STRAIT OF JUAN DE FUCA NATURAL COHO

DRAFT 6_OCTOBER 2018

SALMON REBUILDING PLAN, ENVIRONMENTAL ASSESSMENT, MAGNUSON-STEVENS FISHERY CONSERVATION AND MANAGEMENT ACT ANALYSIS, REGULATORY IMPACT REVIEW, AND INITIAL REGULATORY FLEXIBILITY ANALYSIS

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LIST OF ACRONYMS AND ABBREVIATIONS

ABC	acceptable biological catch
ACL	annual catch limit
BY	brood year
CDFW	California Department of Fish and Wildlife
CoTC	Coho Technical Committee (of the PSC)
Council	Pacific Fishery Management Council
CWT	coded-wire tag
EA	Environmental Assessment
EEZ	exclusive economic zone (from 3-200 miles from shore)
EIS	Environmental Impact Statement
ESA	Endangered Species Act
ESU	evolutionarily significant unit
F_{ABC}	exploitation rate associated with ABC
F_{ACL}	exploitation rate associated with ACL (= F_{ABC})
FMP	fishery management plan
F_{MSY}	maximum sustainable yield exploitation rate
F_{OFL}	exploitation rate associated with the overfishing limit (= F_{MSY}, MFMT)
FONSI	Finding of No Significant Impacts
FRAM	Fishery Regulatory Assessment Model
GAM	generalized additive models
ISBM	individual stock-based management
KMZ	Klamath management zone (ocean zone between Humbug Mountain and Horse Mountain)
KOHM	Klamath Ocean Harvest Model
KRFC	Klamath River fall Chinook
MFMT	maximum fishing mortality threshold
MSA	Magnuson-Stevens Fishery Conservation and Management Act
MSM	mixed stock model
MSST	minimum stock size threshold
MSY	maximum sustainable yield
NA	not available
NEPA	National Environmental Policy Act
NMFS	National Marine Fisheries Service
NPGO	North Pacific Gyre Oscillation
NS1G	National Standard 1 Guidelines
ODFW	Oregon Department of Fish and Wildlife
OFL	overfishing limit
OY	Optimum Yield
PDO	Pacific Decadal Oscillation
PFMC	Pacific Fishery Management Council (Council)
PSC	Pacific Salmon Commission
PST	Pacific Salmon Treaty
RER	rebuilding exploitation rate
S_{ABC}	spawning escapement associated with ABC
S_{ACL}	spawning escapement associated with ACL (= S_{ABC})
SHM	Sacramento Harvest Model
SI	Sacramento Index
S_{MSY}	MSY spawning escapement
S_{OFL}	spawning escapement associated with the overfishing limit (= S_{MSY})

LIST OF ACRONYMS AND ABBREVIATIONS *(continued)*

SRFC	Sacramento River fall Chinook
SRWC	Sacramento River winter Chinook
STT	Salmon Technical Team
VSI	visual stock identification
WDFW	Washington Department of Fish and Wildlife
QIN	Quinault Indian Nation

1.0 EXECUTIVE SUMMARY

To be developed for final Rebuilding Plan.

2.0 INTRODUCTION

In 2018, Strait of Juan de Fuca natural coho salmon (JDF coho) met the criteria for overfished status as defined in section 3.1 of the Pacific Coast Salmon Fishery Management Plan (FMP) (PFMC 2016). In response, the Pacific Fishery Management Council (Council) directed the Salmon Technical Team (STT) to propose a rebuilding plan for Council consideration within one year. The FMP, and the Magnuson-Stevens Fishery Conservation and Management Act (MSA), requires that a rebuilding plan must be developed and implemented within two years of the formal notification from National Marine Fisheries Service (NMFS) to the Council of the overfished status. Excerpts from the FMP relevant to status determinations and rebuilding plans are provided in Appendix A.

The Council's criteria for overfished is met if the geometric mean of escapement, computed over the most recent three years, falls below the Minimum Stock Size Threshold (MSST) which is defined for applicable stocks in Table 3-1 of the FMP. For JDF coho, the number of adult spawners expected to produce maximum sustainable yield (MSY) is defined as 11,000 natural-area adult spawners, also known as S_{MSY}. The MSST for JDF coho is defined as 7,000 natural-area adult spawners. The geometric mean of JDF coho natural-area adult spawners over years 2014-2016 was 6,842, and thus in 2018 the stock met the criteria for overfished status[1]. Figure 2.0.a. displays the time series of JDF coho natural-area adult escapement and the running three year geometric mean of escapement relative to S_{MSY} and the MSST. Table 2.0.a. includes both hatchery and natural spawning escapement and displays the co-manager agreed to values as of the April 2018 PFMC Meeting. The FMP identifies the default criterion for achieving rebuilt status as attainment of a 3-year geometric mean of spawning escapement exceeding S_{MSY}.

Overfished status is defined by recent spawner escapement for salmon stocks, which is not necessarily the result of overfishing. Overfishing occurs when in any one year the exploitation rate on a stock exceeds the maximum fishing mortality threshold (MFMT), which for JDF coho is defined as the MSY fishing mortality rate (F_{MSY}) of 0.60. It is possible that overfished status could represent normal variation, as has been seen in the past for several salmon stocks. However, the occurrence of reduced stock size or spawner escapements, depending on the magnitude of the short-fall, could signal the beginning of a critical downward trend. Imposing fisheries on top of already low abundances could further jeopardize the capacity of the stock to produce MSY over the long term if appropriate actions are not taken to ensure that conservation objectives are achieved.

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[1] Subsequent to publishing the Review of 2017 Ocean Salmon Fisheries, revised escapement estimates for JDF coho were provided in mid-August 2018 which indicate the stock may in fact not have been in an overfished status. These revised escapement estimates were 11,489, 3,860, and 8,435 for 2014, 2015, and 2016 respectively, bringing the three year geometric mean to 7,205, which is above the MSST of 7,000. Preliminary escapement estimates for 2017, however, suggest that the stock is almost certain to be in an overfished status next year. Given this information, the STT has continued with the development of the rebuilding plan for JDF coho as instructed by the Council, with the original data provided in the 2017 Review document. The STT has informed the Council of the situation, and will update all salmon data in the Review of 2018 Ocean Salmon Fisheries.

In this rebuilding plan, we begin by providing an overview of the JDF coho stock, the physical setting of the Strait of Juan de Fuca and its tributaries, and fisheries management. We then review the potential factors that may have contributed to the overfished status. Recommendations regarding alternative rebuilding actions are proposed, as are recommendations for actions outside of the management of salmon fisheries. We end with a socioeconomic analysis of the impact of the recommended rebuilding alternatives.

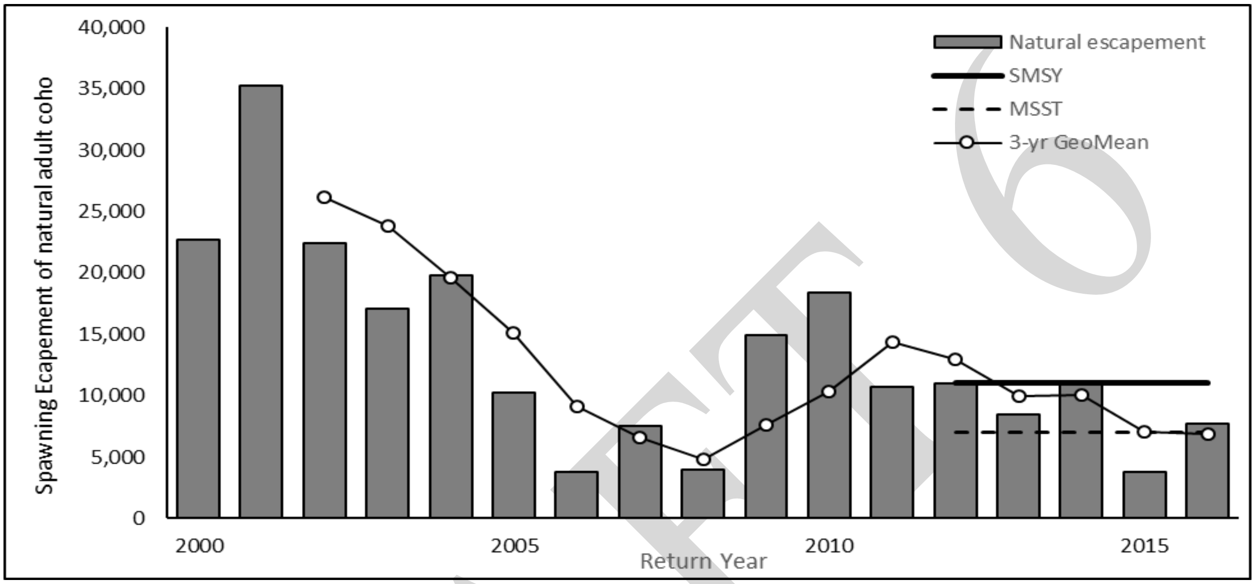

Figure 2.0.a. JDF coho spawning escapement of natural area adults. The current MSST took effect in 2012, at which point the most recent 3-yr geometric mean included escapement in 2008-2010.

Table 2.0.a. Natural spawning adult escapement of JDF coho.

	Spawning Escapement[a/]		
Year[b/]	Hatchery	Natural	Total
	Strait of Juan de Fuca		
2000	19,233	22,654	41,887
2001	24,768	35,274	60,042
2002	10,398	22,375	32,773
2003	18,951	17,042	35,993
2004	6,690	19,755	26,445
2005	4,899	10,201	15,100
2006	738	3,801	4,536
2007	2,516	7,525	10,044
2008	849	3,999	4,027
2009	12,407	14,957	27,364
2010	5,209	18,420	23,568
2011	11,057	10,732	21,181
2012	7,945	11,021	18,928
2013	6,767	8,461	15,228
2014	3,688	11,002	14,690
2015	1,019	3,779	4,717
2016	4,125	7,704	11,829
GOAL		7,000-11,000	

a/ Co-manager agreed to values as of the April 2018 PFMC Meeting.

b/ Years 2012-2016 are preliminary.

2.1 National Environmental Policy Act

In addition to addressing the requirements of the FMP and MSA, this rebuilding plan document integrates the environmental assessment required under the National Environmental Policy Act (NEPA).

2.1.1 Proposed Action

The Proposed Action is for the Council to adopt and NMFS to approve a rebuilding plan for the JDF coho salmon stock, which has been determined by NMFS to be overfished under the MSA. The rebuilding plan must be consistent with the MSA and the provisions of the FMP; therefore, the plan shall include a control rule and a specified rebuilding period. The specified rebuilding period shall be as short as possible, taking into consideration the needs of the commercial, recreational and tribal fishing interests and coastal communities.

2.1.2 Purpose and Need

The purpose of the proposed action is to develop and implement a harvest control rule that will be applied to setting annual ocean salmon fishery management measures that impact JDF coho to allow the stock to attain a three-year geometric mean spawning escapement that meets the SMSY specified for that stock in the FMP in the least amount of time possible while taking into account the biology of the stock, international agreements, and the needs of fishing communities, but not to exceed 10 years. The need for the proposed action is to rebuild JDF coho, which the National Marine Fisheries Service determined, in 2018, to be overfished under the MSA.

2.2 Stock overview

The JDF coho stock managed under the FMP is synonymous with the Strait of Juan de Fuca Management Unit (MU) managed under the Pacific Salmon Treaty (PST) between the United States and Canada. Management information on these coho comes predominately from the Pacific Salmon Commission's Coho Technical Committee (CoTC). The Strait of Juan de Fuca MU is one of thirteen key MUs defined in the PST for naturally spawning coho stocks (PSC 2009) and consists of natural coho salmon inhabiting the numerous streams and tributaries draining from the Olympic Peninsula northward into the Strait of Juan de Fuca, with the exception of the Dungeness and Elwha Rivers. This MU spans two evolutionarily significant units (ESUs), as defined by NMFS. Populations inhabiting the western Straits (from Salt Creek westwards) are part of the Olympic Peninsula ESU, while those east of Salt Creek belong to the Puget Sound/Strait of Georgia ESU (Weitkamp et al. 1995). The Puget Sound/Strait of Georgia ESU is currently a species of concern under the U.S. Endangered Species Act (NOAA Fisheries 2009).

2.2.1 Stock composition

Both natural and hatchery coho salmon are found in the streams and tributaries of the JDF region, however, the JDF coho stock referred to throughout this document refers specifically to the naturally produced salmon only.

Several salmon hatchery facilities are located within the area that encompasses the JDF coho stock. Below is a list of those programs that rear and release coho salmon.

- The Lower Elwha Fish Hatchery, operated by the Lower Elwha Klallam Tribe, is located at river mile (RM) 1.25 on the Elwha River. The current coho program at this facility is an “integrated” program (broodstock is genetically integrated with the local natural population) with the goal of preserving and rebuilding natural coho production in the Elwha River by supplementing the abundance of juvenile and, therefore, returning adult fish. Long term goals include re-colonization of suitable coho spawning and rearing habitat and enhanced in-river terminal harvest opportunities. The program currently has an annual production goal of 425,000 smolts to be released at the hatchery site (on-station). Of the total smolts released, 350,000 smolts are marked (adipose fin clipped), and 75,000 smolts are unmarked, but are coded-wire tagged as part of a double index tag group to estimate impacts of selective fisheries.

- The Dungeness Hatchery operated by Washington Department of Fish and Wildlife (WDFW) is located on the Dungeness River at RM 10.5. The current coho program at this facility is a “segregated” program (broodstock is genetically segregated from the local natural population) with the goal of providing fish for sport and commercial harvest. The program currently has an annual production goal of 500,000 smolts to be released at the hatchery site (on-station). In addition, 2,000 fry are planted into Cooper Creek, and up to 1,900 eyed eggs are transferred to local school projects.
- The Hurd Creek Hatchery operated by WDFW is located on Hurd Creek, a tributary to the Dungeness River at RM 3. The facility began operating in 1980 and its only coho programs are supplying small numbers of eggs to educational and other organizations.
- The Hoko River Hatchery operated by the Makah Tribe is located at river mile 9.6. It does not currently have a coho program, but is considering establishing one to provide harvest opportunity in the river and adjacent salt water areas.

The Elwha and Dungeness Rivers have hatcheries and are managed for hatchery production, therefore natural spawning in these rivers is not included as part of the JDF coho stock. Natural spawners in the Elwha and Dungeness Rivers are considered "secondary" stocks, passively managed in mixed stock fisheries (CCW 1998).

2.2.2 Location and geography

The Strait of Juan de Fuca lies between the Olympic Peninsula of Washington State and Vancouver Island of British Columbia, Canada with the international boundary lying mid-channel (Figure 2.2.2.a).

Strait of Juan de Fuca coho inhabit an area of approximately 1,500 mi^2, including some 48 independent watersheds that support coho ranging in size of basin from less than 10 mi^2 to more than 300 mi^2. These watersheds drain northward into the Strait from Cape Flattery in the west to Point Wilson in the east, and south along the east side of the Quimper Peninsula to include Chimacum Creek.

This region consists of numerous small to large tributaries draining the Olympic Mountain range and surrounding foothills. The western portion of the Strait of Juan de Fuca MU (WSJF) encompasses waters emptying to the Strait of Juan de Fuca west of the Elwha River, to the tip of Cape Flattery. The WSJF contains 27 salmonid-bearing watersheds that drain directly into the Strait of Juan de Fuca. The largest sub basin within the watershed is the Hoko River, followed by the Lyre, Pysht, Sekiu, and Clallam Rivers (Smith 1999). The eastern portion of the Strait of Juan de Fuca MU includes all streams and rivers from the Elwha River east to Chimacum Creek.

The climate varies widely throughout the region, with higher annual precipitation to the west and at higher elevations. Annual rainfall decreases dramatically from west to east across the region, due to the rain-shadow effect of the Olympic Mountains. The eastern portion of the region receives as little as 15 inches [38 cm] of rain a year, increasing to over 85 inches [216 cm] in the western portion.

The estuarine habitat in the region is somewhat transitional between the more sheltered inland estuaries of inner Puget Sound and the open Pacific Ocean, with decreasing shallow, sheltered marine habitat encountered moving westward from inner Puget Sound.

Much of the freshwater habitat in the region is managed for commercial timber production, though the upper reaches of the longer tributaries in the region around the Elwha River originate in Olympic National Park. The main population centers of Sequim and Port Angeles are located in the eastern portion of the region. Urbanization, agricultural activities, and water withdraws have degraded the productivity of streams in these areas, with the exception of the upper reaches of the longer tributaries that originate in Olympic National Park.

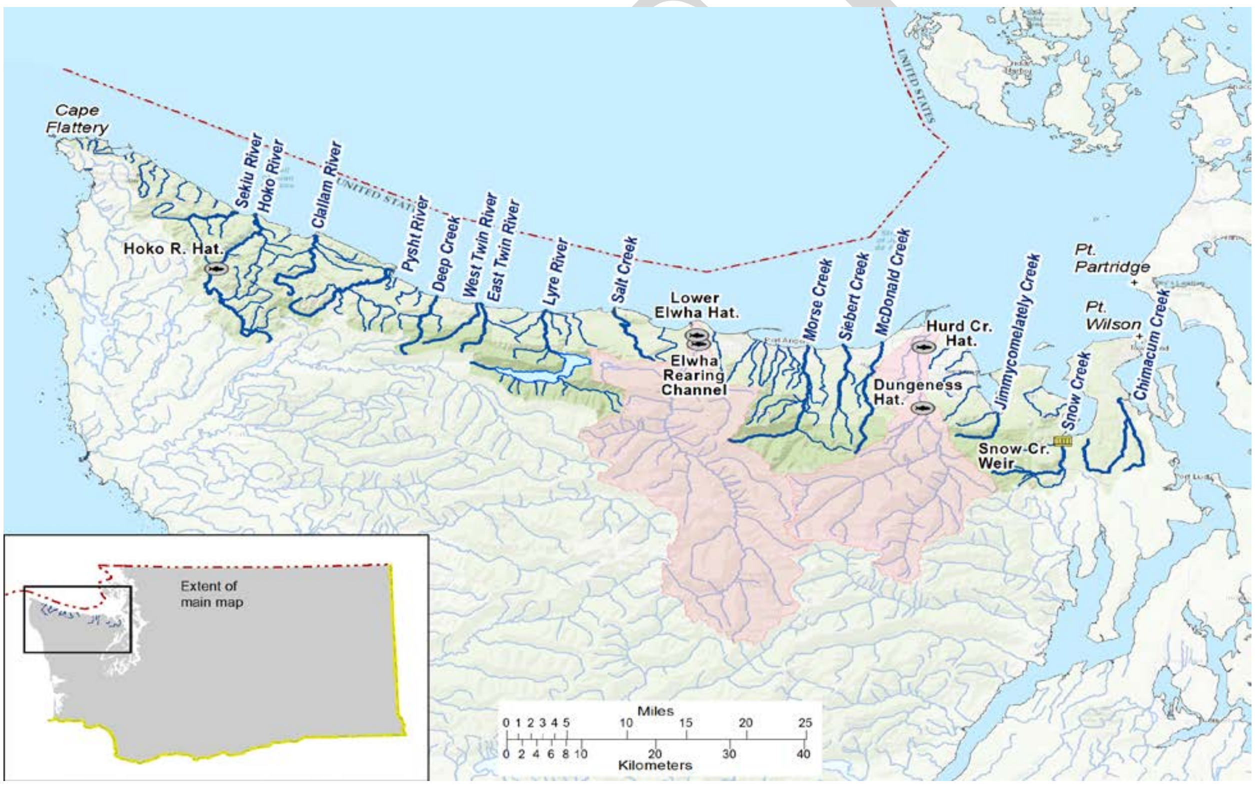

Figure 2.2.2.a. Map of Strait of Juan de Fuca Coho Management Unit (Dale Gombert, WDFW Science Division). The Elwha and Dungeness Rivers are shown shaded but not bolded because, though part of the MU, they are not "primary" management units under the Comprehensive Coho Management Plan (CCW 1998).

