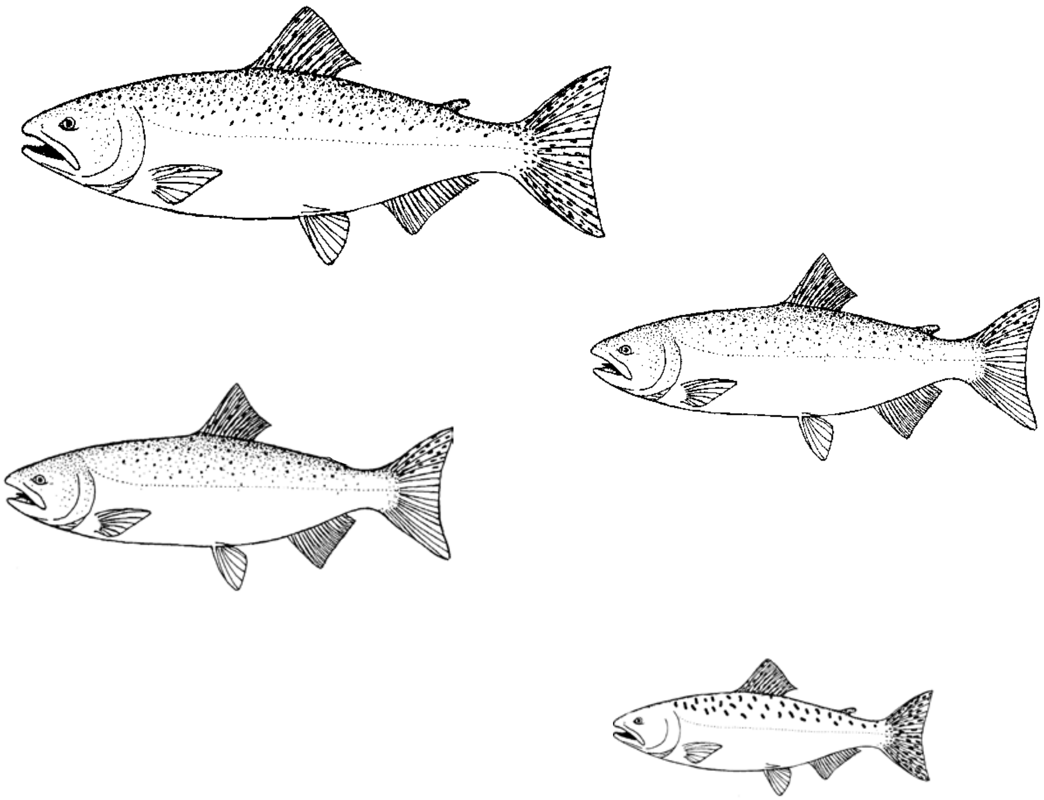
# PACIFIC COAST
# SALMON FISHERY MANAGEMENT PLAN

*FOR COMMERCIAL AND RECREATIONAL SALMON FISHERIES*

*OFF THE COASTS OF WASHINGTON, OREGON, AND CALIFORNIA*

*AS REVISED THROUGH AMENDMENT 19*

*(Effective March 2016)*



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# TABLE OF CONTENTS

# LIST OF TABLES

# LIST OF FIGURES

# SUPPLEMENTARY FMP DOCUMENTS

(Available from Council office and web site:www.pcouncil.org):

APPENDIX A TO THE PACIFIC COAST SALMON PLAN:
IDENTIFICATION AND DESCRIPTION OF ESSENTIAL FISH HABITAT, ADVERSE IMPACTS, AND RECOMMENDED CONSERVATION MEASURES FOR SALMON

APPENDIX B - FROM AMENDMENT 14 TO THE PACIFIC COAST SALMON PLAN:
DESCRIPTION OF THE OCEAN SALMON FISHERY AND ITS SOCIAL AND ECONOMIC CHARACTERISTICS

APPENDIX C TO THE PACIFIC COAST SALMON PLAN:
REVIEW OF OCEAN SALMON FISHERIES – STOCK ASSESSMENT AND FISHERY EVALUATION DOCUMENT FOR THE PACIFIC COAST SALMON FISHERY MANAGEMENT PLAN (Latest annual edition)

PRESEASON REPORT I:
STOCK ABUNDANCE ANALYSIS AND ENVIRONMENTAL ASSESSMENT PART 1 FOR OCEAN SALMON FISHERY REGULATIONS (Latest annual edition)

PRESEASON REPORT III:
COUNCIL ADOPTED MANAGEMENT MEASURES AND ENVIRONMENTAL ASSESSMENT PART 3 FOR OCEAN SALMON FISHERY REGULATIONS (Latest annual edition)

# LIST OF ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| ABC | acceptable biological catch |
| ACL | annual catch limit |
| AEQ | adult equivalent |
| AM | accountability measure |
| ASETF | Anadromous Salmonid Environmental Task Force |
| CRFMP | Columbia River Fish Management Plan |
| Council | Pacific Fishery Management Council |
| CVF | Central Valley fall (Chinook stock complex) |
| EA | Environmental Assessment |
| EEZ | exclusive economic zone (three to 200 miles offshore) |
| EIS | Environmental Impact Statement |
| ESA | Endangered Species Act |
| EFH | essential fish habitat |
| ESU | Evolutionarily significant unit |
| F | instantaneous rate of fishing mortality |
| FAB | Fisheries Advisory Board (established in *U.S. v. Washington*) |
| FNMC | far-north migrating coastal (Chinook stock complex) |
| FMP | fishery management plan |
| FR | Federal Register |
| FRAM | Fishery Regulation Assessment Model |
| HC | Habitat Committee |
| KRFC | Klamath River fall Chinook |
| KRTT | Klamath River Technical Team |
| MFMT | maximum fishing mortality threshold |
| MSA | Magnuson-Stevens Fishery Conservation and Management Act |
| MSP | maximum sustainable production |
| MSST | minimum stock size threshold |
| MSY | maximum sustainable yield |
| N | abundance of fish in numbers |
| NMFS | National Marine Fisheries Service |
| NOAA | National Oceanic and Atmospheric Administration |
| OCN | Oregon coastal natural coho |
| ODFW | Oregon Department of Fish and Wildlife |
| OFL | overfishing limit |
| OFR | Office of the Federal Register |
| OPI | Oregon Production Index |
| OY | optimum yield |
| PFMC | Pacific Fishery Management Council |
| PSC | Pacific Salmon Commission |
| RFA | Regulatory Flexibility Act |
| RIR | Regulatory Impact Review |
| S | number of adult spawners |
| SAS | Salmon Advisory Subpanel |
| Secretary | Secretary of Commerce |
| SEIS | Supplemental Environmental Impact Statement |
| SFA | Sustainable Fisheries Act |
| SONC | Southern Oregon/Northern California (Chinook stock complex) |
| SRFC | Sacramento River fall Chinook |

# LIST OF ACRONYMS AND ABBREVIATIONS (continued)

| | |
|---|---|
| SRFCRT | Sacramento River Fall Chinook Review Team |
| SSC | Scientific and Statistical Committee |
| STT | Salmon Technical Team |
| TAC | total allowable catch |
| WDF | Washington Department of Fisheries |
| WDFW | Washington Department of Fish and Wildlife |

# INTRODUCTION

This document is the *Pacific Coast Salmon Fishery Management Plan*, a fishery management plan (FMP) of the Pacific Fishery Management Council (Council or PFMC) as revised and updated for implementation in 2013 and beyond. It guides management of commercial and recreational salmon fisheries off the coasts of Washington, Oregon, and California.

Since 1977, salmon fisheries in the exclusive economic zone (EEZ) (three to 200 miles offshore) off Washington, Oregon, and California have been managed under salmon FMPs of the Council. Creation of the Council and the subsequent development and implementation of these plans were initially authorized under the Fishery Conservation and Management Act of 1976. This act, now known as the Magnuson-Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act; MSA), was amended by the Sustainable Fisheries Act (SFA) in 1996, and most recently amended by the Magnuson-Stevens Fishery Conservation and Management Reauthorization Act (MSRA) in 2007. The plan presented in this document contains or references all the elements required for an FMP under the MSA. It completely replaces the 1999 version of the *Pacific Coast Salmon Plan*.

The Council's first salmon FMP and its environmental impact statement (EIS) were issued to govern the 1977 salmon season. A new salmon management plan and EIS were issued in 1978 to replace the 1977 documents. To establish management measures from 1979 through 1983, the 1978 FMP was amended annually and published along with a supplemental EIS (SEIS) and Regulatory Impact Review/Regulatory Flexibility Analysis (RIR/RFA). This annual process was lengthy, complex, and costly. It lacked a long-range perspective and was too cumbersome to allow for timely implementation of the annual regulations and efficient fishery management. Therefore, in 1984, the Council adopted a comprehensive framework amendment that was designed to end the need for annual plan amendments and supplemental EISs (PFMC 1984).

The comprehensive framework plan amendment of 1984 (Amendment 6) replaced the 1978 plan as the base FMP document and established a framework of fixed management objectives with flexible elements to allow annual management measures to be varied to reflect changes in stock abundance and other critical factors. Subsequently, at irregular intervals, the Council has developed various amendments to portions of the framework plan to address specific management issues raised by participants in the salmon management process or as necessary to respond to reauthorization of the MSA. The next seven amendments adopted since implementation of the framework FMP in 1984 were accompanied by an environmental assessment (EA). Amendment 14 was accompanied by an SEIS. Amendments 15 and 16 were accompanied by an EA. No additional NEPA analysis was required for Amendment 17 because the actions contained in the amendment were either previously analyzed in a NEPA document or fit within the criteria for Categorical Exclusion.

The primary amendment issues since 1984 have included specific spawner escapement goals for Oregon coastal natural (OCN) coho and Klamath River fall Chinook (Amendments 7, 9, 11, 13, and 15), non-Indian harvest allocation (Amendments 7, 9, 10, and 14), inseason management criteria (Amendment 7), habitat and essential fish habitat (EFH) definition (Amendments 8, 14, and 18), safety (Amendment 8), status determination criteria (SDC) (Amendments 10, 14, 16, and 17), management objectives for stocks listed under the Endangered Species Act (ESA) (Amendments 12 and 14), bycatch reporting and priorities for avoiding bycatch (Amendment 14), selective fisheries (Amendment 14 and 17), stock classification (Amendment 16 and 17), annual catch limits (ACLs) and accountability measures (AMs) (Amendment 16), *de minimis* fishing provisions (Amendments 15 and 16). Amendment 19 was approved in 2015 and added a suite of lower trophic level species to the FMP's list of ecosystem component (EC) species. Consistent with the objectives of the Council's FMPs and its Fishery Ecosystem Plan, Amendment 19 prohibits future development of directed commercial fisheries for the suite of EC species shared between all four FMPs

(Shared EC Species) until and unless the Council has had an adequate opportunity to both assess the scientific information relating to any proposed directed fishery and consider potential impacts to existing fisheries, fishing communities, and the greater marine ecosystem.

In 1996, as part of Amendment 12, the Council made an editorial update to the framework FMP that included incorporating all of the amendments after 1984 into the *Pacific Coast Salmon Plan* (PFMC 1997b). Subsequently, the Council modified the OCN coho management goals under Amendment 13 in 1999 (PFMC 1999) and established *de minimis* fishing provisions for Klamath river fall Chinook under Amendment 15 (PFMC and NMFS 2007). The current salmon FMP incorporates changes through Amendment 17, including Amendments 14 (PFMC 2000a) and 16 (PFMC and NMFS 2011), which included extensive revisions of the FMP primarily to respond to reauthorization of the MSA and to improve the readability and organization of the plan. Table 1 contains a complete listing of the issues in each amendment through Amendment 17.

This document is the current salmon FMP. Appendix A contains the complete description of essential fish habitat, Appendix B provides a description of the fishery, and Appendix C, which will always be the Council's most current annual review of the ocean fisheries, provides an annual updating of the fishery information. The reader may wish to refer to the original salmon FMP and individual amendment documents for more background and explanatory information, including the environmental impact assessments, EISs, and examples of management options not adopted by the Council.

TABLE I. Record of salmon FMP documents.

| DOCUMENT | CONTENT SUMMARY |
|---|---|
| **Final 1977 Plan** | Initial FMP/EIS document for the 1977 salmon season. |
| **Final 1978 Plan**<br>(43 FR 29791, July 11, 1978)<br>Effective July 11, 1978[a/] | Initial, comprehensive FMP/EIS document. Amended each year to establish annual management measures for 1979-1983. |
| **Final Framework Amendment**<br>(49 FR 43679, Oct. 31, 1984)<br>Effective Nov. 25, 1984[b/] | Comprehensive amendment and SEIS that replaced the 1978 Plan as a multi-year FMP document. |
| Technical amendments: | 1) Spawner escapement goals, procedures to modify spawner goals, and inseason modification of daily bag limits (50 FR 812, Jan. 7, 1985)<br>2) Inseason rescission of automatic closures (50 FR 4977, Feb. 5, 1985)<br>3) Season opening and closing dates (50 FR 42529, Oct. 21, 1985) |
| **Amendment 7**<br>(52 FR 4146, Feb. 10, 1987)<br>Effective Mar. 8, 1987 | 1) Sliding scale OCN coho spawner escapement goal<br>2) Inseason management actions and procedures<br>3) Coho harvest allocation south of Cape Falcon |
| **Amendment 8**<br>(53 FR 30285, Aug. 11, 1988)<br>Effective Aug. 8, 1988; required no implementing regulations | 1) Habitat policy and objectives<br>2) Consideration of temporary season adjustments for vessels precluded from harvesting due to unsafe weather |
| **Amendment 9**<br>(54 FR 19185, May 4, 1989)<br>Effective May 1, 1989; except radio report section implemented July 13, 1989 (54 FR 29730, July 14, 1989) | 1) Klamath River fall Chinook harvest rate spawner escapement goal<br>2) Commercial/recreational harvest allocation north of Cape Falcon<br>3) Inseason notice procedures<br>4) Steelhead management intent<br>5) Radio reporting requirements for commercial fishers<br>6) Deleted limitations on season opening and closing dates |
| Clarifying letter: | to Mr. Rolland Schmitten re harvest allocation, Issue 2; Feb. 27, 1989 |
| Technical amendment: | Minor modification of Klamath spawner goal based on Council recommendation, March 8, 1989 (54 FR 19800, May 8, 1989 and 59 FR 23000, May 4, 1994) |
| **Amendment 10**<br>(56 FR 26774, June 11, 1991)<br>Effective July 11, 1991 | 1) Inseason reallocation objectives for commercial and recreational fisheries south of Cape Falcon<br>2) Criteria guiding non-Indian catch allocation north of Cape Falcon, especially concerning recreational port allocation<br>3) Definition of overfishing |

| | |
|---|---|
| **Amendment 11**<br>(59 FR 23013, May 4, 1994)<br>Effective April 29, 1994 | OCN coho spawner escapement goal of 42 spawners/mile, incidental exploitation rate of 20% or less on OCN coho at low stock sizes and sport coho harvest allocation criteria at low harvest levels. |
| Clarifying letter: | to Mr. Gary Smith re incidental harvest and sport allocation; Apr. 15, 1994 |
| Technical amendment: | Minor modification of Klamath spawner goal to meet tribal allocation based on Council recommendation of April 11, 1996 (61 FR 20186, May 6, 1996) |

| DOCUMENT | CONTENT SUMMARY |
|---|---|
| **Amendment 12**<br>(62 FR 35450, July 1, 1997)<br>Effective July 31, 1997 | 1) Procedures governing retention of salmon bycatch in trawl nets<br>2) Management objectives for ESA-listed salmon species<br>3) Update of the salmon FMP (no change in management objectives) |
| **Amendment 13**<br>(64 FR 26328, May 14, 1999)<br>Effective June 14, 1999) | Revision of management objectives for OCN coho to increase the probability of recovery and to prevent listing under the ESA. |
| **Amendment 14**<br>(66 FR 29238, May 30, 2001; Effective June 29, 2001) | 1) Update of the EIS and editorial improvements in the plan<br>2) New requirements of the SFA, including essential fish habitat, optimum yield, overfishing, and bycatch<br>3) Clarification of the stocks managed and management objectives<br>4) Minor revision of allocation north of Cape Falcon to allow more harvest in selective fisheries |
| **Amendment 15**<br>(73 FR 9960, February 25, 2008; Effective March 26, 2008) | Revision of Council action required under a Conservation Alert for Klamath River fall Chinook to allow *de minimis* fisheries. |
| **Amendment 16**<br>(76 FR 81851, December 29, 2011; Effective January 30, 2012) | 1) Application of new requirements of the MSA as amended in 2007 and revised NS1 Guidelines<br>2) Stock classification<br>3) Establishment of ACLs and AMs<br>4) Acceptable biological catch and incorporating scientific uncertainty<br>5) Revision of status determination criteria<br>6) Characterization of stock conservation objectives related to reference points<br>7) Development and modification of *de minimis* fishing provisions. |
| **Amendment 17**<br>(Effective January 1, 2013) | 1) Minor corrections from Amendment 16 and updating language to reflect current practices.<br>2) Approval of maximum fishing mortality threshold for Quillayute fall coho. |
| **Amendment 18**<br>(Effective September 12, 2014) | Update to reflect new information on EFH, including criteria for impassable barriers; addition of HAPCs; adjustments to geographic extent of EFH; addition of non-fishing activities and conservation measures; minor typographical adjustments and clarifications |
| **Amendment 19**<br>(Effective March 10, 2016) | Update to add a suite of lower trophic level species to the FMP's list of ecosystem EC species and to prohibit future development of commercial fisheries for the suite of EC species shared between all four FMPs (Shared EC Species) until and unless the Council has had an adequate opportunity to both assess the scientific information relating to any proposed directed fishery and consider potential impacts to existing fisheries, fishing communities, and the greater marine ecosystem. |

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a/ Implemented by emergency regulation on April 14, 1978 (43 FR 15629) and May 24, 1978 (43 FR 22214).

b/ Implemented by emergency regulation on May 3, 1984 (49 FR 18853; May 3, 1984).

# 1 WHAT THE PLAN COVERS

> *"It is therefore declared to be the purposes of the Congress in this Act (1) to take immediate action to conserve and manage the fishery resources found off the coasts of the United States, and the anadromous species and Continental Shelf Fishery resources of the United States, by exercising (A) sovereign rights for the purposes of exploring, exploiting, conserving, and managing all fish within the exclusive economic zone . . ., and (B) exclusive fishery management authority beyond the exclusive economic zone over such anadromous species and Continental Shelf fishery resources . . .(7) to promote the protection of essential fish habitat in the review of projects conducted under Federal permits, licenses, or other authorities that affect or have the potential to affect such habitat."*
>
> *Magnuson-Stevens Act, § 2*(b)

This fishery management plan (FMP) covers the coastwide aggregate of natural and hatchery salmon species that is contacted by salmon fisheries in the exclusive economic zone (EEZ) off the coasts of Washington, Oregon, and California. Salmon of U.S. and Canadian origin are included except when specific species are managed in those waters by another management entity with primary jurisdiction (i.e., sockeye and pink salmon by the Fraser River Panel of the Pacific Salmon Commission (PSC) in the Fraser River Panel Area (U.S.) between 49°N latitude and 48°N latitude). In addition, the plan contains requirements and recommendations with regard to EFH for the managed stocks as described in Chapter 4 and Appendix A. The essential fish habitat includes marine areas within the EEZ as well as estuarine and freshwater habitat within the internal waters of Washington, Oregon, California, and Idaho.

Chinook or king salmon (*Oncorhynchus tshawytscha*) and coho or silver salmon (*O. kisutch*) are the main species caught in Council-managed ocean salmon fisheries. In odd-numbered years, catches of pink salmon (*O. gorbuscha*) can also be significant, primarily off Washington and Oregon (PFMC 2012a). Therefore, while all species of salmon fall under the jurisdiction of this plan, it currently contains fishery management objectives only for Chinook, coho, pink (odd-numbered years only), and any salmon species listed under the Endangered Species Act (ESA) that is measurably impacted by Council fisheries.

The plan contains no fishery management objectives for even-numbered year pink salmon, chum (*O. keta*), sockeye (*O. nerka*), steelhead (*O. mykiss*), sea-run cutthroat (*O. clarki*) or spring run Chinook from the mid-Columbia River tributaries (White Salmon, Klickitat, Yakima, Deschutes, John Day, Umatilla, and Walla Walla basins). The Council does not manage fisheries for these species and incidental catches are inconsequential (low hundreds of fish each year) to very rare (PFMC and NMFS 2011). In the event this situation should change, management objectives for these species could be developed and incorporated by plan amendment. The incidental harvest of these salmon species can be allowed or restricted under existing federal fishery regulations.

The FMP also includes a suite of EC species that are shared between all four FMPs (Shared EC Species) and prohibits future development of directed commercial fisheries for those species until and unless the Council has had an adequate opportunity to both assess the scientific information relating to any proposed directed fishery and consider potential impacts to existing fisheries, fishing communities, and the greater marine ecosystem.

## *1.1 STOCK CLASSIFICATION*

The MSA requires that an FMP describe the species of fish involved in the fishery. The NS1 Guidelines provide a structure for classifying stocks in and around the fishery, and organizing stock complexes. This classification scheme helps conceptualize how the fishery operates, which stocks are affected by various fishery sectors, and how SDC and ACL provisions, among other MSA Section 303(a) provisions, may be applied.

The stocks identified in an FMP are classified as in or out of the fishery, and as target or non-target stocks. Target stocks and some non-target stocks are in the fishery; ecosystem component (ECs) stocks are non-target stocks that are not in the fishery. Individual stocks can also be formed into stock complexes for management and assessment purposes. Stock complexes are groups of stocks that are sufficiently similar in geographic distribution, life history, and vulnerabilities to the fishery such that the impacts of management actions on the stocks are similar. Stock complexes may be formed to facilitate management requirements such as setting ACLs in a mixed stock fishery. Each stock complex has one or more indicator stocks to establish annual harvest constraints based on status of those indicator stocks.

To the extent practicable, the Council has partitioned the coastwide aggregate of Chinook, coho, and pink salmon into various stock components and complexes with specific conservation objectives. A detailed listing of the individual stocks and stock complexes managed under this plan are provided in Tables 1-1, 1-2, and 1-3. Stocks designated as hatchery stocks rely on artificial production exclusively, while those designated as natural stocks have at least some component of the stock that relies on natural production, although hatchery production and naturally spawning hatchery fish may contribute to abundance and spawning escapement estimates. Table 1-4 lists the non-target Shared EC Species that are not in the fishery, for which future fishery development is prohibited until and unless the Council has had an adequate opportunity to both assess the scientific information relating to any proposed directed fishery and consider potential impacts to existing fisheries, fishing communities, and the greater marine ecosystem.

## *1.2 CHANGES OR ADDITIONS*

The following classification actions will require an FMP amendment: adding stocks to the FMP either to the fishery or as EC species, removing stocks from the FMP, and reclassifying stocks as either in the fishery or as an EC species. The following actions will not require an FMP amendment as long as the stocks and complex remain in their original designation (in the fishery or EC): composition of stock complexes, specification of indicator stocks for complexes, identification as target or non-target stocks. All of these actions require a comprehensive technical review of the best scientific information available providing evidence that, in the view of the Salmon Technical Team (STT), Scientific and Statistical Committee (SSC), and the Council, such modifications are justified. Insofar as possible, proposed changes noted above that do not require a plan amendment will be reviewed and approved within the schedule established for salmon estimation methodology reviews and prior to the preseason planning process. The following actions will not require an FMP amendment: changes or additions involving ESA-listed stocks upon the recommendation of NMFS, changes or additions involving hatchery stocks upon the recommendation of the pertinent federal, state, and tribal management entities; and Federal court-ordered changes.

TABLE 1-1. Chinook stocks and stock complexes identified in the Salmon FMP. (Page 1 of 4)

| **Stocks and Complexes In The Fishery** | | | |
|---|---|---|---|
| **Stock or Stock Complex** | **Component Stocks** | **Description** | **Target/Non-Target** |
| **Central Valley Fall Chinook Stock Complex** | | Fall and late fall Chinook from the Sacramento and San Joaquin basins; the indicator stock is Sacramento River Fall Chinook. | |
| | Sacramento River Fall | Primarily hatchery stock with smaller natural component. Single largest contributor to ocean fisheries off California, a significant contributor off southern and central Oregon, and present north into British Columbia. Primary impact south of Pt. Arena; considerable overlap with coastal and Klamath River fall Chinook between Pt. Arena and Horse Mt. | Target |
| | Sacramento River Late Fall | Natural and hatchery components from upper Sacramento basin. Minor contributions to ocean fisheries. | Target |
| | San Joaquin River Fall | Natural and hatchery components. Minor contributions to ocean fisheries. | Target |
| Sacramento River Spring | | ESA-listed Threatened. Minor contributions to ocean fisheries off California, also known to occur off Oregon. | Non-Target ESA |
| Sacramento River Winter | | ESA-listed Endangered. Minor contributions to ocean fisheries south of Pt. Arena. | Non-Target ESA |
| California Coastal Chinook | | ESA-listed Threatened. Eel, Mattole, Mad Rivers fall and spring stocks. Minor contributions to ocean fisheries off northern California and southern Oregon. | Non-Target ESA |
| **Southern Oregon Northern California Chinook Stock Complex** | | Natural and hatchery stocks south of the Elk River, Oregon to, and including, the Klamath River, plus Umpqua River spring Chinook; the indicator stock is Klamath River fall Chinook. | |
| | Klamath River Fall | Natural and hatchery components from the Klamath basin. Major contributions to ocean fisheries from Humbug Mt. to Horse Mt. and to Klamath River tribal and recreational fisheries. Significant contributions to ocean fisheries from Cape Falcon to Pt. Sur. | Target |
| | Klamath River Spring | Natural and hatchery components from the Klamath basin. Minor contributions to ocean fisheries from Cape Falcon to Pt. Sur. | Non-Target |
| | Smith River | Natural spring and fall stocks from the Smith River basin. Minor contributions to ocean fisheries off northern California and Oregon. | Non-Target |
| | Southern Oregon Coast | Aggregate of natural and hatchery fall and spring stocks in all streams south of Elk River, plus Umpqua spring stock; Rogue River fall stock is used to indicate relative abundance and ocean contribution rates. Significant contributions to ocean fisheries off northern California and Oregon. | Target |

TABLE 1-1. Chinook stocks and stock complexes identified in the Salmon FMP. (Page 2 of 4)

| **Stocks and Complexes In The Fishery** | | | |
|---|---|---|---|
| **Stock or Stock Complex** | **Component Stocks** | **Description** | **Target/Non-Target** |
| **Far-North-Migrating Coastal Chinook Stock Complex** | | Spring/summer and fall stocks from the Central and Northern Oregon Coast (from the Elk River north, except Umpqua River spring Chinook), and spring/summer and fall coastal stocks north of the Columbia River. Indicator stocks for this complex are Quillayute, Hoh, Queets, and Grays Harbor fall Chinook. These stocks are subject to provisions of the Pacific Salmon Treaty. | |
| | Central and Northern Oregon Coast | Aggregate of natural and hatchery fall and spring stocks in all streams from the Elk River to just south of the Columbia River. Significant contributions to Alaska and Canada ocean fisheries. Minor contributions to ocean fisheries off northern Oregon and Washington. | Non-Target |
| | Willapa Bay Fall (natural) | Significant contributions to Alaska and Canada ocean fisheries. Minor contributions to ocean fisheries off Washington. | Non-Target |
| | Willapa Bay Fall (hatchery) | Significant contributions to Alaska and Canada ocean fisheries. Minor contributions to ocean fisheries off Washington. | Non-Target |
| | Grays Harbor Fall | Natural stock. Significant contributions to Alaska and Canada ocean fisheries. Minor contributions to ocean fisheries off Washington. | Non-Target |
| | Grays Harbor Spring | Natural stock. Significant contributions to Alaska and Canada ocean fisheries. Minor contributions to ocean fisheries off Washington. | Non-Target |
| | Quinault Fall | Hatchery stock. Significant contributions to Alaska and Canada ocean fisheries. Minor contributions to ocean fisheries off Washington. | Non-Target |
| | Queets Fall | Natural stock. Significant contributions to Alaska and Canada ocean fisheries. Minor contributions to ocean fisheries off Washington. | Non-Target |
| | Queets Sp/Su | Natural stock. Significant contributions to Alaska and Canada ocean fisheries. Minor contributions to ocean fisheries off Washington. | Non-Target |
| | Hoh Fall | Natural stock. Significant contributions to Alaska and Canada ocean fisheries. Minor contributions to ocean fisheries off Washington. | Non-Target |
| | Hoh Spring/Summer | Natural stock. Significant contributions to Alaska and Canada ocean fisheries. Minor contributions to ocean fisheries off Washington. | Non-Target |
| | Quillayute Fall | Natural stock. Significant contributions to Alaska and Canada ocean fisheries. Minor contributions to ocean fisheries off Washington. | Non-Target |
| | Quillayute Spring/Summer | Hatchery and natural stocks. Significant contributions to Alaska and Canada ocean fisheries. Minor contributions to ocean fisheries off Washington. | Non-Target |
| | Hoko Summer/Fall | Natural stock. Significant contributions to Alaska and Canada ocean fisheries. Minor contributions to ocean fisheries off Washington. | Non-Target |

TABLE 1-1. Chinook stocks and stock complexes identified in the Salmon FMP. (Page 3 of 4)

| **Stocks and Complexes In The Fishery** | | | |
|---|---|---|---|
| **Stock or Stock Complex** | **Component Stocks** | **Description** | **Target/Non-Target** |
| North Lewis River Fall | | Natural stock. Component of Lower Columbia Chinook ESU - ESA-listed Threatened. Significant contribution to Alaska and Canada ocean fisheries. Minor contribution to ocean fisheries off Washington and northern Oregon. | Non-Target ESA |
| Columbia Lower River Hatchery Fall | | Significant contribution to ocean fisheries north of Cape Falcon and Canada. Minor contribution to ocean fisheries south of Cape Falcon. | Target |
| Columbia Lower River Hatchery Spring | | Minor contribution to ocean fisheries north of Cape Falcon and Canada. | Non-Target |
| Upper Willamette Spring | | Natural and hatchery stock. ESA-listed Threatened. Minor contribution to ocean fisheries north of Cape Falcon, Canada, and Alaska. | Non-Target ESA |
| Columbia Mid-River Bright Hatchery Fall | | Hatchery stock, Significant contribution to ocean fisheries off Canada and Alaska. | Non-Target |
| Columbia Spring Creek Hatchery Fall | | Significant contribution to ocean fisheries north of Cape Falcon and Canada. Minor contribution to ocean fisheries south of Cape Falcon. | Target |
| Snake River Fall | | Natural and hatchery stock. ESA-listed Threatened. Significant contributions to Alaska and Canada ocean fisheries. Minor contributions to ocean fisheries off Washington and Oregon. | Non-Target ESA |
| Snake River - Spring/Summer | | Natural and hatchery stock. ESA-listed Threatened. Negligible contributions to ocean fisheries. | Non-Target ESA |
| Columbia Upper River Bright Fall | | Natural and hatchery stock. Significant contribution to Alaska and Canada ocean fisheries. Minor contribution to ocean fisheries off Washington and northern Oregon. Subject to Pacific Salmon Treaty provisions. | Non-Target |
| Columbia Upper River Summer | | Natural and hatchery stock. Significant contribution to Alaska and Canada ocean fisheries. Minor contribution to ocean fisheries off Washington and northern Oregon. Subject to Pacific Salmon Treaty provisions. | Non-Target |
| Columbia Upper River Spring | | Natural and hatchery stock. ESA-listed Endangered. Negligible contributions to ocean fisheries. | Non-Target ESA |

TABLE 1-1. Chinook stocks and stock complexes identified in the Salmon FMP. (Page 4 of 4)

| Stocks and Complexes In The Fishery | | | |
|---|---|---|---|
| **Stock or Stock Complex** | **Component Stocks** | **Description** | **Target/Non-Target** |
| Eastern Strait of Juan de Fuca Summer/Fall | | Natural and hatchery stock. ESA-listed Threatened. Negligible contributions to ocean fisheries. | Non-Target ESA |
| Skokomish Summer/Fall | | Natural and hatchery stock. ESA-listed Threatened. Negligible contributions to ocean fisheries. | Non-Target ESA |
| Nooksack Spring early | | Natural and hatchery stock. ESA-listed Threatened. Negligible contributions to ocean fisheries. | Non-Target ESA |
| Skagit Summer/Fall | | Natural and hatchery stock. ESA-listed Threatened. Negligible contributions to ocean fisheries. | Non-Target ESA |
| Skagit Spring | | Natural and hatchery stock. ESA-listed Threatened. Negligible contributions to ocean fisheries. | Non-Target ESA |
| Stillaguamish Summer/Fall | | Natural and hatchery stock. ESA-listed Threatened. Negligible contributions to ocean fisheries. | Non-Target ESA |
| Snohomish Summer/Fall | | Natural and hatchery stock. ESA-listed Threatened. Negligible contributions to ocean fisheries. | Non-Target ESA |
| Cedar River Summer/Fall | | Natural and hatchery stock. ESA-listed Threatened. Negligible contributions to ocean fisheries. | Non-Target ESA |
| White River Spring | | Natural and hatchery stock. ESA-listed Threatened. Negligible contributions to ocean fisheries. | Non-Target ESA |
| Green River Summer/Fall | | Natural and hatchery stock. ESA-listed Threatened. Negligible contributions to ocean fisheries. | Non-Target ESA |
| Nisqually River Summer/Fall | | Natural and hatchery stock. ESA-listed Threatened. Negligible contributions to ocean fisheries. | Non-Target ESA |

TABLE 1-2. Coho stocks and stock complexes identified in the Salmon FMP. (Page 1 of 2)

| **Stocks and Complexes In The Fishery** | | |
|---|---|---|
| **Stock or Stock Complex** | **Description** | **Target/Non-Target** |
| Central California Coast | ESA Threatened. Very minor natural component of OPI area fisheries, limited contribution to ocean and inland fisheries. Current impacts incidental in ocean fisheries off California. | Non-Target ESA |
| Southern Oregon/Northern California Coast | ESA Threatened. Very minor natural component of OPI area fisheries, minor contribution to ocean fisheries off California and southern Oregon, and inland California fisheries. | Non-Target ESA |
| Oregon Coast Natural | ESA Threatened. Major natural component of OPI area, significant contribution to ocean fisheries off Oregon, and Washington south of Leadbetter Pt., and freshwater fisheries in Oregon coastal streams. | Non-Target ESA |
| Lower Columbia Natural | ESA Threatened. Minor natural component of OPI area minor contribution to ocean fisheries off Oregon and Washington, and mainstem Columbia River fisheries. | Non-Target ESA |
| Oregon Coast Hatchery | Minor component of OPI area; minor contribution to ocean fisheries off Oregon and Washington south of Leadbetter Pt., and freshwater fisheries in Oregon coastal streams. | Target |
| Columbia River Late Hatchery | Hatchery stock. Major component of ocean fisheries north of Cape Falcon. Significant contribution to ocean fisheries off Oregon north into Canada and Columbia River fisheries | Target |
| Columbia River Early Hatchery | Hatchery stock. Major component of OPI area fisheries. Significant contributions to ocean fisheries off California and north to Leadbetter Pt., Washington and to Columbia River fisheries. | Target |
| Willapa Bay - Hatchery | Minor component of ocean fisheries off northern Oregon north into Canada. Significant contribution to inside commercial net and recreational fisheries. | Target |
| Willapa Bay Natural | Minor component of ocean fisheries off northern Oregon north into Canada. | Target |
| Grays Harbor | Minor contribution to ocean fisheries off Oregon and north into Canada. Significant contribution to Washington inside tribal fishery, minor contribution to inside recreational fishery. | Target |
| Quinault - Hatchery | Contribution to ocean fisheries off Washington and north into British Columbia; present south to central Oregon; significance to Puget Sound and tribal fisheries. | Target |
| Queets | Contribution to ocean fisheries off Washington north into British Columbia; present south to central Oregon; significance to Puget Sound and tribal fisheries. | Target |
| Quillayute - Summer Hatchery | Contribution to ocean fisheries off Washington north into British Columbia; present south to central Oregon. | Target |
| Quillayute - Fall | Contribution to ocean fisheries off Washington north into British Columbia; present south to central Oregon. | Target |
| Hoh | Contribution to ocean fisheries off Washington north into British Columbia; present south to central Oregon. | Target |

Table 1-2. Coho stocks and stock complexes identified in the Salmon FMP. (Page 2 of 2)

| Stocks and Complexes In The Fishery | | |
|---|---|---|
| **Stock or Stock Complex** | **Description** | **Target/Non-Target** |
| Strait of Juan de Fuca | Contribution to U.S. ocean fisheries north of Cape Falcon; significant contribution to ocean fisheries off British Columbia, in Puget Sound, and inside tribal fisheries. | Target |
| Hood Canal | Contribution to U.S. ocean fisheries north of Cape Falcon; significant contribution to ocean fisheries off British Columbia, in Puget Sound, and inside tribal fisheries. | Target |
| Skagit | Contribution to U.S. ocean fisheries north of Cape Falcon; significant contribution to ocean fisheries off British Columbia, in Puget Sound, and inside tribal fisheries. | Target |
| Stillaguamish | Contribution to U.S. ocean fisheries north of Cape Falcon; significant contribution to ocean fisheries off British Columbia, in Puget Sound, and inside tribal fisheries. | Target |
| Snohomish | Contribution to U.S. ocean fisheries north of Cape Falcon; significant contribution to ocean fisheries off British Columbia, in Puget Sound, and inside tribal fisheries. | Target |
| South Puget Sound Hatchery | Contribution to U.S. ocean fisheries north of Cape Falcon; significant contribution to ocean fisheries off British Columbia, in Puget Sound, and inside tribal fisheries. | Target |

TABLE 1-3. Pink salmon stocks and stock complexes identified in the Salmon FMP.

| Stocks and Complexes In The Fishery | | |
|---|---|---|
| **Stock or Stock Complex** | **Description** | **Target/Non-Target** |
| Puget Sound | Contribution to U.S. ocean fisheries north of Leadbetter Point; significant contribution to ocean fisheries off British Columbia, in Puget Sound, and inside tribal fisheries. | Target |

Table 1-4. Common and scientific names of EC species shared between all four of the Council's FMPs.

| Common Name | Scientific Name |
|---|---|
| Round herring | *Etrumeus teres* |
| Thread herring | *Opisthonema libertate, O. medirastre* |
| Mesopelagic fishes | Families: *Myctophidae, Bathylagidae, Paralepididae, and Gonostomatidae* |
| Pacific sand lance | *Ammodytes hexapterus* |
| Pacific saury | *Cololabis saira* |
| Silversides | *Atherinopsidae* |
| Smelts | *Osmeridae* |
| Pelagic squids | Families: *Cranchiidae, Gonatidae, Histioteuthidae, Octopoteuthidae, Ommastrephidae* except Humboldt squid (*Dosidicus gigas*), *Onychoteuthidae, and Thysanoteuthidae* |

# 2 ACHIEVING OPTIMUM YIELD

> *"Conservation and management measures shall prevent overfishing while achieving, on a continuing basis, the optimum yield from each fishery"*
>
> *Magnuson-Stevens Act, National Standard I*

This chapter explains the Council's means of meeting the requirements of the Magnuson-Stevens Act to achieve the optimum yield from the salmon fishery.

## 2.1 THEORY

Optimum yield (OY) means the amount of fish that will provide the greatest overall benefit to the Nation, particularly with respect to food production and recreational opportunities, and taking into account protection of marine ecosystems. It is prescribed on the basis of the maximum sustainable yield (MSY) from the fishery, reduced by any relevant economic, social, or ecological factors, and provides for rebuilding of an overfished stock, taking into account the effects of uncertainty and management imprecision.

MSY is a theoretical concept that, for the purposes of the Magnuson-Stevens Act, is defined as the largest long-term average catch or yield that can be taken from a stock or stock complex under prevailing ecological and environmental conditions and fishery technological characteristics, and distribution of catch among fleets. In Council management of naturally spawning salmon stocks, MSY is usually approached in terms of the number of adult spawners associated with this goal ($S_{MSY}$). Often, data are insufficient to directly estimate $S_{MSY}$. In these cases, the Council may use MSY proxies derived from more general estimates of productive capacity and implement harvest strategies that may be expected to result in a long-term average catch approximating MSY.

## 2.2 IMPLEMENTATION

The optimum yield to be achieved for species covered by this plan is the total salmon catch and mortality (expressed in numbers of fish) resulting from fisheries within the EEZ adjacent to the States of Washington, Oregon, and California, and in the waters of those states (including internal waters), and Idaho, that, to the greatest practical extent within pertinent legal constraints, fulfill the plan's conservation and harvest objectives. On an annual basis, the Council recommends management measures to comply with annual catch limits (ACLs) and to achieve the stock conservation objectives for each stock or stock complex, based on the estimated MSY, MSY proxy, maximum sustainable production (MSP), rebuilding schedule, or ESA consultation standard (Chapter 3), while simultaneously seeking to fulfill, to the extent practicable, the harvest and allocation objectives (Chapter 5) that reflect the Council's social and economic considerations. The subsequent catch and mortality resulting under the Council's management recommendations will embody the optimum yield. The level of total allowable harvest, the relative harvest levels in various management areas, and the species and stock composition of optimum yield will vary annually, depending on the relative abundance and distribution of the various stocks and contingencies in allocation formulas.

The Council's annual Review of Ocean Salmon Fisheries (stock assessment and fishery evaluation; SAFE) document and preseason reports (e.g., PFMC 2012a, 2012b, 2012c, and 2012d) assess and specify the present and historical range of harvests and harvest related mortalities that represent the optimum yield. A similar range of yields can be expected in the future, though further stock declines and listings under the ESA could result in even lower levels than experienced prior to 2010.

# 3 CONSERVATION

> *"Conservation and management measures shall be based upon the best scientific information available."*
>
> *Magnuson-Stevens Act, National Standard 2*

Conservation of salmon stocks includes determining and reporting individual stock status and establishing conservation objectives and control rules to manage harvest. To facilitate these processes, reference points, defined by the MSA and/or National Standard 1 (NS1) Guidelines and adapted for salmon stocks are used as benchmarks.

Reference points used in the FMP include:

OFL: Overfishing Limit. Defined in NS1 Guidelines as the annual amount of catch that corresponds to the estimate of MFMT applied to a stock or complex's abundance, expressed in terms of numbers or weight of fish, and is the catch level above which overfishing is occurring.

MFMT: Maximum Fishing Mortality Threshold. Defined in NS1 Guidelines as the level of fishing mortality (F) on an annual basis, above which overfishing is occurring. MFMT is generally less than or equal to $F_{MSY}$.

$F_{MSY}$: MSY fishing mortality rate. The fishing mortality rate that results in MSY over the long term. Generally corresponds to MFMT, which is the basis of the OFL.

$S_{MSY}$: MSY spawner abundance. The abundance of adult spawners that is expected, on average, to produce MSY.

$F_{OFL}$: OFL fishing mortality rate. The level of fishing mortality (F) on an annual basis, above which overfishing is occurring; equivalent to the MFMT.

$S_{OFL}$: OFL spawner abundance. The abundance of adult spawners below which overfishing occurs in a given year.

ABC: Acceptable Biological Catch. Required by the MSA and defined in the NS1 Guidelines as the level of a stock or stock complex's annual catch that accounts for the scientific uncertainty in the estimate of OFL and other scientific uncertainty, and should be specified based on the ABC control rule. ABC may not exceed OFL and should be reduced from OFL to prevent overfishing.

$F_{ABC}$: ABC fishing mortality rate. The annual exploitation rate associated with the ABC.

ACL: Annual Catch Limit. Required by the MSA and defined in the NS1 Guidelines as the level of annual catch of a stock or stock complex that serves as the basis for invoking accountability measures. The ACL cannot exceed the ABC.

$F_{ACL}$: ACL fishing mortality rate. The annual exploitation rate associated with the ACL; equivalent to $F_{ABC}$

$S_{ACL}$: ACL spawner abundance. The annual abundance of adult spawners that achieves the ACL.

MSST: Minimum Stock Size Threshold. Defined in the NS1 Guidelines as level of biomass below which the stock or stock complex is considered to be overfished. The MSST should be no less than one-half of $S_{MSY}$.

ACT: Annual Catch Target. Defined in the NS1 Guidelines as an amount of annual catch of a stock or stock complex that is the management target of the fishery. It should usually be less than its ACL. It is an optional accountability measure that may be adopted to account for management uncertainty in complying with the ACL (see section 3.3.5.3).

## 3.1 STATUS DETERMINATION CRITERIA

> *"Any fishery management plan . . . shall . . . specify objective and measurable criteria for identifying when the fishery . . . is overfished . . . and, . . . contain conservation and management measures to prevent overfishing or end overfishing and rebuild the fishery;"*
>
> *Magnuson-Stevens Act, §303(a)(10)*

> *"Overfishing (to overfish) occurs whenever a stock or stock complex is subjected to a level of fishing mortality or annual total catch that jeopardizes the capacity of a stock or stock complex to produce MSY on a continuing basis"*
>
> *NS1Gs (600.310 (e)(2)(i)(B))*

> *"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))*

> *"Approaching an overfished condition. A stock or stock complex is approaching an overfished condition when it is projected that there is more than a 50 percent chance that the biomass of the stock or stock complex will decline below the MSST within two years."*
>
> *NS1Gs (600.310(e)(2)(i)(G)*

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).

### 3.1.2 Overfishing

A stock will be considered subject to overfishing when the postseason estimate of $F_t$ exceeds the MFMT, where the MFMT is generally defined as less than or equal to $F_{MSY}$. Stock-specific estimates of $F_{MSY}$ based on spawner-recruit data will be used if available. Otherwise, a species-specific proxy value of $F_{MSY}$= 0.78 for Chinook based on species-specific meta-analyses, will be used (PFMC and NMFS 2011). Stock-specific overfishing determinations will be made annually and are based on exploitation during a single biological year.

#### *3.1.2.1 Council Action*

Because salmon are exploited in multiple fisheries, it is necessary to determine fishery specific contribution to the total exploitation rate to determine the actions necessary to end and prevent future overfishing. As the Council has no jurisdiction over river fisheries and ocean fisheries north of the U.S./Canada border, it also may be necessary for other responsible entities to take action to end ongoing and prevent future overfishing.

The STT will report postseason exploitation rates in the annual SAFE document, and when overfishing occurs, the Council shall:

1) notify the NMFS NWR administrator of the STT's findings;
2) direct the STT to assess the mortality rates in fisheries impacting the stock of concern and report their findings;
3) immediately take action to ensure Council area fisheries are not contributing to overfishing, and;
4) notify pertinent management agencies of the stock's status and the contribution of various fisheries to the total exploitation rate.

### 3.1.3 Approaching an Overfished Condition

An approaching overfished determination will be made if the geometric mean of the two most recent postseason estimates of spawning escapement, and the current preseason forecast of spawning escapement, is below the MSST. Stock-specific approaching overfished determinations will be made annually following development of the preseason spawning escapement forecasts.

#### *3.1.3.1 Council Action*

When a stock is approaching an overfished condition the Council shall:

1) notify the NMFS NWR administrator of this situation;
2) notify pertinent management entities, and;
3) structure Council area fisheries to avoid the stock becoming overfished and to mitigate the effects on stock status.

### 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.

## *3.2 SALMON STOCK CONSERVATION OBJECTIVES*

> *"To the extent practicable, an individual stock of fish shall be managed as a unit throughout its range, and interrelated stocks of fish shall be managed as a unit or in close coordination"*
>
> *Magnuson-Stevens Act, National Standard 3*

To achieve OY, prevent overfishing, and assure rebuilding of salmon stocks whose abundance has been depressed to an overfished level, this plan establishes conservation objectives to perpetuate the coastwide aggregate of salmon stocks covered by the plan (Chapter 1). The Council's stock conservation objectives (to be achieved annually) and other pertinent stock management information are contained in Table 3-1. Specific objectives are listed for natural and hatchery stocks that are part of the Council's preseason fishery alternative development process (Chapter 9), including all relevant stocks listed under the Federal ESA. The objectives may be applicable to a single stock independently or to an indicator stock or stocks for a stock complex. Stocks that are not included in the preseason analyses may lack specific conservation objectives because the stock is not significantly impacted by ocean fisheries or insufficient information is available to assess ocean fishery impacts directly. In the latter case, the stock will be included in a stock complex and the conservation objective for an indicator stock will provide for the conservation of closely related stocks unless, or until, more specific management information can be developed.

### 3.2.1 Basis

The Council's conservation objectives for natural stocks may (1) be based on estimates for achieving MSY or an MSY proxy, or (2) represent special data gathering or rebuilding strategies to approach MSY and to eventually develop MSY objectives. The objectives have generally been developed through extensive analysis by the fishery management entities with direct management authority for the stock, or through joint efforts coordinated through the Council, or with other state, tribal, or federal entities. Most of the objectives for stocks north of Cape Falcon have been included in U.S. District Court orders. Under those orders for Washington coastal and Puget Sound stocks (Hoh v. Baldrige No. 81-742 [R] C and U.S. v. Washington, 626 F. Supp. 1405 [1985]), the treaty tribes and WDFW may agree to annual spawner targets or other objectives that differ from the FMP objectives. Details of the conservation objectives in effect at the time the initial framework FMP was approved are available in PFMC (1984), in individual amendment documents (see Table 1 in the Introduction), and as referenced in Table 3-1. Updated conservation objectives and ESA consultation standards are available in Appendix A of the most recent Preseason Report I, and Table 5 of the most recent Preseason Report III produced each year by the STT (PFMC 2012d).

The Council's conservation objectives are generally expressed in terms of an annual fishery or spawning escapement estimated to be optimum for producing MSY over the long-term. The escapement objective may be (1) a specific number or a range for the desired number of adult spawners (spawner escapement), (2) a specific number or range for the desired escapement of a stock from the ocean or at another particular location, such as a dam, that may be expected to result in the target number of spawners, or (3) based on the exploitation rate that would produce MSY over the long-term. Objectives may be expressed as fixed or stepped exploitation or harvest rates and may include spawner floors or substantially reduced harvest rates at low abundance levels, or as special requirements provided in the Pacific Salmon Treaty or NMFS consultation standards for stocks listed under the ESA.

### 3.2.2 Changes or Additions

Conservation objectives generally are fixed quantities intended to provide the necessary guidance during the course of the annual preseason planning process to establish salmon fishing seasons that achieve OY. Changes or additions to conservation objectives may be made either through a plan amendment or notice and comment rulemaking 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. Insofar as possible, proposed changes for natural stocks will only be reviewed and approved within the schedule established for salmon estimation methodology reviews completed prior to the preseason planning process. The Council may change conservation objectives for hatchery stocks upon the recommendation of the pertinent federal, state, and tribal management entities. Federal court-ordered changes in conservation objectives will also be accommodated without a plan amendment. The applicable annual objectives of Council-adopted rebuilding programs and the requirements of consultation standards promulgated by NMFS under the ESA may be employed without plan amendment to assure timely implementation. All of these changes will be documented during the Council's preseason planning process.

The Council considers established conservation objectives to be stable and a technical review of biological data must provide substantial evidence that a modification is necessary. The Council's approach to conservation objectives purposely discourages frequent changes for short-term economic or social reasons at the expense of long-term benefits from the resource. However, periodic review and revision of established objectives is anticipated as additional data become available for a stock or stock complex.

