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### **3.0 DESCRIPTION OF ADVERSE EFFECTS ON PACIFIC SALMON ESSENTIAL FISH HABITAT AND ACTIONS TO ENCOURAGE THE CONSERVATION AND ENHANCEMENT OF ESSENTIAL FISH HABITAT**

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#### **3.1 FISHING ACTIVITIES AFFECTING SALMON ESSENTIAL FISH HABITAT**

The Magnuson-Stevens Act requires the PFMC to minimize adverse effects of fishing activities on EFH to the extent practicable. The interim final rule implementing EFH provisions of the Magnuson-Stevens Act states that adverse effects of fishing may include physical, chemical, or biological alterations of the substrate, and loss of or injury to benthic organisms, prey species and their habitat, and other components of the ecosystem.

Marine activities which PFMC can directly influence are the effects of fishing gear, prey removal by other fisheries, and the effect of salmon fishing on the reduction of nutrient enrichment in salmon spawning streams. This section also considers similar activities under control of the states and tribes, as well as disturbance of redds or fish in shallow water environments from fishing activities (e.g., vessel operation).

Other activities that may be directly or indirectly associated with fishing, but are not regulated by state, federal or tribal fishery management entities, are considered in the section on nonfishing activities. These activities include environmental impacts from fish processing, hatchery operation, vessel operation and maintenance, and marina construction and dredging. The direct harvest and injury impacts of fishing activities on salmon abundance are addressed primarily in Chapters 2 and 3 of the *Pacific Coast Salmon Plan*.

Actions PFMC will take to reduce fishing effects on habitat, and actions PFMC recommends others take to protect habitat, are not the only efforts being undertaken, nor the only efforts necessary, to help restore sustainable fisheries. For example, to restore salmon abundance, many fish hatchery operations have been improved to minimize negative effects on wild salmon populations, and extensive restrictions on salmon fishing have been imposed. In the past decade, PFMC has significantly reduced fishing limits and seasons coastwide to assure sufficient numbers of adult salmon from various stocks reach their spawning grounds. Specifically, to protect salmon listed under the ESA, PFMC has limited recreational salmon fishing on healthy California salmon stocks to reduce the chance of catching endangered Sacramento River winter chinook. Similarly, PFMC limited all commercial ocean fisheries on healthy salmon runs in 1997 to reduce the incidental take of threatened Snake River fall chinook. (It should be noted that PFMC-managed salmon fisheries do not affect Snake River spring-summer chinook or sockeye salmon and have only minor effects on pink salmon stocks.)

Despite fishing curtailments or closures and improved hatchery practices, coho and chinook populations have continued to decline in Oregon, Washington, and California (Nehlsen 1997). Four of 15 stocks of Puget Sound pink salmon are classified as not healthy, with two populations considered depressed and two in critical condition (WDF 1993). In earlier studies of salmon declines, habitat problems were a factor contributing to about 91% of these declines (Nehlsen *et al.* 1991).

#### **3.1.1 Fishing Activities under the Control of the Council – Potential Effects on EFH and Measures to Minimize Adverse Affects**

##### **3.1.1.1 Gear Effects**

Currently, there are no studies that indicate direct gear effects on salmon EFH from PFMC-managed fisheries. A report prepared for NMFS by Auster and Langton (1998) provides a review and analysis of the studies done on fishing gear and habitat effects (primarily trawl and dredging studies from non-West Coast sites). Additionally, the 1998 draft EFH report of NPFMC (1998) provides a review of some of the current research of the Alaska Fisheries Science Center on the effects of trawling on the seafloor and on benthic organisms and their habitat. Fishing effects on habitat include the reduction of fish habitat complexity by directly removing or damaging epifauna leading to mortality, smoothing sedimentary bedforms and reducing bottom

roughness, removing taxa which produce structure (i.e., taxa which produce burrows and pits), or decreasing eelgrass or seagrass density.

Because salmon are not known to be directly dependent on soft ocean bottom habitats, fishing gear that has the potential for disturbing these habitats is not likely to directly affect EFH for salmon. If fishing gear were operated in areas of eelgrass beds and if it removed or caused a decrease in this habitat, this would be of concern. Studies done in the Pacific Northwest have documented the importance of the nearshore environment and eelgrass beds to salmonids (Simenstad 1983; Simenstad and Fresh 1995).

Since chinook salmon may be associated with "bottom topography" at depths of 30-70 m (see Section 2.1), and because juvenile and adult chinook are associated with structure such as channels, ledges, pinnacles, reefs, vertical walls, and artificial structure in marine environments (NPFMC 1998); fishing gear which disrupts these habitats has a potential to affect salmon EFH. However, there is no research information available that documents direct effects on salmon or their prey.

Anecdotal information from fishermen notes concern over the potential effect that both longline and rock-hopper trawl gear have on rocky habitat that supports juvenile rockfish that are prey for juvenile salmon. In studies reviewed by Auster and Langton (1998) and by the NPFMC, trawl gear was found to be able to move or drag boulders, damage and kill organisms, reduce habitat complexity, and resuspend sediments. In studies reviewed by the NPFMC, longline gear was found to snag rocks and corals, break corals and dislodge invertebrates. There is also anecdotal information that lost gill nets can continue to intercept salmon and their prey (both in marine and freshwater environments), until the net tangles up on itself or becomes fouled by marine growth. State and federal regulations preclude the use of gill nets in ocean waters north of 38° N latitude, and gill net usage in nearshore waters south of that line is very limited. Moreover, mesh size restrictions tend to preclude the capture of prey species.

**Gear Types Used In Salmon EFH** - Types of fishing gear used in PFMC-area fisheries are listed below. The list includes fisheries managed by PFMC, states, and tribes. The potential effects of any gear depends on the specifics of each fishery and each gear type (e.g., some trawl gear is fished on or near the bottom and some in mid-water, nets vary by configuration and in response to mesh size restrictions, fisheries are controlled by various time and area restrictions, etc.). Detailed management measures have not been developed, because of the lack of information demonstrating an adverse effect on EFH from salmon "gear".

<u>Fishery</u>	<u>Gear</u>
Anchovy, sardine, mackerel	purse seine, lampara net
Clam	shovel, hydraulic dredge, clam gun
Crab	pot/trap
Groundfish	bottom/mid-water trawl, longline, hook-and-line, pot/trap, set gill net, spear
Hagfish	pot/trap
Halibut (Pacific)	longline, hook-and-line, troll
Herring	purse seine, gill net, pound net, hook-and-line, weir
Lobster	pot/trap
Salmon	troll, gill net, purse seine, hook-and-line, dip net, weir
Sea urchin, abalone	hand rake, abalone iron
Sea cucumber	hand rake, trawl
Scallop	abalone iron, dredge
Shrimp, prawn	pot/trap, trawl
Smelt	dip net, gill net
Squid	seine
Sturgeon	hook-and-line, gill net
Swordfish, thresher shark	drift gill net
Tuna (Albacore)	troll, hook-and-line
Tuna (Yellowfin, skipjack tuna)	purse seine, hook-and-line
White croaker, white sea bass, California halibut, <i>et al.</i>	set gill-net, hook-and-line

**Measures** - Research is needed to study gear effects on EFH of salmon and their prey, especially disturbance of eelgrass beds and rocky habitat.

### 3.1.1.2 Harvest of Prey Species

Commercial or recreational fisheries exist or have existed for herring, sardine, anchovy, squid, smelt, groundfish, and crab. These species, either as adults or juveniles (e.g., juvenile rockfish, crab larvae) serve as important prey for salmon, and their take in fisheries may affect salmon. Additionally, it is known that pinniped eat herring, anchovy, mackerel, whiting, and other schooling fish. Significant fisheries on these prey species could increase pinniped predation on salmon (W. Pearcy, Oregon State University, College of Oceanic and Atmospheric Science, Corvallis, Oregon, 1998, pers. comm.). It is also known that whiting and mackerel prey on juvenile salmon so that harvests of these species may reduce predation on salmon populations.

**Measures** - PFMC manages fisheries for groundfish and anchovy and is expanding the coastal pelagic species plan to include sardine, squid, Pacific mackerel, and jack mackerel. The groundfish and coastal pelagic species plans will include provisions to prevent overfishing and protect EFH for all of the species in these management units, including those that are prey for salmon and other predators. In addition, the harvest formulas proposed for anchovy and sardine set aside a portion of the biomass as forage reserves for predator species. The states manage other fisheries for prey species, (e.g., herring). The herring fisheries occur in bays and estuaries and are tightly regulated by the states to prevent overfishing. Herring and squid are harvested primarily as spawning adults, after which many or most die.

### 3.1.1.3 Removal of Salmon Carcasses (Effects on Stream Nutrient Levels)

Salmon carcasses as well as their eggs, embryos, alevins, and fry provide vital nutrients to stream and lake ecosystems. Carcasses have been shown to enhance salmon growth and survival. Salmon fishing activities, as well as removal of returning fish to support hatchery operations, remove a portion of the fish whose carcasses could otherwise perform that habitat function.

One study in the Willapa Bay basin estimated that more than several thousand metric tons of salmon tissue have been lost each year as a nutrient source to streams, because of reductions in salmon returns. Present amounts of salmon carcasses and their nutrients in that basin were thought to be generally less than 10% of historical levels (NRC 1996).

Carcasses have been shown to be an important habitat component, enhancing smolt growth and survival by contributing significant amounts of nitrogen and phosphorus compounds to streams. (Spence *et al.* 1996). These are the nutrients that most often limit production in oligotrophic (nutrient poor) systems.

During their first year or so, salmon may obtain nourishment from "spawners" by directly feeding on carcasses (as well as eggs) as well as by eating insects or other organisms that have fed on decomposing salmon. Additionally, aquatic and riparian plants uptake nutrients from salmon carcasses. These plants are in turn consumed by invertebrates which are the prey for juvenile salmon (Bilby *et al.* 1997). Studies in western Washington have shown that as much as 40% of the nitrogen and carbon in juvenile salmonids derive from salmon carcasses, and the amount of marine-derived nitrogen increased, up to a point, with increased density of spawning fish. Waters that contained salmon carcasses were also found to have higher densities of juveniles, and those fish grew much faster over the winter than young salmon in waters without salmon carcasses. Following spawning, fingerling coho salmon exhibited a doubling of the rate of growth in streams sections that had been enriched with salmon carcasses (Bilby *et al.* 1997).

Although placing carcasses in streams may be helpful, it is not as effective as allowing natural escapement, because (1) natural spawners provide eggs as well as carcass tissue, (2) natural escapement provides carcasses over about one or two months rather than in a one-shot approach usually associated with carcass placement, and (3) carcasses are also present in the spring, which provides juveniles with food right before they begin their downstream migration (Bilby *et al.* 1997). This multi-month benefit is particularly evident in systems that are managed for natural production and have maintained a broad run timing such as Cedar River sockeye salmon and Snohomish River coho salmon (K. Bauersfeld, WDFW, Olympia, 1998, pers. comm.).

Additionally, naturally spawning salmon perform the additional function of cleaning redd site gravel, which reduces the amount of fine sediment in the gravel.

**Measures** - Theoretically, managing for maximum sustainable yield spawner escapements, the underlying basis for PFMC conservation objectives, should address meeting stream system nutrient recharge needs over the long-term. Section 3.2 of the fishery management plan addresses how PFMC will prevent overfishing and rebuild overfished stocks. Many stocks are currently locked in a state of chronic low abundance as a result of various overall negative environmental conditions and/or specific freshwater habitat degradation, or have been largely replaced by mitigation from hatchery production programs. These stocks are at levels far below their historic maximum sustainable yields and, even with no fishing impacts, are not likely to return in sufficient numbers to provide stream nutrient recharge from carcasses at historic levels. More study is needed on the present importance of carcasses to specific ecosystems and whether or not PFMC conservation goals sufficiently account for nutrient needs. These studies should provide insight into regional differences in the hydrological dynamics affecting natural salmon production, identify limiting factors to production for various stream systems, and account for background levels of nutrient enrichment from other sources, including man-caused pollution.

### **3.1.2. Fishing Activities Not under the Control of the Council – Potential Effects on Essential Fish Habitat and Measures to Minimize Adverse Effects**

#### **3.1.2.1 Gear Effects on Essential Fish Habitat**

See previous section entitled Gear Effects on Essential Fish Habitat.

#### **3.1.2.2 Harvest of Prey Species**

See previous section entitled Harvest of Prey Species.

#### **3.1.2.3 Removal of Salmon Carcasses (Affects on Stream Nutrient Levels)**

See previous section entitled Removal of Salmon Carcasses (Affects on Stream Nutrient Levels).

#### **3.1.2.4 Redd or Juvenile Fish Disturbance**

Trampling of redds during fishing and recreational activities has a potential to cause high mortality of salmonids. Most information on redd disturbance is anecdotal. However, one study of angler wading caused high mortality (43%-96%) of alevins (very young salmon that remain in the gravel) with only one or two passes per day. The extent or cumulative effects of this type of disturbance are not known (Roberts and White 1992).

Studies in Alaska and New Zealand (Horton 1994, Sutherland and Ogle 1975) have found that in shallow water where boat use is high, and especially where channels are constricted, developing salmon eggs and alevins in the gravel can suffer high mortalities as a result of pressure changes caused by boat operations, which can result in removal of gravel or mechanical shock generated in the area under the mid-line of the boat. Studies done on the effects of jet sleds (power boats with jet units), drift boat, or kayak operation on the behavior and survival of free swimming juvenile salmon on the Rogue River have shown minimal effects, though behavioral responses are observed when vessels pass directly overhead (especially nonmotorized kayaks or driftboats) (Satterwaithe 1995). Studies along the Columbia River indicated that the wake (uprush of the bow wave) of large ships (but not smaller vessels, e.g., tugs) caused significant numbers of chinook juveniles to be killed from being washed-up and stranded on sand bars and mud flats. Stranding was not observed on the Skagit River from jet sled use (K. Bauersfeld, WDFW, 1998, pers. comm.), nor on the Rogue River from private motorboat and commercial tour boat use (Satterwaithe 1995).

**Measures** - Conservation recommendations to minimize the effects of anglers/vessels on salmon EFH include angler/vessel restrictions and/or closures in key spawning areas during the time frame when spawning is occurring and while eggs and alevins may be present in the stream substrate, and promoting angler awareness of redd trampling. The states close important spawning reaches during spawning periods to protect spawning fish and their eggs.

### 3.1.2.5 Effects of Fishing Vessel Operation on Habitat

Although effects to eelgrass meadows on the West Coast do not normally result from physical disturbance and cuts made by fishing boat propellers (Phillips 1984), monitoring of effects in shallow water areas with eelgrass and significant vessel activities is needed. Sediment stirred up by constant vessel operation can decrease water clarity and reduce eelgrass survival. Additionally, in both estuarine and stream environments, the wake from boats and ships may cause increased bank erosion, increasing turbidity and sedimentation effects. Also, for navigational safety or to open up stream areas to vessel use, logs are often cleared from estuaries and channels. Effects of activities of nonfishing vessels are discussed in Section 3.2 of this appendix.

**Measures** - Conservation recommendations to minimize the effects of fishing vessels on salmon EFH include speed limits and channel markings to avoid damage to EFH areas susceptible to bank scour and eelgrass damage and shallow water areas susceptible to redd disturbance and alevin mortality.

## 3.2 NONFISHING ACTIVITIES AFFECTING SALMON ESSENTIAL FISH HABITAT

In addition to the effects from fishing activities, adverse effects of habitat alterations, dam and hatchery operations are widely recognized as major contributors to the decline of salmon in the region. Nehlsen *et al.* (1991) associate these activities with over 90% of the documented stock extinctions or declines. The importance of habitat is underscored in undammed coastal watersheds with declining salmon populations. Surveys of both public and private lands in the Pacific Northwest reveal widespread degradation of freshwater, wetland, and estuarine habitat conditions. Attempts to improve salmon survival by reduction in fishing pressure may have little effect on salmon populations if EFH quantity and quality are inadequate. Ocean survival by adults, for example, is of little value if appropriate tributary habitat is not available for spawning and early life history survival of offspring (Gregory and Bisson 1997).

The Magnuson-Stevens Act mandates a consultation process for federal agencies whose activities may adversely affect EFH. This consultation process is intended to provide those agencies with technical assistance in making their activities consistent with conservation of EFH. This section first provides information on the **consultation process** itself, then provides a brief overview of **salmon habitat requirements**, and lastly a discussion of **potential adverse effects** and a **menu of conservation options** which might alleviate those effects. The purpose of identifying adverse effects and companion conservation measures is to provide general guidance for consultations and to make this information available ahead of time to federal and nonfederal actors so they may proactively include habitat conservation in their planning.

### 3.2.1 The Consultation Process

The value of early consultation in avoiding downstream issues can be seen in a review by Drabell (1985) of the first ten years of the ESA implementation when informal consultations increased about 30% per year, correlating with the annual decrease of 30% in formal consultations and jeopardy opinions. While there is no formal requirement for state and private collaboration in the consultation process on adverse effects to salmon EFH, there is a common interest in the reduction of threats to ESA-listed species, prevention of future listings, and productive and sustainable coastal fisheries in the context of the Magnuson-Stevens Act. Conservation of anadromous fish resources through voluntary coordination is a goal without geographical or jurisdictional boundaries.

Established habitat conservation policies and approaches of PFMC and NMFS provide the framework for implementing the Magnuson-Stevens Act. The Magnuson-Stevens Act requires federal agencies undertaking, permitting or funding activities that may adversely affect EFH to consult with NMFS. Under Section 305(b)(4) of the Magnuson-Stevens Act, NMFS is required to provide EFH conservation and enhancement recommendations to federal and state agencies for actions that adversely affect EFH; however, state agencies and private parties are not required to consult with NMFS. EFH consultations will be combined with existing interagency consultations and environmental review procedures that may be required under other statutes such as the ESA, Clean Water Act, the National Environmental Policy Act, the Fish and Wildlife Coordination Act, the Federal Power Act, or the Rivers and Harbors Act. To the extent that EFH and ESA consultations

are integrated, NMFS will apply the provisions of the 1997 Secretarial Order 3206. NMFS NWR and NMFS SWR will provide additional information on the consultation process upon request.

### **3.2.1.1 A Programmatic Approach to the Consultation Process**

EFH consultations may be at either a broad programmatic level or project-specific level. Programmatic is defined as "broad" in terms of process, geography, or policy (e.g., "national level" policy, a "batch" of similar activities at a "landscape level" involving metapopulation dynamics, etc.). The goal of a programmatic consultation is to address as many adverse effects as possible through programmatic EFH conservation recommendations. Programmatic consultations would result in a letter from NMFS to the federal action agency containing advisory programmatic EFH conservation recommendations, as well as identification of any adverse impacts that could not be addressed by the programmatic EFH conservation recommendations. Where appropriate, NMFS will use a programmatic approach designed to reduce redundant paperwork and to focus on the appropriate level of analysis whenever possible. The approach would permit project activities to proceed at broad levels of resolution so long as they conform to the programmatic consultation process. The wide variety of development activities over the extensive range of the salmon EFH, and the Magnuson-Stevens Act requirement for a cumulative effects analysis warrants this programmatic approach.

In collaboration with other federal agencies, states and tribes, NMFS will use and further develop analytic tools. Examples of these include tools for determining adverse effects (e.g., the 1996 NMFS "Matrix of Pathways and Indicators" for evaluating the effects of human activities on anadromous salmonid habitat), watershed assessment protocols, research programs, predictive watershed models for testing policies and assessing adverse impacts, etc. These can be particularly useful for assessing cumulative impacts. Cumulative impact analysis is intended to monitor the effect on EFH of the incremental impacts occurring within a watershed or marine ecosystem context that may result from minor but collectively significant actions. Cumulative impact analysis is a corollary of tiering from the programmatic since iterative actions of increasing focus can have various kinds of adverse effects (additive, synergistic, catalytic, threshold) over the life of a project and beyond. Utilization of such programmatic tools will enhance the predictive capability of cumulative impact analyses and help inform the selection of appropriate mitigation. Another programmatic approach is the development of incentives to defray costs of protecting and enhancing aquatic and associated terrestrial habitats. These include the Conservation Reserve Enhancement Program designed to reduce soil erosion into fragile aquatic habitats, the Federal-State Cooperative Endangered Species Restoration Fund (ESA Section 6), and cost-sharing through the Agricultural Stabilization and Conservation Service.

### **3.2.1.2 Consultation Scenarios**

Table A-8 lists examples of habitat alteration and corresponding potential effects on Pacific salmon. Table A-9 describes most (but not all) of the types of activities which are likely to generate these effects and which may require consultation if undertaken, funded, or permitted by a federal agency in salmon EFH. Specific conservation recommendations for meeting the habitat objectives listed in Table A-10 will be refined during the consultation process and will be based on the particulars of the proposed program or project activities. The range of conservation recommendations will be based on the premise that activities such as aquaculture, forestry, grazing, etc., need not retard or prevent achievement of the habitat objectives listed in Table A-10.

TABLE A-8. How habitat alteration affects Pacific salmon. (Page 1 of 3)

<b>Ecosystem Feature</b>	<b>Altered Component</b>	<b>Effects on Salmonid Fishes and Their Ecosystems*</b>
Water Quality	Increased Temperature	Altered adult migration patterns, accelerated development of eggs and alevins, earlier fry emergence, increased metabolism, behavioral avoidance at high temperatures, increased primary and secondary production, increased susceptibility of both juveniles and adults to certain parasites and diseases, altered competitive interactions between species, mortality at sustained temperatures of >73-84°F, reduced biodiversity.
	Decreased Temperature	Cessation of spawning, increased egg mortalities, susceptibility to disease (U.S. Army Corps of Engineers [USACOE] 1991).
	Dissolved Oxygen	Reduced survival of eggs and alevins, smaller size at emergence, increased physiological stress, reduced growth.
	Gas Supersaturation	Increased mortality of migrating salmon.
	Nutrient Loading	Increased primary and secondary production, possible oxygen depletion during extreme algal blooms, lower survival and productivity, increased eutrophication rate of standing waters, certain nutrients (e.g., nonionized ammonia, some metals) possibly toxic to eggs and juveniles at high concentrations.
Sediment	Surface Erosion	Reduced survival of eggs and alevins, reduced primary and secondary productivity, interference with feedings, behavioral avoidance and breakdown of social organization, pool filling.
	Mass Failures and Landslides	Reduced survival of eggs and alevins, reduced primary and secondary productivity, behavioral avoidance, formation of upstream migration barriers, pool filling, addition of new large structure to channels.
Habitat Access	Physical Barriers	Loss of spawning habitat for adults; inability of juveniles to reach overwintering sites or thermal refugia, loss of summer rearing habitat, increased vulnerability to predation.
Channel Structure	Flood Plains	Loss of overwintering habitat, loss of refuge from high flows, loss of inputs of organic matter and large wood, loss of sediment removal capacity.
	Side-Channels	Loss of overwintering habitat, loss of refuge from high flows.
	Pools and Riffles	Shift in the balance of species, loss of deep water cover and adult holding areas, reduced rearing sites for yearling and older juveniles.
	Large Wood	Loss of cover from predators and high flows, reduced sediment and organic matter storage, reduced pool-forming structures, reduced organic substrate for macroinvertebrates, formation of new migration barriers, reduced capacity to trap salmon carcasses.
	Substrate	Reduced survival of eggs and alevins, loss of inter-gravel spaces used for refuge by fry, reduced macroinvertebrate production, reduced biodiversity.
	Hyporheic Zone (biologically active interface between groundwater area and stream bed)	Reduced exchange of nutrients between surface and subsurface waters and between aquatic and terrestrial ecosystems, reduced potential for recolonizing disturbed substrates.
Hydrology	Discharge	Altered timing of discharge related life cycle cue (e.g., migrations), changes in availability of food organisms related to timing of emergence and recovery after disturbance, altered transport of sediment and fine particulate organic matter, reduced prey diversity.