2.3 Management Overview

Strait of Juan de Fuca coho are one of five Puget Sound coho management units included in the coho chapter of the Pacific Salmon Treaty (PST). Under the PST, Puget Sound management units are managed under a tiered, abundance-based management regime. Each year, the management units are classified as “low” abundance, “moderate” abundance, or “abundant” based on the forecast ocean abundance of age-3 fish (CoTC 2013). The maximum allowable exploitation rate (ER) is determined by the abundance category (Table 2.3.a).

Table 2.3.a. Pacific Salmon Treaty-defined total exploitation rate ceilings by PSC status categories.

Strait of Juan de Fuca natural coho		
Status (PSC/Council)	Ocean Age-3 Abundance Reference Point	Total Exploitation Rate
Low	≤ 11,679	Up to 20%
Moderate	11,680 – 27,445	21% – 40%
Abundant	> 27,445	41% – 60%

2.3.1 Conservation objectives

The abundance-based stepped harvest rates of the PST management regime were adopted as conservation objectives for Puget Sound coho MUs by the Council in November 2009 (Bowhay and Pattillo 2009), and implemented in the 2010 preseason planning process. When the Council adopted Amendment 16 in 2011, the spawning escapements associated with the ocean abundance breakpoints were adopted as status determination criteria (SDC). For JDF coho, the MSST of 7,000 was adopted based on the spawning escapement associated with the Low/Moderate breakpoint and 40 percent allowable ER. Similarly, the S_{MSY} value of 11,000 was adopted based on the spawning escapement associated with the moderate/abundant breakpoint and the 60 percent allowable ER. Amendment 16 to the FMP was implemented starting with the 2012 preseason planning process.

2.3.2 Management strategy

The tiered harvest rates with abundance breakpoints define a control rule that limits the allowable fishery impacts on JDF coho depending on the abundance. However, fisheries impacting JDF coho are also constrained by impacts on other coho management units identified in the Pacific Salmon Treaty, impacts on discrete population segments listed under the U.S. Endangered Species Act, harvest sharing obligations adjudicated by the Boldt decision (under the determinations of the U.S. District Court in *U.S. v. Washington*), and impacts on other salmon stocks identified in the FMP. Each year proposed management measures are modeled using the coho Fishery Regulation Assessment Model (FRAM) parameterized with the current year’s stock abundance forecasts. Final management measures adopted by the Council need to meet all the constraints on stocks and fisheries.

Usually, constraints on fishery impacts to other stocks are more constraining to than those on JDF coho. Coho fisheries impacting JDF coho are constrained by the depressed status of Thompson River (upper Fraser River) coho in British Columbia. Since the mid-1990s, Canadian coho fisheries have been managed to minimize impacts on Thompson River coho, which greatly reduced their impacts on Washington coast and Puget Sound coho stocks. When the current coho chapter of the Pacific Salmon Treaty was adopted in 2002, it constrained the total exploitation rate in US fisheries on Thompson River coho to a maximum of 10% while they are in the low abundance category. This limit has constrained northern US coho fisheries in nearly every year since then.

Postseason, when actual catch and spawning escapement data can be used to parameterize the coho FRAM, management measures actions are assessed to see if the conservation objectives and status determination criteria were met.

3.0 REVIEW OF POTENTIAL FACTORS LEADING TO OVERFISHED STATUS

A number of factors may contribute to a stock falling below the MSST and becoming classified as overfished. Fishing mortality may be higher than was expected when management measures were adopted, or the abundance may be less than forecast. Abundance may be less than forecast because low freshwater survival resulted in fewer smolts than expected, or because low marine survival resulted in fewer adult returns than expected. Freshwater and/or marine survival may be low enough, that even if anticipated, there will simply be too few adults produced to prevent the stock from falling below the MSST, even in the absence of fishing. The FMP specifies that the roles of freshwater survival, marine survival, and fishing should be considered in any rebuilding plan.

3.1 Freshwater survival

3.1.1 Review of freshwater conditions

JDF coho distribution of freshwater habitat spans across the northern Olympic Peninsula, a distance of more than 100 miles wide, encompassing freshwater systems that are comprised of a wide variety of sizes, land uses, and ownership dynamics. Three different Water Resource Inventory Areas (WRIAs) planning areas are involved in resource management, WRIA 17, 18, and 19. Each containing very different social, economic, and ecological dynamics which impact freshwater habitat limiting factors.

In the 1997 Puget Sound Salmon Stock Report, it was argued that the JDF region had experienced some of the greatest impacts to freshwater habitat in Washington. Most of the habitat degradation is attributed to land management activities of logging and agriculture, as well as urbanization leading to extirpation of some stocks. Loss of habitat was also an issue due to fish blocking culverts (PFMC 1997).

Establishment of land management policies and enforcement since 1999 have helped improve habitat conditions in comparison to pre-1999 historic practices. For example, the Forest Practices Act, which guides the management of privately owned forest land, includes significant portions of land. Regulations such as this have helped increase riparian protections and introduce standards for protecting unstable slopes, as well as support proper road management practices. Despite these efforts legacy impacts from land management activities continue to plague the quality of freshwater habitat.

More than forty-five streams and rivers provide habitat for JDF coho spawners. Detailed, current information for each water body is not available, therefore a monitored creek in eastern Strait and two rivers[2] in the western portion of the Strait will serve as freshwater condition proxies during 2011-2015 (when the brood years in question were incubating and/or rearing in streams).

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[2] In previous JDF overfishing reports, the Pysht River was used as a proxy of freshwater conditions in the western Straits. However in recent years, monitoring efforts have been minimized in the western Straits due to budgetary constraints as well as due to landowner cooperation. Streamflow monitoring sites have been discontinued in the Pysht River, which impacts the ability to assess conditions impacting survival during this reporting period.

McDonald Creek is located between Siebert Creek and the Dungeness River, in the eastern portion of the JDF MU (see Figure 2.2.2.a for location). The headwaters originate at 4,700 feet and the high gradient headwaters flow through a deeply incised coastal upland and marine bluff before entering the Strait of Juan de Fuca.

The Hoko River and Clallam River are located between the Seiku River and the Pysht River, in the western portion of the JDF MU (see Figure 2.2.2.a. for location). It is a rain dominant watershed, averaging approximately 110 inches of precipitation annually. The distribution of the precipitation occurs predominantly during the fall and winter months, where daily events of 1-2 inches is common, and storm events of 4-7 inches occur as well. Overall large woody debris (LWD) conditions in the Hoko watershed are considered very poor, as the presence of existing LWD is low, as a result of systematic log jam removals through the 1970's. Also recruitment of large coniferous wood in riparian areas is absent, as a result of past harvest management activities (Haggerty, 2015). On average each river represents more than 10 percent of total coho spawners in the area from 2013-2016.

Maximum summer temperatures in McDonald Creek and the Clallam River, though above the temperature preference range for juvenile coho salmon, are within tolerable limits (Tables 3.1.1.a and 3.1.1.b). Probably of greater significance are the low flows in the 2014-15 summer and fall months in this rain-dominant watershed (Figure 3.1.1.a). Low flows reduce the amount of available habitat, and can result in stranding of rearing juvenile coho.

Table 3.1.1.a. McDonald Creek (eastern Strait) water conditions.

	High Flows		**Low Flows**			
Year	**Months**	**Avg. CFS**	**Months**	**Avg. CFS**	**Avg Temp °C**	**Days above the highest avg of** 14°C
2011	Jan-May	50	July-Oct	3.3	10	3 days ≥ 15°
2012	Jan-April	44	Aug-Oct	2.4	12	15 days ≥ 15°
2013	No Data	-	Aug-Oct		12	3 days ≥ 15°
2014	Incomplete	-	June-Sept	3.3	14	41 days ≥ 15°
2015	Incomplete	-	June- mid-Dec	2.7	14	44 days ≥ 15°
2016	Incomplete	-	June-Sept	1.6	13	44 days ≥ 15°
DATA SOURCE: Washington Department of Ecology https://fortress.wa.gov/ecy/eap/flows/station.asp?sta=18P070#block0						

Table 3.1.1.b. Clallam River (western Strait) water conditions.

	High Flows		**Low Flows**			
Year	**Months**	**Avg. CFS**	**Months**	**Avg. CFS**	**Avg Temp °C**	**Days above the highest avg of** 14°C
2011	Jan-April	266	July-Sept	14	12	0 days ≥ 15°
2012	Jan-April	263	Aug-Sept	11	12	0 days ≥ 15°
2013	Jan-April	192	July-Aug	11	14	0 days ≥ 15°
2014	Jan-April	247	June-Sept	6	14	43 days ≥ 15°
2015	Jan-April	204	June- Aug	5	14	14 days ≥ 15°
2016	Jan-March	375	May-Sept	14	13	0 days ≥ 15°
DATA SOURCE: Washington Department of Ecology. https://fortress.wa.gov/ecy/eap/flows/station.asp?sta=19H080#block0						

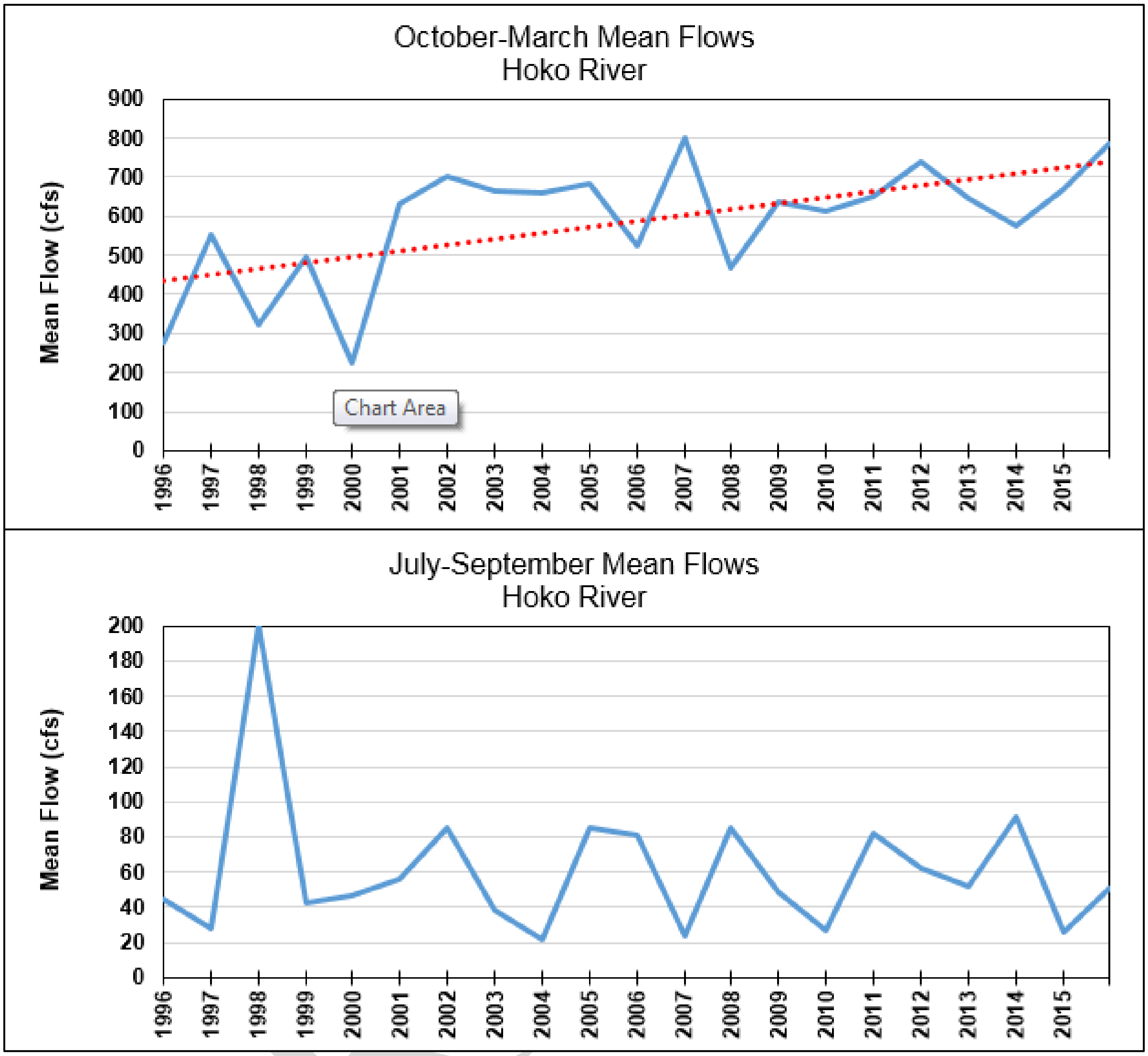

Figure 3.1.1.a. Hoko River (western Strait) water conditions from 1996-2015 across high flow (October-March) and low flow (July-September) months. A regression analysis (red dotted line) indicates statistical significance. The United States Geological Survey has monitored the Hoko River streamflow conditions periodically since 1963, which allows for suitable historic flow comparisons (temperature data is not available). Historic and realtime data can be found at https://waterdata.usgs.gov/usa/nwis/uv?12043300.

3.1.2 Juvenile Production Estimates

Coho salmon in Washington, Oregon, and California enter the ocean as smolts in the spring of their second year, and contribute to fisheries and spawning escapement as 3-year-olds the following calendar year. For JDF coho, smolt production estimates include only natural production with little or no hatchery influence. Hatchery production, as well as natural production from the Elwha and Dungeness Rivers are not included in the total smolt production data. Year classes contributing to the spawning escapements in 2014-2016 were from brood years 2011-2013, and migrated to sea as smolts in 2013, 2014, and 2015 (Figure 3.1.2.a).

Smolt production over the 1996-2015 brood years has ranged from a low of 180,000 in 2010 to a high of 421,000 in 2004. Production from the 2011 and 2012 brood years was above average, and though the production from the 2013 brood year was below average, the JDF coho stock still produced over 220,000 natural smolts that year (Table 3.1.2.a).

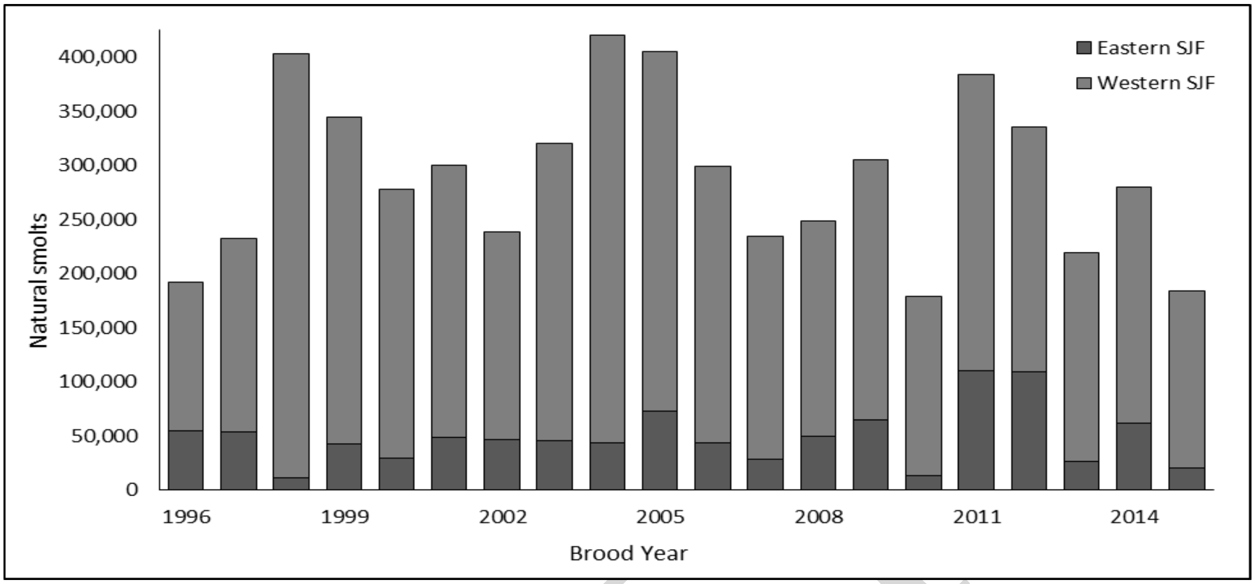

Figure 3.1.2.a. Natural smolt production of JDF coho by brood year.

Table 3.1.2.a. JDF coho natural smolt production. Estimates are expanded from trap counts and exclude natural production from the Elwha and Dungeness Rivers.

		Natural coho smolt production		
Brood year	Smolt year	Eastern Strait	Western Strait	Total
1996	1998	54,881	136,750	191,631
1997	1999	53,401	179,551	232,952
1998	2000	18,125	391,620	409,744
1999	2001	43,139	300,854	343,993
2000	2002	35,675	247,595	283,270
2001	2003	51,835	251,247	303,082
2002	2004	48,183	192,208	240,392
2003	2005	46,917	274,901	321,818
2004	2006	45,260	375,883	421,143
2005	2007	74,817	331,694	406,511
2006	2008	45,177	255,337	300,514
2007	2009	29,827	206,667	236,494
2008	2010	52,447	198,527	250,973
2009	2011	66,835	240,269	307,104
2010	2012	14,001	165,911	179,912
2011	2013	112,970	273,658	386,628
2012	2014	112,804	225,463	338,267
2013	2015	27,647	192,689	220,336
2014	2016	61,582	218,040	279,621
2015	2017	20,550	163,589	184,139

3.2 Marine Survival

3.2.1 Review of Ocean Conditions

While the marine environment affects the survival of coho salmon during their entire marine residence, the most critical time period is shortly after they emigrate from fresh water as smolts.