TABLE 3-1. Conservation objectives and reference points governing harvest control rules and status determination criteria for salmon stocks and stock complexes in the Pacific Coast salmon FMP. These may change periodically. The most recent values are reported annually in Preseason Reports I and III. (Page 1 of 7)

| **CHINOOK** | | | | | |
|---|---|---|---|---|---|
| **Stocks In The Fishery** | **Conservation Objective** | $S_{MSY}$ | MSST | MFMT ($F_{MSY}$) | ACL |
| Sacramento River Fall Indicator stock for the Central Valley fall (CVF) Chinook stock complex. | 122,000-180,000 natural and hatchery adult spawners (MSY proxy adopted 1984). This objective is intended to provide adequate escapement of natural and hatchery production for Sacramento and San Joaquin fall and late-fall stocks based on habitat conditions and average run-sizes as follows: Sacramento River 1953-1960; San Joaquin River 1972-1977 (ASETF 1979; PFMC 1984; SRFCRT 1994). The objective is less than the estimated basin capacity of 240,000 spawners (Hallock 1977), but greater than the 118,000 spawners for maximum production estimated on a basin by basin basis before Oroville and Nimbus Dams (Reisenbichler 1986). | 122,000 | 91,500 | 78% Proxy (SAC 2011a) | Based on $F_{ABC}$ and annual ocean abundance. $F_{ABC}$ is $F_{MSY}$ reduced by Tier 2 (10%) uncertainty |
| Sacramento River Spring ESA Threatened | NMFS ESA consultation standard/recovery plan: Conform to Sacramento River Winter Chinook ESA consultation standard (no defined objective for ocean management prior to listing). | Undefined | Undefined | Undefined | ESA consultation standard applies. |
| Sacramento River Winter ESA Endangered | NMFS ESA consultation standard/recovery plan: Recreational seasons: Point Arena to Pigeon Point between the first Saturday in April and the second Sunday in November; Pigeon Point to the U.S./Mexico Border between the first Saturday in April and the first Sunday in October. Minimum size limit ≥ 20 inches total length. Commercial seasons: Point Arena to the U.S./Mexico border between May 1 and September 30, except Point Reyes to Point San Pedro between October 1 and 15 (Monday through Friday). Minimum size limit ≥ 26 inches total length. Guidance from NMFS in 2010 and 2011 required implementation of additional closures and/or increased sized limits in the recreational fishery South of Point Arena. A new winter-run management framework and consultation standard is expected to be in place for the 2012 fishing season, or no later than March 1, 2012. (NMFS ESA Guidance for 2011). | Undefined | Undefined | Undefined | |
| California Coastal Chinook ESA Threatened | NMFS ESA consultation standard/recovery plan: Limit ocean fisheries to no more than a 16.0% age-4 ocean harvest rate on Klamath River fall Chinook. | Undefined | Undefined | Undefined | |
| Klamath River Fall Indicator stock for the Southern Oregon Northern California (SONC) Chinook stock complex. | At least 32% of potential adult natural spawners, but no fewer than 40,700 naturally spawning adults in any one year. Brood escapement rate must average at least 32% over the long-term, but an individual brood may vary from this range to achieve the required tribal/nontribal annual allocation. Natural area spawners to maximize catch estimated at 40,700 adults (STT 2005). | 40,700 | 30,525 | 71% (STT 2005) | Based on $F_{ABC}$ and annual ocean abundance. $F_{ABC}$ is $F_{MSY}$ reduced by Tier 1 (5%) uncertainty |
| Klamath River - Spring | Undefined | Undefined | Undefined | Undefined | Component stock of SONC complex; ACL indicator stock is KRFC |
| Smith River | Undefined | Undefined | Undefined | 78% Proxy (SAC 2011a) | |
| Southern Oregon | Unspecified portion of an aggregate 150,000 to 200,000 natural adult spawners for Oregon coast (Thompson 1977 and McGie 1982) measured by 60-90 fish per mile in index streams. ODFW developing specific conservation objectives for spring and fall stocks that may be implemented without plan amendment upon approval by the Council. | 60 fish per mile in index streams | 30 fish per mile in index streams | 78% Proxy (SAC 2011a) | |

TABLE 3-1. Conservation objectives and reference points governing harvest control rules and status determination criteria for salmon stocks and stock complexes in the Pacific Coast salmon FMP. These may change periodically. The most recent values are reported annually in Preseason Reports I and III. (Page 2 of 7)

| **CHINOOK** | | | | | | |
|---|---|---|---|---|---|---|
| **Stocks In The Fishery** | **Conservation Objective** | | $S_{MSY}$ | MSST | MFMT ($F_{MSY}$) | ACL |
| Central and Northern Oregon | Unspecified portion of an aggregate 150,000 to 200,000 natural adult spawners for Oregon coast (Thompson 1977 and McGie 1982) measured by 60-90 fish per mile in index streams. ODFW developing specific conservation objectives for spring and fall stocks that may be implemented without plan amendment upon approval by the Council. | | 60 Fish per mile in index streams | 30 Fish per mile in index streams | 78% Proxy (SAC 2011a) | Component stock(s) of FNMC complex; international exception applies, ACLs are not applicable |
| Willapa Bay Fall | Undetermined in FMP. WDFW spawning escapement objective of 4,350. | | 3,393 | 1,697 | 78% Proxy (SAC 2011a) | |
| Grays Harbor Fall Indicator stock for the Far North Migrating Coastal (FNMC) Chinook stock complex | 14,600 natural adult spawners--MSP based on full seeding of spawning and rearing habitat (WDF 1979). | Annual natural spawning escapement targets may vary from FMP conservation objectives if agreed to by WDFW and treaty tribes under the provisions of *Hoh v. Baldrige* and subsequent U.S. District Court orders. | 11,388 | 5,694 | 78% Proxy (SAC 2011a) | FNMC complex; international exception applies, ACLs are not applicable.. |
| Queets Fall Indicator stock for the FNMC Chinook stock complex | Manage terminal fisheries for 40% harvest rate, but no less than 2,500 natural adult spawners, the MSY level estimated by Cooney (1984). | | 2,500 | 1,250 | 87% (Cooney 1984) | |
| Hoh Fall Indicator stock for the FNMC Chinook stock complex | Manage terminal fisheries for 40% harvest rate, but no less than 1,200 natural adult spawners, the MSY level estimated by Cooney (1984). | | 1,200 | 600 | 90% (Cooney 1984) | |
| Quillayute Fall Indicator stock for the FNMC Chinook stock complex | Manage terminal fisheries for 40% harvest rate, but no less than 3,000 natural adult spawners, the MSY level estimated by Cooney (1984). | | 3,000 | 1,500 | 87% (Cooney 1984) | |
| Hoko Summer/Fall Indicator stock for the FNMC Chinook stock complex | 850 natural adult spawners, the MSP level estimated by Ames and Phinney (1977). May include adults used for supplementation program. | | 850 | 425 | 78% Proxy (SAC 2011a) | |
| Grays Harbor Spring | 1,400 natural adult spawners. | | 1,400 | 700 | 78% Proxy (SAC 2011a) | FNMC complex; international exception applies, ACLs are not applicable. |
| Queets Sp/Su | Manage terminal fisheries for 30% harvest rate, but no less than 700 natural adult spawners. | | 700 | 350 | 78% Proxy (SAC 2011a) | |
| Hoh Spring/Summer | Manage terminal fisheries for 31% harvest rate, but no less than 900 natural adult spawners. | | 900 | 450 | 78% Proxy (SAC 2011a) | |
| Quillayute Spring/Summer | 1,200 natural adult spawners for summer component (MSY). | | 1,200 | 600 | 78% Proxy (SAC 2011a) | |
| Willapa Bay Fall (hatchery) | 8,200 adult return to hatchery. WDFW spawning escapement objective of 9,800 hatchery spawners. | | Not applicable to hatchery stocks | | | |
| Quinault Fall (hatchery) | Hatchery production. | | | | | |

TABLE 3-1. Conservation objectives and reference points governing harvest control rules and status determination criteria for salmon stocks and stock complexes in the Pacific Coast salmon FMP. These may change periodically. The most recent values are reported annually in Preseason Reports I and III. (Page 3 of 7)

| **CHINOOK** | | | | | |
|---|---|---|---|---|---|
| **Stocks In The Fishery** | **Conservation Objective** | $S_{MSY}$ | MSST | MFMT ($F_{MSY}$) | ACL |
| North Lewis River Fall | NMFS consultation standard/recovery plan. McIsaac (1990) stock-recruit analysis supports MSY objective of 5,700 natural adult spawners. | 5,700 | ESA consultation standard applies. | 76% | ESA consultation standard applies. |
| Snake River Fall | NMFS consultation standard/recovery plan. No more than 70.0% of 1988-1993 base period AEQ exploitation rate for all ocean fisheries. | Undefined | | Undefined | |
| Upper Willamette Spring | NMFS consultation standard/recovery plan. Not applicable for ocean fisheries. | Undefined | | Undefined | |
| Columbia Upper River Spring | NMFS consultation standard/recovery plan. Not applicable for ocean fisheries. | Undefined | | Undefined | |
| Snake River - Spring/Summer | NMFS consultation standard/recovery plan. Not applicable for ocean fisheries. | Undefined | | Undefined | |
| Columbia Lower River Hatchery - Fall | 12,600 adults for hatchery egg-take. | Not applicable to hatchery stocks | | | |
| Columbia Lower River Hatchery Spring | 2,700 adults to meet Cowlitz, Kalama, and Lewis Rivers broodstock needs. | | | | |
| Columbia Mid-River Bright Hatchery Fall | 4,700 adults for Bonneville Hatchery and 2,000 for Little White Salmon Hatchery egg-take. | | | | |
| Columbia Spring Creek Hatchery Fall | 7,000 adults to meet hatchery egg-take goal. | | | | |
| Columbia Upper River Bright Fall | 40,000 natural bright adults above McNary Dam (MSY proxy adopted in 1984 based on CRFMP). The management goal has been increased to 60,000 by Columbia River managers in recent years. | 39,625 (Langness and Reidinger 2003) | 19,812 | 85.91% (Langness and Reidinger 2003) | International exception applies, ACLs are not applicable. |
| Columbia Upper River Summer | Hold ocean fishery impacts at or below base period; recognize CRFMP objective - MSY proxy of 80,000 to 90,000 adults above Bonneville Dam, including both Columbia and Snake River stocks (state and tribal management entities considering separate objectives for these stocks). | 12,143 (CTC 1999) | 6,071 | 75% (CTC 1999) | |

TABLE 3-1. Conservation objectives and reference points governing harvest control rules and status determination criteria for salmon stocks and stock complexes in the Pacific Coast salmon FMP. These may change periodically. The most recent values are reported annually in Preseason Reports I and III. (Page 4 of 7)

| **CHINOOK** | | | | | | |
|---|---|---|---|---|---|---|
| **Stocks In The Fishery** | **Conservation Objective** | | $S_{MSY}$ | MSST | MFMT ($F_{MSY}$) | ACL |
| Eastern Strait of Juan de Fuca Summer/Fall | NMFS consultation standard/recovery plan. No more than 10.0% Southern U.S. (SUS) Rebuilding Exploitation Rate (RER) for the Elwha River and for the Dungeness River. 2011 comanagers Resource Management Plan (RMP) | Annual natural spawning escapement targets may vary from FMP conservation objectives if agreed to by WDFW and treaty tribes under the provisions of U.S. v. Washington and subsequent U.S. District Court orders. | Undefined | ESA consultation standard applies | Undefined | ESA Consultation standard applies. |
| Skokomish Summer/Fall | NMFS consultation standard/recovery plan. No more than 50.0% total RER. 2011 comanagers RMP | | Undefined | | Undefined | |
| Mid Hood Canal Summer/Fall | NMFS consultation standard/recovery plan. No more than 15.0% preterminal SUS CERC. 2011 comanagers RMP | | Undefined | | Undefined | |
| Nooksack Spring early | NMFS consultation standard/recovery plan. No more than 7.0% SUS CERC. 2011 comanagers RMP | | Undefined | | Undefined | |
| Skagit Summer/Fall | NMFS consultation standard/recovery plan. No more than 50.0% total RER. 2011 comanagers RMP | | Undefined | | Undefined | |
| Skagit Spring | NMFS consultation standard/recovery plan. No more than 38.0% total RER. 2011 comanagers RMP | | Undefined | | Undefined | |
| Stillaguamish Summer/Fall | NMFS consultation standard/recovery plan. No more than 25.0% total RER. 2011 comanagers RMP | | Undefined | | Undefined | |
| Snohomish Summer/Fall | NMFS consultation standard/recovery plan. No more than 15.0% SUS RER. 2011 comanagers RMP | | Undefined | | Undefined | |
| Cedar River Summer/Fall | NMFS consultation standard/recovery plan. No more than 20.0% SUS RER. 2011 comanagers RMP | | Undefined | | Undefined | |
| White River Spring | NMFS consultation standard/recovery plan. No more than 20.0% total RER. 2011 comanagers RMP | | Undefined | | Undefined | |
| Green River Summer/Fall | NMFS consultation standard/recovery plan. No more than 15.0% preterminal SUS RER, at least 5,800 adult spawners. | | Undefined | | Undefined | |
| Nisqually River Summer/Fall | NMFS consultation standard/recovery plan. No more than 65.0% total RER. 2011 comanagers RMP | | Undefined | | Undefined | |
| Puyallup Summer/Fall | NMFS consultation standard/recovery plan. No more than 50.0% total RER. 2011 comanagers RMP | | Undefined | | Undefined | |

TABLE 3-1. Conservation objectives and reference points governing harvest control rules and status determination criteria for salmon stocks and stock complexes in the Pacific Coast salmon FMP. These may change periodically. The most recent values are reported annually in Preseason Reports I and III. (Page 5 of 7)

| **COHO** | | | | | | |
|---|---|---|---|---|---|---|
| **Stocks In The Fishery** | **Conservation Objective** | | $S_{MSY}$ | MSST | MFMT ($F_{MSY}$) | ACL |
| Central California Coast<br>ESA Threatened | NMFS ESA consultation standard/recovery plan: No retention of coho south of the OR/CA border. | | Undefined | ESA consultation standard applies | Undefined | ESA consultation standard applies. |
| Southern Oregon/Northern California Coast<br>ESA Threatened | NMFS ESA consultation standard/recovery plan: No more than a 13.0% AEQ exploitation rate in ocean fisheries on Rogue/Klamath hatchery coho. | | Undefined | | Undefined | |
| Oregon Coastal Natural<br>ESA Threatened | NMFS ESA consultation standard/recovery plan: Total AEQ exploitation rate limit based on parental seeding level and marine survival matrix in FMP Table 3-2. | | Undefined | | Undefined | |
| Lower Columbia Natural<br>ESA Threatened | NMFS ESA consultation standard/recovery plan: AEQ exploitation rate limit on ocean and mainstem Columbia fisheries indentified in annual NMFS guidance. | | Undefined | | Undefined | |
| Oregon Coast Hatchery | Hatchery production. | | Not applicable to hatchery stocks | | | |
| Columbia River Late Hatchery | Hatchery rack return goal of 14,200 adults. | | | | | |
| Columbia River Early Hatchery | Hatchery rack return goal of 6,200 adults. | | | | | |
| Willapa Bay - Hatchery | Hatchery rack return goal of 6,100 adults. | | | | | |
| Quinault - Hatchery | Hatchery production. | | | | | |
| Quillayute - Summer Hatchery | Hatchery production. | | | | | |
| South Puget Sound Hatchery | Hatchery rack return goal of 52,000 adults. | | | | | |
| Willapa Bay Natural | Undefined | Undefined | Undefined | Undefined | Undefined | Undefined |

TABLE 3-1. Conservation objectives and reference points governing harvest control rules and status determination criteria for salmon stocks and stock complexes in the Pacific Coast salmon FMP. These may change periodically. The most recent values are reported annually in Preseason Reports I and III. (Page 6 of 7)

| COHO | | | | | | |
|---|---|---|---|---|---|---|
| **Stocks In The Fishery** | **Conservation Objective** | | $S_{MSY}$ | MSST | MFMT ($F_{MSY}$) | ACL |
| Grays Harbor | 35,400 natural adult spawners (MSP based on WDF [1979]) | Annual natural spawning escapement targets may vary from FMP conservation objectives if agreed to by WDFW and treaty tribes under the provisions of Hoh v. Baldrige, U.S. v. Washington, or subsequent U.S. District Court orders | 24,426 $S_{MSP}$ (FMP) *$F_{SMY}$ (SAC 2010b) | 18,320 (Johnstone et al. 2011) | MFMT=65% (Johnstone et al. 2011)<br>$F_{MSY}$=69% (SAC 2011b) | International exception applies, ACLs are not applicable. |
| Queets | MSY range of 5,800 to 14,500 natural adult spawners (Lestelle et al 1984) | | 5,800 (Johnston et al. 2011) | 4,350 (Johnstone et al. 2011) | MFMT=65% (Johnstone et al. 2011)<br>$F_{MSY}$=68% (SAC 2011b) | |
| Hoh | MSY range of 2,000 to 5,000 natural adult spawners (Lestelle et al. 1984) | | 2,520 (SAC 2010b) | 1,890 $S_{MSY}$*0.75 | MFMT=65% (Johnstone et al. 2011)<br>$F_{MSY}$=69% (SAC 2011b) | |
| Quillayute - Fall | MSY range of 6,300 to 15,800 natural adult spawners (Lestelle et al. 1984) | | 6,300 (Johnston et al. 2011) | 4,725 (Johnstone et al. 2011) | MFMT=59%; $F_{MSY}$=59% (SAC 2011b) | |
| Strait of Juan de Fuca | Total allowable MSY exploitation rate of: 0.60 for ocean age-3 abundance > 27,445; 0.40 for ocean age-3 abundance >11,679 and ≤27,445; 0.20 for ocean age-3 abundance ≤11,679 | | 11,000 (Bowhay et al. 2009) | 7,000 (Bowhay et al. 2009) | 60% (Bowhay et al. 2009) | |
| Hood Canal | Total allowable MSY exploitation rate of: 0.65 for ocean age-3 abundance > 41,000; 0.45 for ocean age-3 abundance >19,545 and ≤41,000; 0.20 for ocean age-3 abundance ≤19,545 | | 14,350 (Bowhay et al. 2009) | 10,750 (Bowhay et al. 2009) | 65% (Bowhay et al. 2009) | |
| Skagit | Total allowable MSY exploitation rate of: 0.60 for ocean age-3 abundance > 62,500; 0.35 for ocean age-3 abundance >22,857 and ≤62,500; 0.20 for ocean age-3 abundance ≤22,857 | | 25,000 (Bowhay et al. 2009) | 14,857 (Bowhay et al. 2009) | 60% (Bowhay et al. 2009) | |
| Stillaguamish | Total allowable MSY exploitation rate of: 0.50 for ocean age-3 abundance > 20,000; 0.35 for ocean age-3 abundance >9,385 and ≤20,000; 0.20 for ocean age-3 abundance ≤9,385 | | 10,000 (Bowhay et al. 2009) | 6,100 (Bowhay et al. 2009) | 50% (Bowhay et al. 2009) | |
| Snohomish | Total allowable MSY exploitation rate of: 0.60 for ocean age-3 abundance > 125,000; 0.40 for ocean age-3 abundance >51,667 and ≤125,000; 0.20 for ocean age-3 abundance ≤51,667 | | 50,000 (Bowhay et al. 2009) | 31,000 (Bowhay et al. 2009) | 60% (Bowhay et al. 2009) | |

TABLE 3-1. Conservation objectives and reference points governing harvest control rules and status determination criteria for salmon stocks and stock complexes in the Pacific Coast salmon FMP. These may change periodically. The most recent values are reported annually in Preseason Reports I and III. (Page 7 of 7)

| **PINK (odd-numbered years)** | | | | | |
|---|---|---|---|---|---|
| **Stocks In The Fishery** | **Conservation Objective** | $S_{MSY}$ | MSST | MFMT ($F_{MSY}$) | ACL |
| Puget Sound | 900,000 natural spawners or consistent with provisions of the Pacific Salmon Treaty (Fraser River Panel). | 900,000 | 450,000 | Undefined | International exception applies, ACLs are not applicable. |

## 3.3 HARVEST CONTROLS

Control rules are used to manage the harvest of stocks to achieve optimum yield while preventing overfishing. Control rules specify the allowable harvest of stocks based on their abundance and are predicated on meeting conservation objectives in addition to relating those objectives to biological reference points such as MSY, MFMT, OFL, MSST, ABC, and ACL. For stocks with escapement based conservation objectives, the control rule limits exploitation to achieve escapement objectives. For stocks with exploitation rate-based conservation objectives, escapement targets vary annually depending on stock abundance.

Reference points defined by the MSA and/or NS1 Guidelines are used as benchmarks within the control rules. They are useful for evaluating and comparing control rules, and in some cases are triggers for management actions. There are several formulations of control rules for different stocks in the FMP, using various combinations of reference points. These stock-specific control rules are applied consistently from year to year.

### 3.3.1 Relationship to ESA consultation standards

The ESA requires federal agencies whose actions may adversely affect listed salmon to consult with NMFS. Because NMFS implements ocean harvest regulations, it is both the action and consulting agency for actions taken under the FMP. To ensure there is no jeopardy, NMFS conducts ESA consultations with respect to the effects of ocean harvest on listed salmon stocks. In cases where the biological consultation results in a “no jeopardy” opinion, NMFS issues an incidental take statement which authorizes a limited amount of take of listed species that would otherwise be prohibited under the ESA. In cases where a “jeopardy” opinion is reached, NMFS develops reasonable and prudent alternatives to the proposed action which authorizes a limited amount of take.

The constraints on take authorized under incidental take statements and reasonable, prudent alternatives are collectively referred to as consultation standards. These constraints take a variety of forms including FMP conservation objectives, limits on the time and area during which fisheries may be open, ceilings on fishery impact rates, and reductions from base period impact rates. NMFS may periodically revise consultation standards and the annual NMFS guidance letter reflects the most current information. Consultation standards that were in place in 2011 when Amendment 16 was completed are shown in the table of conservation objectives (Table 3-1), which is reproduced each year in the latest annual addition of Preseason Report I (PFMC 2012b).

ESA consultation standards represent another form of fishery control rule. Although NMFS consultation standards and recovery plans may not by themselves recover listed populations to historic $S_{MSY}$ levels, they are sufficient to stabilize populations until freshwater habitats and their dependent populations can be restored and estimates of MSY consistent with recovered habitat conditions can be developed. As species are delisted, the Council will establish conservation objectives and associated reference points consistent with the MSA.

### 3.3.2 Relationship to the Pacific Salmon Treaty

Pacific salmon stocks subject to fisheries in both the US and Canada are managed under the provisions of the Pacific Salmon Treaty (PST). Natural stocks managed under the provisions of the PST include: (1) Puget Sound pink salmon stocks, (2) most non-ESA-listed Chinook stocks from the mid-Oregon coast to the US/Canada border, and (3) all non-ESA-listed coho stocks except Willapa Bay natural coho. For these stocks, the PST annually places overall limits on fishery impacts and allocates those impacts between the US and Canada. It allows the US and Canada to each manage their own fisheries to achieve domestic conservation and allocation priorities, while remaining within the overall limits determined under the PST.

The MSA provides an exception to the requirement for a fishery management plan to specify ACLs and Accountability Measures (AMs) for stocks managed under an international agreement in which the United States participates. Because of these provisions of the PST, and the exception provided by the MSA, it is unnecessary for the FMP to specify an ACL or associated reference points for these stocks. The PST also includes measures of accountability which take effect if annual limits established under the Treaty are exceeded, and further reduce these limits in response to depressed stock status. However, it is still necessary to specify MSY and SDC reference points for these stocks.

### 3.3.3 Acceptable Biological Catch

Specification of ABC is required for all stocks or stock complexes in the fishery that are not managed under an international agreement, listed under the ESA, or designated as hatchery stocks. For salmon, ABC is defined in terms of spawner escapement ($S_{ABC}$), which is consistent with the common practice of using spawner escapement to assess stock status for salmon. $S_{ABC}$ is determined annually based on stock abundance, in spawner equivalent units, N, and the exploitation rate $F_{ABC}$.

$$S_{ABC} = N \times (1 - F_{ABC}).$$

The ABC control rule defines $F_{ABC}$ as a fixed exploitation rate reduced from $F_{MSY}$ to account for scientific uncertainty. The degree of the reduction in F between $F_{ABC}$ and $F_{MSY}$ depends on whether $F_{MSY}$ is directly estimated (tier 1 stock) or a proxy value is used (tier 2 stock). For tier 1 stocks, $F_{ABC}$ equals $F_{MSY}$ reduced by five percent. For tier 2 stocks, $F_{ABC}$ equals $F_{MSY}$ reduced by ten percent.

Tier-1: $F_{ABC} = F_{MSY} \times 0.95$.
Tier-2: $F_{ABC} = F_{MSY} \times 0.90$.

The STT will apply the ABC control rule on an annual basis by making preseason forecasts of N, and applying the fixed $F_{ABC}$. Stock abundance forecasts and the resulting $S_{ABC}$ estimates will be reported in Preseason Report I, and presented to the SSC at the March Council meeting. Following its review, the SSC will recommend stock abundance forecasts and $S_{ABC}$ estimates to the Council in an oral and written statement provided at the March meeting.

The SSC will have an ongoing role in evaluating ABCs through their annual review of stock abundance forecasts and their prerogative to initiate re-evaluation of the ABC control rule. Abundance forecast methods are periodically revised and these revisions are evaluated by the SSC through the salmon methodology review process. The SSC could revisit the ABC control rule as needed during the salmon methodology review.

### 3.3.4 Annual Catch Limits

ACLs and OFLs, in addition to ABCs, are required for all stocks or stock complexes classified as in the fishery that are not managed under an international agreement, listed under the ESA, or designated as hatchery stocks. For salmon, these reference points are defined in terms of spawner escapement ($S_{ACL}$, $S_{OFL}$).

$S_{ACL}$ and $S_{OFL}$ are calculated annually, both as preseason estimates and postseason values. Preseason estimates of these reference points are used for development of annual fishery management measures. Postseason values are used to identify whether accountability measures (AMs) are to be triggered, and to assess management performance.

$S_{ACL}$ and $S_{OFL}$ are determined based on stock abundance, in spawner equivalent units, (N) and the corresponding reference point exploitation rates $F_{ACL}$ and $F_{OFL}$, where the exploitation rates are fixed values that do not change on an annual basis. $F_{OFL}$ is defined as being equal to the MFMT, which generally corresponds to and $F_{MSY}$, and

$$S_{OFL} = N \times (1 - F_{OFL}).$$

$F_{ACL}$ is equivalent to $F_{ABC}$ and

$$S_{ACL} = N \times (1 - F_{ACL}),$$

which results in $S_{ACL} = S_{ABC} > S_{OFL}$ for each management year.

#### 3.3.4.1 Preseason ACLs

During the annual preseason salmon management process, $S_{ACL}$ will be estimated using the fixed $F_{ACL}$ exploitation rate and the preseason stock abundance forecast (N). Fishery management measures must result in an expected spawning escapement greater than or equal to this $S_{ACL}$ estimate. In many years, the targeted exploitation rate will be lower than $F_{ACL}$ as a result of stock-specific conservation objectives and the control rule used to specify F on an annual basis. Under the condition where $F < F_{ACL}$, the forecast escapement would exceed the estimated $S_{ACL}$.

#### 3.3.4.2 Postseason ACLs

The postseason value of $S_{ACL}$ will be determined annually using the fixed $F_{ACL}$ exploitation rate and the postseason N. The postseason value of $S_{ACL}$ will be compared to the realized spawner escapement for evaluation of whether the realized escapement fell below the $S_{ACL}$.

Postseason evaluation of $S_{ACL}$ is necessary for determining whether AMs should be triggered and whether the $S_{ACL}$ performance standard is met. AMs will be triggered if the realized escapement is below the $S_{ACL}$ value in any one year. If the realized escapement is below the $S_{ACL}$ value in more than one of four years, the ACL performance standard will not have been met, and a re-evaluation of the ACL framework will be undertaken, consistent with the NS1 Guidelines.

### 3.3.5 Accountability Measures

Accountability measures are required for all stocks and stock complexes in the Salmon FMP that are required to have ACLs. AMs are intended to prevent shortfalls in escapement below the $S_{ACL}$ and to correct or mitigate them if they occur. Some AMs are implemented during the preseason planning process and in-season. Others are implemented postseason through monitoring and reporting requirements. Additional accountability measures will be implemented, as required, if the ACL performance standard is not met as indicated by the realized escapement being below $S_{ACL}$ in more than one in four consecutive years.

#### 3.3.5.1 Preseason and In-season Accountability Measures

The following measures will be implemented during the preseason planning process or inseason to meet the intent of preseason management objectives and to help ensure compliance with ACLs.

- In-season authority to manage quota fisheries (FMP § 10.1) – allows NMFS to close fisheries on short notice when mixed stock quotas are projected to be met. As described above, quotas are designed to ensure that ACLs and conservation objectives for component stocks are met.
- Mixed stock quota monitoring (FMP § 7.1) – collection of data on a daily basis during the season allows projection of when quotas will be met.
- Quota partitioning (FMP § 5.3 and 10.2) – partitioning overall quota among fishery sectors and port areas and time periods allows finer scale management, thereby reducing the chance that overall quota will be exceeded.

- Quota trading (FMP § 5.3 and 10.2) – quota trading allows overages in one sector/time/area to be made up by reductions in others.
- Changes to gear/bag/size/trip limits (FMP § 6 and 10.2) – allow a measure of control over catch rates to reduce the chance of quotas being exceeded.
- Boundary modifications (FMP § 6 and 10.2) – allow limited control over catch composition to limit impacts on constraining stocks.
- Landing restrictions (FMP § 6 and 10.2) - allow better accounting of the location of catches and thus better estimates of catch composition.
- In-season monitoring and reporting requirements. (FMP § 7) – collection of data on a daily basis during the season allows projection of when quotas will be met.
- Annual catch targets - intended to account for management uncertainty.

An ACT may be adopted in any fishing year in which there is uncertainty in the ability to maintain compliance with the ACL or the applicable control rule for a given stock. The ACT would be specified at a level sufficiently above the $S_{ACL}$ to address uncertainty in the ability to constrain catch for ACL compliance and uncertainty in quantifying the true catch amounts (i.e., estimation errors).

#### *3.3.5.2 Post-season Accountability Measures*

The following postseason AMs will be implemented through the assessment and review phases of the salmon management process:

- Salmon Methodology Review Process (COP-15; PFMC 2008) - provides a process for re-evaluation of management objectives, reference points, and modification of models that relate mixed-stock impacts to stock-specific objectives and reference points.
- Annual SAFE (Review of Ocean Salmon Fisheries) document (FMP § 8) - allows postseason assessment of objectives and performance.

If the realized escapement is below the postseason $S_{ACL}$ value, an AM will be to report on the escapement shortfall in the annual Council preseason reports and to notify state, tribal, and federal managers. If it is necessary to correct problems in the assessment or management methods, such changes can be considered during the annual Salmon Methodology Review process.

#### *3.3.5.3 Performance and Re-evaluation of the ACLs and AMs System*

If the postseason-ACL evaluation for assessing compliance with ACLs determines that spawning escapement was not in compliance with the ACL more than once in four consecutive years, the Council will direct the STT to conduct an assessment of the cause and re-evaluate the ACL and AM system. The assessment will include consideration of the tiered buffers used to account for scientific uncertainty, and may include recommendations for changing the buffers. Any recommendations for changing the buffer between the ABC and OFL (i.e., ABC control rule) should be included, along with supporting analyses, in the annual Salmon Methodology Review process. Recommendations on changes to AMs or adding new AMs, including whether an ACT should be implemented, should also be provided in this report.

Pending the outcome of the STT re-evaluation of the ACLs and AMs system, an ACT could be implemented as an interim measure if it was determined that management uncertainty in the fishery was a substantial cause for non-compliance, and/or to reduce the likelihood of future non-compliance with the ACL until any new or updated measures are approved. For example, an additional 5 percent buffer could be used to establish an ACT control rule and to set an ACT below the ACL. The ACT control rule would be used until either additional measures are adopted to ensure an appropriate compliance with ACLs, or it has been demonstrated that the ACT control rule is not necessary to achieve an appropriate compliance level.

## 3.3.6 Specific Control Rules for Stocks, Indicator Stocks, and Complexes

### 3.3.6.1 Klamath River Fall Chinook, Sacramento River Fall Chinook

Klamath River fall Chinook and Sacramento River fall Chinook have the same form of control rule, which is defined in terms of the reference points $F_{ABC}$, MSST, $S_{MSY}$, and two levels of *de minimis* exploitation rates, F = 0.10 and F = 0.25. The maximum allowable exploitation rate, F, in a given year, depends on the pre-fishery ocean abundance in spawner equivalent units, N. At high abundance the rule caps the exploitation rate at $F_{ABC}$, at moderate abundance the rule specifies an F that results in $S_{MSY}$ spawners, and at low abundance (i.e. when expected escapement is below $S_{MSY}$) the rule allows for *de minimis* exploitation rates as shown in Figure 3-1 with the abundance breakpoints defined as

$$A = \mathrm{MSST} / 2$$

$$B = (\mathrm{MSST} + S_{\mathrm{MSY}}) / 2$$

$$C = S_{\mathrm{MSY}} / (1 - 0.25)$$

$$D = S_{\mathrm{MSY}} / (1 - F_{\mathrm{ABC}})\ .$$

For N between 0 and A, F increases linearly from 0 at N = 0, to 0.10 at N = A. For N between A and MSST, F is equal to 0.10. For N between MSST and B, F increases linearly from 0.10 at N = MSST, to 0.25 at N = B. For N between B and C, F is equal to 0.25. For N between C and D, F is the value that results in $S_{MSY}$ spawners. For N greater than D, F is equal to $F_{ABC}$. The control rule may thus be summarized as follows.

$$F = \begin{cases} 0.10 \times (N / A), & \text{if} \quad 0 \le N \le A; \\ 0.10, & \text{if} \quad A < N \le \mathrm{MSST}; \\ 0.10 + (0.15 \times ((N - \mathrm{MSST}) / (B - \mathrm{MSST}))), & \text{if} \quad \mathrm{MSST} < N \le B; \\ 0.25, & \text{if} \quad B < N \le C; \\ (N - S_{\mathrm{MSY}}) / N, & \text{if} \quad C < N \le D; \\ F_{\mathrm{ABC}}, & \text{if} \quad D < N. \end{cases}$$

The control rule describes maximum allowable exploitation rates at any given level of abundance. The Council may recommend lower exploitation rates as needed to address uncertainties or other year specific circumstances. When recommending an allowable *de minimis* exploitation rate in a given year, the Council shall also consider the following circumstances:

- The potential for critically low natural spawner abundance, including considerations for substocks that may fall below crucial genetic thresholds;
- Spawner abundance levels in recent years;
- The status of co-mingled stocks;
- Indicators of marine and freshwater environmental conditions;
- Minimal needs for tribal fisheries;
- Whether the stock is currently in an approaching overfished condition;
- Whether the stock is currently overfished;
- Other considerations as appropriate.

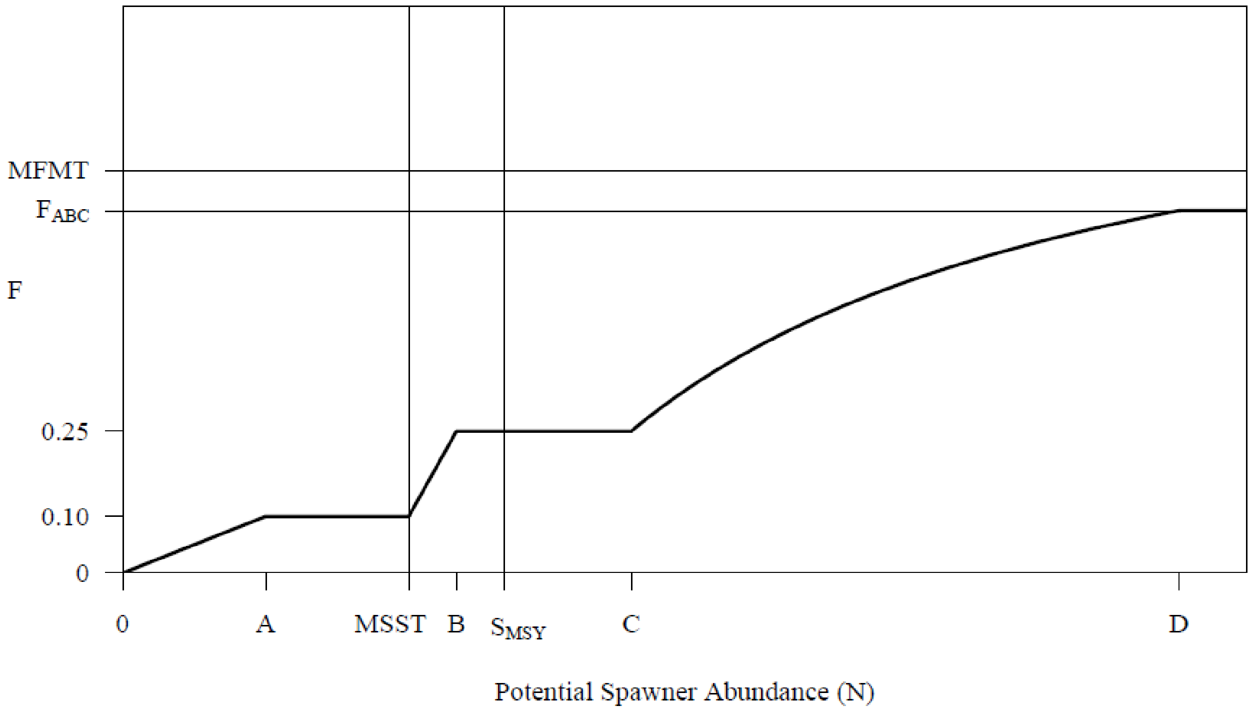

FIGURE 3-1. Control rule for Sacramento River and Klamath River fall Chinook. Abundance is pre-fishery ocean abundance in spawner equivalent units, and F is the exploitation rate. Reference points in the control rule are defined in the text.

#### *3.3.6.2 Washington Coast Chinook and Coho, Columbia River Summer Chinook, Upriver Bright Fall Chinook*

Most non-ESA-listed natural stocks originating north of the Elk River, Oregon are managed under the terms of the PST with control rules designed to achieve MSY either by meeting $S_{MSY}$ annually or by controlling fishing rates to achieve MSY over the long term. Chinook and coho stocks from the Washington coast, Columbia River summer Chinook, and upriver bright fall Chinook fall under this category, and share the same form of control rule, which can be negotiated annually through related federal court orders (Figure 3-2). Council area fisheries represent a minority of the harvest impacts on these stocks, with the majority of harvest impacts occurring in northern and/or inside fisheries. At low abundance levels, some *de minimis* level of fishing impacts are allowed by the provisions of the PST, negotiations through federal court orders, or reserved tribal fishing rights. The magnitude of the *de minimis* impacts, and the actual abundance level at which they occur, vary from stock to stock. At high abundance levels, the control rules are such that F may exceed MFMT in some years because management of some of these stocks is focused on attaining $S_{MSY}$ on an annual basis. If the year specific exploitation rate on a stock exceeds MFMT, the Council will report this as overfishing according to the terms of the MSA and NS1 Guidelines.

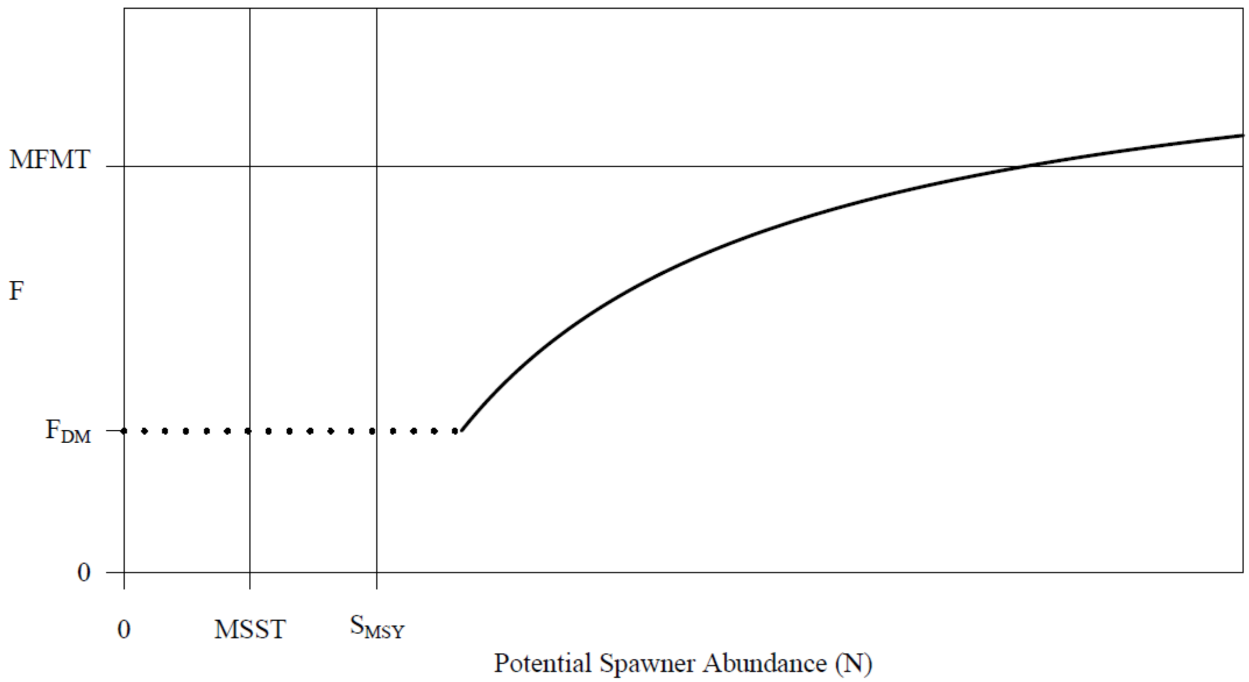

FIGURE 3-2. Control rule for several Chinook and coho stocks managed under the terms of the PST. Abundance is pre-fishery ocean abundance in spawner equivalent units, and F is the exploitation rate. Reference points in the control rule are defined in the text.

### 3.3.6.3 Puget Sound Coho

Puget Sound coho stocks are managed under the PST using a stepped harvest rate control rule (Figure 3-3) (Southern Coho Management Plan Chapter 5, Annex IV, Article XV, PST 2009). Under this control rule, exploitation rate ceilings are determined on the basis of abundance, where abundance is divided into three categories defined by two breakpoints defined as

$A = \frac{MSST}{1-F_{low}}$, breakpoint between critical and low abundance,

$B = \frac{S_{MSY}}{1-MFMT}$, breakpoint between low and normal abundance.

The exploitation rate ceiling has a maximum value of MFMT when $N > B$, is reduced to a low exploitation rate ($F_{low}$) when $A < N < B$, and further reduced to a critical exploitation rate ($F_{critical}$) to allow for *de minimis* impacts not to exceed 0.20 when $N < A$. For all Puget Sound coho stocks, the critical/low spawning escapement breakpoint and low exploitation rate are used to define MSST (Table 3.1).

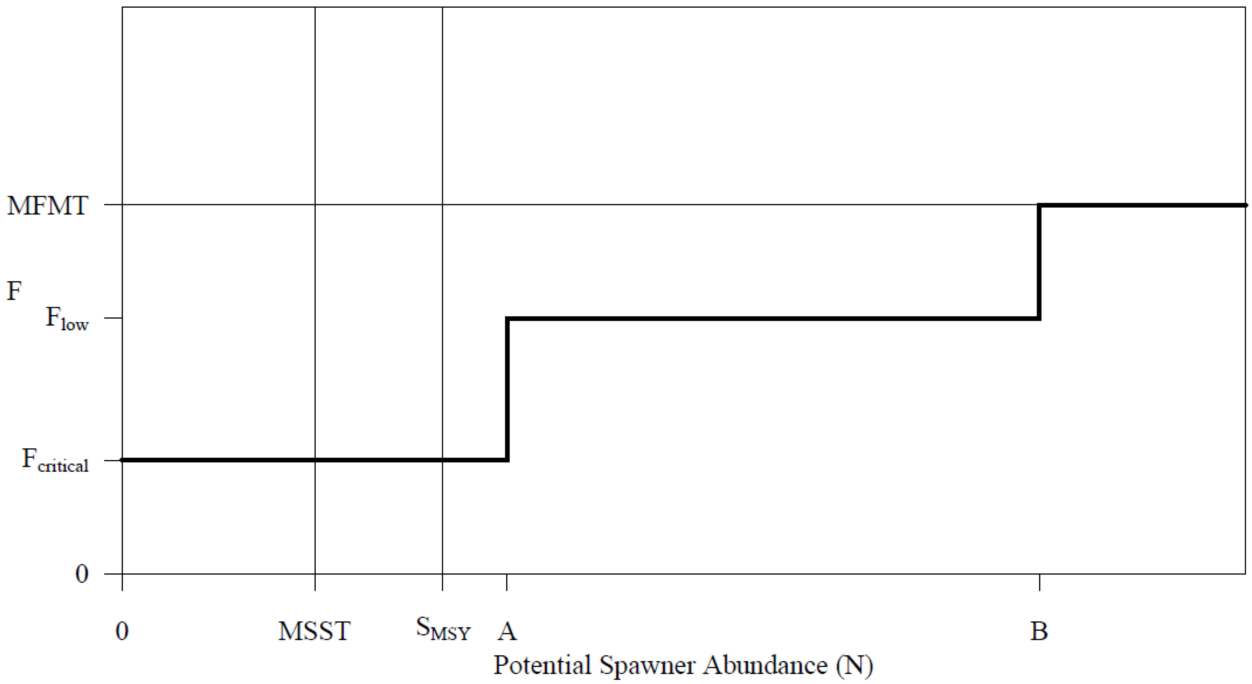

FIGURE 3-3. Control rule for Puget Sound coho. Abundance is pre-fishery ocean abundance in spawner equivalent units, and F is the exploitation rate. Reference points in the control rule are defined in the text.

#### *3.3.6.4 Oregon Coastal Natural Coho*

Oregon coastal natural coho (OCN) are currently listed as threatened under the ESA and are therefore managed under ESA consultation standards. Amendment 13 (PFMC 1999) established a recovery and rebuilding plan for OCN coho which (1) defines individual management criteria for four separate stock components, (2) sets overall harvest exploitation rate targets for OCN coho that significantly limit the impact of fisheries on the recovery of depressed stock components, (3) promotes stock rebuilding while allowing limited harvest of other abundant salmon stocks during critical rebuilding periods, (4) is consistent with the Oregon State recovery plan, and (5) has been adopted by NMFS as a consultation standard for OCN coho. Under the rebuilding program, the overall allowable fishery impact rate in any given year for each stock component is determined by the spawning abundance of the parents and grandparents of the returning adults and upon the marine survival expectations for the current maturing brood, as predicted by smolt-to-jack survival rates for hatchery coho.

The assessment of historical parent abundance utilized in Amendment 13 is based on the number of spawners in each of the four stock components that is projected to achieve full seeding of high quality freshwater habitat at low levels of marine survival. The full seeding estimates (in terms of stratified random sampling numbers) are derived from a model based on freshwater habitat assessment which incorporates measures of variability in the quality of the freshwater habitat and estimates of survival between life stages where numerical indicators have been measured (Nickelson and Lawson 1996). The assessment of marine survival status is based on a partitioning of the observed marine survival for Oregon hatchery reared coho from 1970-1996 (PFMC 1999).

Under the rebuilding plan, the allowable overall fishery impact (exploitation rate) for OCN coho represents all fishing related mortality, including marine and freshwater fisheries for both retention and catch-and-release fishing (Table 3-2). The maximum allowable exploitation rates range from less than 10 percent when parent abundance and/or marine survival is especially low, to a high of 35 percent if two generations of spawner rebuilding have occurred and marine survival is sufficient to expect continued improvements in spawner escapement for a third generation. Regardless of high parental spawning levels or projected favorable ocean conditions, a cap of 35percent in total stock impacts is maintained to provide insight as to the effects of high spawner levels on production. A limitation of 15 percent remains in effect even at the two highest tiers of parent escapement if ocean conditions are not favorable, so as to preserve rebuilding progress achieved to that point. The matrix in Table 3-2 illustrates specifically how spawner abundance and marine survival determine the maximum allowable stock exploitation rate objectives for each OCN coho stock component.

Each of the four OCN coho stock components will be managed in marine fisheries as a separate stock to the extent that the best scientific information allows. Because of apparent similarities in the marine distribution of the four components, little flexibility is expected in marine fishery intensities among the components. If some components begin rebuilding faster than others, but data are not available which allows the marine harvest of OCN coho components at different rates, opportunities for increased ocean harvest may be constrained by the weakest component. Any management flexibility for increased fisheries on any strong OCN coho component will likely be in freshwater or estuarine areas during the initial phase of the rebuilding process. In these areas, the Oregon Department of Fish and Wildlife (ODFW) will base fishing opportunity on the status of populations in individual basins within a stock component, and directed fisheries on natural coho will be allowed only when spawners are expected to be at or above the full seeding level for high quality habitat. Actual seasons would be based on the presence of fin-clipped hatchery fish (e.g., mark-selective fisheries), public comment, and other basin-specific factors. An intensive monitoring program will be implemented by ODFW to measure the overall management effectiveness toward the goal of increasing OCN spawner levels and consequent juvenile and adult progeny. The Environmental Assessment (EA) for Amendment 13 (PFMC 1999) contains further details of the monitoring plan and of the overall OCN coho management criteria and its basis.

Amendment 13 to the Salmon FMP was designed to ensure that fishery related impacts do not act as a significant impediment to the recovery of depressed OCN coho stocks. When the Council first adopted the amendment in November 1997, they stipulated that it should be reviewed and updated periodically with particular attention to the parameters in the matrix that triggered allowable fishery impacts. The OCN work group was formed in 1999 to consider concerns related to persistent observations of low marine survival and low spawner abundance. The work group provided a draft report to the Council in September 2000 (PFMC 2000b). The draft report recommended expanding the harvest matrix to include two new parental abundance categories and one new marine survival category thus expanding the original 3x3 matrix to a 4x5 matrix. The new parental spawner categories occur in the low end of the spawner abundance range and are designated as “Extremely Low” and “Critical.” The new marine survival category, designated as “Extremely Low,” is also in the low end of the range. The work group recommended lower exploitation rates when spawner abundance or marine survival are low and therefore provided a more conservative framework relative to the original Amendment 13 matrix. The recommendations of the work group report were adopted by the Council as expert biological advice for how to implement Amendment 13, and continue to be used by the Council as guidance for implementing Amendment 13.

TABLE 3-2. Allowable fishery impact rate criteria for OCN coho stock components.

| | | MARINE SURVIVAL INDEX (based on return of jacks per hatchery smolt) | | |
|---|---|---|---|---|
| | | **Low** (<0.0009) | **Medium** (0.0009 to 0.0034) | **High** (>0.0034) |
| **PARENT SPAWNER STATUS** | | **Allowable Total Fishery Impact Rate** | | |
| **High:** | Parent spawners achieved Level #2 rebuilding criteria; grandparent spawners achieved Level #1 | ≤15% | ≤30%[a/] | ≤35%[a/] |
| **Medium:** | Parent spawners achieved Level #1 or greater rebuilding criteria | ≤15% | ≤20%[a/] | ≤25%[a/] |
| **Low:** | Parent spawners less than Level #1 rebuilding criteria | ≤15%<br>≤10-13%[b/] | ≤15% | ≤15% |

| | OCN Coho Spawners by Stock Component | | | | |
|---|---|---|---|---|---|
| **Rebuilding Criteria** | **Northern** | **North-Central** | **South-Central** | **Southern** | **Total** |
| Full Seeding at Low Marine Survival: | 21,700 | 55,000 | 50,000 | 5,400 | 132,100 |
| Level #2 (75% of full seeding): | 16,400 | 41,300 | 37,500 | 4,100 | 99,300 |
| Level #1 (50% of full seeding): | 10,900 | 27,500 | 25,000 | 2,700 | 66,100 |
| 38% of Level #1 (19% of full seeding): | 4,100 | 10,500 | 9,500 | 1,000 | 25,100 |

| **Stock Component (Boundaries)** | **Full Seeding of Major Basins at Low Marine Survival (Number of Adult Spawners)** | | | | |
|---|---|---|---|---|---|
| | Nehalem | Tillamook | Nestucca | Ocean Tribs. | |
| **Northern:** (Necanicum River to Neskowin Creek) | 17,500 | 2,000 | 1,800 | 400 | |
| | Siletz | Yaquina | Alsea | Siuslaw | Ocean Tribs. |
| **North-Central:** (Salmon River to Siuslaw River) | 4,300 | 7,100 | 15,100 | 22,800 | 5,700 |
| | Umpqua | Coos | Coquille | Coastal Lakes | |
| **South-Central:** (Siltcoos River to Sixes River) | 29,400 | 7,200 | 5,400 | 8,000 | |
| | Rogue | | | | |
| **Southern:** (Elk River to Winchuck River) | 5,400 | | | | |

a/ When a stock component achieves a medium or high parent spawner status under a medium or high marine survival index, but a major basin within the stock component is less than 10% of full seeding: (1) the parent spawner status will be downgraded one level to establish the allowable fishery impact rate for that component and (2) no coho-directed harvest impacts will be allowed within that particular basin.

b/ This exploitation rate criteria applies when (1) parent spawners are less than 38% of the Level #1 rebuilding criteria, or (2) marine survival conditions are projected to be at an extreme low as in 1994-1996 (<0.0006 jack per hatchery smolt). If parent spawners decline to lower levels than observed through 1998, rates of less than 10% would be considered, recognizing that there is a limit to further bycatch reduction opportunities.

### 3.3.7 Changes and Additions to Control Rules

The form of a control rule should only be changed by plan amendment, or as necessary to rebuild overfished stocks. However, the reference point values that define a particular control rule (e.g., $S_{MSY}$) may be periodically updated. Changes to these reference point values, or specification of reference points for stocks where estimates are currently lacking, may be made through a regulatory process without plan amendment 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. Insofar as possible, a proposed change to the value of a reference point will only be reviewed and approved within the schedule established for salmon estimation Salmon Methodology Reviews (completed at the November meeting prior to the year in which the proposed change would be effective) and apart from the preseason planning process (PFMC 2008). Federal court-ordered changes will also be accommodated without a plan amendment.

## 3.4 MANAGEMENT FOR HATCHERY AND ESA-LISTED STOCKS

> *”Conservation and management measures shall take into account and allow for variations among, and contingencies in, fisheries, fishery resources, and catches.”*
>
> *Magnuson-Stevens Act, National Standard 6*

The NS1 Guidelines provide flexibility under limited circumstances in the way reference points and management measures are specified. The NS1 Guidelines allow for flexibility in the management of ESA-listed species, hatchery stocks, and stocks with unusual life history characteristics like Pacific salmon. Consistent with these provisions of the NS1 Guidelines, this plan takes an alternative approach to the specification of control rules and status determination criteria and subsequent Council actions for hatchery stocks, and stocks listed under the ESA that are in the fishery.