TABLE A-8. How habitat alteration affects Pacific salmon. (Page 2 of 3)

<b>Ecosystem Feature</b>	<b>Altered Component</b>	<b>Effects on Salmonid Fishes and Their Ecosystems*</b>
Hydrology, (continued)	Peak Flows	Scour-related mortality of eggs and alevins, reduced primary and secondary productivity, long-term depletion of large wood and organic matter, involuntary downstream movement of juveniles during high water flows, accelerated erosion of streambanks.
	Low Flows	Crowding and increased competition for foraging sites, reduced primary and secondary productivity, increased vulnerability to predation, increased fine sediment deposition.
	Rapid Fluctuations	Altered timing of discharge-related life cycle events (e.g., migrations), stranding, redd dewatering, intermittent connections between mainstream and floodplain rearing habitats, reduced primary and secondary productivity.
Riparian Forest	Production of Large Wood	Loss of cover from predators and high flows, reduced sediment and organic matter storage, reduced pool-forming structures, reduced organic substrate for macroinvertebrates.
	Production of Food Organisms and Organic Matter	Reduced production and abundance of certain macroinvertebrates, reduced surface-drifting food items, reduced growth in some seasons.
	Shading	Increased water temperature, increased primary and secondary production, reduced overhead cover, altered foraging efficiency.
	Vegetative Rooting Systems and Streambank Integrity	Loss of cover along channel margins, decreased channel stability, increased streambank erosion, increased landslides.
	Nutrient Modification	Altered nutrient inputs from terrestrial ecosystems, altered primary and secondary production.
Exogenous Material	Chemicals	Reduced survival of eggs and alevins, toxicity to juveniles and adults, increased physiological stress, altered primary and secondary production, reduced biodiversity.
Exogenous Material	Exotic Organisms/Plants	Increased mortality through predation, increased interspecific competition, introduction of diseases, habitat structure alteration.
Estuarine Structure	Tide Flats	Loss of primary and secondary productivity, loss of prey.
	Eelgrass Beds	Loss of cover from predators, loss of primary productivity, loss of prey.
	Marshes (salt water, brackish, and tidal-freshwater)	Loss of cover, loss of primary productivity, loss of prey, loss of sediment and nutrient filter.
	Tidal Freshwater Swamps, Including Sloughs	Loss of cover, loss of primary productivity, loss of prey, loss of refuge area during high flows.
	Channels	Loss of cover, loss of refuge from tidal cycles, high flows, loss of sediment/nutrient filter.
	Large Woody Debris	Loss of cover, organic matter storage, habitat complexity.
Estuarine Water Quality	Dissolved Oxygen	Increased physiological stress, reduced growth.
	Nutrients	Increased primary and secondary production, possible oxygen depletion during extreme algal blooms.
	Temperature	Susceptibility to diseases, parasites, behavioral avoidance.

TABLE A-8. How habitat alteration affects Pacific salmon. (Page 3 of 3)

<b>Ecosystem Feature</b>	<b>Altered Component</b>	<b>Effects on Salmonid Fishes and Their Ecosystems*</b>
Estuarine Water Quality, (continued)	Exogenous Chemicals	Toxicity to juveniles and adults and their prey, increased stress, lower disease resistance, behavioral alterations.
	Exogenous Organisms, Plants	Introduction of diseases, habitat competition, increased predation, changes to habitat structure, nutrient cycling, prey species.
Estuarine Hydrology	Low Freshwater Inflows/Alterations in Timing of Flows	Alterations of juvenile survival, alterations in timing of migrations, altered transport of sediment and organic matter, altered estuarine circulation, loss of cover, increased vulnerability to predators.
Marine Water Quality	Water Quality (Sediment, Nutrients)	Reduced cover, prey effects, reduced feeding efficiency.
	Exogenous Chemicals	Toxicity to juveniles and adults, toxicity to prey, increased stress, susceptibility to disease, altered primary and secondary production.
	Low Freshwater Inflows/Timing Alterations	Reduced cover (e.g., in plumes), altered nutrient input.

\* Freshwater portions of this table are excerpted from Gregory and Bisson (1997) with minor adaptations from that paper. See Gregory and Bisson (1997) for references to original documents on freshwater effects. Also see Spence *et al.* (1996), and National Research Council (NRC) (1996) for additional narrative explanation of how alterations in habitat components affect salmon. Estuarine effects from: Casillas *et al.* 1997, Cohen (1997), Cortright *et al.* (1987), FRI (1981); Lebovitz (1992); Levings and Bouillon (1997); Felsot (1997); Levy (1982); NRC (1996); Luiting *et al.* (1997); Phillips (1984); The Resources Agency of California (RAC) (1997); Simenstad (1983, 1985); and Simenstad *et al.* (1990).

TABLE A-9. Actions with the potential to adversely affect salmon habitat and habitat components likely to be altered (see tables A-8 and A-10 for cross reference on how changes in habitat components affect salmon and generally desired habitat conditions). (Page 1 of 2)

ACTIONS LIKELY TO EFFECT SALMON EFH	COMPACTION OF SOIL / CREATION OF IMPERVIOUS SURFACES	DISCHARGE OF WASTE-WATER, RUN-OFF	ESTUARINE HABITAT ALTERATION	INTRODUCE/ TRANSFER/ CONTROL OF EXOTIC ORGANISMS/ PLANTS/DISEASE	CREATION OF MIGRATION BARRIERS/ HAZARDS	MARINE HABITAT ALTERATION	REMOVAL OF PREY (DIRECT REMOVAL)	REDD DISTURBANCE (DIRECT)
<b>EXAMPLES OF ACTIVITIES THAT MAY INVOLVE THOSE ACTIONS</b>	forestry, agriculture, ranching, road building, construction, urbanization	industrial/food processing, mining, desalination, aquaculture, forestry, agric. grazing, urbanization, vessel fueling/repair, dredging, oil/mineral development	jetty or dock constr., dredging, spoil disposal, waste discharge, vessel oper. (shallow water), ballast water disposal, aquaculture, pipeline install.	aquaculture, bilge water discharge, inter-basin water/fish transfer, fish introduction, boating	dam and irrigation facility constr./operation, road building, navigation lock oper., dock installation, stream bed mining, tide gate installation/maintenance	dredge spoil disposal, mineral, oil level/transport, wastewater discharge, ballast discharge, spill dispersal, incineration,	fishing, dredging, water intakes, water diversions	grazing, fishing, dredging, sand and gravel extraction, reservoir excavation for flood control
<b>HABITAT COMPONENTS:</b>								
<b>Stream Water Quality:</b>								
Temperature	X	X			X			
Dissolved Oxygen	X	X		X	X			
Sediment/Turbidity	X	X	X		X			X
Nutrients	X	X	X	X	X			
Contaminants	X	X	X	X	X			
<b>Habitat Access:</b>								
Physical Barriers					X			
<b>Stream Habitat:</b>								
Substrate	X	X	X		X			X
Large Woody Debris	X	X			X			
Pool Frequency	X	X			X			
Pool Quality	X	X			X			
Off-Channel Habitat		X	X		X			
Prey	X	X		X	X		X	X
Predators				X	X		X	
<b>Channel Condition &amp; Dynamics:</b>								
Width/Depth Ratio	X	X			X	X		
Stream bank/Channel Complexity	X	X			X	X		
Floodplain Connectivity	X	X	X		X			
<b>Stream Flow/Hydrology:</b>								
Change in Peak/Base Flows	X	X			X			
Increase in Drainage Network	X	X			X			
<b>Estuarine Habitat:</b>								
Extent/Cond. of Habitat/Types			X		X	X		
Extent/Cond. of Eelgrass Beds			X			X		
Water Quality, Also Disease & Contaminants		X	X	X		X		
Water Quantity/Timing of Fresh Water Inflow	X				X	X		
Prey			X	X	X	X	X	
Predators			X	X	X	X	X	
<b>Marine Habitat Elements:</b>								
Water Quality/Disease/Contaminants		X		X		X		
Water Quantity/Timing-Riverine Plumes	X							
Prey			X			X	X	

TABLE A-9. Actions with the potential to adversely affect salmon habitat and habitat components likely to be altered (see tables A-8 and A-10 for cross reference on how changes in habitat components affect salmon and generally desired habitat conditions). (Page 2 of 2)

ACTIONS LIKELY TO EFFECT SALMON EFH	REMOVAL/ ALTERATION OF RIPARIAN VEGETATION	ALTER AMOUNT OR RATES OF WOODY DEBRIS INPUT	REMOVAL OF WOODY DEBRIS FROM STREAM, LAKES, BAYS	INCREASE/ DECREASE IN SEDIMENT DELIVERY	STREAMBANK OR SHORELINE ALTERATION	STREAM BED AND CHANNEL ALTERATION (ALSO BEDS, CHANNELS OF LAKES, BAYS)	WATER REMOVAL/ DIVERSION	WETLAND OR FLOODPLAIN ALTERATION
<b>EXAMPLES OF ACTIVITIES THAT MAY INVOLVE THOSE ACTIONS</b>	forestry, agriculture, ranching, road building, construction, gravel and mineral mining	forestry, fire suppression, flood suppression, road building, dams, beaver removal	channel clearing for navigation, rafting, flood or erosion control, wood scavenging, beaver dam removal	forestry, agriculture, ranching, road building, construction, sand and gravel extraction, mineral mining, dredging	forestry, agriculture, grazing, urbanization, erosion or flood control, dock construction, habitat restoration	dredging, sand and gravel removal, erosion control, placement of pipelines, habitat restoration	dam/irrigation/ municipal/ industrial power facility operation, push up dams, groundwater pumping, desalinization	agriculture, ranching, construction, road building, flood control, dredging, beaver removal, habitat restoration
<b>HABITAT COMPONENTS</b>								
<b>Stream Water Quality:</b>								
Temperature	X		X	X	X	X	X	X
Dissolved Oxygen	X			X	X	X	X	X
Sediment/Turbidity	X	X	X	X	X	X	X	X
Nutrients	X	X	X	X		X	X	X
Contaminants	X			X		X	X	X
<b>Habitat Access:</b>								
Physical Barriers		X	X			X	X	X
<b>Stream Habitat:</b>								
Substrate	X	X	X	X	X	X	X	X
Large Woody Debris	X	X	X		X	X	X	X
Pool Frequency	X	X	X	X	X	X	X	X
Pool Quality	X	X	X	X		X	X	X
Off-Channel Habitat	X	X	X		X	X	X	X
Prey	X	X	X		X	X	X	X
Predators	X	X	X		X	X		X
<b>Channel Condition &amp; Dynamics:</b>								
Width/Depth Ratio	X	X	X	X		X	X	X
Stream bank/Channel Complexity	X	X	X	X	X	X	X	X
Floodplain Connectivity	X	X	X	X	X	X	X	X
<b>Stream Flow/ Hydrology:</b>								
Change in Peak/Base Flows	X	X	X		X	X	X	X
Increase in Drainage Network	X				X	X	X	X
<b>Estuarine Habitat:</b>								
Extent/Cond. of Habitat Types	X	X	X	X	X	X	X	
Extent/Cond. of Eelgrass Beds				X	X	X	X	X
Water Quality, Also Disease and Contaminants				X	X	X	X	
Water Quantity/Timing of Fresh Water Inflow					X		X	X
Prey	X			X	X	X		X
Predators	X			X	X	X		X
<b>Marine Habitat Elements:</b>								
Water Quality, Also Disease & Contaminants								
Water Quantity/Timing-Riverine Plumes								
Prey								

TABLE A-10. Habitat objectives and indicators. The ranges of criteria presented here are generally applicable, but not absolute, some watersheds may have unique geology, geomorphology, hydrology, and other conditions that may not permit achieving the target habitat conditions. Target conditions can be established on a regional or watershed (USGS 5<sup>th</sup> Field) basis as needed to account for those factors (\*please see footnote). (Page 1 of 3)

HABITAT ELEMENT	INDICATORS	PROPERLY FUNCTIONING	AT RISK	NOT PROPERLY FUNCTIONING	
Water Quality:	Temperature	50-57°F <sup>a/</sup>	57-60°F (spawning) 57-64°F (migration & rearing) <sup>b/</sup>	> 60°F (spawning) > 64°F (migration & rearing) <sup>b/</sup>	
	Sediment/Turbidity	<12% fines (<0.85m m) in gravel, <sup>c/</sup> turbidity low	12-17% (west-side) <sup>c/</sup> 12-20% (east-side), <sup>b/</sup> turbidity moderate	>17% (west-side), <sup>c/</sup> >20% (east side) fines at surface or depth in spawning habitat, turbidity high <sup>b/</sup>	
	Chemical Contamination/ Nutrients	low levels of chemical contamination from agricultural, industrial, and other sources, no excess nutrients, no CWA 303d designated reaches <sup>d/</sup>	moderate levels of chemical contamination from agricultural, industrial and other sources, some excess nutrients, one CWA 303d designated reach <sup>d/</sup>	high levels of chemical contamination from agricultural, industrial, and other sources; high levels of excess nutrients, more than one CWA 303d designated reach <sup>d/</sup>	
Habitat Access:	Physical Barriers	any man-made barriers present in watershed allow upstream and downstream juvenile and adult fish passage at all flows	any man-made barriers present in watershed do not allow upstream and/or downstream fish passage at base/low flows	any man-made barriers present in watershed do not allow upstream and/or downstream fish passage at a range of flows	
Stream Habitat Elements:	Substrate	dominant substrate is gravel or cobble (interstitial spaces clear), or embeddedness <20% <sup>c/</sup>	gravel and cobble is subdominant, or if dominant, embeddedness 20-30% <sup>c/</sup>	bedrock, sand, silt or small gravel dominant or if gravel and cobble dominant, embeddedness >30% <sup>b/</sup>	
	Large Woody Debris Quantity of Key Pieces	Coast: >80 pieces/mile >24" diameter >50 ft. length; <sup>e/</sup> East-side: >20 pieces/mile >12" diameter >35 ft. length <sup>b/</sup> ; and adequate sources of woody debris recruitment in riparian areas.	currently meets standards for properly functioning, but lacks potential sources from riparian areas of woody debris recruitment to maintain that standard	does not meet standards for properly functioning and lacks potential large woody debris recruitment	
	Pool Frequency channel width # pools/mile <sup>f/</sup>	meets pool frequency standards (left) and large woody debris recruitment standards for properly functioning habitat (above)	meets pool frequency standards but large woody debris recruitment inadequate to maintain pools over time	does not meet pool frequency standards	
		5 feet 184 10 " 96 15 " 70 20 " 56 25 " 47 50 " 26 75 " 23 100 " 18			
	Pool Quality	pools >1 m deep (holding pools) with good cover and cool water, <sup>c/</sup> minor reduction of pool volume by fine sediment	few deeper pools (>1 meter) and present or inadequate cover/temperature, <sup>c/</sup> moderate reduction of pool volume by fine sediment	no deep pools (>1 meter) and inadequate cover/temperature <sup>c/</sup> major reduction of pool volume by fine sediment	
	Off-Channel Habitat	backwaters with cover, and low energy off-channel areas (ponds, oxbows, etc.) <sup>c/</sup>	some backwaters and high energy side channels <sup>c/</sup>	few or no backwaters, no off-channel ponds <sup>c/</sup>	
	Refugia (important remnant habitat for sensitive aquatic species)	habitat refugia exist, and are adequately buffered (e.g., by intact riparian reserves); existing refugia are sufficient in size, number and connectivity to maintain viable populations or sub- populations <sup>g/</sup>	habitat refugia exist, but are not adequately buffered (e.g., by intact riparian reserves); existing refugia are insufficient in size, number and connectivity to maintain viable populations or sub-populations <sup>g/</sup>	adequate habitat refugia do not exist. <sup>g/</sup>	

TABLE A-10. Habitat objectives and indicators. The ranges of criteria presented here are generally applicable, but not absolute, some watersheds may have unique geology, geomorphology, hydrology, and other conditions that may not permit achieving the target habitat conditions. Target conditions can be established on a regional or watershed (USGS 5<sup>th</sup> Field) basis as needed to account for those factors (\*please see footnote). (Page 2 of 3)

HABITAT ELEMENT	INDICATORS	PROPERLY FUNCTIONING	AT RISK	NOT PROPERLY FUNCTIONING
Channel Condition & Dynamics:	Width/Depth Ratio	<10 <sup>b/e/</sup>	>10	>10
	Streambank Condition	>90% stable; i.e., on average, less than 10% of banks are actively eroding <sup>b/</sup>	80-90% not eroding	<80% not eroding
	Flood plain Connectivity	off-channel areas are frequently hydrologically linked to main channel; overbank flows occur and maintain wetland functions, riparian vegetation and succession	reduced linkage of wetland, floodplains and riparian areas to main channel; overbank flows are reduced relative to historic frequency, as evidenced by moderate degradation of wetland function, riparian vegetation/succession	severe reduction in hydrologic connectivity between off-channel, wetland, flood plain and riparian areas; wetland extent drastically reduced, riparian vegetation/succession altered significantly, and channel degradation apparent
Flow/Hydrology:	Change in Peak/Base Flows	watershed hydrograph indicates peak flow, base flow and flow timing characteristics comparable to an undisturbed watershed of similar size, geology and geography	some evidence of altered peak flow, baseflow and/or flow timing relative to an undisturbed watershed of similar size, geology and geography.	pronounced changes in peak flow, baseflow and/or flow timing relative to an undisturbed watershed of similar size, geology and geography
	Increase in Drainage Network	zero or minimum increases in drainage network density from roads <sup>h/i/</sup>	moderate increases in drainage network density from roads (e.g., about 5%) <sup>h/i/</sup>	significant increases in drainage network density from roads (e.g., 20-25%) <sup>h/i/</sup>
Watershed Conditions:	Road Density & Location	<2 mi/mi <sup>2</sup> , <sup>j/</sup> no valley bottom roads	2-3 mi/mi <sup>2</sup> , some valley bottom roads	>3 mi/mi <sup>2</sup> , many valley bottom roads
	Disturbance History	<15% ECA <sup>**</sup> (entire watershed) with no concentration of disturbance in unstable or potentially unstable areas, and/or refugia, and/or riparian area; and for NWFP area (except AMAs <sup>**</sup> ), ≥15% retention of LSOG in watershed <sup>k/</sup>	<15% ECA <sup>**</sup> (entire watershed), but disturbance concentrated in unstable or potentially unstable areas, and/or refugia, and/or riparian area; and for NWFP area (except AMAs <sup>**</sup> ), ≥15% retention of LSOG in watershed <sup>k/</sup>	>15% ECA <sup>**</sup> (entire watershed) and disturbance concentrated in unstable or potentially unstable areas, and/or refugia, and/or riparian area; does not meet NWFP standard for LSOG retention
	Riparian Reserves	the riparian reserve system provides adequate shade, large woody debris recruitment, and habitat protection and connectivity in all subwatersheds, and includes known refugia for sensitive aquatic species (>80% intact), and/or for grazing effects: percent similarity of riparian vegetation to the potential natural community/ composition >50% <sup>l/</sup>	moderate loss of connectivity or function (shade, LWD recruitment, etc.) of riparian reserve system, or incomplete protection of habitats and refugia for sensitive aquatic species (~70-80% intact), and/or for grazing effects: percent similarity of riparian vegetation to the potential natural community/composition 25-50% or better <sup>l/</sup>	riparian reserve system is fragmented, poorly connected, or provides inadequate protection of habitats and refugia for sensitive aquatic species (<70% intact), and/or for grazing effects: percent similarity of riparian vegetation to the potential natural community/composition <25% <sup>l/</sup>
Estuarine Conditions:	Habitat Quantity/Quality	the estuarine system provides for adequate, prey production, cover, and habitat complexity, for both smolts and returning adults	moderate loss of prey production, cover, and habitat complexity	gross loss of prey production, cover, and habitat complexity
	Aerial Extent	estuary provides for most (i.e., greater than 80% intact) of its historical areal extent and diversity of shallow water habitat types including vegetated wetlands and marshes, tidal channels, submerged aquatic vegetation, tidal flats, and large woody debris	50-80% of pre-modification area or volume and diversity of habitats	<50% of pre-modification area or volume; low diversity of habitats
	Hydrologic Conditions/Sediment/Nutrient Input	fresh water inflow and other hydrologic circulation patterns and sediment and nutrient inputs are similar to historic conditions	Moderate interruption of estuarine circulation and nutrient and sediment delivery	Gross interruption of estuarine circulation and nutrient and sediment delivery

TABLE A-10. Habitat objectives and indicators. The ranges of criteria presented here are generally applicable, but not absolute, some watersheds may have unique geology, geomorphology, hydrology, and other conditions that may not permit achieving the target habitat conditions. Target conditions can be established on a regional or watershed (USGS 5<sup>th</sup> Field) basis as needed to account for those factors (\*please see footnote). (Page 3 of 3)

HABITAT ELEMENT	INDICATORS	PROPERLY FUNCTIONING	AT RISK	NOT PROPERLY FUNCTIONING
Estuarine Water Quality	Dissolved Oxygen, Temperature, Nutrients, Chemical Contamination	water quality standards for aquatic life protection met	water quality standards are not met intermittently when salmon are present	water quality standards are consistently not met when salmon are present
	Sediments	sediments have low levels of chemical contamination, especially of persistent aromatic hydrocarbons, heavy metals, or other compounds known to bio-accumulate	sediments have moderate levels of chemical contaminants	sediments have high levels of chemical contaminants
	Exotic Species That are Non-indigenous Aquatic Nuisance Species	exotic species that are non-indigenous and aquatic nuisance species are at low and decreasing levels and not interfering with estuarine system functions	sustained presence of multiple exotic species that are nonindigenous and aquatic nuisance species in significant abundance	predominance of exotic species that are nonindigenous and aquatic nuisance species, low abundance of many native species with some low or extirpated.