Coho smolts entering the marine environment in Puget Sound are subject to very different conditions than coastal stocks, which enter more directly into the California Current ecosystem. Consequently, the marine survival of coho stocks that enter salt water in the inside waters of the Salish Sea show different patterns and trends than those of coastal stocks (Zimmerman et al. 2015). The Strait of Juan de Fuca is transitional between Puget Sound and the outer coast, with Western straits populations responding to marine environmental indices more like coastal stocks, and the Eastern straits population responding more like Puget Sound stocks.

Ecosystem indicators that have been associated with early marine survival of Chinook and coho salmon are displayed in Figure 3.2.1.a (Peterson *et al*. 2017). These indicators were selected based primarily on correlations with survival of Columbia River stocks, but are generally indicative of basin-wide marine conditions. Indicators related to the early marine survival of coho are generally related to adult coho abundance in the following year, so the years from 2013-2015 are associated with adult returns in 2014-2016. The mean ranks of indicators were generally neutral, but declining in 2013 and 2014, and have been negative since then. One noteworthy indicator is the catches of juvenile coho in the September surveys. These were highly correlated with coho returns in the following year, but the September surveys were discontinued in 2013, and are thus omitted from the mean ranks.

	Year																		
Ecosystem Indicators	*1998*	*1999*	*2000*	*2001*	*2002*	*2003*	*2004*	*2005*	*2006*	*2007*	*2008*	*2009*	*2010*	*2011*	*2012*	*2013*	*2014*	*2015*	*2016*
PDO (Sum Dec-March)	16	6	3	12	7	18	11	15	13	9	5	1	14	4	2	8	10	19	17
PDO (Sum May-Sept)	10	4	6	5	11	15	14	16	12	13	2	9	7	3	1	8	17	19	18
ONI (Average Jan-June)	18	1	1	6	12	14	13	15	8	11	3	10	16	4	5	7	9	17	19
46050 SST (°C; May-Sept)	15	8	3	4	1	7	19	14	5	16	2	9	6	10	11	12	13	18	17
Upper 20 m T (°C; Nov-Mar)	18	11	8	10	6	14	15	12	13	5	1	9	16	4	3	7	2	19	17
Upper 20 m T (°C; May-Sept)	15	11	13	4	1	3	19	17	7	8	2	5	12	10	6	16	18	9	14
Deep temperature (°C; May-Sept)	19	6	8	4	1	10	12	16	11	5	2	7	14	9	3	15	18	17	13
Deep salinity (May-Sept)	18	3	8	4	5	15	16	9	6	1	2	13	17	12	11	10	19	14	7
Copepod richness anom. (no. species; May-Sept)	17	2	1	7	6	13	12	16	14	10	8	9	15	4	5	3	11	18	19
N. copepod biomass anom. (mg C m^{-3}; May-Sept)	17	13	9	10	3	15	12	18	14	11	6	8	7	1	2	4	5	16	19
S. copepod biomass anom. (mg C m^{-3}; May-Sept)	19	2	5	4	3	13	14	18	12	10	1	7	15	9	8	6	11	16	17
Biological transition (day of year)	17	11	6	7	8	12	10	16	15	3	1	2	14	4	9	5	13	19	19
Ichthyoplankton biomass (log(mg C 1000 m^{-3}); Jan-Mar)	19	10	2	6	8	17	16	12	15	14	1	11	3	13	9	7	18	4	5
Ichthyoplankton community index (PCO axis 1 scores; Jan-Mar)	9	13	1	6	4	10	18	16	3	12	2	14	15	11	5	7	8	17	19
Chinook salmon juvenile catches (no. km^{-1}; June)	18	4	5	16	10	13	17	19	12	8	1	6	7	15	3	2	9	14	11
Coho salmon juvenile catches (no. km^{-1}; June)	18	7	12	5	6	2	15	19	16	3	4	9	10	14	17	1	11	8	13
Mean of ranks	16.4	7.0	5.7	6.9	5.8	11.9	14.6	15.5	11.0	8.7	2.7	8.1	11.8	7.9	6.3	7.4	12.0	15.3	15.3
Rank of the mean rank	19	6	2	5	3	13	15	18	11	10	1	9	12	8	4	7	14	16	16
Ecosystem Indicators not included in the mean of ranks or statistical analyses																			
Physical Spring Trans. UI based (day of year)	3	7	18	15	4	12	14	19	12	1	6	2	8	11	16	9	17	10	5
Physical Spring Trans. Hydrographic (day of year)	18	3	13	8	5	12	14	19	6	9	1	9	17	3	11	2	15	7	16
Upwelling Anomaly (April-May)	9	3	16	5	8	13	12	19	9	4	6	7	14	16	14	11	18	1	2
Length of Upwelling Season UI based (days)	6	2	17	11	1	12	9	19	5	3	8	3	14	16	14	13	18	10	7
SST NH-5 (°C; May-Sept)	8	6	5	4	1	3	19	15	9	17	2	18	10	7	13	12	14	11	16
Copepod Community Index (MDS axis 1 scores)	18	5	4	8	1	13	14	16	15	10	2	6	12	9	7	3	11	17	19
Coho Juv Catches (no. fish km^{-1}; Sept)	11	2	1	4	3	6	12	14	8	9	7	15	13	5	10	NA	NA	NA	NA

Figure 3.2.1.a. Summary of marine indicators from 1998-2017. The top block is basin-wide climate indices, the second block is specific physical oceanographic indicators, and the third block is biological indicators. Numbers inside each block are rank value of that indicator across all years with one being the best and 19 the worst. Color coding is used to reflect ocean conditions for salmon growth and survival (green=good, yellow=intermediate, red=poor). The bottom block includes indicators not included in the mean ranks.

In 2013, there were mixed ocean conditions. The climate-indicators, such as Pacific Decadal Oscillation (PDO) and El Niño, were 'neutral'. However, sea surface temperatures were warmer than usual, and the majority of the upwelling occurred over a short period of time (i.e. July) with the upwelling 'season' ultimately ending much earlier than usual. The biological indicators pointed to good ocean conditions, with a high abundance of large, lipid-rich zooplankton, a moderate abundance of winter fish larvae that develop into salmon prey in the spring, and catches of juvenile spring Chinook salmon during the June survey off Washington and Oregon that were the second highest in 16 years. Overall, juvenile salmon entering the ocean in 2013 encountered average to above average ocean conditions off Oregon and Washington.

In 2014, many of the ecosystem indicators pointed towards a relatively poor year for salmon survival. The summer PDO values were strongly positive (warm), coinciding with a ‘warm blob’ of water centered in the Gulf of Alaska. El Niño conditions were ‘neutral’, sea surface temperatures were warmer than usual, and the upwelling season started late and ended early. The biological indicators featured a high abundance of large, lipid-rich zooplankton, but a low abundance of winter fish larvae that develop into salmon prey in the spring, and moderate catches of juvenile spring Chinook salmon during the June survey off Washington and Oregon. Overall, juvenile salmon entering the ocean in 2014 encountered below average ocean conditions off Oregon and Washington likely leading to below average returns of adult coho salmon in 2015.

In 2015, many of the ocean ecosystem indicators suggested a relatively poor year for juvenile salmon survival. The PDO was strongly positive (warm) throughout 2015, coinciding with anomalously warm ocean conditions in the NE Pacific called “The Blob” that began in the fall of 2013 and persisted through 2015. El Niño conditions also turned positive in April 2015 and remained strongly positive, signaling a strong El Niño at the equator. Despite the strongest upwelling observed since 1998, sea surface and deep water temperatures off Newport Oregon remained warmer than usual (+2°C) throughout most of 2015. During the strongest upwelling period in June, shelf waters did cool and were salty, but returned to positive temperature anomalies quickly from July onward. The zooplankton community remained in a lipid-deplete state throughout 2015, and was dominated by small tropical and sub-tropical copepods and gelatinous zooplankton that generally indicate poor feeding conditions for small fishes upon which juvenile salmon feed. Krill biomass was also among the lowest in 20 years. On the other hand, the biomass of larval fish species that are common in salmon diets in spring was above average this year, however, there were also high concentrations of larval rockfish and Northern anchovy which are generally indicators of poor feeding conditions for salmon. There were also many new copepod species encountered that had never been seen off Newport since sampling began in 1969.

3.2.2 Early life survival rates

Marine survival was calculated for the years from 2004-2016 as the age-3 ocean abundance of JDF coho salmon from postseason FRAM runs divided by the estimated smolt production in the previous year, derived from smolt trapping operations. Postseason coho FRAM runs are conducted by the Pacific Salmon Commission's (PSC) Coho Technical Committee (CoTC) each year to evaluate the Pacific Salmon Treaty. Marine survival is well correlated with age-3 ocean abundance ($r^2 = 0.84$) over the 13 year period from 2004-2016 (Figure 3.2.2.a). Marine survival of the 2012 brood year, which migrated to the ocean in 2014 and returned as adults in 2015, was the third lowest of the 13 year period. Marine survival of the broods returning in 2014 and 2016 were more typical, although they were still below the median survival.

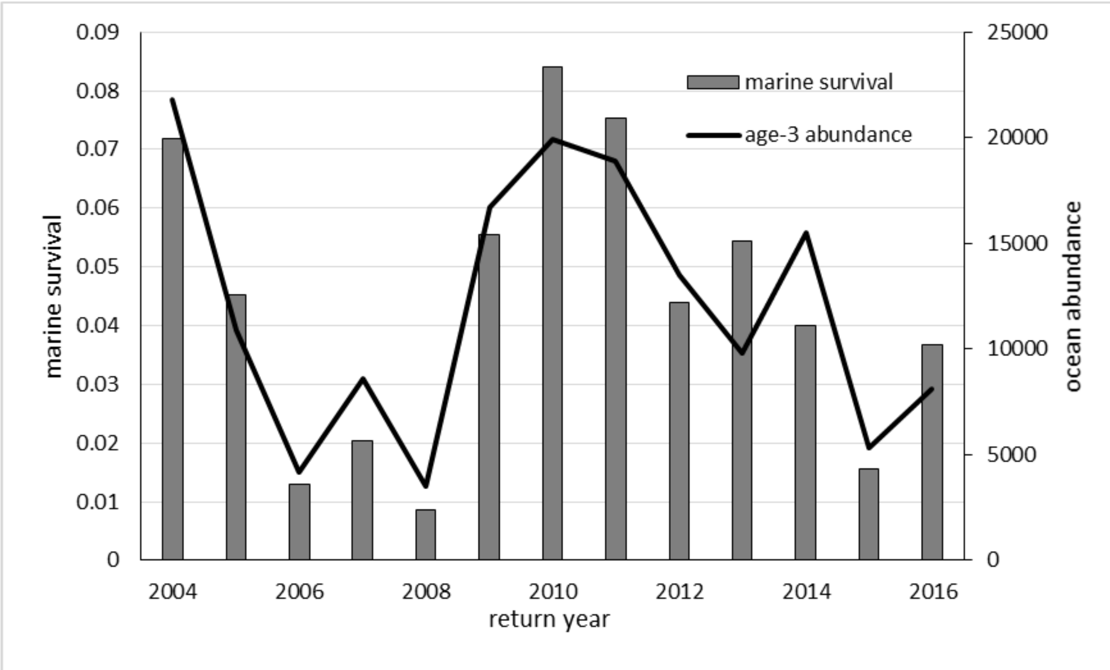

Figure 3.2.2.a. Marine survival of JDF coho salmon calculated from age-3 ocean abundance using postseason FRAM runs (PSC CoTC) and trap-based estimates of natural smolt production in the previous year.

3.3 Harvest Impacts

3.3.1 Ocean fisheries

Season Descriptions

JDF coho are harvested in ocean fisheries in Washington, British Columbia, and to a lesser extent, in Alaska. They are also taken in Puget Sound fisheries, and commercial and recreational fisheries in the Strait of Juan de Fuca. There are no significant terminal net fisheries in the Strait, and recreational harvest in the rivers is negligible. Prior to 1997 the majority of harvest occurred in Canadian fisheries off the west coast of Vancouver Island. Beginning in 1997, Canada severely restricted coho fisheries to minimize impacts on Upper Fraser coho stocks, and Canadian fishery impacts on JDF coho decreased sharply

Commercial Ocean Seasons

Council area commercial troll fisheries south of Cape Falcon typically do not allow retention of coho. North of Cape Falcon, non-Indian and Treaty Indian troll regulations typically allow coho retention from July through September. In 2014 and 2015, coho retention in the non-Indian commercial troll fishery was limited to adipose-marked coho through August; non-selective coho fisheries occurred in September. In 2016, the non-Indian commercial troll fishery was limited to 30 total fishing days in July and August; September was closed to all troll fishing. Coho retention was not allowed in the fishery in 2016. The Treaty Indian troll fishery was open from July through mid-September in 2014 and 2015 for all salmon species, and was limited to July and August in 2016, with no coho retention.

Recreational Ocean Seasons

North of Cape Falcon, the all-species recreational salmon fisheries were open from mid-June through late September in 2014 and 2015. In both years, coho retention was limited to adipose-marked coho through August, and unmarked coho retention was allowed in September. In 2016, the recreational fishery was limited to July 1 through August 27. Coho retention was not allowed north of Leadbetter Point in 2016.

South of Cape Falcon, coho retention was allowed from late June through early August in 2014, 2015, and 2016 with retention limited to adipose-marked coho. Unmarked coho retention was allowed each year in September.

Ocean Harvest

In 2014, 2015, and 2016, landings in both commercial troll and ocean recreational fisheries were managed within their quotas (Table 3.3.1.a). In the area north of Cape Falcon, coho harvest was severely restricted, if not prohibited, in 2016 due to the low forecasted returns. In the area North of Cape Falcon, Council-area fisheries harvested 78 percent of the 282,500 coho quota in 2014, 42 percent of the 216,770 fish quota in 2015, 85 percent of the very low quota of 18,900 in 2016. Table 3.3.1.a shows coho quotas and catch by fishery during 2014, 2015, and 2016.

Table 3.3.1.a. Coho harvest quotas for Council area commercial and recreational fisheries compared with actual harvest by management area and fishery.

	2014			2015			2016		
Fishery Governed by Quota or Guideline	Quota	Catch	Catch/ Quota	Quota	Catch	Catch/ Quota	Quota	Catch	Catch/ Quota
NORTH OF CAPE FALCON									
TREATY INDIAN COMMERCIAL TROLL	62500	55897	0.894	42,500	3,983	9%	-	-	-
NON-INDIAN COMMERCIAL TROLL	35200	23141	0.657	19,200	5,059	26%	-	-	-
RECREATIONAL	184,800	140,450	76%	155,070	82,986	54%	18,900	16,059	85%
TOTAL NORTH OF CAPE FALCON	**282,500**	**219,488**	**78%**	**216,770**	**92,028**	**42%**	**18,900**	**16,059**	**85%**
SOUTH OF CAPE FALCON									
RECREATIONAL									
Coho mark-selective	80,000	48,530	61%	55,000	14,896	27%	26,000	1,547	6%
Coho non-mark-selective	35,000	34,267	98%	20,700	4,445	21%	7,500	4,170	56%
TOTAL SOUTH OF CAPE FALCON	**115,000**	**82,797**	72%	**75,700**	**19,341**	26%	**33,500**	**5,717**	17%
GRAND TOTAL COUNCIL AREA	**397,500**	**302,285**	**76%**	**292,470**	**111,369**	**38%**	**52,400**	**21,776**	**42%**

Source: PFMC Review of Ocean Fisheries, Table I-6, Feb 2015, Feb 2016, Feb 2017

3.3.2 Puget Sound Fisheries

There are no U.S. in-river net or sport fisheries directed at JDF coho salmon. The only sport fishery for salmon is the hatchery coho fishery in the Dungeness River, which is not included in the evaluation of JDF coho escapement. In-river fishery impacts are limited to incidental impacts in net and sport fisheries directed at other species.

Tribal Fisheries

Strait of Juan de Fuca (Area 5) is predominantly gillnet harvest during July-August, and then switches to set net harvest in October. Harvest in Areas 6 and 6C are modest.

In Central Puget Sound, harvest is largely from Area 10, in similar proportions for the month of September, October, and for gillnet and purse seine gears. Tribes have very limited fisheries in Area 9.

Harvest in terminal areas 8A and 8D are much larger in comparison to those in the Strait of Juan de Fuca and the Central Sound. During 2009-2016, total coho harvest amounted to 291,959 fish in Areas 8A and 8D (73,364 and 218,595 respectively). Most of the catch in both areas, occur in September, by gillnet in 8A and set net in 8D. In 8A there is very limited incidental coho catches from pink fisheries (calendar weeks 33-35) in odd-years, and none have occurred past the coho management period, since chum fisheries have remained closed in recent years. The 8D fishery targets Tulalip hatchery origin salmon (coho, chum and Chinook) on average the proportion of non-Tulalip Hatchery coho (around 15 percent) is significantly less than in the outside portion ("the Bubble") at 30 percent.

Coho tribal fisheries catches (all stocks) in the Strait of Juan de Fuca (Areas 5, 6, and 6C), Central Sound, and Terminal areas (8A, 8D) for the period 2009-2016 are summarized in Appendix B.

Non-Indian Commercial seasons

The number of non-Indian commercial fisheries targeting coho within Puget Sound are limited in time and area. Within Puget Sound, non-Indian and Treaty Indian regulations typically allow coho retention from September through mid-October. In 2014 and 2015, coho retention in the non-Indian commercial Gillnet, Purse Seine, and Beach Seine Fisheries was limited to Quilcene Bay, Port Gamble Bay, Bellingham Bay, Dungeness Bay, Tulalip Bay and the waters through Possession Sound Northward to Camano Head. In 2016, the non-Indian commercial fishery targeting coho was not planned in the Tulalip Bay and Possession Sound areas, but was offered in all other areas.

Recreational seasons

Recreational fishing seasons in the marine catch areas of Puget Sound (Areas 5-13; see map in Appendix B, Table B.1) allowed some coho retention in most areas during the 2014-15 and 2015-16 seasons, via non-selective (NSF) or mark-selective (MSF) coho fisheries as specified in Table B.1. The standard daily bag limit in these fisheries was generally 2 salmon – up to 2 hatchery marked (adipose fin-clipped) coho in MSFs, and up to 2 coho (either marked or unmarked) in NSFs. Additionally, in 2015, as is typical for odd-year regulations, a pink salmon bonus limit (2 pink salmon in addition to the standard 2 salmon limit) was allowed in all Puget Sound marine areas except Areas 8-1 and 8-2. In contrast, coho retention was not allowed in most Puget Sound marine areas during the 2016-17 season due to relatively low run size forecasts for most Puget Sound coho stocks, with the exception of Hood Canal (Area 12; see further detail in Appendix B).

