects of Freshwater Salmon Habitat in Washington State. Pages 217-254 in M.M. Elsner, J. Littell, and L.W. Binder (eds.). The Washington Climate Change Impacts Assessment. Center for Science in the Earth System, Joint Institute for the Study of the Atmosphere and Oceans, University of Washington, Seattle.

Mantua, N., I. Tohver, and A. Hamlet. 2010. Climate Change Impacts on Streamflow Extremes and Summertime Stream Temperature and Their Possible Consequences for Freshwater Salmon Habitat in Washington State. Climatic Change 102:187-223.

McCabe, G. T., Jr., W. D. Muir, et al. 1983. Interrelations Between Juvenile Salmonids and Nonsalmonid Fish in the Columbia River Estuary. Fish Bulletin 81.

McCabe, G.T., R.L. Emmett, W.D. Muir, and T.H. Blahm. 1986. Utilization of the Columbia River Estuary by Subyearling Chinook Salmon. Northwest Science 60:113-124.

McElhany, P. 2005. Columbia River Chum Salmon ESU. In T.P. Good, R.S. Waples, and P. Adams, editors. Updated Status of Federally Listed ESUs of West Coast Salmon and Steelhead. NOAA Northwest Fisheries Science Center, Seattle, WA.

McElhany, P. 2010. Personal communication with Patty Dornbusch. August 9, 2010.

McElhany, P., and 11 coauthors. 2003. Interim Report on Viability Criteria for Willamette and Lower Columbia Basin Pacific Salmonids. Willamette/Lower Columbia Technical Recovery Team Interim Report. NOAA Fisheries, Portland.

McElhany, P., and 11 coauthors. 2006. Revised Viability Criteria for Salmon and Steelhead in the Willamette and Lower Columbia Basins. Willamette/Lower Columbia Technical Recovery Team and Oregon Department of Fish and Wildlife. NOAA Fisheries, Portland. Review draft. April 1, 2006.

McElhany, P., M. Chilcote, J. Myers, and R. Beamesderfer. 2007. Viability Status of Oregon Salmon and Steelhead Populations in the Willamette and Lower Columbia Basins. Prepared for the Oregon Department of Fish and Wildlife and National Marine Fisheries Service. September 2007.

McElhany, P., M.H. Ruckelshaus, M.J. Ford, T.C. Wainwright, and E.P. Bjorkstedt. 2000. Viable Salmonid Populations and the Recovery of Evolutionarily Significant Units. U.S. Department of Commerce, NOAA technical memorandum. NMFS-NWFSC-42, 156 p.

McElhany, P., T. Backman, C. Busack, S. Kolmes, J. Myers, D. Rawding, A. Steel, C. Steward, T. Whitesel, and C. Willis. 2004. Status Evaluation of Salmon and Steelhead Populations in the Willamette and Lower Columbia River Basins. Willamette/Lower Columbia Technical Recovery Team report. Northwest Fisheries Science Center, NOAA Fisheries, Seattle. July 2004.

McMichael, G.A., R.A. Harnish, J.R. Skalski, K.A. Deters, K.D. Ham, R.L. Townsend, P.S. Titzler, M.S. Hughes, J. Kim, and D.M. Trott. 2011. Migratory Behavior and Survival of Juvenile Salmonids in the Lower Columbia River, Estuary, and Plume in 2010. Prepared by the Pacific Northwest National Laboratory for U.S. Army Corps of Engineers, Portland District, Portland Oregon.

Miles, E.L., A.K. Snover, A.F. Hamlet, B.M. Callahan, and D.L. Fluharty. 2000. Pacific Northwest Regional Assessment: The Impacts of Climate Variability and Climate Change on the Water Resources of the Columbia River Basin. Journal of the American Water Resources Association 36(2):399-420.

Mote, P., A. Petersen, S. Reeder, H. Shipman, and L.W. Binder. 2008. Sea Level Rise in the Coastal Waters of Washington State. University of Washington Climate Impacts Group and Washington Dept. of Ecology. Available at: http://cses.washington.edu/db/pdf/moteetalslr579.pdf.

Mote, P.W., and E.P. Salathe, Jr. 2009. Future Climate in the Pacific Northwest. Pages 21–43 in M.M. Elsner, J. Littell, and L.W. Binder, editors. The Washington Climate Change Impacts Assessment. Center for Science in the Earth System, Joint Institute for the Study of the Atmosphere and Oceans, University of Washington, Seattle.

Mote, P.W., D. Gavin, and A. Huyer. 2010. Climate Change in Oregon's Land and Marine Environments. Pages 1-45 in Oregon Climate Assessment Report, Oregon Climate Change Research Institute, K.D. Dello and P.W. Mote (eds). College of Oceanic and Atmospheric Sciences, Oregon State University, Corvallis, OR. www.occri.net/OCCAR.

Mote, P.W., D.J. Canning, D.L. Fluharty, R.C. Francis, J.F. Franklin, A.F. Hamlet, M. Hershman, M. Holmberg, K.N. Ideker, W.S. Keeton, D.P. Lettenmaier, L.R. Leung, N.J. Mantua, E.L. Miles, B. Noble, H. Parandvash, D. W. Peterson, A.K. Snover, and S.R. Willard. 1999. Impacts of Climate Variability and Change, Pacific Northwest. NOAA Office of Global Programs, and JISAO/SMA Climate Impacts Group, Seattle, WA. 110p.

Mote, P.W., E.A. Parson, A.F. Hamlet, K.N. Ideker, W.S. Keeton, D.P. Lettenmaier, N.J. Manua, E.L. Miles, D.W. Peterson, D.L. Peterson, R. Slaughter, and A.K. Snover. 2003. Preparing for Climate Change: The Water, Salmon, and Forests of the Pacific Northwest. Climatic Change 61:45-88.

Myers, J., C. Busack, D. Rawding, A. Marshall, D. Teel, D.M. Van Doornik, and M.T. Maher. 2006. Historical Population Structure of Pacific Salmonids in the Willamette River and Lower Columbia River Basins. U.S. Department of Commerce, NOAA Tech. Memo. NMFS-NWFSC-73, 311 pp. February 2006.

Naish, K.A., Taylor, J.E., Levin, P.S., Quinn, T.P., Winton, J.R., Huppert, D., and Hilborn, R. 2008. Advances in Marine Biology 53:61-141.

Narver, D.W. 1976. Stream Management for West Coast Anadromous Salmonids. Pages 7-13 in Stream Management of Salmonids. Trout, Winter 1976 Suppl.

National Marine Fisheries Service 2009c. FCRPS Adaptive Management Implementation Plan. 2008-2018 Federal Columbia River Power System Biological Opinion. September 11, 2009.

National Marine Fisheries Service. 1996. Endangered and Threatened Species: Proposed Endangered Status for Five ESUs of Steelhead and Proposed Threatened Status for Five ESUs of Steelhead in Washington, Oregon, Idaho, and California. Federal Register [Docket No. 960730210-6210-01, 9 August 1996]. Volume 61(155), page 41558.

National Marine Fisheries Service. 1997. Investigation of Scientific Information on the Impacts of California Sea Lions and Pacific Harbor Seals on Salmonids and on the Coastal Ecosystems of Washington, Oregon, and California. NOAA Technical Memorandum NMFS-NWFSC-28.