\* This table is adapted from an August 1996 NMFS report entitled *Making Endangered Species Act Determinations of Effect for Individual or Grouped Actions at the Watershed Scale*. Since this table was designed to be applied to a wide range of environmental conditions, there will be circumstances where the ranges of numerics or descriptions in the table do not apply to a specific watershed or basin. In such instances, more appropriate biological values for the target habitat objectives should be established on a watershed-specific basis. Target conditions to account for specific conditions in various areas have been developed, including, but not limited to: Oregon Coast Province, Southwest Province Tye Sandstone, Western Cascades Physiographic Region, High Cascades Physiographic Region, Klamath Province/Siskiyou Mountains.

\*\* ECA= Equivalent Clear-Cut Area; AMA = Adaptive Management Area

- a/ Bjornn, T. and D. Reiser. 1991. Habitat Requirements of Salmonids in Streams. American Fisheries Society Special Publication 19:83-138. Meehan, W.R., ed.
- b/ Biological Opinion on Land and Resource Management Plans for the: Boise, Challis, Nez Perce, Payette, Salmon, Sawtooth, Umatilla, and Wallowa-Whitman National Forests. March 1, 1995.
- c/ Washington Timber/Fish Wildlife Cooperative Monitoring Evaluation and Research Committee, 1993. Watershed Analysis Manual (Version 2.0). Washington Department of Natural Resources.
- d/ A Federal Agency Guide for Pilot Watershed Analysis (Version 1.2), 1994.
- e/ NMFS Biological Opinion on Implementation of Interim Strategies for Managing Anadromous Fish-producing Watersheds in Eastern Oregon and Washington, Idaho, and Portions of California (PACFISH).
- f/ USDA Forest Service, 1994. § 7 Fish Habitat Monitoring Protocol for the Upper Columbia River Basin.
- g/ Frissell, C.A., Liss, W.J., and David Bayles, 1993. An Integrated Biophysical Strategy for Ecological Restoration of Large Watersheds. Proceedings from the Symposium on Changing Roles in Water Resources Management and Policy, June 27-30, 1993 (American Water Resources Association), p. 449-456.
- h/ Wemple, B.C., 1994. Hydrologic Integration of Forest Roads with Stream Networks in Two Basins, Western Cascades, Oregon. M.S. Thesis, Geosciences Department, Oregon State University.
- i/ e.g., see Elk River Watershed Analysis Report, 1995. Siskiyou National Forest, Oregon.
- j/ U.S. Department of Agriculture (USDA) Forest Service, 1993. Determining the Risk of Cumulative Watershed Effects Resulting from Multiple Activities.
- k/ Northwest Forest Plan, 1994. Standards and Guidelines for Management of Habitat for Late-Successional and Old-Growth Forest Related Species Within the Range of the Northern Spotted Owl. USDA Forest Service and U.S. Department of Industry (USDI) Bureau of Land Management.
- l/ Winward, A.H., 1989 Ecological Status of Vegetation as a base for Multiple Product Management. Abstracts 42nd annual meeting, Society for Range Management, Billings, Montana, Denver, Colorado: Society for Range Management: p. 277.

Four broad scenarios set the stage for EFH consultations. The specifics of each consultation, including suggested EFH conservation and enhancement recommendations, will be tailored to meet the proposed program or project activity.

1. **Federal actions involving ESA-listed species:** In the situation where federal agency actions are subject to Section 7 consultations under the ESA, such consultations will be combined with EFH consultations to accommodate the substantive requirements of both ESA and the Magnuson-Stevens Act as appropriate.
2. **Federal actions that do not involve ESA-listed species:** Under this scenario, federal agency actions are not subject to the ESA Section 7 consultation requirements, but are subject to the EFH consultation requirements of the Magnuson-Stevens Act. In this circumstance, a programmatic approach to consultation, tiering from the general program to specific actions, will be most appropriate. When programmatic consultations are completed, project-specific consultations should only be necessary on those actions not contemplated by the programmatic consultation, or those actions identified as needing individual consultation in the programmatic consultation.

Included in this scenario are federal agency actions subject to the National Environmental Policy Act, Federal Power Act, and/or Section 404 of the Clean Water Act. The federal agency would request NMFS make a finding that an existing process can be used to meet EFH consultation requirements. NMFS would respond with a letter detailing how the existing process would be used for the EFH consultation and would work with the action agency to ensure the EFH consultation process is folded into the agency's environmental review process under one of these statutes. EFH information would be submitted through the existing practice, and NMFS would provide conservation recommendations as part of its existing role in the process.

3. **Nonfederal actions involving ESA-listed species:** For nonfederal actors, EFH consultation is voluntary. In situations where nonfederal actions occur in areas under a NMFS-approved conservation plan, NMFS participation in, and approval of the plan would be combined with the EFH consultation and would constitute the NMFS requirements of the Magnuson-Stevens Act for providing conservation recommendations to state agencies. Included in this scenario would be coordination with Section 4(d) rulemaking, Section 4(f) recovery planning, and Section 10 permitting under the ESA.
4. **Nonfederal actions that do not involve ESA-listed species:** States and tribes are not required to consult with NMFS under the Magnuson-Stevens Act provisions for EFH unless there is a federal nexus. However, NMFS will provide conservation recommendations to state agencies on actions identified by PFMC as having a substantial adverse effect on salmon habitat or upon state agency request.

### 3.2.1.3 NMFS/PFMC Cooperation on EFH

Section 305(b)(3) of the Magnuson-Stevens Act allows regional fishery management councils to comment on and make recommendations to NMFS and any federal or state action agency concerning any activity that, in the view of the Councils, may adversely affect the habitat, including EFH, of a fishery resource under its authority. However, while NMFS and PFMC have the authority to act independently, it is the intention of both to cooperate as closely as possible to identify actions that may adversely affect EFH, to develop comments and EFH conservation recommendations to federal and state agencies, and to provide EFH information to federal or state agencies.

PFMC and NMFS will develop agreements to facilitate sharing information on actions that may adversely affect EFH and in coordinating Council and NMFS comments and recommendations on those actions. For example, if a federal action agency decision is also inconsistent with a PFMC recommendation made pursuant to Section 305(b)(3) of the Magnuson-Stevens Act, PFMC may request NMFS initiate further review of the federal agency's decision and involve PFMC in any interagency discussion to resolve disagreements with the federal agency.

### 3.2.2 Salmonid Habitat Requirements

To maintain or restore habitat necessary for a sustainable salmon fishery requires the biophysical processes producing properly functioning habitat be maintained or restored. However, since watersheds and streams differ in their characteristic flow, temperature, sedimentation, nutrient levels, physical structure, biological components, etc.; specific habitat requirements of salmonids differ among species and life-history types; and these requirements change with season, life stage, and presence/absence of other biota; there is no simple definition of salmonid habitat requirements. Table A-11 is an overview of the general major habitat requirements and habitat concerns during each life stage of the salmon's life cycle. The goal of salmonid conservation should be to ensure salmonid habitat requirements are met by maintaining habitat features within the natural range for the particular system. The range of patterns and processes which define the properly functioning habitat conditions within which salmon can exist are enumerated in the first three columns of Table A-10 ("Habitat objectives and indicators"). These conditions can be used for evaluating the effects of development-related activities on properly functioning habitat conditions for salmonids and as target habitat objectives to be achieved by implementing the conservation measures recommended by NMFS during the EFH consultation process.

Table A-10, modified from the 1996 NMFS "Matrix of Pathways and Indicators" for evaluating the effects of human activities on anadromous salmonid habitat, lists eight major **habitat elements** (column 1), **measurable indicators** associated with habitat function (column 2), and **general parameters or criteria** for the proper functioning of each habitat indicator (column 3). The habitat elements include stream water quality, habitat access, stream habitat elements, channel conditions and dynamics, flow/hydrology, watershed conditions, estuarine conditions, and estuarine water quality. The ranges of criteria presented in this table are generally applicable, and are designed to be applied to a wide range of environmental conditions. The target habitat objectives listed under the "properly functioning condition" column of Table A-10 are by no means absolute since each watershed has a unique geomorphology, hydrology, etc. There will be circumstances where the range of numerics or descriptions simply do not apply to a specific watershed or basin. In such instances, more appropriate biological values for target habitat objectives should be established on a watershed or site-specific basis as needed to account for ecological variability. Maintenance and recovery of such properly functioning conditions can be used to assess effects of proposed federal agency actions on anadromous salmonid habitat.

An extensive review of existing information on salmonid habitat requirements generated the data summarized in Tables A-3, A-4, and A-5 (chinook, coho, and pink salmon habitat use by life history stage), Table A-11 (Summary of major habitat requirements and concerns during each stage of the salmon's life cycle), and Table A-10 ("Habitat objectives and indicators").

- Tables A-3 through A-5 summarize, by species, the life history stage, diet, season/time, location in substrate and in water column, ocean features, and oxygen/temperature/salinity requirements for the stage.
- Table A-11 reviews salmon movements and habitat use (e.g., for adult migration pathways, spawning and incubation, stream rearing, smolt migration, estuarine and marine residence), the characteristic features required in each habitat (e.g., gravel and cobble with sufficient water and oxygen during spawning and rearing), and the commonest expression of habitat degradation found (e.g., elevated temperatures, reduced pool frequency, etc.).
- Table A-10, by describing indicators of the functioning of specified habitat elements or "pathways", as well as criteria for proper functioning/risk/malfunction of the listed habitat elements, sets the broad habitat conditions to be targeted by conservation and enhancement activities.

The information cited on salmonid life history, range of requirements, and types of adverse effects detailed in the tables are reconfirmed throughout the existing technical literature and appear to provide reliable descriptions of generalized baseline habitat.

TABLE A-11. Summary of major habitat requirements and concerns during each stage of the salmon's life cycle.

HABITAT REQUIREMENTS	HABITAT CONCERNS
<p><b>Adult Migration Pathways</b>                      Adult salmon leave the ocean, enter fresh water, migrate upstream to spawn in the stream of their birth.</p>	Passage blockage (e.g., culverts, dams) Water quality (high temperatures, pollutants) High flows/low flows/water diversions Channel modification/simplification Reduced frequency of holding pools Lack of cover, reduced depth of holding pools Reduced cold-water refugia Increased predation resulting from habitat modifications
<p><b>Spawning and Incubation</b>                      Salmon lay their eggs in gravel or cobble nests called redds. To survive eggs (and the alevins that hatch and remain in the gravel) must receive sufficient water and oxygen flow within the gravel.</p>	Availability of spawning gravel of suitable size Siltation of spawning gravels Redd scour caused by high flows Redd de-watering Temperature/water quality problems Redd disturbance from trampling (human, animal).
<p><b>Stream Rearing Habitat</b>                      Juvenile salmon may remain in fresh water streams over a year. They must find adequate food, shelter, and water quality conditions to survive, avoid predators, and grow. They must be able to migrate upstream and downstream within their stream and into the estuary to find these conditions and to escape high water or unfavorable temperature conditions.</p>	Diminished pool frequency, area, or depth Diminished channel complexity, cover Temperature/water quality problems Blockage of access to habitat (upstream or down) Loss of off-channel areas, wetlands Low water flows/high water flows Predation caused by habitat simplification or loss of cover Nutrient availability Diminished prey/competition for prey
<p><b>Smolt Migration Pathways</b>                      Smolts swim and drift through the streams and rivers, and must reach the estuary or ocean when there are adequate prey and water quality conditions and must find adequate cover to escape predators as they migrate.</p>	Water quality Low water flows/high water flows Altered timing/quantity of water flows Passage blockage/diversion away from stream Increased predation resulting from habitat simplification or modification
<p><b>Estuarine Habitat</b>                      Estuaries provide a protected and food-rich environment for juvenile salmon growth and allow the transition for both juveniles and adults between the fresh and salt water environments. Adults also may hold and feed in estuaries before beginning their upstream migration.</p>	Water quality Altered timing/quantity of fresh water in-flow Loss of habitat resulting from diking dredging, filling Diminished habitat complexity Loss of channels, eelgrass beds, woody debris Increased predation resulting from habitat simplification Diminished prey/competition for prey
<p><b>Marine Habitat</b>                      The ocean environment provides the food resources necessary for development and growth. Juvenile salmon may depend on near shore rocks and kelp beds for food resources. Depending on species and stock, salmon may spend from one to five years growing in the ocean.</p>	Water quality Altered timing/quantity/composition of river water plumes Diminished prey/competition for prey Increased predation

### 3.2.3 Adverse Effects on Essential Fish Habitat

The intent of EFH guidance is to enable regional development activities to avoid or minimize adverse effects by forward, informed planning. This is the essence of sustainable development. A measure of its success is the maintenance of properly functioning salmonid habitat conditions (Table A-10). A corollary is the restoration of diminished salmonid resources and their roles in regional economies, culture, and ecosystems through restoration of degraded or lost habitat. Maintenance and recovery of properly functioning conditions can be used to assess effects of proposed federal agency actions on EFH. Useful tools in the assessment

of project effects are the NMFS' 1996 "Matrix of Pathways and Indicators" and associated decision tree for making effective determinations for individual or grouped actions at the watershed scale. The highest benefit to cost ratios of mitigations are achieved with timely informed plans which detail likely resources to be affected and actions which can avoid or minimize adverse effects to properly functioning habitat.

Having established the elements of salmonid habitat and objectives for its proper functioning in Table A-10, the likely adverse effects of common development-associated activities are outlined in Table A-9. Table A-9 shows the various types of actions that are likely to have either a direct, indirect, cumulative, or synergistic effect on salmon EFH. The check marks in Table A-9 indicate the habitat elements, or pathways, that are likely to be altered by the specified action. In other words, this matrix cross-references habitat elements, or pathways, (e.g., channel condition and dynamics) with indicators for these components (e.g., flood plain connectivity or channel width/depth) with sixteen types of adverse actions likely to affect salmon EFH, and examples of activities which generate these actions (e.g., forestry, grazing, spoil disposal, etc.). Table A-9 ("Examples of habitat alteration effects on Pacific salmon") summarizes how habitat alterations listed in Table A-9 can harm salmon. For example, if increased temperature results from grazing activities, altered adult migration patterns, accelerated egg development, parasite susceptibility in juveniles can be expected. The value of describing the effect on the behavior, physiology, and development of the fish, is in devising targeted, effective, useful mitigation.

### **3.2.4 Conservation and Enhancement Measures**

#### **3.2.4.1 Background**

Section 600.815 (a)(7) of the interim final EFH regulations states that FMPs must describe options to avoid, minimize, or compensate for the potential adverse effects and promote the conservation and enhancement of EFH. Terrestrial activities may have adverse impacts on EFH. Activities that may result in significant adverse effects on EFH should be avoided where less environmentally harmful alternatives are available. Environmentally sound engineering and management practices should be employed for all actions which may adversely affect EFH. Disposal or spillage of any material (dredge material, sludge, industrial waste, or other potentially harmful materials) which would destroy or degrade EFH should be avoided. If avoidance or minimization is not possible, or will not adequately protect EFH, compensation for damage to, and/or mitigation to conserve and enhance EFH should be recommended. FMPs may recommend proactive measures to conserve or enhance EFH. When developing proactive measures, regional fishery management councils may develop a priority ranking of the recommendations to assist federal and state agencies undertaking such measures.

#### **3.2.4.2 Measures**

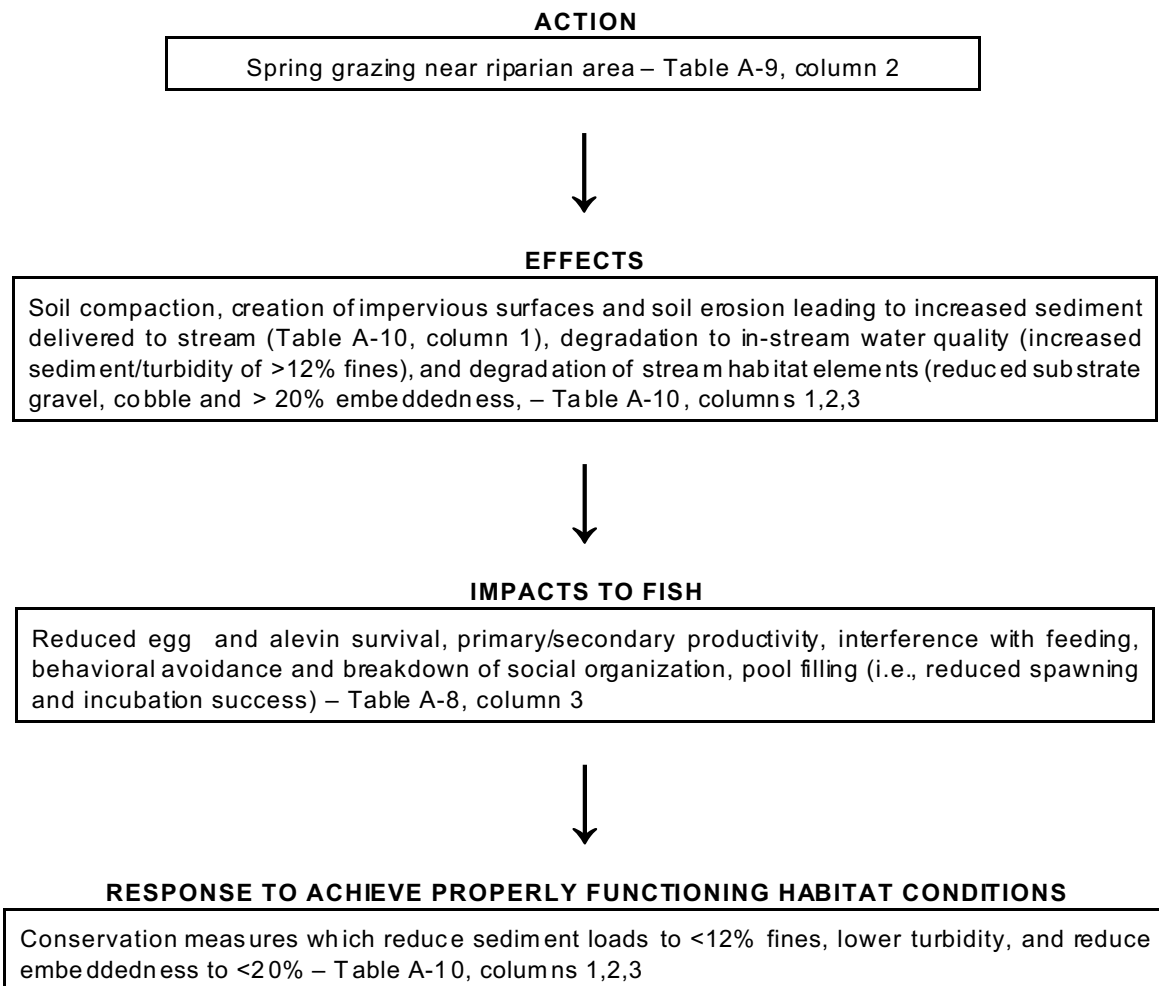
Established policies and procedures of PFMC and NMFS provide the framework for conserving and enhancing EFH. Components of this framework include adverse impact avoidance and minimization, compensatory mitigation, and enhancement. New and expanded responsibilities contained in the Magnuson-Stevens Act will be met through appropriate application of these policies and principles. The Interim Final Rule on EFH provides that NMFS' EFH consultation recommendations will not suggest that federal or state agencies take actions beyond their statutory authority [62 Federal Register 66559, Section 600.925(a)]. In assessing the potential impacts of proposed projects, PFMC and NMFS are guided by the following general considerations:

- The extent to which the activity would directly and indirectly affect the distribution, abundance, health, and continued existence of salmon and their EFH.
- The extent to which the potential for cumulative impact exists.
- The extent to which adverse impacts can be avoided through project modification, alternative site selection or other safeguards.
- The extent to which minimization or mitigation may be used to reduce unavoidable loss of habitat functions and values.

- The extent to which compensation mitigation may be used to offset unavoidable loss of habitat functions and values.

The range of potential conservation measures necessary to avoid, minimize, and compensate for adverse effects needs to be suggested to project proponents and sponsors during an “early involvement” process [e.g., consultation streamlining (USFS/BLM), pre-licensing procedures (FERC), permit comment letters (COE), comments on draft biological assessments, etc.]. NMFS involvement with federal agencies at this stage allows for planning of actions in a manner that maintains properly functioning salmonid habitat. Both land use and remedial actions need to promote achievement of the habitat objectives for properly functioning conditions listed in Table A-10. The logic of the approach which employs the Tables described above is illustrated in Figure A-8. A number of technically informed approaches and methods have been developed for mitigating the adverse effects of different project actions. Experience indicates the specific selection of conservation and enhancement measures, and, mitigation strategies and tactics must respond to the particular kinds of actions and site characteristics. More specific guidelines tailored to specific agency activities and category of threat can be developed during, or prior to, the consultation process in conjunction with federal and state agencies, tribes, and interested parties.

FIGURE A-8. Example of logic train in the use of salmonid EFH conservation recommendations relative to one indicator.