Puget Sound marine area harvest

Table 3.3.2.a. Coho harvest in Puget Sound marine fisheries.

Year	Treaty Indian	Non-Indian Commercial	Recreational[c/]
2004	533,188	39,481	83,708
2005	287,037	19,694	58,309
2006	259,779	9,827	26,688
2007	209,137	13,435	65,306
2008	227,273	6,464	21,400
2009	259,528	20,091	75,719
2010	153,683	18,220	20,290
2011	223,800	28,821	56,775
2012	355,839	35,628	169,884
2013	298,503	29,577	115,934
2014	192,561	11,815	124,185
2015	47,263	4,777	142,669
2016	259,930	14,486	4,983
2017	191,726	11,763	NA
2004-13 Ave.	280,777	22,124	69,401

Source: PFMC Review of 2017 Ocean Fisheries, Tables B-39 and B-40

3.3.3 Total Exploitation Rates

Postseason harvest and exploitation rate data for JDF coho were compiled from post season model runs of the Fishery Regulation Assessment Model (FRAM) that are generated annually by the Coho Technical Committee (CoTC) of the Pacific Salmon Commission. Over the 13 year period from 2004 through 2016, the total exploitation rate on JDF coho averaged 10.8 percent and ranged from a high of 17.8 percent in 2015 to a low of 2.9 percent in 2016 (Table 3.3.3.a). Over this time period, approximately 19 percent of the total exploitation occurred in Alaskan and Canadian fisheries while 21 percent occurred in Council fisheries on average. The remaining 60 percent occurred in other preterminal and terminal fisheries, mostly in sport, net, and troll fisheries in the Strait of Juan de Fuca (Figure 3.3.3.a, Table 3.3.3.a).

Under Amendment 16 to the FMP adopted by the Council in 2011, Puget Sound coho management units in the low abundance category are allowed a *de minimus* exploitation rate of up to 20 percent. Over the period from 2004-2016, total exploitation rates on JDF coho have remained below this limit, even though the management unit has not always been in the low abundance category. It is noteworthy, however, that the most recent three years in the time series included both the two highest exploitation rates (16.6 percent and 17.8 percent in 2014 and 2015, respectively) and the lowest observed exploitation rate (2.9 percent in 2016). During these same three years, exploitation rates in Council area fisheries ranged from 0.5 percent in 2016 to 2.1 percent in 2014 (Figure 3.3.3.a, Table 3.3.3.a).

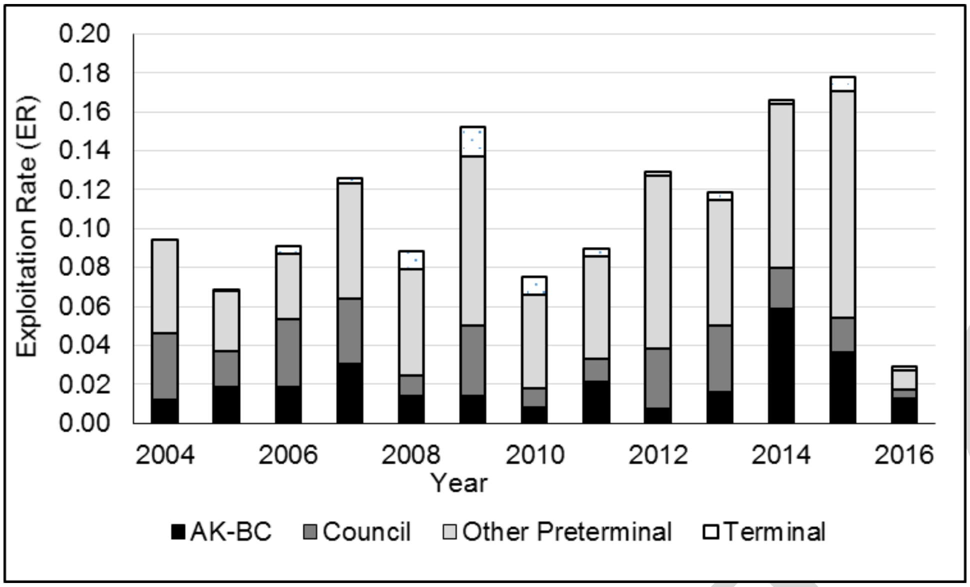

Figure 3.3.3.a. Postseason total exploitation rates by major fishery group on JDF coho (East JDF and West JDF Miscellaneous Wild model stocks) from FRAM estimates generated by the PSC CoTC.

Table 3.3.3.a. Ocean abundance, escapement and exploitation rates for JDF coho (East JDF and West JDF Miscellaneous Wild model stocks) from postseason FRAM estimates generated by the PSC CoTC.

Strata	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
Ocean Age 3 Abundance	21,816	10,933	4,184	8,613	3,487	16,743	19,914
Escapement	19,756	10,186	3,802	7,528	3,179	14,199	18,420
Alaska-Canada	1.2%	1.9%	1.8%	3.0%	1.4%	1.4%	0.8%
NOF - Treaty Troll	2.7%	1.5%	3.0%	2.6%	0.9%	2.8%	0.6%
NOF - Nontreaty Troll	0.2%	0.1%	0.1%	0.2%	0.0%	0.3%	0.1%
NOF - Sport	0.4%	0.2%	0.2%	0.4%	0.1%	0.4%	0.2%
SOF all	0.2%	0.1%	0.2%	0.2%	0.0%	0.1%	0.1%
Preterminal Other	4.8%	3.1%	3.4%	5.9%	5.5%	8.7%	4.8%
Terminal Sport	0.0%	0.0%	0.2%	0.0%	0.9%	1.4%	0.9%
Terminal Net	0.0%	0.1%	0.2%	0.3%	0.0%	0.1%	0.0%
Total ER	9.4%	6.8%	9.1%	12.6%	8.8%	15.2%	7.5%
Strata	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	
Ocean Age 3 Abundance	18,857	13,498	9,752	15,535	4,500	7,933	
Escapement	17,169	11,752	8,592	12,958	3,698	7,703	
Alaska-Canada	2.1%	0.7%	1.6%	5.9%	3.6%	1.3%	
NOF - Treaty Troll	0.7%	2.0%	2.7%	1.4%	0.5%	0.0%	
NOF - Nontreaty Troll	0.1%	0.2%	0.2%	0.1%	0.3%	0.1%	
NOF - Sport	0.2%	0.3%	0.3%	0.2%	0.7%	0.2%	
SOF all	0.2%	0.7%	0.2%	0.3%	0.3%	0.2%	
Preterminal Other	5.3%	8.9%	6.4%	8.4%	11.6%	0.9%	
Terminal Sport	0.3%	0.2%	0.0%	0.0%	0.0%	0.0%	
Terminal Net	0.1%	0.0%	0.4%	0.2%	0.8%	0.2%	
Total ER	9.0%	12.9%	11.9%	16.6%	17.8%	2.9%	

3.4 Assessment and management

3.4.1 Abundance forecast errors

The history of preseason forecasting of JDF coho has not been one of noteworthy accuracy. Through at least the past two decades, the forecasts have relied on the basic principle that the adult recruits are the product of smolt outmigration multiplied by a marine survival rate. That principal is a sound one; however, predicting that marine survival rate has not been an easy task.

Before 2007, the forecasts were developed by multiplying the brood year smolt outmigration by a 3-year average marine survival to December age-2 recruits (an age that is no longer used in FRAM).

In 2007, recognizing that JDF coho had undergone very low marine survival rates for the previous two years, the co-managers used the PDO index to predict marine survival. This method, which had used a regression model that was not statistically significant, reduced the predicted marine survival rate by only a small amount, and ultimately overpredicted the survival rate for that year by about five times. That method was abandoned, and in the following year of 2008, the forecast was again based on a 3-year average marine survival rate. Beginning in 2009, and continuing through the present year, the forecast was developed once again by using independent variables to predict marine survival.

These predictor variables, however, have not been used consistently from year to year. For example, the September juvenile coho catches in the NOAA trawl surveys offshore of Oregon and Washington were an excellent predictor of marine survival for coho returning as adults the following year ($P=0.042$ for predicting marine survival; $P=0.009$ for predicting recruits directly). That data series was collected over a 15-year period, but the September trawl surveys were discontinued after 2012 for funding reasons, and other variables were used to predict marine survival in later years. Predictor variables that were statistically significant have been used in other years, but as post season abundance estimates became available from other years, some of those predictor variables were no longer good predictors, and were dropped from the forecasts.

Additional forecasts using various methods developed by others for coastal and Puget Sound natural coho stocks are also reviewed annually to assess how the different JDF forecast model options fit into the bigger regional picture.

In 2014 and 2016, the forecasts were lower than the postseason estimate of abundance (under-forecast), while in 2015 the forecast abundance was greater than the postseason estimate of abundance (over-forecast) (Figure 3.4.1.a, Figure 3.4.1.b). Despite the inaccuracy, the forecasted abundance fell into the correct abundance category in every year during 2014-2016. Consequently, abundance forecast errors did not play a substantial role in the overfished classification.

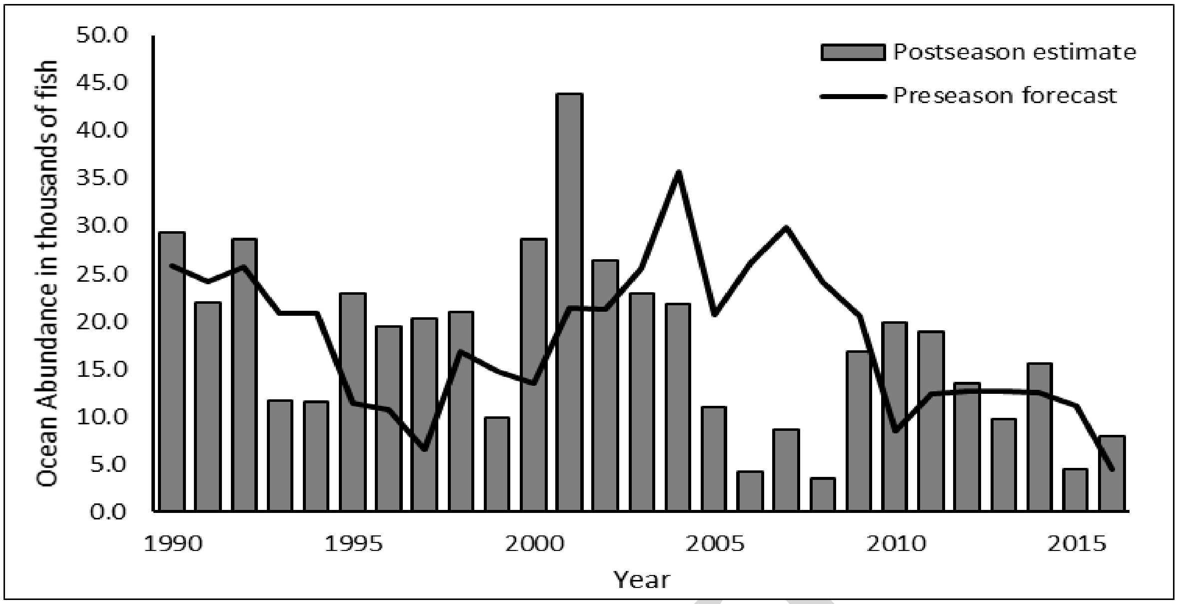

Figure 3.4.1.a. Preseason forecasts and postseason FRAM estimates of ocean age 3 abundance of JDF coho (East JDF and West JDF Miscellaneous Wild model stocks). Preseason forecasts are generated by salmon co-managers and postseason FRAM estimates are generated by the PSC CoTC.

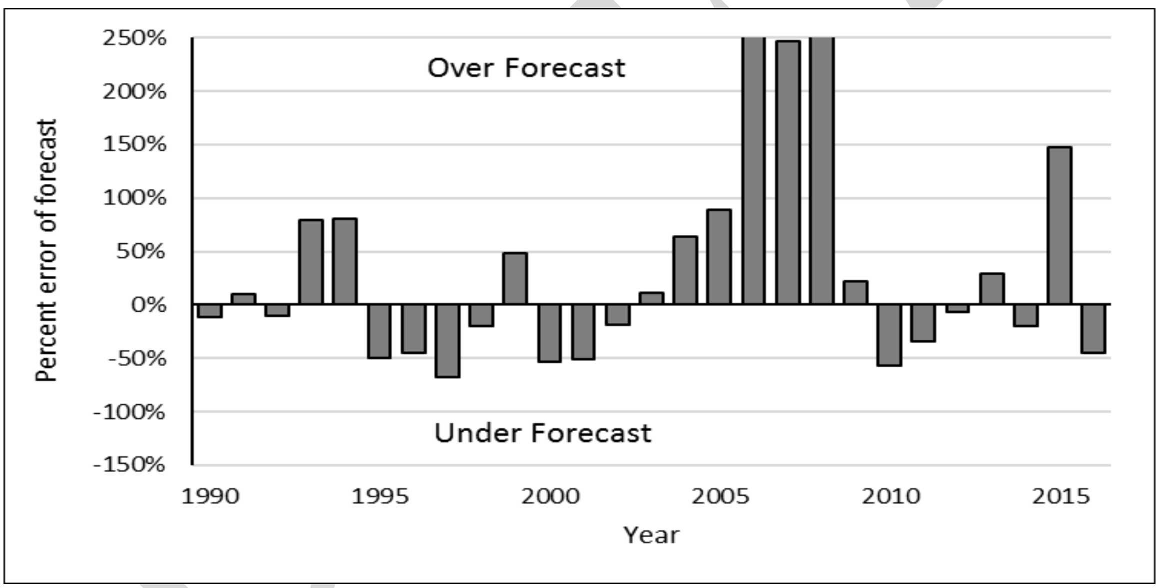

Figure 3.4.1.b. Preseason forecast error when compared to postseason estimates of ocean abundance of JDF coho (East JDF and West JDF Miscellaneous Wild model stocks). Preseason forecasts are generated by salmon co-managers and postseason FRAM estimates are generated by the PSC CoTC.

Table 3.4.1.a. Preseason and postseason estimates of ocean age 3 abundance (in thousands of fish) for JDF coho (in thousands of fish (East JDF and West JDF Miscellaneous Wild model stocks).

Year	Preseason Forecast	Postseason Estimate[a/]	Pre/ Postseason
Strait of Juan de Fuca			
1990	25.8	29.4	0.88
1991	24.1	22.0	1.10
1992	25.7	28.6	0.90
1993	20.8	11.6	1.79
1994	20.8	11.5	1.81
1995	11.4	23.0	0.50
1996	10.7	19.4	0.55
1997	6.5	20.3	0.32
1998	16.8	21.0	0.80
1999	14.7	9.9	1.48
2000	13.5	28.6	0.47
2001	21.4	43.9	0.49
2002	21.3	26.3	0.81
2003	25.6	22.9	1.12
2004	35.7	21.8	1.64
2005	20.7	10.9	1.89
2006	26.1	4.2	6.24
2007	29.9	8.6	3.47
2008	24.1	3.5	6.91
2009	20.5	16.7	1.22
2010	8.5	19.9	0.43
2011	12.3	18.9	0.65
2012	12.6	13.5	0.93
2013	12.6	9.8	1.29
2014	12.5	15.5	0.80
2015	11.1	4.5	2.47
2016	4.4	7.9	0.55

a/ Coho FRAM was used to estimate post season ocean abundance.

3.4.2 Exploitation rate forecast errors

The escapement years that contributed to the overfished determination for JDF coho were 2014 through 2016. The forecasts during these years placed the abundance in the appropriate category. In 2014, the stock was in the moderate abundance category with a total ER cap of 40 percent, and in 2015 and 2016 it was in the low abundance category with a total ER cap of 20 percent. Regardless of the abundance category, both preseason predicted ERs and postseason observed ERs have consistently been less than 20 percent due to management measures necessary to meet more limiting management criteria of other stocks. The postseason estimated total ERs were greater than the preseason projections in 2014 and 2015, but less than the preseason projection in 2016. In 2014 and 2015, the total postseason estimated ERs were higher than those projected preseason, mainly due to greater than anticipated impacts in northern fisheries and in recreational fisheries in the Strait of Juan de Fuca and Puget Sound (Table 3.4.2.b). In every case, the impacts in Council area fisheries were less than anticipated.

A summary of preseason projected and postseason estimated total exploitation rates, compared to those allowed (cap) since 2010 is provided in the following table. This helps illustrate the change in preseason/postseason exploitation rates, and also the change in the ER ‘cap’.

Table 3.4.2.a. Preseason and postseason total exploitation rates for JDF coho generated in FRAM modeling conducted by the PFMC Salmon Technical Team (preseason) and the PSC CoTC (postseason).

	Exploitation Rate			
Return	Preseason		Postseason	
Year	Projected	ER Cap[a/]	Estimated	ER Cap[a/]
2010	11%	20%	8%	40%
2011	11%	40%	9%	40%
2012	13%	40%	13%	40%
2013	13%	40%	12%	20%
2014	**12%**	**40%**	**17%**	**40%**
2015	**13%**	**20%**	**18%**	**20%**
2016	**5%**	**20%**	**3%**	**20%**
Average	11%	31%	11%	31%

a/ See CoTC 2013 for information on determination of ER caps.

Table 3.4.2.b. Preseason forecast and postseason estimates of escapement, total mortality, and exploitation rate by fishery for JDF natural coho during years that contributed to the overfished classification. Data Sources: preseason forecasts generated by salmon co-managers, preseason exploitation rates from FRAM modeling by the PFMC STT, and postseason FRAM estimates generated by the PSC CoTC.

	2014		2015		2016	
FISHERY COMPONENT	Preseason	Postseason	Preseason	Postseason	Preseason	Postseason
Ocean Age 3 Abundance	12,582	15,535	11,170	4,500	4,433	7,933
FMP Smsy	11,000	11,000	11,000	11,000	11,000	11,000
Escapement after all fisheries	11,073	12,958	9,762	3,698	4,203	7,703
Alaska-Canada	153	917	312	164	119	101
Council North of Falcon						
Treaty Troll	357	223	230	22	1	1
Nontreaty Troll	53	23	43	12	5	6
Sport	59	28	55	33	15	13
Council South of Falcon	81	49	47	12	18	18
Council Subtotal	**550**	**323**	**375**	**79**	**39**	**38**
Preterminal Other						
Troll	1	6	36	5	-	-
Net	338	311	211	25	66	74
Sport	459	991	467	494	6	1
Terminal Net and Sport	8	29	7	35	-	16
Total Fishing Mortality	**1,509**	**2,577**	**1,408**	**802**	**230**	**230**
Alaska-Canada	1.2%	5.9%	2.8%	3.6%	2.7%	1.3%
Council North of Falcon						
Treaty Troll	2.8%	1.4%	2.1%	0.5%	0.0%	0.0%
Nontreaty Troll	0.4%	0.1%	0.4%	0.3%	0.1%	0.1%
Sport	0.5%	0.2%	0.5%	0.7%	0.3%	0.2%
Council South of Falcon	0.6%	0.3%	0.4%	0.3%	0.4%	0.2%
Council Subtotal	**4.4%**	**2.1%**	**3.4%**	**1.8%**	**0.9%**	**0.5%**
Preterminal Other						
Troll	0.0%	0.0%	0.3%	0.1%	0.0%	0.0%
Net	2.7%	2.0%	1.9%	0.6%	1.5%	0.9%
Sport	3.6%	6.4%	4.2%	11.0%	0.1%	0.0%
Terminal Net and Sport	0.1%	0.2%	0.1%	0.8%	0.0%	0.2%
Total Exploitation Rate	**12.0%**	**16.6%**	**12.6%**	**17.8%**	**5.2%**	**2.9%**

3.5 Summary of potential causal factors

In analyzing the reasons why JDF coho did not achieve their minimum spawner threshold for the return years 2014 through 2016, it is useful to examine the events and conditions that affect their life cycle and limit their abundance. As the preceding sections discuss, in the three-year coho life from egg to spawner, there are numerous conditions that affect their survival and return rate, but for the purpose of this analysis we can distill those down to freshwater conditions, ocean conditions, and fisheries.