### 3.4.1 Hatchery Stocks

Salmon stocks important to ocean fisheries and comprised exclusively of hatchery production generally have conservation objectives expressed as an egg-take or the number of spawners returning to the hatchery to meet program objectives. This plan recognizes these objectives and strives to meet them. However, these artificially produced stocks generally do not need the protection of ACLs, SDC, and special Council rebuilding programs to maintain long-term production. Because hatchery stocks can generally sustain significantly higher exploitation rates than natural stocks, ocean fisheries rarely present a threat to their long-term survival. In addition, it is often possible to make temporary program modifications at hatcheries to assure adequate production to sustain the stock during periods of low abundance (e.g., sharing brood stock with other hatcheries, arranging for trapping at auxiliary sites, etc.). If specialized hatchery programs are approved in the future to sustain ESA-listed salmon stocks, the rebuilding programs would be developed and implemented under the ESA.

### 3.4.2 Stocks Listed Under the Endangered Species Act

The ESA requires federal agencies whose actions may adversely affect listed salmon to consult with NMFS. Because NMFS implements ocean harvest regulations, it is both the action and consulting agency for actions taken under the FMP. To ensure that ESA standards are met, NMFS conducts internal consultations with respect to the effects of ocean harvest on listed salmon. The Council implements NMFS' guidance as necessary to avoid jeopardy, and conform to the degree possible with recovery plans approved by NMFS. As a result of NMFS' consultation, an incidental take statement may be issued which authorizes take of listed stocks under the FMP that would otherwise be prohibited under the ESA.

The Council believes that the requirements of the ESA are sufficient to meet the intent of the MSA overfishing provisions. Those provisions are structured to maintain or rebuild stocks to levels at or above MSY and require the Council to identify and develop rebuilding plans for overfished stocks. For many fish species regulated under the MSA, the elimination of excess fishing pressure is often the sole action necessary to rebuild depressed stocks. This is, however, not the case for many salmon stocks and, in particular, for most ESA-listed populations.

Although harvest has certainly contributed to the depletion of West Coast salmon populations, the primary reason for their decline has been the degradation and loss of freshwater spawning, rearing, and migration habitats. The quality and quantity of freshwater habitat are key factors in determining the MSY of salmon populations. The Council has no control over the destruction or recovery of freshwater habitat nor is it able to predict the length of time that may be required to implement the habitat improvements necessary to recover stocks. While the Council could theoretically establish new MSY escapement goals consistent with the limited or degraded habitat available to listed species, adoption of revised goals would potentially result in an ESA-listed stock being classified as producing at MSY and; therefore, not overfished under the MSA. As species are delisted, the Council may establish conservation objectives and associated reference points to manage stocks consistent with the MSA, or alternatively, remove the stock from the FMP through a plan amendment.

Since 1990, West Coast salmon fisheries have been modified to accommodate special requirements for the protection of salmon species listed under the federal ESA. The ESA listing of a salmon population may have profound consequences for the management of Council mixed-stock ocean fisheries since listed populations are often incidentally harvested with more abundant healthy populations. As additional stocks of salmon have been listed, the Council's preseason process has increasingly focused on protecting listed stocks. In applying the ESA to Pacific salmon, NMFS determined that a population segment of a salmon species must represent an evolutionarily significant unit (ESU) of that species in order to be eligible for listing. ESUs are characterized by their reproductive isolation and contribution to the genetic diversity of the species as a whole. NMFS establishes consultation standards for listed ESUs, which specify levels of incidental take that are not likely to jeopardize the continued existence of the ESU.

The Council must meet or exceed the requirements of the ESA, which is other applicable law. In addition to the stocks and conservation objectives in Table 3-1, the Council will manage all species listed under the ESA consistent with NMFS consultation standards or recovery plans to meet immediate conservation needs and to achieve the long-term recovery of the species. These standards are provided annually to the Council by NMFS at the start of the preseason planning process. In so far as is practical, while not compromising its ability to meet the requirements of the ESA, NMFS will endeavor to provide opportunity for Council and peer review of any proposed consultation standards, or the objectives of recovery plans, well prior to their implementation. Such review would ideally commence no later than the last Council meeting in the year immediately preceding the first salmon season in which the standards would be implemented.

Table 3-3 summarizes the relationships of the individual stocks and stock units managed under the FMP to the ESUs identified by NMFS in the course of ESA status reviews. With the exception of some hatchery stocks, the stocks managed under the FMP are generally representative of the range of life history features characteristic of most ESUs. The managed stocks therefore serve as indicators for ESUs and provide the information needed to monitor fishery impacts on ESUs as a whole. In some cases, the information necessary for stock specific management is lacking, leaving some ESUs without adequate representation. For these ESUs, it will be necessary in the immediate future to use conservative management principles and the best available information in assessing impacts in order to provide necessary protection. In the meantime, the responsible management entities should implement programs to ensure that data are collected for at least one stock representative of each ESU. Programs should be developed within five years of any ESA listing to provide the information that will permit the necessary stock specific management.

TABLE 3-3. Listing of evolutionarily significant units, their ESA status, and associated stocks managed under the FMP. (Page 1 of 2).

| **ESU$^{a/}$** | **ESA Status Month and Year of Initial Listing** | **Stock Representation in FMP** |
|---|---|---|
| **- - - CHINOOK - - -** | | |
| Central Valley Fall and Late Fall-run | Candidate Species Sept. 1999 | ⚒ Sacramento River Fall |
| Central Valley Spring-run | Listed Threatened Sept. 1999 | ⚒ Sacramento River Spring |
| Sacramento River Winter-run | Listed Endangered Aug. 1989 | ⚒ Sacramento River Winter |
| California Coast | Listed Threatened Sept. 1999 | ⚒ Eel, Mattole, and Mad Rivers |
| Southern Oregon/Northern California Coast | Not Warranted Sept. 1999 | ⚒ Southern Oregon<br>⚒ Smith River<br>⚒ Klamath River Fall |
| Upper Klamath and Trinity Rivers | Not Warranted | ⚒ Klamath River Fall<br>⚒ Klamath River Spring |
| Oregon Coast | Not Warranted | ⚒ Central and Northern Oregon |
| Washington Coast | Not Warranted | ⚒ Willapa Bay Fall<br>⚒ Grays Harbor Fall<br>⚒ Grays Harbor Spring<br>⚒ Queets Fall<br>⚒ Queets Spring/Summer<br>⚒ Hoh Fall<br>⚒ Hoh Spring/Summer<br>⚒ Quillayute Fall<br>⚒ Quillayute Spring/Summer<br>⚒ Hoko Summer/Fall (Western Strait of Juan de Fuca) |
| Puget Sound | Listed Threatened May 1999 | ⚒ Elwha Summer/Fall (Eastern Strait of Juan de Fuca)<br>⚒ Skokomish Summer/Fall (Hood Canal)<br>⚒ Nooksack Spring (early)<br>⚒ Skagit Summer/Fall<br>⚒ Skagit Spring<br>⚒ Stillaguamish Summer/Fall<br>⚒ Snohomish Summer/Fall<br>⚒ Cedar River Summer/Fall (Lake Washington)<br>⚒ White River Spring<br>⚒ Green River Summer/Fall<br>⚒ Nisqually River Summer/Fall (South Puget Sound) |
| Lower Columbia River | Listed Threatened May 1999 | ⚒ Sandy, Kalama, and Cowlitz (fall and spring)<br>⚒ North Lewis River Fall |
| Upper Willamette River | Listed Threatened May 1999 | ⚒ Upper Willamette River |
| | | ⚒ |
| Upper-Columbia River Summer/Fall | Not Warranted | ⚒ Upper River Bright<br>⚒ Upper River Summer |
| Upper Columbia River Spring | Listed Endangered May 1999 | ⚒ Upper River Spring |
| Snake River Fall | Listed Threatened May 1992 | ⚒ Snake River Fall |
| Snake River Spring/Summer | Listed Threatened May 1992 | ⚒ Snake River Spring/Summer |
| **- - - COHO - - -** | | |
| Central California Coast | Listed Threatened Dec. 1996 | ⚒ By proxy - Rogue/Klamath hatchery coho |
| | | |

| | | |
|---|---|---|
| Southern Oregon/Northern California Coasts | Listed Threatened May 1997 | Southern Oregon Coastal Natural<br>Northern California |
| Oregon Coast | Listed Threatened Oct. 1998 | South Central Oregon Coast<br>North Central Oregon Coast<br>Northern Oregon Coastal |
| Lower Columbia River | Listed Threatened June 2005 | Columbia River Natural |
| Southwest Washington Coast | Candidate Species July 1995 | Grays Harbor |
| Olympic Peninsula | Not Warranted | Queets<br>Hoh<br>Quillayute Fall<br>Strait of Juan de Fuca (Western) |
| Puget Sound/Strait of Georgia | Candidate Species | Strait of Juan de Fuca (Eastern)<br>Hood Canal<br>Skagit<br>Stillaguamish<br>Snohomish |
| - - - **PINK** - - - | | |
| Puget Sound, Odd Numbered Years | Not Warranted | Puget Sound |

a/ A description of the ESU boundaries may be found at 63 FR 11486 (March 9, 1998) for Chinook and 60 FR 38016 (July 25, 1995) for coho.

# 3.5 BYCATCH

> *”Conservation and management measures shall, to the extent practicable, (A) minimize bycatch and (B) to the extent bycatch cannot be avoided, minimize the mortality of such bycatch.”*
>
> *Magnuson-Stevens Act, National Standard 9*

> *”...Establish a standardized reporting methodology to assess the amount and type of bycatch occurring in the fishery, and include conservation and management measures that, to the extent practicable and in the following priority▪*
> *(A) minimize bycatch; and*
> *(B) minimize the mortality of bycatch which cannot be avoided;”*
>
> *Magnuson-Stevens Act , § 303(a)(11)*

## 3.5.1 Definition and Management Intent

“Bycatch” for the purposes of this fishery management plan is defined as fish caught in an ocean salmon fishery which are not sold or kept for personal use and includes economic discards, regulatory discards, and fishery mortality due to an encounter with fishing gear that does not result in capture of fish. Bycatch does not include any fish that legally are retained in a fishery and kept for personal, tribal, or cultural use, or that enter commerce through sale, barter, or trade. In addition, under the provisions of the MSA, bycatch does not include salmon released alive under a recreational catch-and-release fishery management program.

Under the salmon FMP, the primary bycatch that occurs is bycatch of salmon species. Therefore, the Council’s conservation and management measures shall seek to minimize salmon bycatch and bycatch mortality (drop off and hooking mortality) to the greatest extent practical in all ocean fisheries. When bycatch cannot be avoided, priority will be given to conservation and management measures that seek to minimize bycatch mortality and ensure the extended survival of such fish. These measures will be developed in consideration of the biological and ecological impacts to the affected species, the social and economic impacts to the fishing industry and associated communities, and the impacts upon the fishing, management, and enforcement practices currently employed in ocean salmon fisheries (see also Section 6.5.3).

Shared EC Species, identified in Table 1-4, could continue to be taken incidentally without violating Federal regulations, unless regulated or restricted for other purposes, such as with bycatch minimization regulations. The targeting of Shared EC Species is prohibited.

### 3.5.2 Occurrence

The present bycatch and bycatch mortality estimates and methodologies for salmon in salmon fisheries are documented by the STT annually in the SAFE and Preseason Report III documents. Bycatch of salmon in Pacific Coast trawl fisheries is documented in Amendment 12 (PFMC 1997a). More recent information is reported in a Section 7 biological opinion regarding salmon bycatch in the groundfish fishery (NMFS 2006), and a subsequent report that summarizes the bycatch of salmon in recent years (Bellman et al. 2011). Salmon fisheries or fishery practices that lack or do not have recent observation data or estimates of bycatch composition and associated mortality rates will be identified by the Council for future research priority in their biannual Research and Data Needs Report to NMFS. Future changes in the procedures and methodologies will occur only if a comprehensive technical review of existing biological data justifies a modification and is approved by the STT, SSC, and Council. All of these changes will occur within the schedule established for Salmon Methodology Review and apart from the preseason planning process (PFMC 2008).

Bycatch of fish other than salmon in salmon fisheries is generally very limited. Only hook-and-line gear is allowed in ocean salmon fisheries and regulations allow for retention of most groundfish species and limited numbers of Pacific halibut that are caught incidentally while salmon fishing.

### 3.5.3 Standard Reporting Methodology

Within the salmon preseason planning process, management alternatives will be assessed for the effects on the amount and type of salmon bycatch and bycatch mortality. Estimates of salmon bycatch and incidental mortalities associated with salmon fisheries will be included in the modeling assessment of total fishery impact and assigned to the stock or stock complex projected to be impacted by the proposed management measures. The resultant fishery impact assessment reports for the ocean salmon fisheries will specify the amount of salmon bycatch and bycatch mortality associated with each accompanying management alternative. The final analysis of Council-adopted management measures will contain an assessment of the total salmon bycatch and bycatch mortality for ocean salmon fisheries, and include the percentage that these estimates represent compared to the total harvest projected for each species, as well as the relative change from the previous year’s total bycatch and bycatch mortality levels.

# 4 HABITAT AND PRODUCTION

> *"Any fishery management plan . . . shall . . . protect, restore, and promote the long-term health and stability of the fishery."*
>
> *Magnuson-Stevens Act, §303(a)(1)*

The Council will be guided by the principle that there should be no net loss of the productive capacity of marine, estuarine, and freshwater habitats that sustain commercial, recreational, and tribal salmon fisheries beneficial to the nation. Within this policy, the Council will assume an aggressive role in the protection and enhancement of anadromous fish habitat, especially essential fish habitat (EFH).

## *4.1 ESSENTIAL FISH HABITAT*

> *"...Describe and identify essential fish habitat for the fishery . . . minimize to the extent practicable adverse effects on such habitat caused by fishing, and identify other actions to encourage the conservation and enhancement of such habitat;"*
>
> *Magnuson-Stevens Act, §303(a)(7)*

Protecting, restoring, and enhancing the natural productivity of salmon habitat, especially the estuarine and freshwater areas, is an extremely difficult challenge that must be achieved if salmon fisheries are to remain healthy for future generations. Section 3(10) of the MSA defines EFH as those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity. The following interpretations have been made by NMFS to clarify this definition: waters include aquatic areas and their associated physical, chemical, and biological properties that are used by fish, and may include historical areas if appropriate; substrate includes sediment, hard bottom, structures underlying the waters, and associated biological communities; necessary means the habitat required to support a sustainable fishery and the managed species contribution to a healthy ecosystem; and spawning, breeding, feeding, or growth to maturity covers a species full life cycle.

### 4.1.1 Identification and Description

Appendix A to the *Pacific Coast Salmon Fishery Management Plan* contains the Council's complete identification and description of Pacific coast salmon EFH, along with a detailed assessment of adverse impacts and actions to encourage conservation and enhancement of EFH. Pacific coast salmon EFH includes those waters and substrate necessary for salmon production needed to support a long-term sustainable salmon fishery and salmon contributions to a healthy ecosystem. In the estuarine and marine areas, salmon EFH extends from the extreme high tide line in nearshore and tidal submerged environments within state territorial waters out to the full extent of the exclusive economic zone (200 nautical miles or 370.4 km) offshore of Washington, Oregon, and California north of Point Conception. Foreign waters off Canada, while still salmon habitat, are not included in salmon EFH, because they are outside U.S. jurisdiction. Pacific coast salmon EFH also includes the marine areas off Alaska designated as salmon EFH by the North Pacific Fishery Management Council for stocks also managed by the Pacific Fishery Management Council. The geographic extent of freshwater EFH is identified as all water bodies currently or historically occupied by Council-managed salmon in Washington, Oregon, Idaho, and California as identified in Table 1 of Appendix A. Salmon EFH includes aquatic areas above all artificial barriers except the impassible barriers (dams) listed in Table 1 of Appendix A. However, activities occurring above impassable barriers that are likely to adversely affect EFH below impassable barriers are subject to the EFH consultation provisions of the MSA. The identification and description of EFH may be modified in the future through the process outlined in 4.1.4 below, or through salmon FMP amendments as new or better information becomes available.

### 4.1.2 Adverse Effects of Fishing on Essential Fish Habitat

To the extent practicable, the Council must minimize adverse impacts of fishing activities on salmon EFH. Fishing activities may adversely affect EFH if the activities cause physical, chemical, or biological alterations of the substrate, and loss of or injury to benthic organisms, prey species and their habitat, and other components of the ecosystem. The marine activities under Council management authority or influence that may impact EFH are fishing activities and the use of fishing gear, prey removal by other fisheries, and salmon fishing that reduces stream nutrients due to fewer salmon carcasses on the spawning grounds. Within its fishery management authority, the Council may use fishing gear restrictions, time and area closures, or harvest limits to reduce negative impacts on EFH. Section 4.1 of Appendix A provides descriptions of the potential impacts on EFH from fishing activities. The descriptions include both fisheries within Council management authority and those under other management jurisdictions.

In determining actions to take to minimize any adverse effects from fishing, the Council will consider the nature and extent of the impact and the practicality and effectiveness of management measures to reduce or eliminate the impact. The consideration will include long- and short-term costs and benefits to the fishery and EFH along with other appropriate factors consistent with National Standard 7 (”Conservation and management measures shall, where practicable, minimize costs and avoid unnecessary duplication.”).

### 4.1.3 Adverse Effects of Non-Fishing Activities on Essential Fish Habitat

> *“Each Council shall comment on and make recommendations to the Secretary and any Federal or State agency concerning any such activity (authorized, funded, or undertaken, or proposed to be undertaken by any Federal or State agency) that, in the view of the Council, is likely to substantially affect the habitat, including essential fish habitat, of an anadromous fishery resource under its authority.”. . . “Within 30 days . . . a Federal agency shall provide a detailed response in writing ....”*
>
> *Magnuson-Stevens Act, §305(b)*

The Council will strive to assist all agencies involved in the protection of salmon habitat. This assistance will generally occur in the form of Council comments endorsing protection, restoration, or enhancement programs; requesting information on, and justification for, actions which may adversely impact salmon production; and in promoting salmon fisheries’ needs among competing uses for the limited aquatic environment. In commenting on actions which may affect salmon habitat, the Council will seek to ensure implementation of consistent and effective habitat policies with other agencies having environmental control and resource management responsibilities over production and harvest in inside marine and fresh waters.

Specific recommendations for conservation and enhancement measures for EFH are listed in Appendix A. In implementing its habitat mandates, the Council will seek to achieve the following overall objectives:

1. Work to assure that Pacific salmon, along with other fish and wildlife resources, receive equal treatment with other purposes of water and land resource development.

2. Support efforts to restore Pacific salmon stocks and their habitat through vigorous implementation of federal, tribal, and state programs.

3. Work with fishery agencies, tribes, land management agencies, and water management agencies to assess habitat conditions and develop comprehensive restoration plans.

4. Support diligent application and enforcement of regulations governing ocean oil exploration and development, timber harvest, mining, water withdrawals, agriculture, or other stream corridor uses by local, state, and federal authorities. It is Council policy that approved and permitted activities employ the best management practices available to protect salmon and their habitat from adverse effects of contamination from domestic and industrial wastes, pesticides, dredged material disposal, and radioactive wastes.

5. Promote agreements between fisheries agencies and land and water management agencies for the benefit of fishery resources and to preserve biological diversity.

6. Strive to assure that the standard operation of existing hydropower and water diversion projects will not substantially reduce salmon productivity.

7. Support efforts to identify and avoid cumulative or synergistic impacts in drainages where Pacific salmon spawn and rear. The Council will assist in the coordination and accomplishment of comprehensive plans to provide basin-wide review of proposed hydropower development and other water use projects. The Council encourages the identification of no-impact alternatives for all water resource development.

8. Support and encourage efforts to determine the net economic value of conservation by identifying the economic value of fish production under present habitat conditions and expected economic value under improved habitat conditions.

### 4.1.4 Procedures for Amending Salmon EFH

The EFH regulations (600.815(a)(10)) require periodic review and revision of EFH provisions, as appropriate. The regulations also require FMPs to outline the procedures the Council will follow to review and revise EFH information. The following process provides a mechanism for the Council to update certain EFH provisions. Potential changes to EFH provisions can result from periodic EFH reviews, or in response to any other information that becomes available and warrants consideration of changes to EFH. Amending the FMP may not be required to make these changes, as long as the changes are consistent with the overall identification and description of EFH contained in the FMP itself.

**Process for Making Changes to EFH**

Revisions to Pacific salmon EFH can be made when the Council determines that such action is warranted by new information that has become available. Such new information is typically generated during the periodic reviews, but can come before the Council through other established Council avenues. The process is as follows, and can typically be accomplished via a three-meeting Council process:

1. Council advisory bodies, particularly the Habitat Committee (HC), should develop an assessment of potential revisions to the provisions in Appendix A after relevant new information becomes available that indicates a change is warranted.
2. The HC will present a report of their assessment and make recommendations to the Council. Other Advisory Bodies may comment on proposed changes.
3. The Council will review the report and, if appropriate, direct staff to revise Appendix A.

At a subsequent meeting, the Council will adopt the revised Appendix A and based on guidance from the Secretary, will either submit it to the Secretary for the appropriate review process or implement the revisions without further review. Upon completion of the appropriate review process by the Secretary, or immediately if no review process is required, the revised Appendix A will supersede the previous version and will be posted on the Council's website in a format that allows the reader to identify changes.

Examples of the type of changes to Pacific salmon EFH that may not need an FMP amendment are:

1. Changes to the 4th field HUs that are designated as EFH for any of the three species of salmon managed under the plan (this could result from new information on current or historic distribution, newly accessible habitat, removal/addition of stocks from/to the FMP, or other information);
2. Modifications, additions, or removals of HAPCs;
3. Changes to the impassable dams that represent the upstream extent of EFH (this could result from new information on fish passage, or a Council determination that upstream habitat should be designated as EFH);
4. Changes to the detailed EFH descriptions for any of the three species of salmon managed under the plan (this could be based on new information regarding habitat requirements by life stage, prey species, or other information);
5. Changes to recommended conservation or enhancement measures;
6. Changes to the descriptions of non-fishing activities that may adversely affect EFH, and the conservation measures to avoid, minimize, mitigate, or otherwise offset those adverse effects;
7. Changes to the descriptions of fishing activities that may adversely affect EFH; and
8. Changes to the research and information needs.

Some changes to Pacific salmon EFH would still require an FMP amendment, for example:

1. Changes to the overall identification and description of Pacific salmon EFH that is in the FMP; and
2. Inclusion of fishing management measures designed to minimize, avoid, or mitigate adverse impacts to salmon EFH.

## 4.2 COMPENSATION FOR NATURAL PRODUCTION LOSSES

Whenever unavoidable fish population losses occur as a result of various development programs or other action, the Council will recommend compensatory measures that, to the extent practicable, meet the following guidelines:

1. Replacement of losses will be by an equivalent number of fish of the appropriate stock of the same fish species or by habitat capable of producing the equivalent number of fish of the same species that suffered the loss.

2. Mitigation or compensation programs will be located in the immediate area of loss.

3. In addition to direct losses of fish production, compensation programs will include consideration of the opportunity to fish and potential unrealized production at the time of the project.

4. Measures for replacement of runs lost due to construction of water control projects should be completed in advance of, or concurrent with, completion of the project.

## 4.3 ARTIFICIAL PRODUCTION

Artificial production programs can be an important component of healthy salmon fisheries. They may fall under one of four general categories: fishery enhancement, natural stock recovery, coded-wire tag indicator stock, or mitigation. To assure the effectiveness and maximize the benefits of artificial production programs, the Council recommends meeting the following objectives:

1. Maximize the continued production of hatchery stocks consistent with harvest management and stock conservation objectives.

2. Ensure that mitigation and enhancement programs, with a primary objective of producing hatchery origin salmon for harvest, minimize adverse ecological and genetic impacts to naturally producing populations (e.g., straying and mixing on the spawning grounds, unbalanced exploitation rates, loss of genetic diversity). Further, the methods employed to produce salmon for harvest should ensure high survival and high contribution rates to the fisheries targeting the enhanced stock while meeting natural stock objectives.

3. Ensure that artificial production programs designed to perpetuate and/or rebuild depressed natural populations are designed to be short-term in duration, boost the abundance of targeted natural populations over a few generations, and terminate when the population is able to sustain itself naturally.

4. Support efforts to continually review and improve the effectiveness of artificial propagation.

# 5 HARVEST

> *"Conservation and management measures shall, consistent with the conservation requirements of this Act, … take into account the importance of fishery resources to fishing communities in order to (A) provide for the sustained participation of such communities, and (B) to the extent practicable, minimize adverse economic impacts on such communities."*
>
> *Magnuson-Stevens Act, National Standard 8*

The Council process for determining the allowable ocean fishery harvest centers primarily around protecting weak or listed natural salmon stocks, while providing harvest opportunity on stronger natural and hatchery stocks in ways that conform to the plan's harvest allocation objectives. Achieving these multiple objectives is complicated by natural variability in annual stock abundance, variability in the ocean migratory routes and timing, the high degree of mixing of different salmon species and stocks in ocean fisheries, and imprecision in the estimation of these important parameters. Within this complexity and uncertainty, the Council attempts to achieve its fishery harvest objectives by using the various management tools described in Chapter 6.

Procedures for determining allowable ocean harvest vary by species, fishery complexity, available data, and the state of development of predictive tools. Descriptions of the various procedures in effect in 1984 have been documented (PFMC 1984). These procedures have and will change over time to incorporate the best science. Specific changes resulting from improvements in forecasting techniques or changes in outside/inside allocation procedures due to treaty or user-sharing revisions are anticipated by the plan's framework mechanism. Such technical changes may be adopted without formal amendment. Changes in procedures and the rationale for such changes are described in Council documents developed during the preseason regulatory process (see Chapter 9), in pertinent plan amendment documents, and in various Salmon Methodology Reviews by the SSC.

## *5.1 OVERALL FISHERY OBJECTIVES*

The following objectives guide the Council in establishing fisheries against a framework of ecological, social, and economic considerations.

1. Establish ocean exploitation rates for commercial and recreational salmon fisheries that are consistent with requirements for stock conservation objectives and ACLs within Section 3, specified ESA consultation or recovery standards, or Council adopted rebuilding plans.

2. Fulfill obligations to provide for Indian harvest opportunity as provided in treaties with the United States, as mandated by applicable decisions of the federal courts, and as specified in the October 4, 1993 opinion of the Solicitor, Department of Interior, with regard to federally recognized Indian fishing rights of Klamath River Tribes.

3. Maintain ocean salmon fishing seasons supporting the continuance of established recreational and commercial fisheries while meeting salmon harvest allocation objectives among ocean and inside recreational and commercial fisheries that are fair and equitable, and in which fishing interests shall equitably share the obligations of fulfilling any treaty or other legal requirements for harvest opportunities.[1]

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[1] In its effort to maintain the continuance of established ocean fisheries, the Council includes consideration of maintaining established fishing communities. In addition, a significant factor in the Council's allocation objectives in Section 5.3 is aimed at preserving the economic viability of local ports and/or specific coastal communities (e.g., recreational port allocations north of Cape Falcon). Chapter 6 in

4. Minimize fishery mortalities for those fish not landed from all ocean salmon fisheries as consistent with achieving OY and the bycatch management specifications of Section 3.5.

5. Manage and regulate fisheries so that the OY encompasses the quantity and value of food produced, the recreational value, and the social and economic values of the fisheries.

6. Develop fair and creative approaches to managing fishing effort and evaluate and apply effort management systems as appropriate to achieve these management objectives.

7. Support the enhancement of salmon stock abundance in conjunction with fishing effort management programs to facilitate economically viable and socially acceptable commercial, recreational, and tribal seasons.

8. Achieve long-term coordination with the member states of the Council, Indian tribes with federally recognized fishing rights, Canada, the North Pacific Fishery Management Council, Alaska, and other management entities which are responsible for salmon habitat or production. Manage consistent with the Pacific Salmon Treaty and other international treaty obligations.

9. In recommending seasons, to the extent practicable, promote the safety of human life at sea.

## *5.2 MANAGEMENT CONSIDERATIONS BY SPECIES AND AREA*

Following, are brief descriptions of the stock management considerations which guide the Council in setting fishing seasons within the major subareas of the Pacific Coast.

### 5.2.1 Chinook Salmon

#### *5.2.1.1 South of Horse Mountain*

Within this area, considerable overlap of Chinook originating in Central Valley and northern California coastal rivers occurs between Point Arena and Horse Mountain. Ocean commercial and recreational fisheries are managed to address impacts on Chinook stocks originating from the Central Valley, California Coast, Klamath River, Oregon Coast, and the Columbia River. With respect to California stocks, ocean commercial and recreational fisheries operating in this area are managed to maximize natural production consistent with meeting the U.S. obligation to Indian tribes with federally recognized fishing rights, and recreational needs in inland areas. Special consideration must be given to meeting the consultation or recovery standards for threatened California Coastal Chinook, for threatened Sacramento River spring Chinook and endangered Sacramento River winter Chinook in the area south of Point Arena, and for threatened Snake River fall Chinook north of Pigeon Point.

#### *5.2.1.2 Horse Mountain to Humbug Mountain (Klamath Management Zone)*

Major Chinook stocks contributing to this area originate in streams located along the southern Oregon/California coasts as well as California's Central Valley. The primary Chinook run in this area is from the Klamath River system, including its major tributary, the Trinity River. Ocean commercial and recreational fisheries operating in this area are managed to maximize natural production of Klamath River fall and spring Chinook consistent with meeting the U.S. obligations to Indian tribes with federally recognized fishing rights, and recreational needs in inland areas. Ocean fisheries operating in this area must

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Appendix B and the tables it references provides additional specific information on the fishing communities.

balance management considerations for stock-specific conservation objectives for Klamath River, Central Valley, California coast, Oregon coast, and Columbia River Chinook stocks.

#### *5.2.1.3 Humbug Mountain to Cape Falcon*

The major Chinook stocks contributing to this area primarily originate in Oregon coastal rivers located north of Humbug Mountain, as well as from the Rogue, Klamath, and Central Valley systems. Allowable ocean harvests in this area are an annual blend of management considerations for impacts on Chinook stocks originating from the Central Valley, California Coast, Klamath River, Oregon Coast, Columbia River, and the Washington Coast.

#### *5.2.1.4 North of Cape Falcon*

The majority of the ocean Chinook harvest in this area primarily originates from the Columbia River, with additional contributions from Oregon and Washington coastal areas, Puget Sound and some California stocks. Bonneville Pool (Spring Creek hatchery tule) fall and lower Columbia River (lower river hatchery tule) fall and spring (Cowlitz) Chinook, all primarily of hatchery-origin, comprise a majority of the ocean Chinook harvest between Cape Falcon, Oregon and the U.S.-Canada border. Hatchery production escapement goals of these stocks are established according to long-range production programs and/or mitigation requirements associated with displaced natural stocks. Allowable ocean harvest in this area is directed at Columbia River stocks with contributions from the Oregon Coast, Washington Coast, and Puget Sound.

### 5.2.2 Coho Salmon

#### *5.2.2.1 South of Cape Falcon*

Columbia River, Oregon, and California coho are managed together within the framework of the Oregon Production Index (OPI) since these fish are intermixed in the ocean fishery. These coho contribute primarily to ocean fisheries off the southern Washington coast and Oregon coast; coho fisheries are prohibited off the California coast. Ocean fishery objectives for the OPI area address the following (1) conservation and recovery of Oregon and California coastal coho, including consultation or recovery standards for LCN, OCN, SONCC and California Central coast coho; (2) providing viable fisheries inside the Columbia River, and; (3) impacts on conservation objectives for other key stocks.

Until 2010, the OPI was used as a measure of the annual abundance of adult three-year-old coho salmon resulting from production in the Columbia River and Oregon and California coastal basins. The index itself was simply the combined number of adult coho that can be accounted for within the general area from Leadbetter Point, Washington to as far south as coho are found. Starting in 2010 a new method has been used to estimate ocean abundance. A "Mixed Stock Model" (MSM) uses hatchery returns, spawning escapements, and coded-wire-tag (CWT) data (recoveries and hatchery mark rates) and estimates of catch and incidental mortalities in all fisheries for OPI origin stocks. The primary difference between the traditional OPI and the MSM system is in the accounting of OPI origin stocks in ocean fisheries. In the traditional OPI accounting system, all coho in ocean fisheries south of Leadbetter Point, Washington were treated as OPI origin stocks. None of the coho caught in fisheries north of Leadbetter Point, Washington were counted in the OPI. The general assumption--backed by CWT data--was that the number of non-OPI coho caught South of Leadbetter Point equaled the number of OPI coho caught North of Leadbetter Point. This was a good assumption until 1996, when all coho fisheries in the OPI area were closed. Since then, OPI Area fisheries have been more restricted than northern fisheries. In the MSM system, CWT data are used to estimate the harvest of OPI area stocks regardless of where they were caught. Thus, the MSM method takes into account changing harvest patterns in ocean fisheries that were assumed to be static in the original index.

The methodology used to estimate ocean abundance of OPI-area coho stocks may continue to evolve and any changes will be approved by the SSC in order to ensure the use of the best available science.

#### *5.2.2.2 North of Cape Falcon*

Management of ocean fisheries for coho north of Cape Falcon is complicated by the overlap of OCN stocks and other stocks of concern. Allowable harvests in the area between the U.S./Canada border and Cape Falcon, Oregon will be determined by an annual blend of LCN, OCN, Washington, and Canadian coho management considerations including:

1. Abundance of contributing stocks.
2. Stock-specific conservation objectives (as found in Table 3-1).
3. Consultation standards of the Endangered Species Act.
4. Relative abundance of Chinook and coho.
5. Obligations under the PST.
6. Allocation considerations of concern to the Council.

Coho occurring north of Cape Falcon, Oregon are comprised of a composite of coho stocks originating in Oregon, Washington, and southern British Columbia. Ocean fisheries operating in this area must balance management considerations for stock-specific conservation objectives for Southern Oregon/Northern California, Oregon Coast, Southwest Washington, Olympic Peninsula, Puget Sound, Columbia River, and southern British Columbia stocks.

### 5.2.3 Pink Salmon

Ocean pink salmon harvests occur off the Washington coast and are predominantly of Fraser River origin. Pink salmon of Puget Sound origin represent a minor portion of the ocean harvest. Ocean impacts are generally negligible in relation to the terminal return during years of very low abundance.

The Fraser River Panel of the PSC manages fisheries for pink salmon in the Fraser River Panel Area (U.S.) north of 48° N latitude to meet Fraser River natural spawning escapement and U.S./Canada allocation requirements. The Council manages pink salmon harvests in that portion of the EEZ which is not in the Fraser River Panel Area (U.S.) waters consistent with Fraser River Panel management intent and in accordance with the conservation objectives for Puget Sound pink salmon.

Pink salmon management objectives must address meeting natural spawning escapement objectives, allowing ocean pink harvest within fixed constraints of coho and Chinook harvest ceilings and providing for treaty allocation requirements.

## *5.3 ALLOCATION*

> *“▪Conservation and management measures shall not discriminate between residents of different states. If it becomes necessary to allocate or assign fishing privileges among various United States fishermen, such allocation shall be (A) fair and equitable to all such fishermen; (B) reasonably calculated to promote conservation; and (C) carried out in such manner that no particular individual, corporation, or other entity acquires an excessive share of such privileges.”*
>
> *Magnuson-Stevens Act, National Standard 4*

Harvest allocation is required when the number of fish is not adequate to satisfy the perceived needs of the various fishing industry groups and communities, to divide the catch between non-Indian ocean and inside fisheries and among ocean fisheries, and to provide Federally recognized treaty Indian fishing opportunity. In allocating the resource between ocean and inside fisheries, the Council considers both in-river harvest and spawner escapement needs. The magnitude of in-river harvest is determined by the states in a variety of ways, depending upon the management area. Some levels of in-river harvests are designed to accommodate federally recognized in-river Indian fishing rights, while others are established to allow for non-Indian harvests of historical magnitudes. Several fora exist to assist this process on an annual basis. The North of Cape Falcon Forum, a state and tribal sponsored forum, convenes the pertinent parties during the Council's preseason process to determine allocation and conservation recommendations for fisheries north of Cape Falcon. The individual states also convene fishery industry meetings to coordinate their input to the Council.

## 5.3.1 Commercial (Non-Tribal) and Recreational Fisheries North of Cape Falcon

### *5.3.1.1 Goal, Objectives, and Priorities*

Harvest allocations will be made from a total allowable ocean harvest, which is maximized to the largest extent possible but still consistent with PST and treaty-Indian obligations, state fishery needs, and spawning escapement requirements, including consultation standards for stocks listed under the ESA. The Council shall make every effort to establish seasons and gear requirements that provide troll and recreational fleets a reasonable opportunity to catch the available harvest. These may include single-species directed fisheries with landing restrictions for other species.

The goal of allocating ocean harvest north of Cape Falcon is to achieve, to the greatest degree possible, the objectives for the commercial and recreational fisheries as follows:

- Provide recreational opportunity by maximizing the duration of the fishing season while minimizing daily and area closures and restrictions on gear and daily limits.

- Maximize the value of the commercial harvest while providing fisheries of reasonable duration.

The priorities listed below will be used to help guide establishment of the final harvest allocation while meeting the overall commercial and recreational fishery objectives.

At total allowable harvest levels up to 300,000 coho and 100,000 Chinook:

- Provide coho to the recreational fishery for a late June through early September all-species season. Provide Chinook to allow (1) access to coho and, if possible, (2) a minimal Chinook-only fishery prior to the all-species season. Adjust days per week and/or institute area restrictions to stabilize season duration.

- Provide Chinook to the troll fishery for a May and early June Chinook season and provide coho to (1) meet coho hooking mortality in June where needed and (2) access a pink salmon fishery in odd years. Attempt to ensure that part of the Chinook season will occur after June 1.

At total allowable harvest levels above 300,000 coho and above 100,000 Chinook:

- Relax any restrictions in the recreational all-species fishery and/or extend the all-species season beyond Labor Day as coho quota allows. Provide Chinook to the recreational fishery for a Memorial Day through late June Chinook-only fishery. Adjust days per week to ensure continuity with the all-species season.

- Provide coho for an all-salmon troll season in late summer and/or access to a pink fishery. Leave adequate Chinook from the May through June season to allow access to coho.

#### 5.3.1.2 Allocation Schedule Between Gear Types

Initial commercial and recreational allocation will be determined by the schedule of percentages of total allowable harvest as follows:

TABLE 5-1. Initial commercial/recreational harvest allocation schedule north of Cape Falcon.

| Coho | | | Chinook | | |
|---|---|---|---|---|---|
| Harvest (thousands of fish) | Percentage[a/] | | Harvest (thousands of fish) | Percentage[a/] | |
| | Troll | Recreational | | Troll | Recreational |
| 0-300 | 25 | 75 | 0-100 | 50 | 50 |
| >300 | 60 | 40 | >100-150 | 60 | 40 |
| | | | >150 | 70 | 30 |

a/ The allocation must be calculated in additive steps when the harvest level exceeds the initial tier.

This allocation schedule should, on average, allow for meeting the specific fishery allocation priorities described above. The initial allocation may be modified annually by preseason and inseason trades to better achieve (1) the commercial and recreational fishery objectives and (2) the specific fishery allocation priorities. The final preseason allocation adopted by the Council will be expressed in terms of quotas, which are neither guaranteed catches nor inflexible ceilings. Only the total ocean harvest quota is a maximum allowable catch.

To provide flexibility to meet the dynamic nature of the fisheries and to assure achievement of the allocation objectives and fishery priorities, deviations from the allocation schedule will be allowed as provided below and as described in Section 6.5.3.2 for certain selective fisheries.

1. Preseason species trades (Chinook and coho) that vary from the allocation schedule may be made by the Council based upon the recommendation of the pertinent recreational and commercial SAS representatives north of Cape Falcon. The Council will compare the socioeconomic impacts of any such recommendation to those of the standard allocation schedule before adopting the allocation that best meets FMP management objectives.

2. Inseason transfers, including species trades of Chinook and coho, may be permitted in either direction between recreational and commercial fishery allocations to allow for uncatchable fish in one fishery to be reallocated to the other. Fish will be deemed "uncatchable" by a respective commercial or recreational fishery only after considering all possible annual management actions to allow for their harvest which meet framework harvest management objectives, including single species or exclusive registration fisheries. Implementation of inseason transfers will require (1) consultation with the pertinent recreational and commercial SAS members and the STT, and (2) a clear establishment of available fish and impacts from the transfer.

3. An exchange ratio of four coho to one Chinook shall be considered a desirable guideline for preseason trades. Deviations from this guideline should be clearly justified. Inseason trades and transfers may vary to meet overall fishery objectives. (The exchange ratio of four coho to one Chinook approximately equalizes the species trade in terms of average ex-vessel values of the two salmon species in the commercial fishery. It also represents an average species catch ratio in the recreational fishery.)

4. Any increase or decrease in the recreational or commercial total allowable catch (TAC), resulting from an inseason restructuring of a fishery or other inseason management action, does not require reallocation of the overall north of Cape Falcon non-Indian TAC.

5. The commercial TACs of Chinook and coho derived during the preseason allocation process may be varied by major subareas (i.e., north of Leadbetter Point and south of Leadbetter Point) if there is a need to do so to decrease impacts on weak stocks. Deviations in each major subarea will generally not exceed 50 percent of the TAC of each species that would have been established without a geographic deviation in the distribution of the TAC. Deviation of more than 50 percent will be based on a conservation need to protect weak stocks and will provide larger overall harvest for the entire fishery north of Cape Falcon than would have been possible without the deviation. In addition, the actual harvest of coho may deviate from the initial allocation as provided in Section 6.5.3.2 for certain selective fisheries.

6. The recreational TACs of Chinook and coho derived during the preseason allocation process will be distributed among four major recreational port areas as described for coho and Chinook distribution in Section 5.3.1.3. The Council may deviate from subarea quotas (1) to meet recreational season objectives based on agreement of representatives of the affected ports and/or (2) in accordance with Section 6.5.3.2 with regard to certain selective fisheries. Additionally, based on the recommendations of the SAS members representing the ocean sport fishery north of Cape Falcon, the Council will include criteria in its preseason salmon management recommendations to guide any inseason transfer of coho among the recreational subareas to meet recreational season duration objectives. Inseason redistributions of quotas within the recreational fishery or the distribution of allowable coho catch transfers from the commercial fishery may deviate from the preseason distribution.

#### *5.3.1.3 Recreational Subarea Allocations*

##### Coho

The north of Cape Falcon preseason recreational TAC of coho will be distributed to provide 50 percent to the area north of Leadbetter Point and 50 percent to the area south of Leadbetter Point. The distribution of the allocation north of Leadbetter point will vary, depending on the existence and magnitude of an inside fishery in Area 4B, which is served by Neah Bay.

In years with no Area 4B fishery, the distribution of coho north of Leadbetter Point (50 percent of the total recreational TAC) will be divided to provide 74 percent to the area between Leadbetter Point and the Queets River (Westport), 5.2 percent to the area between Queets River and Cape Flattery (La Push), and 20.8 percent to the area north of the Queets River (Neah Bay). In years when there is an Area 4B (Neah Bay) fishery under state management, the allocation percentages north of Leadbetter Point will be modified to maintain more equitable fishing opportunity among the ports by decreasing the ocean harvest share for Neah Bay. This will be accomplished by adding 25 percent of the numerical value of the Area 4B fishery to the recreational TAC north of Leadbetter Point prior to calculating the shares for Westport and La Push. The increase to Westport and La Push will be subtracted from the Neah Bay ocean share to maintain the same total harvest allocation north of Leadbetter Point. Table 5-2 displays the resulting percentage allocation of the total recreational coho catch north of Cape Falcon among the four recreational port areas (each port area allocation will be rounded to the nearest hundred fish, with the largest quotas rounded downward if necessary to sum to the TAC).

TABLE 5-2. Percentage allocation of total allowable coho harvest among the four recreational port areas north of Cape Falcon.[a]

| Port Area | Without Area 4B Add-on | With Area 4B Add-on | |
|---|---|---|---|
| Columbia River | 50.0% | 50.0% | |
| Westport | 37.0% | 37.0% | plus 17.3% of the Area 4B add-on |
| La Push | 2.6% | 2.6% | plus 1.2% of the Area 4B add-on |
| Neah Bay | 10.4% | 10.4% | minus 18.5% of the Area 4B add on |

a/ The Council may deviate from these percentages as described under #6 in Section 5.3.1.2.

TABLE 5-3. Example distributions of the recreational coho TAC north of Leadbetter Point.

| Sport TAC North of Cape Falcon | Without Area 4B Add-On | | | | With Area 4B Add-On [a] | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Columbia River | Westport | La Push | Neah Bay | Columbia River | Westport | La Push | Neah Bay | | |
| | | | | | | | | Ocean | Add-on | Total |
| 50,000 | 25,000 | 18,500 | 1,300 | 5,200 | 25,000 | 19,900 | 1,400 | 3,700 | 8,000 | 11,700 |
| 150,000 | 75,000 | 55,500 | 3,900 | 15,600 | 75,000 | 57,600 | 4,000 | 13,600 | 12,000 | 25,600 |
| 300,000 | 150,000 | 111,000 | 7,800 | 31,200 | 150,000 | 114,500 | 8,000 | 27,500 | 20,000 | 47,500 |

a/ The add-on levels are merely examples. The actual numbers in any year would depend on the particular mix of stock abundances and season determinations.

#### Chinook

Subarea distributions of Chinook will be managed as guidelines and shall be calculated by the STT with the primary objective of achieving all-species fisheries without imposing Chinook restrictions (i.e., area closures or bag limit reductions). Chinook in excess of all-species fisheries needs may be utilized by directed Chinook fisheries north of Cape Falcon or by negotiating a Chinook/coho trade with another fishery sector.

Inseason management actions may be taken by the NMFS NW Regional Administrator to assure that the primary objective of the Chinook harvest guidelines for each of the four recreational subareas north of Cape Falcon are met. Such actions might include: closure from 0 to 3, or 0 to 6, or 3 to 200, or 5 to 200 nautical miles from shore; closure from a point extending due west from Tatoosh Island for 5 miles, then south to a point due west of Umatilla Reef Buoy, then due east to shore; closure from North Head at the Columbia River mouth north to Leadbetter Point; change species that may be landed; or other actions as prescribed in the annual regulations.

### 5.3.2 Commercial and Recreational Fisheries South of Cape Falcon

The allocation of allowable ocean harvest of coho salmon south of Cape Falcon has been developed to provide a more stable recreational season and increased economic benefits of the ocean salmon fisheries at varying stock abundance levels. When coupled with various recreational harvest reduction measures or the timely transfer of unused recreational allocation to the commercial fishery, the allocation schedule is designed to help secure recreational seasons extending at least from Memorial Day through Labor Day when possible, assist in maintaining commercial markets even at relatively low stock sizes, and fully utilize available harvest. Total ocean catch of coho south of Cape Falcon will be treated as a quota to be allocated between troll and recreational fisheries as provided in Table 5-4.

(Note: The allocation schedule provides guidance only when coho abundance permits a directed coho harvest, not when the allowable impacts are insufficient to allow coho retention south of Cape Falcon. At such low levels, allocation of the allowable impacts will be accomplished during the Council's preseason process.)

TABLE 5-4. Allocation of allowable ocean harvest of coho salmon (thousands of fish) south of Cape Falcon.[a/]

| Total Allowable Ocean Harvest | Recreational Allocation | | Commercial Allocation | |
|---|---|---|---|---|
| | Number | Percentage | Number | Percentage |
| #100 | #100[b/c/] | 100[b/] | b/ | b/ |
| 200 | 167[b/c/] | 84[b/] | 33[b/] | 17[b/] |
| 300 | 200 | 67 | 100 | 33 |
| 350 | 217 | 62 | 133 | 38 |
| 400 | 224 | 56 | 176 | 44 |
| 500 | 238 | 48 | 262 | 52 |
| 600 | 252 | 42 | 348 | 58 |
| 700 | 266 | 38 | 434 | 62 |
| 800 | 280 | 35 | 520 | 65 |
| 900 | 290 | 32 | 610 | 68 |
| 1,000 | 300 | 30 | 700 | 70 |
| 1,100 | 310 | 28 | 790 | 72 |
| 1,200 | 320 | 27 | 880 | 73 |
| 1,300 | 330 | 25 | 970 | 75 |
| 1,400 | 340 | 24 | 1,060 | 76 |
| 1,500 | 350 | 23 | 1,150 | 77 |
| 1,600 | 360 | 23 | 1,240 | 78 |
| 1,700 | 370 | 22 | 1,330 | 78 |
| 1,800 | 380 | 21 | 1,420 | 79 |
| 1,900 | 390 | 21 | 1,510 | 79 |
| 2,000 | 400 | 20 | 1,600 | 80 |
| 2,500 | 450 | 18 | 2,050 | 82 |
| 3,000 | 500 | 17 | 2,500 | 83 |

a/ The allocation schedule is based on the following formula: first 150,000 coho to the recreational base (this amount may be reduced as provided in footnote b); over 150,000 to 350,000 fish, share at 2:1, 0.667 to troll and 0.333 to recreational; over 350,000 to 800,000 the recreational share is 217,000 plus 14% of the available fish over 350,000; above 800,000 the recreational share is 280,000 plus 10% of the available fish over 800,000.

Note: The allocation schedule provides guidance only when coho abundance permits a directed coho harvest, not when the allowable impacts are insufficient to allow general coho retention south of Cape Falcon. At such low levels, allocation of the allowable impacts will be determined in the Council=s preseason process. Deviations from the allocation may also be allowed to meet consultation standards for ESA-listed stocks (e.g., the 1998 biological opinion for California coastal coho requires no retention of coho in fisheries off California).

b/ If the commercial allocation is insufficient to meet the projected hook-and-release mortality associated with the commercial all-salmon-except-coho season, the recreational allocation will be reduced by the number needed to eliminate the deficit.

c/ When the recreational allocation is 167,000 coho or less, special allocation provisions apply to the recreational harvest distribution by geographic area (unless superseded by requirements to meet a consultation standard for ESA-listed stocks); see text of FMP as modified by Amendment 11 allocation provisions.

The allocation schedule is designed to give sufficient coho to the recreational fishery to increase the probability of attaining no less than a Memorial Day to Labor Day season as stock sizes increase. This increased allocation means that, in many years, actual catch in the recreational fishery may fall short of its allowance. In such situations, managers will make an inseason reallocation of unneeded recreational coho to the south of Cape Falcon troll fishery. The reallocation should be structured and timed to allow the commercial fishery sufficient opportunity to harvest any available reallocation prior to September 1, while still assuring completion of the scheduled recreational season (usually near mid-September) and, in any event, the continuation of a recreational fishery through Labor Day. This reallocation process will occur no later than August 15 and will involve projecting the recreational fishery needs for the remainder of the summer season. The remaining projected recreational catch needed to extend the season to its scheduled closing date will be a harvest guideline rather than a quota. If the guideline is met prior to Labor Day, the season may be allowed to continue if further fishing is not expected to result in any significant danger of impacting the allocation of another fishery or of failing to meet an escapement goal.

The allocation schedule is also designed to assure there are sufficient coho allocated to the troll fishery at low stock levels to ensure a full Chinook troll fishery. This hooking mortality allowance will have first priority within the troll allocation. If the troll allocation is insufficient for this purpose, the remaining number of coho needed for the estimated incidental coho mortality will be deducted from the recreational share. At higher stock sizes, directed coho harvest will be allocated to the troll fishery after hooking mortality needs for Chinook troll fishing have been satisfied.

The allowable harvest south of Cape Falcon may be further partitioned into subareas to meet management objectives of the FMP. Allowable harvests for subareas south of Cape Falcon will be determined by an annual blend of management considerations including:

1. abundance of contributing stocks
2. allocation considerations of concern to the Council
3. relative abundance in the fishery between Chinook and coho
4. escapement goals
5. maximizing harvest potential

Troll coho quotas may be developed for subareas south of Cape Falcon consistent with the above criteria. California recreational catches of coho, including projections of the total catch to the end of the season, would be included in the recreational allocation south of Cape Falcon, but the area south of the Oregon-California border would not close when the allocation is met; except as provided below when the recreational allocation is at 167,000 or fewer fish.

When the south of Cape Falcon recreational allocation is equal to or less than 167,000 coho:

1. The recreational fisheries will be divided into two major subareas, as listed in #2 below, with independent quotas (i.e., if one quota is not achieved or is exceeded, the underage or overage will not be added to or deducted from the other quota; except as provided under #3 below).

2. The two major recreational subareas will be managed within the constraints of the following impact quotas, expressed as a percentage of the total recreational allocation (percentages based on avoiding large deviations from the historical harvest shares):

    a. Central Oregon (Cape Falcon to Humbug Mountain) - 70%

    b. South of Humbug Mountain - 30%

    In addition,
    (1) Horse Mountain to Point Arena will be managed for an impact guideline of 3 percent of the south of Cape Falcon recreational allocation, and

   (2) there will be no coho harvest constraints south of Point Arena. However, the projected harvest in this area (which averaged 1,800 coho from 1986-1990) will be included in the south of Humbug Mountain impact quota.

3. Coho quota transfers can occur on a one-for-one basis between subareas if Chinook constraints preclude access to coho.