### **3.2.5 Potential Impacts and Conservation Measures for Nonfishing Activities That May Affect Salmon Essential Fish Habitat**

Section 600.815 (a) (5) of the draft interim EFH regulations pertain to identifying nonfishing related activities that may adversely affect EFH. The section states that FMPs must identify activities that have the potential to adversely affect, directly or cumulatively, EFH quantity or quality, or both. Broad categories of activities which can adversely affect salmonid EFH include, but are not limited to:

Agriculture  
Artificial Propagation of Fish and Shellfish  
Bank Stabilization  
Beaver Removal and Habitat Alteration  
Construction/Urbanization  
Dam Construction/Operation  
Dredging and Dredged Spoil Disposal  
Estuarine Alteration  
Forestry  
Grazing  
Habitat Restoration Projects  
Irrigation Water Withdrawal, Storage and Management  
Mineral Mining  
Nonnative Species, Introduction/Spread of  
Offshore Oil and Gas Exploration, Drilling and Transportation Activities  
Road Building and Maintenance  
Sand and Gravel Mining  
Vessel Operations  
Wastewater/Pollutant Discharge  
Wetland and Floodplain Alteration  
Woody Debris/Structure Removal From Rivers and Estuaries

Any of the above activities may eliminate, diminish, or disrupt the functions of salmonid EFH. These activities can potentially affect EFH through associated factors, including increased suspended solids, sedimentation, nutrient loading, toxic chemicals, high bacterial concentrations and physical disruption of habitat. While toxic contaminants, nutrient loading, oxygen depletion and eutrophication, increased suspended solids, bacterial contamination, and hypoxia may not directly affect loss of physical habitat, all these factors are elements of water quality and hence EFH quality. The goals specified under Section 101(a)(2) of the federal Clean Water Act inherently address the EFH needs of aquatic organisms: "water quality which provides for the protection and propagation of fish, shellfish, and wildlife ...". Section 303(d) of the federal Clean Water Act used in conjunction with standards, provides the tools to manage water quality, and hence EFH quality. Under the mandate promulgated by the 1996 amendment to the Magnuson-Stevens Act, only federal agencies are required to consult with Fishery Management Councils and NMFS regarding activities that may adversely affect EFH. Under the Clean Water Act, states, territories and tribes obtain approval of water quality standards from the EPA. Under EFH, EPA will have the opportunity to consult with NMFS prior to standards approval.

Each of these nonfishing-related activities may directly, indirectly, or cumulatively, temporarily or permanently, threaten the physical, chemical, and biological properties of the habitat utilized by salmonid species and/or their prey. The direct results of these threats is that salmonid EFH may be eliminated, diminished, or disrupted. The list includes common activities with known or potential impacts to salmonid EFH. The list is not prioritized, nor is it all-inclusive. Each of the above activities is described below along with conservation measures and management alternatives.

The conservation measures and management alternatives are not designed to be site-specific, but rather to be indicative of the spectrum of possible considerations for the conservation and enhancement of salmon EFH, and which might be applied to specific activities. This menu of suggested conservation options is based on the best scientific information available at this time. NMFS and PFMC are not bound by these measures in the future. All of these measures are not necessarily applicable to each future project or activity that may adversely impact salmon EFH. More specific or different measures based on the best and most current

scientific information may be developed during or prior to the consultation process and communicated to the appropriate agencies.

### 3.2.5.1 Agriculture

During agricultural activities, land surface alterations may be extensive, because vegetation alteration and disturbances to the soil can occur several times per year. In addition, agriculture can take place on historical flood plains of river systems, where it has a direct effect on stream channels and riparian functions. Furthermore, irrigated agriculture frequently requires diversion of surface waters, which may decrease streamflow, lower water tables, and increase water quality problems, e.g., higher water temperatures. (See section on irrigation water withdrawal below.)

Replacing natural grasslands, forests, and wetlands with annual crops may leave areas unvegetated during part of the year and can change the function of plants and soil microbes in the tilled areas. Repeated tillage, fertilization, pesticide application and harvest can permanently alter soil character, resulting in reduced infiltration and increased surface runoff. These changes alter seasonal streamflow patterns by increasing high flows, lowering water tables, and reducing summer base flows in streams.

Agricultural land use can contribute substantial quantities of sediments to streams (Spence *et al.* 1996). Deposited sediment can reduce juvenile salmonid rearing and adult habitat by the filling of pools (Waters 1995), filling the interstitial spaces of bottom gravel, and by reducing the overall surface area available for invertebrates (i.e., prey) and fish production. Suspended sediment can decrease primary productivity, deplete invertebrate populations (by increasing downstream drifting) as well as interfere with feeding behavior (Waters 1995).

Agriculture can negatively affect stream temperatures by the removal of riparian forests and shrubs which reduces shading and increases wind speeds. In addition, bare soils may retain greater heat energy than vegetated soils, thus increasing conductive transfer of heat to water that infiltrates the soil or flows overland into streams (Spence *et al.* 1996). In areas of irrigated agriculture, temperature increases during the summer may be exacerbated by heated return flows (Dauble 1994). Warm water temperatures can harm fish directly through various mechanisms (see Table A-8) including oxygen depletion and increased stress and decreased survival.

Agricultural crops may require substantial inputs of water, fertilizer, and pesticides to thrive. Nutrients (e.g., phosphates, nitrates), insecticides, and herbicides are typically elevated in streams draining agricultural areas, reducing water quality, and affecting fish and other aquatic organisms (Omernik 1977; Waldichuk 1993). These changes in water quality can cause ecosystem alterations that affect many biological components of aquatic systems including vegetation within streams, as well as the composition, abundance, and distribution of macroinvertebrates and fishes. These changes can affect the spawning, survival, food supply, and the health of salmon (Stober *et al.* 1979, Northwest Power Planning Council [NPPC] 1986). Though currently used pesticides are not as persistent as previously used chlorinated hydrocarbons, most are still toxic to aquatic life. However, where biocides are applied at recommended concentrations and rates and where there is a sufficient riparian buffer, the toxic effects to aquatic life may be minimal (Spence *et al.* 1996).

Chemicals such as some pesticides, phosphorus, and ammonium are transported with sediment in the adsorbed state. Changes in the aquatic environment, such as a lower concentration of chemicals in the overlying waters or the development of anaerobic conditions in the bottom sediments, can cause these chemicals to be released from the sediment. Phosphorus transported by the sediment may not be immediately available for aquatic plant growth, but does serve as a long-term contributor to eutrophication, a form of pollution caused by over-enrichment (EPA 1993).

Agricultural practices may also include stream channelization, large woody debris removal, installation of riprap and revetments along stream banks, and removal of riparian vegetation (Spence *et al.* 1996). Natural channels in easily eroded soils tend to be braided and meander, creating considerable channel complexity as well as accumulations of fallen trees, which help create large, deep, relatively permanent pools, and meander cutoffs. These factors are important to salmon habitat.

Confined animal facilities (e.g., feed lots) may also adversely affect salmon habitat if the concentrated animal waste, process water (e.g., from that of a milking operation), and the feed, bedding, litter, and soil which comes intermixed with the fecal and urinary wastes is not properly contained and managed. If not properly treated, storm water run-off water and process water can carry nutrients, sediment, organic solids, salts, as well as bacteria, viruses, and other microorganisms into salmon habitat (EPA 1993). These pollutants can cause oxygen depletion, turbidity, eutrophication and other effects on the water quality and habitat quality for salmon.

**Conservation Measures for Agriculture** - The restoration of natural vegetative communities and functions should be a goal of riparian restoration and management projects on agricultural lands. Once riparian areas have recovered, agricultural activities should strive to protect riparian vegetation and water quality through conservation practices and management plans. Conservation practices and management plans should include the measurement of water quality and the attainment of applicable federal and state water quality standards.

The 1996 reauthorization of the Farm Bill (the "Federal Agricultural Improvement and Reform Act") included several conservation programs that provide potential benefit to EFH. They are the Environmental Quality Incentives Program, the Wetlands Reserve Program, and the Conservation Reserve and Enhancement Programs. These programs provide farmers assistance for idling erosion-prone land, preserving wetlands, and undertaking land management conservation practices. Land owners are encouraged to contact their local agricultural extension agents to find out further information about these programs.

Following are the types of measures that can be undertaken by the action agency on a site-specific basis to conserve salmon habitat to conserve, enhance, or restore EFH adjacent to agricultural lands that have the potential to be adversely affected by agricultural activities. Not all of these suggested measures are necessarily applicable to any one project or activity that may adversely affect salmon EFH. More specific or different measures based on the best and most current scientific information may be developed prior to or during the EFH consultation process, and communicated to the appropriate agency. The options represent a short menu of general types of conservation actions that can contribute to the restoration and maintenance of properly functioning salmon habitat. These recommendations are broadly applicable and useful inland as well as in coastal areas. The following suggested measures are adapted from EPA (1993).

- Maintain riparian management zones of appropriate width on all permanent and ephemeral streams that include or influence EFH. The riparian management zones should be wide enough to restore and support riparian functions including shading, large woody debris input, leaf litter inputs, sediment and nutrient control, and bank stabilization functions.
- Reduce erosion and run-off by using such practices as contour plowing and terracing, nontill agriculture, conservation tillage, crop sequencing, cover and green manure cropping and crop residue, and, by maximizing the use of filter strips, field borders, grassed waterways, terraces with safe outlet structures, contour strip cropping, diversion channels, sediment retention basins, and other mechanisms including re-establish vegetation
- Participate in, and benefit from existing programs to encourage wetland conservation and conservation reserves, avoid planting in areas of steep slopes and erodible soils, and avoid disturbance or draining of wetlands and marshes.
- Incorporate water quality monitoring as an element of land owner assistance programs for water quality. Evaluate monitoring results and adjust practices accordingly.
- Minimize the use of chemical treatments within the riparian management zone. Review pesticide use strategies to minimize impact to EFH. Reduce pesticide application by evaluating pest problems, past pest control measures, and following integrated pest management strategies. Select pesticides considering their persistence, toxicity, runoff potential, and leaching potential.
- Optimize the siting of new confined animal facilities or the expansion of existing facilities to avoid areas adjacent to surface waters containing EFH or in areas with high leaching potential to surface or

groundwater. Use appropriate methods to minimize discharges from confined animal facilities (for both wastewater and process water).

- Where water quality is limited from nutrients or where leaching potential is high, avoid land application of manure or other fertilizer unless appropriate management measures are in place to assure that sediment and nutrient input to surface water is controlled. Observe best management practices to assure that application and timing measures fostering high nutrient utilization are employed.
- Apply conservation measures for water intake (see irrigation water withdrawal, storage and management section below) to agricultural activities where applicable.

### 3.2.5.2 Artificial Propagation of Fish and Shellfish

Public and private hatcheries, acclimation sites, and netpens producing Pacific salmon (coho, chinook, chum, pink, kokanee, sockeye, steelhead, and cutthroat), trout (Atlantic salmon, brown, rainbow, and golden), char (eastern brook, and lake trout), sturgeon, and several species of warmwater fish operate in and adjacent to salmon EFH in fresh and sea water (NRC 1996, WDFW 1998). Additionally, captive breeding of threatened or endangered stocks of sockeye and spring chinook salmon occurs in Idaho, Oregon, and Washington, and of endangered winter chinook salmon in California (Flagg *et al.* 1995). Shellfish culture in salmon EFH consists primarily of oyster culture, although clams, mussels, and abalone are grown as well.

Currently, there are several hundred public facilities (federal, tribal, and state-operated) producing Pacific salmonids for release into fresh and sea water salmon EFH (NRC 1996). In addition, hundreds of private hatcheries in salmon EFH produce various salmon and trout species, as well as catfish and tilapia, for commercial sale.

The artificial propagation of native and nonnative fish and shellfish species in or adjacent to salmon EFH has the potential to adversely affect that habitat by altering water quality, modifying physical habitat, and creating impediments to passage. Artificial propagation may also adversely impact EFH by predation of native fish by introduced hatchery fish, competition between hatchery and native fish for food and habitat, exchange of diseases between hatchery and wild populations, the release of chemicals in natural habitat, and the establishment of nonnative populations of salmonids and nonsalmonids. Many of these potential adverse effects have been summarized by Fresh (1997). These concerns have led to revision of many hatchery policies to eliminate or reduce impacts on wild fish (USFWS 1984; ODFW 1995; WDF 1991; NWIFC/WDFW 1998).

Various methods of shellfish culture and harvest also have the potential to adversely impact salmon EFH, such as dredging in eelgrass beds, off-bottom culture, raft and line culture, and the use of chemicals to control burrowing organisms detrimental to oyster culture. To control burrowing shrimp, for example, Washington State has used the pesticide carbaryl since 1963. About 800 acres are treated with carbaryl annually in Grays Harbor and Willapa Bay, with a given oyster bed sprayed about every 6 years. Nontarget effects of carbaryl use include short-term decreases in the density of prey species for salmon as well as the mortality of nontarget benthic invertebrates and nonsalmonid fish (Pozarycki *et al.* 1997, Simenstad and Fresh 1995). Concerns over such potential adverse impacts have led to the development of regulations for the use of chemicals in natural habitat and policies for offsetting losses to eelgrass beds (WDF 1992). On a positive note, some methods of mollusc culture have been shown to create beneficial habitat for salmonids (Johnson 1998, pers. comm.).

Treated wood structures in salmon EFH (e.g., creosote, chromated copper, arsenate) used for docks, pilings, raceway separators, fish ladders etc., and other structures can release toxic heavy metals and persistent aromatic hydrocarbons into the aquatic environment (see estuarine section).

**Conservation Measures for Artificial Propagation of Fish and Shellfish** - The following lists the types of measures that can be undertaken by the action agency on a site-specific basis to conserve salmon EFH in areas that have the potential to be adversely affected by the artificial propagation of fish and shellfish. Not all of these suggested measures are necessarily applicable to any one project or activity that may adversely affect salmon EFH. More specific or different measures based on the best and most current scientific

information may be developed prior to, or during, the EFH consultation process and communicated to the appropriate agency. The options represent a short menu of general types of conservation actions that can contribute to the restoration and maintenance of properly functioning salmon habitat.

- Follow published guidelines and policies designed for artificial propagation operations in salmon EFH to reduce or eliminate ecological interactions between cultured and native salmonids (Alaska Department of Fish and Game [ADFG] 1985; ODFW 1995; WDF 1991; NWIFC/WDFW 1998).
- Follow state, tribal, and federal regulations pertaining to the transfer of fish and eggs to minimize the potential for adverse effects from the transfer of disease organisms (ADFG 1988; USFWS 1984; NWIFC/WDFW 1998).
- Use either local stocks, or a stock or species with no documented or likely risk for ecological interactions with Pacific salmonids in public or private marine net-pen and aquaculture systems for salmonids which are located near streams with depressed population(s) of native salmonids (ODFW 1995; WDF 1991; NWIFC/WDFW 1998).
- Comply with state and federal regulations on use and reporting of drugs, pesticides, and chemicals (ADFG 1983; USFWS 1984; NWIFC/WDFW 1998).
- Comply with state and federal regulations for discharge, monitoring, and reporting of water quality (e.g., discharge of fish and food wastes), sediment, and benthic habitat conditions in and around artificial propagation facility discharges (Washington Department of Ecology [WDOE] 1986), disease outbreaks, and for the disposal of dead fish.
- Minimize the use of biocides and wood preservatives. Promote the use of plastic building materials. Treated wood should be certified as produced in accordance with the most current version of "Best Management Practices for Treated Wood in Western Aquatic Environments" (Western Wood Preservers Institute [WWPI] 1996). Treated materials containing copper compounds should not be installed when migrating salmon are present.
- Comply with current policies for release of hatchery fish to minimize impacts on native fish populations and their ecosystems and to minimize the percentage of nonlocal hatchery fish spawning in streams containing native stocks of salmonids (ODFW 1995; WDFW 1997).
- Manage shellfish culture activities to provide levels of salmon prey production, cover, and habitat complexity for both salmon smolts and returning adults which are similar to, or better than, levels provided by the natural environment.

### **3.2.5.3 Bank Stabilization**

The extent and magnitude of stream bank erosion has been greatly increased by human activities that remove riparian vegetation, increase sediment inputs, relocate and straighten channels, or otherwise cause channel down-cutting. Vessel traffic and the resulting wakes can also create bank scour.

Attempts to deal with the bank erosion resulting from these activities often involve the use of adding adamantine-like materials. In smaller streams, particularly those that seasonally become dry or nearly dry, bulldozing of streambed gravel against the banks has been a common practice to retard erosion. In larger streams (and rivers) the dumping or placement of rock (riprap), broken concrete, and mixtures of materials (i.e., rocks, dirt, branches) along the banks is a common practice (Oregon Water Resources Research Institute [OWRRI] 1995). Additionally bulkheads and concrete walls have been used on lake and estuarine shores. Concerns for salmon that are associated with shoreline stabilization include loss of shallow edgewater rearing habitat, changes to benthic vegetation, impacts to eelgrass and other vegetation important for herring spawning, loss of shoreline riparian vegetation and reduction in leaf fall, loss of wetland vegetation, alteration of groundwater flows, loss of large woody debris, changes in food resources, and loss of migratory corridors (Puget Sound Water Quality Action Team [PSWQAT] 1997, Thom and Shreffler 1994).

The installation of riprap or other streambank stabilization devices can reduce or eliminate recruitment of crucial spawning gravel by eliminating lateral erosion, as has occurred in the Sacramento River (PFMC 1988). By confining the stream or shoreline with hard materials, the development of side channels, functioning riparian and floodplain areas, and off-channel sloughs are precluded (WDFW 1997).

Another concern is the use of chemicals (e.g., creosote, chromated copper arsenate, copper zinc arsenate) on bulkheads or other wood materials used for bank stabilization. These chemicals can introduce toxic substances into the water, injure or kill prey organisms and salmon directly, or concentrate in the food chain ([WMOA] 1995). Their use is generally prohibited. In freshwater, copper concentrations are acutely toxic to yearly coho salmon at 60-74 mg/l in freshwater, but affect smoltification, migration, and survival at 5-30 mg/l (Lorz and McPherson 1976).

**Conservation Measures for Bank Stabilization** - Following are the types of measures that can be undertaken by the action agency on a site-specific basis to conserve salmon EFH in areas that have the potential to be affected by bank stabilization activities. Not all of these suggested measures are necessarily applicable to any one project or activity that may adversely affect salmon EFH. More specific or different measures based on the best and most current scientific information may be developed prior to, or during, the EFH consultation process and communicated to the appropriate agency. The options represent a short menu of general types of conservation actions that can contribute to the restoration and maintenance of properly functioning salmon habitat. The following suggested measures are adapted from Streif (1996) and Meyer (1997 pers. comm.).

- Use vegetative methods of bank erosion control whenever feasible. Where vegetative mechanisms are not sufficient alone, explore these methods in conjunction with ground contouring. Hard bank protection should be a last resort and the following options should be explored, in order of priority: tree revetments, stream barbs/flow deflectors, toe-rock, and vegetation riprap.
- Determine the cumulative effects of existing and proposed bio-engineered or bank hardening projects on salmon EFH, including salmon prey species before planning new bank stabilization projects.
- Contour slopes according to the preferred ratio of 3-5:1 and avoid slopes of less than 2:1.
- Develop plans that minimize alteration or disturbance of the bank and existing riparian vegetation. Use temporary fencing to minimize disturbance from intrusion.
- Revegetate sites to resemble the appropriate natural community associations, utilizing vegetation management to limit livestock grazing and maintain an appropriate buffer zone.
- Minimize the use of creosote or treated wood in lakes and in estuarine or other areas with low circulation or flow. Where treated wood is used, it should be certified as produced in accordance with the most current version of "Best Management Practices for Treated Wood in Western Aquatic Environments" (WWPI 1996). Treated materials containing copper compounds should not be installed when migrating salmon are present.

#### **3.2.5.4 Beaver Removal and Habitat Alteration**

Beavers have long co-existed with salmon and were once much more abundant in the region. Beavers have multiple effects on water bodies and riparian ecosystems, altering hydrology, channel morphology, biochemical pathways, and the productivity of a stream system (Olson and Hubert 1994). Their presence can have both positive and negative influences on salmon habitat, but overall, beavers are considered to impart a significant positive benefit to both water quality and salmon, particularly juvenile coho. The removal of beavers has fundamentally altered natural aquatic ecosystem processes.

Beaver dams can cause channel obstruction, the redirection of channel flow, and the flooding of streambanks and side channels. By ponding water, beaver dams create enhanced rearing and over-wintering habitat that offer juvenile salmonids protection from both freezing and high winter flows (NRC 1996).

Bank dens and channels can increase erosion potential, but ponds can lessen bank erosion by reducing the channel gradient during high flows as well as by settling out and trapping sediment. Beaver ponds also provide a sink for nutrients from tributary streams and create conditions that promote anaerobic decomposition and de-nitrification. Anaerobic decomposition and de-nitrification results in nutrient enrichment and increased primary and secondary production downstream from the pond and increased nutrient retention time and enhanced invertebrate prey production (NRC 1996).

Although beaver dams can occasionally block the upstream migration by adult and juvenile salmonids, studies on trout movement indicate that fish not only can pass over dams during high water, but also can travel upstream and downstream through most beaver dams during all seasons (Olson and Hubert 1994).

Beaver ponds increase the surface-to-volume ratio of the impounded area, which can result in increased summer temperatures (Spence *et al.* 1996). However, beaver ponds also cause increased storage of water in the banks and flood plains. This increases the water table, enhances summer flows, adds cold water during summer, and causes more even stream flow throughout the year. During winter, beaver ponds in cold environments prevent anchor ice from forming and prevent super-cooling of the water. By storing spring and summer storm run-off, beaver ponds help to reduce downstream flooding and the damage from rapid increases in stream flows (Olson and Hubert 1994).

Beavers also help shape riparian habitat. Beaver ponds increase the surface area of water several hundred times and thereby enhance the overall riparian habitat development. They also enhance vegetation growth by increasing the amount of groundwater for use by riparian plants. They also create and expand wetland areas (Olson and Hubert 1994).

**Conservation Measures for Beaver Removal and Habitat Alteration** - Following are the types of measures that can be undertaken by the action agency on a site-specific basis to conserve salmon EFH in areas that have the potential to be affected by beaver removal/habitat alteration. Not all of these suggested measures are necessarily applicable to any one project or activity that may adversely affect salmon EFH. More specific or different measures based on the best and most current scientific information may be developed prior to, or during, the EFH consultation process and communicated to the appropriate agency. The options represent a short menu of general types of conservation actions that can contribute to the restoration and maintenance of properly functioning salmon habitat. The following suggested measures are adapted from Olson and Hubert (1994) and Buckman (1998 pers. comm.).

- Reintroduce beaver as a watershed restoration technique when deemed appropriate by natural resource professionals.
- Manage livestock grazing to improve riparian areas (e.g., through pasture rotation, fencing, changes in the timing of grazing, rest periods, improving upslope conditions for grazers) which can, in turn, support beneficial beaver activity.
- Where appropriate, replace culverts with bridges where there are chronic culvert plugging problems that induce beaver removal activities, or install culvert protective devices that do not impede fish passage for either adult or juvenile passage.
- Explore alternatives to beaver removal with fish biologists.
- Educate the public on the value of beavers to salmon EFH and mechanisms to co-exist with beavers.
- Update land use planning guidance to avoid activity in the flood plain that would be in conflict with beaver activity (e.g., avoid the siting of structures where beaver dams would cause flooding).