In this section, we compare the effects of events and conditions at different life-cycle stages by applying the range of variables from one life stage to the average from another. This approach shows the effect that each life stage can make when the other life stages are held constant. The results of this analysis are shown in Table 3.5.1, and discussed here.

Freshwater conditions, including parent-year spawning escapement, are reflected in annual smolt abundance. We can view the smolt abundance as incorporating the effects of not only the parent-year spawning escapement, but also the events and environmental conditions the coho experience during incubation and freshwater residence. For brood years 2001 through 2013 (return years 2004 through 2016) the abundance of smolts has varied by a factor of less than 2-to1, from a high of about 420,000 to a low of 219,000. If we apply the average marine survival rate for this stock, 4.2 percent, to this range of smolt abundance we find that the entire freshwater life history, from egg to smolt, makes a difference of about 10,000 ocean age-3 recruits.

By contrast, marine survival rates for Strait of Juan de Fuca coho over these same brood years have varied by a factor of 8-to-1, from a high of over 8 percent to a low of less than 1 percent. Applying these rates to an average smolt production over this time period of 299,000 smolts, we can conclude that the marine survival rates make the difference of about 18,500 ocean age-3 recruits. Marine survival was below the median value for the three broods, especially for the brood returning in 2015. Lower marine survival in 2015 is attributed to poor ocean conditions and lack of available prey. In 2015, JDF coho returned in much lower numbers than forecasted preseason. They were also much smaller than normal, resulting in less fecundity per returning adult. This had a compounding effect on the resource, resulting in both low escapement and low spawning potential for those that did return.

To put this in terms of ocean age-3 recruits, if we apply the range of marine survival rates to the average smolt abundance for brood years 2001 through 2013, we find that the marine survival rates make a difference of about 18,500 ocean age-3 recruits, while all the variability in freshwater conditions and parent-year escapement combined make a difference of about 10,000 ocean age-3 recruits. These recruits could contribute to either catch or spawning escapement, depending on fishery management decisions.

The low marine survival resulted in ocean age-3 abundances that were in the low, or lower end, of the moderate abundance categories for all three broods. Since 2004, the ocean age-3 abundance has never been high enough to be categorized as abundant, despite marine survival rates that have averaged more than 4 percent, and have exceeded 8 percent. This suggests that freshwater productivity may be a chronic problem that, coupled with recent marine conditions, has reduced the productivity of the JDF coho, to the point where the breakpoints in stepped exploitation rate harvest policy and/or the allowable total ERs may need to be reexamined.

By comparison, fishery mortality on this stock has been fairly low, and has made a correspondingly low difference in spawning escapement. The total fishery mortality of Strait of Juan de Fuca natural coho in all fisheries (calculated from the data shown in Table 3.3.3.a) has ranged from about 200 to 2,500. In North of Falcon ocean fisheries, the total fishery mortality of this stock, excluding the year 2016, when there were no ocean coho fisheries, has ranged from a low of 68 fish to a high of 720 fish.

During the 2004-2016 time period, exploitation rates have consistently been maintained at levels below the rate allowed when the stock is in the low abundance category, and have averaged less than 11 percent. However, 2014 and 2105 experienced the highest ERs in this time period, and this did contribute to the stock being classified as overfished. Council area fisheries have accounted for about one-fifth of the harvest impacts on JDF coho during this time period, while other pre-terminal fisheries in the Strait of Juan de Fuca and Puget Sound have accounted for a little over half. Consequently, harvest reductions have limited efficacy in rebuilding this stock.

Forecasting errors have been large in past years, with forecasts in some years being greater than five times the actual abundance. However, in 2014-2016 the forecasts placed the abundance status in the correct category in every year, and thus did not contribute to the stock becoming overfished. In each year the ER in Council-area fisheries was less than the preseason expectation, so management error in Council-area fisheries did not play a role in the stock becoming overfished. However, in 2014 and 2015 total ERs exceeded the preseason expectation by 4 percent and 5 percent respectively, so it could be argued that although ERs were lower that the FMP allowed, management error contributed to the stock becoming overfished.

Table 3.5.a. applies the extremes of one set of conditions to the average of three stages in the life of the coho. The results shown in the table are not the actual numbers of recruits or spawners, but are the product of the calculations: for example, the high marine survival rate applied to an average number of smolts. The table shows the extent to which freshwater and marine conditions and fishery mortality can affect the number of adult recruits or the number of spawners. These results make it clear that ocean conditions, as reflected in marine survival rates, drive the abundance of adult recruits of this stock more than any other factor, and therefore affect the abundance of spawners more than any other factor. Although the only regulatory tool available to the Council is management of ocean fisheries, ocean conditions have led to rebuilding in the past – as recently as the past decade. While we cannot predict future ocean conditions, they might also allow for rebuilding this stock sooner than restrictions on fisheries can.

Table 3.5.a. Comparison of factors affecting abundance of JDF coho.

		High	Low	Difference
Recruit abundance as limited by freshwater conditions				
Average marine survival rates	4.2%			
Smolt abundance		419,695	179,266	
Resulting ocean age-3 recruits		17,616	7,524	10,091
Recruit abundance as limited by marine survival				
Average smolts	299,134			
Marine survival rates		8.5%	0.9%	
Resulting ocean age-3 recruits		20,645	2,113	18,532
Spawner abundance as limited by fishery mortality				
Average ocean age-3 recruits	11,982			
Fishery mortality, all fisheries combined		2,577	230	
Resulting spawners		9,405	11,752	2,347

4.0 RECOMMENDATIONS FOR ACTION

4.1 Recommendations 1: Rebuilt criterion

Consider the JDF coho stock to be rebuilt when the 3-year geometric mean of natural-area adult escapement meets or exceeds S_{MSY}. This is the default rebuilt criterion in the FMP.

4.2 Recommendation 2: Management Strategy Alternatives

Recommend the Council adopt a management strategy (control rule) that will be used to guide management of fisheries that impact JDF coho until rebuilt status is achieved. We offer three alternative management strategies for consideration. The rebuilding time frame under each of the three Alternatives are not expected to exceed 10 years. The probability of achieving rebuilt status for years 1 through 10 are projected for Alternatives I and III in Section 4.4. *Analysis of Management Strategy Alternatives.*

The description of Alternatives may include references intended to meet NEPA or MSA criteria. Guidelines suggest that alternatives are identified as either an 'action' or a no-action' alternative, and that the minimum time (T_{MIN}) and maximum time (T_{MAX}) estimated to achieve rebuilt status is acknowledged within the suite of alternatives.

<u>Alternative I</u>: Status quo control rule. During the rebuilding period continue to use the current management framework and reference points, as defined in the FMP and the PST, to set maximum allowable exploitation rates on an annual basis. Projected rebuilding time is five years (see Section 4.4). This would be considered a 'no-action' alternative, and represents T_{MAX}.

<u>Alternative II</u>: Reduced Coho Harvest. The Council will plan ocean fisheries to limit impacts on the rebuilding stock consistent with escapement thresholds and exploitation rate limits identified by the Washington co-managers, and consistent with the FMP. The co-

managers may adjust escapement thresholds and exploitation rate limits annually, as described in the FMP, to promote rebuilding of the stock while allowing limited fisheries to occur. The state and tribal co-managers will plan inside fisheries during the North of Falcon preseason process that, when combined with PFMC fisheries, will meet the applicable escapement and exploitation rate objectives.

Alternative III: Suspend all salmon-directed ocean and in-river fisheries from the U.S/Canada border to Cape Falcon until rebuilt status is achieved. Projected rebuilding time is four years (see Section 4.4). This is considered an 'action' alternative, representing T_{MIN}.

Alternative III includes fisheries that the Council does not have jurisdiction over. It also does not meet the purpose and need because it would restrict tribal fisheries in a manner that is inconsistent with their treaty right. Alternative III is provided solely to serve as a bookend in the analysis of rebuilding probabilities over a ten year period when assuming an exploitation rate of zero. This Alternative fulfills the requirement of National Standard 1 in calculating the minimum time (T_{MIN}) estimated to achieve rebuilt status.

4.3 Recommendation 3: Habitat Committee

This report has identified that habitat conditions may have contributed to escapement shortfalls and thus the overfished status determination. It is recommended that the Council direct the Habitat Committee to work with federal, state, local, and tribal habitat experts to review the status of the essential fish habitat affecting the overfished stock and, as appropriate, provide recommendations to the Council for restoration and enhancement measures within a suitable time frame, as described in the FMP.

4.4 Analysis of Management Strategy Alternatives

The STT has developed a simple model to assess the probability of a stock achieving rebuilt status in each year following the overfished declaration. Future abundance is based on observed past abundance levels for the stock. Realistic levels of error in abundance forecasts, escapement estimates, and exploitation rate implementation contribute to the projected adult spawner escapement. Replicate simulations are performed to allow for computation of the probability of rebuilt status by year. The model framework allows for evaluation of alternative rebuilding plans by specifying the rebuilding plans as alternative harvest control rules. The tool has some elements of a management strategy evaluation (MSE), but lacks an explicit biological operating model. This simplification is necessary because for many stocks data limitations do not allow for the development of full population dynamics models. Model structure, parameterization, and additional results are presented in Appendix C.

Figure 4.4.a. displays the projected probability of achieving rebuilt status in year one through 10 of the rebuilding period for status quo (Alternative 1) and no fishery impacts (Alternative III). Year one is assumed to be the year following the stock meeting the criteria for overfished status. Thus, year one in Figure 4.4.a represents year 2017. Under each of the alternatives the probability of achieving rebuilt status in year one essentially zero. The probability of achieving rebuilt status by year five is greater than 0.50 for both Alternatives I and III, and greater than 0.80 by year 10.

The projected rebuilding time is defined as the number of years needed for the probability of achieving rebuilt status to exceed 0.50. Rebuilding times are projected to be five years for Alternative I, and four years for Alternative III.

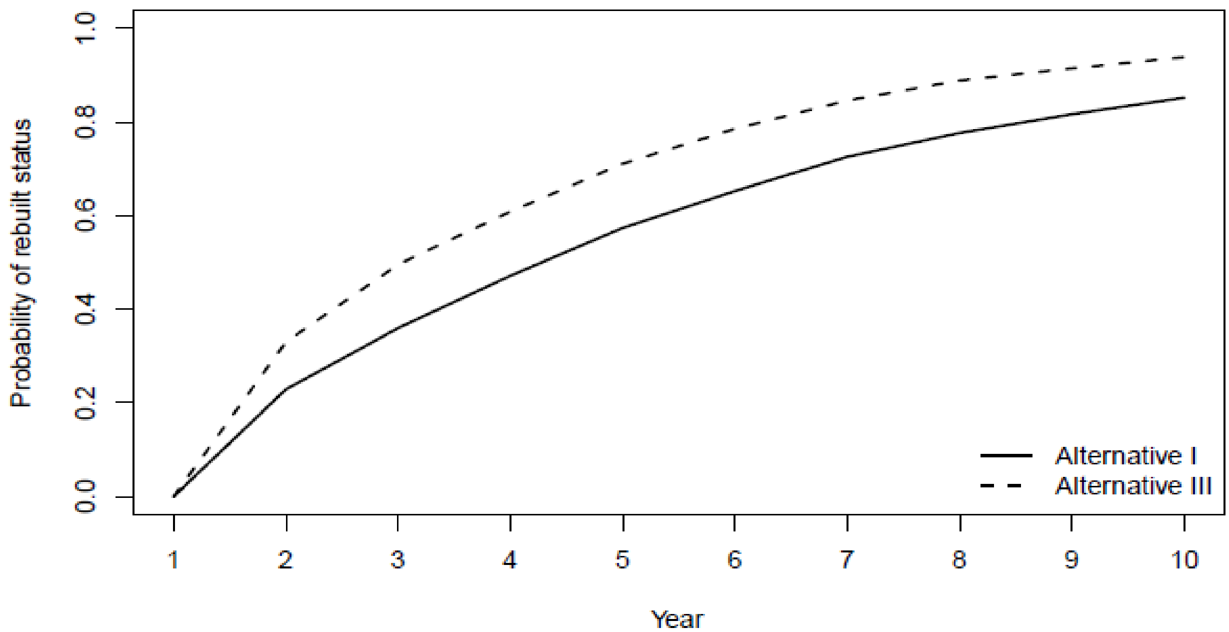

Figure 4.4.a. Projected probability of achieving rebuilt status by year under two alternative rebuilding plans.

4.5 Further recommendations

In light of the current habitat conditions and recent marine survival, it is recommended that the co-managers re-examine S_{MSY} and MSST reference points that are incorporated into the FMP and the Comprehensive Coho Management Plan. Since the development of the reference points in 2000, new data and modeling analysis are available that may provide for more appropriate values.

5.0 SOCIOECONOMIC IMPACT OF MANAGEMENT STRATEGY ALTERNATIVES

5.1 Alternative I

Current management framework and reference points, as defined in the FMP and the PST, to set maximum allowable exploitation rates on an annual basis would remain in place. Domestic ocean fisheries impacting JDF coho occur mainly in Washington state and north of Cape Falcon, Oregon.

For purposes of describing the status quo economic situation, data for port areas in coastal Washington and Oregon north of Cape Falcon during 2004 to 2016 are used, since that period is representative of possible outcomes under the current status quo control rule. Estimates of total coastal community personal income impacts during 2004-2016 in affected port areas for the non-tribal commercial ocean troll salmon fishery averaged approximately $3.4 million (in inflation-adjusted 2016 dollars), ranging from $1.6 million in 2008 to $5.6 million in 2015, and for the ocean recreational salmon fishery averaged approximately $9.9 million, ranging from $4 million in 2008 to $16 million in 2014. Total community personal income impacts in affected areas from the combined non-tribal commercial troll and recreational salmon fisheries conducted in ocean areas averaged approximately $13.3 million during 2004-2016, ranging from $5.6 million in 2008 to $21.3 million in 2014.[3]

For the individual port areas, inflation-adjusted personal income impacts during the period from combined ocean non-tribal commercial troll and recreational salmon fisheries averaged approximately $1.3 million in Neah Bay, ranging from $0.4 million in 2008 to $2.2 million in 2004; $0.7 million in La Push, ranging from $0.3 million in 2016 to $1 million in 2015; $6.7 million in Westport, ranging from $3 million in 2008 to $10.2 million in 2015; $3.3 million in Ilwaco, ranging from $1.2 million in 2008 to $5.8 million in 2014; and $1.5 million in Astoria, ranging from $0.7 million in 2008 to $3.1 million in 2014.

2008 was the lowest year for combined non-tribal ocean salmon fishery inflation-adjusted personal income impacts during the period overall and for three of the five affected port areas: Neah Bay, Westport and Ilwaco, while 2016 was the lowest year for La Push and Astoria. 2014 had the highest inflation-adjusted combined salmon fishery personal income impacts during the period overall and also for two port areas: Ilwaco and Astoria. The highest years for the remaining three port areas were 2004 for Neah Bay, and 2015 for both La Push and Westport.

Although not included in these economic impact estimates, JDF coho are also taken in commercial and tribal net fisheries and recreational fisheries in Puget Sound and its tributaries. During 2004-2016, commercial net harvests of adult JDF coho in the Puget Sound region averaged 3,320 fish, ranging from 6,877 fish in 2009 to 385 fish in 2015.[4]

Provided that a sufficient likelihood of rebuilding is achieved during the allowable 10-year period under Status Quo (Alternative I), economic impacts under the two action alternatives (Alternatives II and III) are measured relative to the Status Quo fishery. The estimated timeframe needed to achieve rebuilt status (with a probability of at least 50 percent) under Status Quo exploitation rates is five years, during which time it is assumed the 2004-2016 inflation-adjusted average of $13.3 million per year in income from combined ocean commercial and recreational salmon fisheries would accrue in the affected communities north of Cape Falcon. By definition there would be no direct or indirect economic impact from the rebuilding plan under the Status Quo (no-action) alternative.

[3] It is important to note that income impact estimates for the two sectors (commercial and recreational) cannot be directly compared because they are derived using different methodologies.

[4] Puget Sound catch data from *Review of 2017 Ocean Salmon Fisheries: Stock Assessment and Fishery Evaluation Document for the Pacific Coast Salmon Fishery Management Plan*. Table B-42.

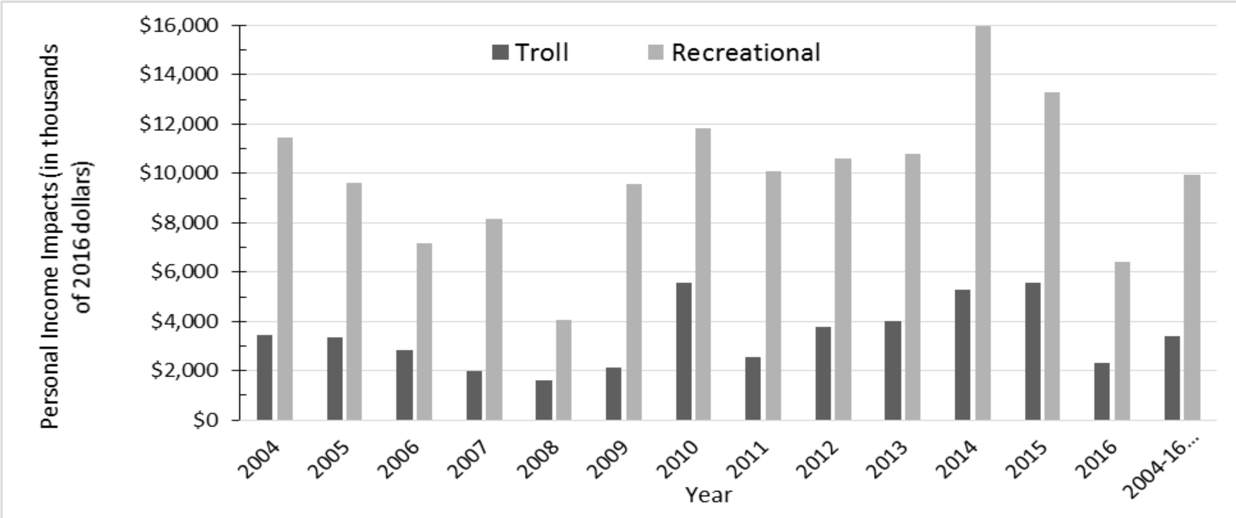

Figure 5.1.a. Estimates of total, aggregated personal income impacts in affected coastal communities in Washington and Oregon north of Cape Falcon in thousands of real (inflation adjusted, 2016) dollars for the non-tribal commercial ocean troll and ocean recreational salmon fisheries.