## 5.3.3 Tribal Indian Fisheries

### *5.3.3.1 California*

On October 4, 1993 the Solicitor, Department of Interior, issued a legal opinion in which he concluded that the Yurok and Hoopa Valley Indian tribes of the Klamath River Basin have a federally protected right to the fishery resource of their reservations sufficient to support a moderate standard of living or 50 percent of the total available harvest of Klamath-Trinity basin salmon, whichever is less. The Secretary of Commerce recognized the tribes' federally reserved fishing right as applicable law for the purposes of the MSA (58 FR 68063, December 23, 1993). The Ninth Circuit Court of Appeals upheld the conclusion that the Hoopa Valley and Yurok tribes have a federally reserved right to harvest fish in Parravano v. Babbitt and Brown, 70 F.3d 539 (1995) (Cert. denied in Parravano v. Babbitt and Brown 110, S.Ct 2546 [1996]). The Council must recognize the tribal allocation in setting its projected escapement level for the Klamath River.

### *5.3.3.2 Columbia River*

Pursuant to a September 1, 1983 Order of the U.S. District Court, the allocation of harvest in the Columbia River was established under the "Columbia River Fish Management Plan" which was implemented in 1988 by the parties of U.S. v. Oregon. This plan replaced the original 1977 plan (pages 16-20 of the 1978 FMP). Since the Columbia River Fishery Management Plan expired on December 31, 1998, fall Chinook in Columbia River fisheries were managed through 2007 under the guidance of annual management agreements among the U.S. v. Oregon parties. In 2008, a new 10 year management agreement was negotiated through the U.S. v. Oregon process, which included revisions to some in-river objectives. This most recent plan is the "2008-2017 U.S. v Oregon Management Agreement". The plan provides a framework within which the relevant parties may exercise their sovereign powers in a coordinated and systematic manner in order to protect, rebuild, and enhance upper Columbia River fish runs while providing harvest for both treaty Indian and non-Indian fisheries. The parties to the agreement are the United States, the states of Oregon, Washington, and Idaho, and four Columbia River treaty Indian tribes-Warm Springs, Yakama, Nez Perce, and Umatilla.

### *5.3.3.3 U.S. v. Washington Area*

Treaty Indian tribes have a legal entitlement to the opportunity to take up to 50 percent of the harvestable surplus of stocks which pass through their usual and accustomed fishing areas. The treaty Indian troll harvest which would occur if the tribes chose to take their total 50 percent share of the weakest stock in the ocean, is computed with the current version of the Fishery Regulation Assessment Model (FRAM), assuming this level of harvest did not create conservation or allocation problems on other stocks. A quota may be established in accordance with the objectives of the relevant treaty tribes concerning allocation of the treaty Indian share to ocean and inside fisheries. The total quota does not represent a guaranteed ocean harvest, but a maximum allowable catch.

The requirement for the opportunity to take up to 50 percent of the harvestable surplus determines the treaty shares available to the inside/outside Indian and all-citizen fisheries. Ocean coho harvest ceilings off the Washington coast for treaty Indians and all-citizen fisheries are independent within the constraints that (1) where feasible, conservation needs of all stocks must be met; (2) neither group precludes the other from the opportunity to harvest its share, and; (3) allocation schemes may be established to specify outside/inside sharing for various stocks.

## 5.4 U.S. HARVEST AND PROCESSING CAPACITY AND ALLOWABLE LEVEL OF FOREIGN FISHING

> *"... Assess and specify . . . (A) the capacity and the extent to which fishing vessels of the United States, on an annual basis, will harvest the optimum yield . . . (B) the portion of such optimum yield which, on an annual basis, will not be harvested by fishing vessels of the United States and can be made available for foreign fishing, and (C) the capacity and extent to which United States processors, on an annual basis, will process that portion of such optimum yield that will be harvested by fishing vessels of the United States."*
>
> *Magnuson-Stevens Act, §303(a)(4)*

At the highest conceivable level of recent past, present, or expected future abundance, the total allowable harvest of salmon stocks can be fully taken by U.S. fisheries. There is no recent record of processors in the Council area refusing fish from fishermen because of inadequate processing capacity. Because shore-based processors can fully utilize all the salmon that can be harvested in marine waters, joint venture processing is fixed as zero.

In view of the adequacy of the domestic fisheries to harvest the highest conceivable level of abundance, the total allowable level of foreign fishing also is fixed as zero. The United States allowed Canadian fishing in U.S. waters under a reciprocal agreement until 1978. Negotiations between the two governments, including those within the context of the PSC, continue to seek a resolution of all transboundary salmon issues. These negotiations are aimed at stabilizing and reducing, where possible, the interception of salmon originating from one country by fishermen of the other. No U.S./Canada reciprocal salmon fishing is contemplated in the foreseeable future.

# 6 MEASURES TO MANAGE THE HARVEST

A number of management controls are available to manage the ocean fisheries each season, once the allowable ocean harvests and the basis for allocation among user groups have been determined. Among these are management boundaries, seasons, quotas, minimum harvest lengths, fishing gear restrictions, and recreational daily bag limits. Natural fluctuations in salmon abundance require that annual fishing periods, quotas, and bag limits be designed for the conditions of each year. What is suitable one year probably will not be suitable the next. New information on the fisheries and salmon stocks also may require other adjustments to the management measures. The Council assumes these ocean harvest controls also apply to territorial seas or any other areas in state waters specifically designated in the annual regulations.

Some of the more common measures that have been applied to manage ocean salmon fisheries since 1977 under the MSA are described below, along with a clarification of the process and flexibility in implementing the measures. The Framework Amendment (PFMC 1984) provides a more detailed history of salmon harvest controls and rationale for their designation as fixed or flexible elements of the salmon FMP.

## *6.1 MANAGEMENT BOUNDARIES AND MANAGEMENT ZONES*

Management boundaries and zones will be established during the preseason regulatory process or adjusted inseason (Section 10.2) as necessary to achieve a conservation or management objective. A conservation or management objective is one that protects a fish stock, simplifies management of a fishery, or results in the sustainable use of the resources. For example, management boundaries and management zones can be used to separate fish stocks, facilitate enforcement of regulations, separate conflicting fishing activities, or facilitate harvest opportunities. Management boundaries and zones will be described in the annual regulations by geographical references, coordinates (latitude and longitude), depth contours, distance from shore, or similar criteria. Figure 6-1 displays management boundaries in common use in 2000-2010.

While there are many specific reasons for utilizing management boundaries or zones, which may change from year to year, some boundaries or zones have purposes that remain relatively constant. The boundary used to separate management of Columbia River Chinook from those stocks to the south and to divide the Council's harvest allocation schedules has always been at or near Cape Falcon, Oregon. The Klamath management zone (beginning in 1990, the area between Humbug Mountain, Oregon and Horse Mountain, California) has been used to delineate the area where primary concern is the management of Klamath River fall Chinook. A closed control zone at the mouth of the Columbia River has been used for many years to eliminate fishing in an area believed to generally contain a high percentage of sublegal "feeder" Chinook. A similar control zone has been established at the mouth of the Klamath River to allow fish undisturbed access to the river. Changes to these boundaries or zones may require special justification and documentation; however, the basis of establishing most other management boundaries and zones depends on the annual management needs as determined in the preseason process.

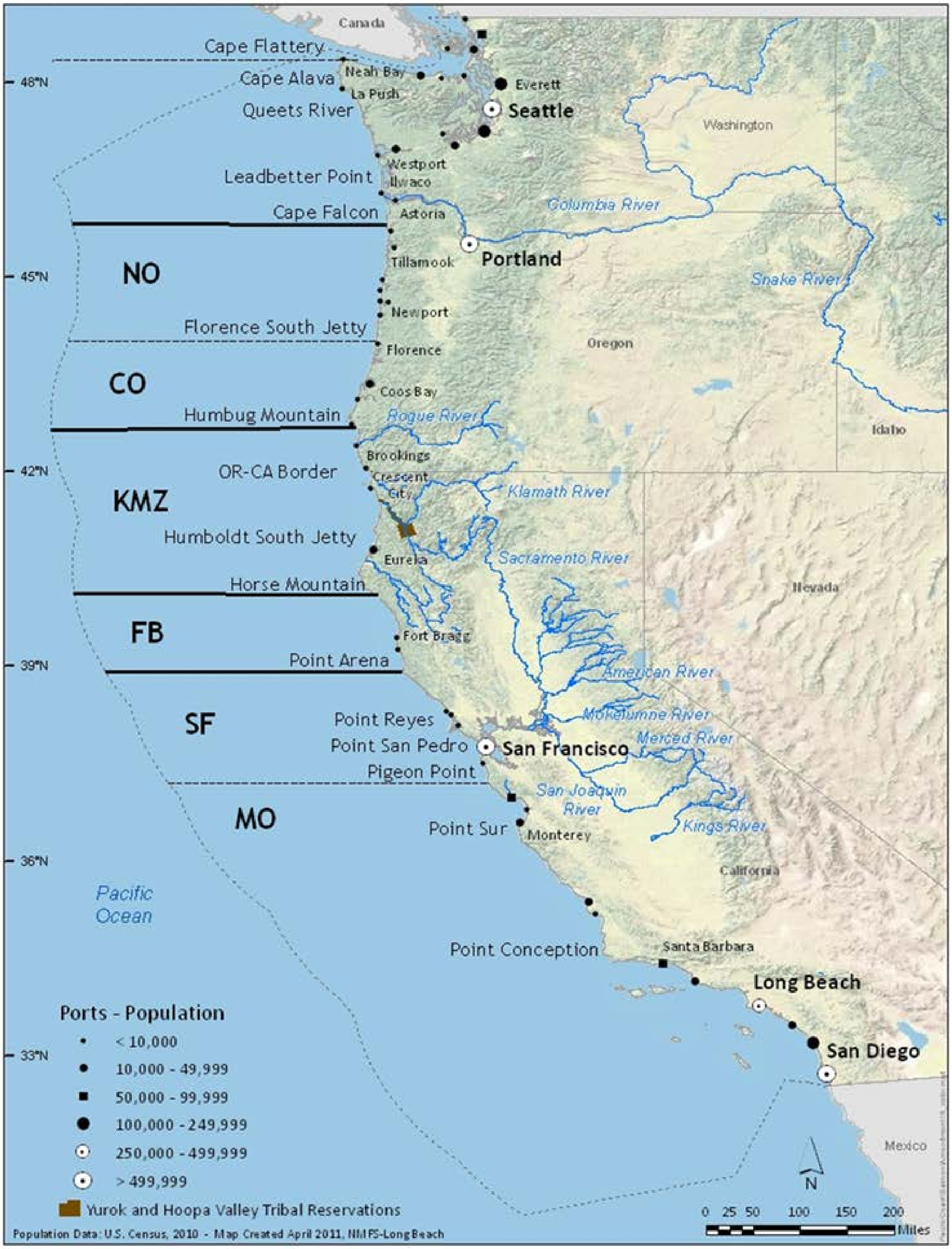

**FIGURE 6-1. Management boundaries in common use in 2000-2011.**

## 6.2 MINIMUM HARVEST LENGTHS FOR OCEAN COMMERCIAL AND RECREATIONAL FISHERIES

Minimum size limits for ocean commercial and recreational fisheries may be changed each year during the preseason regulatory process or modified inseason under the procedures of Section 10.2. Recommended changes must serve a useful purpose which is clearly described and justified, and projections made of the probable impacts resulting from the change.

Chinook minimum size limits are set annually to address several specific issues, including but not limited to: targeting/avoiding specific stocks (Sacramento Winter Chinook) or broods (age-3/4 Klamath fall Chinook), market demand (preference for larger fish), enforcement (regional consistency), season length (slower quota attainment) bycatch reduction, and data collection (CWT recovery of smaller fish). Commercial size limits for Chinook are generally between 26 and 28 inches total length, and recreational size limits are generally between 20 and 24 inches total length, and may vary within the year. Coho minimum size limits are consistently set at 16 inches total length for both commercial and recreational fisheries. In Oregon and Washington, where pink salmon are available, there are no minimum size limits for pink salmon.

## 6.3 RECREATIONAL DAILY BAG LIMIT

Recreational daily bag limits for each management area may be set during the preseason regulatory process or modified inseason (Section 10.2). They will be set to maximize the length of the fishing season consistent with the allowable level of harvest. In recent years, bag limits of one or two salmon have been commonplace.

In general, for every fishing area the level of allowable ocean harvest will be determined for the recreational fishery; next, the fishing season will be set to be as long as practicable, including the Memorial Day and/or Labor Day weekends if feasible, consistent with the allowable level of harvest. Bag limits will be simultaneously set to accommodate that fishing season. In years of low salmon abundance, the season will be short and the bag limits will be low; in years of high salmon abundance, the season will be long and the bag limits will be higher.

## 6.4 FISHING GEAR RESTRICTIONS

Gear restrictions may be changed annually during the preseason regulatory process and inseason as provided in Section 10.2. Recommended changes must serve one or more useful purposes while being consistent with the goals of the plan. For example, changes could be made to facilitate enforcement, reduce hooking mortality, or reduce gear expenses for fishermen. Annual gear restriction changes in previous years have included the requirement for barbless hooks in both the troll and recreational fisheries, and a limit to the number of spreads per line in the troll fishery. Both of these gear changes were instituted to reduce total hook-and-release mortality. Other restrictions have included bait size, number of rods per recreational fisher, and requirements for the number of lines or the attachment of lines to the vessel in the commercial fishery.

## 6.5 SEASONS AND QUOTAS

For each management area or subarea, the Council has the option of managing the commercial and recreational fisheries for either coho or Chinook using the following methods: (1) fixed quotas and seasons; (2) adjustable quotas and seasons; and (3) seasons only. The Council may also use harvest guidelines within quotas or seasons to trigger inseason management actions established in the preseason regulatory process.

Quotas provide very precise management targets and work best when accurate estimates of stock abundance and distribution are available, or when needed to ensure protection of depressed stocks from potential overfishing. The Council does not view quotas as guaranteed harvests, but rather the maximum allowable harvest, which assures meeting the conservation objective of the species or stock of concern. While time and area restrictions are not as precise as quotas, they allow flexibility for effort and harvest to vary in response to abundance and distribution.

## 6.5.1 Preferred Course of Action

Because of the need to use both seasons and quotas, depending on the circumstances, the Council will make the decision regarding seasons and quotas annually during the preseason regulatory process, subject to the limits specified below. Fishing seasons and quotas also may be modified during the season as provided under Section 10.2.

## 6.5.2 Procedures for Calculating Seasons

Seasons will be calculated using the total allowable ocean harvest determined by procedures described in Chapter 5, and further allocated to the commercial and recreational fishery in accordance with the allocation plan presented in Section 5.3, and after consideration of the estimated amount of effort required to catch the available fish, based on past seasons.

Recreational seasons will be established with the goal of encompassing Memorial Day and/or Labor Day weekends in the season, if feasible. Opening dates will be adjusted to provide reasonable assurance that the recreational fishery is continuous, minimizing the possibility of an in-season closure.

Criteria used to establish commercial seasons, in addition to the estimated allowable ocean harvests, the allocation plan, and the expected effort during the season, will be: (1) bycatch mortality; (2) size, poundage, and value of fish caught; (3) effort shifts between fishing areas; (4) harvest of pink salmon in odd-numbered years; and (5) protection for weak stocks when they frequent the fishing areas at various times of the year.

## 6.5.3 Species-Specific and Other Selective Fisheries

### *6.5.3.1 Guidelines*

In addition to the all-species and single or limited species seasons established for the commercial and recreational fisheries, other species-limited fisheries, such as "ratio" fisheries and fisheries selective for marked or hatchery fish, may be adopted by the Council during the preseason regulatory process. In adopting such fisheries, the Council will consider the following guidelines:

1. Harvestable fish of the target species are available.

2. Harvest impacts on incidental species will not exceed allowable levels determined in the management plan.

3. Proven, documented, selective gear exists (if not, only an experimental fishery should be considered).

4. Significant wastage of incidental species will not occur or a written economic analysis demonstrates the landed value of the target species exceeds the potential landed value of the wasted species.

5. The selective fishery will occur in an acceptable time and area where wastage can be minimized and target stocks are maximally available.

6. Implementation of selective fisheries for marked or hatchery fish must be in accordance with U.S. v. Washington stipulation and order concerning co-management and mass marking (Case No. 9213, Subproceeding No. 96-3) and any subsequent stipulations or orders of the U.S. District Court, and consistent with international objectives under the PST (e.g., to ensure the integrity of the coded-wire tag program).

#### *6.5.3.2 Selective Fisheries Which May Change Allocation Percentages North of Cape Falcon*

As a tool to increase management flexibility to respond to changing harvest opportunities, the Council may implement deviations from the specified port area allocations and/or gear allocations to increase harvest opportunity through mark-selective fisheries. The benefits of any mark-selective fishery will vary from year to year and fishery to fishery depending on stock abundance, the mix of marked and unmarked fish, projected hook-and-release mortality rates, and public acceptance. These factors should be considered on an annual and case-by-case basis when utilizing mark-selective fisheries. The deviations for mark-selective fisheries are subordinate to the allocation priorities in Section 5.3.1.1 and may be allowed under the following management constraints:

1. Mark-Selective fisheries will first be considered during the months of May and/or June for Chinook and July through September for coho. However, the Council may consider mark-selective fisheries at other times, depending on year to year circumstances identified in the preceding paragraph.

2. The total impacts within each port area or gear group on the critical natural stocks of management concern are not greater than those under the original allocation without the mark-selective fisheries.

3. Other allocation objectives (i.e., treaty Indian, or ocean and inside allocations) are satisfied during negotiations in the North of Cape Falcon Forum.

4. The mark-selective fishery is assessed against the guidelines in Section 6.5.3.1.

5. Mark-selective fishery proposals need to be made in a timely manner in order to allow sufficient time for analysis and public comment on the proposal before the Council finalizes its fishery recommendations.

If the Council chooses to deviate from specified port and/or gear allocations, the process for establishing a mark-selective fishery would be as follows:

1. Allocate the TAC among the gear groups and port areas according to the basic FMP allocation process described in Section 5.3.1 without the mark-selective fishery.

2. Each gear group or port area may utilize the critical natural stock impacts allocated to its portion of the TAC to access additional harvestable, marked fish, over and above the harvest share established in step one, within the limits of the management constraints listed in the preceding paragraph.

### 6.5.4 Procedures for Calculating Quotas

Quotas will be based on the total allowable ocean harvest and the allocation plan as determined by the procedures of Chapter 5.

To the extent adjustable quotas are used, they may be subject to some or all of the following inseason adjustments:

1. For coho, private hatchery contribution to the ocean fisheries in the OPI area.

2. Unanticipated loss of shakers (bycatch mortality of undersized fish or unauthorized fish of another species that have to be returned to the water) during the season. (Adjustment for coho hooking mortality during any all-salmon-except-coho season will be made when the quotas are established.)

3. Any catch that take place in fisheries within territorial waters that are inconsistent with federal regulations in the EEZ.

4. If the ability to update inseason stock abundance is developed in the future, adjustments to total allowable harvest could be made, where appropriate.

5. The ability to redistribute quotas between subareas depending on the performance toward achieving the overall quota in the area.

Changes in the quotas as a result of the inseason adjustment process will be avoided unless the changes are of such magnitude that they can be validated by the STT and Council, given the precision of the original estimates.

The basis for determining the private hatchery contribution in (1) above will be either coded-wire tag analysis or analysis of scale patterns, whichever is determined by the STT to be more accurate, or another more accurate method that may be developed in the future, as determined by the STT and Council.

In reference to (4) and (5) above, if reliable techniques become available for making inseason estimates of stock abundance, and provision is made in any season for its use, a determination of techniques to be applied will be made by the Council through the Salmon Methodology Review process and discussed during the preseason regulatory process.

### 6.5.5 Procedures for Regulating Ocean Harvests of Pink and Sockeye

Sockeye salmon are only very rarely caught in Council-managed ocean salmon fisheries and no specific procedures have been established to regulate their harvest. Procedures for pink salmon are as follows:

1. All-species seasons will be planned such that harvest of pink salmon can be maximized without exceeding allowable harvests of Chinook and/or coho and within conservation and allocation constraints of the pink stocks.

2. Species specific or ratio fisheries for pink salmon will be considered under the guidelines for species specific fisheries presented in Section 6.5.3, and allocation constraints of the pink stocks.

## *6.6 OTHER MANAGEMENT MEASURES*

### 6.6.1 Treaty Indian Ocean Fishing

Since 1977 the Council has adopted special measures for the treaty Indian ocean troll fisheries off the Washington Coast. The Makah, Quileute, Hoh, and Quinault tribes are entitled by federal judicial determination to exercise their treaty rights in certain ocean areas. In addition, Lower S'Klallam, Jamestown S'Klallam, and Port Gamble S'Klallam tribes are entitled by federal judicial determination to exercise their treaty rights in ocean salmon Area 4B, the entrance to the Strait of Juan de Fuca.

The treaty Indian ocean salmon fishing regulations will be established annually during the preseason regulatory process. The affected tribes will propose annual treaty Indian ocean fishing alternatives at the March meeting of the Council. After a review of the proposals, the Council will adopt treaty Indian regulations along with non-Indian ocean fishing regulations for submission to the Secretary of Commerce at the April Council meeting.

The specific timing and duration of the treaty Indian ocean salmon season varies with expected stock abundance and is limited by quotas for both Chinook and coho. Within these constraints, the general season structure has been a Chinook-directed fishery in May and June, followed by an all-salmon season from July through the earliest of quota attainment or October 31.

#### *6.6.1.1 Seasons*

Given that the traditional tribal ocean season has changed in recent years and because it is largely up to the tribes to recommend annual ocean management measures applicable to their ocean fishery, a flexible mechanism for setting fishing seasons is proposed so that desired changes can be made in the future without the need for plan amendment.

The treaty Indian troll season will be established based upon input from the affected tribes, but would not be longer than that required to harvest the maximum allowable treaty Indian ocean catch. The maximum allowable treaty Indian ocean catch will be computed as the total treaty harvest that would occur if the tribes chose to take their total entitlement of the weakest stock in the ocean, assuming this level of harvest did not create conservation or allocation problems on other stocks.

#### *6.6.1.2 Quotas*

Fixed or adjustable quotas by area, season, or species may be employed in the regulation of treaty Indian ocean fisheries, provided that such quotas are consistent with established treaty rights. The maximum size of quotas shall not exceed the harvest that would result if the entire treaty entitlement to the weakest run were to be taken by treaty ocean fisheries. Any quota established does not represent a guaranteed ocean harvest, but a maximum ceiling on catch. Catches in ocean salmon Area 4B are counted within the tribal ocean harvest quotas during the May 1-September 30 ocean management period.

To the extent adjustable quotas are used, they may be subject to some or all of the following inseason adjustments:

1. Unanticipated shaker loss during the season.

2. Catches by treaty ocean fisheries that are inconsistent with federal regulations in the EEZ.

3. If an ability to update inseason stock abundance is developed in the future, adjustments to quotas could be made where appropriate.

4. Ability to redistribute quotas between subareas depending upon performance toward catching the overall quota for treaty ocean fisheries in the area.

Procedures for the above inseason adjustments will be made in accordance with Section 10.2.

Changes in the quotas as a result of the inseason adjustment process will be avoided unless the changes are of such magnitude that they are scientifically valid as determined by the STT and Council, given the precision of the original estimates.

Harvest guidelines may be used within overall quotas to trigger inseason management actions established during the preseason regulatory process.

#### *6.6.1.3 Areas*

Current tribal ocean fishing areas in the EEZ (subject to change by court order) are as follows:

Makah - north of 48°02'15" N to the U.S./Canada border and east of 125°44'00".

Hoh - south of 47°54'18" N and north of 47°21'00" N and east of 125°44'00".

Quileute - south of 48°07'36" N and north of 47°31'42" N and east of 125°44'00".

Quinault - south of 47°40'06" N and north of 46°54'03" N and east of 125°44'00".

In addition, a portion of the usual and accustomed fishing areas for the Lower Elwha, Jamestown, and Port Gamble S'Klallam tribes is in ocean salmon Area 4B at the entrance to the Strait of Juan de Fuca (Bonilla-Tatoosh line east to the Sekiu River).

Area restrictions may be employed in the regulation of treaty Indian ocean fisheries, consistent with established treaty rights. For example, in 1982 treaty Indian fishing was prohibited within a six-mile radius around the Queets and Hoh River mouths when the area was closed to non-Indian salmon fishing.

#### *6.6.1.4 Size Limits and Gear Restrictions*

Regulations for size limits and gear restrictions for treaty ocean fisheries will be based on recommendations of the affected treaty tribes.

### 6.6.2 Net Prohibition

No person shall use nets to fish for salmon in the EEZ except that a hand-held net may be used to bring hooked salmon on board a vessel. Salmon caught incidentally in trawl nets while legally fishing under the groundfish FMP are a prohibited species as defined by the groundfish regulations (50 CFR Part 660, Subpart G). However, in cases where the Council determines it is beneficial to the management of the groundfish and salmon resources, salmon bycatch may be retained under the provisions of a Council-approved program that defines the handling and disposition of the salmon. The provisions must specify that salmon remain a prohibited species and, as a minimum, include requirements that allow accurate monitoring of the retained salmon, do not provide incentive for fishers to increase salmon bycatch, and assure fish do not reach commercial markets. In addition, during its annual regulatory process for groundfish, the Council must consider regulations that would minimize salmon bycatch in the monitored fisheries.

### 6.6.3 Prohibition on Removal of Salmon Heads

No person shall remove the head of any salmon caught in the EEZ, nor possess a salmon with the head removed if that salmon has been marked by removal of the adipose fin to indicate that a coded-wire tag has been implanted in the head of the fish.

### 6.6.4 Steelhead Prohibition

Persons, other than Indians with judicially-declared rights to do so and legally licensed recreational fishermen, may not take and retain, or possess any steelhead within the EEZ.

### 6.6.5 Prohibition on Use of Commercial Troll Fishing Gear for Recreational Fishing

No person shall engage in recreational fishing for salmon while aboard a vessel engaged in commercial fishing.

### 6.6.6 Experimental Fisheries

The Council may recommend that the Secretary allow experimental fisheries in the EEZ for research purposes that are proposed by the Council, federal government, state government, or treaty Indian tribes having usual and accustomed fishing grounds in the EEZ.

The Secretary may not allow any recommended experimental fishery unless he or she determines that the purpose, design, and administration of the experimental fishery are consistent with the goals and objectives of the Council's fishery management plan, the national standards of the MSA, and other applicable law. Each vessel that participates in an approved experimental fishery will be required to carry aboard the vessel the letter of approval, with specifications and qualifications (if any), issued and signed by the Regional Administrator of NMFS. EFP proposals targeting EC species shared between all four FMPs, including the Salmon FMP, will be subject to the protocol for Shared EC Species (Council Operating Procedure 24).

### 6.6.7 Scientific Research

This plan neither inhibits nor prevents any scientific research in the EEZ by a scientific research vessel. The Secretary will acknowledge any notification received regarding scientific research on salmon being conducted by a research vessel. The Regional Administrator of NMFS will issue to the operator/master of that vessel a letter of acknowledgment, containing information on the purpose and scope (locations and schedules) of the activities. Further, the Regional Administrator will transmit copies of such letters to the Council and to state and federal fishery and enforcement agencies to ensure that all concerned parties are aware of the research activities.

# 7 DATA NEEDS, DATA COLLECTION METHODS, AND REPORTING REQUIREMENTS

Successful management of the salmon fisheries requires considerable information on the fish stocks, the amount of effort for each fishery, the harvests by each fishery, the timing of those harvests, and other biological, social, and economic factors. Much of the information must come from the ocean fisheries; other data must come from inside fisheries, hatcheries, and spawning grounds. Some of this information needs to be collected and analyzed daily, whereas other types need to be collected and analyzed less frequently, maybe only once a year. In general, the information can be divided into that needed for inseason management and that needed for annual and long-term management. The methods for reporting, collecting, analyzing, and distributing information can be divided similarly.

## *7.1 INSEASON MANAGEMENT*

### 7.1.1 Data Needs

Managers require certain information about the fisheries during the season if they are to control the harvests to meet established quotas and goals. If conditions differ substantially from those expected it may be necessary to modify the fishing seasons, quotas, or other management measures. The following information is useful for inseason management:

a. harvest of each species by each fishery in each fishing area by day and by cumulative total;

b. number of troll day boats and trip boats fishing;

c. estimated average daily catch for both day and trip boats;

d. distribution and movement of fishing effort;

e. average daily catch and effort for recreational fishery;

f. estimates of expected troll fishing effort for the remainder of the season;

g. information on the contribution of various fish stocks, determined from recovered coded-wire tags, scales, or other means.

### 7.1.2 Methods for Obtaining Inseason Data

Inseason management requires updating information on the fisheries daily. Thus, data will be collected by sampling the landings, exit/trailer counts, radio reports, electronic media reports, and telephone interviews.

In general, data necessary for inseason management will be gathered by one or more of the following methods. Port exit counts, radio or electronic media reports, and processor reports will be used to obtain information on the distribution, amount, and type of commercial fishing effort. Data on the current harvests by commercial and treaty Indian ocean fishermen will be obtained by telephoning selected (key) fish buyers, by sampling the commercial landings on a daily basis, and from radio or electronic media reports. Data on the current effort of, and harvests by, the recreational fisheries will be obtained by port exit counts, trailer counts, contacting selected charter boat and boat rental operators and by sampling landings at selected ports. Analyses of fish scales, recovered fish tags, genetic stock identification samples, and other methods will provide information on the composition of the stocks being harvested.

## *7.2 ANNUAL AND LONG-TERM MANAGEMENT*

### 7.2.1 Data Needs

In addition to the data used for inseason management, a considerable amount of information is used for setting the broad measures for managing the fishery, evaluating the success of the previous year's management, and evaluating the effectiveness of the plan in achieving the long-term goals. Such data include landings, fishing effort, dam counts, smolt migration, returns to hatcheries and natural spawning areas, stock contribution estimates, and economic information.

The Council also produces a periodic research and data needs document, which identifies current priorities for information collection needs and contemporary management strategies.

### 7.2.2 Methods for Obtaining Annual and Long-Term Data

In addition to those methods used for collecting data for in-season management, the longer term data will be collected by the use of (a) fish tickets (receipts a fish buyer completes upon purchasing fish from a commercial fisherman), (b) log books kept by commercial fishermen and submitted to the state fishery management agencies at the end of the season, and (c) catch record cards completed by a recreational fisherman each time he catches a fish to show location, date, and species and submitted to the state agency, either when the whole card is completed or at the end of the season.

The local fishery management authorities (states, Indian tribes) will collect the necessary catch and effort data and will provide the Secretary with statistical summaries adequate for management. The local management authorities, in cooperation with the National Marine Fisheries Service, will continue the ongoing program of collecting and analyzing data from salmon processors.

Data on spawning escapements and jack returns to public and private hatcheries, other artificial production facilities, and natural spawning grounds will be collected by the accepted methods now being used by those authorities. The methods used to collect these data should be identified and available to the public.

## *7.3 REPORTING REQUIREMENTS*

This plan authorizes the local management authorities to determine the specific reporting requirements for those groups of fishermen under their control and to collect that information under existing state data-collection provisions. With one exception, no additional catch or effort reports will be required of fishermen or processors as long as the data collection and reporting systems operated by the local authorities continue to provide the Secretary with statistical information adequate for management. The one exception would be to meet the need for timely and accurate assessment of inseason management data. In that instance the Council may annually recommend implementation of regulations requiring brief radio, phone, or electronic media reports from commercial salmon fishermen who leave a regulatory area in order to land their catch in another regulatory area. The federal or state entities receiving these reports would be specified in the annual regulations.

# 8 SCHEDULE AND PROCEDURES FOR ANALYZING THE EFFECTIVENESS OF THE SALMON FMP

To effectively manage the salmon fisheries, the Council must monitor the status of the resource and the fisheries harvesting that resource to make sure that the goals and objectives of the plan are being met. Fishery resources vary from year to year depending on environmental factors, and fisheries vary from year to year depending on the state of the resource and social and economic factors. The Council must ensure that the plan is flexible enough to accommodate regulatory changes that will allow the Council to achieve its biological, social, and economic goals.

Annually, the STT will review the previous season's commercial, recreational, and tribal Indian fisheries and evaluate the performance of the plan with respect to achievement of the framework management objectives (Chapters 2, 3, and 5). Consideration will be given by the STT to the following areas:

1. Allowable harvests
2. Escapement goals, natural and hatchery
3. Mixed-stock management
4. Federally recognized tribal fishing rights
5. Allocation goals
6. Mortality factors, including bycatch
7. Achievement of optimum yield
8. Effort management systems
9. Coordination with all management entities
10. Consistency with international treaties
11. Comparison with previous seasons
12. Progress of any Council-adopted recovery plan
13. ESA consultation standards
14. Annual catch limits
15. Stock status based on the SDC identified in this FMP

This evaluation will be submitted annually for review by the Salmon Advisory Subpanel, SSC, and the Council.

Additionally, at various Council meetings, the Habitat Committee and state and tribal management entities will help keep the Council apprised of achievements and problems with regard to the protection and improvement of the environment (i.e., EFH) and the restoration and enhancement of natural production.

During the Council’s annual preseason salmon management process, issues may arise that indicate a need to consider changes to the fixed elements of the FMP. Such issues may be considered in FMP amendments on an as needed basis under the guidelines of Chapter 11.

# 9 SCHEDULE AND PROCEDURES FOR PRESEASON MODIFICATION OF REGULATIONS

The process for establishing annual or preseason management measures under the framework FMP contains a nearly equivalent amount of analysis, public input, and review to that provided under the former annual amendment process and will not require annual preparation of a supplemental environmental impact statement (SEIS) and regulatory impact review/regulatory flexibility analysis (RIR/RFA). This allows the STT to wait to prepare its report until all of the data are available, thus eliminating the need to discuss an excessively broad range of alternatives as presented prior to the framework plan.

The process and schedule for setting the preseason regulations will be approximately as follows:

| Approximate Date | Action |
|---|---|
| First week of March | Notice published in the Federal Register announcing the availability of team and Council documents, the dates and location of the two Council meetings, the dates and locations of the public hearings, and publishing the complete schedule for determining proposed and final modifications to the management measures. Salmon Technical Team reports which review the previous salmon season, project the expected salmon stock abundance for the coming season, and describe any changes in estimation procedures, are available to the public from the Council office. |
| First or second full week of March[a/] | Council and advisory entities meet to adopt a range of season regulatory alternatives for formal public hearing. Proposed options are initially developed by the Salmon Advisory Subpanel and further refined after analysis by the STT, public comment, and consideration by the Council. |
| Following March Council meeting | Council newsletter, public hearing announcement, and STT/Council staff report are released which outline and analyze Council-adopted alternatives. The STT/staff report includes a description of the alternatives, brief rationale for their selection, and an analysis of expected biological and economic impacts. |
| Last week of March or first week of April | Formal public hearings on the proposed salmon management alternatives. |
| First or second full week of April[a/] | Council and advisory entities meet to adopt final regulatory measure recommendations for implementation by the Secretary of Commerce. |
| First week of May | Final notice of Secretary of Commerce decision and final management measures in Federal Register. |

a/ Scheduling of the March and April Council meetings is determined by the need to allow for complete availability of pertinent management data, provide time for adequate public review and comment on the proposed alternatives, and afford time to process the Council's final recommendations into federal regulations by May 1. Working backward from the May 1 implementation date, the April Council meeting is generally set as late as possible while not extending past April 15 for approval of final salmon management recommendations. The March Council meeting is set as late as possible while ensuring no less than three to four weeks between the end of the March meeting and beginning of the April meeting.

The actions by the Secretary after receiving the preseason regulatory modification recommendations from the Council will be limited to accepting or rejecting in total the Council's recommendations. If the Secretary rejects such recommendations he or she will so advise the Council as soon as possible of such action along with the basis for rejection, so that the Council can reconsider. Until such time as the Council and the Secretary can agree upon modifications to be made for the upcoming season, the previous year's regulations will remain in effect. This procedure does not prevent the Secretary from exercising his authority under

Sections 304(c) or 305(c) of the MSA and issuing emergency regulations as appropriate for the upcoming season.

Preseason actions by the Secretary, following the above procedures and schedule, would be limited to the following:

1. Specify the annual abundance, total allowable harvest, and allowable ocean harvest.

2. Allocate ocean harvest to commercial and recreational fishermen and to treaty Indian ocean fishermen where applicable.

3. Review ocean salmon harvest control mechanism from previous year; make changes as required in:

   a. Management area boundaries
   b. Minimum harvest lengths
   c. Recreational daily bag limits
   d. Gear requirements (i.e., barbless hooks, etc.)
   e. Seasons and/or quotas
   f. Ocean regulations for treaty Indian fishermen
   g. Inseason actions and procedures to be employed during the upcoming season
   h. annual catch limits

Because the harvest control measures and restrictions remain in place until modified, superseded, or rescinded, changes in all of the items listed in "3" above may not be necessary every year. When no change is required, intent not to change will be explicitly stated in preseason decision documents.

The Framework Amendment (1984) provides further rationale for the current preseason procedures and the replacement of the old process of annual plan amendments to establish annual regulations.

# 10 INSEASON MANAGEMENT ACTIONS AND PROCEDURES

Inseason modifications of the regulations may be necessary under certain conditions to fulfill the Council's objectives. Inseason actions include "fixed" or "flexible" actions as described below.

## *10.1 FIXED INSEASON ACTIONS*

Three fixed inseason actions may be implemented routinely as specifically provided in the subsections below.

### 10.1.1 Automatic Season Closures When the Quotas Are Reached

The STT will attempt to project the date a quota will be reached in time to avoid exceeding the quota and to allow adequate notice to the fishermen. The State Directors and the Council Chairman will be consulted by the NMFS Regional Administrator before action is taken to close a fishery. Closures will be coordinated with the states so that the effective time will be the same for EEZ and state waters. A standard closure notice will be used and will specify areas that remain open as well as those to be closed. To the extent possible, all closures will be effective at midnight and a 48-hour notice will be given of any closure. When a quota is reached, the Regional Administrator will issue a notice of closure of the fishery on the telephone hotline and via USCG Notice to Mariners radio broadcast. Other means of notification may include posting on the NMFS NWR website, email or other electronic media. Notice of fishery closure is published in the Federal Register as soon as is practicable.

### 10.1.2 Rescission of Automatic Closure

If, following the closing of a fishery after a quota is reached, it is discovered that the actual catch was over-estimated and the season was closed prematurely, the Secretary is authorized to reopen the fishery if:

1. The shortfall is sufficient to allow at least one full day's fishing (24 hours) based on the best information available concerning expected catch and effort; and

2. The unused portion of the quota can be taken before the scheduled season ending.

### 10.1.3 Adjustment for Error in Preseason Estimates

The Secretary may make changes in seasons or quotas if a significant computational error or errors made in calculating preseason estimates of salmon abundance have been identified, provided that such correction to a computational error can be made in a timely fashion to affect the involved fishery without disrupting the capacity to meet the objectives of the management plan. Such correction and adjustments to seasons and quotas will be based on a Council recommendation and STT analysis.

## *10.2 FLEXIBLE INSEASON ACTIONS*

Fishery managers must determine that any inseason adjustment in management measures is consistent with escapement goals, conservation of the salmon resource, any federally recognized Indian fishing rights, and the ocean allocation scheme in the Section 5.3. In addition, all inseason adjustments must be based on consideration of the following factors:

- Predicted sizes of salmon runs
- Harvest quotas and hooking mortality limits for the area and total allowable impact limitations if applicable
- Amount of the recreational, commercial, and treaty Indian fishing effort and catch for each species in the area to date

- Estimated average daily catch per fisherman
- Predicted fishing effort for the area to the end of the scheduled season
- Other factors as appropriate (particularly, fisher safety affected by weather or ocean conditions as noted in Amendment 8)

Flexible inseason provisions must take into consideration the factors and criteria listed above and would include, but not be limited to, the following.

1. Modification of quotas and/or fishing seasons would be permitted. Redistribution of quotas between recreational and commercial fisheries would be allowed if the timing and procedure are described in preseason regulations. If total quotas or total impact limitations by fishery are established, subarea quotas north and south of Cape Falcon, Oregon can be redistributed within the same fishery (north or south of Cape Falcon). Other redistributions of quotas would not be authorized. Also allowable would be establishment of, or changes to, hooking mortality and/or total allowable impact limitations during the season. Action based on revision of preseason abundance estimates during the season would be dependent on development of a Council approved methodology for inseason abundance estimation.

2. Modifications in the species that may be caught and landed during specific seasons and the establishment or modification of limited retention regulations would be permitted (e.g., changing from an all-species season to a single-species season, or requiring a certain number of one species to be caught before a certain number of another species can be retained).

3. Changes in the recreational bag limits and recreational fishing days per calendar week would be allowed.

4. Establishment or modification of gear restrictions would be authorized.

5. Modification of boundaries, including landing boundaries, and establishment of closed areas would be permitted.

6. Temporary adjustments for fishery access due to weather, adverse oceanic conditions, or other safety considerations (see Council policy of September 18, 1992 regarding implementation of this action).

The flexibility of these inseason management provisions imposes a responsibility on the Regional Administrator to assure that affected users are adequately informed and have had the opportunity for input into potential inseason management changes.

## 10.3 PROCEDURES FOR INSEASON ACTIONS

1. Prior to taking any inseason action, the Regional Administrator will consult with the Chairman of the Council and the appropriate State Directors.

2. As the actions are taken by the Secretary, the Regional Administrator will compile, in aggregate form, all data and other information relevant to the action being taken and shall make them available for public review upon request, contact information will be published annually in the Federal Register and announced on the telephone hotline.

3. Inseason management actions taken under both the "fixed" and "flexible" procedures will become effective by announcement in designated information sources (rather than by filing with the Office of the Federal Register [OFR]). Notice of inseason actions will still be filed with the OFR as soon as is practicable.

   The following information sources will provide actual notice of inseason management actions to the public: (1) the U.S. Coast Guard "Notice to Mariners" broadcast (announced over Channel 16 VHF-FM and 2182 KHZ); (2) state and federal telephone hotline numbers specified in the annual regulations and (3) filing with the *Federal Register*, email or other electronic forms of notification. Identification of the sources will be incorporated into the preseason regulations with a requirement that interested persons periodically monitor one or more source. In addition, all the normal channels of informing the public of regulatory changes used by the state agencies will be used.

# 11 SCHEDULE AND PROCEDURES FOR FMP AMENDMENT AND EMERGENCY REGULATIONS

Modifications not covered within the framework mechanism will require either an FMP amendment, rulemaking, or emergency Secretarial action. Depending on the required environmental analyses, the amendment process generally requires at least a year from the date of the initial development of the draft amendment by the Council. In order for regulations implementing an amendment to be in place at the beginning of the general fishing season (May 1), the Council will need to begin the process by no later than April of the previous season. It is not anticipated that amendments will be processed in an accelerated December-to-May schedule and implemented by emergency regulations.

Emergency regulations may be promulgated without an FMP amendment. Depending upon the level of controversy associated with the action, the Secretary can implement emergency regulations within 20 days to 45 days after receiving a request from the Council. Emergency regulations remain in effect for no more than 180 days after the date of publication in the Federal Register. A 186-day extension by publication in the *Federal Register* is possible if the public has had an opportunity to comment on the emergency regulation and the Council is actively preparing a plan amendment or proposed regulations to address the emergency on a permanent basis.

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# APPENDIX A
# TO THE
# PACIFIC COAST SALMON
# FISHERY MANAGEMENT PLAN

**As Modified by Amendment 18 to**
**the Pacific Coast Salmon Plan**

## IDENTIFICATION AND DESCRIPTION OF ESSENTIAL FISH HABITAT, ADVERSE IMPACTS, AND RECOMMENDED CONSERVATION MEASURES FOR SALMON

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# TABLE OF CONTENTS

## 8. FIGURES

## List of abbreviations, acronyms, and initialisms

| | |
|---|---|
| °C | degrees Celsius |
| µPa | micropascal |
| ATTF | Alaska Timber Task Force |
| BMP | best management practice |
| BTA | best technology available |
| CFR | Code of Federal Regulations |
| cm | centimeter |
| Cm/s | centimeters per second |
| Council | Pacific Fishery Management Council |
| CWT | coded wire tags |
| dB | decibels |
| EEZ | Exclusive Economic Zone |
| EFH | essential fish habitat |
| EMF | electromagnetic field |
| EPA | Environmental Protection Agency |
| ESA | Endangered Species Act |
| FAD | fish aggregating device |
| FERC | Federal Energy Regulatory Commission |
| FHWG | Fisheries Hydroacoustic Working Group |
| FMP | fishery management plan |
| fps | feet per second |
| FRI | Fisheries Research Institute |
| HAPC | habitat areas of particular concern |
| HU | hydrologic unit |
| Hz | hertz |
| IAS | invasive alien species |
| JNCC | Joint Nature Conservation Committee |
| kg | kilogram |
| km | kilometer |
| kPa | kilopascal |
| LNG | liquefied natural gas |
| LTF | log transfer facility |
| LWD | large woody debris |
| m | meter |
| MSA | Magnuson-Stevens Fishery Conservation and Management Act |
| MSF | multi-stage flash |
| nm | nautical miles |
| NMDMP | National Marine Debris Monitoring Program |
| NMFS | National Marine Fisheries Service |
| NOAA | National Oceanic and Atmospheric Administration |
| NPDES | National Pollution Discharge Elimination System |
| NPFMC | North Pacific Fishery Management Council |
| NRC | National Research Council |
| NWFSC | Northwest Fisheries Science Center |
| NWIFC | Northwest Indian Fisheries Commission |
| NWSI | Northwest Straits Initiative |
| ODFW | Oregon Department of Fish and Wildlife |
| OTC | once-through cooling |
| Pa | pascal |
| PFMC | Pacific Fishery Management Council |

| | |
|---|---|
| PNCCC | Pacific Northwest Pollution Control Council |
| Ppt | parts per thousand |
| PS | Puget Sound |
| RAC | Resource Agency of California |
| RO | reverse osmosis |
| SAFE | Stock Assessment and Fishery Evaluation |
| SAV | submerged aquatic vegetation |
| SCV | submerged combustion vaporization |
| sec | second |
| SEL | sound exposure level |
| $SEL_{cum}$ | cumulative sound exposure level |
| TMDL | total maximum daily load |
| TNT | trinitrotoluene |
| U.S. DOE | U.S. Department of Energy |
| USDA | US Department of Agriculture |
| USFWS | U.S. Fish and Wildlife Service |
| USGS | U.S. Geological Survey |
| WDF | Washington Department of Fisheries |
| WDFW | Washington Department of Fish and Wildlife |
| WDOE | Washington Department of Ecology |
| WFWC | Washington Fish and Wildlife Commission |
| WSCC | Washington State Conservation Commission |
| WWPI | Western Wood Preservers Institute |

# 1. INTRODUCTION

*Essential fish habitat means those waters and substrate necessary*
*to fish for spawning, breeding, feeding, or growth to maturity.*

*MSA Section 3(10)*

This document contains the identification and description of essential fish habitat (EFH) for salmon managed by the Pacific Fishery Management Council (Council) under the Pacific Coast Salmon Fishery Management Plan (salmon FMP). These managed salmon include most of the Chinook salmon (*Oncorhynchus tshawytscha*) stocks and all of the coho salmon (*O. kisutch*) stocks from Washington, Oregon, Idaho, and California as well as pink salmon (*O. gorbuscha*) stocks originating from watersheds within Puget Sound (PFMC 1997b).

The Magnuson-Stevens Fishery Conservation and Management Act (MSA) requires all fishery management councils to amend their fishery management plans (FMPs) to describe and identify EFH for each managed fishery. As defined in the MSA, the term "essential fish habitat" means those waters and substrate necessary to fish for spawning, breeding, feeding or growth to maturity. For the purpose of interpreting this definition of EFH: ‘‘waters’’ include aquatic areas and their associated physical, chemical, and biological properties that are used by fish and may include aquatic areas historically used by fish where appropriate; ‘‘substrate’’ includes sediment, hard bottom, structures underlying the waters, and associated biological communities; ‘‘necessary’’ means the habitat required to support a sustainable fishery and the managed species’ contribution to a healthy ecosystem; and ‘‘spawning, breeding, feeding, or growth to maturity’’ covers a species’ full life cycle (50 CFR 600.10).

The waters and substrate that comprise EFH designated in the FMPs managed by the Council are diverse and widely distributed. They are also closely interconnected with other aquatic and terrestrial environments. From a broad perspective, EFH is the geographic area where the species occurs at any time during its life. This area can be described in terms of ecological characteristics, location, and time. In ecological terms, EFH includes waters and substrate that focus distribution (e.g., migration corridors, spawning areas, rocky reefs, intertidal salt marshes, or submerged aquatic vegetation (SAV)) and other characteristics that are less distinct (e.g., turbidity zones, salinity gradients). Spatially, habitats and their use may shift over time due to natural habitat-forming processes, such as sediment transport or extreme weather events, and human activities, such as shoreline armoring or timber harvest. The type of habitat available, its attributes, and its functions are important to species productivity, diversity, health, and survival.

An FMP should minimize, to the extent practicable, adverse effects on EFH caused by fishing and identify other actions to encourage the conservation and enhancement of EFH. The MSA also require Federal agencies to consult with the National Marine Fisheries Service (NMFS) with respect to any action authorized, funded, or undertaken, or proposed to be authorized, funded, or undertaken, by such agency that may adversely affect any EFH identified under this Act.

The regulatory guidance that implements the EFH provisions of the MSA (50 CFR 600) defines an “adverse effect” as any impact that reduces quality and/or quantity of EFH. Adverse effects may include direct or indirect physical, chemical, or biological alterations of the waters or substrate and loss of, or injury to, benthic organisms, prey species and their habitat, and other ecosystem components, if such modifications reduce the quality or quantity of EFH. Adverse effects on EFH may result from actions occurring within EFH or outside of EFH and may include site-specific or habitat-wide impacts, including individual, cumulative, or synergistic consequences of actions.

The regulatory guidance also requires FMCs and NMFS to periodically review the EFH provisions of FMPs and that those provisions should be revised or amended, as warranted, based on available information (50 CFR 600.815(a)(10)). The review should evaluate published scientific literature, unpublished scientific reports, information solicited from interested parties, and previously unavailable or inaccessible data. EFH for Pacific Coast salmon was first identified and described in Appendix A to the salmon FMP (PFMC 1999), and was reviewed by the PFMC and NMFS in 2011 (see Stadler et al. 2011). This revised appendix reflects the result of that review and subsequent Council action, and contains information required by the EFH regulatory guidance (50 CFR 600).

Chapter 2 of this document identifies EFH for the three species Pacific salmon managed under the salmon FMP and designates habitat areas of particular concern (HAPC). Chapter 3 describes the habitat requirements for each life history stage for each of the three species of salmon. Chapter 4 describes potential adverse effects on salmon EFH from both fishing and non-fishing activities as well as potential conservation and enhancement measures to avoid, minimize, mitigate, or otherwise offset those effects. Chapter 5 describes additional information and research needs for improving the identifications and descriptions of EFH for Pacific Coast salmon.

# 2. IDENTIFICATION OF ESSENTIAL FISH HABITAT FOR THE PACIFIC SALMON FISHERY

EFH for the Pacific Coast salmon fishery means those waters and substrate necessary for salmon production needed to support a long-term, sustainable salmon fishery and salmon contributions to a healthy ecosystem. To achieve that level of production, salmon EFH must include all freshwater, estuarine, and marine habitats in, and off of, Washington, Oregon, Idaho, and California and the marine waters off Alaska that are currently occupied by stocks of salmon managed under this FMP, as well as most of the habitats that were historically occupied by those same stocks. EFH cannot be designated for salmon stocks that are not managed under the FMP, and cannot be designated for stocks that are listed as Ecosystem Component Species in the FMP.

The geographic extent of freshwater EFH is identified as all water bodies currently or historically occupied by Council-managed salmon. In the estuarine and marine areas, salmon EFH extends from the extreme high tide line in nearshore and tidal submerged environments within state territorial waters out to the full extent of the Exclusive Economic Zone (EEZ) (200 nautical miles or 370.4 km) offshore of Washington, Oregon, and California north of Point Conception. Foreign waters off Canada, while still salmon habitat, are not included in salmon EFH, because they are outside United States jurisdiction. Pacific Coast salmon EFH also includes the marine areas off Alaska designated as salmon EFH by the North Pacific Fishery Management Council (NPFMC)[1]. If the NPFMC alters its designation of EFH for salmon in Alaskan marine waters, the marine EFH for Pacific Coast salmon under this FMP will change accordingly, without action by this Council. The coast-wide geographic range of EFH for Pacific Coast salmon, both freshwater and marine, is shown in Figure 1. This identification of EFH is based on the descriptions of habitat utilized by Chinook salmon, coho salmon, and Puget Sound pink salmon provided in Chapter 3 of this appendix. Areas above long-standing naturally impassable barriers (e.g., waterfalls) and above specific impassable dams are excluded from EFH, as are some areas that are the focus of reintroductions under Section 10(j) of the U.S. Endangered Species Act (ESA).