### 3.2.5.5 Construction/Urbanization

Activities associated with urbanization (e.g., building construction, utility installation, road and bridge building, storm water discharge) can significantly alter the land surface, soil, vegetation, and hydrology and adversely impact salmon EFH through habitat loss or modification. Construction in and adjacent to waterways can involve dredging and/or filling activities, bank stabilization (see other sections), removal of shoreline vegetation, waterway crossings for pipelines and conduits, removal of riparian vegetation, channel realignment, and the construction of docks and piers. These alterations can destroy salmon habitat directly or indirectly by interrupting sediment supply that creates spawning and rearing habitat for prey species (e.g., sand lance, surf smelt, herring), by increasing turbidity levels and diminishing light penetration to eelgrass and other vegetation, by altering hydrology and flow characteristics, by raising water temperature, and by re-suspending pollutants (Phillips 1984).

Projects in or along waterways can be of sufficient scope to cause significant long-term or permanent adverse effects on aquatic habitat. However, most waterway projects and other projects associated with growth, urbanization, and construction within the region are small-scale projects that individually cause minor losses or temporary disruptions and often receive minimal or no environmental review. The significance of small-scale projects lies in the cumulative and synergistic effects resulting from a large number of these activities occurring in a single watershed.

Construction activities can also have detrimental effects on salmon habitat through the run-off of large quantities of sediment, as well as the nutrients, heavy metals, and pesticides. Run-off of petroleum products and oils from roads and parking lots and sediment, nutrients, and chemicals from yards as well as discharges from municipal sewage treatment plants and industrial facilities are also associated with urbanization (EPA 1993). Urbanized areas also alter the rate and intensity of run-off into streams and waterways. Urban runoff can cause immunosuppression by organic contaminants (Arkoosh *et al.* 1998).

Similarly, effects on run-off rates can be much greater than in any other type of land use, because of the amount of impervious surfaces associated with urbanization. Buildings, rooftops, sidewalks, parking lots, roads, gutters, storm drains, and drainage ditches, in combination, quickly divert rainwater and snow melt to receiving streams, resulting in an increased volume of runoff from each storm, increased peak discharges, decreased discharge time for runoff to reach the stream, and increased frequency and severity of flooding (EPA 1993). Flooding reduces refuge space for fish, especially where accompanied by loss of instream structure, off-channel areas, and habitat complexity. Flooding can also scour eggs and young from the gravel. Increases in streamflow disturbance frequencies and peak flows also compromises the ability of aquatic insects and fish life to recover (May *et al.* 1997)

The amount of impervious surfaces also can influence stream temperatures. Summer time air and ground temperatures in impervious areas can be 10-12° warmer than in agricultural and forested areas (Metro 1997). In addition, the trees that could be providing shade to offset the effects of solar radiation are often missing in urban areas. The alteration in quantity and timing of surface run-off also accelerates bank erosion and the scouring of the streambed, as well as the downstream transport of wood. This results in simplified stream channels and greater instability, all factors harmful to salmon (Spence *et al.* 1996). The lack of infiltration also results in lower stream flows during the summer by reducing the interception, storage, and release of ground water into streams. This affects habitat availability and salmonid production, particularly for those species that have extended freshwater rearing requirements (e.g., coho). Generally, it has been found that instream functions and value begin to seriously deteriorate when the levels of impervious surfaces exceed 10% of a sub-basin (WDFW 1997).

**Conservation Measures for Construction/Urbanization** - Existing urban and industrial sites, highways, and other permanent structures will prevent restoration of riparian zones in heavily developed areas. In these areas, generally along major river systems, buffers will not be continuous, and riparian areas will remain fragmented. Habitat improvement plans will need to identify locations of healthy riparian zones and opportunities for re-establishing corridors of riparian vegetation between them, so that nodes of good quality habitat can be maintained and managed in ways that protect salmon habitat (Sedell *et al.* 1997).

Following are the types of measures that can be undertaken by the action agency on a site-specific basis to conserve salmon EFH in areas that have the potential to be affected by construction and urbanization activities. Not all of these suggested measures are necessarily applicable to any one project or activity that

may adversely affect salmon EFH. More specific or different measures based on the best and most current scientific information may be developed prior to, or during, the EFH consultation process, and communicated to the appropriate agency. The EPA (1993) publication "Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters" extensively describes best management practices for control of runoff from developing areas, construction sites, roads, highways and bridges affecting salmon EFH. In addition to the previous guidelines, the options following represent a short menu of general types of conservation actions that can contribute to the restoration and maintenance of properly functioning salmon habitat. The following suggested measures are adapted from Metro (1997), ODFW (1989), and EPA (1993).

- Protect existing, and wherever practicable, establish new riparian buffer zones of appropriate width on all permanent and ephemeral streams that include or influence EFH. Establish buffers wide enough to support shading, large woody debris input, leaf litter inputs, sediment and nutrient control, and bank stabilization functions.
- Plan development sites to minimize clearing and grading and cut-and-fill activities.
- During construction, temporarily fence setback areas to avoid disturbance of natural riparian vegetation and maintain riparian functions for EFH.
- Use best management practices in building as well as road construction and maintenance operations such as avoiding ground disturbing activities during the wet season, minimizing the time disturbed lands are left exposed, using erosion prevention and sediment control methods, minimizing vegetation disturbance, maintaining buffers of vegetation around wetlands, streams and drainage ways, and avoiding building activities in areas of steep slopes with highly erodible soils. Use methods such as sediment ponds, sediment traps, or other facilities designed to slow water run-off and trap sediment and nutrients.
- Where feasible, remove impervious surfaces such as abandoned parking lots and buildings from riparian areas, and re-establish wetlands.

### **3.2.5.6 Dam Construction/Operation**

Dams built to provide power, water storage, and flood control have significantly contributed to the decline of salmonids in the region. Potential adverse effects include impaired fish passage (including blockages, diversions), alterations to water temperature, water quality, water quantity, and flow patterns, the interruption of nutrients, large woody debris, and sediment transport which affect river, wetland, riparian, and estuarine systems, increased competition with nonnative species, and increased predation and disease.

The construction of dams without fish passage facilities has blocked salmon from thousands of miles of mainstream and tributary stream habitat in the Columbia River basin, Sacramento-San Joaquin system, and other streams throughout the western United States (PFMC 1988). While technology exists for providing fish passage around dams, it has not always been successful, and migration delays and increased mortality may still occur at some projects under certain water temperatures and flows. Poorly designed fishways, or fishways that are improperly operated and maintained, can inhibit movement of adults upstream causing migration delays and unsuccessful spawning. Additionally, the fallback of adult salmon through spillways and turbines contribute to migration delays and increased mortality. Increased vulnerability to predation is also an impact of dams and fish passage structures.

Dams are also a barrier to downstream passage of juveniles. In general, reservoirs and water diversions (see section on irrigation water withdrawal) reduce water velocities and change current patterns, resulting in increased migration times (Raymond 1979), exposure to less favorable environmental conditions, and increased exposure to predation. At dams, injury and mortality to juveniles occurs as a result of passage through turbines, sluiceways, juvenile bypass systems, and adult fish ladders. Encounters with turbine blades, rough surfaces, or solid objects can cause death or injury. Changes in pressure within turbines or over spillways also can result in death or injury. Juveniles, frequently stunned and disoriented as they are expelled at the base of the dam, are particularly vulnerable to predation (PFMC 1988). Dams also result in changes in concentrations of dissolved oxygen and nitrogen. Above the dams, slow-moving water has lower dissolved oxygen levels than faster, turbulent waters, a factor that may stress fish (Spence *et al.* 1996). Below

hydroelectric facilities, nitrogen supersaturation may also negatively affect migrating as well as incubating or rearing salmon by causing gas-bubble disease. Gas bubble disease increases in years of high flow and high spill.

Hydrologic effects of dams include water-level fluctuations, altered seasonal and daily flow regimes, reduced water velocities, and reduced discharge volume. These altered flow regimes can affect the migratory behavior of juvenile salmonids. Water-level fluctuations associated with hydro power peak operations may reduce habitat availability, inhibit the establishment of aquatic macrophytes that provide cover for fish, and in some cases strand fish or allow desiccation of spawning redds. Drawdowns reduce available habitat area and concentrate organisms, potentially increasing predation and transmission of disease (Spence *et al.* 1996). Drawdown in the fall for flood control produces high flows during spawning which allow fish to spawn in areas which may not have water during the winter and spring, resulting in loss of the redds.

Impoundments may also change the thermal regimes of streams causing effects on salmon. Temperatures may increase in shallow reservoirs to the detriment of salmon. Below deeper reservoirs that thermally stratify, summer temperatures may be reduced, but fall temperatures tend to increase as heated water stored during the summer is released. These changes in water temperatures affect development and smoltification of salmonids, decreasing survival. Water temperatures also can affect adult migration (Spence *et al.* 1996). Water temperature changes also influence the success of predators and competitors and the virulence of disease organisms. Additionally, in winter, drawdown of impoundments may facilitate freezing, which diminishes light penetration and photosynthesis, potentially causing fish kills through anoxia (Spence *et al.* 1996).

In watersheds where temperatures and flows may limit salmon production, dams can sometimes be operated to have positive benefits such as lowering water temperatures during the summer and providing stable flows and temperatures which may benefit both salmonid spawning, rearing, and invertebrate production.

Dam impoundments alter natural sediment and large woody debris transport processes. Water storage at dams may prevent the high flows that are needed to scour fine sediments from spawning substrate and move wood and other materials downstream. Behind dams, suspended sediments settle to the bottoms of reservoirs, depriving downstream reaches of needed sediment inputs, leading to the loss of high-quality spawning gravels (as substrate becomes dominated by cobble unsuitable for spawning) as well as to changes in channel morphology (Spence *et al.* 1996).

Dams can also affect the health and extent of downstream estuaries. Reservoir storage can alter both the seasonal pattern and the characteristics of extremes of freshwater entering the estuary. Flow damping has also resulted in a reduction in average sediment supply to the estuary. Except for times of major floods, residence time of water in estuaries has increased with decreasing salinity. Estuaries have also been converted into a less-energetic microdetritus-based ecosystem with higher organic sedimentation rates. Detritus and nutrient residence has increased; vertical mixing has decreased, likely increasing primary productivity in the water column, and enhancing conditions for detritivorous, epibenthic, and pelagic copepods (Sherwood *et al.* 1990). The effects of these changes have not been evaluated as yet, though there are concerns about possible effects on fish and other resources which depend on a highly co-evolved and biologically diverse estuarine environment (NRC 1996).

**Conservation Measures for Dam Construction/Operation** - Following are the types of measures that can be undertaken by the action agency on a site-specific basis to conserve salmon EFH in areas that have the potential to be affected by dam construction and operation activities. Not all of these suggested measures are necessarily applicable to any one project or activity that may adversely affect salmon EFH. More specific or different measures based on the best and most current scientific information may be developed prior to, or during, the EFH consultation process and communicated to the appropriate agency. The options represent a short menu of general types of conservation actions that can contribute to the restoration and maintenance of properly functioning salmon habitat. The following suggested measures are adapted from Spence *et al.* (1996), NMFS (1997a).

- Operate facilities to create flow conditions adequate to provide for passage, water quality, proper timing of life history stages, avoid juvenile stranding and redd dewatering, and maintain and restore properly

functioning channel, floodplain, riparian, and estuarine conditions. Specific flow objectives have been developed for the Columbia and Snake river and Sacramento bay/delta river systems and other systems with federally operated facilities where there are species listed under the ESA, through FERC orders, through specific legislative acts (e.g., the Central Valley Water Improvement Act, the Bay-Delta Accord), water quality orders, and through legal settlement agreements. Federal projects are operated within the context of the projects' authorized purposes, applicable state water laws, and contractual commitments.

- Provide adequate designing and screening for all dams, hydroelectric installations, and bypasses to meet specific passage criteria developed by the Columbia Basin fish managers.
- Develop water and energy conservation guidelines and integrate them into dam operation plans and into regional and watershed-based water resource plans.
- Provide mitigation (including monitoring and evaluation) for non-avoidable adverse effects to salmon EFH.

### **3.2.5.7 Dredging and Dredged Spoil Disposal**

Dredging is associated with improving river navigation for commercial and recreational activities and for maintaining the navigation channels of ports and marinas. Dredging may also be carried out during the construction of roads and bridges and the placement of pipe, cable, and utility lines. Dredging is also conducted to maintain channel flow capacity for flood control purposes.

Dredging results in the temporary elevation of suspended solids emanating from the project area as a turbidity plume. Excessive turbidity can affect salmon or their prey by abrading sensitive epithelial tissues, clogging gills, decreasing egg buoyancy (of prey), and affects photosynthesis of phytoplankton and submerged vegetation leading to localized oxygen depression. Suspended sediments subsequently settle, which can destroy or degrade benthic habitats (NMFS 1997).

The removal of bottom sediments during dredging operations can disrupt the entire benthic community and eliminate a significant percentage of the feeding habitat available to fish for a significant period of time. The rate of recovery of the dredge area is temporally and spatially variable and site specific. Recolonization varies considerably with geographic location, sediment composition, and types of organisms inhabiting the area (Kennish 1997). Dredging may also affect the migration patterns of juvenile salmonids as a result of noise, turbulence, and equipment (FRI 1981).

The suspended sediments dredged from estuarine and coastal marine systems are generally high in organic matter and clay, both of which may be biologically and chemically active. Dredged spoils removed from areas proximate to industrial and urban centers can be contaminated with heavy metals, organochlorine compounds, polycyclic aromatic hydrocarbons, petroleum hydrocarbons, and other substances (Kennish 1997) and thereby prone to resuspension. Sediments in estuaries downstream from agricultural areas may also contain herbicide and pesticide residues (NMFS 1997).

Dredging and subsequent sediment deposition poses a potential threat to the eelgrass ecosystems in estuaries, which provide important structural habitat and prey for salmon (see estuary alteration section, below). Dredging not only removes plants and reduces water clarity, but can change the entire physical, biological, and chemical structure of the ecosystem (Phillips 1984). Dredging also can reverse the normal oxidation/reduction potential of the sediments of an eelgrass system, which can reverse the entire nutrient-flow mechanics of the ecosystem (Phillips 1984).

Concomitant with dredging is spoil disposal. Dredged material disposal has been used in recent years for the creation, protection and restoration of habitats (Kennish 1997). When not used for beneficial purposes, spoils are usually taken to marine disposal sites and this in itself may create adverse conditions within the marine community. When contaminated dredged sediment is dumped in marine waters, toxicity and food-chain transfers can be anticipated, particularly in biologically productive areas. The effects of these changes on salmon are not known.

**Conservation Measures for Dredging and Dredged Spoil Disposal** - Following are the types of measures that can be undertaken by the action agency on a site-specific basis to conserve salmon habitat in spawning redds, eelgrass beds, and other EFH areas of particular concern, that have the potential to be affected by dredging/spoil disposal activities. Not all of these suggested measures are necessarily applicable to any one project or activity that may adversely affect salmon EFH. More specific or different measures based on the best and most current scientific information may be developed prior to, or during, the EFH consultation process and communicated to the appropriate agency. The options represent a short menu of general types of conservation actions that can contribute to the restoration and maintenance of properly functioning salmon habitat. The following suggested measures are adapted from NMFS (1997), NMFS (1997d), and Meyer (1997 pers. comm.).

- Explore collaborative approaches between material management planners, pollution control agencies, and others involved in watershed planning to identify point and nonpoint sources of sediment and sediment pollution; to promote the establishment of riparian area buffers to help reduce sediment input, and to promote use of best management measures to control sediment input.
- Avoid dredging in or near spawning redds, eelgrass beds, and other EFH areas of particular concern; especially where the areal extent of the dredging could affect the prey base for outmigrating juvenile salmon.
- Monitor dredging activities especially contaminate sediments and regularly report effects on EFH. Re-evaluate activities based on the results of monitoring.
- Employ best engineering and management practices for all dredging projects to minimize water-column discharges. Avoid dredging during juvenile outmigration through estuaries. Where avoidance is not fully possible, area and timing guidelines should be established in consultation with local, state, tribal, and federal fish biologists.
- When reviewing open-water disposal permits for dredged material, identify direct and indirect effects of such projects on EFH. Consider upland disposal options as an alternative. Mitigate all nonavoidable adverse effects and monitor mitigation effectiveness.
- Determine cumulative effects of existing and proposed dredging operations on EFH.
- Explore the use of clean dredged material for beneficial use opportunities.

#### **3.2.5.8 Estuarine Alteration**

Estuaries represent transitional environments coupling land and sea water. The dominant features of estuarine ecosystems are their salinity variances, productivity, and diversity, which, in turn are governed by the tides and the amount of freshwater runoff from the land. These systems present a continuum along a fresh-brackish-salt water gradient as a river system empties into the sea. Estuarine ecosystems, containing a large diversity of species that reflect the great structural diversity and resultant differentiation of niches, may be characterized as:

- Unique hydrological features by which fresh water slows and flows over a wedge of heavier intruding tidal salt water resulting in suspended terrestrial and autochthonous products settling into the inflowing salt water or into bottom sediments.
- Shallow nutrient-rich environments resulting in an enormously productive vegetative habitat and detrital food chain for many organisms, such as crustaceans and juvenile fish.
- Critical nursery habitats for many aquatic organisms, particularly anadromous fish and ecotones for shorebirds and waterfowl.
- Contributing to the “trapping” and recycling of nutrients: an area where an accumulation of nutrients such as potassium and nitrogen are concentrated and recycled – a repeating interactive process by which the

incoming tidal water re-suspends nutrients at the fresh-salt water interface while moving them back up the estuary, and the land-based sources of nutrients move towards the sea.

- Accumulating fine sediments transported in by tides and rivers, further enhancing productivity by being adsorptive surfaces for nutrients.

In Oregon and Washington where there are relatively few estuarine wetlands because of the steep topography of the shore, it is estimated that between 50% and 90% of the tidal marsh systems in estuaries have been lost this century (Frenkel and Morlan 1991). The estuarine environment benefits salmon by providing a food rich environment for rapid growth, physiological transition between fresh and salt water environments, and refugia from predators (Simenstad 1983). Estuarine eelgrass beds, macroalgae, emergent marsh vegetation, marsh channels, and tidal flats provide particularly important estuarine habitats for the production, retention, and transformation of organic matter within the estuarine food web as well as a direct source of food for salmon and their prey. Additionally, estuarine marsh vegetation, overhanging riparian vegetation, eelgrass beds, and shallow turbid waters of the estuary provide cover for predator avoidance. Estuaries provide enough habitat variety to allow the numerous species and stocks of salmonids to segregate themselves by niche.

Chinook salmon fry, for example, prefer protected estuarine habitats with lower salinity, moving from the edges of marshes during high tide to protected tidal channels and creeks during low tide (Healey 1980, 1982; Levy and Northcote 1981, 1982; Kjelson *et al.* 1982; Levings 1982). As the fish grow larger, they are increasingly found in higher salinity waters and increasingly utilize less-protected habitats, including delta fronts or the edge of the estuary before dispersing into marine waters. As opportunistic feeders, chinook salmon consume larval and adult insects and amphipods when they first enter estuaries, with increasing dependence on larval and juvenile fish such as anchovy, smelt, herring, and stickleback as they grow larger (Sasaki 1966; Dunford 1975; Birtwell 1978; Levy *et al.* 1979; Northcote *et al.* 1979; Healey 1980, 1982; Kjelson *et al.* 1982; Levy and Northcote 1981; Levings 1982; Gordon and Levings 1984; Myers 1980; Reimers 1973).

For juvenile coho, large woody debris is an important element of estuarine habitat (McMahon and Holtby 1992). During their residence time in estuaries, coho salmon consume large planktonic or small nektonic animals, such as amphipods, insects, mysids, decapod larvae, and larval juvenile fishes (Myers and Horton 1982; Simenstad *et al.* 1982; Dawley *et al.* 1986; McDonald *et al.* 1987). In estuaries, smolts occur in intertidal and pelagic habitats with deep marine-influenced habitats often preferred (Pearce *et al.* 1982, Dawley *et al.* 1986; McDonald *et al.* 1987).

Although pink salmon generally pass directly through the estuary en route to nearshore areas, populations that do reside in estuaries for one to two months utilize shallow, protected habitats such as tidal channels and consume a variety of prey items, such as larvae and pupae of various insects, cladocerans, and copepods (Bailey *et al.* 1975; Hiss 1995).

While in the estuary, lake-rearing yearling sockeye are generally found in faster flowing mid-channel regions and are rarely observed in off-channel areas such as marshes and sloughs. These juvenile fish consume copepods, insects, amphipods, euphausiids, and fish larvae (Simenstad *et al.* 1982; Levings *et al.* 1995). In contrast, sea-type and river-type sockeye salmon rear in riverine and estuarine environments. For those "zero-age" sockeye that migrate to the ocean during their first year of life, Birtwell *et al.* (1987) reports extensive use of estuarine areas of up to five months in the Fraser River estuary. During estuarine residence, zero-age sockeye salmon are widely dispersed, with highest concentrations in protected, shallow water habitats with low flow. Common prey during this period include copepods, insects, cladocerans, and oligochaetes (Birtwell *et al.* 1987; Levings *et al.* 1995).

There are four general categories of impacts on estuarine ecosystems: *enrichment* with excessive levels of organic materials, inorganic nutrients, or heat; *physical alterations* which include hydrologic changes and reclamation; *introduction of toxic materials*; *introduction of exotic species* leading to direct changes in species composition and food web dynamics.

Progressive *enrichment* of estuarine waters with inorganic nutrients, organic matter, or heat leads to changes in the structure and processes of estuarine ecosystems. Nutrient enrichment can lead to excessive algal growth, increased metabolism, and changes in community structure, a condition known as eutrophication.