National Marine Fisheries Service. 1999. Updated Review of the Status of the Upper Willamette River and the Middle Columbia River ESUs of Steelhead (*Oncorhynchus mykiss*). January 12, 1999, NMFS-NWFSC Status Review Update Memo, Available on the Internet at: http://www.nwr.noaa.gov/Publications/Biological-Status-Reviews/upload/SR1999-steelhead.pdf.

National Marine Fisheries Service. 2000a. White Paper: Passage of Juvenile and Adult Salmonids Past Columbia and Snake River Dams. Northwest Fisheries Science Center, 2725 Montlake Blvd. E., Seattle, Washington, 98112-2097.

National Marine Fisheries Service. 2000b. Biological Opinion, Reinitiation of Consultation on the Operation of the Federal Columbia River Power System, Including the Juvenile Fish Transportation Program, and 19 Bureau of Reclamation Projects in the Columbia Basin.

National Marine Fisheries Service. 2004a. Interim Endangered and Threatened Species Recovery Planning Guidance, Version 1.0. October 2004.

National Marine Fisheries Service. 2004b. Salmonid Hatchery Inventory and Effects Evaluation Report. Technical Memorandum NMFS-NWR/SWR (NMFS 2004b). An Evaluation of the Effects of Artificial Propagation on the Status and Likelihood of Extinction of West Coast Salmon and Steelhead under the Federal Endangered Species Act. May 28, 2004.

National Marine Fisheries Service. 2005a. Draft Interim Regional Recovery Plan for Portions of Three Evolutionarily Significant Units (ESUs) of Salmon and Steelhead—Columbia River Chinook (Onchorhynchus tshawytscha), Columbia River Chum (Onchorhynchus keta), and Lower Columbia River Steelhead (Onchorhynchus mykiss)—within the Washington Lower Columbia Management Unit. National Oceanic and Atmospheric Administration's National Marine Fisheries Service Supplement to the Lower Columbia Salmon Recovery and Fish and Wildlife Subbasin Plan. Prepared by National Marine Fisheries Service Northwest Region. April 15, 2005.

National Marine Fisheries Service. 2005b. Green Sturgeon (*Acipenser medirostris*) Status Review Update. NOAA Fisheries Biological Review Team, Santa Cruz Laboratory, Southwest Fisheries Science Center. February 2005.

National Marine Fisheries Service. 2005c. Final Assessment of NOAA Fisheries' Critical Habitat Analytical Review Teams for 12 Evolutionarily Significant Units of West Coast Salmon and Steelhead, Appendix J: CHART Assessment for the Middle Columbia River Steelhead ESU. Prepared by NMFS Protected Resources Division. August, 2005. Available at http://www.nwr.noaa.gov/Salmon-Habitat/Critical-Habitat/Redesignations/upload/F-CHART-STMCR.PDF.

National Marine Fisheries Service. 2007. Adaptive Management for ESA-Listed Salmon and Steelhead Recovery: Decision Framework and Monitoring Guidance. Prepared by National Marine Fisheries Service Northwest Region and Northwest Fisheries Science Center. May 1, 2007. Available at http://www.nwr.noaa.gov/Salmon-Recovery-Planning/.

National Marine Fisheries Service. 2008a. Recovery Plan Module: Mainstem Columbia River Hydropower Projects. September 24, 2008.

National Marine Fisheries Service. 2008b. NOAA Fisheries 2008-2017 United States v. Oregon Management Agreement. May 5, 2008.

National Marine Fisheries Service. 2008c. Supplemental Comprehensive Analysis of the Federal Columbia River Power System and Mainstem Effects of U.S. Bureau of Reclamation Upper Snake and Other Tributary Actions. NMFS, Portland, Oregon. May

5, 2008. Available at http://www.nwr.noaa.gov/Salmon-Hydropower/Columbia-Snake-Basin/upload/Final_SCA_Ch1_7.pdf.

National Marine Fisheries Service. 2008d. Memo: Northwest Region Recovery Implementation Strategy. NMFS Northwest Region. February 26, 2008.

National Marine Fisheries Service. 2008e. Draft Environmental Assessment: Reducing the Impact on At-Risk Salmon and Steelhead by California Sea Lions in the Area Downstream of Bonneville Dam on the Columbia River, Oregon and Washington. NMFS Northwest Region. January 11, 2008.

National Marine Fisheries Service. 2008f. Endangered Species Act Section 7(a)(2) Consultation Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Consultation on Remand for Operation of the Federal Columbia River Power System, 11 Bureau of Reclamation Projects in the Columbia Basin and ESA Section 10(a)(1)(A) Permit for Juvenile Fish Transportation Program. NMFS, Portland, Oregon.

National Marine Fisheries Service. 2008g. Questions and Answers on the NOAA Fisheries Service Decision to Conduct an Endangered Species Act Status Review for the West Coast Eulachon (Smelt). March 2008. Available at http://www.nwr.noaa.gov/Other-Marine-Species/eulachon.cfm. Web site accessed March 16, 2010.

National Marine Fisheries Service. 2008h. Biological Opinion: Endangered Species Act (ESA) Section 7 Consultation Number F/NRW/2008/00486: Assessment of Impacts from Sea Lion Removal Program. National Marine Fisheries Service, Northwest Region. Protected Resources Division, Portland, Oregon.

National Marine Fisheries Service. 2008i. Recovery Plan for Southern Resident Killer Whales (*Orcinus orca*). National Marine Fisheries Service, Northwest Region, Seattle, Washington.

National Marine Fisheries Service. 2008k. Recovery Plan for the Steller Sea Lion: Eastern and Western Distinct Population Segments (*Eumetopias jubatus*). National Marine Fisheries Service, Northwest Region, Seattle, Washington.

National Marine Fisheries Service. 2009a. Middle Columbia River Steelhead Distinct Population Segment ESA Recovery Plan. National Marine Fisheries Service, Northwest Region. November 30, 2009.

National Marine Fisheries Service. 2009b. Designation of Critical Habitat for the Threatened Southern Distinct Population Segment of North American Green Sturgeon. Final biological report. NMFS, Southwest Region, Protected Resources Division, Long Beach, CA.

National Marine Fisheries Service. 2010a. Endangered Species Act—Section 7 Consultation Supplemental Biological Opinion. Supplemental Consultation on Remand for Operation of the Federal Columbia River Power System, 11 Bureau of Reclamation

Projects in the Columbia Basin, and ESA Section 10(a)(1)(A) Permit for Juvenile Fish Transportation Program. NMFS, Portland, Oregon. Available at https://pcts.nmfs.noaa.gov/pls/pctspub/pcts_upload.summary_list_biop?p_id=124302.

National Marine Fisheries Service. 2010b. Status Review Update for Eulachon in Washington, Oregon, and California. Prepared by the Eulachon Biological Review Team, NMFS, January 20, 2010. Available at http://www.nwr.noaa.gov/Other-Marine-Species/eulachon.cfm. Web site accessed March 16, 2010.

National Marine Fisheries Service. 2010c. Draft Environmental Impact Statement to Inform Columbia River Basin Hatchery Operations and the Funding of Mitchell Act Hatchery Programs.