## 2.1 COMPREHENSIVE APPROACH TO IDENTIFICATION

The Council chose a comprehensive rather than a limiting approach to the identification of salmon EFH for several reasons. In the marine environment, Pacific salmon distribution can only be identified generally throughout the EEZ, because it is extensive, varies seasonally and inter-annually, and has not been extensively sampled in many ocean areas. In estuaries and freshwater, delimiting habitat to that which is essential is difficult, because of the diversity of habitats utilized by Pacific salmon coupled with (1) natural variability in habitat quality and use (e.g., some streams may have fish present only in years with plentiful rainfall; also, habitat of intermediate and low value may be important depending upon the health of the fish population and the ecosystem); (2) the current low abundance of Pacific salmon; (3) the lack of data on specific stream-by-stream historical distribution; and (4) the fact that salmon migrate through this entire continuum of habitats. Many of the current databases on salmon distribution were developed during recent periods of low salmon abundance and may not accurately reflect the complete distribution and habitats utilized by salmon. Furthermore, the current information on salmon freshwater distribution is useful at the regional level for determining which watersheds salmon inhabit, but not necessarily for identifying EFH down to specific stream reaches and habitats utilized by salmon.

After considering these factors, the Council adopted an inclusive, watershed-based approach, and designated EFH at the level of the U.S. Geological Survey (USGS) 4th field hydrologic units (HUs). Such an approach is appropriate, because it (1) recognizes the species' use of diverse habitats and underscores

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[1] Contact the North Pacific Fishery Management Council for information on salmon EFH in the marine waters off of Alaska. http://www.alaskafisheries.noaa.gov/npfmc/index.html

the need to account for all of the habitat types supporting the species' freshwater and estuarine life stages, from small headwater streams to migration corridors and estuarine rearing areas; (2) considers the variability of freshwater habitat as affected by environmental conditions (droughts, floods, etc.) that make precise mapping difficult; and (3) reinforces important linkages between aquatic and adjacent upslope areas. Habitat available and utilized by salmon changes frequently in response to floods, landslides, woody debris inputs, sediment delivery, and other natural events. To expect the distribution of salmon within a stream, watershed, province, or region to remain static over time is unrealistic. Furthermore, this watershed-based approach is consistent with other Pacific salmon habitat conservation and recovery efforts such as those implemented under the ESA. Additional detail on Pacific salmon freshwater essential habitat is provided in Chapter 3 of this appendix.

Salmon EFH is designated for each species within the USGS 4th field HUs identified in Table 1 using current and historical distribution data. These 4th field HUs were identified using several databases of current salmon distribution, augmented with additional other historical and current distribution data identified in Table 2. Current distribution information in Washington, Oregon, and Idaho was obtained from StreamNet (2012a; 2012b; 2012c; and 2012d), and current distribution information in California was obtained from Calfish (2012) and NMFS (2005a; 2005b).

Salmon EFH includes the channels within the designated 4th field HUs with a lateral extent as defined by the ordinary high-water line (33 CFR 319.11). Salmon EFH excludes areas upstream of longstanding naturally impassable barriers (i.e., natural waterfalls in existence for several hundred years). Salmon EFH includes aquatic areas above all artificial barriers except the impassable barriers (dams) listed in Table 1. Although the habitats above these dams are not designated as EFH, activities in these areas that may adversely affect the EFH below the dams are subject to the consultation provisions of the MSA. The rationale used to identify these dams is described in detail in Section 2.2.

## 2.2 CONSIDERATION OF REINTRODUCTIONS UNDER SECTION 10(j) OF THE ESA

Throughout their historical range, salmon have been extirpated from many freshwater habitats that once supported self-sustaining populations. Man-made impassable barriers, such as dams and culverts, block access to a significant portion of historically occupied areas. In some areas that remain accessible, the habitats have been so degraded by anthropogenic activities that they no longer support salmon. Although many of these areas are currently unoccupied, they are recognized as important and reestablishing populations in most of these areas is necessary for maintaining a sustainable salmon fishery and the contribution of salmon to a healthy ecosystem.

Many of these extirpated populations were part of a larger population (i.e., an evolutionarily significant unit [ESU]) that has been listed as either threatened or endangered under the ESA. The ESA contains provisions under Section 10(j) that facilitate cooperative efforts to reintroduce listed species into historical habitats, where NMFS works with a range of stakeholders that include Federal, state, and local agencies, Tribal governments, industry, and private citizens, to reach agreement on where reintroductions will occur. Designation as an experimental population under Section 10(j) encourages stakeholder support by allowing for the easing of certain ESA liabilities, such as the consultation requirements under Section 7 or the prohibition of take under Section 9, for potentially affected parties within the reintroduction area. Cooperation is essential to these reintroduction efforts, and in certain cases, EFH designations that are not aligned with reintroduction planning could confuse the public and could have implications for ongoing and future efforts to build support to reestablish listed salmon populations in these areas. Therefore, the Council intends to consider these areas, on a case-by-case basis and in cooperation with NMFS, to determine whether it is appropriate to have EFH designations in areas where experimental populations have been, or are proposed to be, reintroduced.

## 2.3 CONSIDERATION OF IMPASSABLE DAMS

Numerous hydropower, water storage, and flood control projects have been built that block access to large areas that were historically used by salmon. This loss of habitat is widely recognized as a major factor in the decline of salmon populations throughout their range. The EFH regulations note that if degraded or inaccessible aquatic habitat has contributed to reduced yields of a species or assemblage and if those conditions can be reversed through such actions as improved fish passage techniques, improved water quality measures, and similar measures that are technologically and economically feasible, EFH should include those habitats that would be necessary to the species to obtain increased yields [50 CFR 600.815(a)(1)(iv)(F)]. In addition, the EFH regulations recognize the importance of ecosystem restoration and allows EFH to be designated in certain historical habitats, provided that they are necessary to support rebuilding the fishery and that restoration is technologically and economically feasible [50 CFR 600.815(a)]. These dams vary greatly in size, permanence, the feasibility of reestablishing fish passage, and the contribution that the habitats above the dam would make to a sustainable fishery and conservation of the species. Therefore the Council, in 1999, established a set of criteria for determining whether the habitat above them should be designated as EFH, or whether the dams should be designated as the upstream extent of EFH on that system. The Council applied these criteria to more than 50 large dams in Washington, Oregon, Idaho, and California, and designated 44 of them as the upstream extent of EFH. As part of the 5-year review, these 44 dams were re-evaluated, based on a modified set of criteria. These modified criteria are as follows:

1) Is the dam federally owned or operated, licensed by the Federal Energy Regulatory Commission (FERC), state licensed, or subject to state dam safety supervision? Is the dam of sufficient size, permanence, impassability, and legal identity to warrant consideration for inclusion in this list?
    - If Yes both question, go to 2
    - If No, then the dam is not the upstream extent and the habitat above the dam should be designated as EFH.

2) Is the dam upstream of any other impassable dam that is designated as the upstream extent of EFH?
    - If Yes, then the upstream extent of EFH is, by definition, downstream of the dam, and it should not be included in the list of impassable dams.
    - If No, then go to 3.

3) Is fish passage in the construction or planning phase by a state or Federal agency or facility operator?
    - If Yes, then the dam should not be considered the upstream extent, and the habitat above the dam should be designated as EFH.
    - If No, then go to 4.

4) Has NMFS or the Council determined that restoration of passage and conservation of the habitat above the dam is necessary for the long-term survival of the species and sustainability of the fishery? In making this determination, NMFS or the Council should consider information contained in official NMFS documents such as a biological opinion, critical habitat designation, NMFS recovery plan, fish passage prescription under the Federal Power Act, or other formal NMFS policy position. This criterion provides for designation of habitat upstream of dams that would otherwise be listed as the upstream extent of EFH, and reflects the fact that the habitats in many portions of watersheds have not previously been formally evaluated.
    - If Yes, then the dam should not be considered the upstream extent and the habitat above the dam should be designated as EFH.
    - If No, then the dam should be designated as the upstream extent of EFH.

In determining the upstream extent of EFH, the Council and NMFS also considered reintroduction efforts under Section 10(j) of the ESA. Consideration of new EFH designations should be aligned with reintroduction planning, to the extent feasible.

Using this process, the Council designated 43 dams as the upstream extent of EFH. These dams are identified in Table 1. The locations of these dams are also indicated on the species-specific maps of EFH (Figures 2 through 6). It is important to note that some of the dams block passage of one species of salmon but not another. For example, Chinook salmon are passed, via a trap and haul operation, at Big Cliff Dam on the North Santiam River, but coho salmon are not.

Throughout the range of Pacific salmon, numerous hydropower dams have undergone, or are scheduled for, relicensing by FERC. Information developed during the process of relicensing requires evaluation to determine whether fish passage facilities will be required at such dams to restore access to historically occupied habitat. Even though habitat above such barriers may not currently be designated as EFH, this conclusion does not diminish the potential importance of restoring access to these areas. The FERC relicensing process may result in requirements for the establishment of fish passage when the habitat above currently impassable FERC-licensed dams is necessary. Passage may also be required via other non-FERC mechanisms. If, through these processes, salmon access or reintroduction above any of the dams listed in Table 1 become feasible, the Council may remove them from the list and designate the areas above them as EFH.

## 2.4 HABITAT AREAS OF PARTICULAR CONCERN

The implementing regulations for the EFH provisions of the MSA (50 CFR part 600) recommend that the FMPs include specific types or areas of habitat within EFH as “habitat areas of particular concern” (HAPC) based on one or more of the following considerations: (1) the importance of the ecological function provided by the habitat; (2) the extent to which the habitat is sensitive to human-induced environmental degradation; (3) whether, and to what extent, development activities are, or will be, stressing the habitat type; and (4) the rarity of the habitat type. Based on these considerations, the Council designated five HAPCs: 1) complex channels and floodplain habitats; 2) thermal refugia; 3) spawning habitat; 4) estuaries; and 5) marine and estuarine SAV. With the exception of estuaries, none of these HAPCs have been comprehensively mapped, and some may vary in location and extent over time. For these reasons, the mapped extent of these areas is only a first approximation of their location. Defining criteria of these HAPCs are described below, which should be applied to determine whether a given area is designated as a HAPC for Pacific Coast salmon. It is important to note that HAPCs include all waters, substrates, and associated biological communities falling within the area defined by the criteria below. In some cases, HAPCs may overlap with each other (e.g., estuaries with marine and estuarine SAV), an indicator of the multiple habitat functions provided by, and the increased importance of, that area.

The intended goal of identifying HAPCs is to provide additional focus for conservation efforts. While the HAPC designation does not add any specific regulatory process, it highlights certain habitat types that are of high ecological importance. As a result, Federal actions with potential adverse impacts to HAPCs will be more carefully scrutinized during the EFH consultation process and may result in greater conservation of EFH.

### 2.4.1 Complex Channels and Floodplain Habitats

Complex channels consisting of meandering, island-braided, pool-riffle and forced pool-riffle channels and complex floodplain habitats consisting of wetlands, oxbows, side channels, sloughs and beaver ponds, and steeper, more constrained channels with high levels of large woody debris (LWD), provide valuable habitat for all Pacific salmon species. The densities of both spawning and rearing salmon are highest in areas of high quality naturally functioning floodplain habitat and in areas with LWD than in anthropogenically modified floodplains (Brown and Hartman 1988; Chapman and Knudsen 1980; Brown and Hartman 1988; Montgomery et al. 1999). These important habitats are typically found within complex floodplain channels defined as meandering or island-braided channel patterns and in pool-riffle or forced-pool mountain river systems (see Montgomery and Buffington 1998 and Beechie et al. 2006 for detailed description of these channel types). Complex floodplain habitats are dynamic systems that change over time. As such, the habitat-forming processes that create and maintain these habitats (e.g., erosion and aggradation, channel avulsion, input of large wood from riparian forests) should be considered as integral to the habitat.

An important component of these habitats is large wood, which typically occurs in the form of logjams in floodplains and larger rivers and accumulations of single or multiple logs in smaller mountain channels. LWD helps create complex channels and floodplain habitats and important spawning and rearing habitat by trapping sediment, nutrients, and organic matter, creating pools, sorting gravels, providing cover and hydrologic heterogeneity, and creating important spawning and rearing areas for salmon (Harmon et al. 1986; Abbe and Montgomery 1996; Bilby and Bisson 1998). Complex channels, floodplain habitat, and LWD are very sensitive to land, riparian, or river management. These areas also provide pools, off-channel areas, shade, cooler temperatures, and thermal refugia during both summer and winter (Crispin et al. 1993).

Juvenile coho salmon frequently move from main-channel habitats to off-channel habitats during the winter months, presumably to seek refuge from high winter flows (Cederholm and Scarlett 1982; Peterson 1982). Juvenile coho salmon inhabiting beaver ponds and other off-channel ponds exhibit higher densities, higher growth rates, and higher overwinter survival rates than coho salmon inhabiting other main-channel and side-channel habitats (Bustard and Narver 1975; Swales et al. 1986; Swales and Levings 1989).

Side channels are important spawning habitat for Chinook salmon as well as coho salmon, and complex floodplain habitat and associated channels have higher densities of spawning fish than modified or constrained habitats (Vronskiy 1972; Drucker 2006; NOAA unpublished data).

In higher-gradient reaches with more confined channels, large wood plays a major role in creating deep, complex pools that provide winter refuge where off-channel habitats are not available. Densities of juvenile coho salmon and other salmonids are often substantially higher in stream reaches with higher wood volumes compared to streams with little wood (reviewed in Bilby and Bisson 1998).

In most river systems throughout the Pacific Northwest and California, complex floodplain habitats have been subject to a high degree of direct anthropogenic modification. Floodplain areas have been cleared of woodland vegetation, drained, and filled to allow agricultural, residential, and urban development (Pess et al. 2002; 2003). Channelization and diking of rivers has effectively separated rivers from many off-channel habitats once available to salmonids (Beechie et al. 1994; Reeves et al. 1998). Clearing of large wood accumulations in rivers was commonplace to both improve navigation and facilitate transport of logs from upstream forest to mill sites downstream (Bilby and Bisson 1998). Active removal of beaver ponds or isolation of beaver ponds by levees has resulted in substantial losses of these habitats in many Pacific Northwest rivers (Beechie et al. 1994; 2001).

Low-gradient, unconstrained reaches that typify where complex floodplain habitats are expressed are also highly responsive to disturbances that happen higher up in the watershed. For example, sediments generated by land-use and road-building practices are typically routed through higher-gradient, transport reaches and are deposited in low-gradient reaches. This can lead to widening and shallowing of the river channel, filling in of pool habitats, and reductions in the average particle size of the substrate (Montgomery and Buffington 1998). These changes, in turn, diminish the quality of spawning and rearing habitats for salmon, as well the capacity of affected reaches to produce invertebrates that salmonids depend on for food.

In moderate-gradient stream reaches, historical land-use practices including logging of riparian forests, splash damming, and active removal of wood from the stream channel to facilitate fish passage and protect local infrastructure has fundamentally altered the structure and function of salmon habitats. Despite improvements in riparian forest management that have occurred in the last 40-50 years, the legacy of early practices remains apparent in diminished sources for recruitment of large wood (particularly of coniferous origin), decreased quantities of large wood in stream channels, and a shift in composition of large wood pieces from large-diameter pieces of coniferous origin to smaller diameter pieces of hardwood origin, which decompose at a much faster rate (Bilby and Bisson 1998).

Many areas that historically were part of complex floodplain habitats have been permanently lost to urban development. Restoration of other such habitats would require major shifts in land-use practices including abandonment of agricultural lands and removal of dikes and levees. Consequently, maintaining those few relatively intact floodplain habitats that remain on the landscape should be a high priority in salmon conservation.

Conditions in riparian forests along more confined channels are likely to improve over the long term in response to forest practice rules; however, the time lag between establishment of these rules and expected attainment of instream benefits is long (100-200 years). Consequently, ensuring protection of stream reaches that are characterized by intact, coniferous riparian stands and/or that currently have high amounts of inchannel wood is a high priority to bridge this gap.

Historically, neither complex floodplain habitats nor mid-gradient channels with large quantities of in-channel wood were inherently rare within forested landscapes of the Pacific Northwest and California, but they have become increasingly so in response to human alterations of the landscape. For example, in the Skagit and Stillaguamish River watersheds, agricultural and urban development in floodplain areas has led to a 50 percent loss of side-channel sloughs habitats, and roughly 90 percent of beaver ponds have been isolated from main channel habitats (Beechie et al. 1994; 2001). As a consequence of intensive forest management on the vast majority of landscape within the Pacific Coastal Ecoregion, streams throughout the region have experienced reductions in the quantity and average size of in-channel large wood, as well as loss of wood recruitment potential from adjacent riparian zones (Bilby and Bisson 1998).

The location and extent of these complex habitats can vary over space and time and have not been comprehensively mapped. Therefore, maps or spatial descriptions may not reliably identify them at the project scale. As such, this HAPC relies on the detailed text that describes the general attributes of these habitats, rather than spatially explicit descriptions or maps.

### 2.4.2 Thermal Refugia

Thermal refugia that provide areas to escape high water temperatures are critical to salmon survival, especially during hot, dry summers in California, Idaho, and eastern Oregon and Washington. Thermal refugia provide important holding and rearing habitat for adults and juveniles (Goniea et al. 2006; Sutton et al. 2007). Important thermal refugia often exist higher in HUs and are most susceptible to blockage by artificial barriers (Yoshiyama et al. 1998). Reduced flows that are either anthropogenic, natural or climate-change induced can also reduce or eliminate access to refugia (Battin et al. 2007; Riley et al. 2009). Loss of structural elements such as large wood can also influence the formation of thermal refugia. Thermal refugia typically include coolwater tributaries, lateral seeps, side channels, tributary junctions, deep pools, areas of groundwater upwelling and other mainstem river habitats that are cooler than surrounding waters (≥2° C cooler) (Torgersen et al. 1999; Ebersole et al. 2003). As such, refugia can occur at spatial scales ranging from entire tributaries (e.g., spring-fed streams), to stream reaches (e.g., alluvial reaches with high hyporheic flow), to highly localized pockets of water only a few square meters in size embedded within larger rivers.

Studies have shown that salmon increase their use of thermal refugia (e.g., cool water tributaries) when exposed to elevated water temperatures (Sutton et al. 2007), which can significantly reduce migration rates and suggests these areas provide crucial habitat in warm years (Goniea et al. 2006). Torgersen et al. (1999) state that the ability for cold water fish such as salmon to persist in warm water environments (>25°C) that experience elevated summer temperatures and seasonal low flows may be attributed to thermal refugia because even relatively minor differences in temperature are ecologically relevant for fish. In addition, climate change is expected to cause a rise in freshwater temperatures and a reduction in snowpack, which would lead to lower flows in the summer and fall (Battin et al. 2007; Mote et al. 2003; Stewart et al. 2004). These impacts would likely result in a reduction in the quantity and quality of fresh water salmon habitat, making thermal refugia even more important in the future.

Artificial barriers can block access to thermal refugia, which are often located at higher elevations. These barriers can also restrict flows, potentially increasing downstream temperatures (Yoshiyama et al. 1998). Land-use practices and resource extraction (e.g., agricultural and forestry practices) can affect riverine habitat and alter thermal spatial structure leading to elevated temperatures and reduced cool water habitat (Torgersen et al. 1999). Climate change is expected to exacerbate these impacts (ISAB 2007; Miles et al. 2000; Stewart et al. 2004).

The abundance of cool water habitat features can vary substantially depending upon many factors including geographic location, flow characteristics and time of year. However, in certain areas with hot, dry summers (e.g., lower Sacramento River); it is likely that little, if any, suitable holding habitat exists for salmon to take refuge from elevated water temperatures (NMFS 2009a). Moreover, because climate change is expected to cause an increase in freshwater temperatures and prolonged summer drought periods (Battin et al. 2007; Mote et al. 2003; Stewart et al. 2004), these habitat types can be expected to become more rare (ISAB 2007).

The location and extent of thermal refugia are poorly understood, and maps or spatial descriptions may not reliably identify them at the project scale. As such, this HAPC relies on the detailed text that describes the general attributes of these habitats, rather than spatially explicit descriptions or maps.

### 2.4.3 Spawning Habitat

Spawning habitat has an extremely high ecological importance, and it is especially sensitive to stress and degradation by a number of land- and water-use activities that affect the quality, quantity and stability of spawning habitat (e.g., sediment deposition from land disturbance, streambank armoring, water withdrawals) (Independent Scientific Group 2000; Snake River Salmon Recovery Board 2006). Salmon spawning habitat is typically defined as low gradient stream reaches (<3%), containing clean gravel with low levels of fine sediment and high inter gravel flow. Many spawning areas have been well defined by historical and current spawner surveys and detailed maps exist for some HUs.

Spawning is a particularly important element of the life history of any species of fish. Adverse effects on salmon spawning habitat can be caused by natural conditions such as drought, as well as from human activities. Regardless of potential impacts, the selection of suitable habitat and successful spawning can mean the difference between a successful recruitment year and a poor one.

Spawning habitat consists of the combination of gravel, depth, flow, temperature, and dissolved oxygen, among others. Impacts to any of these factors can make the difference between a successful spawning event and failure. Several anthropogenic activities are known to impact various physical, chemical, or biological features of spawning habitat, including road construction, timber harvest, agriculture, and residential development among others.

Although there are modest differences in spawning preferences between the species, all salmon require cold, highly oxygenated, flowing water as suitable spawning habitat. Many human activities and natural occurrences can affect spawning habitat, including road building, culvert construction, forestry activities, agriculture, dams, and others. The population of the contiguous U.S. west coast grew nearly 27 percent between 1990 and 2009 (U.S. Census 2010). This represents about 10 million people who need housing, transportation, and other infrastructure. As population growth continues to spur development, stresses to salmon habitat are inevitable.

Chinook salmon spawn in a broad range of habitats. Depths can range from a few centimeters to several meters deep, and in small tributaries to large river systems (PFMC 1999). Coho salmon typically spawn in smaller tributaries than Chinook salmon, but are known to also spawn in larger rivers and occasionally lakes. Puget Sound pink salmon tend to spawn in larger rivers, but can also spawn in the lower reaches of rivers and even the intertidal zone (Quinn 2005). But as with other salmon species, pink salmon require high dissolved oxygen and adequate temperatures. Although salmon do require suitable habitat for successful spawning, such habitat is generally available and therefore not considered rare.

The location and extent of spawning habitat can vary over space and time, and not all spawning habitat is adequately mapped. Therefore maps or spatial descriptions may not reliably identify them at the project scale. As such, this HAPC relies on the detailed text that describes the general attributes of these habitats, rather than spatially explicit descriptions or maps.

### 2.4.4 Estuaries

Estuaries are "waters that are semi-enclosed by land but have open, partly obstructed, or sporadic access to the ocean, and in which seawater is at least occasionally diluted by freshwater runoff from land" (Dethier 1990), and include nearshore areas such as bays, sounds, inlets, river mouths and deltas, pocket estuaries, and lagoons influenced by ocean and freshwater. Because of tidal cycles and freshwater runoff, salinity varies within estuaries and results in great diversity, offering freshwater, brackish and marine habitats within close proximity (Haertel and Osterberg 1967). Such areas tend to be shallow, protected, nutrient rich, and are biologically productive, providing important habitat for marine organisms, including salmon.

The inland extent of the estuary HAPC is the high water tidal level along the shoreline or the upriver extent of saltwater intrusion, defined as upstream and landward to where ocean-derived salts measure less than 0.5 parts per thousand (ppt) during the period of average annual low flow. The seaward extent is an imaginary line closing the mouth of a river, bay, or sound; and to the seaward limit of wetland emergents, shrubs, or trees occurring beyond the lines closing rivers, bays, or sounds. This HAPC also includes those estuary-influenced offshore areas of continuously diluted seawater. This definition is based on Cowardin, et al. (1979).

Estuaries are complex systems that encompass a number of habitat types in a relatively small area, including sand and gravel beaches, mudflats, tidal creeks, shallow nearshore waters, pocket estuaries, and mixing zones, that are vital to the growth and survival of salmon, primarily during their juvenile phase. These systems provide protected habitat for juvenile salmon before entering the marine environment (Macdonald et al. 1988; Miller and Sadro 2003; Blackmon et al. 2006). Juvenile salmon are thought to utilize estuaries for three distinct purposes: (1) as a rich nursery area capable of sustaining increased growth rates; (2) to gain temporary refuge from marine predators; and (3) as a physiological transition zone where juveniles can gradually acclimate to saltwater (Bottom et al. 2005). Chinook salmon are well known for utilizing natal river tidal deltas, non-natal "pocket estuaries" (nearshore lagoons and marshes), and other estuarine habitats for rearing during outmigration (Ehinger et al. 2007). In the larger, deeper estuaries of the west coast of North America (e.g., Puget Sound, Columbia River, and San Francisco Bay), the shallow nearshore habitats of estuaries are especially important to juvenile salmon. For example, in Puget Sound, pink salmon and some ocean-type Chinook salmon enter the estuary at a very small size and rear in the shallow nearshore waters (<3 m deep) until they reach 70 mm in length, when they then move offshore. These shallow waters provide access to benthic prey and protection from predators. Functional estuaries also promote a diversity of life history types in salmon populations, with variation in estuarine use and residence time of juveniles contributing to variations in the timing and size of fish at ocean entry (Bottom et al. 2005). This diversity buffers populations from extreme events in the freshwater or marine environments, and may increase resilience of populations following such disturbances (Bottom et al. 2005).

Estuaries are highly sensitive to anthropogenic activities (Johnston 1994). A number of human activities (e.g., diking, dredging and filling, shoreline armoring, stormwater and wastewater discharge, industrialization, removal of riparian vegetation and large wood), including those that occur upstream in the rivers that flow into an estuary, can reduce both the quality and quantity of estuarine habitat that is available to salmon.

Degradation and loss of these sensitive habitats has been shown to have a detrimental effect on salmon populations (Magnusson and Hilborn 2003), and much estuarine habitat has been lost along the Pacific Coast. A number of human activities (e.g., diking, dredging and filling, shoreline armoring, stormwater and wastewater discharge, industrialization, removal of riparian vegetation and large wood), including those that occur upstream in the rivers that flow into an estuary, can reduce both the quality and quantity of estuarine habitat that is available to salmon. In Puget Sound alone, more than one third of the shoreline has been armored, with significant alteration of the shallow nearshore habitat (Shipman 2009). Shipping ports are often located in estuaries because they provide protected harbors. Development of port facilities (e.g., dredging and filling, armoring, overwater structures) has resulted in extensive loss of estuarine habitats along the West Coast. Although the effects of water withdrawals and control structures are little studied (Good 2000), there is evidence that they can alter the estuarine mixing zone (Jay and Simenstad 1996). Population growth is expected to increase water withdrawals from streams, which will reduce freshwater inflow to estuaries and lead to reduced flushing capacity for wastes, changes in habitat types and distribution, and other unknown risks to these ecosystems (Good 2000). Many estuaries have been converted to agriculture and urban land uses. For example, the Duwamish River has lost more than 99 percent of its tidal delta habitat (Simenstad et al. 1982), while the Skagit River, which contains the largest tidal delta in Puget Sound, has lost 80-90 percent of its aquatic habitat area (Collins et al. 2003).

Estuaries are not especially rare, although many have been reduced in size through diking, draining, filling, dredging, and other human activities. Therefore, much of the historical estuarine habitat has been lost and much of the remaining habitat is often severely degraded.

### 2.4.5 Marine and Estuarine Submerged Aquatic Vegetation

Submerged aquatic vegetation includes the kelps and eelgrass. These habitats have been shown to have some of the highest primary productivity in the marine environment (Foster and Schiel 1985; Herke and Rogers 1993; Hoss and Thayer 1993) and provide a significant contribution to the marine and estuarine food webs (see reviews by Fresh 2006 and Mumford 2007).

The kelps are brown macroalgae and include those that float to form canopies and those that do not, such as *Laminaria* spp. Canopy-forming kelps of the eastern Pacific Coast are dominated by two species, giant kelp (*Macrocystis pyrifera*) and bull kelp (*Nereocystis leutkeana*). Kelp plants, besides requiring moderate to high water movement and energy levels, are most likely limited by the availability of suitable substrate (Mumford 2007). Native eelgrass (*Zostera marina*) forms dense beds of leafy shoots year-round in the soft sediments of the lower intertidal and shallow subtidal zone, and they form a three-dimensional structure in an otherwise two-dimensional (sand or mud) environment (Mumford 2007).

These habitats provide important nurseries, feeding grounds, and shelter to a variety of fish species, including salmon (Shaffer 2002; Mumford 2007), as well as spawning substrate to Pacific herring (*Clupea pallasii*), an important prey species for all marine life stages of Pacific salmon. Juvenile salmon utilize eelgrass beds as migratory corridors as they transition to the open ocean, and the beds provide both refuge from predators and an abundant food supply (see reviews by Fresh 2006 and Mumford 2007).

Both kelp and eelgrass are highly sensitive to human activities. Stressors include those that affect the amount of light available to the plant, and the direct and indirect effects of high or low nutrient levels, toxins, and physical disturbance (Mumford 2007). Activities that produce such stressors include shoreline development (bulkheads, docks and piers, etc.), dredging, faulty septic systems, and stormwater discharge. These activities can alter shoreline erosion and sediment transport, alter depth profiles, generate turbidity plumes, and impair water quality, all of which can degrade eelgrass habitat (Fresh 2006) and, presumably, kelp habitat as well. Vessels can directly damage SAV through prop scour, groundings, and anchoring (Nightingale and Simenstad 2001). Eelgrass beds near ferry terminals are often heavily impacted by the propwash from these large vessels, and those near recreational facilities often show clear propeller damage. A number of studies (e.g., Walker et al. 1989; Hastings et al. 1995) have shown that anchor chains, especially those anchoring a mooring buoy, can scour a sizable area of seagrass when they drag across the bottom.

Short et al. (2006) noted a world-wide decline in seagrass habitats, many of which were attributable to anthropogenic activities. Development has altered a significant portion of the estuarine and marine shores along the West Coast, and is expected to increase in the future.

Although marine and estuarine SAV are not especially rare across the geographic range of Pacific Coast salmon, they can be locally rare. In Puget Sound, for example, only 11 percent of the shoreline has kelp, while up to 34 percent of the shoreline has eelgrass (Mumford 2007).

The location and size of both kelp and seagrass beds vary over space and time, and they have not been comprehensively mapped. Therefore, maps or spatial descriptions may not reliably identify them at the project scale. As such, this HAPC should rely on detailed text that describes the general attributes of these habitats, rather than spatially explicit descriptions or maps.

# 3. ESSENTIAL FISH HABITAT DESCRIPTIONS

The following essential habitat and life-history descriptions were developed for the three species of Pacific salmon managed under the Pacific Coast Salmon FMP: Chinook salmon, coho salmon, and Puget Sound pink salmon.

## 3.1 GEOGRAPHIC EXTENT OF SALMON EFH

The geographic extent of salmon freshwater EFH is described as all water bodies currently or historically occupied by Council-managed salmon within the USGS 4th field hydrologic units (HU) identified in Table 1. The extent of current salmon freshwater and estuarine distribution was determined using two online databases: Streamnet.org for distribution in Washington, Oregon, and Idaho, and Calfish.org for distribution in California. Because current data do not represent the full historical extent of salmon distribution, the online databases were supplemented with historical data identified by the Council (PFMC 1999) to identify a number of 4th field HUs that were historically, but are not currently, occupied by salmon (Table 2) and are not above the dams listed in Table 1.

Both StreamNet and Calfish are small-scale, regional databases that incorporate data from various sources. They are suitable for portraying the overall distribution of salmon and have some utility for determining presence on the majority of specific stream reaches. Various life stages (migration, spawning and rearing, and rearing only) are delimited in the distribution data as well.

As described in Chapter 1, the formation and modification of stream channels and habitats is a dynamic process. Habitat available and utilized by salmon changes frequently in response to floods, landslides, woody debris inputs, sediment delivery, and other natural events (Sullivan et al. 1987; Naiman et al. 1992; Reeves et al. 1995). To expect the distribution of salmon within a stream, watershed, province, or region to remain static over time is unrealistic. Therefore, current information on salmon distribution is useful for determining which watersheds salmon inhabit, but not necessarily for identifying specific stream reaches and habitats utilized by the species. As such, the Council used an inclusive, watershed-based description of EFH using USGS 4th field HUs. This watershed-based approach is consistent with other Pacific salmon habitat conservation and recovery efforts such as those implemented under the ESA.

In the estuarine and marine areas, salmon EFH extends from the nearshore and tidal submerged environments within state territorial waters out to the full extent of the EEZ (370.4 km) offshore of Washington, Oregon, and California north of Point Conception. Foreign waters off Canada, while still salmon habitat, are not included in salmon EFH, because they are outside United States jurisdiction. Pacific Coast salmon EFH also includes the marine areas off Alaska designated as salmon EFH by the NPFMC.

## 3.2 ESSENTIAL FISH HABITAT DESCRIPTION FOR CHINOOK SALMON (*Oncorhynchus tshawytscha*)

### 3.2.1 General Distribution and Life History

The following is an overview of Chinook salmon life-history and habitat use as a basis for identifying EFH for Chinook salmon. More comprehensive reviews of Chinook salmon life-history can be found in Allen and Hassler (1986), Nicholas and Hankin (1988), Healey (1991), Myers et al. (1998), and Quinn (2005). This description serves as a general description of Chinook salmon life-history for Washington, Oregon, Idaho, and California and is not specific to any region, stock, or population.

Chinook salmon, also called king, spring, or tyee salmon, is the least abundant and largest of the Pacific salmon (Netboy 1958). They are distinguished from other species of Pacific salmon by their large size, the small black spots on both lobes of the caudal fin, black pigment at the base of the teeth, and a large number of pyloric caeca (McPhail and Lindsey 1970). Chinook salmon follow a generalized life-history, which includes the incubation and hatching of embryos; emergence and initial rearing of juveniles in freshwater; estuarine migration and rearing, migration to oceanic habitats for extended periods of feeding and growth; and return to natal waters for completion of maturation, spawning, and death. Within this general life-history strategy, however, Chinook salmon display diverse and complex life-history patterns. Their spawning environments range from just above tidewater to over 3,200 km from the ocean, from coastal rainforest streams to arid mountain tributaries at elevations over 1,500 m (Major et al. 1978). At least 16 age categories of mature Chinook salmon have been documented, involving 3 possible freshwater ages and total ages of 2-8 years, reflecting the high variability within and among populations in freshwater, estuarine, and oceanic residency (Healey 1986; Wissmar and Simenstad 1998). Chinook salmon also demonstrate variable ocean migration patterns and timing of spawning migrations (Ricker 1972; Healey 1991; Quinn 2005).

This variation in life-history has been partially explained by separating Chinook salmon into two distinct races: stream-type and ocean-type fish (Gilbert 1912; Healey 1983). Stream-type fish have long freshwater residence as juveniles (1-2 years), migrate rapidly to oceanic habitats, and adults often enter freshwater in spring and summer, spawning far upriver in late summer or early fall. Ocean-type fish have short, highly variable freshwater residency (from a few days to several months), extensive estuarine residency, and adults show considerable geographic variation in month of freshwater entry. Within some large systems like the Columbia River, these two types show extensive genetic divergence (Waples et al. 2010). However, for other systems, there is also substantial variability, due to a combination of phenotypic plasticity and genetic selection to local conditions (Myers et al. 1998).

The natural freshwater range of the species includes large portions of the Pacific rim of North America and Asia. In North America, Chinook salmon have been occasionally reported in systems as far south as the Ventura River in California (~34° N latitude), but the southern extent of the historical distribution is highly uncertain. Chinook salmon populations extend northward along the Pacific Coast and into the Arctic Ocean as far east as Mackenzie River (McPhail and Lindsey 1970; Major et al. 1978). At present, the southern-most populations occur in the San Joaquin River, although Chinook salmon are occasionally observed in rivers south of San Francisco Bay. In Asia, natural populations of Chinook salmon have been documented from Hokkaido Island, Japan (~42° N latitude), to the Andyr River in Russia (~64° N latitude). In marine environments, Chinook salmon from Washington, Oregon, and California range widely throughout the North Pacific Ocean and the Bering Sea, as far south as the U.S./Mexico border.

The largest rivers tend to support the largest aggregate runs of Chinook salmon and have the largest individual spawning populations (Healey 1991). Major rivers near the southern and northern extremes of the range support populations of Chinook salmon comparable to those near the middle of the range. For example, in North America, the Yukon River near the north edge of the range and the Sacramento-San Joaquin River system near the south edge of the range have historically supported Chinook salmon runs comparable to those of the Columbia and Fraser rivers, which are near the center of the species range in North America (Healey 1991).

Declines in the abundance of Chinook salmon have been well documented throughout the southern portion of the range. Concern over coast-wide declines from southeastern Alaska to California was a major factor leading to the signing of the Pacific Salmon Treaty between the United States and Canada in 1985. Wild Chinook salmon populations have been extirpated from large portions of their historical range in a number of watersheds in California, Oregon, Washington, Idaho, and southern British Columbia (Nehlsen et al. 1991), and a number of Evolutionarily Significant Units (ESUs) have been listed by NMFS as at risk of extinction under the ESA (70 FR 37160; 76 FR 50448). For example, the Columbia River formerly supported the world's largest Chinook salmon run, but currently four Columbia Basin ESUs are listed as "threatened" under the ESA (Snake River spring/summer, Snake River fall, lower Columbia River and upper Willamette River Chinook salmons) and one is listed as "endangered" (upper Columbia River spring-run) (50 FR 37160). Another ESU of Chinook salmon (upper Klamath and Trinity Rivers Basin) is a candidate for listing and is undergoing a status review (76 FR 20302).

Habitat degradation is the major cause for extinction of populations; many extinctions are related to dam construction and operation (NMFS 1996; Myers et al. 1998). Urbanization, agricultural land use, water diversion, logging, and some combination of these stressors are also factors contributing to habitat degradation and the decline of Chinook salmon (Nehlson et al. 1991; Spence et al. 1996; Hoekstra et al. 2007; Holsman et al. 2012). The developments of large-scale hatchery programs have, to some degree, mitigated the decline in abundance of Chinook salmon in some areas. However, genetic and ecological interactions of hatchery and wild fish have also been identified as risk factors for wild populations (Hoekstra et al. 2007; Buhle et al. 2009), and the high harvest rates directed at hatchery fish may cause over-exploitation of co-mingled wild populations (Mundy 1997; Reisenbichler 1997). Recent increases in pinniped populations also raise concerns over the impacts of pinniped predation on the recovery of salmonids in certain situations (NMFS 1997c; Stansell et al. 2010), and southern resident orca whales appear to rely extensively on adult Chinook salmon as prey (Ford and Ellis 2006; Hanson et al. 2010; Williams et al. 2011), raising the question as to whether one listed species is effecting the status of another.

### 3.2.2 Relevant Trophic Information

Chinook salmon eggs, alevins, and juveniles in freshwater streams provide an important nutrient input and food source for aquatic invertebrates, other fishes including salmonids, birds, and small mammals. The carcasses of Chinook salmon adults can also be an important nutrient input in their natal watersheds, as well as providing food sources for terrestrial mammals such as bears, otters, minks, and birds such as gulls, eagles, and ravens (Cederholm et al. 1989; Bilby et al. 1996; Ben-David et al. 1997; Helfeld and Naiman 2001; Schindler et al. 2003). Because of their relatively low abundance in coastal and oceanic waters, Chinook salmon in the marine environment are typically only an incidental food item in the diet of other fishes, marine mammals, and coastal sea birds (Botkin et al. 1995; Duffy et al. 2008; Evans et al. 2012), although they are a major prey item for some orca populations (Ford and Ellis 2006; Hanson et al. 2010). Predator impacts on juvenile Chinook salmon in the open ocean may vary with climatic conditions. Emmett et al. (2006) observed greater abundances of Pacific hake and jack mackerel in onshore waters coincident with juvenile salmonids during years with a late spring transition and warmer ocean waters. Moreover, pinniped predation on migrating salmonids, both adult spawners and downstream migrating smolts, can be substantial (~2-3 percent of total run) especially at sites of restricted passage and small salmonid populations (NMFS 1997c; Stansell et al. 2010). Recent studies also show that predation by birds (e.g., gulls, terns, Stephenson et al. 2005) and non-native fish species can be substantial in the Columbia River system (Major et al. 2005; Sanderson et al. 2009). Parasites are also an overlooked source of Chinook salmon mortality (Fujiwara et al. 2011), and rates of infection may increase with water temperature (Ferguson et al. 2011).

### 3.2.3 Habitat and Biological Associations

An overview of major diet items by habitat and life stage for Chinook salmon is in Table 3. Table 4 summarizes Chinook salmon habitat use by life stage.

#### *3.2.3.1 Eggs and Spawning*

Chinook salmon spawning generally occurs from July to March depending primarily upon the geographic location and the specific race or population. In general, northern populations tend to spawn from July to October and southern populations from October to February. The Sacramento River supports a unique winter run Chinook salmon that spawn from March through July with peak spawning occurring in June (Myers et al. 1998). There is a general tendency for stream-type fish to spawn earlier than ocean-type fish in the central and southern parts of the species range, but the difference is generally less than one to two months in most streams. However, spawn timing may vary several months among some Chinook salmon populations in larger river systems such as the Columbia or the Sacramento (Healey 1991; Quinn 2005).

Chinook salmon fecundity and size of eggs, like that of other salmon species, is related to female size, and exhibits considerable small-scale geographic and temporal variability. Fecundity in Chinook salmon increases with latitude and ranges from 2,000-17,000 eggs per female, with females in most populations having 4,000-7,000 eggs (Healey and Heard 1984; Beacham and Murray 1993). Stream-type fish also tend to have higher fecundity than ocean-type fish, and northern populations are dominated by stream-type fish (Healey and Heard 1984).

Chinook salmon spawn in a broad range of habitats but appear to prefer pool-riffle channel types (Montgomery et al. 1999) and spawning areas with high connectivity and large size (Isaak et al. 2007). In some Columbia River tributaries with relatively warm summer water temperatures (>20° C), adult Chinook salmon require deep holding pools with riparian cover that provide cool water refugia near spawning areas (Torgersen et al. 1999). They have been known to spawn in water depths ranging from a few centimeters to several meters deep, and in small tributaries 2-3 m wide to large rivers such as the Columbia and the Sacramento (Chapman 1943; Burner 1951; Vronskiy 1972; Healey 1991). Chinook salmon redds (nests) range in size from 2 to 40 $m^2$, occur at depths of 10-700 cm and at water velocities of 10-150 cm/s (Healey 1991). Typically, Chinook salmon redds are 5-15 $m^2$ and located in areas with water velocities of 40-60 cm/s. The depth of the redd is inversely related to water velocity, and the female buries her eggs in clean gravel or cobble 10-80 cm in depth (Healey 1991). Because of their large size, Chinook salmon are able to spawn in higher water velocities and utilize coarser substrates than other salmon species. Female Chinook salmon select areas of the spawning stream with high subgravel flow such as pool tailouts, runs, and riffles (Vronskiy 1972; Burger et al. 1985; Healey 1991). Chinook salmon egg to fry survival can range from 0 to as high as 80 percent depending upon the quality of spawning habitat including factors such as levels of fine sediment, depth of scour, and dissolved oxygen (Healey 1991; Johnson et al. 2012). For example, egg survival is negatively related fine sediment (<0.85 mm) levels in spawning gravels, with models based on empirical data suggesting that every 1 percent increase in fine sediment in spawning gravels leads to a 10 to 15 percent reduction in egg to fry survival (Jensen et al. 2009). Parental effects may explain a significant source of variation in egg-to-fry survival in systems with low fine sediment loads (Johnson et al. 2012). Because their eggs are the largest of the Pacific salmon, ranging from 6 to 9 mm in diameter (Rounsefell 1957; Nicholas and Hankin 1988), with a correspondingly small surface-to-volume ratio, they may be more sensitive to reduced oxygen levels and require a higher rate of irrigation than other salmonids. Fertilization of the eggs occurs simultaneous with deposition. Males compete for spawning females. Chinook salmon females have been reported to remain on their redds from 6 to 25 days after spawning (Neilson and Geen 1981; Neilson and Banford 1983), defending the area from superimposition of eggs from another female. This period of redd protection roughly coincides with the period the eggs are most sensitive to physical shock.

#### *3.2.3.2 Larvae/Alevins*

Fertilized eggs begin their two- to-eight month (typically three- to-four month) period of embryonic development and growth in intragravel interstices. The length of the incubation period is primarily determined by water temperature, dissolved oxygen concentrations, and egg size. To survive successfully, the eggs, alevins, and pre-emergent fry must first be protected from freezing, desiccation, stream bed scouring or shifting, sediment inputs and predators. Water surrounding them must be non-toxic, and of sufficient quality and quantity to provide basic requirements of suitable temperatures, adequate supply of oxygen, and removal of waste materials. Rates of egg development, survival, size of hatched alevins and percentage of deformed fry are related to temperature and oxygen levels during incubation. Under natural conditions, 30 percent or less of the eggs survive to emerge from the gravel as fry (Healey 1991) though a recent study using egg boxes showed Chinook salmon egg-to-fry survival ranged from 60-87 percent in the

Yakima River tributaries (Johnson et al. 2012).

#### *3.2.3.3 Juveniles (Freshwater)*

Chinook salmon fry are typically 33-36 mm in length when they emerge, though there is considerable variation among populations and size at emergence is determined in part by egg size. Juvenile residence in freshwater and size and timing of seawater migration are highly variable. Ocean-type fish can migrate seaward immediately after yolk absorption, but most migrate 30-90 days after emergence. At the higher end of the residence period, juveniles move seaward as fingerlings in the summer or fall of their first year (Reimers 1973). In less-productive or cold water systems, juveniles often overwinter and migrate as yearling or two-year old fish (Taylor 1990a; 1990b). The proportion of fingerling and yearling migrants within a population may vary significantly among years (Roni 1992; Myers et al. 1998) and hydrology (Beechie et al. 2006).

In contrast, stream-type fish generally spend at least one year in freshwater before emigrating to sea. Alaskan fish are predominantly stream-type, while Chinook salmon from northern British Columbia are approximately half stream-type and half ocean-type (Taylor 1990a; Healey 1991). Ocean-type life histories are most common in central and southern British Columbia, Washington, Oregon, and California, with the exception of populations inhabiting the upper reaches of large river basins such as the Fraser, Columbia, Snake, Sacramento, and to a lesser extent the Klamath. Within a region, hydrologic regime may determine the relative proportion of stream and ocean-type fish. For example, in the Puget Sound region tributaries with snowmelt-dominated hydrographs had a higher proportion of the stream-type life-history; however, salmon have lost access to many of these tributaries because of habitat fragmentation (Beechie et al. 2006).

Water quality, habitat quality and quantity, and prey availability determine the productivity of a watershed for Chinook salmon. Both stream- and ocean-type fish utilize a wide variety of habitats during their freshwater residency, and are dependent on the quality of the entire watershed, from headwater to estuary. Juvenile Chinook salmon inhabit primarily pools and stream margins, particularly undercut banks, behind woody debris accumulations, and other areas with cover and reduced water velocity while maintaining access to locations of high prey availability (Lister and Genoe 1970; Bjornn and Reiser 1991; Sommer et al. 2001). Although their habitat preferences are similar to coho salmon, Chinook salmon prefer slightly deeper (15-120 cm) and higher velocity (0-38 cm/s) areas than coho salmon (Bjornn and Reiser 1991; Healey 1991). The stream or river must provide adequate summer and winter rearing habitat, and migration corridors from spawning and rearing areas to the sea. Stream-type juveniles are more dependent on freshwater ecosystems, because of their extended residence in these areas. The length of freshwater residence and growth conditions is determined partially by water temperature and food resources. Spring-type Chinook salmon in particular use off-channel habitats such as wetlands, side-channels, sloughs and other floodplain habitat (Sommer et al. 2001). Recent evidence suggests juvenile Chinook salmon rearing in these areas have much higher growth than those rearing in mainstem areas (Jeffres et al. 2008; Bellmore et al. 2013).

Growth rates during the period of initial freshwater residency depend on the quality (i.e., habitat complexity prey availability, water temperature, and density of competitors) of habitats occupied by the fish. Growth rates between 0.21 mm/d and 0.62 mm/d have been reported for ocean-type fish and between 0.09 mm/d and 0.33 mm/d for stream-type fish (Kjelson et al. 1982; Healey 1991; Rich 1920; Mains and Smith 1964; Meeh and Siniff 1962; Loftus and Lenon 1977). For ocean-type fish, growth rates in estuarine habitats are generally much higher than they are in riverine or stream habitats, most likely due to a higher abundance of prey.

The foraging ecology of juvenile Chinook salmon is dependent on a variety of factors including time of year, body size, stream and riparian conditions, density and composition of fish community. Juvenile Chinook salmon are generally opportunistic predators that consume prey based on availability though they can exhibit selectivity as well (Macneale et al. 2009). In freshwater systems, they consume aquatic and terrestrial insects (larvae/nymphs and adult life stages) with major prey items (by number and biomass) including Chironomidae and Ephemeroptera (Merz 2001; Macneale et al. 2009; Sanderson et al. in prep).

#### *3.2.3.4 Juvenile (Estuarine)*

Although both stream- and ocean-type Chinook salmon may reside in estuaries, stream-type Chinook salmon generally spend a very brief period in the lower estuary before moving into coastal waters and the open ocean (Healey 1980; 1982; 1983; Levy and Northcote 1981; Beamer et al. 2005; Jacobson et al. 2012). In contrast, ocean-type Chinook salmon typically reside in estuaries for several months before entering coastal waters of higher salinity (Healey 1980; 1982; Congleton et al. 1981; Levy and Northcote 1981; Kjelson et al. 1982; Beamer et al. 2005; Bottom et al. 2005). Wild juvenile Chinook salmon show more protracted seasonal presence in estuarine and nearshore habitats than hatchery fish (Levings et al. 1986; Beamer et al. 2005; Rice et al. 2011) and disproportionately high use of shallow fringing delta habitats compared to hatchery fish (Beamer et al. 2005). Historical populations of outmigrant Chinook salmon showed greater life-history diversity and more extensive seasonal presence than contemporary populations (Burke 2004; Bottom et al. 2005).

Ocean-type Chinook salmon typically begin their estuarine residence as fry immediately after emergence or as fingerling after spending several months in freshwater. Fry generally enter the upper reaches of estuaries in late winter or early spring, beginning in January at the southern end of their range in the Sacramento-San Joaquin Delta, to February in Puget Sound (Beamer et al. 2005), and April farther north, such as in the Fraser River Delta (Sasaki 1966; Dunford 1975; Levy et al. 1979; Healey 1980; 1982; Gordon and Levings 1984). In contrast, Chinook salmon fingerling typically enter estuarine habitats in May, June, and July (April through June in the Sacramento), or approximately as the earlier timed fry are emigrating to higher salinity marine waters. Regardless of time of entrance, juvenile ocean-type Chinook salmon spend from one to three months in estuarine habitats (Rich 1920; Reimers 1973; Myers 1980; Kjelson et al. 1982; Levy and Northcote 1981; Healey 1980; 1982; Levings 1982; Bottom et al. 2005; Jacobson et al. 2012).

Chinook salmon fry prefer protected estuarine habitats with lower salinity, moving from the edges of marshes during high tide to protected tidal channels and creeks during low tide, although they venture into less-protected areas at night (Healey 1980; 1982; Levy and Northcote 1981; 1982; Kjelson et al. 1982; Levings 1982). As the fish grow larger, they are increasingly found in higher-salinity waters and increasingly utilize less-protected habitats, including delta fronts or the edges of the estuary before finally dispersing into marine habitats (Beamer et al. 2005). In contrast to fry, Chinook salmon fingerling, with their larger size, immediately take up residence in deeper-water estuarine habitats (Everest and Chapman 1972; Healey 1991).

The Chinook salmon diet during estuarine residence is highly variable and is particularly dependent upon the fish size, as well as the particular estuary, year, season, and prey abundance (Brodeur 1991; Schabetsberger et al. 2003; Brennan et al. 2004; Sweeting et al. 2007; Bollens et al. 2010; Duffy et al. 2010). In general, Chinook salmon are opportunistic feeders, consuming larval and adult insects, polychaetes, copepods, mysid shrimp, and amphipods when they first enter estuaries, with increasing dependence on larval and juvenile fish (including other salmonids) as they grow larger (Brennan et al. 2004; Duffy 2010). Preferred diet items for Chinook salmon include aquatic and terrestrial insects such as psocoptera, chironomid larvae and other dipterans, cladoceans such as *Daphnia*, amphipods including *Eogammarus* and *Corophium*, and other crustacea such as *Neomysis*, crab larvae, and cumaceans (Sasaki 1966; Dunford 1975; Birtwell 1978; Levy et al. 1979; Northcote et al. 1979; Healey 1980; 1982; Kjelson et al. 1982; Levy and Northcote 1981; Levings 1982; Gordon and Levings 1984; Myers 1980; Reimers 1973; Brennan 2004; Sweeting et al. 2007; Duffy et al. 2010). Larger juvenile Chinook salmon consume juvenile fishes such as herring *(Clupeidae)*, anchovy *(Engraulidae)*, smelt *(Osmeridae)*, sandlance

*(Ammodytidae)* and stickleback *(Gasterosteidae)*.