Jaworski (1981) discusses sources of nutrients and scale of eutrophication problems in estuaries. Addition of excessive levels of organic matter to estuarine waters results in bacterial contamination and lowered dissolved oxygen concentrations which then results in concomitant changes in community structure and metabolism. Inorganic nutrients from mineralization of the organic matter can stimulate dense algal blooms and lead to another source of excessive organic matter. The source of high levels of organic matter is normally sewage waste water, but high levels can also result from seafood processing wastes and industrial effluents (Weiss and Wilkes 1974). Impacts from thermal loading include interference with physiological processes, behavioral changes, disease enhancement, and impacts from changing gas solubilities. These impacts may combine to affect entire aquatic systems by changing primary and secondary productivity, community respiration, species composition, biomass, and nutrient dynamics (Hall *et al.* 1978).

Local *physical alterations* in estuarine systems include such activities as filling and draining of wetlands, construction of deep navigation channels, bulkheading, and canal dredging through wetlands. Two major types of impacts resulting from these activities are estuarine habitat destruction and hydrologic alteration. For example, canals and deep navigation channels can alter circulation, increase saltwater intrusion, and promote development of anoxic waters in the bottoms of channels. Upstream changes in rivers can also have pronounced effects on estuaries into which they discharge. Construction of dams, diversion of fresh water, and groundwater withdrawals lower the amount of fresh water, nutrients, and suspended input – all important factors in estuarine productivity (Day *et al.* 1989).

The measurable consequences of anthropogenic disturbances in the Columbia River estuary have been dramatic since the initial comprehensive surveys and contemporaneous initiation of dredging, diking, shipping, groin and jetty construction, and riverflow diversion between the 1870s and the end of the twentieth century. Thomas (1983) documented a 30% loss (142 square kilometers) of the surface area of the estuary, although some 45 square kilometers have been changed from open water to shallows. Thomas (1983) also reported a 43% loss of tidal marshes and a 76% loss of tidal wetlands. The loss of shallow estuarine areas can shift the estuarine prey composition from benthic crustaceans and terrestrial insects, the preferred food of most salmon smolts, to water-column dwelling zooplankton. These zooplankton are favored by species such as herring, smelt, and shad (Sherwood *et al.* 1990).

*Toxic materials* include such compounds as pesticides, heavy metals, petroleum products, and exotic by-products of industrial activity near estuaries. Such contaminants can be acutely toxic, or more commonly, they can cause chronic or sublethal effects. Toxins can also bioaccumulate in food chains. The same processes that lead to the trapping of nutrients, and thereby to the productivity of the estuary, also lead to the trapping and concentrating of pollutants. Fine sediments not only retain phosphorous and other nutrients, but also petroleum and pesticide residues. Odum (1971) noted that estuarine sediments can concentrate DDT over 100,000 times higher than in the water of the estuary. Such pesticide residues enter the food chain via detritus-eating invertebrates and are further concentrated. The same features of water circulation in the estuary that concentrate nutrients also concentrate pollutants such as mercury and lead, heavy metals from sewage, industrial and pulp mill effluents. Estuarine food chains are extremely complex and sensitive to alterations in the physical and chemical range of stresses. Loss or disruption of one element can have a cascading effect on species presence and productivity.

*Introduction of exotic species* has the potential to change species composition and food web dynamics. See the section on "Introduction and Spread of Non native Species" for further detail.

**Conservation Measures for Estuarine Alteration** - Following are the types of measures that can be undertaken by the action agency on a site-specific basis to conserve salmon habitat in areas that have the potential to be affected by estuarine alteration. Not all of these suggested measures are necessarily applicable to any one project or activity that may adversely affect salmon EFH. More specific or different measures based on the best and most current scientific information may be developed prior to, or during, the EFH consultation process and communicated to the appropriate agency. The options represent a short menu of general types of conservation actions that can contribute to the restoration and maintenance of properly functioning salmon habitat. The following suggested measures are adapted from NMFS (1997), NMFS (1997d), Lockwood (1990), and Meyer, (1997 pers. comm.).

In addition to the relevant conservation measures listed for “Dredging and Dredged Spoil Disposal”, “Irrigation Water Withdrawal, Storage, and Management,” “Bank Stabilization, Wastewater/Pollutant Discharge”, “Artificial Propagation of Fish and Shellfish”, “Offshore Oil and Gas Exploration, Drilling and Transportation”, and the “Introduction and Spread of Nonnative Species”, the following are suggested to minimize potential adverse effects of estuarine alteration activities.

- Minimize alteration of estuarine habitat in areas of salmon EFH, including eelgrass beds, tidal channels, and estuarine and tidally-influenced marshes. Minimize effects through appropriate site design, engineering, best management practices, and mitigate all nonavoidable adverse effects (See EPA 1993, Metro 1997, SCS Engineers 1989).
- Utilize best management practices for controlling pollution from marina operations, boatyards, and fueling facilities.
- Determine cumulative effects of a past and current estuarine alterations on salmon EFH before additional estuarine alteration occurs.
- Design appropriate restoration and mitigation performance objectives for properly functioning conditions and values of EFH and monitor achievement of these objectives.
- Utilize the placement of woody debris as a part of marsh and estuary enhancement and mitigation work; avoid scavenging logs from estuarine areas; re-position, rather than remove, logs that are hazardous to navigation within river or estuary; and maximize removal of dikes where possible.
- Promote awareness and use of the U.S. Department of Agriculture’s (USDA’s) Wetland Reserve Program to encourage restoration of estuarine habitat.
- Maximize maintenance of freshwater inflow to estuaries.
- Design culvert replacements and repairs in EFH to increase fish passage for both adult and juvenile fish.

### 3.2.5.9 Forestry

Forest practices can affect salmon habitat. Among the most important effects of forest management on fish habitat in western North America have been changes in the distribution and abundance of large woody debris in streams (Hicks *et al.* 1991). Timber harvest has reduced the amount and size of large woody debris compared to that in nonharvested areas (Ralph *et al.* 1994). Large woody debris in streams is a fundamental building block for creating and maintaining salmon habitat. Physical processes associated with debris in streams includes the formation of pools (important to both juvenile and adult salmon) and other important rearing areas, control of sediment and organic matter storage, and modification of water quality. Biological properties of debris-created structures can include blockages to fish migration, protection from predators and high streamflow, and maintenance of organic matter processing sites within the benthic community (Bisson *et al.* 1987).

Site disturbance and road construction typically increase sediment delivered to streams through mass wasting and surface erosion (Spence *et al.* 1996). This can elevate the level of fine sediments in spawning gravels and fill substrate interstices that provide habitat for aquatic invertebrates. Fine sediment (usually <0.8 mm diameter) is detrimental to embryo survival, because it reduces substrate permeability (Murphy 1995). The relative magnitude of forest practices on sediment delivery depends on factors such as soil type, topography, climate, vegetation, the aerial extent of the disturbance, the proximity of forestry activities to the stream channel, and the integrity of the riparian zone (Spence *et al.* 1996). Poor road location, construction, and maintenance, as well as inadequate culverts result in forest roads contributing more sediment to nearby streams than any other forest activity. On a per-unit basis, mass wasting events associated with forest roads produce 26-34 times the volume of sediment as undisturbed forests (Furniss *et al.* 1991).

The removal of riparian canopy reduces shading and increases the amount of solar radiation reaching the streams. The result is higher maximum stream temperatures and increased daily stream temperature

fluctuations (Beschta *et al.* 1987; Beschta *et al.* 1995). Even small increases in temperature (1-2° C) can result in shifts in the timing of life history events such as spawning and incubation. The cumulative effects of stream temperature changes downstream of logged areas are not well documented.

Fertilizers, herbicides, and insecticides are commonly used in forestry operations to prepare sites for planting, to allow conifers to out compete with other vegetation and to control diseases and pests. In addition, fire retardants are used to halt the spread of wildfires. These chemicals or their carriers that reach surface waters can be toxic to salmon directly or may alter the primary and secondary production of a stream, influencing the amount and type of food available to salmon (Spence *et al.* 1996). Risks associated with these compounds depend on the form and application rate of the chemicals, the method of application, whether buffers are maintained, the soil type, weather conditions during and after application, and the persistence of the chemicals in the environment.

**Conservation Measures for Forestry** - Each watershed and each stream reach has a unique set of defining geologic, biological, topographic, and other characteristics. An evaluation of effective riparian zone dimensions (for buffering temperature and pollutants, provision of organic debris, and the other elements of healthy EFH) should generate riparian management zones of appropriate width for each stream reach. Mitigation of impacts of forest management activities on salmonid EFH has improved in recent decades. On many federal forests, riparian buffer areas now extend up to 300 feet on fish bearing streams. Land-owners have also become more active in fish restoration and conservation work at the watershed level. Some of this work is being undertaken through watershed groups seeking to restore salmon runs. These watershed groups are composed of the fishing industry, conservation groups, timber industry, state, federal and local government, and other stakeholders.

Following are the types of activities that can be undertaken by the action agency on a site-specific basis to conserve salmon habitat to protect and enhance EFH adjacent to forest lands that have the potential to be affected by forestry related activities. Not all of these suggested measures are necessarily applicable to any one project or activity that may adversely affect salmon EFH. More specific or different measures based on the best and most current scientific information may be developed prior to, or during, the EFH consultation process and communicated to the appropriate agency. The options represent a short menu of general types of conservation actions that can contribute to the restoration and maintenance of properly functioning salmon habitat. The following suggested measures are adapted from Murphy (1995).

- Establish riparian management zones and avoid forestry activities in zones of old growth and late successional forests. Use limited harvest, thinning, planting, or other management in second-growth forests in order to facilitate recovery and protection of the key functions identified through watershed analyses.
- Utilize appropriate buffer strips (e.g., riparian trees and shrubs, grass filter strips, etc.) as a management option to protect and enhance salmon freshwater EFH.
- As part of forestry planning, analyze the cumulative effects of past and current forestry management activities on EFH as indicated in watershed analyses.
- Determine harvest suitability methods based on risk assessment for site-specific conditions (e.g., unstable slopes, erodible soils). Avoid harvest and road building activities on sites that have a high potential for landslides and on sites that can contribute large woody debris to streams directly or through landslides and debris flows. Plan timber harvest, road construction, and site preparation activities for the dry season or on snow to minimize erosion. Design ground-based logging operations to minimize total area subject to compaction by skid trails.
- Apply chemicals by following forestry best management practices (EPA 1993) for ensuring federal and state water quality, including practices designed to avoid drift of chemical sprays, pollution from the cleaning of equipment used in spraying or fueling activities, and erosion.
- Avoid reliance on in-channel manipulation until problems in riparian and upland habitats that caused the habitat to be degraded have been addressed by controlling erosion, stabilizing or obliterating roads,

upgrading culverts for fish passage, and restoring native vegetative communities. Use silvicultural treatments which minimize stream disturbance.

### 3.2.5.10 Grazing

Livestock grazing represents the second most dominant land use in the Pacific Northwest (after timber production), occupying about 41% of the total land base. An aspect of grazing is the impact it imparts on riparian ecosystems.<sup>1/</sup>

Riparian areas provide a critical link between aquatic and terrestrial ecosystems. Sustained grazing of these areas can affect substantially fish and aquatic habitats. The riparian zone contributes over 90% of the plant detritus which supports the entire aquatic biological food chain in upper tributaries (Cummins and Spengler 1974). Even in larger downstream waters, the riparian zone provides over half (54%) of the organic matter ingested by fish (Berner in Kennedy 1977). Management efforts to enhance the riparian zone for one species will generally have positive impacts on many other organisms within this biotype.

The quality and persistence of the riparian zone is a function of its fragility. A large body of research and monitoring indicates that overgrazing by domestic livestock has damaged riparian and stream ecosystems (Armour *et al.* 1994, Mosely 1997) resulting in decreased production of salmonids (Platts 1991).

Impacts to the riparian zone vary. Livestock grazing can affect the riparian environment by changing, reducing, or eliminating vegetation and actually eliminating riparian areas through channel widening, channel aggrading, or lowering of the watertable (Platts 1991). Soil compaction by trampling can result in a reduction in water infiltration by 40-90% (Rauzi and Hanson 1966, Berwick 1976). Streams modified by improper livestock grazing are also wider and shallower than normal (Duff 1983) leading to pool loss by elevating sediment delivery (MacDonald and Ritland 1989). In addition, removal of riparian vegetation along rangeland streams can result in increased solar radiation and thus increased summer temperatures (Li *et al.* 1994). Livestock presence in the riparian zone can affect bank stability (Beschta *et al.* 1993), increase sediment transport rates by increasing both surface erosion and mass wasting (Marcus *et al.* 1990), and shift vegetative growth to less productive, often exotic plants when Kentucky bluegrass, timothy, and orchard grass replace the native sedges, rye and bunch grasses. Streamside shrubs and trees are also eliminated as the sprouts are browsed by livestock. Regeneration is prevented and the even-aged stands of aspen, willow, cottonwood, and associates eventually age, die, and disappear (Berwick 1978).

Finally, a major grazing-related historical impact to riparian functions has been (and remains) the clearing of hundreds of thousands of acres of riparian bottoms of willow, mountain maple, cottonwood, and other vegetation which sequestered, pumped, and transpired enormous amounts of water. Ranchers convert meadows to hay pastures of introduced timothy, orchard grass, and clover harvested for winter forage throughout the west, often in close functional relationship to salmonid EFH.

**Conservation Measures for Grazing** - Grazing management is key to attaining the benefits which a productive riparian offers livestock while maintaining water quality standards and fully functioning riparian ecosystems (Mosely *et al.* 1997). Vegetation in riparian areas responds relatively quickly to changes in grazing management and can usually be restored (Platts 1991). Progressive stockmen and land managers have demonstrated there are no insurmountable technological barriers to restoring and protecting the long-term productivity of western riparian areas and adjacent lands (Chancy *et al.* 1993).

There is great potential for livestock management in the terrestrial and riparian areas of western watersheds to conserve and enhance EFH. Some grazing systems have achieved dramatic successes and others show promise. This is a significant departure from the historically common season-long grazing of summer range riparian zones which resulted in many of the impacts discussed above. Particularly promising are variants

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1/ Riparian ecosystems can best be defined as ". . . those assemblages of plant, animal, and aquatic communities whose presence can be either directly or indirectly attributed to factors that are stream-induced or related" (Kauffman 1982).

of rest-rotation grazing systems. In Idaho, Hayes (1978) found improved forage species composition (i.e., toward pristine deep-rooted perennial climax plants) and a reduction of 65% in bank sloughing with such a system. His data indicate few to no riparian impacts when forage utilization is kept to less than 25%. Bryant (1985 pers. comm.) found that a low/moderate riparian grazing rate promoted more productive, diverse and stable aquatic and riparian systems in the Starkey experimental forest of northeast Oregon. Claire and Storch (in Kauffman 1984) found a rest-rotation system the preferred streamside management if rest is given a pasture for one of every three years. A four-pasture system with summer rest two out of three years increased riparian browse from 78 to 2,616 plants/ha within two years (Davis 1982). Simulated grazing (clippings) after one August had no measurable effects on production or species composition in Wyoming wet meadows (Pond 1961). Late season riparian grazing systems can often increase livestock production, plant vigor and productivity, and minimize wildlife disturbance (Pond 1961, Kauffman 1982). Winter grazing, which considers winter game range use, can effect the same benefits to livestock. Management of stocking rates to reduce damage to wet soils and insure carbohydrate stores for spring growth and vigor is important in these cases (Heady and Child 1994). The above discussion does not address concentrated grazing from dairy cattle which are nowhere near the extent of beef cattle grazing east of the Cascades.

A review of attempts to devise appropriate grazing regimes illustrates the site-specific nature of any conservation measure which would presume to be useful. For grazing systems, it has been repeatedly demonstrated that one size does not fit all. The peculiar mix of browse and herbaceous vegetation, warm and cool season grasses, and site factors, dictate local solutions. At each extreme of the grazing spectrum, it has been found that some sites can benefit from continuous grazing at reduced levels while others need rest. An empirically observed rule of thumb which has been supported by numerous studies (including some cited above) is that consumption of annual growth of woody and herbaceous forage on healthy ranges should be held under 50-60% to provide the nutrients required for initiating new seasonal growth and prevent range degradation (Hedrick 1950, Valentine 1970 in Heady and Child 1994).

Following are the types of measures that can be undertaken by the action agency on a site-specific basis to conserve salmon EFH in rangeland area streams and rivers. Lotic systems are intimately associated with their adjacent riparian zones and can be affected by grazing activity or potential grazing-related impact. Not all of these suggested measures are necessarily applicable to any one project or activity that may adversely affect salmon EFH. More specific or different measures based on the best and most current scientific information may be developed prior to, or during, the EFH consultation process, and communicated to the appropriate agency. The options represent a short menu of general types of conservation actions that can contribute to the restoration and maintenance of properly functioning salmon habitat.

- Minimize livestock access to stream reaches containing salmon redds during spawning and incubation periods (McCullough and Espinosa 1996) by utilizing grazing and vegetation management schemes that promote grazing in other areas and by locating water facilities away from the stream channel and riparian zone wherever feasible.
- Utilize special monitoring, management, and grazing regimes or mitigation activities that allow recovery of degraded areas and maintain streams, wetlands, and riparian areas in properly functioning condition.
- Utilize upland grazing management that minimizes surface erosion and disruption of hydrologic processes. Where range is not in properly functioning condition, forage species composition is altered, productivity reduced, and trends are down, select demonstrably restorative grazing regimes or minimize grazing activity until vegetation has recovered. Once conditions have improved, adjust the grazing strategies to account for all herbivory (e.g., including wildlife) at proper use levels to minimize deterioration of range conditions in the future (Spence *et al.* 1996).
- Determine cumulative effects of past and current grazing operations on EFH when designing grazing management strategies.
- Minimize application of chemical treatments within the riparian management zone.

- Utilize innovative grazing practices such as variants of rest-rotation grazing systems, late season riparian grazing systems, winter grazing and management of stocking rates (Heady and Child 1994, Bryant 1985, Davis 1982, Claire and Storch in Kauffman 1982, Hayes 1978, Valentine 1970, and Hedrick in Heady and Child 1994, Pond 1961).

### 3.2.5.11 Habitat Restoration Projects

Although intended to help restore salmon habitat or habitat for other organisms, habitat restoration activities can be detrimental to salmon and their habitats. Inadequate, and often absent, analyses of habitat deficiencies and their causes can result in ineffective restoration efforts or habitat injury (Gregory and Bisson 1997, Kauffman *et al.* 1997, Roper *et al.* 1997). This should not discourage efforts to restore functional aquatic and riparian ecosystems, but efforts should be part of a watershed or basin conservation plan, carefully monitored and evaluated, and revised accordingly. Efforts should initially identify and eliminate the causes of habitat impairment and only then consider active restoration techniques to accelerate habitat recovery (Bisson *et al.* 1997, Lawson 1997).

If restoration efforts are not undertaken with an understanding of the conditions in the watershed, not only may they be unsuccessful, but they may also create additional problems. For example, while stabilizing an eroding bank may improve local water quality, the same treatment may deflect water flow and create erosion elsewhere, thereby decreasing streambank cover, and constricting the natural dynamics of stream channels.

Additionally, habitat restoration activities can be based solely on the needs of an individual species, without consideration of the immediate ecosystem. A single species focus is a concern if the habitat improvement project is designed solely to enhance a particular species, life history stage, or life history pattern. While perhaps being successful in the short term for the limited purpose for which the restoration project was intended, the addition of structure to a channel for specific habitat components in some instances may actually be counterproductive to restoring total ecological functions (Beschta 1997)

**Conservation Measures for Habitat Restoration Projects** - Various documents are available to help those involved in habitat restoration efforts. For example EPA has produced a watershed assessment primer (EPA 1994a) and the various impact management techniques to be used for habitat protection and restoration approaches used in the region are described by the BPA in their watershed management program (BPA 1997). The California salmonid stream habitat restoration manual (CDFG 1994) provides guidance and forms for assessment, monitoring, and restoration work. Other habitat restoration guidance documents dealing with everything from in-stream projects to road maintenance and beaver management have been briefly summarized. Ordering information for the above is provided by "For The Sake of the Salmon" (FSOS 1998). Each state's fish and wildlife's habitat division also has information and guidance on habitat restoration activities, including the permits needed, as well as specifications as to when in-stream work is allowed in the various systems.

Following are the types of measures that can be undertaken by the action agency on a site-specific basis to conserve salmon EFH and that have the potential to be affected by habitat restoration activities. Not all of these suggested measures are necessarily applicable to any one project or activity that may adversely affect salmon EFH. More specific or different measures based on the best and most current scientific information may be developed prior to, or during, the EFH consultation process and communicated to the appropriate agency. The options represent a short menu of general types of conservation actions that can contribute to the restoration and maintenance of properly functioning salmon habitat. The following suggested measures are adapted from Bisson *et al.* (1997) and Gregory and Bisson (1997).

- Protect a watershed's habitat-forming processes (e.g., riparian community succession, bedload transport, runoff pattern) that maintain the biophysical structure and function of aquatic ecosystems.
- Develop and conduct habitat restoration activities based on a watershed-scale analysis and conservation plan, and where practicable, a sub-basin or basin-scale analysis and plan with restoration of habitat-forming processes as the primary goal.
- Monitor and evaluate all habitat restoration activities for sustained biophysical process and function.

### 3.2.5.12 Irrigation Water Withdrawal, Storage, and Management

Water is diverted from lakes, streams, and rivers for irrigation, power generation, industrial use, and municipal use. Additionally, water is withdrawn from the ocean by offshore water intake structures in California. Ocean water may be withdrawn for providing sources of cooling water for coastal power generating stations or as a source of potential drinking water as in the case of desalinization plants.

In general, potential effects of freshwater system irrigation withdrawals on salmonid EFH include physical diversion and injury to salmon (see below), as well as impediments to migration, changes in sediment and large woody debris transport and storage, altered flow and temperature regimes, and water level fluctuations. In addition, fish and other aquatic organisms may be affected by the reduced dilution of pollutants in rivers and streams where substantial volumes of water are withdrawn. Alterations in physical and chemical attributes in turn affect many biological components of aquatic systems including riparian vegetation as well as composition, abundance, and distribution of macroinvertebrates and fish (Spence *et al.* 1996). In addition, the volume of fresh water diverted for agriculture can be substantial and can affect both the total volume of water available to salmon as well as the seasonal distribution of flow.

Returned irrigation water to a stream, lake, or estuary project can substantially alter and degrade the habitat (NRC 1989). Generally problems associated with return flows of surface water from irrigation projects include increased water temperature, salinity, pathogens, decreased dissolved oxygen, increased toxicant concentrations from pesticides and fertilizers, and increased sedimentation (NPPC 1986).