National Marine Fisheries Service. 2011a. Columbia River Estuary ESA Recovery Plan Module for Salmon and Steelhead. NMFS Northwest Region. Portland, OR. Prepared for NMFS by the Lower Columbia River Estuary Partnership (contractor) and PC Trask & Associates, Inc. (subcontractor). January 2011.

National Marine Fisheries Service. 2011b. Draft ESA Recovery Plan for the White Salmon River Watershed. December 2011.

National Marine Fisheries Service. 2011c. 5-Year Review: Summary & Evaluation of Lower Columbia River Chinook, Columbia River Chum, Lower Columbia River Coho, Lower Columbia River Steelhead. Northwest Region. Portland, OR. Available at http://www.nwr.noaa.gov/ESA-Salmon-Listings/5-yr-rpts.cfm.

National Marine Fisheries Service. 2011d. Effects of Hatchery Programs on Salmon and Steelhead Populations: Reference Document for NMFS ESA Hatchery Consultations. March 7, 2011. NMFS Northwest Regional Office, Salmon Management Division. Portland, Oregon, 50p.

National Research Council. 1996. Upstream: Salmon and Society in Pacific Northwest. National Academy Press. Washington, D.C. 452 pp.

National Research Council. 2004. Managing the Columbia River: Instream Flows, Water Withdrawals, and Salmon Survival. The National Academies Press. Washington, D.C.

Natural Resources Conservation Service. 2006. Bull Trout (*Salvelinus confluentus*). Wildlife Habitat Council. Fish and Wildlife Habitat Management Leaflet No. 36. January 2006.

Noren, D.P. 2010. Estimated Field Metabolic Rates and Prey Requirements of Resident Killer Whales. Marine Mammal Science. 27:60–77.

Normandeau Associates Inc., J.R. Skalski, and Mid-Columbia Consulting Inc. 1995. Turbine Passage Survival of Juvenile Chinook Salmon (*Oncorhynchus tshawytscha*) at Lower Granite Dam, Snake River, Washington. Report to U.S. Army Corps of Engineers. Contract DACW68-95-C-0031, 78 p. (Available from U.S. Army Corps of Engineers, Walla Walla, WA 99362.)

Normandeau Associates Inc., J.R. Skalski, and Mid-Columbia Consulting Inc. 1996. Draft Report on Potential Effects of Spillway Flow Deflectors on Fish Condition and Survival at the Bonneville Dam, Columbia River. Report to the U.S. Army Corps of Engineers, Contract DACW57-95-C-0086, 51 p. plus App. (Available from U.S. Army Corps of Engineers, Portland, OR 97208.)

Normandeau Associates Inc., J.R. Skalski, and Mid-Columbia Consulting Inc. 1999. Relative Passage Survival and Injury Mechanisms for Chinook Salmon Smolts Within the Turbine Environment at McNary Dam, Columbia River. Draft Report to U.S. Army Corps of Engineers, Contract DACW68-96-D-003. (Available from U.S. Army Corps of Engineers, Walla Walla, WA 99362.)

Northwest Fisheries Science Center (NFWSC). 2010. Lower Columbia River Tule Chinook Salmon Life-Cycle Modeling. Draft report. National Marine Fisheries Service. February 10.

Northwest Power and Conservation Council. 2001. Dams and Hydropower. Personal communication (e-mail). Portland, OR.

Northwest Power and Conservation Council. 2004a. Mainstem Lower Columbia River and Columbia River Estuary Subbasin Plan. In Columbia River Basin Fish and Wildlife Program. Portland, OR. Available at http://www.nwcouncil.org/fw/subbasinplanning/Default.htm.

Northwest Power and Conservation Council. 2004b. White Salmon Subbasin Plan. In Columbia River Basin Fish and Wildlife Program. Portland, OR. May 28, 2004. Available at http://www.nwcouncil.org/fw/subbasinplanning/Default.htm.

Omernik, J.M. 1987. Ecoregions of the Conterminous United States. Annals of the Association of American Geographers. 77(1): 118-125.

Oregon Climate Change Research Institute. 2010. Oregon Climate Assessment Report. K.D. Dello and P.W. Mote (eds). College of Oceanic and Atmospheric Sciences, Oregon State University, Corvallis, OR. Available at: www.occri.net/OCAR.

Oregon Department of Energy. 2009. Report to the Legislature: Oregon Global Warming Commission. January 2009. Available at: http://www.oregon.gov/ENERGY/GBLWRM/GWC/docs/09CommissionReport.pdf.

Oregon Department of Fish and Wildlife and National Marine Fisheries Service Northwest Region. 2011. Upper Willamette River Conservation and Recovery Plan for Chinook Salmon and Steelhead. August 5, 2011.

Oregon Department of Fish and Wildlife. 2005. 2005 Oregon Native Fish Status Report. Oregon Department of Fish and Wildlife, Salem, Oregon.

Oregon Department of Fish and Wildlife. 2010. Lower Columbia River Conservation and Recovery Plan for Oregon Populations of Salmon and Steelhead. August 6, 2010. Available at http://www.dfw.state.or.us/fish/CRP/lower_columbia_plan.asp.

Oregon Department of Land Conservation and Development. 2010. The Oregon Climate Change Adaptation Framework. December 2010. Available at: http://www.oregon.gov/LCD/docs/ClimateChange/Framework_Final.pdf?ga=t

Pacific Northwest Fish Health Protection Committee. 1989. Model Comprehensive Fish Health Protection Program. Olympia, Washington. 33 pp.

Portland General Electric Company. 2006. Settlement Agreement Concerning the Relicensing of the Clackamas River Hydroelectric Project – FERC Project No. 2195. Exhibit D, Fish Passage and Protection Plan. March 2006.

Quinn, T.P. 2005. The Behavior and Ecology of Pacific Salmon and Trout. University of Washington Press. 363 pp.

Recovery Implementation Science Team (RIST). 2009. Hatchery Reform Science: A Review of Some Applications of Science to Hatchery Reform Issues. April 9, 2009.

Reischel, T.S., and T.C. Bjornn. 2003. Influence of Fishway Placement on Fallback of Adult Salmon at the Bonneville Dam on the Columbia River. North American Journal of Fisheries Management 23:1215-1224.

Reisenbichler, R.R., and J.D. McIntyre. 1977. Genetic Differences in Growth and Survival of Juvenile Hatchery and Wild Steelhead Trout, *Salmo gairdneri*. Journal of the Fisheries Research Board of Canada 34: 123-128.

Roby, D.D., D.P. Craig, K. Collis, and S.L. Adamany. 1998. Avian Predation on Juvenile Salmonids in the Lower Columbia River, 1997 Annual Report. Bonneville Power Administration Contract 97BI33475 and U.S. Army Corps of Engineers Contract E96970049. 70 pp.

Roegner, G.C., D.L. Bottom, A. Baptista, S. Hinton, C.A. Simenstad, E. Casillas, and K. Jones. 2004. Estuarine Habitat and Juvenile Salmon: Current and Historical Linkages in the Lower Columbia River and Estuary, 2003. Northwest Fisheries Science Center, National Marine Fisheries Service, Seattle, WA.

Roelofs, T.D. 1983. Current Status of California Summer Steelhead (*Salmo gairdneri*) Stocks and Habitat, and Recommendations for Their Management. Submitted to USDA Forest Service, Region 5, 77 p. (Available from Protected Resources Division, National Marine Fisheries Service, 1201 E Lloyd Blvd., Suite 1100, Portland, Oregon 97232.)