Growth in estuaries is quite rapid and Chinook salmon may enter the upper reaches of estuarine environments as 35-40 mm fry, and leave as 70-110 mm smolts (Rich 1920; Levy and Northcote 1981; 1982; Reimers 1973; Healey 1980). Growth rates during this period are difficult to estimate because small individuals are continually entering the estuary from upstream, while larger individuals depart for marine waters. Reported growth for populations range from 0.22 mm/d to 0.86 mm/d, and is as high as 1.32 mm/d for groups of marked fish (Rich 1920; Levy and Northcote 1981; 1982; Reimers 1973; Healey 1980; Kjelson et al. 1982; Healey 1991; Levings et al. 1986).

#### *3.2.3.5 Juveniles (Marine)*

After leaving the freshwater and estuarine environment, juvenile Chinook salmon disperse to marine feeding areas. Ocean-type fish, which have a longer estuarine residence, tend to be coastal oriented, preferring protected waters and waters along the continental shelf (Healey 1983). In contrast, stream-type fish pass quickly through estuaries, are highly migratory, and may migrate great distances into the open ocean. In addition, a subset of Chinook salmon populations (“blackmouth”) throughout Puget Sound and the Strait of Georgia remain within the protected waters of the Salish Sea to feed before returning to their natal systems as adults (Pressey 1953; Chamberlin et al. 2011).

Chinook salmon typically remain at sea for one to six years. They have been found in oceanic waters at temperatures ranging from 1-15 ºC, although few Chinook salmon are found in waters below 5° C (Major et al. 1978). They do not concentrate at the surface as do other Pacific salmon, but are most abundant at depths of 30-70 m and often associated with bottom topography (Taylor 1969; Argue 1970). However, during their first several months at sea, juvenile Chinook salmon < 130 mm are predominantly found at depths less than 37 m (Fisher and Pearcy 1995). Because of their distribution in the water column, the majority of Chinook salmon harvested in commercial troll fisheries are caught at depths of 30 m or greater.

Chinook salmon range widely throughout the North Pacific Ocean and the Bering Sea, occurring as far south as the U.S./Mexico border (Godfrey 1968; Major et al. 1978). Chinook salmon from California, Oregon, Washington, and Idaho have been recovered in coastal areas throughout the Strait of Georgia and Inland Passage, along the Alaskan coast into Cook Inlet and waters surrounding Kodiak Island, extending out into the Aleutian/Rat Island chains to 180° W longitude, and northward in the Bering Sea to the Pribilof Islands (Hart and Dell 1986; Myers et al. 1996).

Chinook salmon may stay in coastal waters or may migrate into offshore oceanic habitats. Migration from coastal to more oceanic waters may begin off the coast of Vancouver Island, or may be delayed until reaching as far as Kodiak Island (Hartt and Dell 1986). Limited tag release and recovery data have found Washington origin Chinook salmon in the Emperor Sea Mounts area, at ~44° N latitude and 175° W longitude (Myers et al. 1996). Based on high seas tagging data presented in Myers et al. (1996) and Hartt and Dell (1986), the oceanic distribution of Pacific Northwest Chinook salmon appears to include the Pacific Ocean and Gulf of Alaska north of ~44° N latitude and east of 180° W longitude, including some areas of the Bering Sea.

The coastal distribution of Chinook salmon is similar to coho salmon (Hartt and Dell 1986), with high concentrations in areas of pronounced coastal upwelling. Juvenile Chinook salmon are generally found within 55 km of the Washington, Oregon, and California coast, with the vast majority of fish found less than 28 km offshore (Pearcy and Fisher 1990; Fisher and Pearcy 1995). Winans et al. (2001) reported on adult Chinook salmon captured in the region between Point Mugu and Point Lopez, California, demonstrating that this species occurs, at least occasionally, as far south as Ventura, California. Point Conception (34° 30' N latitude), California, is considered the faunal break for marine fishes, with salmon and other temperate water fishes found north and subtropical fishes found south of this point (Allen and

Smith 1988). Therefore, the historical southern edge of the marine distribution appears to be near Point Conception, California, and expands and contracts seasonally and between years depending on ocean temperature patterns and upwelling.

Ocean migration patterns are influenced by both genetics and environmental factors (Healey 1991). Migratory patterns in the ocean may have evolved as a balance between the benefits of accessing specific feeding grounds and the energy expenditure and dispersion risks (i.e., predation) necessary to reach them. Along the eastern Pacific Rim, Chinook salmon originating north of Cape Blanco on the Oregon coast tend to migrate north towards and into the Gulf of Alaska, while those originating south of Cape Blanco migrate south and west into waters off Oregon and California (Godfrey 1968; Major et al. 1978; Cleaver 1969; Wahle and Vreeland 1977; Wahle et al. 1981; Healey and Groot 1987).

While the marine distribution of Chinook salmon can be highly variable within and among populations, migration and ocean distribution patterns show similarities among some geographic areas. For example, Chinook salmon that spawn in rivers south of the Rogue River in Oregon disperse and rear in marine waters off the Oregon and California coast, while those spawning north of the Rogue River migrate north and west along the Pacific coast (Godfrey 1968; Major et al. 1978; Cleaver 1969; Wahle and Vreeland 1977; Wahle et al. 1981; Healey and Groot 1987). In Puget Sound, up to 30 percent of hatchery releases remain as “residents” but it is unknown how common this migratory variation is in wild fish, though their presence clearly pre-dates significant hatchery input into the region (Pressey 1953; O’Neill and West 2009; Chamberlin et al. 2011). These migration patterns result in the harvest of fish from Oregon, Washington, and British Columbia within the EEZ off the Alaskan coast.

Chinook salmon are the most piscivorous of the Pacific salmon, and the proportion of fish in the diet increases with size (Brodeur 1991; Schabetsberger et al. 2003; Sweeting et al. 2007; Duffy et al. 2010). Accordingly, fishes make up the largest component of their diet at sea, although squids, pelagic amphipods, copepods, euphausiids, and insects are also important at times (Merkel 1957; Prakash 1962; Ito 1964; Hart 1973; Healey 1991; Brodeur et al. 1991; Schabetsberger et al. 2003).

#### *3.2.3.6 Adults*

Throughout their range, adult Chinook salmon enter freshwater during almost any month of the year, although there are generally one to three peaks of migratory activity in most areas. In northern areas, Chinook salmon river entry peaks in June, while in rivers such as the Fraser and Columbia, Chinook salmon enter freshwater between March and November, with peaks in spring (March through May), summer (May through July), and fall (August through September). The Sacramento River has a winter-run population that enters freshwater between December and July, in addition to spring, fall, and late-fall runs.

Chinook salmon exhibit a wide array of life histories that vary in freshwater, estuarine and ocean residence (Wissmar and Simenstad 1998). They become sexually mature at a wide range of ages from two to eight years, with “jacks" or precocious males maturing after one to two years. Within the Columbia River, “minijacks” – precocious males that migrate only to the lower river but do not leave freshwater – also exist for systems associated with large production hatcheries (Beckman and Larsen 2005). Overall, the most common age of ocean- and stream-type maturing adults is three to five years, with males tending to be slightly younger than females. In general, stream-type fish have a longer generation time than do ocean-type fish, presumably owning to their longer freshwater residence, and Chinook salmon from Alaska and more northern latitudes typically mature a year or more later than their southern counterparts (Roni and Quinn 1995; Myers et al. 1998).

The size and age of adults varies considerably among populations and years and is influenced by genetic and environmental factors, as well as by fishing pressure. Adult Chinook salmon size is thought to represent adaptation to local spawning environment (Ricker 1980; Healey 1991; Roni and Quinn 1995). Most adult Chinook salmon females are 65-85 cm in length, while the slightly younger males are 50-85 cm. However, male and female fish larger than 100 cm in length are not uncommon in many populations.

A variety of factors influence the foraging ecology of adult Chinook salmon including migration patterns, ocean conditions (e.g., El Niño events), and density of other salmon species. They primarily consume fish in the open ocean including cottids, anchovies, clupeids, and sand lance, as well as squid and euphausiids (Kaeriyama et al. 2004; Daly et al. 2009). Chinook salmon show a positive relationship between fork length and the relative proportion of fish in the diet; at > 376 mm in fork length fish make up 90 percent (by weight) of their stomach contents (Daly et al. 2009). Recent studies indicate that the relative importance of some prey items may change with climatic events, such as El Niño events. During the 1997 El Niño and 1999 La Niña events, squid consumption by adult Chinook salmon decreased sharply. Based on $\delta^{15}N$ levels, studies show that adult Chinook salmon feed at a higher trophic level than other salmon species except coho salmon and they likely feed extensively on coastal food webs based on enriched $\delta^{13}C$ levels (Johnson and Schindler 2009).

During upriver migrations prior to spawning, adult Chinook salmon often hold in large, deep, low velocity pools, with abundant LWD or other cover features. These areas may serve as a refuge from high river temperatures, predators, or a refuge to reduce metabolic demands and reserve energy until spawning commences (Berman and Quinn 1991; Torgersen et al. 1999). The spawning densities of Chinook salmon and coho salmon have been correlated with a number of factors including channel type, LWD, pool frequency, and habitat connectivity and area (Montgomery et al. 1999; Isaak et al. 2007).

The survival of Chinook salmon is affected by factors including run type (i.e., spring, summer, fall), freshwater migration length, ocean conditions, and predator abundance. Hatchery spring and summer Chinook salmon have smolt-to-adult survival rates that average 1 percent, although survival of many upper Columbia and Snake River basin hatchery stocks is typically less than 0.2 percent (Coronado-Hernandez 1995). Wild stocks from these areas are thought to have ocean survival rates 2-10 times greater than hatchery fish (Coronado-Hernandez 1995). Fall Chinook salmon hatchery stocks also survive from smolt to adult at approximately 1 percent, although fish from some areas, such as the Oregon coast, are consistently higher, but typically less than 5 percent (Coronado-Hernandez 1995).

#### *3.2.3.7 Freshwater Essential Fish Habitat*

Freshwater EFH for Chinook salmon consists of four major components, (1) spawning and incubation; (2) juvenile rearing; (3) juvenile migration corridors; and (4) adult migration corridors and holding habitat. Freshwater EFH depends on lateral (e.g., floodplain, riparian), vertical (e.g., hyporheic) and longitudinal connectivity to create habitat conditions for spawning, rearing, and migration including: (1) water quality (e.g., dissolved oxygen, nutrients, temperature, etc.); (2) water quantity, depth, and velocity; (3) riparian-stream-marine energy exchanges; (4) channel gradient and stability; (5) prey availability; (6) cover and habitat complexity (e.g., LWD, pools, aquatic and terrestrial vegetation, etc.); (7) space; (8) habitat connectivity from headwaters to the ocean (e.g., dispersal corridors); (9) groundwater-stream interactions; and (10) substrate composition. This incorporates, but is not limited to, life-stage specific habitat criteria summarized in Table 4.

Chinook salmon EFH includes all habitat currently or historically occupied within Washington, Oregon, Idaho, and California. Figure 2 illustrates the 4th field HUs designated as EFH for Chinook salmon in Washington, Oregon, and Idaho and Figure 3 illustrates the 4th field HUs designated as EFH in California within the USGS 4th field HUs identified in Table 1.

The diversity of habitats utilized by Chinook salmon makes it difficult to identify all specific stream reaches, wetlands, and water bodies essential for the species at this time. Defining specific river reaches is also complicated, because of the current low abundance of the species and our imperfect understanding of the species' freshwater distribution, both current and historical. Adopting a more inclusive, watershed-based description of EFH is appropriate, because it (1) recognizes the species' use of diverse habitats and underscores the need to account for all of the habitat types supporting the species' freshwater and estuarine life stages, from small headwater streams to migration corridors and estuarine rearing areas; (2) takes into account the natural variability in habitat quality and use (e.g., some streams may have fish present only in years with plentiful rainfall) that makes precise mapping difficult; and (3) reinforces the important linkage between aquatic areas and adjacent upslope areas. Therefore, the geographic extent of Chinook salmon essential habitat was delineated using USGS cataloging unit boundaries.

#### *3.2.3.8 Marine Essential Fish Habitat*

The important elements of Chinook salmon marine EFH are (1) estuarine rearing; (2) ocean rearing; and (3) juvenile and adult migration. Important features of this estuarine and marine habitat are (1) good water quality; (2) cool water temperatures; (3) abundant prey species and forage base (food); (4) connectivity with terrestrial ecosystems; and (4) adequate depth and habitat complexity including marine vegetation and algae in estuarine and near-shore habitats. The available information on the habitat needs for each life-history stage is summarized in Table 4. Overall Chinook salmon marine distribution is extensive, varies seasonally, interannually, and can be identified in general terms only.

Limited information exists on Chinook salmon habitat use in marine waters but recent efforts are expanding our understanding of their marine ecology (Johnson and Schindler 2009; Jacobson et al. 2012). Chinook salmon are found throughout the North Pacific and have been encountered in waters far offshore. Available research (Pearcy and Fisher 1990; Fisher and Pearcy 1995), suggests that ocean-type juvenile Chinook salmon are found in highest concentrations over the continental shelf. However, Fisher et al. (1983; 1984) found no clear evidence that young Chinook salmon were more abundant close to the coast. Ocean-type juvenile Chinook salmon appear to utilize different marine areas for rearing than stream-type juvenile Chinook salmon which are believed to migrate to ocean waters further offshore early in their ocean residence (Healey 1991). CWT recoveries of Chinook salmon from high-seas fisheries and tagging programs (Myers et al. 1996; Healey 1991; Fig.18) provide evidence that Chinook salmon utilize areas outside the continental shelf. Catch data and interviews with commercial fishermen indicate that maturing Chinook salmon are found in highest concentrations along the continental shelf within 60 km of the Washington, Oregon, and California coast lines. Recent ocean surveys indicate that different Chinook salmon stocks occupy different habitats in the coastal ocean (Jacobson et al. 2012). For example, Columbia River fall-run Chinook salmon are commonly found in the near-shore areas from the intertidal to within a few kilometers off shore. Spring-run Chinook salmon are most often found from the near-shore zone to mid-shelf waters. Based on natural abundance levels of $^{13}C$ and $^{15}N$, Johnson and Schindler (2009) suggested that Chinook salmon fed mostly on coastal food webs (i.e., benthic vs. pelagic based).

Many stream-type Chinook salmon populations do not appear to be as heavily exploited as ocean-type Chinook salmon, indicating that stream-type fish may be vulnerable to coastal fisheries for only a short time during their spawning migrations (Healey 1991). Determination of a specific or uniform westward boundary within the EEZ which covers the distribution of essential marine habitat is difficult and would contain considerable uncertainty. Therefore, the geographic extent of essential marine habitat for Chinook salmon includes all marine waters within the EEZ north of Point Conception, California (Figure 1) and the marine areas off Alaska designated as salmon EFH by the NPFMC.

## 3.3 ESSENTIAL FISH HABITAT DESCRIPTION FOR COHO SALMON *(Oncorhynchus kisutch)*

### 3.3.1 General Distribution and Life History

The following is an overview of coho salmon life-history and habitat use as a basis for identifying EFH for coho salmon. Comprehensive reviews of coho salmon life-history and habitat requirements can be found in Shapovalov and Taft (1954), Sandercock (1991), Weitkamp et al. (1995), Quinn (2005) and others. This description serves as a general description of coho salmon life-history for Washington, Oregon, and California, and is not specific to any region, stock, or population.

Coho salmon or "silver" salmon are a commercially and recreationally important species found in small streams and rivers throughout much of the Pacific Rim, from central California to Korea and northern Hokkaido, Japan (Godfrey 1965; Scott and Crossman 1973). They are distinguished from other Pacific salmon by the presence of irregular black spots confined to the back and the upper lobe of the caudal fin, and bright red sides and a bright green back and head when sexually mature (Godfrey 1965; Scott and Crossman 1973). Coho salmon spawn in freshwater streams and most juveniles rear in freshwater for one year and spend about 18 months at sea before reaching maturity as adults. However, there is increasing evidence that some coho salmon fry and parr may rear in estuarine environments in summer and fall before returning to freshwater habitats to overwinter (Miller and Sadro 2003; Koski 2009). Moreover, recent studies of streams without estuaries that flow directly into near-shore areas have found that some juveniles emigrate directly to sea in the fall at age-0 and that some of these do survive to return as adults (Bennett et al. 2011; Roni et al. 2012). Other age 0 coho salmon appear to briefly enter the estuarine environment before entering other nearby streams to overwinter (Koski 2009; Roni et al. 2012). This suggests that the juvenile coho salmon life-history is much more complex than previously thought. Precocious male coho salmon or “jacks” become sexually mature after only 6 months at sea, one year earlier than typical adult fish. Most coho salmon populations south of central British Columbia consist of two-year-old jacks and three-year-old adults, while populations north of central British Columbia have two or three-year-old jacks and three or four-year-old adults (Gilbert 1912; Pritchard 1940; Shapovalov and Taft 1954; Wright 1970; Godfrey et al. 1975; Crone and Bond 1976). The older age at maturity of more northern populations is a product of the juveniles spending two years in freshwater as opposed to one year residence of more southern populations.

Unlike some other Pacific salmon species, where the majority of production comes from large spawning populations in a few river basins, coho salmon production results from spawners using numerous small streams (Sandercock 1991). North American coho salmon populations are widely distributed along the Pacific coast and historically spawned in tributaries to most coastal streams and rivers from the southern Santa Cruz Mountains, California, to Point Hope, Alaska, and through the Aleutian Islands (Godfrey 1965; Sandercock 1991; Spence et al. 2011). The species is most abundant in coastal areas from central Oregon through southeast Alaska and widely distributed throughout the North Pacific (Manzer et al. 1965; French et al. 1975; Godfrey et al. 1975).

In Alaska, coho salmon catches have recently achieved historically high levels, and trends in abundance of most stocks are stable (Baker et al. 1996; Slaney et al. 1996; Northcote and Atagi 1997; Wertheimer 1997). However, many coho salmon populations in southern British Columbia, Washington, Oregon, and California are depressed from historical levels with stocks at the southern-most end of the range generally at greatest risk of extinction (Nehlsen et al. 1991; Nelson 1993; 1994; Brown et al. 1994; Bryant 1994; Good et al. 2005; Spence and Williams 2011). Some stocks, particularly those in the Columbia River Basin above Bonneville Dam (*e.g.*, Idaho coho salmon stocks), are thought to be extinct (Nehlsen et al. 1991). All coastal stocks of coho salmon from the lower Columbia River to the southern extent of their range in Central California are listed as either "threatened" or “endangered” species under the ESA (70 FR 37160; 76 FR 50448), while coho salmon in Puget Sound and the Strait of Georgia are considered by NMFS to be a species of concern (NMFS 2009).

Hatchery production of coho salmon is extensive in southern British Columbia, Washington, Oregon, and California, and is used to provide sport and commercial harvest opportunities (Bledsoe et al. 1989). The Columbia River is the world's largest producer of hatchery coho salmon, with over 50 million fry and smolts released annually in recent years, followed closely by Puget Sound (Flagg et al. 1995; Weitkamp et al. 1995). In contrast, most production of coho salmon from northern British Columbia and Alaska is natural, with minimal hatchery influence (Baker et al. 1996; Slaney et al. 1996). Coho salmon are also used in net-pen cultures in Washington and British Columbia, and attempts to establish coho salmon runs in other areas of the world have met with limited success (Sandercock 1991). On the Oregon coast, hatchery coho salmon negatively influence survival of wild stocks (Buhle et al. 2009).

### 3.3.2 Relevant Trophic Information

Coho salmon (both live and carcasses) provide important food for bald eagles and other avian scavengers, and terrestrial, plants, invertebrates and mammals (e.g., bear, river otter, raccoon, weasels), aquatic invertebrates and fish, marine mammals (e.g., California and Steller sea lion, harbor seal, and orca), and salmon sharks (Scott and Crossman 1973; Cederholm et al. 1989). Carcasses also transfer essential nutrients from marine to freshwater and terrestrial environments (Bilby et al. 1996). Eggs, larvae, and alevins are consumed by various fishes, including juvenile steelhead, coho salmon, and cutthroat trout. Juveniles are eaten by a variety of birds (e.g., gulls, terns, kingfishers, cormorants, mergansers, herons), fish (e.g., Dolly Varden, steelhead, cutthroat trout, sculpins, and arctic char), and mammals (e.g., mink and water shrew) (Shapovalov and Taft 1954; Chapman 1965; Godfrey 1965; Scott and Crossman 1973; Frechette et al. 2012). Pinniped predation on migrating salmonids, both adult spawners and downstream migrating smolts, can be substantial especially at sites of restricted passage and small salmonid populations (NMFS 1997c; Stansell et al. 2010). Juvenile coho salmon are also predators of pink salmon, sockeye, and Chinook salmon fry and may be cannibalistic on the succeeding year's eggs and alevins (Gribanov 1948; Shapovalov and Taft 1954; Scott and Crossman 1973; Beacham 1986; Bilby et al. 1996).

### 3.3.3 Habitat and Biological Associations

An overview of major diet items by habitat and life stage for coho salmon is in Table 3. Table 5 summarizes coho salmon habitat use by life stage.

Coho salmon can exhibit substantial movement at each stage of their life and are dependent on high-quality spawning, rearing, and migration habitat. Water depth, water velocity, water quality, cover, and lack of physical obstruction are important elements in all migration habitats. Soon after emergence in spring, fry move from spawning areas to rearing areas. In fall, juveniles may move from summer rearing areas to areas with suitable winter habitat (Sumner 1953; Skeesick 1970; Swales et al. 1988). Such juvenile movements may be extensive within the natal stream basin, or, less frequently, fish may move between basins through salt water or connecting estuaries (Koski 2009; Roni et al. 2012). As noted previously, in some populations some fry and parr may overwinter in the estuarine environment or migrate directly to marine environment to overwinter. Seaward migration of coho salmon smolts in Washington, Oregon, and California occurs predominantly after one year in fresh water, but may not occur until two or more years in more northern or less productive environments. This migration is primarily triggered by photoperiod and usually coincides with spring freshet (Shapovalov and Taft 1954; Chapman 1962; Crone and Bond 1976; Quinn 2005). During this transition, coho salmon undergo major physiological changes to enable them to osmoregulate in salt water and are especially sensitive to environmental stress at that time. Although migration patterns at sea differ considerably by province and stock, juvenile coho salmon generally migrate north or south in coastal waters and may move north and offshore into the North Pacific Ocean (Loeffel and Forster 1970; Hartt 1980; Miller et al. 1983; Pearcy and Fisher 1988; Jacobson et al. 2012). After 12 to 14 months at sea they migrate along the coast to their natal streams.

### *3.3.3.1 Eggs and spawning*

Most coho salmon spawn between November and January, with occasional individuals in certain populations spawning as late as March (Godfrey et al. 1965; Sandercock 1991; Weitkamp et al. 1995). Populations spawning in the northern portion of the species range or at higher elevations generally spawn earlier than those at lower elevations or in the southern portion of the range (Godfrey et al. 1965; Sandercock 1991; Weitkamp et al. 1995). Spawn timing also exhibits considerable small-scale geographical and interannual variability.

In general, coho salmon select sites in coarse gravel where the gradient increases and the currents are moderate, such as pool tailouts and riffles (e.g., Mull 2005). In these areas, intergravel flow must be sufficient for adequate dissolved oxygen delivery to eggs and alevins. Coho salmon typically spawn in small streams where flows are 0.3-0.5 m$^3$/s, although they also spawn in large rivers and lakes (Burner 1951; Bjornn and Reiser 1991). Coho salmon spawning habitat consist primarily of coarse gravel with a few large cobbles, a mixture of sand, and a small amount of silt. High quality spawning grounds of coho salmon can best be summarized as clean, coarse gravel. Typically, redd (nest) size is 1.5 m$^{2;}$ constructed in relatively silt-free gravels ranging from 0.2 to 10 cm in diameter, with well-oxygenated intragravel flow and nearby cover (Burner 1951; Willis 1954; Bjornn and Reiser 1991; van den Berghe and Gross 1984).

Coho salmon eggs are typically 4.5-6 mm in diameter, smaller than most other Pacific salmon (Beacham and Murray 1987; Fleming and Gross 1990). The fecundity of female coho salmon is dependent on body size, population, and year, and is generally between 2,500 and 3,500 eggs (Shapovalov and Taft 1954; Beacham 1982; Fleming and Gross 1990). Several males may compete for each female, but larger males usually dominate by driving off smaller males (Holtby and Healey 1986; van den Berghe and Gross 1989). After spawning, coho salmon females remain on their redds one to three weeks before dying, defending the area from superimposition of eggs from other females (Briggs 1953; Willis 1954; Crone and Bond 1976; Fleming and Gross 1990).

### *3.3.3.2 Larvae/Alevins*

Egg incubation time is influenced largely by water temperature and lasts from approximately 38 days at 10.7°C to 137 days at 2.2°C (Shapovalov and Taft 1954; Koski 1965; McPhail and Lindsey 1970; Fraser et al. 1983; Murray et al. 1990). Eggs, alevins, and pre-emergent fry must be protected from freezing, desiccation, stream bed scouring or shifting, fine sediment inputs and predators to survive to emergence. Water surrounding them must be non-toxic and of sufficient quality and quantity to provide basic requirements of suitable temperatures, adequate supply of oxygen, and removal of organic waste materials and fine sediment. Under natural "average" conditions, 15-27 percent of the eggs survive to emerge from the gravel as fry, although values of 85 percent survival have been reported under "optimal" conditions, and survival in degraded habitats or under harsh conditions may be essentially zero (Briggs 1953; Shapovalov and Taft 1954; Koski 1965; Crone and Bond 1976). Similar to Chinook salmon and other salmon, the levels of fine sediment in spawning gravels are negatively correlated with egg to fry survival (Jensen et al. 2009).

As the yolk sac is absorbed, the larvae become photopositive and emerge from the substrate (Shapovalov and Taft 1954; Koski 1965). Fry emerge between March and July, with most emergence occurring between March and May, depending on when the eggs were fertilized and the water temperature during development (Briggs 1953; Shapovalov and Taft 1954; Koski 1965; Crone and Bond 1976). These 30 mm-long newly emerged fry initially congregate in schools in protected, low-velocity areas such as quiet backwaters, side channels, and small creeks before venturing into protected areas with stronger currents (Shapovalov and Taft 1954; Godfrey 1965; Scrivener and Anderson 1984).

#### *3.3.3.3 Juveniles (Freshwater)*

The majority of juvenile coho salmon from California to southern British Columbia spend one year in freshwater or estuaries before migrating to sea as 85-115 mm-long smolts (Pritchard 1940; Sumner 1953; Drucker 1972; Blankenship and Tivel 1980; Seiler et al. 1981; 1984; Blankenship et al. 1983; Lenzi 1983; 1985; 1987; Irvine and Ward 1989; Lestelle and Weller 1994). Because growth rates are lower in colder water, juveniles from northerly areas require two years in fresh water to attain this size, and some individuals may need as many as four to five years to reach this size (Gribanov 1948; Drucker 1972; Crone and Bond 1976).

Coho salmon smolt production is most often limited by the availability of summer and winter freshwater rearing habitats (Williams et al. 1975; Reeves et al. 1989; Nickelson et al. 1992). Limited winter rearing habitat, such as small tributaries, backwater pools, beaver ponds, lakes, wetlands, and other off-channel rearing areas, is considered the primary factor limiting coho salmon production in many coastal streams (Cederholm and Scarlett 1981; Swales et al. 1988; Nickelson et al. 1992). If spawning escapement is adequate, sufficient fry are usually produced to exceed the carrying capacity of rearing habitat (Bradford et al. 2000). In such cases, carrying capacity of summer habitats set a density-dependent limit on the juvenile population, which then may suffer density-independent mortality during winter depending on the severity of conditions, fish size, prey availability, and quality of winter habitat.

Coastal streams, wetlands, lakes, sloughs, tributaries, estuaries, and to large rivers can all provide coho salmon rearing habitat. The most productive habitats exist in smaller streams less than fourth-order having low-gradient alluvial channels with intact riparian zones that provide abundant pools formed by LWD (Foerster and Ricker 1953; Chapman 1965) and high prey availability (Rosenfeld et al. 2005). Beaver ponds, small lakes and large slackwater areas can provide some of the best rearing areas for juvenile coho salmon (Bustard and Narver 1975; Nickelson et al. 1992; Pollock et al. 2005). Loss of beaver ponds was hypothesized to be the main cause for an estimated 89 percent and 94 percent reduction in summer and winter smolt production potential, respectively, in the Stillagamish River, WA (Pollock et al. 2005). Small ephemeral streams can also provide important winter rearing habitat for juvenile coho salmon (Ebersole et al. 2005). Coho salmon juveniles may also use brackish-water estuarine areas in summer and migrate upstream to fresh water to overwinter (Crone and Bond 1976). In addition, some age-0 coho salmon may migrate to coastal waters in fall rather than overwinter in freshwater habitats in streams that drain directly to the ocean (Bennett et al. 2011; Roni et al. 2012).

During spring-summer rearing, the highest juvenile coho salmon densities tend to occur in areas with abundant prey (e.g., drifting aquatic invertebrates and terrestrial insects that fall into the water) and structural habitat elements (e.g., LWD and associated pools, side channels). Preferred habitats primarily include slow water environments (pools, sloughs, off-channel) with cover (e.g., wood debris) but juvenile coho salmon will also use a glides and riffles with LWD, undercut banks, and overhanging vegetation, which provide advantageous positions for feeding (Foerster and Ricker 1953; Chapman 1965; Reeves et al. 1989; Bjornn and Reiser 1991). Coho salmon grow best where water temperature is between 10° and 15°C, and dissolved oxygen (DO) is near saturation. Juvenile coho salmon can tolerate temperatures between 0° and 25°C if changes are not abrupt (Brett 1952; Konecki et al. 1995; McCullough et al. 2001) and there are temporal or spatial refugia (Welsh et al. 2001; McCullough et al. 2009). Moreover, defining thermal limits for salmon under natural conditions is a challenge because these limits depend on several factors, including the duration of exposure, frequency of stressful thermal events, food availability, and fish density, to name a few. In terms of changes in DO, salmon growth and stamina decline significantly when DO levels drop below 4 mg/l, and a sustained concentration less than 2 mg/l is lethal (Reeves et al. 1989). Summer populations are usually constrained by density-dependent effects mediated through territorial behavior and prey availability. In flowing water, juvenile coho salmon usually establish individual feeding territories, whereas in lakes, large pools, and estuaries they are less likely to establish territories and may aggregate where food is abundant (Chapman 1962; McMahon 1983). Because growth in summer is often density-dependent, the size of juveniles in late summer is often inversely related to population density.

In winter, territorial behavior is diminished, and juveniles aggregate in freshwater habitats that provide cover with relatively stable depth, velocity, and water quality. Winter mortality factors include winter peak stream flow (e.g., scour, high velocities), stranding of fish during floods or by ice damming, physiological stress from low temperature, and starvation (Hartman et al. 1984). In winter, juveniles prefer a narrower range of habitats than in summer, especially large mainstream pools, backwaters, beaver ponds, off-channel ponds, sloughs, and secondary channel pools with abundant LWD, and undercut banks and debris along riffle margins (Skeesick 1970; Nickelson et al. 1992). Survival in winter, in contrast to summer, is generally density-independent, and varies directly with fish size and amount of cover and ponded water, prey availability and inversely with the magnitude of the peak stream flow. Juvenile coho salmon overwinter survival can range from 11 to 87 percent depending upon environmental factors and fish condition (Brakensiek and Hankin 2007; Roni et al. 2012). Survival from eggs to smolts is usually less than 6 percent (Neave and Wickett 1953; Bradford 1995).

Habitat requirements during seaward migration are similar to those of rearing juveniles. High streamflow potentially aids coho salmon migration by flushing them downstream and reducing their vulnerability to predators. Migrating smolts are particularly vulnerable to predation, because they are concentrated and moving through areas of reduced cover. Mortality during seaward migration can be quite high (Tytler et al. 1978; Dawley et al. 1986; Seiler 1989). The seaward migration of smolts in native stocks is thought to be timed so that the smolts arrive in the estuary and nearshore marine waters when food is plentiful (Foerster and Ricker 1953; Shapovalov and Taft 1954; Drucker 1972; Spence and Hall 2010). In California the seaward migration generally occurs prior to closing of some estuaries and tidal reaches by the formation of impassable sand bars (Bryant 1994). Rapid growth during the early period in the estuary and nearshore ocean is critical to survival, because of mortality from predation which may be size dependent (Myers and Horton 1982; Dawley et al. 1986; Pearcy and Fisher 1988; Holtby et al. 1990; Pearcy 1992; Moss et al. 2005).

Similar to juvenile Chinook salmon in freshwater, coho salmon are opportunistic predators that feed on a variety of food items depending on availability. On average, juvenile coho salmon primarily consume aquatic and terrestrial insects; most studies indicate that the dominant prey items in coho salmon stomachs are Diptera (especially Chironomidae) and Ephemeroptera (Gonzales 2006; Olegario 2006). In systems with abundant salmon populations, juvenile coho salmon obtain most of their energy needs for growth by consuming salmon eggs, but this subsidy was limited to individuals > 70 mm in length due to gape limitation (Armstrong et al. 2010).

#### *3.3.3.4 Juveniles (Estuarine)*

The amount of time juvenile coho salmon rear in estuaries appears to be highly variable, with more northern populations generally dwelling longer in estuaries than more southern populations (Pearce et al. 1982; Simenstad et al. 1982; Tschaplinksi 1982). For example, Oregon coast, Columbia River, and Puget Sound, coho salmon are thought to remain in estuarine areas for several days to nearly two months (Miller and Sadro 2003; Brennan et al, 2004; Sweeting et al. 2007), while many British Columbian, and Alaskan populations remain in estuaries for several months (Myers and Horton 1982; Pearce et al. 1982; Simenstad et al. 1982; Tschaplinksi 1982; Levings et al. 1995). Similar to the stream environment, LWD is also an important element of juvenile coho salmon habitat in estuaries (McMahon and Holtby 1992). In estuarine environments, coho salmon consume large planktonic or small nektonic animals, such as amphipods (*Corophium* spp., *Eogammarus* spp.), insects, mysids, decapod larvae, and larval and juvenile fishes (Myers and Horton 1982; Simenstad et al. 1982; Dawley et al. 1986; Brodeur 1991; Schabetsberger et al. 2003; Brennan et al, 2004; Sweeting et al. 2007; Bollens et al. 2010). They are in turn preyed upon by marine fishes, birds, and mammals. In estuaries, smolts occur in intertidal and pelagic habitats, with deep, marine-influenced habitats often preferred (Pearce et al. 1982; Dawley et al. 1986).

#### *3.3.3.5 Juveniles (Marine)*

Two primary dispersal patterns have been observed in coho salmon after emigrating from freshwater. Some juveniles spend several weeks in coastal waters before migrating northwards into offshore waters of the Pacific Ocean (Hartt 1980; Hartt and Dell 1986; Pearcy and Fisher 1988; Pearcy 1992; Jacobson et al. 2012), while others remain in coastal waters near their natal stream for at least the first summer before migrating north. The later dispersal pattern is commonly seen in coho salmon from California, Oregon, and Washington (Shapovalov and Taft 1954; Godfrey 1965; Miller et al. 1983). It is not clear whether these less-migratory fish, particularly those from coastal areas, make extensive migrations after the first summer. However, it is known that some Puget Sound/Strait of Georgia-origin coho salmon spend their entire ocean residence in the Sound and Strait, while others migrate to the open ocean in late summer (Healey 1980; Godfrey et al. 1975; Buckley 1969; Hartt and Dell 1986; Rohde et al. in review). The spatial distribution of suitable habitat conditions is affected by annual and seasonal changes in oceanographic conditions and may affect the tendency for fish to migrate from, or reside in, coastal areas after ocean entry.

Juvenile coho salmon generally stay in nearshore coastal and inland waters well into October (Hartt and Dell 1986). Juvenile coho salmon from Oregon and presumably other areas will initially be found south of their natal streams, moved by strong southerly currents (Pearcy 1992). When these currents weaken in the winter months, juvenile coho salmon migrate northward. In strong upwelling years, where the band of favorable temperatures and available prey is more extensive, coho salmon appear to be more dispersed off shore. In weak upwelling years, coho salmon concentrate in upwelling zones closer to the shore (Pearcy 1992), and often near submarine canyons and other areas of consistent upwelling (N. Bingham, Pacific Coast Federation of Fishermen’s Associations, pers. comm., February 1998). Generally, juvenile coho salmon are found in highest concentrations within 60 km of the California, Oregon, and Washington coast, with the majority found within 37 km of the coast (Pearcy and Fisher 1990; Pearcy 1992). Puget Sound origin coho salmon are typically found in the Strait of Juan de Fuca and coastal waters of Vancouver Island throughout summer months (Hartt and Dell 1986).

Coho salmon leaving Puget Sound and other inland waters are found to migrate north along the east or West Coast of Vancouver Island and out into the Pacific Ocean (Williams et al. 1975; Hartt and Dell 1986). Tag, release, and recovery studies suggest that immature coho salmon from Washington and Oregon are found as far north as 60° N latitude along the Pacific Coast, and California-origin coho salmon as far north as 58° N latitude in Southeast Alaska (Myers et al. 1996). Coho salmon from Oregon streams have been taken in offshore waters near Kodiak Island in the northern Gulf of Alaska (Hart and Dell 1986; Myers et al. 1996). Westward migration of coho salmon into offshore oceanic waters appears to extend beyond the EEZ beginning around 45° N latitude, off the Oregon coast (Myers et al. 1996). Coded-wire and high-seas tag data for Washington and Oregon suggest that oceanic migration for these coho salmon stocks can extend as far south and west as 43° N latitude and 175° E. longitude around the Emperor Sea Mounts (Myers et al. 1996), believed to be an area of high prey abundance. Thus it appears that coho salmon stocks from Washington, Oregon, and California are found at least occasionally in the Pacific Ocean and Gulf of Alaska north of 44° N latitude to 57° N latitude, extending westward and southward along the Aleutian chain to the Emperor Sea Mounts area near 43° N latitude and 175° E longitude.

While juvenile and maturing coho salmon are found in the open North Pacific, the highest concentrations appear to be found in more productive waters of the continental shelf within 60 km of the coast. Coho salmon have been occasionally reported off the coast of southern California near the Mexican border (Schofield 1937). However, Point Conception (34° 30' N latitude), California, is considered the faunal break for marine fishes, with salmon and other temperate water fishes primarily found north and subtropical fishes to the south (Allen and Smith 1988), although the southern limit expands and contracts seasonally and between years depending on ocean temperature patterns and upwelling.

Coho salmon in coastal and oceanic waters are comprised of stocks from a wide variety of streams from Washington, Oregon, and California (Godfrey et al. 1975; French et al. 1975; Burgner 1980; Hartt 1980; Hartt and Dell 1986; Weitkamp et al. 1995). Analysis of coded-wire tag (CWT) data indicates distinct migration patterns for various basins, provinces, and states. For example, coho salmon from the Columbia River make up a high proportion of fish captured in Oregon waters, whereas coho salmon from the Washington coast are rarely recovered in Oregon waters, but frequently recovered in British Columbia (Weitkamp et al. 1995). The vast majority of CWT coho salmon are recovered in coastal waters where coho salmon fisheries occur.

Coho salmon foraging ecology in marine waters is dependent on fish size, migratory patterns, density of competitors, and ocean conditions. Marine invertebrates, such as copepods, euphausiids, amphipods, and crab larvae, are the primary food when coho salmon first enter salt water (King and Beamish 2000; Weitkamp et al. 2008; Daly et al. 2009). Fish represent an increasing proportion of the diet as coho salmon grow and mature (Shapovalov and Taft 1954; Healey 1978; Myers and Horton 1982; Pearcy 1992; Sweeting et al. 2007; Weitkamp et al. 2008; Daly et al. 2009) showed that this shift to consuming mostly fish occurred at about 160 mm fork length. Growth is controlled mainly by food quantity, food quality, and temperature (e.g., Weitkamp et al. 2008). Growth is best in pelagic habitats where forage is abundant and sea surface temperature is between 12 and 15°C (Godfrey et al. 1975; Hartt 1980; Healey 1980). Coho salmon rarely use areas where sea surface temperature exceeds 15°C and are generally found in the uppermost 10 m of the water column. Coho salmon do not aggregate in offshore oceanic waters and prefer slightly warmer ocean temperatures than do other Pacific salmon (Godfrey 1965; Manzer et al. 1965; Welch 1995). Before entering fresh water, most coho salmon slow their feeding and begin to lose weight as they develop secondary sexual characteristics and large gonads. Precocious males return to spawn after approximately six months at sea, but most coho salmon remain at sea for about 16-19 months before returning to coastal areas and entering fresh water to spawn (Godfrey 1965; Wright 1968; 1970; Sandercock 1991). Marine survival of coho salmon in the California Current is strongly linked to prey and growth indicators (Beckman et al. 2004; Burke et al. 2012).

#### *3.3.3.6 Adults*

Sub-adult and adult coho salmon in marine waters consume primarily fish including capelin, northern anchovy, clupeids, and osmerids. For example, at fork lengths > 376 mm coho salmon diets are made up of about 90 percent fish (by weight). Invertebrates can also be important to adult coho salmon diets including squid, euphasiids, copepods and crabs (Kaeriyama et al. 2004; Weitkamp et al. 2008; Daly et al. 2009).

Adult coho salmon enter fresh water from early July through December, often after the onset of fall freshets, with peak river entry occurring as early as September in Alaska, in October and November in British Columbia, Washington, and Oregon, and in December and even January in California (Briggs 1953; Godfrey 1965; Ricker 1972; Fraser et al. 1983; Bryant 1994). Some populations, often referred to as the "summer-run" coho salmon, are exceptionally early, entering rivers in late spring and early summer (Aro and Shepard 1967; Houston 1983; Washington Department of Fisheries [WDF] et al. 1993). In general, larger river basins have a wider range of river entry times than do smaller systems, and river entry occurs later the farther south a river is situated (Godfrey 1965; Sandercock 1991). The fish feed little and migrate upstream to their natal stream using olfactory cues imprinted in early development (Harden Jones 1968; Quinn and Tolson 1986; Sandercock 1991). Fidelity of mature fish to natal streams is high, and straying rates are generally 15 percent or less (Shapovalov and Taft 1954; Lister et al. 1981; Labelle 1992). Adult coho salmon may travel for a short time and distance upstream to spawn in small streams or may enter large river systems and travel for weeks to reach spawning areas more than 2,000 km upstream (Godfrey 1965; Aro and Shepard 1967; McPhail and Lindsay 1970; Sandercock 1991; WDF et al. 1993).

Most coho salmon spawn at approximately the same time regardless of when they entered fresh water (Foerster and Ricker 1953; Shapovalov and Taft 1954; Sandercock 1991). Consequently, populations that enter fresh water in late summer and early fall may reside in fresh water three to four months before spawning, while fish entering fresh water in late fall may spawn within weeks of fresh water entry. At the extreme southern end of their range in central California, most coho salmon enter fresh water in late December or January and spawn shortly thereafter (Briggs 1953; Shapovalov and Taft 1954; Bryant 1994).

The survival of coho salmon is generally affected by numerous factors in both salt and fresh water, including ocean conditions, location of natal stream, freshwater migration length, stream flow, and other environmental factors Marine survival rates for coho salmon can vary significantly among years and areas. Beamish et al. (2000) reported survival rates for hatchery coho salmon in Puget Sound and the Strait of Georgia ranging from a low of 1 percent to a high of 21 percent for the brood years of 1970 through 1993. In contrast, this same study found far lower survival rates for hatchery coho salmon along the Oregon Coast, ranging from 0.4 to 9.3 percent for these same brood years. Wild stocks from the northern stocks typically show a higher marine survival rate than those from southern stocks, and stocks from Puget Sound show a higher survival rate than those from the Washington Coast (Lestelle et al. 2007). The observed differences in survival of the wild stocks are thought to reflect the different ocean conditions encountered by the various stocks. Wild stocks typically show marine survival rates two- to three-times greater than hatchery fish (Seiler 1989; Pearcy 1992; Coronado-Hernandez 1995).

#### *3.3.3.7 Freshwater Essential Fish Habitat*

Freshwater EFH for coho salmon consists of four major components, (1) spawning and incubation; (2) juvenile rearing; (3) juvenile migration corridors; and (4) adult migration corridors and holding habitat. Freshwater EFH depends on lateral (e.g., floodplain, riparian), vertical (e.g., hyporheic) and longitudinal connectivity to create habitat conditions for spawning, rearing, and migration including: (1) water quality (e.g., dissolved oxygen, nutrients, temperature, etc.); (2) water quantity, depth, and velocity; (3) riparian-stream-marine energy exchanges (4) channel gradient and stability; (5) prey availability; (6) cover and habitat complexity (e.g., LWD, pools, aquatic and terrestrial vegetation, etc.); (7) space; (8) habitat connectivity from headwaters to the ocean (e.g., dispersal corridors, floodplain connectivity), (9) groundwater-stream interactions and (10) substrate composition. This incorporates, but is not limited to, life-stage specific habitat criteria summarized in Table 5.

Coho salmon EFH includes all habitats currently or historically occupied within Washington, Oregon, and California. Figure 4 illustrates the 4th field HUs designated as EFH for coho salmon in Washington, Oregon, and Idaho and Figure 5 depicts the 4th field HUs designated as EFH for coho salmon in California within the USGS 4th field HUs identified in Table 1.

The diversity of habitats utilized by coho salmon makes it extremely difficult to identify all specific stream reaches, wetlands, and water bodies essential for the species at this time. Designating each specific river reach would invariably exclude small important tributaries from designation as EFH. Defining specific river reaches is also complicated, because of the current low abundance of the species and of our imperfect understanding of the species' freshwater distribution, both current and historical. Adopting a more inclusive, watershed-based description of EFH is appropriate because, it (1) recognizes the species' use of diverse habitats and underscores the need to account for all of the habitat types supporting the species' freshwater and estuarine life stages, from small headwater streams to migration corridors and estuarine rearing areas; (2) takes into account the natural variability in habitat quality and use (e.g., some streams may have fish present only in years with plentiful rainfall) that makes precise mapping difficult; and (3) reinforces the important linkage between aquatic areas and adjacent upslope areas. Therefore, the geographic extent of coho salmon essential habitat was delineated using USGS cataloging units.

#### *3.3.3.8 Marine Essential Fish Habitat*

The important elements of coho salmon marine EFH are (1) estuarine rearing; (2) ocean-rearing; and (3) juvenile and adult migration. Important features of this estuarine and marine habitat are (1) adequate water quality; (2) adequate temperature; (3) adequate prey species and forage base (food); and (4) adequate depth, cover, and marine vegetation in estuarine and nearshore habitats. Overall, coho salmon marine distribution is extensive, varies seasonally, interannually, and can be identified in general terms only (Figure 5).

Limited information exists on coho salmon habitat use in marine waters. While juvenile and maturing coho salmon are found in the open north Pacific, the highest concentrations appear to be found in more productive waters of the continental shelf, coho salmon have also been encountered in an extensive offshore area as far west as 44° N latitude, 175° W longitude (Sandercock 1991). CWT recoveries of coho salmon from high seas fisheries and tagging programs (Myers et al. 1996; Healey 1991; fig.18) provide evidence that coho salmon utilize offshore areas. Shapovalov and Taft (1954) reported coho salmon within 150 km offshore in their study of Waddell Creek coho salmon. Catch data and interviews with commercial fishermen indicate that maturing coho salmon are found in highest concentrations along the continental shelf within 60 km of the Washington, Oregon, and California coast lines. However, determination of a specific or uniform westward boundary within the EEZ which covers the distribution of essential marine habitat is difficult and would contain considerable uncertainty. Therefore, the geographic extent of essential marine habitat for coho salmon includes all marine waters within the EEZ north of Point Conception, California (Figure 1) and the marine areas off Alaska designated as salmon EFH by the NPFMC.

## 3.4 ESSENTIAL FISH HABITAT DESCRIPTION FOR PUGET SOUND PINK SALMON (*Oncorhynchus gorbuscha*)

### 3.4.1 General Distribution and Life History

The following is an overview of pink salmon life-history and habitat use as a basis for identifying EFH for Puget Sound pink salmon. Comprehensive reviews of pink salmon life-history and habitat requirements can be found in Aro and Shepard (1967), Neave (1966), Heard (1991), Hard et al. (1996), and others. This description serves as a general description of pink salmon life-history with an emphasis on populations from Puget Sound and the Fraser River.

Pink (or "humpback") salmon are the smallest of the Pacific salmon, averaging just 1.0-2.5 kg at maturity (Scott and Crossman 1973). Adult pink salmon are distinguished from other Pacific salmon by the presence of large dark oval spots on the back and entire caudal fin, and their general coloration and morphology (Scott and Crossman 1973). Maturing males develop a marked hump on their back, which is responsible for their vernacular name "humpback" salmon. Pink salmon are unique among Pacific salmon by exhibiting a nearly invariant two-year life span within their natural range (Gilbert 1912; Davidson 1934; Pritchard 1939; Bilton and Ricker 1965; Turner and Bilton 1968). Upon emergence, pink salmon fry migrate quickly to sea and grow rapidly as they make extensive feeding migrations. After 18 months in the ocean the maturing fish return to freshwater to spawn and die. Pink salmon spawn closer to tidewater than most other Pacific salmon species, generally within 50 km of a river mouth, although some populations may migrate up to 700 km upstream to spawn (Groot and Margolis 1991; Pess et al. 2012), and a substantial fraction of other populations may spawn intertidally (Hanavan and Skud 1954; Hunter 1959; Atkinson et al. 1967; Aro and Shepard 1967; Helle 1970; WDF et al. 1993). Pink salmon often have extremely large spawning populations throughout much of their range, exceeding hundreds of thousands of adult fish in many populations (Takagi et al. 1981; Heard 1991; WDF et al. 1993).

The natural range of pink salmon includes the Pacific rim of Asia and North America north of approximately 40° N latitude. However, the spawning distribution is more restricted, ranging from 48° N latitude (Puget Sound) to 64° N latitude (Norton Sound, Alaska) in North America and 44° N latitude (North Korea) to 65° N latitude (Anadyr Gulf, Russia) in Asia (Neave et al. 1967; Takagi et al. 1981). Within this vast area, spawning pink salmon are widely distributed in streams of both continents as far north as the Bering Strait. North, east, and west of the Bering Strait, spawning populations become more irregular and occasional. In marine environments along both the Asian and North American coastlines, pink salmon occupy waters south of the limits of spawning streams. In North America, pink salmon regularly spawn as far south as Puget Sound and the Olympic Peninsula. However, most Washington state spawning occurs in northern Puget Sound (Williams et al. 1975; WDF et al. 1993). On rare occasions, pink salmon are observed in rivers along the Washington, Oregon, and California coasts, with recent, verified reports of pink salmon in Big Creek and the Salinas River in California (Skiles et al. 2013) but it is unlikely spawning populations regularly occur south of northwestern Washington (Hubbs 1946; Ayers 1955; Herrmann 1959; Hallock and Fry 1967; Williams et al. 1975; Moyle et al. 1995; Hard et al. 1996).

Because of its fixed two-year life cycle, pink salmon spawning in a particular river system in odd- and even-numbered years are reproductively isolated from each other and exist as genetically distinct lines (Neave 1952; Beacham et al. 1988; Gharret et al. 1988; Shaklee et al. 1991; 1995; Hard et al. 1996). In some river systems, such as the Fraser River in British Columbia, the odd-year line dominates; returns to the same systems in even-numbered years are negligible (Vernon 1962; Aro and Shepard 1967). In Bristol Bay, Alaska, the major runs occur in even-numbered years, whereas the coastal area between these two river systems is characterized by runs in both even- and odd-numbered years. In Washington state and southern British Columbia, odd-numbered-year pink salmon are the most abundant (Ellis and Noble 1959; Aro and Shepard 1967; Ricker and Manzer 1974; WDF et al. 1993). However, small even-numbered-year populations exist in the Snohomish River in Puget Sound and in several Vancouver Island rivers (Aro and Shepard 1967; Ricker and Manzer 1974; WDF et al. 1993), although within Puget Sound the even-year pink salmon are sharply declining and will likely soon disappear.

### 3.4.2 Relevant Trophic Information

Pink salmon eggs, alevins, and fry in freshwater streams provide an important nutrient input and food source for aquatic invertebrates, other fishes, especially sculpins, birds, and small mammals (Pritchard 1934; Hoar 1958; Hunter 1959; Tagmazyan 1971; Khorevin et al. 1981). Recent studies suggest that the productivity of coho salmon stocks in the Skagit River, WA are related to the abundance of spawning pink salmon in the previous year (Michael 1995). In the marine environment, pink salmon fry and juveniles are food for a host of other fishes, including other Pacific salmon and coastal sea birds (Thorsteinson 1962; Parker 1971; Bakshtansky 1980; Karpenko 1982). Within Puget Sound, pink salmon may compete with Chinook salmon populations, as marine survival of hatchery releases decreases when juvenile pink salmon are abundant (Ruggerone and Goetz 2004).

Subadult and adult pink salmon are known to be eaten by 15 different marine mammal species, sharks, other fishes such as Pacific halibut, and humpback whales (Fiscus 1980). Because pink salmon are the most abundant salmon in the North Pacific, it is likely they comprise a significant portion of the salmonids eaten by marine mammals.

Pink salmon spawning populations often number in the hundreds of thousands of fish, consequently, their carcasses provide significant nutrient input into many coastal watersheds. Adult pink salmon in streams are major food sources for gulls, eagles, and other birds, along with bear, otter, mink and other mammals, fishes, and aquatic invertebrates (Cederholm et al. 1989; Michael 1995; Bilby et al. 1996).