Water impoundments can result in raised or lowered summer temperatures and increases in fall and winter temperatures. Increases in fall and winter temperatures can accelerate embryonic development of salmonid emergence, harming their chances of survival. Low dissolved oxygen can also be a problem in irrigation impoundments that have been drawn down, as is freezing which inhibits light penetration and photosynthesis (Ploskey 1983, Guenther and Hubert 1993). Elevated fall water temperatures from impoundments can also result in disease outbreaks in adult salmon that cause high prespawning mortality (Spence *et al.* 1996).

Irrigation withdrawals and impoundments also change sediment transport and storage. Siltation and turbidity in streams generally increase as a result of increased irrigation withdrawals, because of high sediment loads in return waters (Spence *et al.* 1996). In some systems, sediments may accumulate in downstream reaches covering spawning gravels and filling in pools that chinook salmon use for rearing (Spence *et al.* 1996). In other systems, water withdrawals and storage reservoirs can lead to improved water clarity, because they trap sediment. This can lead to aggradation of the stream channel as the capacity of the stream to transport sediment is reduced. The settling of gravel sediments behind impoundments and the reduced sediment transport capacity can cause downstream reaches to become sediment starved. This results in loss of high quality spawning areas as substrate becomes dominated by cobble and other large fractions not suitable for spawning (Spence *et al.* 1996).

Water diversions and impoundments also can change the quantity and timing of streamflow. Changes in flow quantity alters stream velocity which affects the composition and abundance of both insect and fish populations (Spence *et al.* 1996). Changed flow velocities may also delay downstream migration of salmon smolts and result in salmon mortality (Spence *et al.* 1996). Low flows can concentrate fish, rendering juveniles more vulnerable to predation (PFMC 1988).

Water level fluctuations from impoundment releases/storage can de-water eggs, strand juveniles (PFMC 1988), and, by eliminating aquatic plants along stream bank margins and shorelines, decrease fish cover and food supply (Spence *et al.* 1996).

The physical means of withdrawing water may adversely affect salmon. For major irrigation withdrawals, water is either stored in impoundments or diverted directly from the river channel at pumping facilities. Individual irrigators commonly construct smaller "push-up" dams from soil and rock within the stream channel, to divert water into irrigation ditches or to create small storage ponds from which water is pumped. In addition, pumps may be submerged directly into rivers and streams to withdraw water. Effects of these irrigation withdrawals and impoundments on aquatic systems include creating impediments or blockages to migration

(for both adults and juveniles), diverting juveniles into irrigation ditches or damage to juveniles as a result of impingement on poorly designed fish exclusion screens (Spence *et al.* 1996).

Groundwater pumping for irrigation, while providing an alternative to surface water diversion, also can cause a reduction in surface flows, especially summer flows which can be derived from groundwater discharges (Spence *et al.* 1996).

**Conservation Measures for Irrigation Water Withdrawal, Storage, and Management** - Water conservation is one of the most promising sources to meet new and expanding needs for additional water (Gillilan and Brown 1997). For example, Washington State's Water Resources Management Trust Water Rights Program, started in 1991, provides a means of enhancing instream flows using water saved through conservation. Participants in the instream flow protection processes in the states of Washington, Idaho, Oregon, and California include:

California      The state's most potent instream flow protection is a result of administrative activities of the State Water Resources Control Board, which is required to consider the comments of CDFG when making decisions about appropriation and transfer permits. Since 1991, individuals have been authorized to change the purpose of existing rights to instream purposes. Private individuals and organizations have also taken advantage of the opportunity to initiate public trust proceedings.

Idaho             Only the Idaho Water Resources Board is allowed to apply to the Department of Water Resources for an instream water right. State statutes allow "the public" to petition the Board to apply for instream flow rights, but the Board has interpreted this language to mean that it may accept petitions only from state agencies. Applications approved by the Department of Water Resources must be submitted to the Idaho State Legislature for approval.

Oregon          Only the Oregon Water Resources Department may hold instream water rights. The Water Resource Department considers requests from ODFW, Environmental Quality, and Parks and Recreation agencies. Individuals may acquire existing rights and take responsibility for changing the use to instream purposes in an administrative hearing, but then must turn the right over to the Water Resources Department to be held in trust.

Washington     WDOE establishes minimum flows either at its own initiative or after request from the Department of Fisheries and Wildlife. Because minimum flows are established through administrative rule-making procedures, public notice and hearings are involved. Individuals may donate rights to the state and specify that they are to be used for instream purposes under the state's trust water rights program, which is administered by WDOE.

In 1996, the Bureau of Reclamation released policy guidance on the content of water conservation plans for water districts. Recommended water measures include (1) water management and accounting designed to measure and account for the water conveyed through the districts distribution system to water users; (2) a water pricing structure that encourages efficiency and improvements by water users; (3) an information and education program for users designed to promote increased efficiency of water use; and (4) a water conservation coordinator responsible for development and implementation of the water conservation plan (Bureau of Reclamation 1996).

Following are the types of measures that can be undertaken by the action agency on a site-specific basis to conserve salmon EFH in areas that have the potential to be affected by irrigation water withdrawal and storage. Not all of these suggested measures are necessarily applicable to any one project or activity that may adversely affect salmon EFH. More specific or different measures based on the best and most current scientific information may be developed prior to, or during, the EFH consultation process and communicated to the appropriate agency. The options represent a short menu of general types of conservation actions that can contribute to the restoration and maintenance of properly functioning salmon habitat. The following suggested measures are adapted from McCullough and Espinosa, Jr. (1996) and OCSRI (1997).

- Apply conservation and enhancement measures for dams (see dam section) to water management activities and facilities, where applicable.
- Establish adequate instream flow conditions for salmon by using, for example, the Instream Flow Incremental Methodology.
- Undertake efforts to purchase or lease, from willing sellers and lessors, water rights necessary to maintain instream flows in accordance with appropriate state and federal laws.
- Identify and use appropriate water conservation measures in accordance with state law.
- In accordance with state law, install totalizing flow meters at major diversion points. For water withdrawn from reservoirs, install gauges that identify the water surface elevation range from full reservoir elevation to dead pool storage elevation. Additionally, if the reservoir is located in-channel, install gauges upstream and downstream of the reservoir.
- Screen water diversions on all fish-bearing streams.
- Incorporate juvenile and adult salmon passage facilities on all water diversions.

### 3.2.5.13 Mineral Mining

The effects of mineral mining on salmon EFH depends on the type, extent, and location of the activities. Minerals are extracted by several methods. Surface mining involves suction dredging, hydraulic mining, panning, sluicing, strip mining, and open-pit mining (including heap leach mining). Underground mining utilizes tunnels or shafts to extract minerals by physical or chemical means. Surface mining probably has greater potential to affect aquatic ecosystems, though specific effects will depend on the extraction and processing methods and the degree of disturbance (Spence *et al.* 1996).

Water pollution by heavy metals and acid is also often associated with mineral mining operations, as ores rich in sulfides are commonly mined for gold, silver, copper, iron, zinc, and lead. When stormwater comes in contact with sulfide ores, sulfuric acid is commonly produced (West *et al.* 1995). Abandoned pit mines can also cause severe water pollution problems.

Mining activities can result in substantial increased sediment delivery, although this varies with the type of mining. While mining may not be as geographically pervasive as other sediment-producing activities, surface mining typically increases sediment delivery much more per unit of disturbed area than other activities because of the level of disruption of soils, topography, and vegetation. Erosion from surface mining and spoils may be one of the greatest threats to salmonid habitats in the western United States (Nelson *et al.* 1991).

Hydraulic mining for gold from streams, flood plains, and hillslopes occurred historically in California, Oregon, and Washington in areas affecting salmon EFH. Though hydraulic mining is not common today, past activities have left a legacy of altered stream channels, and abandoned sites and tailings piles can continue to cause serious sediment and chemical contamination problems (Spence *et al.* 1996).

Placer mining for gold and associated suction dredging continues to occur in watersheds supporting salmon. Recreational gold mining with such equipment as pans, motorized or nonmotorized sluice boxes, concentrators, rockerboxes, and dredges can locally disturb streambeds and associated habitat. Additionally, mining activities may involve the withdrawal of water from the stream channel. Commercial mining is likely to involve activities at a larger scale with much disturbance and movement of the channel involved (OWRRI 1995). In some cases, water may be completely diverted from the stream bed while gravel is processed.

Commercial operations may also involve road building, tailings disposal, and the leaching of extraction chemicals, all of which may create serious impacts to salmon EFH. Cyanide, sulfuric acid, arsenic, mercury, heavy metals, and reagents associated with such development are a threat to salmonid habitat. Improper or in-water disposal of tailings may cause toxicity to salmon or their prey downstream. On land placement of

tailings in unstable or landslide prone areas can cause large quantities of toxic compounds to be released into streams or to contaminate groundwater (NPFMC 1997). Indirectly, the sodium cyanide solution used in heap leach mining is contained in settling ponds from where they might contaminate groundwater and surface waters (Nelson *et al.* 1991).

Mineral mining can also alter the timing and routing of surface and subsurface flows. Surface mining can increase streamflow and storm runoff as a result of compaction of mine spoils, reduction of vegetated cover, and the loss of organic topsoil, all of which reduce infiltration. Increased flows may result in increased width and depth of the channel.

Mining and placement of gravel spoils in riparian areas can cause the loss of riparian vegetation and changes in heat exchange, leading to higher summer temperatures and lower winter stream temperatures (Spence *et al.* 1996). Bank instability can also lead to altered width-to-depth ratios, which further influences temperature (Spence *et al.* 1996).

**Conservation Measures for Mineral Mining** - State and federal law (i.e., the Clean Water and Surface Mining Control and Reclamation Acts) contain provisions for regulating mining discharges. State and local governments are taking an increasingly active role in controlling irresponsible mining operations (Nelson *et al.* 1991) and most western states require operators to draw up a mining plan that details potential environmental damage from that operation, and reclamation and performance bonds must be posted (Nelson *et al.* 1991). A challenge still lies in the reclamation of the thousands of abandoned sites that have or may potentially impact salmon EFH.

Following are the types of measures that can be undertaken by the action agency on a site-specific basis to conserve salmon EFH in areas that have the potential to be affected by mining related activities. Not all of these suggested measures are necessarily applicable to any one project or activity that may adversely affect salmon EFH. More specific or different measures based on the best and most current scientific information may be developed prior to, or during, the EFH consultation process and communicated to the appropriate agency. The options represent a short menu of general types of conservation actions that can contribute to the restoration and maintenance of properly functioning salmon habitat. The following suggested measures are adapted from recommendations in Spence *et al.* (1996), NMFS (1996), and WDFW (1998).

- Avoid mineral mining in waters, riparian areas, or flood plains of streams containing or influencing the salmon spawning and rearing habitats.
- Assess the cumulative effects of past and proposed mineral extraction activities and take these into account in planning for mining operations.
- Utilize an integrated environmental assessment, management, and monitoring package in accordance with state and federal law.
- Minimize spillage of dirt, fuel, oil, toxic materials, and other contaminants into the water and riparian areas. Monitor turbidity during operations. Prepare a spill prevention plan and maintain spill containment and water repellent/oil absorbent clean-up materials on hand.
- Treat wastewater (acid neutralization, sulfide precipitation, reverse osmosis, electrochemical, or biological treatments) and recycle on site to minimize discharge to streams. Test wastewater before discharge for compliance with the federal and state clean water standards.
- Minimize mine-generated sediments from entering or affecting EFH. Minimize the aerial extent of ground disturbance (e.g., through phasing of operations), and stabilize disturbed lands to reduce erosion. Employ methods such as contouring, mulching, and construction of settling ponds to control sediment transport.
- Reclaim, rather than bury, mine waste that contains heavy metals, acid materials, or other toxic compounds if leachate can enter EFH through groundwater.

- Restore natural contours and plant native vegetation on site after use to restore habitat function to the extent practicable.

#### 3.2.5.14 Introduction/Spread of Nonnative Species

Introduction of nonnative plant and animal species may be either deliberate (to enhance sport-fishing or control aquatic weeds, for example) or accidental without thought to the consequences (e.g., the dumping of live bait-fish and the seaweeds in which they are packed, aquaculture escapees, the pumping of bilge or ballast water, or releases from aquariums by individuals). Although the impacts are poorly known, the introduction or spread of nonnative species into areas of salmon EFH can potentially alter habitat process and function. Introduced fish can dominate or displace native fish through various mechanisms including competition, predation, inhibition of reproduction, environmental modification, transfer of new parasites, or diseases and hybridization (Spence *et al.* 1996).

In the Columbia Basin, introduced predator species including walleye, channel catfish, and small mouth bass have high predation rates on outmigrating salmon smolts. Boyd (1994) reports that the presence of striped bass in a river system near California's San Francisco Bay region resulted in estimated losses of 11% to 28% of native run of fall chinook. White bass and northern pike introduced into the inland delta of the Sacramento and San Joaquin rivers prey on salmon and other species (Cohen 1997). In Oregon's coastal lakes and reservoirs, introduced fish species such as striped bass, largemouth bass, small mouth bass, crappie, bullheads and yellow perch have become established with obvious predation impacts in some basins and negligible impacts in others. Foreexample, nonendemic Umpqua squawfish are voracious predators of juvenile salmonids in Oregon's Rogue River Basin (Satterwaithe 1998, pers. comm.) and the Coos and Umpqua estuaries contain striped bass that prey on salmonids (OSCRI 1997). Introduced grass carp and common carp can destroy beds of aquatic plants which results in concomitant reductions in cover for juvenile fishes, destruction of substrates supporting diverse invertebrate food chain assemblages, and increases in turbidity (Spence *et al.* 1996).

Many typical warmwater species from other regions, such as small mouth bass, carp, and catfish have been introduced as exotics to the Snake River basin. Displacement of salmonids and other cold water species by native coolwater species (e.g., reddsides shiners) or by the exotic warmwater species results in a reduced total usable habitat area for spawning and rearing, and thereby a diminished production capability for salmon (McCullough *et al.* 1996).

The introduction of organisms other than fish is also of great concern in estuarine environments. The food webs of San Francisco Bay have been dramatically altered by this invasion, more recently by the arrival of an Asian clam which has multiplied to such abundance that it can filter all the water over a significant portion of the bay in less than a day, removing bacteria, phytoplankton, and zooplankton in the process and leaving little behind for other organisms (The Resources Agency of California [RAC] 1997).

Introduced plants can also have serious detrimental effects on salmon habitat. The exotic aquatic plant, egeria (*Egeria densa*) is known to harm coho rearing in coastal lakes (OCSRI 1997). The spread in estuaries of various species of cordgrass (*Spartina* spp.) and another grass, the common reed (*Phragmites australis*), are of concern. *Spartina* spp. may affect salmon habitat in a number of ways, many of which appear to be detrimental to salmon and their prey. *Spartina* forms dense uniform stands in the upper intertidal area, traps sediment and raises the elevation of the mudflat. The macroinvertebrate population in areas dominated by *Spartina alterniflora* is somewhat different than that in mudflat areas. Nonnative plant invasions may decrease food for some species such as chum salmon that feed on the mudflats, while it may increase resources for chinook salmon that feed on invertebrates in the water column or on the surface, though the interactions are complicated and are still being studied (Luiting *et al.* 1997).

Other effects from *Spartina* invasion (as well as from *Phragmites*) results from the meadows being a good filter of nutrients and sediment washing off the land. While this may be beneficial in terms of reducing pollution, it can also have negative effects by raising the elevation of the high intertidal area and sequestering nutrients from the estuarine system.

Efforts to control *Spartina* and other exotics may cause additional affects to salmon and their habitat. Long term impacts of either the use of mechanical mowing measures or of the use of herbicides (e.g., Rodeo®) and various surfactants have not been well studied. Concerns exist on both the acute and sublethal toxicity to nontarget species and the potential for bio accumulation. These chemicals are known to adsorb to sediments under certain conditions and some of the surfactants are known to be estrogen disrupters in fish (Felsot 1997). The use of biological control agents is also under study.

Many of the region's riparian habitats have also been extensively altered by invasive species (e.g., blackberries, reed canary grass, and scotch broom), deterring the establishment of native species, and altering the habitat (e.g., shading, stream bank stability) and the nutrient cycling characteristics of the area. The effects of these changes are not fully known.

**Conservation Measures for Introduction/Spread of Nonnative Species** - Watershed management strategies for enhancement and conservation of salmon EFH in many instances will include restoration of water flows and riparian areas, as well as other habitat conditions. These measures should discourage nonnative species from establishing or expanding their territories (i.e., colder water will favor salmonids over centrarchids).

Following are the types of measures that can be undertaken by the action agency on a site-specific basis to conserve salmon EFH in areas that have the potential to be affected by the introduction of nonnative or nonendemic species. Not all of these suggested measures are necessarily applicable to any one project or activity that may adversely affect salmon EFH. More specific or different measures based on the best and most current scientific information may be developed prior to, or during, the EFH consultation process, and communicated to the appropriate agency. The options represent a short menu of general types of conservation actions that can contribute to the restoration and maintenance of properly functioning salmon habitat. The following suggested measures are adapted from Cohen (1997).

- Provide public awareness materials on the potential impacts resulting from the release of nonnative organisms into the natural environment.
- For the commercial import of plants and animals for aquarium and ornamental plant trades, import those organisms that have been evaluated and determined to be safe for importing.
- Avoid ballast water exchange in nearshore coastal waters. Use shore-based ballast water treatment systems and ship-board ballast treatment systems as alternatives.
- Use native organisms for aquaculture and mariculture operations whenever possible.
- Develop appropriate eradication methods for nonnative plant species and nonnative predatory species.

### **3.2.5.15 Offshore Oil and Gas Exploration, Drilling, and Transportation**

Oil is extracted from offshore platforms in southern California and large amounts of Alaskan crude oil also enter the region on Alaskan tankers bound for refineries. These nearshore oil and gas related activities have the potential to pollute salmon EFH and harm prey resources. Oil exploration/production areas are vulnerable to an assortment of physical, chemical, and biological disturbances resulting from activities used to locate oil and gas deposits such as high energy seismic surveys to actual physical disruptions from anchors, chains, drilling templates, dredging, pipes, platform legs, and the platform jacket. During actual operations, chemical contaminants may also be released into the aquatic environment (NMFS 1997b). Physical alterations in the quality and quantity of local habitats may also occur during the construction and operation of shore-side facilities, tanker terminals, pipelines, and the tankering of oil. These activities may be of concern if they occurred in habitats of special biological importance to salmon stocks or their prey (NPFMC 1997).

Accidents and spills during transport and during oil transfer from ships or pipelines to refineries are the greatest potential threats to salmon EFH. They are likely to affect shallow nearshore areas or sensitive habitats such tidal flats, kelp beds, estuaries, river mouths, and streams.

Although oil is toxic to all marine organisms at high concentrations (parts per million), certain species are more sensitive than others. The type, volume, and properties of the spilled oil (environmental variables such as water density, wave height, currents, wind speed, etc.) and the type of response effort all affect the potential risk to salmon EFH. Oil spills in marine waters probably affect salmon more through their effects on salmon food organisms than on the salmon themselves, because juvenile and adult fish generally are able to avoid oil slicks in open seas. However, if an oil spill reached nearshore areas with productive nursery grounds, such as an estuary, or if a spill occurred at a location where fish were concentrated, a year's production of smolts could be lost (NPFMC 1997).

Injuries to fish and their prey in the surface slick results from both physical coating by oil as well as to the toxicity of the petroleum hydrocarbons and other compounds in the oil. Many low molecular weight aromatic hydrocarbons are soluble in water, increasing the potential for exposure to aquatic resources. Adult fish tolerate much higher concentrations of petroleum hydrocarbons than eggs and larvae. Sublethal effects of oil typically manifested in adult fish are primarily physiological and affect feeding, migration, reproduction, swimming activity, and schooling behaviors (Kennish 1997, Strickland and Chasan 1993).

Clean-up activities for oil residues on beaches, rocky shorelines or sea surface sometimes involve physical or chemical methods such as high pressure hoses, steam, or dispersants. These activities may be more hazardous to plants and animals than the oil itself and may also adversely affect salmon habitat.

Dispersants are also sometimes used to emulsify oil (i.e., reduce the water-oil interfacial tension) so that it can enter the water column rather than remaining on the surface. While reducing the adverse effects on the shoreline, birds, and marine mammals, the dispersants may be toxic themselves to marine organisms and plants as well as make the oil itself more available for uptake by marine organisms and hence more toxic (Falco 1992).

Degradation byproducts of petroleum hydrocarbons have high acute toxicities to fish. Studies of bivalve tissue from beaches heavily oiled by the *Exxon Valdez* incident showed that a complex assemblage of intermediate hydrocarbon oxidation byproducts were bioavailable for uptake in marine organisms for several years post-spill. Thus, oxidation byproducts may be an additional source of chronic exposure and effects on fish populations (NOAA 1996).

**Conservation Measures for Offshore Oil and Gas Exploration, Drilling, and Transportation** - Following are the types of measures that can be undertaken by the action agency on a site-specific basis to conserve salmon EFH in nearshore and estuarine regions that have the potential to be affected by transportation and onshore support activities associated with oil and gas exploration, drilling, and production. Not all of these suggested measures are necessarily applicable to any one project or activity that may adversely affect salmon EFH. More specific or different measures based on the best and most current scientific information may be developed prior to, or during, the EFH consultation process and communicated to the appropriate agency. The options listed below represent a short menu of general types of conservation actions that can contribute to the protection and restoration of properly functioning salmon habitat. The following suggested measures are adapted from Cameron (1998 pers. comm.), Lollock (1998 pers. comm.), and Logan (1998 pers. comm.).

- Monitor and enforce double hull standards for all oil tankers doing business in U.S. waters, as well as other pollution prevention measures of the Oil Pollution Act of 1990.
- Utilize adequate spill prevention measures such as tug escorts, speed limits, the use of marine pilots, vessel traffic systems, designated areas to be avoided, traffic separation schemes, rescue/salvage tugs, and compliance with international, national, and state spill prevention standards.
- Utilize the agreement between the ten major oil company members of the Western States Petroleum Association as a catalyst to involve other oil carriers and maximize routing of tankers carrying Alaskan North Slope crude to California ports at least 50 miles seaward of the Pacific coast while transiting the coastline after leaving Prince William Sound.