Roni, P., G.R. Pess, T.J. Beechie, and S.A. Morley. 2011. Estimating Salmon and Steelhead Response to Watershed Restoration: How Much Restoration Is Enough? North American Journal of Fisheries Management, 30:1469 1484.

Ruggiero, P., C. Brown, P. Komar, J. Allan, D. Reusser, and H. Lee. 2010. Impacts of Climate Change on Oregon's Coasts and Estuaries. P. 209-265 In: K.D. Dello and P.W. Mote (eds). Oregon Climate Assessment Report. Oregon Climate Change Research Institute, College of Oceanic and Atmospheric Sciences, Oregon State University, Corvallis, OR. Available at: www.occri.net/OCAR.

Ryan, B.A., S.G. Smith, J.M. Butzerin, and J.W. Ferguson. 2003. Relative Vulnerability to Avian Predation of Juvenile Salmonids Tagged with Passive Integrated Transponders in the Columbia River Estuary, 1998-2000. Transactions of the American Fisheries Society 132:275-288.

Ryman, N., and L. Laikre. 1991. Effects of Supportive Breeding on the Genetically Effective Population Size. Conservation Biology 5:325-329.

Salathe, E.P, L. R. Leung, Y. Qian, and Y. Zhang. 2009. Regional Climate Model Projections for the State of Washington. Pages 45–67 in M. M. Elsner, J. Littell, and L.W. Binder, editors. The Washington Climate Change Impacts Assessment. Center for Science in the Earth System, Joint Institute for the Study of the Atmosphere and Oceans, University of Washington, Seattle.

Salathe, E.P. 2005. Downscaling Simulations of Future Global Climate with Application to Hydrologic Modelling. International Journal of Climatology 25(4):419-436.

Sandercock, F. K. 1991. Life History of Coho Salmon (*Oncorhynchus kisutch*). Pacific Salmon Life Histories. C. Groot and L. Margolis. University of British Columbia Press, Vancouver. 395-446.

Shapovalov, L. and A.C. Taft. 1954. The Life Histories of the Steelhead Rainbow Trout (*Salmo gairdneri*) and Silver Salmon (*Oncorhynchus kisutch*) with Special Reference to Waddell Creek, California, and Recommendations Regarding Their Management. Calif. Dept. Fish and Game, Fish Bull. No. 98. 373 pp.

Sherwood, C.R., D.A. Jay, R.B. Harvey, P. Hamilton, and C.A. Simenstad. 1990. Historical Changes in the Columbia River Estuary. Pages 299-352 in M.V. Angel and R.L. Smith eds., Columbia River: Estuarine System. Progress in Oceanography 25(1-4).

Snover, A.K., A.F. Hamlet, and D.P. Lettenmaier. 2003. Climate Change Scenarios for Water Planning Studies: Pilot Applications in the Pacific Northwest. Bulletin of the American Meteorological Society 84(11):1513-1518.

Stansell, R.J., K.M. Gibbons, W.T. Nagy, and B.K. van der Leeuw. 2011. 2011 Field Report: Evaluation of Pinniped Predation on Adult Salmonids and Other Fish in the Bonneville Dam Tailrace, 2011. U.S. Army Corp. of Eng., Portland Dist., Fish. Field. Unit, Bonneville Lock and Dam, Cascade Locks, OR 97014. 29 pp.

State of Oregon Office of Economic Analysis. 2004. Forecasts of Oregon's County Populations and Components of Change, 2000—2040.

Steel, E. A., and M. B. Sheer. 2003. Appendix I: Broad-Scale Habitat Analyses to Estimate Fish Densities for Viability Criteria. In Willamette/Lower Columbia Technical Recovery Team, Interim Report on Viability Criteria for Willamette and Lower Columbia Basin Pacific Salmonids. Northwest Fisheries Science Center, NMFS, Seattle, WA.

Steward, C.R., and T.C. Bjornn. 1990. Supplementation of Salmon and Steelhead Stocks with Hatchery Fish: A Synthesis of Published Literature. Tech. Report 90-1. Bonneville Power Administration.

Steward, I.T., D.R. Cayan, and M.D. Dettinger. 2004. Changes in Snowmelt Runoff Timing in Western North America Under a "Business as Usual" Climate Change Scenario. Climatic Change 62:217-232.

Stock, C. A., M. Alexander, N. Bond, K. Brander, W. Cheung, E. Curchitser, T. Delworth, J. Dunne, S. Griffies, M. Haltuchg, J. Hare, A. Hollowed, P. Lehodey, S. Levin, J. Link, K. Rose,R. Rykaczewski, J. Sarmienton, R. Stouffer, F. Schwingo, G. Vecchi, and F. Werner. 2011. On the Use of IPCC-class Models to Assess the Impact of Climate on Living Marine Resources. Progress in Oceanography 88: 1-27.

Stout, H.A., P.W. Lawson, D. Bottom, T. Cooney, M. Ford, C. Jordan, R. Kope, L. Kruzic, G.Pess, G. Reeves, M. Scheuerell, T. Wainwright, R. Waples, L. Weitkamp, J. Williams and T. Williams. 2011. Scientific Conclusions of the Status Review for Oregon Coast Coho Salmon (*Oncorhynchus kisutch*). Draft revised report of the Oregon Coast Coho Salmon Biological Review Team. NOAA/NMFS/NWFSC, Seattle, WA. Available at: http://www.nwr.noaa.gov/ESA-Salmon-Listings/Salmon-Populations/Alsea-Response/upload/OCC-review-2011.pdf.

Trombulak, S.C., K.S. Omland, J.A. Robinson, J.J. Lusk, T.L. Fleischner, G. Brown, and M. Domroese. 2004. Principles of Conservation Biology: Recommended Guidelines for Conservation Literacy from the Education Committee of the Society for Conservation Biology. Conservation Biology 18:1180-1190.

Turner, Richard. 2011. Personal communication with Richard Turner, Fisheries Biologist, Salmon Recovery Division, NOAA Fisheries. Portland, Oregon.

Tymchuk, W. E., C. Biagi, R. E. Withler, and R. H. Devlin. 2006. Growth and Behavioral Consequences of Introgression of a Domesticated Aquaculture Genotype into a Native Strain of Coho Salmon. Transactions of the American Fisheries Society 135:442-455.

U.S .Fish and Wildlife Service, National Oceanographic and Atmospheric Administration, and New York State Division of Fish, Wildlife, and Marine Resources (Co-lead agencies). 2012. National Fish, Wildlife and Plants Climate Adaptation Strategy, Public Review Draft. January 2012. Available at: http://www.wildlifeadaptationstrategy.gov/pdf/public_review_draft.pdf.

U.S. Army Corps of Engineers. 2007. Status Report—Pinniped Predation and Hazing at Bonneville Dam in 2007. Fisheries Field Unit CENWPOP-SRF Bonneville Lock and Dam, Cascade Locks, Oregon.

U.S. Army Corps of Engineers. 2011a. 2011 Field Report: Evaluation of Pinniped Predation on Adult Salmonids and Other Fish in the Bonneville Dam Tailrace. Portland District, Fisheries Field Unit. Prepared by Robert J. Stansell, Karrie M. Gibbons, William T. Nagy, and Bjorn K. van der Leeuw.