### 3.4.3 Habitat and Biological Associations

An overview of major diet items by habitat and life stage for Puget Sound (PS) pink salmon is in Table 3. Table 6 summarizes PS pink salmon habitat use by life-history stage.

#### *3.4.3.1 Eggs and Spawning*

Pink salmon choose a fairly uniform spawning bed in both small and large streams in Asia and North America. Generally, these spawning beds are situated on riffles with clean gravel, or along the borders between pools and riffles in shallow water with moderate to fast currents (Semko 1954; Heard 1991; Mathisen 1994). In large rivers, they may spawn in discrete sections of main channels or in tributary channels. Pink salmon avoid spawning in deep, quiet water, in pools, in areas with slow current, or over heavily silted or mud-covered streambeds. Places selected for egg deposition is determined primarily by the optimal combination of water depth and velocity. Although intertidal spawning is extensive in some areas of the North Pacific such as Prince William Sound (Hanavan and Skud 1954; Helle 1970), it is not in Washington, Oregon, and California (Williams et al. 1975; WDF et al. 1993; Hard et al. 1996).

On both the Asian and North American sides of the Pacific Ocean, pink salmon generally spawn at depths of 30-100 cm (Dvinin 1952; Hourston and MacKinnon 1956; Graybill 1979; Goloranov 1982). High densities of spawning pink salmon are usually found at depths of 20-25 cm, but occasionally to depths of 100-150 cm. In dry years, on crowded spawning grounds, nests can be found at shallower depths of 10-15 cm. Water velocities in pink salmon spawning grounds vary from 30-100 cm/s, sometimes reaching 140 cm/s (Hourston and MacKinnon 1956; Smirnov 1975; Graybill 1979; Golovanov 1982), but usually average 60-80 cm/s.

In general, pink salmon select sites in gravel where the gradient increases and the currents are relatively fast. In these areas, surface stream water must have permeated sufficiently to provide intragravel flow for dissolved oxygen delivery to eggs and alevins. Pink salmon spawning beds consist primarily of coarse gravel with a few large cobbles, a mixture of sand, and a small amount of silt. Pink salmon are often found spawning in the same river reaches and habitats as Chinook salmon. High quality spawning grounds of pink salmon can best be summarized as clean, coarse gravel (Hunter 1959).

Pink salmon have the lowest fecundity of Pacific salmon, averaging 1,200-1,900 eggs per female, and also some of the smallest eggs (Pritchard 1937; Neave 1948; Beacham et al. 1988; Beacham and Murray 1993). In Washington and southern British Columbia spawning areas, eggs are deposited from August to October slightly earlier in northern Puget Sound and the upper Dungeness River than elsewhere in northwestern Washington (WDF et al. 1993; Hard et al. 1996).

#### *3.4.3.2 Larvae/Alevins*

Fertilized eggs begin their five- to eight-month period of embryonic development and growth in intragravel interstices (Heard 1991). To survive successfully, the eggs, alevins, and pre-emergent fry must first be protected from freezing, desiccation, stream bed scouring or shifting, mechanical injury, and predators. Water surrounding them must be non-toxic and of sufficient quality and quantity to provide basic requirements of suitable temperatures, adequate supply of oxygen, and removal of waste materials. These requirements are only met partially even under the most favorable natural conditions. Overall, freshwater survival of pink salmon from egg to advanced alevin and emerged fry is frequently 10-20 percent, but can be as low as 1 percent (Neave 1953; Hunter 1959; Wickett 1962; Taylor 1983). Some British Columbia artificial spawning channels have achieved egg-to-fry survival as high as 57 percent (MacKinnon 1963; Cooper 1977).

#### 3.4.3.3 Juveniles (Freshwater)

Newly emerged pink salmon fry are fully capable of osmoregulation in sea water. Schools of pink salmon fry may move quickly from the natal stream area or remain to feed along shorelines up to several weeks. The timing and pattern of seaward dispersal is influenced by many factors, including general size and location of the spawning stream, characteristics of adjacent shoreline and marine basin topography, extent of tidal fluctuations and associated current patterns, physiological and behavioral changes with growth, and possibly different genetic characteristics of individual stocks (Heard 1991).

Pink salmon fry emerge from gravels at a size of 28-35 mm, and begin migrating downstream shortly thereafter. This downstream migration timing varies widely by region and from year to year within regions and individual streams. In Puget Sound and southern British Columbia, fry migrate downstream in March and April, occasionally extending into May.

Pink salmon spend a short time in freshwater and rarely feed while there (Robins et al. 2005), but one study indicated that juveniles not migrating directly to saltwater consume aquatic insects (immature stages, pupae, adults) and zooplankton (Robins et al. 2005).

#### 3.4.3.4 Juveniles (Estuarine)

The use of estuarine areas by pink salmon varies widely, ranging from passing directly through the estuary en route to nearshore areas to residing in estuaries for one to two months before moving to the ocean (Hoar 1956; McDonald 1960; Vernon 1966; Heard 1991). In general, most pink salmon populations use this former pattern and, therefore, depend on nearshore, rather than estuarine environments, for their initial rapid growth.

Pink salmon populations that reside in estuaries for extended periods utilize shallow, protected habitats such as tidal channels and consume a variety of prey items, such as larvae and pupae of various insects (especially chironomids), cladocerans, and copepods (Bailey et al. 1975; Hiss 1995). Even more estuarine-dependent pink salmon populations have relatively short residence period when compared to fall Chinook salmon and chum salmon that use estuaries extensively. For example, while these other species reside in estuaries throughout the summer and early fall, pink salmon are rarely encountered in estuaries beyond June (Hiss 1995).

#### 3.4.3.5 Juveniles (Marine)

Immediately after entering marine waters, pink salmon fry form schools, often in tens or hundreds of thousands of fish (McDonald 1960; Vernon 1966; Heard 1991). During this time, they tend to follow shorelines and, at least for the first few weeks at sea, spend much of their time in shallow water of only a few centimeters deep (LeBrasseur and Parker 1964; Healey 1967; Bailey et al. 1975; Simenstad et al. 1982). It has been suggested that this inshore period involves a distinct ecological life-history stage in pink salmon (Kaczynski et al. 1973). In many areas throughout their ranges, pink salmon and chum salmon fry of similar age and size co-mingle in both large and small schools during early sea life (Heard 1991).

Pink salmon juveniles routinely obtain large quantities of food sufficient to sustain rapid growth from a broad range of habitats providing pelagic and epibenthic foods (Parker 1965; Martin 1966; Neave 1966; Healey 1967; Bailey et al. 1975). Collectively, diet studies show that pink salmon are both opportunistic and generalized feeders and, on occasion, they specialize on specific prey items. Diel stomachs sampling suggests that juvenile pink salmon are diurnal feeders, foraging primarily at night (Parker and LeBrasseur 1974; Bailey et al. 1975; Simenstad et al. 1982; Godin 1981). Common prey items include copepods (especially harpacticoids), pteropods (Armstrong et al. 2008), barnacle nauplii, mysids, amphipods, euphausiids, decapod larvae, insects, larvaceans, eggs of invertebrates and fishes, and fish larvae (Gerke and Kaczynski 1972; Bailey et al. 1975; Healey 1980; Simenstad et al. 1982; Godin 1981; Takagi et al. 1981; Landingham 1982; Boldt and Haldorson 2003; Bollens et al. 2010). Growth rates during this period of early marine residence range from 3.5-7 percent of body weight per day, equivalent to an approximately 1 mm increase in length per day (LeBrasseur and Parker 1964; Phillips and Barraclough 1978; Healey 1980; Karpenko 1987).

At approximately 45-70 mm in length, pink salmon move out of the nearshore environment into deeper, colder waters to begin their ocean migration (Manzer and Shepard 1962; LeBrasseur and Parker 1964; Phillips and Barraclough 1978; Healey 1980). For populations originating from Puget Sound and southern British Columbia rivers, this movement begins in July and lasts through October as fish migrate out of protected waters and northward along the coast towards Alaska (Pritchard and DeLacy 1944; Barraclough and Phillips 1978; Hartt 1980; Healey 1980). After reaching approximately Yakutat in central Alaska, Washington-origin pink salmon move out into the Gulf of Alaska and follow the main current in the gyre, subsequently migrating southward during their first fall and winter in the ocean, then northward the following spring and summer. They then begin their homewards migration, again entering coastal waters as they move south toward their natal streams (Manzer et al. 1965; Neave et al. 1967; Takagi et al. 1981; Ogura 1994). Tagging studies indicate that juvenile and maturing Puget Sound pink salmon are most concentrated in nearshore areas of Vancouver Island and the Hecate Strait extending as far north as approximately 58° N latitude (Yukatat Bay, Alaska), and seaward to approximately 140° W longitude (Myers et al. 1996). The southernmost distribution of Puget Sound pink salmon is not clear, but in general the largest concentrations of pink salmon of British Columbia and Washington-origin are found north of 48° N latitude (Hartt and Dell 1986; Myers et al. 1996).

Pink salmon from Washington State and British Columbia and those originating in southeastern, central, and southwestern Alaska, occur in marine waters where they might interact in some way with the salmon fisheries off the coast of southeast Alaska. Pink salmon from these regions also co-mingle in the Gulf of Alaska during their second summer at sea while migrating toward natal areas (Manzer et al. 1965; Neave et al. 1967; Takagi et al. 1981).

In contrast to this extended ocean migration, it is believed that some Stillaguamish River and possibly other Puget Sound pink salmon remain within Puget Sound for their entire ocean residence period (Jensen 1956; Hartt and Dell 1986). This tendency to reside in Puget Sound and the Strait of Georgia is commonly exhibited by both coho salmon and Chinook salmon, but is unusual for pink salmon. These "resident" fish are much smaller than individuals that migrated to the ocean, reaching only 35-45 cm as adults, some 10 cm shorter than migratory fish from the same area (Hartt and Dell 1986).

In the ocean, pink salmon primarily consume fish, squid, euphausiids, and amphipods, with lesser numbers of pteropods, decapod larvae, and copepods (Allen and Aron 1958; Ito 1964; LeBrasseur 1966; Manzer 1968; Takagi et al. 1981). During this phase, most pink salmon are found in the upper-most 12 m of the water column, the actual depth varying with seasonal and diurnal patterns (Manzer and LeBrasseur 1959; Manzer 1964).

#### *3.4.3.6 Adults*

Ocean growth of pink salmon is a matter of considerable interest; because, although this species has the shortest life span among Pacific salmon, it also is among the fastest growing (Heard 1991). Entering the estuary as fry at around 30 mm in length, maturing adults return to the same area 14-16 months later ranging in length from 450 to 550 mm. Adults display a latitudinal trend in size, with the largest fish occurring in the southern portion of the range (Heard 1991). Most odd-year Fraser River and Washington fish weigh approximately 2.5 kg, while Washington even-year fish may be slightly smaller at 2.1 kg. By comparison, pink salmon from central and southeast Alaska typically weigh 1.3-1.8 kg (Takagi et al. 1981; Heard 1991).

Based on stable isotope levels ($^{15}$N, $^{13}$C), adult pink salmon feed at a lower tropic level than Chinook salmon and coho salmon and feed primarily in off-shore pelagic waters (Johnson and Schindler 2009). They feed less on fish relative to coho salmon and Chinook salmon and more on invertebrates including squid, copepods, amphipods and pteropods (Kaeriyama et al. 2004; Armstrong et al. 2005; Armstrong et al. 2008).

Adult pink salmon enter freshwater between June and September, with northern populations generally entering earlier than southern populations (Neave et al. 1967; Takagi et al. 1981). Odd-year pink salmon from Puget Sound typically enter freshwater between mid-July and late September, with considerable local variation the earliest run (Dungeness River) begin entering freshwater in mid-July, while the median return date of the latest-returning runs is October 15 (WDF et al. 1993; Hiss 1995). Snohomish River even-year fish enter freshwater three to four weeks earlier than the odd-year run in the same system, even though the two populations use the same habitat (WDF et al. 1993). As noted above, the even-year coho salmon runs are rapidly declining.

As with other Pacific salmon, fertilization of pink salmon eggs occurs upon deposition (Heard 1991). Males compete with each other to breed with spawning females. Pink salmon females remain on their redds one to two weeks after spawning, defending the area from superimposition of eggs from another female (McNeil 1962; Ellis 1969; Smirnov 1975).

Measured marine survivals of pink salmon, from entry of fry into stream mouth estuaries to returning adults, have ranged from 0.2 percent to over 20 percent. For North America, estimated fry-to-adult survival averages between 1.7 percent and 4.7 percent (Pritchard 1948; Parker 1962; Ricker 1964; Ellis 1969; McNeil 1980; Taylor 1980; Vallion et al. 1981; Blackbourn 1990). Generally, much of the natural mortality of pink salmon in the marine environment occurs within the first few months before advanced juveniles move offshore into more pelagic ocean waters (Parker 1965; 1968). Pink salmon populations can be very resilient, rebounding from weak to strong run strength in regional stock groups within one or two generations. Conversely, strong runs may also become weak within several generations, causing pink salmon populations to exhibit high natural variability (Neave 1962; Ricker 1962).

#### *3.4.3.7 Freshwater Essential Fish Habitat*

Freshwater EFH for Puget Sound pink salmon consists of three major components, (1) spawning and incubation; (2) juvenile migration corridors; and (3) adult migration corridors and holding habitat. Important features of essential habitat for spawning, rearing, and migration include adequate, (1) substrate composition; (2) water quality (e.g., dissolved oxygen, nutrients, temperature, etc.); (3) water quantity, depth, and velocity; (4) channel gradient and stability; (5) prey availability; (6) cover and habitat complexity (e.g., LWD, channel complexity, etc.); (7) space; (8) access and passage; and (9) habitat and flood plain connectivity. This incorporates, but is not limited to, life-stage specific habitat criteria summarized in Table 6. Puget Sound pink salmon EFH includes all habitats currently or historically within Washington. Figure 6 illustrates the watersheds designated as EFH for PS pink salmon within the USGS 4th field HUs identified in Table 1.

The inadequacy of existing species distribution maps makes it extremely difficult to identify all specific stream reaches essential for the species at this time. Designating each specific river reach would invariably exclude small, important tributaries from designation as EFH. Adopting a more inclusive, watershed-based description of EFH is appropriate, because it (1) recognizes the species' use of diverse habitats and underscores the need to account for all of the habitat types supporting the species' freshwater and estuarine life stages, from small headwater streams to migration corridors and estuarine rearing areas; (2) takes into account the natural variability in habitat quality and habitat use (e.g., some streams may have fish present only in years with plentiful rainfall) that makes precise mapping difficult; and (3) reinforces the important linkage between aquatic and adjacent upslope areas. Therefore, the geographic extent of Puget Sound pink salmon essential habitat was delineated using USGS cataloging unit boundaries.

#### *3.4.3.8 Marine Essential Fish Habitat*

The important elements of pink salmon marine EFH are (1) estuarine rearing; (2) early ocean rearing; and (3) juvenile and adult migration. Important features of this estuarine and marine habitat are (1) adequate water quality; (2) adequate temperature; (3) adequate prey species and forage base (food); and (4) adequate depth, cover, and marine vegetation in estuarine and nearshore habitats. Overall pink salmon marine distribution is extensive, varies seasonally, interannually, and can be identified in general terms only. Estuarine and nearshore areas such as Puget Sound and other inland marine waters of Washington State and British Columbia are critical to the early marine survival of pink salmon. Therefore, essential marine habitat for PS pink salmon includes all nearshore marine waters north and east of Cape Flattery, Washington, including Puget Sound, the Strait of Juan de Fuca and Strait of Georgia, and waters of the U.S. EEZ north of 48° N latitude (Figure 6). It is difficult to determine a western limit for pink salmon essential marine habitat, because of limited information on their ocean distribution, but it is clear that the vast majority are found in Canadian, Alaskan, and international waters both within and outside the EEZ north of Cape Flattery, Washington. Accordingly, EFH for PS pink salmon also includes the marine areas off Alaska designated as pink salmon EFH by the NPFMC.

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

## 4.1 FISHING ACTIVITIES AFFECTING SALMON ESSENTIAL FISH HABITAT

Pacific salmon are highly prized in commercial, recreational, and tribal fisheries, and represent major economic benefits to the region. In addition to economic benefits, spawning salmon are a significant contributor of nutrients to streams, supporting the stream ecology, aquatic insects, and ultimately, juvenile salmon.

The MSA requires FMCs for each FMP to identify fishing activities that may adversely affect EFH and to minimize adverse effects of those activities to the extent practicable. Fishing activities should include those regulated under the Pacific salmon FMP that affect EFH identified under any FMPs, as well as those fishing activities regulated under other FMPs that affect EFH designated under the Pacific salmon FMP. The fishing activities that have the potential to adversely affect EFH for Pacific Coast salmon are shown in Table 7 These include fishing activities managed under the MSA as well as non-MSA fishing activities that may adversely affect salmon EFH. In many cases, MSA and non-MSA activities operate in similar locations and use similar gears. Therefore, they are described here together.

Fishing activities, derelict gear, harvest of prey species, vessel operations, and the removal of salmon carcasses and their nutrients from streams are identified as fishing-related activities that can affect Pacific Coast salmon EFH. Some of these activities are controlled by the Council and some are not.

Although it is unlikely that any potential effects to Pacific salmon EFH from commercial and recreational fishing activities have increases substantially since 1999, the activities identified in Amendment 14 warrant a more thorough review and description. In addition, the identified marine debris (and derelict fishing gear, separately) are included as activities that may adversely affect EFH. Although minor changes in location may have occurred, it is unlikely that these would have a substantial effect on impacts to EFH for Pacific salmon. Further, it is likely that overall fishing activities have remained level or have decreased since 1999.

Ocean fisheries targeting Chinook salmon use hook-and-line gear, but gill nets are used in commercial and tribal freshwater fisheries in the Columbia and Klamath Rivers, Puget Sound, Grays Harbor, Willapa Bay, and other river systems (PFMC 2011). Chinook salmon fisheries have some bycatch associated with them, most often other salmonids and undersized Chinook salmon. While the majority of these fish survive the hooking encounter, substantial (> 25 percent) mortality may occur (Wertheimer 1988, Wertheimer *et al*. 1989, Gjernes *et al*. 1993). A complete and current description of ocean fisheries, harvest levels, and management framework can be found in the most recent versions of the annual Stock Assessment and Fishery Evaluation (SAFE) document *Review of Ocean Salmon Fisheries* (PFMC 2011a).

Commercial, tribal, sport, and subsistence fisheries for coho historically and currently occur from the eastern Pacific through the Bering Sea and along the West Coast of North America as far south as central California (Godfrey 1965). Hook-and-line is the primary gear type used in ocean fisheries; however, gill nets and purse seines are used in near-shore or in-river commercial fisheries. Sport catches of coho are typically taken by hook-and-line.

Most coho salmon from Washington, Oregon, and California recruit to fisheries after one year in fresh water and about 16 months at sea. These fisheries take place in coastal adult migration corridors, near the mouths of river and in freshwater and marine migration areas (Williams *et al*. 1975) and largely target fish returning to hatcheries.

Bycatch in coho salmon fisheries is usually limited to other salmon species, primarily Chinook and chum salmon, and occasionally pink salmon. Species such as steelhead, Dolly Varden, pollock, Pacific cod, halibut, salmon sharks, and coastal rockfish make up a small part of the catch. Coho salmon are also taken incidentally in other salmon fisheries. When regulations prohibit the retention of coho, the majority of released fish survive the hooking encounter, however, large numbers can be hooked and substantial mortality incurred. Substantial coho salmon bycatch can lead to restrictions on these fisheries (PFMC 1998). A complete and current description of ocean fisheries, harvest levels, and management framework can be found in the most recent versions of the annual SAFE Report (PFMC 2011a).

Pink salmon are the most abundant Pacific salmon, contributing about 39 percent by weight and 54 percent in numbers of all salmon caught commercially in the North Pacific Ocean and adjacent waters (AKDFG 2012). Coastal fisheries for pink salmon presently occur in Asia (Japan and Russia) and North America (Canada and the United States), with major fisheries in Russia, Canada, and the U.S. Historically, some pink salmon were caught in high seas fisheries by Japan and Russia. Most pink salmon in the U.S. are caught in Alaska where major fisheries occur in the Southeast, Prince William Sound, and Kodiak regions; with lesser fisheries in the Cook Inlet, Alaska Peninsula, and Bristol Bay regions (Heard 1991). Catches of pink salmon decrease south of Alaska, with about 10 million fish caught annually in British Columbia, 2-3 million in Washington, and a negligible number in Oregon and California (Heard 1991, PFMC 1999a). More recently, the Duwamish River has experienced pink salmon returns estimated at 2.875 million fish in 2009 and 864,000 fish in 2011 (A. Bosworth, pers comm. 2012). Most pink salmon are harvested in the marine environment by purse seines with smaller commercial catches made by set and drift gill net and troll fisheries. Marine recreational fisheries primarily use troll gear. Washington marine pink salmon harvests are predominantly composed of Fraser River-origin fish (Hard *et al*.1996, PFMC 1984). The Pacific Salmon Commission (PSC) manages fisheries for pink salmon in U.S. Convention waters north of 48° N latitude to meet Fraser River natural spawning escapement and U.S./Canada allocation requirements. Fisheries for pink salmon have some bycatch associated with them, primarily other Pacific salmon species.

### 4.1.1 Potential Effects to EFH by Gear Type

**Roundhaul Gear (includes purse seines, lampara nets, dip nets, and drum seines)**: Fisheries for coastal pelagic and highly migratory species use purse seines, lampara nets, and other roundhaul gear to target Pacific sardine, northern anchovy, Pacific mackerel, jack mackerel, market squid, and tuna. Most tuna fishing occurs in the western and central Pacific, and tropical eastern Pacific. However, tuna are highly migratory and are present off the U.S. West Coast. They are therefore included in this consideration of habitat impacts from fishing activities.

Roundhaul gear can potentially affect EFH for all three managed Pacific salmon species by direct removal of species that are prey for Pacific salmon, as well as for other managed species. It could potentially also affect squid, which are prey for salmon, if nets are allowed to contact the benthos of squid spawning areas. Although roundhaul gear co-occurs with waters that are EFH for Pacific salmon, it is unlikely that there would be more than a temporary negligible effect on the habitat.

**Pot and Trap Gear**: This gear type is dominated by commercial and recreational crab fisheries prevalent in estuaries and the marine environment along the entire West Coast. Lobster traps are used in California, but not typically north of the central California coast. To a lesser extent, pot gear is used in the sablefish fishery but typically at depths in the marine environment much greater than are associated with salmon (NWFSC 2009).

Pot and trap gear can adversely affect Pacific salmon EFH by damaging estuarine eelgrass beds and other marine/estuarine benthic habitats such as cobble and vegetated surfaces utilized by Pacific salmon. Although typically placed in areas of sandy bottom, gear can also be deployed in more sensitive habitats and are often dragged across the benthos by strong tidal or ocean currents. Lost trap and pot gear could potentially affect EFH and are discussed below under Derelict Gear.

**Bottom Trawling**: Bottom trawling activity is conducted primarily by the West Coast groundfish fishery, harvesting over 90 species. These include 64 species of rockfish (e.g., widow, cowcod, yelloweye, and Pacific ocean perch); 12 species of flatfish (e.g., English sole, starry flounder, sanddab); six species of roundfish (e.g., lingcod, sablefish, and whiting); six species of sharks and skates (e.g., leopard shark, big skate and spiny dogfish); and several other species (e.g., ratfish, finescale codling, and Pacific rattail grenadier).

Appendix C to Amendment 19 of the Pacific Coast Groundfish FMP (PFMC 2005) presents a risk assessment framework, including a sensitivity index and recovery rates for a variety of groundfish habitats. Several habitats considered would likely overlap with salmonid habitat in the marine environment. Chinook salmon may be associated with "bottom topography” at depths of 30-70 meters, and juveniles are associated with pinnacles, reefs and vertical walls.

Impacts of bottom trawling to physical and biogenic habitats may include removal of vegetation, corals, and sponges that provide structure for prey species; disturbance of sediments; and possible alteration of physical formations such as boulders and rocky reef formations (NMFS 2005b).

Bottom trawling is managed under biennial specifications and includes a complicated matrix of sectors, seasons, and spatial limitations. There are many areas closed to bottom contact gear, including bottom trawling, many based on the designated HAPCs in the groundfish FMP EFH designations (PFMC 2008). In addition, the groundfish fishery underwent rationalization and currently operates under a catch share system. Overall effort, duration, and intensity has generally decreased in recent years. Given the significant minimization measures implemented in the groundfish fishery, coupled with the fact that there is minimal co-occurrence of bottom trawling with benthic Pacific salmon EFH, it is unlikely that there is more than a temporary, minimal impact from this fishing activity.

**Midwater trawling**: Midwater trawls are used to harvest Pacific whiting, shrimp, and other species (PFMC 2008). Like bottom trawling, it is managed under the Pacific groundfish FMP. Effects are generally limited to the effects of (1) removal of prey species, (2) direct removal of adult and juvenile salmon (Bellinger 2009), and (3) effects resulting from loss of trawl gear, potentially resulting in impacts to bottom habitats and ghost fishing (see Section 4.1.2.4 Derelict Gear).

**Long Line:** Pelagic and bottom long-line fishing in the marine environment is prevalent on the Pacific Coast. Pelagic long-lining targets chiefly tuna and swordfish, while bottom long lining targets halibut, sablefish, and other species. Both types of long lining can incidentally harvest managed species as well as prey species. If long-line gear breaks loose and is lost, it can continue ghost fishing and potentially harm bottom habitat (see Section 4.1.2.4 Derelict Gear).

### 4.1.2 Fishing-related potential impacts

#### *4.1.2.1 Removal of Salmon Carcasses*

Salmon carcasses provide vital nutrients to stream and lake ecosystems (Scheuerell et al. 2005). Carcasses enhance salmonid growth and survival, but fishing activities remove a portion of returning adults that would otherwise supply nutrients to stream systems. This is especially relevant to nutrient-poor streams that depend on the phosphorous, nitrogen, and other nutrients provided by salmon carcasses. In the Willapa Bay basin an estimated several thousand metric tons of salmon tissue have been lost each year as a nutrient source to streams because of reductions in salmon returns (Naiman et al. 2002), while net transport of marine-derived phosphorous into the Snake River basin over the past 40 years was estimated at less than 2 percent of historical levels (Scheuerell et al. 2005). Gresh et al (2000) estimated that just 6-7 percent of the marine-derived nitrogen and phosphorous once delivered to the rivers of the Pacific Northwest by salmon carcasses is currently reaching those streams.

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

#### *4.1.2.2 Vessel Operations*

The variety of fishing and other vessels on the Pacific Coast range can be found in freshwater streams, estuaries, and the marine environment. Vessel size ranges from small single-person vessels used in streams and estuaries, to mid-size commercial or recreational vessels, to large-scale vessels limited to deep-draft harbors and marine waters. See Section 4.2.2.28 Vessel Operations for a detailed description of the effects of this activity on EFH.

#### *4.1.2.3 Harvest of Prey Species*

Prey species can be considered a component of EFH (NMFS 2006). For Pacific salmon, commercial and recreational fisheries for many types of prey species potentially decrease the amount of prey available to Pacific salmon. Herring, sardine, anchovy, squid, smelt, groundfish, shrimp, crab, burrowing shrimp, and other species of finfish and shellfish are potential salmon prey species that are directly fished, either commercially or recreationally.

Some prey species (e.g., herring and crab) are state-managed while others are federally managed, and it concluded that both state and Federal management already includes considerations for the forage needs of predator species, including salmon. For example, the harvest guideline formula for Pacific sardine incorporates a 150,000 metric ton (mt) cutoff and a relatively low harvest fraction, both of which are intended in part to provide adequate forage for dependent species. Other prey species such as krill, copepods, and amphipods, are salmon prey species that are not directly fished (krill harvest is prohibited under the CPS FMP), but that can be adversely affected by fishing activities.

#### *4.1.2.4 Derelict Gear*

When gear associated with commercial or recreational fishing breaks free, is abandoned, or becomes otherwise lost in the aquatic environment, it becomes derelict gear. This phenomenon occurs in fishing activities managed under all four Pacific Coast FMPs, as well as recreational fishing and fishing activities not managed by the Council. In commercial fisheries, trawl nets, gillnets, long lines, purse seines, crab and lobster pots, and other material, are occasionally lost to the aquatic environment. Recreational fisheries also contribute to the problem, mostly via lost crab pots.

Derelict fishing gear, as with other types of marine debris, can directly affect salmon habitat and can directly affect managed species via "ghost fishing." Ghost fishing is included here as an impact to EFH because the presence of marine debris affects the physical, chemical, or biological properties of EFH. For example, once plastics enter the water column, they contribute to the properties of the water. If debris is ingested by fish, it would likely cause harm to the individual. Another example is in the case of a lost net in a river. Once lost, the net becomes not only a potential barrier to fish passage, but also a more immediate entanglement threat to the individual.

Along the Pacific Coast, Dungeness crab pots are especially prevalent as derelict gear (NWSI 2010). Commercial pots are required to use degradable cord that allows the trap lid to open after some time. This is thought to significantly reduce the effects of ghost fishing. However, only the State of Washington has such a requirement for recreational crab pots. There is little reliable information regarding the numbers or impacts of lost recreational crab pots.

Derelict gear can adversely affect salmon EFH directly by such means as physical harm to eelgrass beds or other estuarine benthic habitats; harm to coral and sponge habitats or rocky reefs in the marine environment; and by simply occupying space that would otherwise be available to salmon. Derelict gear also causes direct harm to salmon (and potentially prey species) by entanglement. Once derelict gear becomes a part of the aquatic environment, it affects the utility of the habitat in terms of passive use and passage to adjacent habitats. More specifically, if a derelict net is in the path of a migrating fish, that net can entangle and kill the individual fish.

The Northwest Straits Initiative (NWSI) estimates that 2493 lost nets were removed in Puget Sound by a project funded under the American Recovery and Reinvestment Act (NWSI 2011b). Since 2002, over 3,800 partial gillnets (average size 7,000 square feet) have been removed from Puget Sound, with an estimated 1000 additional gillnets remaining in the shallow subtidal areas. An analysis of 870 derelict gillnets recovered from Puget Sound found 154 salmon were entangled at the time of recovery (Good et al. 2010). Some of these gillnets that had been derelict as long as 24 years were still catching marine fish, although the report did not note if salmon were among those caught. Most derelict gear removal efforts in Puget Sound are conducted during the winter, when fewer adult salmon are present (NWSF 2007). Nets recovered when adult salmon are more abundant have greater numbers of salmon. For instance, two nets recovered off of Lummi Island after the 2003 chum salmon season had 157 salmon, at least 12 of which were Chinook salmon (NWSF 2007). In 2008, a derelict gillnet was recovered with 14 salmon, and caught an estimated 450 salmon in the 23 weeks since it was lost (NWSI 2011a).

The Columbia River Inter-Tribal Fish Commission recovered a total of 33 derelict gillnets in 2002 and 2004 from the Bonneville and Dalles Reservoirs on the Columbia River (Kappenman and Parker 2007). While Kappenman and Parker (2007) provided no estimate of the number of nets remaining in these reservoirs or in the rest of the Columbia River, they estimated that approximately 10 gillnets are lost each year. In contrast to the derelict gillnets recovered in Puget Sound, white sturgeon, *Acipenser transmontanus*, was the only species found in these nets, some of which had been derelict for as long as seven years. However, the authors acknowledged that the recovery operations were conducted during the winter, when few adult salmon are present. Kappenman and Parker (2004) suggested that in the Columbia River, surface-fishing gillnets targeting salmon are likely to be quickly retrieved by other commercial fishers, river users, or state agencies and do not continue fishing for extended periods, thereby reducing the risk to salmon. In addition, currents in the Columbia River may also cause derelict gillnets to collapse and spin into balls relatively quickly (Kappenman and Parker 2007). Although it is clear that there are derelict gillnets in these reservoirs, the impact that such gear has on salmon in the Columbia River, or other West Coast river systems where the issue has not been examined, is presently unknown.

#### *4.1.2.5 Recreational Fishing*

Most recreational fishing impacts are combined in the sections above. One activity not yet captured is the potential for impacts to juvenile salmon and eggs in redds resulting from trampling by recreational fishers. In freshwater streams, recreational fishers often use waders and boots to walk in streams to access good fishing spots. This can crush eggs and alevins in a salmon redd. Trampling of redds has potential to cause high mortality of salmonids. Most information on redd disturbance is anecdotal. However, one study showed that trampling by anglers can kill eggs and pre-emergent fry in trout redds (Roberts and White 1992).

#### *4.1.2.6 Minimizing Effects*

FMPs are required to minimize adverse effects to EFH to the extent practicable. Minimization measures can include, but are not limited to, time/area closures, fishing equipment restrictions, and harvest limits. Adverse impacts include incidental harvest of managed species through legal fishing activity, but incidental harvest is addressed in other sections of FMPs, rather than under EFH provisions. All four FMPs include management measures that are intended to protect habitat, species, or both. There are no additional management measures proposed to conserve Pacific salmon EFH.

## 4.2 NONFISHING ACTIVITIES AFFECTING SALMON ESSENTIAL FISH HABITAT

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

Section 305(b)(2) of the MSA directs Federal agencies to consult with NMFS on all actions authorized, funded, or undertaken, or proposed to be authorized, funded, or undertaken, by such agency that may adversely affect EFH[2]. In order to facilitate this process and promote the conservation of EFH, FMPs are

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[2] An adverse effect means any impact that reduces either the quantity or quality of EFH [50 CFR 600.810(a)]. Adverse effects may include direct or indirect physical, chemical, or biological alterations of the waters or substrate and loss of, or injury to, benthic organisms, prey species and their habitat, and other ecosystem components, if such modifications reduce the quality and/or quantity of EFH. Adverse effects on EFH may result from actions occurring within EFH or outside of EFH and may include site specific or

required to identify non-fishing activities that may adversely affect EFH and describe the adverse effects from those activities. The FMP must also identify potential conservation measures to avoid, minimize, mitigate, or otherwise offset those adverse effects. Incorporation of the appropriate conservation measures into the design of the project can, in some cases, obviate the need for consultation.

Section 4.2.1 describes the EFH consultation requirements and process. Section 4.2.2 describes 31 non-fishing activities that may adversely affect salmon EFH and, for each of these activities, identifies potential measures to conserve EFH.

### 4.2.1 The EFH Consultation Process

As described above, Federal agencies must consult with NMFS on any action that is authorized, funded, or undertaken, or proposed to be so, if it may adversely affect EFH. Adverse effects may result from actions that take place within EFH as well as those that take place outside of EFH (e.g., road construction upslope of a stream designated as EFH) [50 CFR 600.910(a)]. Activities proposed to occur in EFH areas do not automatically require consultation. Consultations are triggered only when the proposed action may adversely affect EFH, and then, only Federal actions require consultation.

The consultation process is summarized here. The complete regulations to implement the EFH provisions of the MSA can be found at 50 CFR 600.

Before consultation begins, the Federal agency must first assess the effects of their action on EFH. If they determine that the action will not adversely affect EFH, then no consultation is required. But if they determine that the action “may adversely affect” EFH, they must prepare and submit a written assessment of the effects of their action (EFH assessment). The EFH Assessment must include the following: (1) a description of the action; (2) an analysis of the potential adverse effects of the action on EFH and the managed species; (3) the Federal agency’s conclusions regarding the effects of the action on EFH; and (4) proposed mitigation, if applicable. The assessment should also contain additional information. If appropriate, including: (1) the results of an on-site inspection to evaluate the habitat and the site-specific effects of the project; (2) the views of recognized experts on the habitat or species that may be affected; (3) a review of pertinent literature and related information; (4) an analysis of alternatives to the action, including alternatives that could avoid or minimize adverse effects on EFH; and (5) other relevant information. The level of detail in an EFH assessment should be commensurate with the complexity of the action and the severity of the adverse effects on EFH.

NMFS then reviews the EFH assessment and provides the Federal agency with EFH Conservation Recommendations that avoid, minimize, mitigate, or otherwise offset those adverse effects. Councils may also provide comments or recommendations to the Federal agency on actions that may adversely affect EFH and must do so for actions that are likely to substantially affect the habitat, including EFH, of anadromous fishery resources under its authority, such as salmon.

The Federal agency must provide a detailed response in writing to NMFS, and to any Council commenting on the action, within 30 days after receiving EFH Conservation Recommendations. The response must include a description of measures proposed by the agency for avoiding, minimizing, mitigating, or offsetting the impact of the activity on EFH. If the Federal agency chooses not to adopt the EFH Conservation Recommendations, it must provide an explanation. The response must also include the scientific justification for any disagreements with NMFS over the anticipated effects of the action or the measures needed to conserve EFH.

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habitat-wide impacts, including individual, cumulative, or synergistic consequences of actions.

To provide the greatest level of efficiency, the EFH consultation process is often integrated into existing environmental review procedures such as the National Environmental Policy Act, ESA, or the Fish and Wildlife Coordination Act. However, the existing procedure, or a modified version of it, must meet the requirements described at 50 CFR 600.920. These requirements ensure that NMFS is notified of the action in a timely manner and that it provides all of the information normally contained in an EFH assessment. Combining these procedures can reduce the consultation workload, and associated costs, on both the Federal agency and NMFS.

The consultation requirement applies to Federal agencies only. While state agencies are not required to consult, NMFS can provide EFH Conservation Recommendations for state actions that would adversely affect EFH. However, states are not required to respond to NMFS's recommendations.

The regulations identify four basic types of consultations, where the type selected will depend on the nature of the action and the effects on EFH.

- Programmatic consultations occur when NMFS consults on a group of similar actions that fall within a program (e.g., a road maintenance program). In most cases, when EFH conservation recommendations are accepted by the Federal agency, no further consultation will be required.
- General concurrences can be issued for specific types of actions that do not cause greater than minimal adverse effects on EFH and *no further consultation* will generally be required.
- Abbreviated consultations are conducted if no general concurrence, programmatic consultation, or existing environmental review process is available or appropriate for the action and where the effect on EHF will *not be substantial*.
- Expanded consultation takes place when no other review process is available or appropriate for the Federal action, and that action might result in *substantial adverse effects on EFH*. Procedures for expanded consultation allow for more detailed analysis of effects and more time for NMFS to coordinate with the action agency and develop EFH conservation recommendations.

### 4.2.2 Description of Non-Fishing Activities That May Adversely Affect Salmon EFH and Potential Conservations Measures

Broad categories of activities which can adversely affect salmon EFH include, but are not limited to:

- Activities causing high intensity underwater acoustic or pressure waves
- Agriculture
- Alternative energy development
- Artificial Propagation of Fish and Shellfish
- Bank Stabilization
- Beaver Removal and Habitat Alteration
- Coal export terminal activities
- Construction/Urbanization
- Culvert construction
- Dam Construction/Operation
- Debris Removal
- Desalination
- Dredging and Dredged Spoil Disposal
- Estuarine Alteration
- Flood control maintenance
- Forestry
- Grazing

- Habitat Restoration Projects
- Introduction/Spread of Invasive Alien Species (IAS)
- Irrigation Water Withdrawal, Storage, and Management
- Liquefied natural gas projects
- Mineral Mining
- Offshore Oil and Gas Exploration, Drilling and Transportation Activities
- Over-water structures
- Pesticide use
- Power plant intakes
- Road Building and Maintenance
- Sand and Gravel Mining
- Vessel Operations
- Wastewater/Pollutant Discharge
- Wetland and Floodplain Alteration

This list of activities is not prioritized by the magnitude of the threat it poses to EFH, nor is it intended to be comprehensive. Federal agencies are required to consult on any activity that may adversely affect EFH, regardless of whether or not it is described in this document. Each of these activities may directly indirectly, cumulatively, temporarily, or permanently, threaten the physical, chemical, and biological properties of the habitat used by salmon species and/or their prey. The results of these threats are that the quality or quantity of salmon EFH may be reduced. The list includes common activities with known or potential impacts to salmon EFH.

Each of these activities is described below along with potential conservation measures and management alternatives. It is important to note that many actions consist of a combination of activities that may adversely affect EFH. For example, construction of a marina may involve overwater structures, pile driving, bank armoring, and dredging. Therefore, it is necessary to break each project into its constituent activities and assess the full suite of adverse effects from all of those activities.

The conservation measures and management alternatives are not designed to be site-specific, but rather to be indicative of the spectrum of possible considerations for the conservation and enhancement of salmon EFH and that might be applied to specific activities. The menu of suggested conservation options is based on the best scientific information available at this time. Not all of these measures are necessarily applicable to every action that includes these activities. Additional measures based on the most current scientific information and project-specific factors may be developed during, or prior to, the consultation process.

#### *4.2.2.1 Activities causing high intensity underwater acoustic or pressure waves*

A number of human activities can introduce high levels of sound into the aquatic environment. Some of these sounds are incidental to the purpose of the activity, such as the intense impulsive sounds produced when a pile is driven by an impact hammer or the lower level continuous sounds produced by a cargo ship. Other sounds are an integral and necessary part of the activity, such as the high energy impulsive sounds generated by seismic airguns when exploring for oil and gas or the continuous sounds produced by a sonar array. All of these activities can have unintended consequences to living aquatic resources such as fishes and marine mammals that can range from disrupting important behaviors to injury or even death.

While the effects of underwater sound on fishes has received increased attention over the past decade, a review by Popper and Hastings (2009b) point out that that different sources of noise have widely different characteristics (e.g., frequencies, durations, and intensities) and that different species and sizes of fishes can vary widely in their anatomy and, therefore, in their sensitivity to underwater noise. Fishes with swimbladders are far more susceptible to injury from underwater sound than are fishes that lack swimbladders. Additionally, sound level, and the effects on fishes, declines rapidly with distance from the sound source. Consequently, it is very difficult to extrapolate study results from one noise source, one species of fish, or one size of fish to another source, species, or size. This difficulty is especially relevant when trying to extrapolate between impulsive and continuous sounds. Impulsive sounds are those with high peak pressures, rapid rise and fall times, and relatively short duration while continuous sounds are longer in duration and lack the steep rise and fall times. Current research suggests that impulsive sounds pose the greatest risk to fishes.

Despite the difficulty in extrapolating between sources, species, and sizes of fishes, the paucity of data for most of these makes extrapolating necessary. For example, a coalition of Federal and state resources and transportation agencies along the West Coast, the Fisheries Hydroacoustic Working Group (FHWG), used data from a variety of sound sources (primarily underwater explosions and seismic airguns) and species to establish interim acoustic criteria for the onset of injury to fishes from impact pile driving (FHWG 2008). As a result, they are considered to be conservative (i.e., protective) estimates of the impulsive sound levels that can injure fishes. These criteria, in turn, are also used to estimate the risk to fishes from other types of impulsive sounds. They are not appropriate, however, for non-impulsive, continuous sounds.

Most historical studies have used peak pressure, impulse, or energy flux density to evaluate the effects on fishes form underwater sound. Current research, however, suggests that sound exposure level (SEL), a measure of the total sound energy expressed as the time-integrated, sound pressure squared, is the most relevant metric for evaluating the effects of sound on fishes. An advantage of the SEL metric is that the acoustic energy can be accumulated across multiple events and expressed as the cumulative SEL ($\mathrm{SEL}_{\mathrm{cum}}$). The interim criteria established by the FHWG includes a threshold for peak pressure[3] (206 dB re: 1µPa) and $\mathrm{SEL}_{\mathrm{cum}}$[4] (187 dB re: $1\mu\mathrm{Pa}^2\cdot\mathrm{sec}$ for fishes 2 grams or larger and 183 dB for fishes smaller than 2 grams). Injury would be expected if either threshold is exceeded. These criteria were based on the available information at the time and are subject to change as new information comes to light.

According to Popper and Fay (2010), the most common mode of hearing in fishes involves sensitivity to acoustic particle motion via direct inertial stimulation of the otolith organ(s). Sensitivity to acoustic pressure is the result of the presence of an air bubble (e.g., the swim bladder). Fishes that possess anatomical specializations such as connections or close proximity between the inner ear and that gas bubble may have greater ability to detect, and therefore respond to, sound pressure. Salmon lack these specializations and, as such, they are unlikely to detect sounds when far from the source, except perhaps when the sounds are transmitted through the substrate and reradiated into the water closer to the fish, such as may occur during pile driving. While this may limit the range at which behavioral and auditory effects can occur, the range at which non-auditory effects (e.g., damage to the swimbladder or other barotrauma) can occur will be determined by the sound source, the surrounding environment, and the non-auditory anatomy of the fish.

Anthropogenic noise differs from many other aquatic stressors, such as turbidity or contaminants, in that it does not persist beyond the activity itself – once the activity ceases so does the stressor. In addition, the effects of this stressor are directly on the fish, and are not often recognized as effects on the habitat. These differences raise the question of whether or not acoustic effects meet the definition of an adverse effect under the EFH mandate. The definition of EFH includes “aquatic areas and their associated physical, chemical and biological properties that are used by fish” (50CFR 600), and an adverse effect is any effect that reduces either the quality or quantity of EFH. Underwater sound is but one of the many physical properties of the aquatic habitat used by fishes, and the addition of anthropogenic sound may alter the physical properties of the habitat. Therefore, it is appropriate to consider anthropogenic sound an adverse effect when it reduces the quality of the habitat, even for a very short period of time.

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[3] dB peak pressure is referenced to 1 µPa throughout the rest of this document.

[4] dB SEL and $\mathrm{SEL}_{\mathrm{cum}}$ are references to $1\ \mu\mathrm{Pa}^2\cdot\mathrm{sec}$ throughout this document

While many activities introduce noise into the aquatic environment, it is not realistic to describe them all because of the lack of information on the effects of the activity or the frequency with which they occur. Therefore, this document will focus on the three activities that pose the greatest risk because they produce impulsive sounds and are frequently conducted: 1) pile driving; 2) underwater explosions; and 3) seismic surveys.

###### *4.2.2.1.1 Pile driving*

Piles are an integral component of many overwater and in-water structures. They provide support for the decking of piers and docks, function as fenders and dolphins to protect structures, support navigation markers, and are used for breakwaters and bulkheads. Piles can be made of steel, concrete, wood (both treated and untreated), plastic, or a combination thereof. Piles are usually driven into the substrate using one of two types of hammer: impact hammers and vibratory hammers. Impact hammers consist of a heavy weight that is repeatedly dropped onto the top of the pile, driving it into the substrate. Vibratory hammers utilize a combination of a stationary, heavy weight and vibration, in the plane perpendicular to the long axis of the pile, to force the pile into the substrate. The type of hammer used depends on a variety of factors, including pile material and substrate type. Impact hammers can be used to drive all types of piles, while vibratory hammers are generally most efficient at driving piles with a cutting edge (e.g., hollow steel pipe) and are less efficient at driving “displacement” piles (those without a cutting edge that must displace the substrate). Displacement piles include solid concrete, wood, and closed-end steel pipe. While impact hammers are able to drive piles into most substrates (including hardpan, glacial till, etc.), vibratory hammers are limited to softer, unconsolidated substrates (e.g., sand, mud, gravel). Since vibratory hammers do not use force to drive the piles, the bearing capacity is not known and the piles must often be “proofed” with an impact hammer. This involves striking the pile a number of times with the impact hammer to ensure that it meets the designed bearing capacity. Although less common, the bearing capacity of a pile can be tested using a static load.

Under certain circumstances, piles may be driven using a combination of vibratory and impact hammers. The vibratory hammer makes positioning and plumbing of the pile easier; therefore, it is often used to drive the pile through the soft, overlying material. Once the pile stops penetrating the sediment, the impact hammer is used to finish driving the pile to final depth. An additional advantage of this method is that the vibratory hammer can be used to extract and reposition the pile, while the impact hammer cannot.

Overwater structures must often meet seismic stability and bearing capacity criteria, requiring that the supporting piles are attached to, or driven into, the underlying hard material. This requirement often means that at least some impact driving is necessary. Piles that do not need to be seismically stable, including temporary piles, fender piles, and some dolphin piles, may be driven with a vibratory hammer, providing the surrounding sediments provide sufficient lateral support.

Piles can be removed using a variety of methods, including vibratory hammer, direct pull, clam shell grab, or cutting/breaking the pile below the mudline. Vibratory hammers can be used to remove all types of pile, including wood, concrete, and steel. However, old, brittle piles may break under the vibrations and necessitate another method. The direct pull method involves placing a choker around the pile and pulling upward with a crane or other equipment. Broken stubs are often removed with a clam shell and crane. In this method, the clam shell grips the pile near the mudline and pulls it out. In other instances, piles may be cut or broken below the mudline, leaving the buried section in place.

Potential adverse effects from pile driving

Pile driving can generate intense underwater sound pressure waves that have been observed to injure and kill a number of species of fishes, including Pacific salmon (e.g., Caltrans 2001; Longmuir and Lively 2001; Stotz and Colby 2001; Abbott and Bing-Sawyer 2002; Stadler, pers. obs. 2002). It is one of the most frequent sources of intense underwater sound in coastal waters. This issue came to light in 2001 and has gained considerable attention from Federal and state resource and transportation agencies because of the large number of piles that are driven into aquatic habitats for transportation infrastructure and other purposes. Injuries to non-auditory tissues associated directly with pile driving (collectively known as barotrauma) include rupture of the swimbladder, bruising of the internal organs, and internal or external hemorrhaging. The sounds can over-stimulate the auditory system of fishes and may result in temporary threshold shifts (a non-injurious temporary reduction in hearing sensitivity) or physical injury, such as a loss of hair cells of the sensory maculae (Hastings and Popper 2005).

The type and intensity of the sounds produced during pile driving depend on a variety of factors including, but not limited to, the type and size of the pile-driving hammer, the type and size of the pile, the type of substrate, and the depth of water. All reported instances of fishes killed or injured during pile driving have occurred when impact hammers were used, and none were associated with vibratory hammers. One reason for these observed differences is the different types of sounds that each hammer produces. Impact hammers produce intermittent but intense impulse sounds while vibratory hammers produce continuous sounds of lower intensity. While injury and death have not been observed from vibratory hammers, there are no data to show they are harmless. Firmer substrates require more energy to drive piles, and produce more intense sound pressures. Water depth affects the propagation of the sound, which attenuates more rapidly with distance from the source in shallow water than in deep water (Rogers and Cox 1988).

The magnitude of the effect on salmon that are exposed to the sounds from pile driving will depend on the size and physical condition, depth in the water column, and buoyance state of the fish, as well as the characteristics of the received sound including the shape and energy content of the sound pressure wave. Injury or death associated with pile driving appears to be positively correlated with the size of the pile because driving larger piles requires more energy than smaller piles and produce higher sound levels. The type of pile seems to influence the severity of impacts to fishes. All of the observed fish-kills have been associated with impact driving of hollow steel piles ranging from 24 to 96 inches in diameter. Wood and concrete piles appear to produce lower sound pressures than hollow steel piles of a similar size, although it is not yet clear if the sounds produced by wood or concrete piles are harmful to fishes.

Transportation and resources agencies along the West Coast share a common concern about the effects of pile driving on living resources and a common interest in developing consistent approaches to assessing and minimizing the risk to those resources. As a result, these agencies formed the FHWG that developed and adopted a set of interim criteria to estimate the response of fishes exposed to these sounds (FHWG 2008). These are dual criteria based on protective thresholds for two sound metrics: peak pressure and SEL. SEL is an energy index that is indicative of mechanical work done on the tissues and can be summed over all pile strikes to which the fishes are exposed ($\text{SEL}_{\text{cum}}$). Injury is expected to any fish that is exposed to either a peak pressure that exceeds 206 dB or a size-dependent $\text{SEL}_{\text{cum}}$ that exceeds 187 dB for fishes larger than 2 grams, and 183 dB for fishes smaller than 2 grams. It is important to note that these criteria represent the onset of injury and that higher sound levels are required to cause serious injury or death. When setting these criteria, the FHWG acknowledged that they were based on sparse data and sound sources other than pile driving and are likely to be conservative. The criteria are interim until new information upon which to base changes becomes available.

In recent years, a few field studies were designed to take advantage of a project with pile driving (e.g., Abbott et al. 2005; Ruggerone et al. 2008; Caltrans 2010a, 2010b). However, such “opportunistic” field studies cannot control the levels of sound to which the fish are exposed. In addition, Halvorsen et al. (2012) noted that these studies lacked appropriate biological control groups because the experimental fishes may not have been neutrally buoyant. All salmonids are physostomous, inflating and deflating their swimbladder by gulping in or burping out air, and may have deflated the swimbladder when handled prior to the experiment. A deflated swimbladder could put the fish at a lower risk of injury from the sounds, leaving the validity of the results open to question

To address these issues, Halvorsen et al. (2011, 2012) conducted a laboratory study on juvenile Chinook salmon using an apparatus that was specially designed to simulate, and precisely control, the sounds and intensities produced during impact pile driving. It also incorporated a protocol to ensure that the test fish were neutrally buoyant before exposure to the sound. This study attempted to establish thresholds for the sound levels that would cause physical injury to juvenile Chinook salmon. Juvenile Chinook salmon (mean standard length 103 mm, mean weight 11.8 g) were exposed to between 204 dB and 220 dB $SEL_{cum}$, at single strike SELs of 171 dB to 187 dB. The authors concluded that the onset of injury to Chinook salmon occurred at 210 dB $SEL_{cum}$.