- Route dry cargo vessels and other vessels carrying significant quantities of oil or hazardous cargo at least 50 miles seaward of the Pacific coast while transiting the coast.
- Avoid national marine sanctuaries and areas designated as areas to be avoided and support efforts to re-evaluate and strengthen precautionary and readiness measures in national marine sanctuaries.
- Apply vessel maintenance, inspection programs, and crew training programs, required for oil tank vessels to dry cargo and other vessels carrying significant quantities of oil.
- Monitor and report water and sediment quality around all oil extraction, bunkering, or transfer facilities, and gather other baseline information to assure better natural resource damage assessments after spill events.

### 3.2.5.16 Road Building and Maintenance

Roads may affect groundwater and surface water by intercepting and re-routing water that might otherwise drain to springs and streams. This increases the density of drainage channels within a watershed and results in water being routed more quickly into the streams (NRC 1996, Spence *et al.* 1996). Altering the connection between surface and groundwater can affect water temperatures, instream flows, and nutrient availability. These factors can affect egg development, the timing of fry emergence, fry survival, aquatic diversity, and salmon growth (NRC 1996).

In urban areas, extensive road and pavement can effectively double the frequency of hydrologic events that are capable of mobilizing stream substrates (NRC 1996) (also see Construction/Urbanization section). This increased scour of gravel and cobble in areas where salmon eggs, alevins, or fry reside can kill salmon directly or indirectly increase mortality by carrying them downstream and away from stream cover.

Urban roads can be a major source of sediment input during construction as can the installation of bridges, culverts, and diversions with coffer dams. However, these project impacts seem to be more temporary and less pervasive on sediment input than forest roads (Waters 1995).

In small forested watersheds, streamflow appears to be directly related to the total area of the watershed composed of roads and other heavily compacted surfaces. In larger watersheds, where roads and impermeable areas represent a relatively small area of the basin, little or no effect is seen (Adams and Ringer 1994). Altered hydrology was noted when roads covered 4% or more of a drainage area (King and Tennyson 1984).

Road culverts can block both adult and juvenile salmon migrations. Blockage can result from the culvert becoming perched above stream bed level, lack of pools that could allow salmon to reach the culvert, or from high water flow velocities in the culvert.

The effect of logging roads on erosion and sedimentation has been well studied. Furniss *et al.* (1991) concluded that forest roads contribute more sediment than all other forest activities combined on a per-unit basis. Road surfaces can break down with repeated heavy wheel loads of hauling trucks, particularly under wet conditions, resulting in a continual source of fine sediment input (Murphy 1995). However, improvements in road-construction and logging methods can reduce erosion rates (NRC 1996). For additional detail, see the "Forestry" section of this document.

**Conservation Measures for Road Building and Maintenance** - Following are the types of measures that can be undertaken by the action agency on a site-specific basis to conserve salmon EFH habitat in areas that have the potential to be affected by road building and maintenance activities. Not all of these suggested measures are necessarily applicable to any one project or activity that may adversely affect salmon EFH. More specific or different measures based on the best and most current scientific information may be developed prior to, or during, the EFH consultation process and communicated to the appropriate agency. The options represent a short menu of general types of conservation actions that can contribute to the protection and restoration of properly functioning salmon habitat. The following suggested measures are adapted from Murphy (1995), Mirati (1998), ODFW (1989), and NMFS (1996b).

- Revegetate cut banks, road fills, bare shoulders, disturbed streambanks, etc. after construction to prevent erosion. Check and maintain sediment control and retention structures throughout the rainy season.
- Minimize riparian corridor damage during construction of roads (and bridges, culverts, and other crossings) and avoid locating roads in floodplains.
- Rehabilitate roads by upgrading problem culverts or replacing with bridges, outsloping road surfaces to drain properly without maintenance, revegetating bare surfaces, and other measures as necessary for stability.
- Utilize state or federal culvert design guidelines (e.g., NMFS 1996b) for design and installations of culverts.

### 3.2.5.17 Sand and Gravel Mining

Mining of sand and gravel in the region's watersheds is extensive. Mining occurs by several methods. Sand and gravel extraction from seasonally exposed stream gravel bars occurs through wet-pit mining (i.e., remove material from below the water table) and dry-pit mining on exposed bars and ephemeral streambeds that are excavated by bulldozers, scrapers, and loaders. Bar scalping or skimming operations, which removes the tops of river gravel bars without excavating below the summer water, is one of the most common methods of gravel extraction practiced today. The bars are almost always attached to the stream banks and are frequently located on the inside of bends. Excavation of floodplain and river terrace deposits adjacent to an active or former channel is another common method for gravel extraction. Gravel extraction in these locations may occur to the level of seasonal flow, or may excavate below the level of seasonal flow, and require pumping of seepage water or underwater extraction from a pond. As active channels naturally move, the channel may migrate into the excavated area. The chance of this occurring is increased in the event of a flood.

Extraction of sand and gravel may directly eliminate the amount of gravel available for spawning if the extraction rate exceeds the deposition rate of new gravel in the system. The aerial extent of suitable spawning habitat may be reduced where degradation reduces gravel depth or exposes bedrock (Spence *et al.* 1996). Sand and gravel mining can suspend materials at the sites, resulting in turbidity plumes which may move several kilometers downstream. Sedimentation may be a delayed effect, because gravel removal typically occurs at low flow when the stream has the least capacity to transport the fines out of the system. Mechanical disturbance of spawning beds by mining equipment may also lead to high mortality rates of eggs and alevins. Gravel operations can also interfere with salmon migration past the site if they create physical or thermal changes at the work site or downstream from the site (OWRRI 1995).

Examples of using gravel removal to improve habitat and water quality are limited and isolated (OWRRI 1995). Deep pools created by material removal in streams appears to attract migrating adult salmon for holding. These concentrations of fish may result in high losses as a result of increase predation or recreational fishing pressure. In specific cases, gravel removal can be effectively used to remove stresses on streambanks and streambeds, resulting in greater stabilization and less need for streambank stabilization and greater stability of some spawning beds (OWRRI 1995).

By making the stream channel wider and shallower, the suitability of stream reaches as rearing habitat for juveniles may be decreased, especially during summer low-flow periods when deeper waters are important for survival. Similarly a reduction in pool frequency may adversely affect migrating adults that require holding pools (Spence *et al.* 1996). Changes in the frequency and extent of bedload movement and increased erosion and turbidity can also remove spawning substrates, scour redds (resulting in a direct loss of eggs and young), or reduce their quality by deposition of increased amounts of fine sediments. Other effects that may result from sand and gravel mining include increased temperatures (from reduction in summer base flows and decreases in riparian vegetation), decreased nutrients (from loss of floodplain connection and riparian vegetation), and decreased food production (loss of invertebrates) (Spence *et al.* 1996).

**Conservation Measures for Sand and Gravel Mining** - Following are the types of measures that can be undertaken by the action agency on a site-specific basis to conserve salmon EFH in areas that have the potential to be affected by sand and gravel mining activities. Not all of these suggested measures are

necessarily applicable to any one project or activity that may adversely affect salmon EFH. More specific or different measures based on the best and most current scientific information may be developed prior to, or during, the EFH consultation process and communicated to the appropriate agency. The options represent a short menu of general types of conservation actions that can contribute to the protection and restoration of properly functioning salmon habitat. The following suggested measures are adapted from NMFS (1996) and OWRRI (1995).

- Avoid gravel mining within or proximal to spawning reaches.
- Where possible, identify upland or off-channel (where channel will not be captured) gravel extraction sites as alternatives to gravel mining in salmon EFH.
- Design, manage, and monitor gravel operations to minimize potential impacts to migrating salmon and stream/river banks, riparian, and habitat, etc.
- Minimize the areal extent and depth of extraction.
- Include restoration, mitigation, and monitoring plans in gravel extraction plans.

### **3.2.5.18 Vessel Operations**

The discharge of contaminated ballast or bilge water and trash has the potential to adversely affect salmon EFH. Ship wakes can also cause increased bank erosion, increasing turbidity and sedimentation effects. Depending on the size of waves generated by ships, wash caused by ship wakes can result in the stranding of juvenile salmonids along the shoreline. Fish stranding, a function of fish size and swimming performance, tends to be a problem for smolts less than 60-70 mm and can be a significant source of juvenile mortality (Bauersfeld 1977).

Onshore, the discharge of solvents, grease, or paints from ship yard maintenance activities (see sections on "Waste Water...", "Oil Exploration...", and "Introduction of Nonnative Plants and Animals") also has the potential to adversely affect salmon EFH.

**Conservation Measures for Vessel Operations** - Following are the types of measures that can be undertaken by the action agency on a site-specific basis to conserve salmon EFH in areas that have the potential to be affected by vessel operations. Not all of the suggested measures are necessarily applicable to any one project or activity that may adversely affect salmon EFH. More specific or different measures based on the best and most current scientific information may be developed prior to, or during, the EFH consultation process and communicated to the appropriate agency. The options represent a short menu of general types of conservation actions that can contribute to the protection and restoration of properly functioning salmon habitat. Also refer to sections on "Waste Water...", "Oil Exploration...", and "Introduction and Spread of Nonnative Species." The following suggested measures are adapted from Bauersfeld (1977), Cohen (1997), and EPA (1993).

- Avoid ballast water exchange in nearshore coastal waters. Use shore-based ballast water treatment systems and ship-board ballast treatment systems as alternatives.
- Minimize ship speeds on rivers to those that do not create ship wakes.
- Utilize appropriate methods for containment of waste water, surface water collection, and recycling to avoid the discharge of pollution from boat yards, shipyards, and marinas or during the maintenance and operation of vessels.

### 3.2.5.19 Wastewater/Pollutant Discharge

Water quality essential to salmon and their habitat can be altered when pollutants are introduced through surface runoff, through direct discharges of pollutants into the water, when deposited pollutants are resuspended (e.g., dredging), and when flow is altered (e.g., nitrogen supersaturation at dams).

Atmospheric discharges of pollutants from power plants or industrial facilities can deposit metals, complex hydrocarbons, and synthetic chemicals into salmon EFH. These pollutants can be carried directly into salmon EFH or can settle on land and be carried into the water through rain run-off or snow-melt.

Similarly, wastewater or pollutants can be directly or indirectly discharged into ocean, estuarine, or fresh water environments. Examples of direct input of pollutants include the wastewater discharges of municipal sewage or stormwater treatment plants, power generating stations, industrial facilities (e.g., pulp mills, desalination plants, fish processing facilities), spills or seepage from oil and gas platforms, marine fueling facilities, hatcheries, boats (e.g., sewage, bilge water), the dumping of dredged materials or sewage sludge, or even from vessel maintenance, if it occurs over the water. These sources can result in the introduction of heavy metals, nutrients, hydrocarbons, synthetic compounds, organic materials, salt, warm water, disease organisms, or other pollutants into the environment.

Indirect sources of water pollution in salmon habitat results from run-off from streets, yards, construction sites, gravel or rock crushing operations, or agricultural and forestry lands. This run-off can carry oil and other hydrocarbons, lead and other heavy metals, pesticides, herbicides, sediment, nutrients, bacteria, and pathogens into salmon habitat. Water pollution can also result from the resuspension of buried contaminated sediments (e.g., from dredging operations). (See sections on "Dredging.....;" "Grazing;" "Mineral Mining;" "Agriculture;" "Construction/Urbanization;" and "Forestry").

The introduction of pollutants into EFH can create both lethal and sublethal habitat conditions to salmon and their prey. For example, fish kills may result from a pesticide run-off event, high water temperatures, or when algae blooms caused by excess nutrients deplete the water of oxygen.

Pollutant and water quality impacts to EFH can also have more chronic effects detrimental to fish survival. Contaminants can be assimilated into fish tissues by absorption across the gills or through bio-accumulation as a result of consuming contaminated prey. Pollutants either suspended in the water column (e.g., nitrogen, contaminants, fine sediments) or settled on the bottom (through food chain effects) can affect salmon. Many heavy metals and persistent organic compounds such as pesticides and polychlorinated biphenyls tend to adhere to solid particles. As the particles are deposited these compounds or their degradation products (which may be equally or more toxic than the parent compounds) can bioaccumulate in benthic organisms at much higher concentrations than in the surrounding waters (Oregon Territorial Sea Management Study [OTSMS] 1987, Stein *et al.* 1995).

**Conservation Measures for Wastewater/Pollutant Discharge** - Numerous federal and state programs have been established to improve and protect water quality. One of the most important programs relating to salmon EFH is the Clean Water Act's Section 319 program administered by the EPA. Under this section, states are required to submit to EPA for approval of an assessment of waters within the state that, without additional action to control nonpoint sources of pollution, cannot be expected to attain or maintain applicable water quality standards. In addition, states are to submit to EPA their management programs that identify measures to reduce pollutant loadings, including best management practices and monitoring programs. It is, therefore, critical that actions aimed at improving EFH water quality, especially in streams and rivers, are taken in concert with state agencies (e.g., Oregon Department of Environmental Quality, WDOE California Water Resources Control Board; Idaho Department of Health and Welfare) responsible for water quality management.

Some pollutant discharges are regulated through discharge permits which set effluent discharge limitations and/or specify operation procedures, performance standards, or best management practices. Additional effort to improve water quality is also being fostered by states under the guidance of the Coastal Zone Management Reauthorization Act. These efforts rely on the implementation of best management practices to control polluted run-off (EPA 1993). Although not yet a consistently applied mechanism to improve water quality,

vegetated buffers along streams have been shown to be effective in providing such functions as sediment trapping, removal of nutrients and metals, moderation of water temperatures, increasing stream and channel stability and allowing recruitment of woody debris.

Following are the types of measures that can be undertaken by the action agency on a site-specific basis to conserve salmon EFH in areas that have the potential to be affected by both point and nonpoint sources of pollution. Not all of these suggested measures are necessarily applicable to any one project or activity that may adversely affect salmon EFH. More specific or different measures based on the best and most current scientific information may be developed prior to, or during, the EFH consultation process, and communicated to the appropriate agency. The options represent a short menu of general types of conservation actions that can contribute to the protection and restoration of properly functioning salmon habitat. The following suggested measures are adapted from Gauvin (1997), Washington Fish and Wildlife Commission (WFWC) (1997), OCSRI (1997), NMFS (1997b), The Resources Agency of California (RAC) (1997) and EPA (1993).

- Monitor water quality discharges following National Pollutant Discharge Elimination System requirements from all discharge points (including municipal storm water systems, and desalinization plants).
- Apply the management measures developed for controlling pollution from run-off in coastal areas to all watersheds affecting salmon EFH.
- For those water bodies that are defined as water quality limited in salmon EFH (303(d) list), establish total maximum daily loads and develop appropriate management plans to attain management goals.
- Where in-stream flows are insufficient for water quality maintenance, establish conservation guidelines for water use permits, encourage the purchase or lease of water rights and the use of water to conserve or augment instream flows in accordance with state and federal water law.
- Establish and update, as necessary, pollution prevention plans, spill control practices, and spill control equipment for the handling or transporting toxic substances in salmon EFH. Consider bonds or other damage compensation mechanisms to cover clean-up, restoration, and mitigation costs.

### **3.2.5.20 Wetland and Floodplain Alteration**

Many river valleys in the west were once marshy and well vegetated, filled with mazes of floodplain sloughs, beaver ponds, and wetlands. Salmon evolved within these systems. Juvenile salmon, especially coho, can spend large portions of their fresh water residence rearing and over-wintering in floodplain environments and riverine wetlands. Salmon survival and growth are often better in floodplain channels, oxbow lakes, and other river-adjacent waters than in mainstream systems (NRC 1996). Additionally wetlands provide other ecosystem functions important to salmonids such as regulation of stream flow, stormwater storage and filtration, and often provide key habitat for beavers (that in turn may provide instream habitat benefits to coho from their active and continual placement of wood in streams) (OCSRI 1997). Floodplains (even those that are not wetlands) also help store water, filter nutrients, and cycle nutrients into the aquatic ecosystem.

Wetlands and side channels throughout the region have been converted through diking, draining and filling to create agricultural fields, livestock pasture, areas for ports, cities, and industrial lands. Wetlands were further altered to improve navigation along rivers. These changes have transformed the complex river valley habitat, with many backwater areas, into a simplified drainage systems most of whose flow is confined to the mainstream (Sedell and Luchessa 1982). As a result of these alterations, these areas became less capable of absorbing flood waters. Further habitat alteration often occurs as flood control projects are then undertaken. These projects include such things as water storage dams, dredging to increase channel capacity, or the building of dikes and levees to prevent rivers from over-topping their banks.

The construction of dikes, levees, and roads in the floodplain have further effects on salmon habitat. These structures prevent the connections between the rivers and floodplain, depriving the rivers of supplies of large woody debris as well as decreasing the input of fine organic matter and dissolved nutrients which support the food web for salmon (NRC 1996). These structures also deprive the river of a place to deposit sediment, so

more sediment moves downstream, causing stream channel aggradation, the scouring of spawning redds, and estuary filling.

**Conservation Measures for Wetland and Floodplain Alteration** - Following are the types of measures that can be undertaken by the action agency on a site-specific basis to conserve salmon EFH in areas that have the potential to be affected by wetland and floodplain alterations. Not all of these suggested measures are necessarily applicable to any one project or activity that may adversely affect salmon EFH. More specific or different measures based on the best and most current scientific information may be developed prior to, or during, the EFH consultation process, and communicated to the appropriate agency. The options represent a short menu of general types of conservation actions that can contribute to the protection and restoration of properly functioning salmon habitat. The following suggested measures are adapted from NMFS (1997b), Metro (1997) and Streif (1996).

In addition to applicable measures described in the estuarine alteration section, the following general measures may apply:

- Minimize alteration of wetlands for nonwater-dependent uses in areas of salmon EFH.
- Minimize adverse effects on wetlands from water-dependent uses.
- Where ever possible avoid floodplain development, and mitigate for unavoidable floodplain losses to maintain water storage capacity.
- Complete compensation mitigation for unavoidable wetland loss prior to conducting activities that may adversely affect wetlands wherever possible, and perform such mitigation only in areas which have been prioritized as to long term viability and functionality.
- Design wetland mitigation to meet specific performance objectives for function and value and monitored to assure achievement of these objectives. Use wetland mitigation and enhancement ratios that are sufficient to attain a net gain in acreage as well as function and value.
- Determine cumulative effects of all past and current wetland and floodplain alterations before planning activities that further alter wetlands and floodplains.
- Promote awareness and use of the USDA's wetland and conservation reserve programs to conserve and restore wetland and floodplain habitat.
- Promote restoration of degraded wetlands.

#### **3.2.5.21 Woody Debris/Structure Removal From Rivers and Estuaries**

The functional importance of large woody debris and structure (e.g., large rocks and boulders) has been well documented in stream environments. Large woody debris is also important in riverine and estuarine environments.

Large woody debris provides structure to stream channels which promotes habitat complexity that allows multiple salmon species to coexist. For example, depending on the size of the woody debris and the stream, the debris may create plunge, lateral, scour and backwater pools, short riffles, undercut banks, side channels and backwaters, and create different water depths (Spence *et al.* 1996). Large woody debris in the stream also helps retain gravel for spawning habitat, provides long-term nutrient storage and substrate for aquatic invertebrates that are salmon prey, and provides refuge for fish and prey during high and low-flow periods (Spence *et al.* 1996). Additionally, large woody debris provides cover for salmon, influences water flow, allows for the storage and transport of sediment and fine organic debris (as well as salmon carcasses), and influences the physical structure and stability of important habitat features such as pools (Ralph *et al.* 1994, Spence *et al.* 1996).

The pools that are associated with large woody debris are preferred habitats for various age classes of juvenile coho salmon (as well as cutthroat trout and steelhead) (Bisson *et al.* 1987). Additionally, pools are important as resting and holding habitat for upstream migrating adult salmon and are necessary for attaining the swimming speed needed to jump obstacles (Spence *et al.* 1996).

The ecological functions of large woody debris in lower river and estuarine environments is similar, but has not been as widely acknowledged. Large woody debris in the tidal river segment of coastal stream systems create riffles and provide shelter from predators for salmonids and other aquatic organisms. The woody debris can also affect local water flow by creating turbulence and thereby affecting the sedimentation pattern and the formation of gravel bars or mud banks. Large woody debris influences the estuarine portion of the ecosystem, mainly through their physical properties as large masses and by creating substrate in an environment where the bottom consists mainly of fine sediment (Maser and Sedell 1994). Fallen trees that reach the upper and lower estuary system are degraded by various species of woodborers, providing important sources of nutrients for the detritus based food webs of the estuary. Downed trees also play roles in creating important habitat in salt marshes by catching sediment and organic material, elevating the general area of the ground around them. When these trees refloat during high tides, floods, or storm surges, the shallow depressions that remain in the marsh increase habitat diversity; at low tide, these depressions are filled with juvenile fishes (Gonor *et al.* 1988). The depletion of woody debris has diminished these channel formation, predator avoidance, and nutrient/prey functions. Additionally, the important structure that tree branches once provided in estuaries as spawning substrate for herring is lacking, resulting in overcrowding on the remaining spawning substrates (Phillips 1984).

The removal of large woody debris from streams, rivers, and estuaries is not encouraged, though it continues in attempts to control riverbank erosion or to protect structures (e.g., bridges). Additionally, recreational boaters, kayakers, and rafters may remove snags from rivers and lakes. This is done for reasons of aesthetics and safety, leaving popular white water rivers and many recreational lakes nearly devoid of snags (Gonor *et al.* 1988). Additionally, streams in urban and urbanizing areas are devoid of wood due in part to the removal of wood by river-side property owners for aesthetic reasons, concerns about flooding, and for firewood. Additionally, property owners cut trees along riparian areas and replace these areas with lawns, thus depriving the stream of a replacement supply of large wood (May *et al.* 1997).

Removal of large rocks and boulders is also of concern since these structures also create hydrologic and stream channel complexity important to salmon.

**Conservation Measures for Woody Debris/Structure Removal From Rivers and Estuaries** - Following are the types of measures that can be undertaken by the action agency on a site-specific basis to conserve salmon EFH in areas that have the potential to be affected by the removal of large woody debris. Not all of these suggested measures are necessarily applicable to any one project or activity that may adversely affect salmon EFH. More specific or different measures based on the best and most current scientific information may be developed prior to, or during, the EFH consultation process, and communicated to the appropriate agency. The options represent a short menu of general types of conservation actions that can contribute to the protection and restoration of properly functioning salmon habitat.

- Avoid removing woody debris and large rocks and boulders in salmon EFH.
- Educate landowners and boaters about the benefits of maintaining large woody debris in streams to enhance properly functioning salmon habitat conditions.