U.S. Army Corps of Engineers. 2011b. Survival and Passage of Juvenile Chinook Salmon and Steelhead Passing Through Bonneville Dam, 2010. Draft Final Report. Prepared for the U.S. Army Corps of Engineers, Portland District, by Pacific Northwest National Lab, under an Interagency Agreement with the U.S. Department of Energy, Contract DE-AC05-76RLO1830. PNNL 20835. October 2011.

U.S. Department of Agriculture and U.S. Department of Interior. 1994. Record of Decision for Amendments to Forest Service and Bureau of Land Management Planning Documents within the Range of the Northern Spotted Owl. Washington, D.C.

U.S. Fish and Wildlife Service. 1995. Fish Health Policy and Implementation, 713 FW., U.S. Fish and Wildlife Service Manual (FWM). U.S. Fish & Wildlife Service, Washington, D.C.

U.S. Fish and Wildlife Service. 1998. Bull Trout Facts. Public Affairs Office, USFWS, Portland Oregon. May 1998.

U.S. Fish and Wildlife Service. 2004. Fish Health Policy and Implementation, 713 FW 1-5, U.S. Fish and Wildlife Service Manual (FWM) U.S. Fish & Wildlife Service, Washington, D.C.

U.S. Fish and Wildlife Service. 2005. Caspian Tern Management to Reduce Predation of Juvenile Salmonids in the Columbia River Estuary. Final environmental impact statements. Portland, Oregon.

U.S. Fish and Wildlife Service. 2006. Revised Hawaiian Forest Birds Recovery Plan. Available at: http://www.fws.gov/pacificislands/recoveryplans.html.

U.S. Fish and Wildlife Service. 2008. Bull Trout (*Salvelinus confluentus*) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service, Portland, Oregon.

U.S. Fish and Wildlife Service. 2010. Bull trout background information (biology, species description, proposed critical habitat description, species profile). Available at http://www.fws.gov/pacific/bulltrout/. Website accessed March 31, 2010.

Volkman, J.M. 1997. A River in Common: The Columbia River, the Salmon Ecosystem, and Water Policy. A report to the Western Water Policy Review Advisory Commission. Springfield, VA: National Technical Information Service.

Waples, R.S., R.P. Jones, Jr., B.R. Beckman, and G.A. Swan. 1991. Status Review for Snake River Fall Chinook Salmon. United States Department of Commerce, National Oceanic and Atmospheric Administration.

Ward, B.R., and P.A. Slaney. 1988. Life History and Smolt-to-Adult Survival of Keogh River Steelhead Trout (*Salmo gairdneri*). Canadian Journal of Fisheries and Aquatic Sciences 45:1110-1122.

Washington Department of Ecology. 2011. Interim Recommendations from Topic Advisory Group 3: Species, Habitats and Ecosystems, February, 2011. Washington State

Integrated Climate Change Response Strategy. Available at: http://www.ecy.wa.gov/climatechange/2011TAGdocs/E2011_interimreport.pdf.

Washington Department of Fish and Wildlife and Oregon Department of Fish and Wildlife. 2002. Status Report: Columbia River Fish Runs and Fisheries, 1938-2000. July 2002. 324 pg.

Washington Department of Fish and Wildlife, Western Washington Treaty Indian Tribes, and Northwest Indian Fisheries Commission. 1995. Dungeness River Chinook Salmon Rebuilding Project Progress Report 1992-93. C.J. Smith and P. Wampler, Editors.

Washington Department of Fish and Wildlife and Western Washington Treaty Indian Tribes. 1998. Salmonid Disease Control Policy of the Fisheries Co-Managers of Washington State. Olympia, Washington.

Washington Department of Fish and Wildlife. 1996. Fish Health Manual. Fish Health Division, Hatcheries Program. Washington Department of Fish and Wildlife, Olympia, Washington.

Washington State Department of Transportation. Population Growth in Relation to the State's Counties. Website accessed November 29, 2011. http://www.wsdot.wa.gov/planning/wtp/datalibrary/population/PopGrowthCounty.htm.

Washington State Natural Resources Cabinet. 1999. Statewide Strategy to Recover Salmon: Extinction Is Not an Option. Washington Governor's Salmon Recovery Office. Olympia, WA.

Welander, A.D. 1940. Notes on the Dissemination of Shad, *Alosa sapidissima* (Wilson), along the Pacific Coast of North America. Copeia 1940(4): 221-223.

Welch, K.F., M. Yinger and K. Callahan. 2002. WRIA 29: Hydrology and Geology Assessment. Review draft. Prepared for Envirovision Corp. and WRIA 29 Planning Unit.

Western Regional Climate Center. 2003. National Oceanic and Atmospheric Organization, National Climatic Data Center. http://www.wrcc.dri.edu/index.html.

Whitney, R.R., L. Calvin, M. Erho, and C. Coutant. 1997. Downstream Passage for Salmon at Hydroelectric Projects in the Columbia River Basin: Development, Installation, and Evaluation. U.S. Department of Energy, Northwest Power Planning Council, Portland, Oregon. Report 97-15. 101 pp.

Wiles, G.J. 2004. Washington State Status Report for the Killer Whale. Washington Department of Fish and Wildlife. March 2004.

Wiley, M.W. 2004. Analysis Techniques to Incorporate Climate Change Information into Seattle's Long Range Water Supply Planning. Master's Thesis, Department of Civil and Environmental Engineering, University of Washington; Seattle, WA.

Wipfli, M.S., J.P. Hudson, D.T. Chaloner, and J.P. Caouette. 1999. Influence of Salmon Spawner Densities on Stream Productivity in Southeast Alaska. Canadian Journal of Fisheries and Aquatic Sciences 56:1600-1611.

Withler, R.E. 1988. Genetic Consequences of Fertilizing Chinook Salmon (*Oncorhynchus tshawytscha*) Eggs with Pooled Milt. Aquaculture 68: 15-25.

Zamon, J.E., T.J. Guy, K. Balcomb, and D. Ellifrit. 2007. Winter Observations of Southern Resident Killer Whales (*Orcinus Orca*) near the Columbia River Plume during the 2005 Spring Chinook Salmon (*Oncorhynchus Tshawytscha*) Spawning Migration. Northwestern Naturalist. Volume 88, pages 193 to 198.

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Northwest Region
7600 Sand Point Way N.E., Bldg. 1
Seattle, WA 98115

August 31, 2012

Donald O. McIsaac, Ph.D.
Executive Director
Pacific Fisheries Management Council
7700 NE Ambassador Place, Suite 101
Portland, Oregon 97220-1384

Dear Dr. McIsaac:

Thank you for your recent letter requesting an extension of the public comment period on the Proposed Endangered Species Act Recovery Plan for Lower Columbia River coho salmon, Lower Columbia River Chinook Salmon, Columbia River chum salmon, and Lower Columbia River steelhead (Proposed Plan). The Pacific Fisheries Management Council (Council) is a valued partner in recovery planning and implementation for West Coast salmon and steelhead. We agree that it is important that the Council be provided sufficient opportunity to review the Proposed Plan and provide comments through its typical processes.