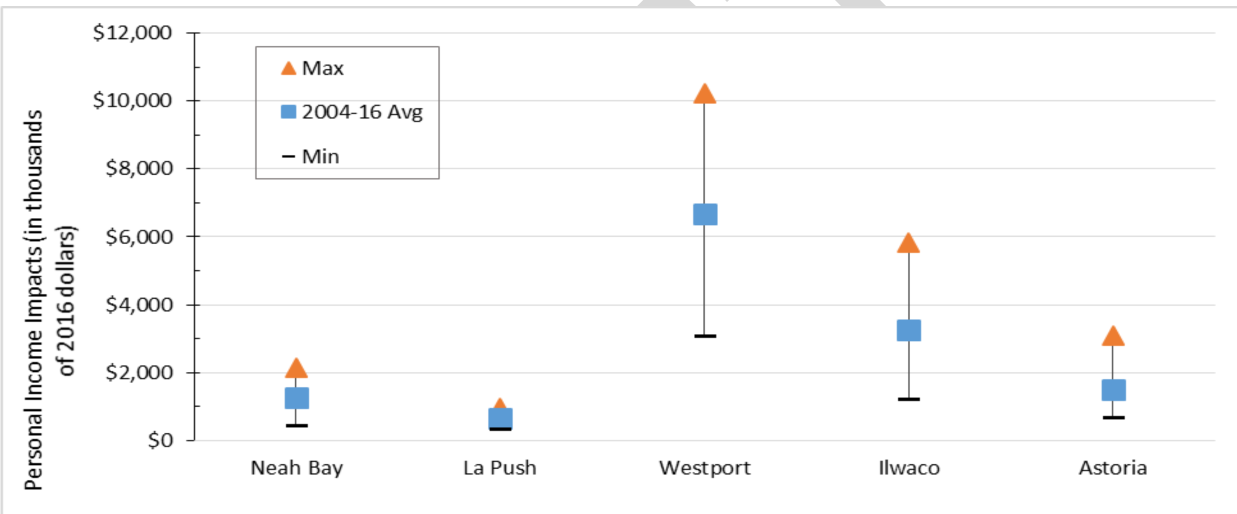

Figure 5.1.b. Estimates of personal income impacts by coastal community in thousands of real (inflation adjusted, 2016) dollars for the combined non-tribal commercial ocean troll and ocean recreational salmon fisheries in Washington and Oregon north of Cape Falcon.

Table 5.1.a. Estimates of personal income impacts by coastal community in thousands of real (inflation adjusted, 2016) dollars for the non-tribal commercial ocean troll and ocean recreational salmon fisheries for major Washington and Oregon port areas north of Cape Falcon.

OCEAN TROLL	**Neah Bay**	**La Push**	**Westport**	**Ilwaco**	**Astoria**	**Total**
2004	928	293	1,154	113	969	3,457
2005	761	454	1,170	144	803	3,333
2006	566	459	440	295	1,050	2,811
2007	250	254	1,038	129	310	1,981
2008	163	216	616	164	442	1,601
2009	331	342	1,192	83	180	2,128
2010	251	403	3,843	95	972	5,563
2011	575	228	1,407	96	244	2,551
2012	862	501	1,467	234	723	3,788
2013	485	448	2,674	74	354	4,035
2014	385	445	1,528	1,108	1,840	5,305
2015	315	641	3,021	420	1,171	5,568
2016	206	204	1,386	219	305	2,321
2004-16 Avg	**468**	**376**	**1,611**	**244**	**720**	**3,419**
Max	**928**	**641**	**3,843**	**1,108**	**1,840**	**5,568**
Min	**163**	**204**	**440**	**74**	**180**	**1,601**
RECREATIONAL	**Neah Bay**	**La Push**	**Westport**	**Ilwaco**	**Astoria**	**Total**
2004	1,228	260	5,332	3,494	1,151	11,465
2005	842	263	4,866	2,829	835	9,636
2006	552	231	3,593	2,200	600	7,176
2007	563	180	3,687	2,875	842	8,146
2008	244	108	2,425	1,024	242	4,043
2009	657	288	4,626	3,166	848	9,586
2010	777	332	6,312	3,422	976	11,819
2011	758	363	5,180	3,033	756	10,089
2012	944	343	5,848	2,853	606	10,594
2013	1,088	368	5,679	2,987	687	10,810
2014	1,190	484	8,315	4,731	1,242	15,962
2015	1,059	334	7,203	3,793	909	13,298
2016	595	112	2,746	2,604	352	6,410
2004-16 Avg	**807**	**282**	**5,062**	**3,001**	**773**	**9,926**
Max	**1,228**	**484**	**8,315**	**4,731**	**1,242**	**15,962**
Min	**244**	**108**	**2,425**	**1,024**	**242**	**4,043**
Combined	**Neah Bay**	**La Push**	**Westport**	**Ilwaco**	**Astoria**	**Total**
2004	2,156	553	6,486	3,607	2,120	14,922
2005	1,603	718	6,036	2,974	1,638	12,969
2006	1,118	690	4,033	2,495	1,649	9,986
2007	813	434	4,725	3,004	1,151	10,127
2008	407	324	3,041	1,189	683	5,644
2009	989	630	5,819	3,249	1,029	11,715
2010	1,028	735	10,155	3,517	1,948	17,382
2011	1,333	590	6,587	3,129	1,001	12,640
2012	1,806	845	7,315	3,087	1,329	14,382
2013	1,573	816	8,353	3,061	1,041	14,844
2014	1,576	928	9,842	5,839	3,082	21,268
2015	1,374	975	10,223	4,213	2,080	18,866
2016	800	316	4,132	2,824	658	8,730
2004-16 Avg	**1,275**	**658**	**6,673**	**3,245**	**1,493**	**13,344**
Max	**2,156**	**975**	**10,223**	**5,839**	**3,082**	**21,268**
Min	**407**	**316**	**3,041**	**1,189**	**658**	**5,644**

Income impact estimates from *Review of 2017 Ocean Salmon Fisheries: Stock Assessment and Fishery Evaluation Document for the Pacific Coast Salmon Fishery Management Plan.* Tables IV-17 and IV-18

5.2 Alternative II

Analysis pending

5.3 Alternative III

Under Alternative III, rebuilding is estimated to occur after four years assuming an exploitation rate of zero during that time. Compared with the 'no action', or Status Quo management strategy, of Alternative I, this would result in an overall income impact of negative (-) $10.7 million per year in coastal communities in the affected region over the five years it would take to rebuild under the Status Quo management strategy of Alternative I.

5.4 Note on economic impacts

These estimates should be considered upper bounds on the magnitude of economic effect under the action alternatives because it is assumed that equal, proportional management measures would be put in place for all ocean commercial and recreational fisheries in all affected areas along the coast, whereas past experience has shown that overall economic impacts may be mitigated in many cases by using an approach in which areas in the affected region are managed differentially depending on the degree of interaction between fisheries and stocks of concern in each area.

6.0 AFFECTED ENVIRONMENT AND ENVIRONMENTAL EFFECTS OF MANAGEMENT STRATEGY ALTERNATIVES CONSIDERED

6.1 Introduction

This chapter will analyze the environmental impacts of the alternatives on the resources that would be more than minimally affected by the proposed action. This is a required component to adopt this integrated document as an environmental assessment under NEPA. The action area for the proposed action is the exclusive economic zone (EEZ), from three to 200 miles offshore of the coasts of Washington and Oregon, from the U.S./Canada border to Cape Falcon, Oregon. In this document, the action area and the analysis area are largely synonymous, exceptions are noted below.

6.2 Targeted Salmon Stocks

6.2.1 Affected Environment

Ocean salmon fisheries in the analysis area target Chinook and coho salmon.

The Council manages several stocks of Chinook salmon under the FMP (PFMC 2016). In the ocean, stocks of salmon comingle which results in mixed-stock fisheries. Non-target stocks, including ESA-listed stocks, will be encountered in mixed-stock fisheries. The Council's Salmon Technical Team (STT) models the degree to which target and non-target stocks are impacted by proposed fisheries, and the Council uses tools such as harvest restrictions, time and area closures, and mark-selective fisheries to limit impacts to non-target stocks (PFMC and NMFS 2017).

In the analysis area, the primary management tools are time and area closures and recreational bag limits; some fisheries also have quotas. The primary salmon stocks targeted in the analysis area are: Lower Columbia River hatchery fall-run Chinook salmon, Columbia River Spring Creek

Hatchery fall-fun Chinook salmon, and Columbia River late hatchery coho stocks. Coastal coho stocks also contribute to fisheries in the analysis area, but individual stock contributions are minor. Fisheries in the analysis area are managed to meet FMP conservation objectives for these stocks, and to comply with ESA consultation requirements for any ESA-listed salmon stocks that are affected by salmon fisheries in the analysis area.

Detailed information on spawning escapement and fisheries impacts on salmon stocks are reported in the Council's annual Stock Assessment and Fishery Evaluation (SAFE) document, known as the Annual Review of Ocean Salmon Fisheries. These documents are available on the Council's website (www.pcouncil.org/salmon/stock-assessment-and-fishery-evaluation-safe-documents/).

6.2.2 Environmental Consequences of Alternatives on Target Salmon Stocks

Analysis pending

6.3 Marine Mammals

6.3.1 Affected environment

A number of non-ESA-listed marine mammal species occur in the analysis area. The non-ESA-listed marine mammal species that are known to interact with ocean salmon fisheries are California sea lion (*Zalophus californianus*) and harbor seals (*Phoca vitulina*), both species will feed on salmon, when available, and have been documented preying on hooked salmon in commercial and recreational fisheries (e.g., Weise and Harvey 1999). All marine mammals are protected under the Marine Mammal Protection Act (MMPA). Ocean salmon fisheries employ hook-and-line gear and are classified under NMFS' MMPA List of Fisheries as Category III (83 FR 5349, February 7, 2018), indicating there is no record of substantive impacts to marine mammals from these fisheries (MMPA 118(c)(1)).

ESA-listed marine mammal species that co-occur with Council-managed salmon fisheries include Guadalupe fur seal, southern sea otter, northern sea otter, and Southern Resident killer whale (SRKW). Among the ESA-listed marine mammals, only the SRKW is known to interact with Pacific salmon or salmon fisheries, in that SRKW are known to prey on salmon. The range of SRKW in spring, summer, and fall includes the inland waterways of Washington State and the transboundary waters between the United States and Canada. In recent years, SRKW have been regularly spotted as far south as central California during the winter months (http://www.nmfs.noaa.gov/pr/species/mammals/whales/killerwhale.html) and their range is currently defined as extending as far south as Point Sur, California (Teresa Mongillo, pers. comm.[5]). In 2009 NMFS consulted on the effects of the ocean salmon fisheries on the SRKW and concluded that Council-managed salmon fisheries were not likely to jeopardize these whales. In the time since that consultation, there has been additional research on SRKW life history, feeding habits, fecundity, and mortality rates. This new information indicates that prey base, environmental contaminants, and disturbance by vessel traffic are among the factors that may affect the recovery of SRKW. NMFS is working with researchers from the U.S. and Canada to evaluate impacts of various human activities, including salmon fisheries, on the survival and recovery of SRKW. Until such time as sufficient information is developed to inform a new ESA consultation on the impacts of salmon fisheries on the survival and recovery of SRKW, NMFS is

[5] Personal communication from T. Mongillo (NMFS) to P. Mundy (NMFS), email dated September 28, 2017.

working on identifying and developing short-term management actions to improve Chinook salmon availability and reducing acoustic and vessel disturbance in key SRKW foraging areas.

6.3.2 Environmental Consequences of the Alternatives on Marine Mammals

Analysis pending

6.4 ESA listed Salmon Stocks

6.4.1 Affected environment

Several ESUs of Pacific salmon that are ESA-listed as threatened or endangered occur in the areas where Council-managed ocean salmon fisheries occur. As stated above, the only salmon species encountered in fisheries in the action area are Chinook and coho salmon. ESA-listed Chinook and coho salmon ESUs that occur within the analysis area are listed in Table 6.4.1.a.

Table 6.4.1.a. ESA-listed Chinook and coho salmon ESUs that occur within the analysis area.

	ESA-listed ESUs	Status	Most recent citation
Chinook (*Oncorhynchus tshawytscha*)			
	Snake River Fall-run	Threatened	70 FR 37160 (June 28, 2005)
	Snake River Spring/Summer-run	Threatened	70 FR 37160 (June 28, 2005)
	Puget Sound	Threatened	70 FR 37160 (June 28, 2005)
	Lower Columbia River	Threatened	70 FR 37160 (June 28, 2005)
	Upper Willamette River	Threatened	70 FR 37160 (June 28, 2005)
	Upper Columbia River Spring-run	Endangered	70 FR 37160 (June 28, 2005)
Coho (*Oncorhynchus kisutch*)			
	Oregon Coastal	Threatened	76 FR 35755 (June 20, 2011)
	Lower Columbia River	Threatened	70 FR 37160 (June 28, 2005)

NMFS has issued biological opinions on the impacts of Council-managed salmon fisheries on ESA-listed salmon. Based on those biological opinions, NMFS provides guidance to the Council during the preseason planning process for setting annual management measures for ocean salmon fisheries based on the coming year's abundance projections. This guidance addresses allowable impacts on ESA-listed salmon. The Council structures fisheries to not exceed those allowable impacts.

NMFS has previously consulted on the effects of Council-area salmon fisheries on the ESA-listed salmon ESUs in the analysis area, and has produced the biological opinions listed in Table 6.4.1.b.

Table 6.4.1.b. NMFS biological opinions regarding ESA-listed salmon ESUs likely to be affected by Council-area ocean salmon fisheries in the analysis area.

Date	Duration	Citation	Species Considered
8-Mar-96	Until reinitiated	NMFS 1996	Snake River spring/summer and fall Chinook (and sockeye)
28-Apr-99	Until reinitiated	NMFS 1999	Oregon Coast coho (S. Oregon/N. California Coast coho, and Central California Coast coho)
30-Apr-01	Until reinitiated	NMFS 2001	Upper Willamette Chinook, Upper Columbia River spring-run Chinook (Lake Ozette sockeye, Columbia River chum, and 10 steelhead ESUs)
30-Apr-04	Until reinitiated	NMFS 2004	Puget Sound Chinook
26-Apr-12	Until reinitiated	NMFS 2012	Lower Columbia River Chinook
9-Apr-15	Until reinitiated	NMFS 2015	Lower Columbia River coho

6.4.2 Environmental Consequences of the Alternatives on ESA-Listed Salmon Stocks

Analysis pending

6.5 Non-target Fish Species

6.5.1 *Affected environment*

Pacific halibut, and Pacific halibut fisheries, occur north of Point Arena, California. Halibut allocations are established annually in the International Pacific Halibut Commission's (IPHC) regulations and the PFMC's Area 2A Catch Sharing Plan (e.g., 82 FR 18581, April 20, 2017). Allocation of halibut quota to fisheries in the analysis area would not be affected by the Proposed Action, as the IPHC's halibut quota for the U.S. West Coast and the sub-area allocations set forth in the Catch Sharing Plan are set annually under separate processes from setting the annual salmon management measures.

Fisheries for coastal pelagic species (e.g., northern anchovy, market squid, Pacific sardine, Pacific mackerel, and jack mackerel), Dungeness crab, shrimp/prawns, and sea cucumbers occur in the analysis area and are managed by either NMFS and the PFMC (coastal pelagics) or the states (crab, shrimp/prawns, and sea cucumbers). The species targeted in these fisheries are not encountered in ocean salmon fisheries. It is possible that reductions in salmon fishing opportunities could result in a shift of effort toward these other species; however, we could not find any documentation to support this.

Fishermen that participate in salmon fisheries, both commercial and recreational, may also fish for groundfish (i.e., species such as rockfish and flatfish that live on or near the bottom of the ocean). Groundfish fisheries are managed under the Council's Groundfish FMP. Commercial salmon trollers that retain groundfish are considered to be participating in the open access groundfish fishery with non-trawl gear; therefore, they must comply with the regulations for the open access groundfish fishery. Likewise, recreational fishers that retain groundfish, must comply with recreational groundfish regulations. As fishery impacts to groundfish are managed under the Groundfish FMP and regulations, there would be no measurable effect on these species from the proposed action.

Albacore (Thunnus alalunga) is harvested on the West Coast, including the analysis area, by many of the same commercial and recreational fishermen that fish for salmon. Fishery impacts to albacore are managed under the Council's Highly Migratory Species FMP. Commercial and recreational fishers shift effort between salmon and albacore in response to available fishing opportunities, catch limits, angler demand (recreational fisheries), and changing prices for the species being harvested (commercial fisheries). As fishery impacts to albacore are managed under the Highly Migratory Species FMP and regulations, there would be no measurable effect on these species from the proposed action.

6.5.2 Environmental Consequences of the Alternatives on non-target Fish Species

Analysis pending

6.6 Seabirds

6.6.1 Affected environment

Numerous seabird species, as well as raptors, are protected under the Migratory Bird Treaty Act, including several species that are present in areas coincident with Pacific salmon. These seabirds include grebes, loons, petrels, albatrosses, pelicans, double-crested cormorants, gulls, terns, auks, and auklets (PFMC 2013c). ESA-listed seabird species include short-tailed albatross (endangered) and marbled murrelet (threatened). Interactions with the Pacific salmon fishery typically occur in two ways: when seabirds feed on outmigrating juvenile salmon, and when seabirds are entangled or otherwise interact with fishing gear or activities. Predation on juvenile salmon by seabirds is known to occur in estuarine environments, such as the lower Columbia River, as salmon smolts migrate downstream and into marine waters. We do not know the extent to which seabirds in the analysis area depend upon juvenile salmonids as prey. Council-managed ocean salmon fisheries are limited to hook-and-line tackle. Interactions with seabirds are uncommon in these fisheries.