We will be reopening the public comment period for 30 days to allow the Council's advisory bodies and staff time to review the Proposed Plan and provide their recommended comments for Council approval at its September 2012 meeting. We anticipate that the notice reopening the comment period will publish in the Federal Register in mid-September. We hope that will provide the Council sufficient time to submit any comments prior to the close of the public comment period in mid-October. We will notify you of the exact dates for the reopened comment period when the notice publishes.

Thank you for your commitment to salmon recovery in the Lower Columbia River and throughout the region. We look forward to our continued close collaboration and coordination as we complete the remaining recovery plans for West Coast salmon and steelhead and continue our efforts implementing priority recovery actions.

Sincerely,

William W. Stelle, Jr.
Regional Administrator

cc: Dr. Chuck Tracy, PFMC
Peter Dygert, Donna Darm, Patty Dornbusch, Scott Rumsey, NMFS-NWR
Jeff Bash, NMFS-NWFSC

Agenda Item E.5.b
Supplemental HC Report
September 2012

HABITAT COMMITTEE REPORT ON LOWER COLUMBIA ENDANGERED SPECIES ACT SALMON AND STEELHEAD RECOVERY PLAN

The Habitat Committee (HC) received a presentation from Ms. Patty Dornbusch, National Oceanic and Atmospheric Administration, on the Lower Columbia Endangered Species Act Salmon and Steelhead Recovery Plan. The goal of developing the integrated plan, which includes recovery actions for steelhead, Chinook, coho, and chum salmon, is to de-list these species from the Endangered Species Act. Comments on the plan are due October 9, 2012.

Although these species are at high risk of extinction in the next 100 years, there have been notable successes in recent years. These include the removal of three major dams (on the Sandy, Deschutes, and White Salmon rivers), improved fish passage at other tributary dams, reduced harvest impacts, and reduced hatchery impacts on wild salmon. Unfortunately, habitat improvements progress slowly where private landowner partnerships are essential.

The HC noted some inconsistencies in the plan, reflecting the 12 years of plan development and the combining of different sub-plans. Some information is also out of date; for example, the White Salmon River is described as having limited salmon production due to the Condit dam, but the plan recognizes removal of the Condit dam in other chapters.

The plan represents a long-term commitment where funding is a large concern, especially under declining Federal budgetary constraints. However, the HC recognized the importance of monitoring and reporting to showcase recovery action successes, identify shortcomings, and maintain momentum.

PFMC
09/14/2012

Agenda Item E.5.b
Supplemental NMFS PPT
September 2012

Science, Service, Stewardship

Overview of Proposed ESA Recovery Plan

Lower Columbia River Chinook Salmon
Lower Columbia River Coho Salmon
Lower Columbia River Steelhead
Columbia River Chum Salmon

September 2012
Patty Dornbusch, NOAA Fisheries

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Species covered:

LCR Chinook
LCR Coho
LCR Steelhead
CR Chum

Main components:

- ESU-level plan
- 3 local plans
- Estuary module
- Hydropower module

Geographic area covered

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Plan Goals

- Primary goal: achieve ESA de-listing
- Local plans also incorporate broad sense recovery goals
  - Related to harvest, other social and economic goals, or achieving lower risk levels than needed for de-listing
  - NMFS supports these broad-sense goals
    - Work with co-managers and stakeholders using non-ESA authorities to pursue broad sense goals while maintaining robust natural populations

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ESA De-listing Goals

TRT developed technical foundation:

- Need some populations at high persistence probability, others can be at moderate or low persistence
- Considerations related to spatial distribution, conserving historically productive populations, genetic legacy, etc.
- Concept of strata – each needs to be at high persistence probability (approximately half populations in each stratum viable)

Recovery scenario:

- Developed by local planners and NMFS using framework of TRT criteria
- Target status for each population

NMFS delisting criteria:

- Biological - population targets same as local plans = a possible scenario
- Threats criteria

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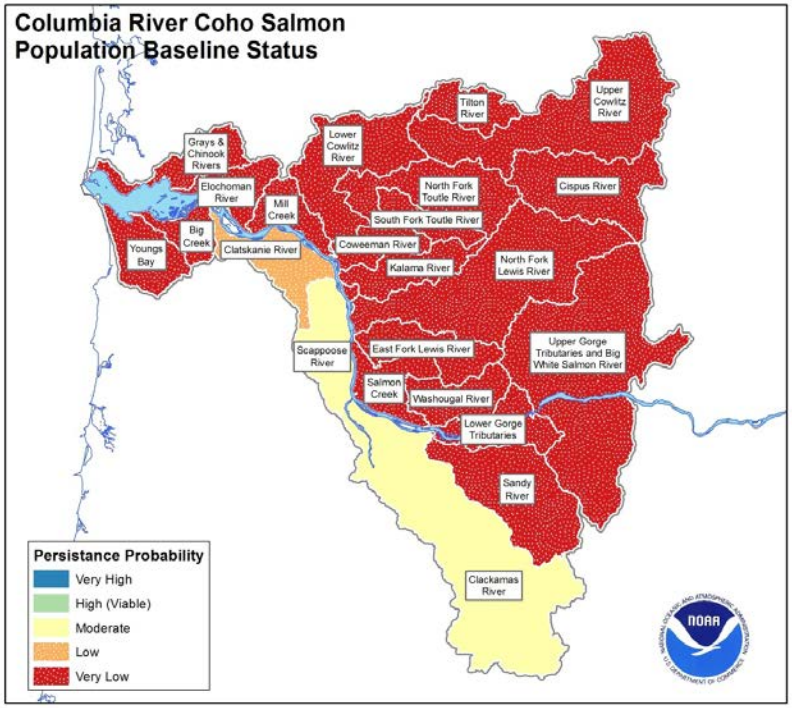
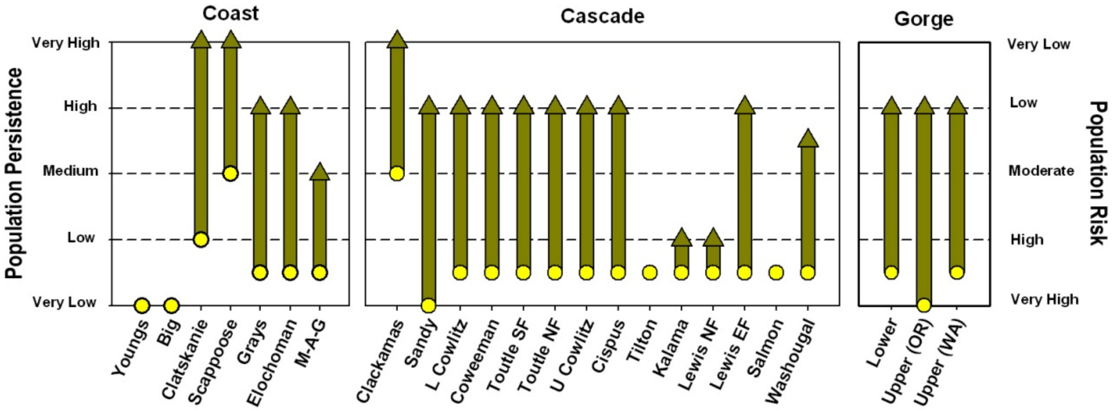
Recovery Scenario:

Lower Columbia River Coho Salmon





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Overall Approach to Recovery

1. Evaluate status of each population (using TRT's approach)
2. Identify limiting factors for each population
3. For each population, quantify baseline impacts for:
   - tributary habitat degradation
   - estuary habitat degradation
   - hydropower
   - harvest
   - hatcheries
   - ecological interactions
4. Establish target status for each population
5. Calculate improvements in abundance and productivity needed for each population to achieve target status
6. Identify combination of reductions in threats that would lead to the population achieving its target status – difference in OR and WA approach
7. Identify and scale recovery actions to reduce threats by targeted amount in each category
8. RME

Table 6-6

Impacts of Potentially Manageable Threats and Impact Reduction Targets Consistent with Recovery of LCR Coho Salmon Populations

Population	Impacts at Baseline							Impacts at Target							% Survival Improve-ment Needed
	T.Hab	Est	Dams	Harv	Hat	Pred	Cumul-ative	T.Hab	Est	Dams	Harv	Hat	Pred	Cumul-ative	
Coast															
Youngs Bay (OR)	0.98	0.10	0.00	0.90	0.86	0.06	0.9998	0.97	0.08	0.00	0.90	0.86	0.03	0.9996	60
Grays/Chinook (WA)	0.70	0.16	0.00	0.50	0.50	0.14	0.9458	0.40	0.09	0.00	0.29	0.29	0.08	0.7468	370
Big Creek (OR)	0.98	0.10	0.00	0.70	0.86	0.06	0.9993	0.97	0.08	0.00	0.70	0.86	0.03	0.9989	60
Eloch/Skam (WA)	0.60	0.16	0.00	0.50	0.50	0.14	0.9278	0.42	0.11	0.00	0.35	0.35	0.10	0.8037	170
Clatskanie (OR)	0.83	0.10	0.00	0.35	0.13	0.06	0.9187	0.68	0.08	0.00	0.25	0.10	0.04	0.8092	140
Mill/Ab/Germ (WA)	0.50	0.16	0.00	0.50	0.50	0.15	0.9108	0.25	0.08	0.00	0.25	0.25	0.08	0.6429	>500
Scappoose (OR)	0.83	0.10	0.00	0.35	0.05	0.06	0.9112	0.77	0.08	0.00	0.25	0.05	0.04	0.8553	60

Summary Strategies: Habitat

TRIBUTARY: Achieve adequate quantities of high-quality, well-functioning salmon and steelhead habitat through a combination of

1. site-specific projects that will protect habitat or provide benefits relatively quickly,
2. watershed-based actions that will repair habitat-forming processes and provide benefits over the long term, and
3. landscape-scale programmatic actions that affect a class of activities (such as stormwater management or forest practices) over multiple watersheds.

Many habitat actions already have been implemented but do not reflect the scale of improvements needed.

ESTUARY: Provide adequate off-channel and intertidal habitats; restore habitat complexity in areas modified by agricultural or residential use; decrease exposure to toxic contaminants

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Summary Strategies: Hydropower

1. Improve passage survival at Bonneville Dam for Lower Columbia River populations that spawn above the dam (FCRPS BiOp actions)
2. Implement mainstem flow management operations designed to benefit migrants from the interior Columbia Basin, which we expect will improve estuarine survival (FCRPS BiOp actions)
3. Address impacts in tributaries by implementing FERC agreements regarding operation of tributary dams (Lewis, Cowlitz, White Salmon, Hood, Sandy, Clackamas)

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Summary Strategies: Hatchery

1. Reduce hatchery impacts on natural-origin populations as appropriate for each population,
2. Ensure that some populations have no in-subbasin hatchery releases and are isolated from stray out-of-subbasin hatchery fish,
3. Use hatchery stocks in the short term for reintroduction or supplementation programs to restore naturally spawning populations in some watersheds, and
4. Ensure rigorous monitoring and evaluation to better understand existing population status and the effects of hatchery strategies on natural populations.
5. Maintain harvest opportunities created by hatchery fish (a societal goal that NOAA Fisheries has carried forward from the local plans to the proposed recovery plan).

Summary Strategies: Harvest

- Impacts on Lower Columbia River species substantially lower since ESA listing.
- LCR spring Chinook, steelhead, and chum: precautionary measures to ensure that harvest does not adversely affect future conservation and recovery efforts.
- LCR fall Chinook and coho: focus on (1) refinements in harvest management to further reduce impacts to naturally produced fish, and (2) continued review of overall harvest rates
- Use abundance-based management, weak stock management principles, mark-selective harvest, fill information needs

Summary Strategies: Predation, Climate Change

Plan includes actions to reduce predation on salmon and steelhead by birds, fish, and marine mammals.

Also incorporates a regional climate change strategy focused on (1) implementation of greenhouse gas reduction strategies, such as through the West Coast Governors' Global Warming Initiative and the Oregon Global Warming Commission's recommendations, and (2) adaptation to reduce the impacts of climate change.

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RME

- Local planners have developed or will develop detailed RME plans for their areas, based on regional guidance for adaptive management and RME

- PNAMP ISTM Demonstration Project:
  - Effort to apply master sample concept to selection of sampling locations in Lower Columbia
  - Goal to develop a coordinated VSP monitoring program

- Continued Needs:
  - Research on critical uncertainties
  - Linking RME and 5-Year ESA Reviews
  - Coordination and strategic use of limited resources

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Costs

Management Unit	5-Year Cost Estimate (millions)	25-Year Cost Estimate (millions)
Washington (LCFRB 2010a)	$245	$738
Oregon (ODFW 2010)	$189	$758
White Salmon (NMFS 2011b)	$16	$16
Estuary Module (NMFS 2011a)	$164	$592
TOTAL	$614	$2,104

Total estimated cost: $2.1 billion over 25 years

- $614 million in the first 5 years.
- Total includes $592 million ($164 million in the first 5 years) for actions in the Columbia River estuary that are expected to benefit all Columbia Basin salmon and steelhead.
- Cost estimates expected to change as implementation schedules are developed and actions more clearly scoped and planned.