6.6.2 Environmental Consequences of the Alternatives on Seabirds

Analysis pending

6.7 Ocean and Coastal Habitats and Ecosystem Function

6.7.1 Affected environment

Salmon FMP stocks interact with a number of ecosystems along the Pacific Coast, including the California Current Ecosystem (CCE), numerous estuary and freshwater areas and associated riparian habitats. Salmon contribute to ecosystem function as predators on lower trophic level species, as prey for higher trophic level species, and as nutrient transportation from marine ecosystems to inland ecosystems. Because of their wide distribution in both the freshwater and marine environments, Pacific salmon interact with a great variety of habitats and other species of fish, mammals, and birds. The analysis area for the Proposed Action is dominated by the CCE. An extensive description of the CCE can be found in chapter three of the Council's Pacific Coast Fishery Ecosystem Plan (PFMC 2013c). Council managed salmon fisheries use hook and line gear, exclusively. This gear does not touch the ocean floor and does not disturb any habitat features. Therefore, salmon fisheries have no physical impact on habitat.

6.7.2 Environmental Consequences of the Alternatives on Ocean Coastal habitats and Ecosystem function

Analysis pending

6.8 Cultural resources

6.8.1 Affected environment

Analysis pending

6.8.2 Environmental Consequences of the Alternatives on Cultural resources

Analysis pending

6.9 Cumulative Impacts

Analysis pending

7.0 REFERENCES

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APPENDIX A. STATUS DETERMINATION CRITERIA

The following is an excerpt from the Salmon Fishery Management Plan

3.1 STATUS DETERMINATION CRITERIA

"Overfished. A stock or stock complex is considered ''overfished'' when its biomass has declined below a level that jeopardizes the capacity of the stock or stock complex to produce MSY on a continuing basis."

NS1Gs (600.310 (e)(2)(i)(E))

In establishing criteria by which to determine the status of salmon stocks, the Council must consider the uncertainty and theoretical aspects of MSY as well as the complexity and variability unique to naturally producing salmon populations. These unique aspects include the interaction of a short-lived species with frequent, sometimes protracted, and often major variations in both the freshwater and marine environments. These variations may act in unison or in opposition to affect salmon productivity in both positive and negative ways. In addition, variations in natural populations may sometimes be difficult to measure due to masking by hatchery produced salmon.

3.1.1 General Application to Salmon Fisheries

In establishing criteria from which to judge the conservation status of salmon stocks, the unique life history of salmon must be considered. Chinook, coho, and pink salmon are short-lived species (generally two to six years) that reproduce only once shortly before dying. Spawning escapements of coho and pink salmon are dominated by a single year-class and Chinook spawning escapements may be dominated by no more than one or two year-classes. The abundance of year-classes can fluctuate dramatically with combinations of natural and human-caused environmental variation. Therefore, it is not unusual for a healthy and relatively abundant salmon stock to produce occasional spawning escapements which, even with little or no fishing impacts, may be significantly below the long-term average associated with the production of MSY.

Numerous West Coast salmon stocks have suffered, and continue to suffer, from nonfishing activities that severely reduce natural survival by such actions as the elimination or degradation of freshwater spawning and rearing habitat. The consequence of this man-caused, habitat-based variation is twofold. First, these habitat changes increase large scale variations in stock productivity and associated stock abundances, which in turn complicate the overall determination of MSY and the specific assessment of whether a stock is producing at or below that level. Second, as the productivity of the freshwater habitat is diminished, the benefit of further reductions in fishing mortality to improve stock abundance decreases. Clearly, the failure of several stocks managed under this FMP to produce at an historical or consistent MSY level has little to do with current fishing impacts and often cannot be rectified with the cessation of all fishing.

To address the requirements of the MSA, the Council has established criteria based on biological reference points associated with MSY exploitation rate and MSY spawning escapement. The criteria are based on the unique life history of salmon and the large variations in annual stock abundance due to numerous environmental variables. They also take into account the uncertainty and imprecision surrounding the estimates of MSY, fishery impacts, and spawner escapements. In recognition of the unique salmon life history, the criteria differ somewhat from the general guidance in the NS1 Guidelines (§600.310).

3.1.4 Overfished

"For a fishery that is overfished, any fishery management plan, amendment, or proposed regulations… for such fishery shall (A) specify a time period for ending overfishing and rebuilding the fishery that shall:(i) be as short as possible, taking into account the status and biology of any overfished stocks of fish, the needs of the fishing communities, recommendations by international organizations in which the United States participates, and the interaction of the overfished stock within the marine ecosystem; and (ii) not exceed 10 years, except in cases where the biology of the stock of fish, other environmental conditions, or management measures under an international agreement in which the United States participates dictate otherwise…."

Magnuson-Stevens Act, §304(e)(4)

A stock will be considered overfished if the 3-year geometric mean of annual spawning escapements falls below the MSST, where MSST is generally defined as $0.5*S_{MSY}$ or $0.75*S_{MSY}$, although there are some exceptions (Table 3-1). Overfished determinations will be made annually using the three most recently available postseason estimates of spawning escapement.

3.1.4.1 Council Action

When the overfished status determination criteria set forth in this FMP have been triggered, the Council shall:

1) notify the NMFS NWR administrator of this situation;
2) notify pertinent management entities;
3) structure Council area fisheries to reduce the likelihood of the stock remaining overfished and to mitigate the effects on stock status;
4) direct the STT to propose a rebuilding plan for Council consideration within one year.

Upon formal notification from NMFS to the Council of the overfished status of a stock, a rebuilding plan must be developed and implemented within two years.

The STT's proposed rebuilding plan shall include:

1) an evaluation of the roles of fishing, marine and freshwater survival in the overfished determination;
2) any modifications to the criteria set forth in section 3.1.6 below for determining when the stock has rebuilt,
3) recommendations for actions the Council could take to rebuild the stock to S_{MSY}, including modification of control rules if appropriate, and;
4) a specified rebuilding period.

In addition, the STT may consider and make recommendations to the Council or other management entities for reevaluating the current estimate of S_{MSY}, modifying methods used to forecast stock abundance or fishing impacts, improving sampling and monitoring programs, or changing hatchery practices.

Based on the results of the STT's recommended rebuilding plan, the Council will adopt a rebuilding plan for recommendation to the Secretary. Adoption of a rebuilding plan will require implementation either through an FMP amendment or notice and comment rule-making process. Subject to Secretarial approval, the Council will implement the rebuilding plan with appropriate actions to ensure the stock is rebuilt in as short a time as possible based on the biology of the stock but not to exceed ten years, while taking into consideration the needs of the commercial, recreational and tribal fishing interests and coastal communities. The existing control rules provide a default rebuilding plan that targets spawning escapement at or above MSY, provided sufficient recruits are available, and targets a rebuilding period of one generation (two years for pink salmon, three years for coho, and five years for Chinook). If sufficient recruits are not available to achieve spawning escapement at or above MSY in a particular year, the control rules provide for the potential use of *de minimis* exploitation rates that allow continued participation of fishing communities while minimizing risk of overfishing. However, the Council should consider the specific circumstances surrounding an overfished determination and ensure that the adopted rebuilding plan addresses all relevant issues.

Even if fishing is not the primary factor in the depression of the stock, the Council must act to limit the exploitation rate of fisheries within its jurisdiction so as not to limit rebuilding of the stock or fisheries. In cases where no action within Council authority can be identified which has a reasonable expectation of contributing to the rebuilding of the stock in question, the Council will identify the actions required by other entities to recover the depressed stock. Due to a lack of data for some stocks, environmental variation, economic and social impacts, and habitat losses or problems beyond the control or management authority of the Council, it is possible that rebuilding of depressed stocks in some cases could take much longer than ten years. The Council may change analytical or procedural methodologies to improve the accuracy of estimates for abundance, harvest impacts, and MSY escapement levels, and/or reduce ocean harvest impacts when it may be effective in stock recovery. For those causes beyond Council control or expertise, the Council may make recommendations to those entities which have the authority and expertise to change preseason prediction methodology, improve habitat, modify enhancement activities, and re-evaluate management and conservation objectives for potential modification through the appropriate Council process.

In addition to the STT assessment, the Council may direct its Habitat Committee (HC) to work with federal, state, local, and tribal habitat experts to review the status of the essential fish habitat affecting the overfished stock and, as appropriate, provide recommendations to the Council for restoration and enhancement measures within a suitable time frame. However, this action would be a priority only if the STT evaluation concluded that freshwater survival was a significant factor leading to the overfished determination. Upon review of the report from the HC, the Council will consider appropriate actions to promote any solutions to the identified habitat problems.

3.1.5 Not Overfished-Rebuilding

After an overfished status determination has been triggered, once the stock's 3-year geometric mean of spawning escapement exceeds the MSST, but remains below S_{MSY}, or other identified rebuilding criteria, the stock status will be recognized as "not overfished-rebuilding". This status level requires no Council action, but rather is used to indicate that stock's status has improved from the overfished level but the stock has not yet rebuilt.

3.1.6 Rebuilt

The default criterion for determining that an overfished stock is rebuilt is when the 3-year geometric mean spawning escapement exceeds S_{MSY}; the Council may consider additional criteria for rebuilt status when developing a rebuilding plan and recommend such criteria, to be implemented subject to Secretarial approval.

Because abundance of salmon populations can be highly variable, it is possible for a stock to rebuild from an overfished condition to the default rebuilding criterion in as little as one year, before a proposed rebuilding plan could be brought before the Council.

In some cases it may be important to consider other factors in determining rebuilt status, such as population structure within the stock designation. The Council may also want to specify particular strategies or priorities to achieve rebuilding objectives. Specific objectives, priorities, and implementation strategies should be detailed in the rebuilding plan.

3.1.6.1 Council Action

When a stock is determined to be rebuilt, the Council shall:

1) notify the NMFS NWR administrator of its finding, and;
2) notify pertinent management entities.

3.1.7 Changes or Additions to Status Determination Criteria

Status determination criteria are defined in terms of quantifiable, biologically-based reference points, or population parameters, specifically, S_{MSY}, MFMT (F_{MSY}), and MSST. These reference points are generally regarded as fixed quantities and are also the basis for the harvest control rules, which provide the operative guidance for the annual preseason planning process used to establish salmon fishing seasons that achieve OY and are used for status determinations as described above. Changes to how these status determination criteria are defined, such as MSST = $0.50*S_{MSY}$, must be made through a plan amendment. However, if a comprehensive technical review of the best scientific information available provides evidence that, in the view of the STT, SSC, and the Council, justifies a modification of the estimated values of these reference points, changes to the values may be made without a plan amendment. Insofar as possible, proposed reference point changes for natural stocks will only be reviewed and approved within the schedule established for salmon methodology reviews and completed at the November meeting prior to the year in which the proposed changes would be effective and apart from the preseason planning process. SDC reference points that may be changed without an FMP amendment include: reference point objectives for hatchery stocks upon the recommendation of the pertinent federal, state, and tribal management entities; and Federal court-ordered changes. All modifications would be documented through the salmon methodology review process, and/or the Council's preseason planning process.

APPENDIX B. PUGET SOUND RECREATIONAL FISHERY REGULATIONS

Puget Sound Recreational Fisheries

Provided below are descriptions of recreational fishing seasons for coho as planned preseason during the state-tribal North of Falcon process, for each of the Puget Sound marine areas during the 2014-15, 2015-16, and 2016-17 seasons (the period from July 1, 2014 through June 30, 2017). Recreational fisheries were implemented as planned preseason unless specified otherwise via footnotes in Table B.1.

Areas 5 and 6

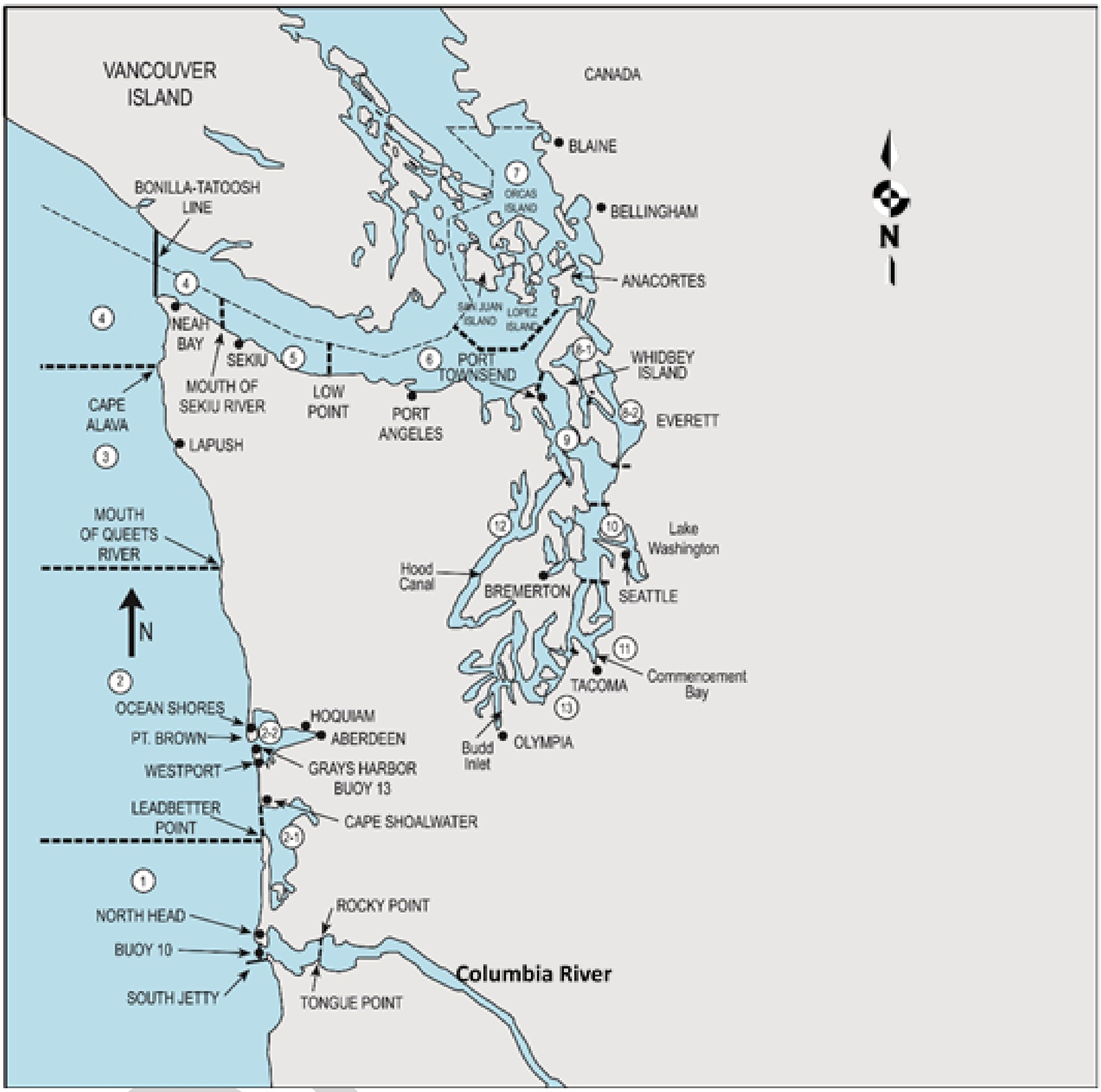
In the Strait of Juan de Fuca, both Area 5 (Sekiu and Pillar Point) and Area 6 (East Juan de Fuca Strait) were open to mark-selective coho fishing during the summer of 2014 and 2015 from July 1-September 30. In Area 5 only, non-selective coho fishing was allowed from September 19-25 during 2014, and on the specific dates of September 12-14, 19-21, and 26-27 in 2015. Additionally, Area 5 was open during October 1-31 for mark-selective coho fishing in 2014 and for non-selective coho fishing in 2015. In Area 6, non-selective coho fishing was open in the month of October in both 2014 and 2015. During the winter and spring seasons, Area 5 was open for non-selective coho fishing from February 16 - April 10 in 2015, and from February 16 - April 30 in 2016. During the 2016-17 season, there were no fisheries allowing coho salmon retention in Areas 5 and 6.

Area 9

In Area 9 (Admiralty Inlet), non-selective coho fishing was open from July 1 through November 30, and again from January 16 through April 15, in both the 2014-15 and 2015-16 seasons. In contrast, during the 2016-17 season, there were no fisheries allowing coho salmon retention in Area 9.

Area 10

In Area 10 (Seattle/Bremerton area), non-selective coho fishing was open from July 1 through January 31 in both the 2014-15 and 2015-16 seasons. In contrast, during the 2016-17 season, there were no fisheries allowing coho salmon retention in Area 10. The Elliott Bay terminal area near Seattle was closed for all salmon retention during summer 2014 and 2016 but open in 2015 for non-selective coho and pink salmon fishing from August 14-31 (Fridays through Sundays only) in 2015.



Map of Western Washington, showing the Marine Catch Areas of Puget Sound (Areas 5 through 13) and the Washington coast (Areas 1 through 4).

Appendix Table B.1. Recreational Coho Fishing Seasons in Puget Sound Marine Areas 5, 6, 9, and 10 during the period from July 1, 2014 through June 30, 2017. Recreational fisheries were implemented as planned preseason unless noted otherwise below via footnotes (a/ through l/).

Area	Fishery Type [1/]	Dates of Season, by Fishery Year (July 1 - June 30)		
		2014-15	**2015-16**	**2016-17**
5	NR	n/a	n/a	July 1-Aug 15; Feb 16-Apr 30
	NSF	Sept 19-25; Feb 16-Apr 10	Sept 12-14, 19-21, 26-27; Oct 1-31; Feb 16-Apr 30	n/a
	MSF	July 1-Sept 18; Sept 26-30; Oct 1-31	July 1-Sept 11; Sept 15-18, 22-25, 28-30	n/a
	Closed	Nov 1-Feb 15; Apr 11-June 30	Nov 1 - Feb 15; May 1-June 30	Aug 16-Feb 15; May 1-June 30
6	NR	n/a	n/a	July 1-Aug 15; Dec 1-Apr 30
	NSF	Oct 1-31; Dec 1-Apr 10	Oct 1-31; Dec 1-Apr 10 [d/]	n/a
	MSF	July 1-Sept 30	July 1-Sept 30	n/a
	Closed	Nov 1-30; Apr 11-June 30	Nov 1-30; Apr 11-June 30	Aug 16-Nov 30; May 1-June 30
9	NR	n/a	n/a	July 1-Aug 15; Nov 1-30; Jan 16-Apr 15
	NSF	July 1-Nov 30; Jan 16-Apr 15	July 1-Nov 30 [b/]; Jan 16-Apr 15 [g/]	n/a
	MSF	n/a	n/a	n/a
	Closed	Dec 1-Jan 15; April 16-June 30	Dec 1-Jan 15; April 16-June 30	Aug 16-Oct 31; Dec 1-Jan 15; May 1-June 30
10	NR	June 1-30	June 1-30	July 1-Aug 15; Nov 1-Feb 28 [l/]; June 1-30
	NSF	July 1 - Jan 31	July 1 - Jan 31 [c/]	n/a
	MSF	n/a	n/a	n/a
	Closed	Feb 1 - May 31	Feb 1 - May 31	Aug 16-Oct 31; Mar 1-May 30

[1/] Definitions of fishery types:

- NR= Non-retention regulation for coho salmon. Anglers may fish for other salmon or bottomfish species, but may not retain coho salmon.
- NSF = Non-selective fishery for coho salmon. Anglers may keep either hatchery marked (adipose fin-clipped) or unmarked (adipose fin intact) coho. Daily bag limit is typically 2 salmon (at most 2 coho).
- MSF = Mark-selective fishery for coho salmon. Anglers may keep hatchery marked (adipose fin-clipped) coho but must release unmarked (adipose fin intact) coho. Daily bag limit is typically 2 hatchery coho.
- Closed = Closed for coho and all other salmon species.

In-season changes:

[b/] Area 9, summer 2015:

Effective August 6, 2015, the sub-area in northern Hood Canal (from south and west of a line from Foulweather Bluff to Olele Point to the Hood Canal Bridge) was closed to salmon fishing, except angling for salmon from shore was permissible, from the Hood Canal Bridge to the northern boundary of Salsbury Point Park. Daily limit was 2 salmon plus 2 additional pink salmon. Reason for in-season change: to protect mid-Hood Canal Chinook per state-tribal management plans agreed to during the North of Falcon preseason process.

Effective November 1 through November 30, 2015, Area 9 closed for Chinook and coho salmon retention. Reason for in-season change: Area 9 winter mark-selective Chinook fishery had higher than expected sublegal-size Chinook encounters. Puget Sound coho run sizes were below preseason forecasts; therefore, non-retention of coho was required beginning November 1, 2015.

[c/] Area 10, winter 2015-16:

Effective October 19, 2015, Area 10 closed for salmon fishing. Area 10 opened again on October 28 for chum salmon retention only -- coho and Chinook still had to be released. Effective December 1, 2015 through January 31, 2016, Area 10 closed again for salmon fishing. Reason for in-season changes: Chinook encounters in the Area 10 winter Chinook MSF had reached preseason expectations; needed to ensure compliance with conservation objectives and agreed-to management plans.

[d/] Area 6, spring 2016:

Area 6 closed for salmon fishing effective February 22 through April 10, 2016 to slow down the number of Chinook encounters in the Area 6 Chinook MSF and comply with agreed-to management plans. From March 12 through March 18, however, the area opened again for a short time with a daily limit of 2 salmon, no more than 1 hatchery Chinook (release wild Chinook) for limited fishing opportunity.

Area 9, spring 2016:

Area 9 closed to salmon fishing effective April 11 through April 15, 2016. Reason for in-season change: encounters of Chinook in the Area 9 Chinook MSF had reached preseason expectations; needed to ensure compliance with conservation objectives and agreed-to management plans.

[h/] Multiple Areas, spring 2016

Effective May 1 through June 24, 2016, the following areas were closed to salmon fishing (changed from coho non-retention to closed): Marine Area 8-2 (including Tulalip Terminal Area Fishery), Marine Area 11, Marine Area 13, and year-round piers (Marine Areas 9, 10, 11, and 13). Reason for change: State-tribal co-managers were delayed in coming to agreement during the 2016 North of Falcon process. Endangered Species Act (ESA) coverage for Chinook and steelhead impacts expired April 30, 2016; therefore, starting May 1, 2016, scheduled fisheries did not have the needed federal ESA permit and could not be implemented. Effective June 24, 2016, these areas opened to salmon fishing per permanent rules due to receiving the federal ESA permit.

[l/] Area 10, winter-spring 2017:

Area 10 closed to salmon fishing effective January 23, 2017 through February, 28, 2017 (changed from coho non-retention to closed), except for year-round piers. Reason for in-season change: encounters of Chinook reached preseason expectations in the Area 10 Chinook MSF; needed to ensure compliance with conservation objectives and agreed-to management plans.

APPENDIX C. MODEL DESCRIPTION

Introduction

Salmon rebuilding plans must include, among other requirements, a specified rebuilding period. In addition, the National Environmental Policy Act (NEPA) analysis of rebuilding plans requires the development of rebuilding plan alternatives. In past assessments, the rebuilding period and alternative rebuilding plans were developed using expert knowledge, with no particular quantitative assessment. In 2018 the Salmon Technical Team (STT) developed a simple tool to assess the probability of a stock achieving rebuilt status in each year following an overfished declaration. Here we describe this model and provide additional results for the Strait of Juan de Fuca coho salmon stock.

Methods

The methods described here are for a single replicate in one year.

The "known", true abundance (N) is determined by a random draw from the set of past abundance estimates. For Strait of Juan de Fuca coho, N is the pre-fishery ocean age-3 abundance, defined as the sum of all fishery impacts and spawning escapement.

The forecast abundance ($\widehat{N}$) is drawn from a lognormal distribution,

$$\widehat{N} \sim \text{Lognormal}[\log(N) - 0.5\sigma_{\log(\widehat{N})},\ \sigma_{\log(\widehat{N})}] \quad (1)$$

with the bias corrected mean and standard deviation specified on the log scale. The log-scale standard deviation is

$$\sigma_{\log(\widehat{N})} = \sqrt{\log\left(1 + \text{CV}_{\widehat{N}}^2\right)} \quad (2)$$

with $\text{CV}_{\widehat{N}}$ representing the coefficient of variation for the abundance forecast. $\text{CV}_{\widehat{N}}$ is a model parameter that defines the degree of abundance forecast error.

The forecast abundance $\widehat{N}$ is applied to the harvest control rule to determine the allowable exploitation rate, $\widehat{F}$. However, for Strait of Juan de Fuca coho, there are not directed fisheries. Fishery impacts have consistently been less than allowed under the stepped harvest rates of the control rule. Because the abundance or status of other stocks has determined the exploitation rate in fisheries, including Council-area fisheries, the use of an abundance-based control rule would poorly describe the degree of exploitation on this stock. As a result, $\widehat{F}$ was determined by randomly drawing from postseason exploitation rates, estimated using backwards FRAM, from the 2004-2016 set of years.

Projected natural-area adult spawner escapement E is thus

$$E = N \times (1 - F) \quad (3)$$

where N is the "true" abundance and F is the realized exploitation rate. The realized exploitation rate is a random draw from the beta distribution

$$F \sim \text{Beta}(\alpha, \beta) \tag{4}$$

with parameters

$$\alpha = \frac{1 - \hat{F}(1 + \text{CV}_F^2)}{\text{CV}_F^2} \tag{5}$$

and

$$\beta = \frac{\frac{1}{\hat{F}} - 2 + \hat{F} + (\hat{F} - 1)\text{CV}_F^2}{\text{CV}_F^2}. \tag{6}$$

The coefficient of variation for the exploitation rate implementation error, CV_F, is a model parameter that determines the degree of error between the target and realized exploitation rates.

Because escapement is estimated with error, escapement estimates $\hat{E}$ are drawn from a lognormal distribution,

$$\hat{E} \sim \text{Lognormal}[\log(E) - 0.5\sigma_{\log(\hat{E})},\ \sigma_{\log(\hat{E})}] \tag{7}$$

where the bias corrected mean and standard deviation are specified on the log scale. The log-scale standard deviation is computed in the same manner as Equation (2).

The procedure described above is repeated for each year (years 1 through 10 following the overfished status determination), and each replicate.

A stock is assumed to be rebuilt when the geometric mean of $\hat{E}$ computed over the previous three years exceed the maximum sustainable yield spawner escapement, S_{MSY}. The probability of achieving rebuilt status in year *t* is the cumulative probability of achieving a 3-year geometric mean greater than or equal to S_{MSY} by year *t*.

Results

Results for Strait of Juan de Fuca coho presented here are the product of 1000 replicates in each of 10 years. The probability of being rebuilt in year *t* = 1 is the proportion of the 1000 replicates that resulted in the geometric mean of the estimated Strait of Juan de Fuca coho escapement in *t*-2 (4507: the 2015 adult escapement), the estimated escapement in *t*-1 (7937: the 2016 adult escapement), and the simulated escapement estimate in year *t* (2017) exceeding S_{MSY}. For *t* = 2, the probability of being rebuilt is the probability that the stock was rebuilt in either *t* = 1 or *t* = 2.

Figure 4.4.a in the body of the report displays the probability of achieving rebuilt status under two management strategies: (1) the status quo control rule and (2) no fishing. For these simulations the following parameter values were assumed: $\mathrm{CV}_{\hat{N}} = 0.2$, $\mathrm{CV}_{\hat{E}} = 0.2$, and $\mathrm{CV}_{F} = 0.1$. The parameter values were chosen because they produce reasonable levels of abundance forecast error, escapement estimation error, and implementation error for realized exploitation rates.

Rebuilding probabilities were also computed for the status quo control rule under an increased CV of the abundance forecast error ($\mathrm{CV}_{\hat{N}} = 0.6$), the escapement estimation error CV ($\mathrm{CV}_{\hat{E}} = 0.5$), and the CV of the exploitation rate implementation error ($\mathrm{CV}_{F} = 0.2$). Figure (1) displays results for these alternative scenarios. Overall, the probability of achieving rebuilt status by year, for the status quo scenario, is relatively insensitive to increased values of these parameters.

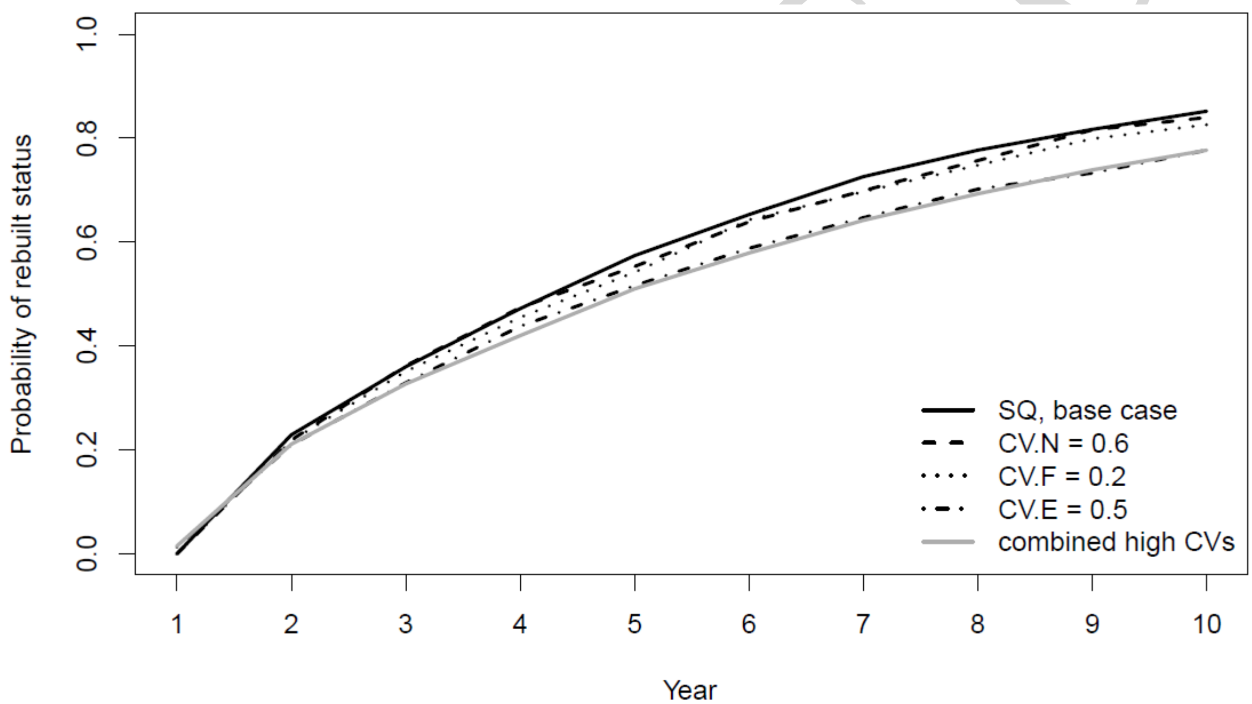


Figure 1. Probability of achieving rebuilt status in years 1 through 10, under the status quo control rule (Alternative 1) and under different parameter values.

Simulations were also performed assuming potentially biased abundance forecasts. Bias was incorporated by modifying the log-scale mean term in Equation (1) by adding the log of the observed ratio of the preseason forecast of the abundance to the postseason estimate of abundance. Thus, the mean term in Equation (1) becomes $\log(N) - 0.5\sigma_{\log(\hat{N})} + \log(r)$, where r is a drawn (with replacement) from the set of 13 ratios of forecast to observed Strait of Juan de Fuca coho abundance. On the arithmetic scale this ratio ranged from 6.91 to 0.43 and the average of these ratios was 2.19. Figure (2) displays the effect of including these ratios, given management under the status quo control rule. Because in this analysis the abundance forecast does not affect the allowable exploitation rate (as exploitation rates are drawn randomly from the set of past exploitation rates), there is no effect on the probability of achieving rebuilt status

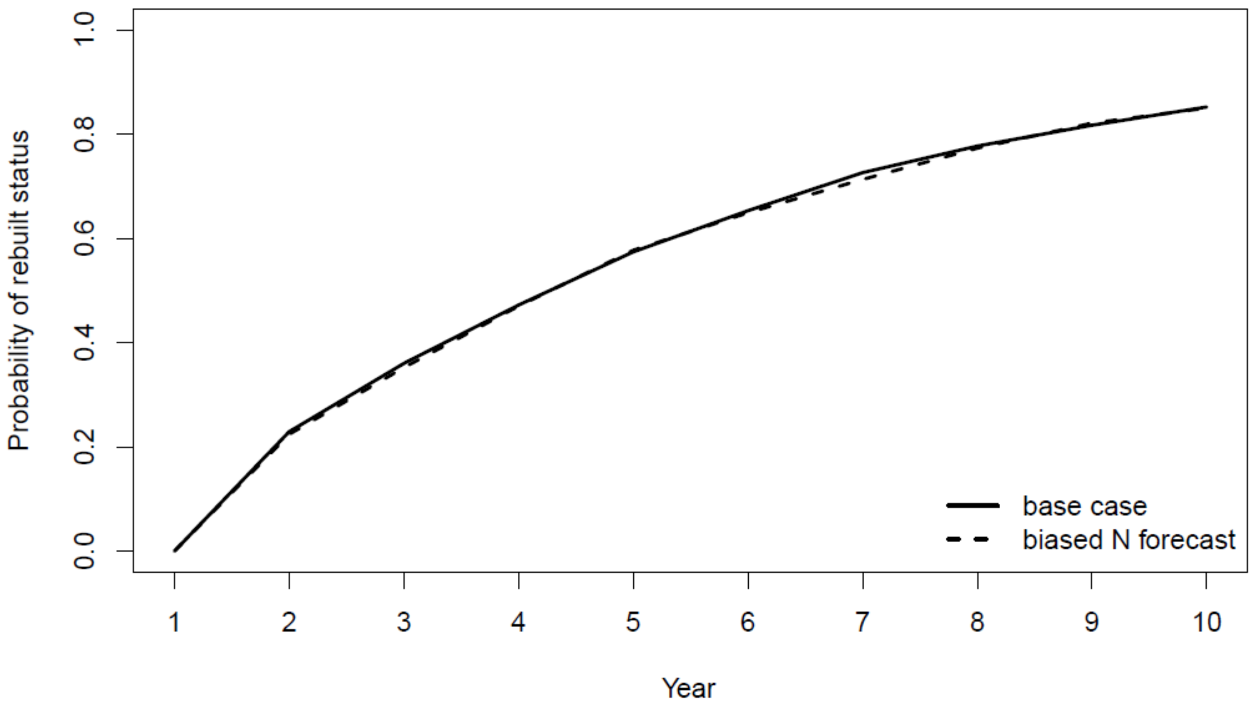


Figure 2. Probability of achieving rebuilt status under unbiased abundance forecasts and abundance forecasts that could potentially be biased.

Discussion

This model was created to allow for a quantitative assessment of alternative rebuilding plans. It shares some attributes with MSE approaches, but lacks some important features.

The model relies on random draws from past estimates of abundance to characterize future abundance. As such, autocorrelation in abundance is not modeled and there is no explicit population dynamics. Thus the model fails to capture multi-year increases or declines in abundance exhibited by many salmon stocks. Data limitations and the short time frame for development of rebuilding plans did not allow constructing a more detailed operating model.

The probability of achieving rebuilt status each year within a 10 year window for alternative rebuilding plans is the core result of this analysis. The results for particular alternatives should be interpreted in a relative rather than absolute sense. Rebuilding periods could be much shorter or longer than these results suggest due to the vagaries of future production and fisheries.

APPENDIX D. DRAFT FINDING OF NO SIGNIFICANT IMPACT

Pending

APPENDIX E. PAST, PRESENT AND REASONABLY FORESEEABLE FUTURE IMPACTS

Pending

APPENDIX F. LIST OF AGENGIES AND PERSONS CONSULTED

Pending, incomplete

The following public meetings were held as part of the salmon management process (Council-sponsored meetings in bold):

March 2018
April 2018
May 17, 2018
June, 2018:
August 2018
September 2018

The following organizations were consulted and/or participated in preparation of supporting documents:

Northwest Indian Fisheries Commission
Columbia River Intertribal Fish Commission
West Coast Indian Tribes

California Department of Fish and Wildlife
Oregon Department of Fish and Wildlife
Washington Department of Fish and Wildlife

National Marine Fisheries Service, West Coast Region, Sustainable Fisheries Division
National Marine Fisheries Service, Northwest Fisheries Science Center
National Marine Fisheries Service, Southwest Fisheries Science Center
U.S. Fish and Wildlife Service, Columbia River Fisheries Program Office
United States Coast Guard

APPENDIX G. REGULATORY IMPACT REVIEW

Pending

APPENDIX H. INITIAL REGULATORY FLEXIBILITY ANALYSIS

Pending

APPENDIX I. NATIONAL STANDARDS ANALYSIS

Pending

APPENDIX J. CONSISTENCY WITH OTHER APPLICABLE LAWS ANALYSIS

Pending, incomplete

- MSA
- CZMA
- ESA

- MMPA
- MBTA
- PRA
- EO 12898 Environmental Justice
- EO 13132 Federalism
- EO 13175 Tribal Consultation and Coordination
- Regulatory Flexibility Act
- EO 12866 Regulatory Planning and Review
- EO 13771 Reducing Regulation and Controlling Regulatory Costs