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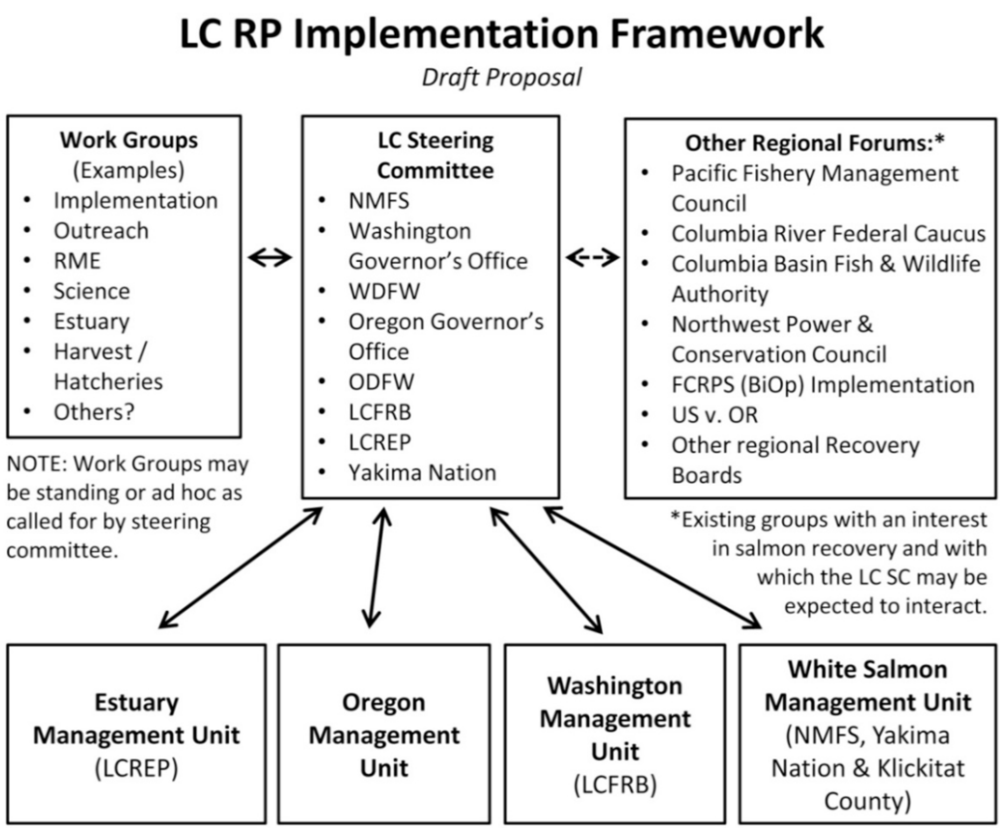
Implementation

- In general, local plans are the primary documents guiding implementation.
- Coordination at the LCR scale will occur as needed and will be achieved primarily through the Lower Columbia Recovery Plan Implementation Steering Committee



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Comment Period

FRN published May 16, 2012

60-day public comment period, through July 16, 2012

Comment period re-opened, September 7-October 9, 2012

Documents available at:
http://www.nwr.noaa.gov/Salmon-Recovery-Planning/Recovery-Domains/Willamette-Lower-Columbia/LC/Plan.cfm

SALMON ADVISORY SUBPANEL REPORT ON LOWER COLUMBIA ENDANGERED SPECIES ACT SALMON AND STEELHEAD RECOVERY PLAN

Ms. Patty Dornbusch provided a summary of the Lower Columbia River Recovery Plan (Plan) for the Salmon Advisory Subpanel (SAS). The SAS would like to make the following comments on the Plan, as presented at its meeting Sept. 13, 2012. Our comments are particularly directed towards the Harvest component of the Plan.

On page 4-27 , a paragraph is devoted to describing the reductions in harvest that have occurred in the last several decades; however, no correlation has been made regarding what those reductions contributed towards recovery. We raise the question, "Did reductions in harvest mask continued habitat degradation and other causes of salmonid decline?" Reducing harvest without reducing other threats, e.g., habitat degradation, passage, and flow issues, will not produce long-term recovery. We are not aware of any research that correlates these reductions to increases in populations. Moreover, on p. 8-4 of the Proposed ESA Recovery Plan for the White Salmon River watershed, Dec. 2011, NMFS lays out the four principles of adaptive management. The third principle is "effectiveness monitoring." Effectiveness monitoring has not been applied to the continual ratcheting down of harvest with the expectation that it will contribute to recovery. No metrics have been proposed or implemented to see if draconian harvest restrictions have been effective in producing desired results.

On page 4-33 of the Plan, we note that "In ESA evaluations...when harvest levels being evaluated are supported by hatchery production, the ecological, genetic, and other effects of hatchery production on both the juvenile and adult life stages also need to be considered as part of the harvest impact analysis." This statement overlooks the fact that numerous hatcheries, especially those supported by the Mitchell Act, were mitigation hatcheries, i.e. they were a surrogate for or substitute for habitat that had been degraded or destroyed, generally (but not always) by hydroelectric power generation. We suggest that the accountability in this statement as belonging to harvest is misplaced. The accountability rightfully belongs to those who degraded the habitat in the first place, and who continue to degrade it. We strongly object to the ecological, genetic, and other issues mentioned being charged to the harvest side of the ledger.

On p. 4- 34, we urge development of a more streamlined process to deal with terns, cormorants, marine mammals, and invasive species; one that is responsive at the beginning of a problem, rather than letting it get out of hand.

We support the goal of recovery and recognize the years of effort that have gone into the Plan; however, we note that the term "Refine harvest management" is frequently used in this document. We hope this is not a euphemism for "reduce harvest." Harvest reductions of considerable magnitude have already taken place, dramatically reducing harvest to a fraction of what it was in recent memory. The baseline from which recovery actions are measured does not account for prior harvest reductions in response to conservation measures for declining returns of Lower Columbia stocks and constraints on ocean fisheries from other stocks such as OCN coho and Snake River fall Chinook. While these harvest restrictions were being enacted, continued habitat and hydropower impacts to LCR stocks were being accrued. This leads to a disproportionate burden being placed on harvest when the Plan calls for, according to Ms. Dornbusch, “proportionate impact reduction from all sources from the time of listing”.

Continued reduction in harvest needs to take into account economic cost of such measures and the economic viability of fishing businesses and infrastructure, or the reductions will collide with the Lower Columbia Fish Recovery Board’s goal of recovering “Washington Lower Columbia River salmon, steelhead, and bull trout to healthy, harvestable levels that will sustain productive recreational, commercial and tribal fisheries through the restoration and protection of the ecosystems upon which they depend and the implementation of supportive hatchery and harvest practices” (P. 3-2). As the rollup plan notes, “Harvestability is a key aspect of the vision for recovery presented in the Washington management unit plan.” Likewise, the Oregon Plan focused on restoring “Oregon’s native fish populations and the aquatic systems that support them to productive and sustainable levels that will provide substantial environmental, cultural and economic benefits” (P. 3-3).

Frequent allusions to future harvest reductions and reduced hatchery production in the rollup plan do not inspire confidence that these overarching goals and an economic return to society from restored salmonid populations are supported as enthusiastically as they might be. For example, on p. ES-24 “Although recent actions have substantially reduced harvest of spring Chinook salmon from baseline conditions, ancillary and precautionary actions are needed to ensure that harvest does not adversely affect conservation and recovery in the future.” Harvest was not a significant cause of loss of spring Chinook; hydropower dams were. We will not achieve recovery by reducing harvest to nothing. We believe that the Plan is weak in its commitment to the harvest goal, and would like to see more supportive and robust language throughout. We also point out that mitigation for lost harvest is a legal obligation under a number of FERC licensing agreements and the Mitchell Act.

In support of the Plan, we recognize its significance not only to the lower Columbia River but along the entire coast. The Plan covers a large geographic area and has a large number of listed stocks (72). It can contribute significantly to the future of multiple fisheries and the overall health and quality of life of the entire lower Columbia and California Current large marine ecosystems. We are concerned about the funding issues for such a large undertaking that will need to occur over a period of many years. We also are concerned about how to maintain the momentum and commitment such a long-term plan requires in order to complete its mission. We appreciate NMFS’ willingness to re-open the comment period in order for us to attend the presentation and present our comments as a means of ensuring that the livelihoods of many fishing communities will be enhanced by implementation of the Lower Columbia Salmon Recovery Plan.

PFMC
09/15/12