Based on these results, the authors suggested that a minimum $SEL_{cum}$ of 210 dB was required to inflict injury on these fish, far lower than the 187 dB or 183 dB set by the FHWG. However, the FHWG has not yet revised its criteria because of several concerns. First, the study developed a novel model to reflect the onset of injury from impulsive sounds that used undescribed energetic costs to weight the injuries. Without knowing these costs, it is difficult to evaluate the validity of the model. Second, the study was unable to assess the effects of noise exposure on the inner ear, an important sensory system that can be damaged by exposure to sounds. Finally, although eye hemorrhaging and bruising of the spleen were observed, they were excluded from the analysis because they were inconsistently scored and recorded (Halvorsen, pers. com). Because the studies did not account for these injuries, there remains uncertainty around the proposed 210 dB $SEL_{cum}$ threshold. It should be noted here that the interim criteria developed by the FHWG were intended for the protection of salmonids listed under the ESA. Under the ESA, any form of injury, even apparently non-life threatening injuries such, as eye hemorrhage or bruises to the spleen, are to be avoided when possible. However, the EFH mandate is intended to maintain a species or stock at a level that supports a sustainable fishery. As such, the interim criteria should be viewed as conservative.

Despite the uncertainty regarding the acoustic threshold for onset of injury to Chinook salmon, this study provides important new insights into the effects on Chinook salmon from pile driving. First, no fish died immediately to $SEL_{cum}$ as high as 220 dB (Halvorsen et al. 2012). And second, there was 100 percent survival and near full recovery from injuries in fish held for two weeks in the laboratory (Casper et al. 2012). These findings are important because it is a first step in distinguishing acoustic thresholds that inflict mortal injuries from those for the onset of injury. While these studies showed that the observed injuries were not directly fatal to fish held in the safety of the laboratory, the survival of fish with these types of injuries has yet to be tested in the wild, where injured fishes could be more susceptible to predation or disease or be less efficient at foraging or reproducing.

The behavioral response of fishes to underwater sound depends on a variety of factors, including the species of fish, the type of sound (impulsive vs continuous), and the intensity of the sound (see review by Hastings and Popper 2005). The observed behavioral changes include startle responses, changes in swimming activity, and increases in stress hormones. However, few studies have examined the behavioral response of fishes to the sounds that are comparable to those from pile driving. A number of species of fishes, including chinook salmon and Atlantic salmon (*Salmo salar*), have been shown to avoid continuous sounds (similar to vibratory pile driving) at frequencies below 30 Hz (infrasound), but not impulsive-type sounds (similar to those from impact pile driving) at frequencies above 100 Hz (e.g., Knudsen et al. 1992; Enger et al. 1993; Knudsen, et al. 1997; Sand et al. 2001). In contrast, McKinley and Patrick (1988) successfully used impulsive-type sounds to divert downstream migrating sockeye salmon (*O. nerka*) smolts from at a hydroelectric dam. Feist et al. (1992) observed that juvenile pink salmon and chum salmon appeared to be less prone to spooking by an observer on the shore when piles were being driven. This reduced awareness could lead to increased predation. Ruggerone et al. (2008) found no observable changes in the behavior of caged coho salmon in the vicinity of impact pile driving; however, the behavior may have been affected by the cages themselves. Atlantic cod (*Gadus morhua*) and Dover sole (*Solea solea*) increased swimming speed in response to impact pile driving sounds at levels as low as 140 dB (re: 1µPa rms) (Mueller-Blenkle et al. 2010). Atlantic cod also showed significant freezing response at the onset and cessation of these sounds. Fewtrell and McCauley (2011) found that two species of demersal/pelagic schooling fish demonstrated significant increases in alarm responses to airgun noise exceeding 147 dB SEL, and that alarm responses increased with increasing noise levels, but the responses differed between the two species. Faced with the paucity of data on the response of salmon to pile driving sounds, the FHWA is currently using a conservative level of 150 dB (re: 1 µPa) root-mean-square as a trigger for closer analysis of potential adverse behavioral effects from all types of sounds, including those from impact and vibratory hammers. The potential for adverse behavioral effects will depend on a number of factors, including the life stages that are present. For example, the level of concern would be higher for juvenile salmon that are migrating through an area to the ocean and face a greater risk of predation than a subadult or adult in marine waters.

*Potential conservation measures for pile driving*

- When possible, avoid driving piles when salmon are present, especially the younger life stages and spawning adults.
- Avoid driving piles with an impact hammer when salmon or their prey are present. Alternatives include vibratory hammers or press-in pile drivers.
- In cases where an impact hammer must be used, drive the piles as far as possible with a vibratory or other method that produces lower levels of sound before using an impact hammer.
- Select piles that are made of alternate materials that produce less-harmful sounds than those from hollow steel piles, such as concrete or untreated wood instead of steel.
- When driving piles in intertidal or shallow subtidal areas, do so during periods of low tide. Sound does not propagate as well in shallow water as it does in deep water.
- Implement measures to attenuate the sound. Such measures include the use of a bubble curtain or a dewatered pile sleeve or coffer dam. Monitor the sound levels during pile driving to ensure that the attenuation measures are functioning as expected.
- Where tidal currents can be strong, drive the piles when the current is reduced (i.e., centered on slack current) to minimize the number of fish exposed to adverse levels of underwater sound. Strong currents can bring more fish into close proximity to the pile than would a weak current.
- Monitor, and report back to NMFS, the sound levels during pile driving to verify that the assumptions in the analysis were correct and to ensure that any attenuation device is properly functioning. Develop the monitoring and reporting protocols according to guidance provided by the FHWG (2013). The report should be provided to NMFS according to the individual project requirements, but no later than 60 days after completion of the pile driving.
  - The FHWG (2013) developed a hydroacoustic monitoring protocol and reporting template for use on pile driving projects along the West Coast.

##### *4.2.2.1.2 Underwater explosions*

Explosives are detonated underwater for a number of reasons, such as deepening a shipping channel or demolishing in-water structures such as a bridge pier or an offshore oil rig. Seismic surveys were historically conducted using explosives but have since been replaced by other methods. Explosives produce two types of waves: shock waves and pressure waves.

*Potential adverse effects of underwater explosions*

The effects of underwater explosions on fishes have been studied for at least 60 years and have been shown to depend on a variety of factors, including the type of explosive and the anatomy of the fish. Hubbs and Rechnitzer (1952) used caged-fish experiments to compare the effects of two types of explosives – black powder and trinitrotoluene (TNT). The study found that black powder charges inflicted fewer injuries and killed fewer fishes than did TNT charges that produced the same peak pressure. The authors attributed this difference to the slower detonation rate and associated slower rise time of the low explosive black powder charges. Baldwin (1954) found that adult Pacific salmon were not killed during a seismic survey that used black powder charges and caught salmon by trolling within close proximity to the seismic shots, indicating that they did not leave the area and were still feeding.

Yelverton et al. (1975) exposed eight species of freshwater fishes to underwater explosions and found that smaller individuals were more sensitive to the explosion than were larger individuals, regardless of the species. There also did not appear to be a difference in sensitivity between those species with ducted swimbladders (physostomous) and non-ducted swimbladders (physoclistous). The authors found impulse, to be a better predictor of injury rather than peak pressure and provided equations to predict impulse levels that would kill 50 percent and 1 percent of individuals and the levels that would cause no injury. Unfortunately, the there is no clear way to convert the impulse metric used by Yelverton et al. to SEL. In contrast to the lack of a difference between species found by Yelverton et al. (1975), Teleki and Chamberlain (1978) found that laterally compressed fishes were more susceptible to blast injury than were fusiform fishes. In addition, they reported that approximately 47 percent of the fishes killed sank and were not visible from the surface.

Several efforts have been made to estimate the distances at which fishes will be affected by underwater explosions. Young (1991) provides equations for calculating the distance, based on charge weight body mass, where the probability of survival was 90 percent. Wright and Hopky (1998) assumed a peak pressure threshold for impacts to fishes at 100 kPa (220 dB) and provide equations for calculating the distance from the explosion to the 220 dB isopleth.

More recently, Govoni et al. (2003; 2008) exposed juvenile and larvae of two species, spot (*Lieostomus xanthurus*) and pinfish (*Lagodon rhomboids*), to underwater explosions and considered impulse and energy flux density to be the relevant metrics. Hastings (2007) subsequently calculated the SEL for each treatment using the original waveform data and suggested that SELs as low as 183 dB was sufficient to injure fishes smaller than 2 g.

Keevin et al. (1997) found that bubble curtains, created by injecting compressed air into the water column were highly effective at reducing the mortality of caged bluegills (*Lepomis macrochirus*) during detonation of a 2kg high-explosive charge. The bubble curtain reduced peak pressure, impulse, and energy flux density by 88 to 99 percent. Another potential mitigation measure is dividing large explosive charges into smaller charges by use of blasting caps with timing delays (Keevin 1998). The use of delays effectively reduces each detonation to a series of small explosions rather than one larger one. However, the effectiveness of delays and defining the delay period that provides maximum protection requires further examination.

*Potential conservation recommendations for underwater explosions*

- Evaluate the need to use explosives and use practical alternatives if they are available.
- Avoid times of the year when salmon are present. If it is not practicable to conduct the activity when salmon are absent, avoid doing so when the smallest, and therefore most vulnerable, life stages are present.
- Do not conduct the activity where it could affect spawning adult salmon.
- Rather than use a single large charge, use a series of smaller charges that are separated by delays that are longer than the duration of the blast wave.
- Plan the blasting program to minimize the size of explosive charges per delay and the number of days that explosives are used.
- Surround the explosion with a bubble curtain or other sound attenuation device to minimize the extent of the habitat area where salmon could be injured.

#### *4.2.2.1.3 Seismic surveys*

Seismic surveys direct sound waves at, and into, the seafloor and use the reflected waves to map the geology of the earth's subsurface. The most common use of seismic surveys is to explore for oil and gas, both onshore and offshore, but they have other uses such as assessing the geology underlying roads and bridges (OGP 2011). Towed in arrays behind ships, the air guns release repetitive bursts of compressed air underwater to produce the high-energy, low-frequency impulsive sound waves used in the survey. The sounds produced by an airgun array can reach nominal peak-to-peak pressures of up to 264 dB (LGL and MAI 2011). Sound waves can also be generated by marine vibroseis, a technology that uses hydraulic or electrical vibrators to generate continuous, low-frequency sounds (5-250 Hz) at levels that are considerably lower than an airgun array (LGL and MAI 2011). In addition to the lower sound levels, marine vibroseis produces a continuous sound, with strong suppression of unwanted higher frequencies associated with airguns, and, under most conditions, would be less damaging to the environment than would airguns (LGL and MAI 2011).

*Potential adverse effects of seismic surveys*

The possible impact of seismic surveys on marine life has been of great concern and a number of experimental studies have been conducted to investigate these effects on fishes. However, few studies, to date, have investigated the effects of seismic surveys on salmonids. Svedrup et al. (1994) exposed Atlantic salmon to detonating blasting caps, which simulated the blast from a seismic survey. The vascular endothelium showed signs of injury within 30 minutes of exposure, as compare to control specimens that did not show these effects. The fish recovered from their injuries within one week. The study also found short-term changes in the levels of stress hormones that were attributed to exposure the seismic shots. However, the received $SEL_{cum}$ was not reported so it is difficult to assess the actual risk to salmon. These results are consistent with those of Santulli et al. (1999), who found that European sea bass (*Dicentrarchus labrax*) exposed to airgun blasts also showed short-term (48 hours) variations in several biochemical stress indicators.

A study on the effects of seismic airguns on three species of fishes found temporary auditory threshold shifts in two of them [adult northern pike (*Esox lucius*), and lake chub (*Couesius plumbeus*)] after exposure to 5 to 20 airgun blasts with a $SEL_{cum}$ of 185 to 191 dB (Popper et al. 2005). Normal hearing returned in less than 24 hours. In contrast, no threshold shift was observed in broad whitefish (*Coregonus nasus*), a salmonid and close relative of Pacific salmon, exposed to 5 airgun blasts with a $SEL_{cum}$ of 187 dB. They also found no damage to the inner ears or any signs of external injury in the exposed fish and no significant difference in the survival of experimental and control fish (Popper et al. 2005; Song et al. 2008). Unfortunately, the study did not include detailed necropsies so it is unknown if the exposed fishes incurred any internal damage.

Several studies have investigated how the sounds from seismic surveys affect non-salmonids, with differing results. McCauley et al (2003) exposed caged pink snapper (*Pagrus auratus*) to hundreds of shots from an air gun as it approached and moved over and beyond the cages. Received SELs reached 180 dB for several of the individual shots, but the $SEL_{cum}$ from all the shots was not reported. The results showed that 2-7 percent of the sensory hair cells in the inner ears were lost in several of the animals after a post exposure period of 58 days, and that the damage did not become apparent until sometime after exposure. Popper and Hastings (2009a) pointed out that this was only a visual manifestation of what may have been a much greater effect. Hastings et al. (2008) found no hearing loss in three species of reef fishes following exposures up to 190 dB $SEL_{cum}$. These results reinforce the need for caution when extrapolating the effects of seismic airguns on one species to the effects on another species.

Booman et al. (1996, cited in Hastings and Popper 2005) found significant death of the eggs, larvae, and fry of Atlantic cod (*Gadus morhua*), saith (*Pollachius virens*), and Atlantic Herring (*Clupea harengus*), as well as damage to the neuromasts of the lateral line, but only when the specimens were within about 5 m of the source, with the most substantial effects occurring when the fishes were within 1.4 m of the source. However, at such close distances to the air-gun, the hydrodynamic motion would be huge and could have been the case of the injury, but the received sound pressure and fluid motion were not reported in this study (Popper and Hastings 2009a).

Seismic surveys have been shown to affect the behavior of a number of fish species. These effects include changes in distribution (e.g., Skalski et al. 1992; Engås et al. 1996; Engås and Løkkeborg 2002; Slotte et al, 2004) and other minor behavioral effects such as an initial startle response at the beginning of the exposure that wanes as the airgun shots continue (Wardle et al. 2001; Boeger et al, 2006). Fewtrell and McCauley (2011) found that two species of demersal/pelagic schooling fish demonstrated significant increases in alarm responses to airgun noise exceeding 147 dB SEL, and that alarm responses increased with increasing noise levels, but the responses differed between the two species.

How a Pacific salmon would respond to these seismic sounds has not been investigated, but even minor injuries, small but temporary changes in hearing sensitivity, or short-term changes in behavior could interfere with their ability to perform normal functions, such as detecting predators. Feist, et al. (1992) reported that juvenile pink salmon and chum salmon appeared to be less apt to startle when approached by observers when pile driving was occurring compared to when it was not, perhaps making them more susceptible to predators. The likelihood that such small changes could affect Pacific salmon will depend in large part on the life stage and activity, with small juveniles likely being more sensitive than the larger sub-adults and adults. Fortunately, the most sensitive life stages – eggs, alevins, fry, and spawning adults – reside in riverine habitats, where seismic surveys are less likely to occur.

As described above, the FHWG established interim criteria for the onset of injury to fishes exposed to impulsive sounds. However, several factors complicate our ability to predict whether or not those criteria will be exceeded: 1) an airgun array produces sound from multiple sources; 2) the array moves as it is towed along the transect; 3) the movements of the salmon are unpredictable; and 4) salmon do not appear to avoid vessels at sea and may come in close proximity to the airgun array. As such, it may be more practical to simply implement measures to minimize the exposure risk.

Most discussions of techniques to mitigate or minimize the effects of seismic surveys address the effects to marine mammals (e.g., JNCC 2010; Nowacek 2013). Passive acoustic monitoring or the use of observers will not benefit salmon, and ramping up the power of the airgun array ("soft start") to allow time for the animals to move out of the area is likely of little benefit. However, several other mitigation measures, such as using the least powerful airgun necessary to conduct the survey and minimizing the footprint of the survey to the extent feasible, can benefit salmon. Although marine vibroseis is not commonly used, it is likely to be less damaging to aquatic animals than airguns (LGL and MAI 2011), because the signals are continuous, at lower levels, and have better suppression of unwanted higher frequencies.

### *Potential conservation measures for seismic surveys*

- Avoid areas and times of year when salmon, such as smaller juveniles, are present. If surveys must be conducted when salmon are present, do so when the abundances are relatively low.
- Avoid areas and times of year when the fish species that salmon prey upon are present. If surveys must be conducted with these species are present, so when the abundances are relatively low.
- When salmon are migrating through the area, provide sufficient breaks in the survey to allow transit through the area.
- Use marine vibroseis instead of airguns when possible.
- Use the least powerful airguns that will meet the needs of the survey.
- Survey the smallest area possible to meet the needs of the survey.

#### *4.2.2.2 Agriculture*

<u>*Potential adverse effects from agriculture*</u>

The nature of agricultural activities and their potential effects cover a very broad range. Meat and milk production can have effects ranging from the nutrient discharges that may be associated with large confined animal feeding operations to slight modification of natural vegetation that may occur with properly managed grazing on rangelands. The effects of crop production range from significant soil disturbance and use of chemicals producing row crops to the minimal effects that may occur in pasture and hay production on organic farms. Agriculture activities often take place on historical flood plains of river systems, where they have a direct effect on stream channels and riparian functions. Furthermore, irrigated agriculture frequently requires significant use of water, which may decrease streamflow, lower water tables, and increase water quality problems, e.g., higher water temperatures. (see Section 4.2.2.19 Irrigation Water Withdrawal, Storage, and Management).

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

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

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

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

Chemicals such as some pesticides, phosphorus, and ammonium are transported while adsorbed to sediment. Changes in the aquatic environment, such as a lower concentration of chemicals in the overlying waters or the development of anaerobic conditions in the bottom sediments, can cause these chemicals to be released from the sediment. Phosphorus transported by the sediment may not be immediately available for aquatic plant growth but does serve as a long-term contributor to eutrophication, a condition in which excess nutrients lead to algal blooms and decreased oxygen levels as the algae decompose (EPA 1993).

Groundwater is susceptible to nutrient contamination in agricultural lands composed of sandy or other coarse-textured soil (Franco et al. 1994). Nitrate, a highly soluble form of nitrogen, can leach rapidly through the soil and accumulate in groundwater, especially in shallow zones (Jordan and Weller 1996; Brady and Weil 1996). This groundwater can be a significant source of nutrients in surface waters when discharged through seeps, drains, or by direct subsurface flow to water bodies (Lee and Taylor 2000).

Agricultural practices may also include stream channelization, LWD removal, installation of rip-rap and revetments along stream banks, and removal of riparian vegetation (Spence et al. 1996). Natural channels in easily eroded soils tend to be braided and meander, creating channel complexity as well as accumulations of fallen trees, which help create large, deep, relatively permanent pools, and meander cutoffs. These complex channel habitats create important spawning and rearing habitat by trapping sediment, nutrients, and organic matter, sorting gravels, providing cover and hydrologic heterogeneity (Harmon et al. 1986; Abbe and Montgomery 1996; Bilby and Bisson 1998).

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

### *Potential conservation measures for agriculture*

The establishment of properly functioning riparian conditions and achieving instream water quality standards should be the goal of restoration and management projects on agricultural lands. Agricultural activities should strive to protect riparian vegetation and water quality through conservation practices and management plans.

The 2008 reauthorization of the Farm Bill (the "Food, Conservation, and Energy Act") included several conservation programs that provide potential benefit to EFH. They are the Environmental Quality Incentives Program, the Wetlands Reserve Program, and the Conservation Reserve and Enhancement Programs. These programs provide farmers assistance for idling erosion-prone land, preserving wetlands, and undertaking land management conservation practices. Land owners are encouraged to contact their local agricultural extension agents to find out further information about these programs.

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

- Maintain riparian management zones of appropriate width on all permanent and ephemeral streams that include or influence EFH. The riparian management zones should be wide enough to restore and support riparian functions including shading, LWD input, leaf litter inputs, sediment and nutrient control, and bank stabilization functions.

- Reduce erosion and run-off by using practices such as contour plowing and terracing, no till agriculture, conservation tillage, crop sequencing, cover and green manure cropping and crop residue, and, by maximizing the use of filter strips, field borders, grassed waterways, terraces with safe outlet structures, contour strip cropping, diversion channels, sediment retention basins and other mechanisms including re-establishment of vegetation.
- Participate in and benefit from existing programs to encourage wetland conservation and conservation reserves, avoid planting in areas of steep slopes and erodible soils and avoid disturbance or draining of wetlands and marshes.
- Incorporate water quality monitoring as an element of land owner assistance programs for water quality. Evaluate monitoring results and adjust practices accordingly.
- Minimize the use of chemical treatments within the riparian management zone. Review pesticide use strategies to minimize impact to EFH. Reduce pesticide application by evaluating pest problems, past pest control measures and following integrated pest management strategies. Select pesticides considering their persistence, toxicity, runoff potential, and leaching potential.
- Optimize the siting of new confined animal facilities or the expansion of existing facilities to avoid areas adjacent to surface waters containing EFH or in areas with high leaching potential to surface or groundwater. Use appropriate methods to minimize discharges from confined animal facilities (for both wastewater and process water).
- Where water quality is limited from nutrients or where leaching potential is high, avoid land application of manure or other fertilizer unless appropriate management measures are in place to assure that sediment and nutrient input to surface water is controlled. Observe best management practices (BMPs) to assure that application and timing measures fostering high nutrient utilization are employed.
- Apply conservation measures for water intake (see Sectin 4.2.2.19 Irrigation Water Withdrawal, Storage, and Management) to agricultural activities where applicable.
- Encourage farmers to take advantage of the conservation programs that were reauthorized in the Food, Conservation, and Energy Act of 2008 (i.e., Farm Bill).

#### *4.2.2.3 Alternative energy development*

Marine, estuarine, and freshwater hydrokinetic energy refers to electrical energy that comes from “waves, tides, and currents in oceans, estuaries, and tidal areas; free flowing water in rivers, lakes, and streams; free flowing water in man-made channels; and differentials in ocean temperatures (ocean thermal energy conversion)” (U.S. DOE 2009). For the purpose of considering threats to designated salmon EFH on the West Coast of the United States, this report focuses on nearshore wave energy and tidal turbine energy development because it is the most likely form of hydrokinetic technology to move forward within the next 5-years. Ocean thermal energy and offshore wind development is not considered in this discussion because they are not likely to be proposed off the West Coast of the United States in the near future.

Wave energy conversion devices can be grouped by the design features to capture wave energy, into six main types: point absorbers, attenuators, oscillating wave surge converters, oscillating water column, overtopping devices, and submerged pressure differential devices (U.S.DOE 2009). Tidal turbines are placed on the bottom and can have an exposed or closed blade. Although each design is unique, these devices are typically attached to the seafloor, channel bottom, or some type of structure and deployed at or near the water’s surface or at depth.

In order to develop and operate wave or tidal hydrokinetic projects, there are four phases of activities that can potentially affect salmon EFH. The potential effects of each phase of a hydrokinetic project (preconstruction, construction, operation and maintenance, and decommissioning) need to be considered (Boehlert and Gill 2010; Gill 2005; Kramer et al. 2010; Previsic 2010; U.S.DOE 2009). In addition to the design features and footprint of an individual device, the spatial and temporal scales of a project (single device /short-term; single device /long term; multiple devices /short term; multiple devices /long term) are important considerations when evaluating effects on salmon EFH (Boehlert and Gill 2010). The potential cumulative effects of the spatial arrangement (vertical and horizontal) of multiple devices in the water column also need to be evaluated.

Construction activities typically include: horizontal directional drilling to land cables from the device to the shoreline; laying of subsea transmission cable; foundation/mooring installation; deployment and commissioning of device(s). Operation and maintenance include the mechanical functioning of the devices and appurtenances, as well as inspection and repair of equipment. Decommissioning at the end of the project (typically 5-30 years) involves removal of all equipment in the water column and transmission cables and restoration of the site, if needed.

Related activities that pertain to both the construction and operations phases include installation and maintenance of navigation buoys to mark the deployment area; and reliable port infrastructure to accommodate work vessels as well as delivery and retrieval of large hydrokinetic devices to pier-side for repair and maintenance, if necessary.

*Potential adverse impacts from alternative energy development*

Because the majority of hydrokinetic renewable energy technologies remain at the conceptual stage and have not yet been developed as full-scale prototypes or tested in the field, there have been few studies of their environmental effects. Currently, identification of the potential environmental effects have been developed from: (1) predictive studies; (2) workshop reports from expert panels; and (3) report syntheses prepared from published literature related to other technologies, e.g., noise generated by similar marine construction activities, measurements of electromagnetic fields (EMFs) from existing submarine cables, environmental monitoring of active offshore wind farms in Europe, and turbine passage injury reduction mechanisms employed in conventional hydropower turbines.(Boehlert and Gill 2010; Kramer et al. 2010; Nelson et al. 2008; U.S. DOE 2009).

The majority of potential effects on salmon EFH are from the presence and operation of a wave energy convertor device or turbine. Although all phases of an individual project will alter the physical marine environment, the types and duration of those changes are varied. Numerous reviews (Kramer et al. 2010; U.S.DOE 2009) have identified the following potential effects of the wave energy converter devices, all of which may affect the quality and quantity of salmon EFH: (1) alteration of current and wave strengths and directions; (2) alteration of substrates and sediment transport and deposition; (3) interference with animal movements and migrations, including fish (prey and predators) and invertebrate attraction to subsurface components of device, concentration of displaced fishing gear; (4) presence of rotor blades or other moving parts; and attraction and concentration of predators on surface components of device; (5) alteration of habitats for benthic organisms; (6) sound and vibration in water column during construction and operation; (7) generation of EMFs by electrical equipment and transmission lines; (8) release into water column of toxic chemicals from paints, lubricants, antifouling coatings, as well as spills of petroleum products from service vessels. These potential effects on salmon EFH apply to tidal turbines as well.

Presence of subsurface structures may affect water movements, as well as sediment transport, erosion, and deposition at a local scale. During construction and decommissioning, the installation and removal of the foundations, anchors, and transmission cables will disturb and suspend sediments, and may mobilize contaminants, if present. Disturbances to the benthic habitat will occur during temporary anchoring of construction vessels; clearing, digging and refilling trenches for power cables; and installation of permanent anchors, pilings, and other mooring devices. Prior to installation of a buried cable, any debris is typically cleared from the cable route using a ship-towed grapnel (Carter et al. 2009). Cables are buried using a ship mounted plow, whereas buried cables are usually exposed and reburied using a water-jetting technique when needing repair (Carter et al. 2009). Water quality will be temporarily affected by: (1) increased suspended sediments and resultant increased turbidity and decreased water clarity; (2) localized reduction of dissolved oxygen where anoxic sediments are suspended; and (3) mobilization of anoxic or buried contaminated sediments during cable route clearing and installation of cables.

The physical structures associated with ocean and tidal energy operations could potentially interfere with the migration and rearing habitat functions for juvenile and adult salmonids (U.S.DOE 2009). The floating and submerged structures, mooring lines, and transmission cables may create complex structural habitat that could act as a fish aggregating/attraction device (FAD), as well as provide substrate for attachment of invertebrates (considered biofouling where unwanted). Salmonids may be attracted to the physical structure itself, and/or to forage fish attracted to the structure. Floating offshore wave energy facilities could potentially (1) create artificial haul-out sites for marine mammals (pinnipeds) and roosting of seabirds; and (2) trap floating vegetation (e.g., kelp, eelgrass, large wood), and lost fishing gear (e.g., nets, traps, and crab pots). Aggregation of predators (e.g., fish, marine mammals, sea birds) near FADs may reduce the safe passage attribute of a migration corridor by subjecting juvenile or adult salmonids to increased predation. Drifting nets and other fishing gear that may become entangled on mooring lines or the devices may decrease the quality of salmon migration routes due to capture from passive fishing of gear. Deposition of organic matter from biofouling on the structure can change the chemical properties and biological communities near the structures. There will be new lighted, fixed surface structures (devices and navigation buoys marking the project area) in the marine environment which may attract prey and predators of juvenile and adult salmonids.

Depending on the frequency and amplitude of the sound of the moving parts of the device, as well as how far the sound waves propagate, the operational sounds of the devices may affect rearing and migration corridor habitat. There is limited information on sound levels produced during construction (e.g., offshore pile driving) and operation of ocean energy conversion devices, as well as the spatial extent of any altered acoustic environment. Turbines with exposed rotor blades may impede or entrained salmon.

Migrating adult and juvenile salmonids may be exposed to EMFs generated at a project site, which may affect the movement of salmon. The electric current in the cables will induce a magnetic field in the immediate vicinity (U.S.DOE 2009). During transmission of produced electricity, the matrix of vertical and horizontal cables will emit low-frequency EMFs. The source and effects of EMFs in the marine environment are limited and uncertain (Gill 2005).

Accidental, but acute, release of chemicals from leaks or spills (e.g., hydraulic fluids from a wave energy conversion device, drilling fluids during horizontal drilling) could have adverse effects on water quality. Anti-fouling coatings inhibit the settling and growth of marine organisms, and chronic releases of dissolved metals or organic compounds could occur from these compounds (U.S.DOE 2009). The cumulative effects on salmon and their prey from decreased water quality associated with the release of toxic chemicals could vary substantially depending upon the number of units deployed, type of antifouling coating used, and the maintenance frequency of the coating.

### *Potential conservation measures for alternative energy development*

Structural and operational mitigation options are often unique to the technology or issue of concern.

- Locate and operate devices at sites and times of the year, to avoid salmon migration routes and seasons, respectively.
- Schedule the noisiest activities, i.e., pile driving, at times of the year to minimize exposure of juvenile and adult salmon.
- Schedule transmission cable installation to minimize overlap with salmon migration seasons.
- Conduct pre-construction contaminant surveys of the sediment in excavation and scour areas.
- To avoid concentration of predators, above water structures could have design features to prevent or minimize pinniped haul-out and bird roosting.

- Sheath or armor the vertical transmission cable to reduce transmission of EMF into the water column.
- Bury transmission cables on the sea floor to minimize benthic and water column EMF exposure.
- Align transmission cables along the least environmentally damaging route. Avoid sensitive habitats (e.g., rocky reef, kelp beds) and critical migratory pathways.
- Use horizontal drilling where cables cross nearshore and intertidal zones to avoid disturbance of benthic and water column habitat.
- Design the mooring systems to minimize the footprint by reducing anchor size, and cable/chain sweep.
- Develop and implement a device/array maintenance program to remove entangled derelict fishing gear and other materials that may affect passage.
- Use non-toxic paints and lubricating fluids where feasible.
- Limit the number of devices and size of projects until effects are better understood and minimization measures tested.

#### *4.2.2.4 Artificial Propagation of Fish and Shellfish*

Public and private hatcheries, acclimation sites, and net pens producing Pacific salmon (coho salmon, Chinook salmon, chum, pink, kokanee, sockeye, steelhead, and cutthroat), trout (Atlantic salmon, brown, rainbow, and golden), char (eastern brook, and lake trout), sturgeon, and several species of warmwater fish operate in and adjacent to salmon EFH in fresh and sea water (NRC 1996; WDFW 1998). Additionally, captive breeding of threatened or endangered stocks of sockeye and spring Chinook salmon occurs in Idaho, Oregon, and Washington, and of endangered winter Chinook salmon and coho salmon in California (Flagg et al. 1995; Sturm et al. 2009). Shellfish culture in salmon EFH consists primarily of oyster culture, although clams, mussels, and abalone are grown as well. Geoduck culture is the fastest growing segment of shellfish culture located in salmon EFH.

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

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

Various methods of shellfish culture and harvest also have the potential to adversely impact salmon EFH, such as mechanical harvest in eelgrass beds, harrowing, off-bottom culture, and raft and line culture. Typically, the greatest impacts are temporary and are realized during mechanical harvest or harrowing, which involved physical disturbance of the benthic zone. Recovery time after disturbance to seagrass varies with seagrass species, disturbance size, disturbance intensity, and sediment characteristics (Dumbauld et al. 2009). Mechanical harvest or harrowing typically follows a 3-5 year (depending on species cultured) growth period. Mechanical harvest and harrowing are only applicable for on-bottom culture methods. The use of chemicals to control burrowing organisms detrimental to oyster culture may also adversely affect EFH for both salmon and non-salmonids. To control burrowing shrimp, for example, Washington State has used the pesticide carbaryl since 1963. About 800 acres are treated with carbaryl annually in Grays Harbor and Willapa Bay, with a given oyster bed sprayed about every 6 years. Nontarget effects of carbaryl use include short-term decreases in the density of prey species for salmon as well as the mortality of nontarget benthic invertebrates and nonsalmonid fish (Pozarycki et al. 1997; Simenstad and Fresh 1995). Concerns over such potential adverse impacts have led to the development of regulations for the use of chemicals in natural habitat and policies for offsetting losses to eelgrass beds (WDF 1992).

On a positive note, some methods of mollusk culture have been shown to create beneficial habitat for salmonids (Johnson 1998, pers. comm.). Geoduck culture has been shown to support species richness significantly higher than control sites (Brown and Theusen, 2011). Dumbauld et al. (2009) found that structure provided by aquaculture appears functionally similar to eelgrass for small benthic infauna and mobile epibenthic fauna.

Treated wood structures in salmon EFH (e.g., creosote, chromated copper, arsenate) used for docks, pilings, raceway separators, fish ladders etc., and other structures can release toxic heavy metals and persistent aromatic hydrocarbons into the aquatic environment (see Section 4.2.2.14 Estuarine Alteration).

*Potential conservation measures for artificial propagation of fish and shellfish*

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

- Minimize the use of biocides and wood preservatives. Promote the use of plastic building materials. Treated wood should be certified as produced in accordance with the most current version of “Best Management Practices for Treated Wood in Western Aquatic Environments” (WWPI et al. 2011). Treated materials containing copper compounds should not be installed when migrating salmon are present.
- Manage shellfish culture activities to provide levels of salmon prey production, cover, and habitat complexity for both salmon smolts and returning adults which are similar to, or better than, levels provided by the natural environment.
- Any gravel used for shellfish bed preparation should be washed prior to placement.
- Unsuitable material (e.g., trash, debris, car bodies, asphalt, tires) should not be discharged or used as fill (e.g., used to secure nets, create berms, or provide nurseries).
- A Pacific herring spawn survey should be conducted prior to undertaking the activities listed below if any of these activities will occur outside the approved work window for the project area’s Tidal Reference Area, which is [insert work window]. The activities requiring a spawn survey are: 1) mechanical dredge harvesting, 2) raking, 3) harrowing, 4) tilling or other bed preparation activities, 5) frosting or applying oyster shell on beds, 5) geoduck harvesting, net removal, or tube removal. Vegetation, substrate, and aquaculture materials (e.g., nets, tubes) should be inspected for Pacific herring spawn. If Pacific herring spawn is present, these activities are prohibited in the areas where spawning has occurred until such time as the eggs have hatched and Pacific herring spawn is no longer present. The Corps encourages the permittee to complete a training class on identifying Pacific herring spawn with the Washington Department of Fish and Wildlife (WDFW). A map showing the Tidal Reference Areas and a table with the approved work windows for Pacific herring can be found at the Corps, Seattle District, Regulatory Branch website. You should maintain a record of Pacific herring spawn surveys, including the date and time of surveys; the area, materials, and equipment surveyed; results from the survey; etc. The record of Pacific herring spawn surveys should be made available upon request.

- Avoid or minimize impacts to eelgrass. New aquaculture activities (new or expanded farms) should not occur within a buffer distance of 25-30 feet from existing native eelgrass beds.
- Newly positioned[5] shellfish culturing (e.g., culturing by rack and bag, raft, long-line, ground methods) in existing plots should not be placed within 10 horizontal feet of eelgrass or kelp.
- Newly positioned shellfish culturing (e.g., culturing by rack and bag, raft, long-line, ground methods ) should not be placed above the tidal elevation of +7 feet Mean Lower Low Water if the area is documented as surf smelt spawning habitat
- Newly positioned shellfish culturing (e.g., culturing by rack and bag, raft, long-line, ground methods) should not be placed above the tidal elevation of +5 feet Mean Lower Low Water if the area is documented as Pacific sand lance spawning habitat.
- Tidelands waterward from the line of mean higher high water should not be used for storing aquaculture gear (e.g., bags, racks, marker stakes, rebar, nets, tubes) for a consecutive period of time exceeding 7 days.
- All pump intakes (e.g., for geoduck harvest, washing down gear) that use seawater should be screened in accordance with NMFS criteria.
- Land vehicles (e.g., all-terrain, trucks) and equipment should not be washed within 150 feet of any stream, waterbody, or wetland. All wash water should be treated before being discharged to any stream, waterbody, or wetland.
- Land vehicles should be stored, fueled, and maintained in a vehicle staging area placed 150 feet or more from any stream, waterbody, or wetland.
- All vehicles operated within 150 feet of any stream, waterbody, or wetland should be inspected daily for fluid leaks before leaving the vehicle staging area. Repair any leaks detected in the vehicle staging area before the vehicle resumes operation.
- At least once every three months beaches in the project vicinity should be patrolled by crews who will retrieve aquaculture debris (e.g., anti-predator nets, tubes, tube caps, stakes) that escapes from the project area. Within the project vicinity, locations should be identified where debris tends to accumulate due to wave, current, or wind action, and after weather events these locations should be patrolled by crews who will remove and dispose of aquaculture debris appropriately.
- Ensure area nets (e.g., anti-predator nets) are tightly secured to prevent them from escaping from the project area.
- Vessels used for shellfish culturing should not ground in eelgrass beds.

#### *4.2.2.5 Bank Stabilization and Protection*

The alteration of riverine and estuarine habitat from bank and shoreline stabilization, and protection from flooding events can result in varying degrees of change in the physical, chemical, and biological characteristics of existing shoreline and riparian habitat. The use of dikes and berms can also have long-term adverse effects in riparian, tidal marsh and estuarine habitats. Tidal marshes are highly variable, but typically have freshwater vegetation at the landward side, saltwater vegetation at the seaward side, and a gradient of species in between that are in equilibrium with the prevailing climatic, hydrographic, geological, and biological features of the coast. These systems normally drain through highly dendritic tidal creeks that empty into the bay or estuary. Freshwater entering along the upper edges of the marsh drains across the surface and enter the tidal creeks. Structures placed for bank stabilization and coastal shoreline protection include, but are not limited to, concrete or wood seawalls; rip-rap revetments (sloping piles of rock placed against the toe of the dune or bluff in danger of erosion from wave action); dynamic cobble revetments (natural cobble placed on an eroding beach to dissipate wave energy and prevent sand loss); vegetative plantings; sandbags; and other bioengineering techniques.

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[5] "Newly positioned" is defined as being placed within a portion of the project area where aquaculture is not currently located and has not previously occurred.

### *Potential adverse effects of bank stabilization and protection*

Human activities removing riparian vegetation, armoring, relocating, straightening and confining stream channels and along tidal and estuarine shorelines influences the extent and magnitude of stream bank erosion and down-cutting in the channel (Gerstein and Harris 2005). In addition, these actions have reduced hydrological connectivity and availability of off-channel habitat and floodplain interaction. Dikes, levees, ditches, or other water controls at the upper end of a tidal marsh can cut off all tributaries feeding the marsh, preventing freshwater flushing and annual flushing, annual renewal of sediments and nutrients, and the formation of new marshes. Water controls within the marsh proper intercept and carry away freshwater drainage, block freshwater from flowing across seaward portions of the marsh, increase the speed of runoff of freshwater to the bay or estuary, lower the water table, permit saltwater intrusion into the marsh proper, and create migration barriers for aquatic species. In deeper channels where reducing conditions prevail, large quantities of hydrogen sulfide are produced that are toxic to marsh grasses and other aquatic life. Acid conditions of these channels can also result in release of heavy metals from the sediments.

Long-term effects on the tidal marsh include land subsidence (sometimes even submergence), soil compaction, conversion to terrestrial vegetation, greatly reduced invertebrate populations, and general loss of productive wetland characteristics. Loss of these low-salinity environments reduces estuarine fertility, restricts suitable habitat for aquatic species, and creates abnormally high salinity during drought years. Low-salinity environments form a barrier that prevents the entrance of many marine species, including competitors, predators, parasites and pathogens.

Armoring of shorelines to prevent erosion and maintain or create shoreline real estate simplifies habitats, reduces the amount of intertidal habitat, and affects nearshore processes and the ecology of a myriad of species (Williams and Thom 2001) and reduces recruitment of crucial spawning gravel (PFMC 1988). Hydraulic effects on the shoreline include increased energy seaward of the armoring, reflected wave energy, dry beach narrowing, substrate coarsening, beach steepening, changes in sediment storage capacity, loss of organic debris, and downdrift sediment starvation (Williams and Thom 2001). Installation of breakwaters and jetties can result in community changes from burial or removal of resident biota; changes in cover and preferred prey species; and predator attraction (Williams and Thom 2001). As with armoring, breakwaters and jetties modify hydrology and nearshore sediment transport as well as movement of larval forms of many species (Williams and Thom 2001).

Bank stabilization and in-stream structures can be misapplied and used often in restoration projects to create what is perceived as “good habitat”. The physical, chemical and biological processes driving the riverine ecosystem are not correctly considered in designs (Beechie et al. 2010). Frequently, bank stabilization and shoreline protection techniques do not consider alteration of stream flows and temperatures and effectiveness on restoring salmon habitat for and potential changing climate remains a concern (Beechie et. al 2012).

The use of chemicals (creosote, chromated copper arsenate, and copper zinc arsenate) on bulkheads or other wood materials used for bank stabilization is of concern. These chemicals can introduce toxic substances into the water, injure or kill prey organisms and salmonids, or concentrate in the food chain (WMOA 1995). Use of these chemicals is generally prohibited. In freshwater copper concentrates have been observed to have a numerous potential adverse effects on salmonid behavior, development, navigation and mortality in a range of species and life stages (Baldwin et al. 2003; Sandahl et al. 2007; Hetcht et al. 2007; McIntyre et al. 2012).

### *Potential conservation measures for bank stabilization and protection*

- Minimize the loss of riparian habitats as much as possible.

- The diking and draining of tidal marshlands and estuaries should not be undertaken unless a satisfactory compensatory mitigation plan is in effect and monitored.
- Determine the cumulative effects of existing and proposed bio-engineered or bank hardening projects on salmon EFH, including prey species before planning new bank stabilization projects.
- Bank erosion control should use vegetation methods or “soft” approaches (such as beach nourishment, vegetative plantings, and placement of LWD) to shoreline modifications whenever feasible. Hard bank protection should be a last resort and the following options should be explored (tree revetments, stream flow deflectors, and vegetative riprap.
- Re-vegetate sites to resemble the natural ecosystem community, using vegetation management to limit livestock grazing and maintain an appropriate riparian buffer zone.
- Develop design criteria based on site-specific geomorphological, hydrological and sediment transport processes appropriate for the stream channel for any stabilization, protection and restoration projects.
- Include efforts to preserve and enhance EFH by providing new gravel for spawning areas; removing barriers to natural fish passage; and using weirs, grade control structures, and low flow channels to provide the proper depth and velocity for fish.
- Construct a low-flow channel to facilitate fish passage and help maintain water temperature in reaches where water velocities require armoring of the riverbed.
- Replace in-stream fish habitat by providing root wads, deflector logs, boulders, rock weirs and by planting shaded riverine aquatic cover vegetation.
- Avoid or minimize the use of wood treated with creosote or copper-based chemicals in aquatic habitats there is low flow circulation, and where there is known salmon habitat.
- Use an adaptive management plan with ecological indicators to oversee monitoring and ensure mitigation objectives are met. Take corrective action as needed.

#### *4.2.2.6 Beaver Removal and Habitat Alteration*

Historically, beaver were an integral component of wetland and low-gradient stream systems throughout North America (Burchsted et al. 2010). Beaver are of particular importance within West Coast watersheds because of the habitat benefits they provide to salmon (Westbrook et al. 2006). Historical population estimates for beaver range from 60-400 million (Seton 1929), with current beaver populations thought to be at 2 to 20 percent of historic levels (Naiman 1988). Beavers and the dams they create fundamentally alter the physical condition of stream ecosystems, supporting numerous other species (Gurnell 1998, Pollock et al. 2003, Burchsted et al. 2010). Observed physical benefits include increased streamflow, raised water tables, lower stream temperatures, and increased floodplain connectivity and habitat complexity, including an expansion of riparian and wetland habitat (Rosell et al. 2005, Westbrook et al. 2006, Pollock et al. 2007). Observed biological benefits of beaver dams include increases in biological diversity and productivity for suites of taxa such as plants, mammals, birds, herpetofauna, and fishes (Pollock et al. 1998, Pollock et al. 2003, Pollock et al. 2004, Burchsted et al. 2010). The positive relationships between beaver salmonid fishes been particularly well studied. Habitats created by beaver have been shown to be important rearing areas for coho salmon, sockeye salmon, steelhead trout and cutthroat trout (Collen and Gibson 2000, Pollock et al. 2003).

Beaver can have a number of impacts to human infrastructure and land use including localized flooding, removal of riparian vegetation. Because of this they are sometimes targeted for removal in agricultural and urban landscapes. The removal of beaver has, unfortunately, substantially reduced the functionality and quality of thousands of miles of stream, wetland, and riparian habitat in Pacific Coast watersheds and elsewhere. Historical accounts of stream ecosystems in alluvial valleys describe entire valley bottoms as saturated, with numerous wetlands, multi-threaded streams, dense riparian vegetation, abundant beaver dams and continuously flowing water (Walter and Merritts 2008, Cluer and Thorne 2013). This contrasts with the current condition of streams throughout the west, where the removal of beaver, channel straightening and riparian vegetation removal have contributed to the creation of downcut streams that are confined within a narrow trench below former floodplains; the extent and quality of stream, riparian and wetland habitat are greatly diminished or altogether eliminated (Darby and Simon 1999). Stream incision has been particularly problematic because it causes long-term stream degradation resulting in lowered water tables, loss of groundwater storage, loss of perennial stream flow, and a reduction in water availability for both commercial and conservation purposes.

Throughout the Pacific Coast states and elsewhere, there is rapidly growing interest in the use of beaver to restore degraded stream ecosystems. This is because past and current land use practices have caused widespread degradation of streams and climate change threatens to further degrade these ecosystems (Beechie et al. 2010, Roni and Beechie 2013). Encouraging beaver recolonization through the use of artificial beaver dams and riparian enhancements provides an inexpensive, yet effective method to restore degraded stream and wetland systems (Pollock et al. 2012). The observed positive effects of beaver dams on groundwater storage and streamflow have broadened the appeal of beaver dams beyond conservationists to water users such as ranchers and farmers, some of whom have realized improved crop production after reintroducing beaver, and to entities seeking to replace developed wetlands. Thus there is growing recognition from diverse interests that beaver can be used not only as a "habitat conservation tool", but also as a "water conservation tool" to address current and future water shortages. Using beaver as a restoration tool is relatively inexpensive approach compared to traditional restoration techniques that involve engineering, permitting, construction, and maintenance costs. Reintroducing beaver and facilitating their successful establishment through the use of artificial beaver dams and lodges, along with food supplementation, is extremely cost effective (Pollock et al. 2012).

### *Potential conservation measures for beaver removal and habitat alteration*

Following are the types of measures that should be undertaken by action agencies for the purpose of encouraging the use of beaver to create and restore habitat that is generally beneficial to salmonids and numerous other species. More specific or different measures based on the best and most current scientific information may be developed prior to, or during, the EFH consultation process and communicated to the appropriate agency. The options represent a menu of general types of conservation actions that can contribute to the restoration and maintenance of properly functioning salmon habitat and were derived, in part, from consultation with NMFS personnel involved in the development of recovery plans for ESA-listed coho salmon and steelhead.

#### Develop integrated beaver management strategies

Develop an integrated beaver management strategy so that when beaver produce unwanted effects on private land or public infrastructure, there is a mandatory sequence of integrated actions (The "Educate-Mitigate-Relocate" approach) that should be followed by landowners, habitat restoration groups, government agencies (e.g. Departments of Transportation and Public Works) and individuals as outlined below:

- Educate: Use educational materials developed to educate landowners, agencies and other affected parties about the benefits beaver provide by leaving them in place undisturbed. To this end; (1) develop programs to educate landowners and the public in general about the benefits of beaver to the health of our ecosystems, with a focus on benefits to salmonids, and (2) develop a program of outreach and technical assistance to habitat restoration groups about the benefits of including beaver and potential beaver habitat into restoration projects. Include a description of restoration techniques designed to entice beaver to colonize an area. Also include techniques for construction of beaver dam analogues that will simulate the effects of beaver dams both for the purposes of creating habitat suitable for beaver and for creating the beneficial effects of beaver dams in locations that beaver are unlikely to occupy in the near future.

- Mitigate: If the landowner, agency or other affected parties still believe there is a conflict, manage beaver in place with such techniques as tree cages, fencing, flow devices, and (fish passable) culvert exclusion devices. Implementation of this step should also include a synthesis, description and publication of existing mitigation techniques.
- Relocate: Only if all other methods to keep beavers in place fail to resolve the conflict, relocate beaver within the range of coho salmon to an acceptable, priority stream. This step should also include a synthesis, description and publication of existing relocation techniques, and possible identification or licensing of individuals who are qualified to translocate beaver.
- Develop procedures to identify and rank watersheds and stream reaches where beaver reintroduction or relocation would most likely be successful and where it would be of most benefit coho salmon.
- Within the coastal province of Oregon, Burnett et al. (2007) identified the intrinsic habitat potential for coho salmon based on physical factors such as stream flow, valley constraint and stream gradient. A similar approach should be applied to identifying the intrinsic habitat potential of streams for beaver. Identifying areas of high intrinsic potential for both salmonids and beaver for all Pacific Coast watersheds would help to focus restoration efforts using beaver to areas where they would be most useful.

#### *4.2.2.7 Coal Export Terminal Facilities*

The construction, maintenance, and operation of coal export facilities can include many non-fishing activities that are already described here, including activities causing high intensity underwater acoustic or pressure waves, construction/urbanization, dredging, estuarine alteration, over-water structures, road building and maintenance, vessel operations, wastewater/pollutant discharge, and wetland and floodplain alteration. All applicable effects associated with these activities should be considered as potential adverse effects from the development, presence, and operations of coal export facilities.

Other potential effects are specific to the exportation of coal and are not described under other non-fishing activities. Although limited, the available information on the effects of coal export facilities documents physiological effects to salmonids and describes physical pathways for coal dust and associated products to enter and remain in the aquatic environment.

Campell and Devlin (1997) describe sublethal effects of coal dust on juvenile Chinook salmon. These include findings that coal dust affects the expression of the L5 and CYP1A1 genes which encode proteins that are crucial to cellular metabolism. In addition, they found that polyaromatic hydrocarbons which leach from coal dust into sea water contained procarcinogens such as benzopyrene, which can be converted in active carcinogens by the CYP1A1 gene. Herbert and Richards (1963) found that coal and coal byproducts reduce growth rates in trout, although it is not clear whether those findings would apply to other salmonids.

The persistence of coal dust and coal byproducts in the aquatic environment should be considered during EFH consultation. Johnson and Bustin (2005) examined the fate of coal dust in the marine environment by assessing sediments adjacent to the Roberts Bank coal terminal in Delta, British Columbia, Canada. They found that over a 22-year time period (1977 – 1999) the concentration of coal dust particles increased substantially, from 1.8 percent in 1975 to 3.6 percent in 1999. The spatial extent of coal dust particles did not increase, decreasing with greater distance from the coal terminal, but the concentration did increase.

*Potential conservation measures for coal export terminal facilities*

Conservation measures that apply to the following activities should also apply to coal export terminal facilities: Construction/urbanization, dredging and dredged spoil disposal, estuarine alteration, introduction/spread of IAS, over-water structures, road building and maintenance, vessel operations, wastewater/pollutant discharge, and wetland and floodplain alteration.

Conservation measures specific to coal export terminal facilities should focus on the potential for release of coal and coal dust into the aquatic environment. The design and function of coal facilities is variable, and conservation measures should be tailored to each facility. What works at one facility may not work at another. Examples of measures that could be employed, but are not limited to the following:

- Cover or enclose conveyors when practicable, to contain the coal and coal dust
- Employ coal dust suppression system on open stockpiles, using automatic sprinklers or other mechanisms
- Utilize other active or passive control systems as appropriate
- Have an emergency response plan in place, to address accidental release of coal or coal dust, fuel spills, and other emergency situations

#### *4.2.2.8 Construction/Urbanization*

Activities associated with urbanization (e.g., building construction, utility installation, road and bridge building, storm water discharge) can significantly alter the land surface, soil, vegetation, and hydrology and adversely impact salmon EFH through habitat loss or modification. Effects of urbanization on stream ecology are second only to agriculture, even though urban areas occupy significantly less land surface than farmlands (Paul & Meyer 2001). Construction in and adjacent to waterways can involve dredging and/or filling activities, bank stabilization (see other sections), removal of shoreline vegetation, waterway crossings for pipelines and conduits, removal of riparian vegetation, channel re-alignment, and the construction of docks and piers. These alterations can destroy salmon habitat directly or indirectly by interrupting sediment supply that creates spawning and rearing habitat for prey species (e.g., sand lance, surf smelt, herring), by increasing turbidity levels and diminishing light penetration to eelgrass and other vegetation, by altering hydrology and flow characteristics, by raising water temperature, and by re-suspending pollutants (Phillips 1984).

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

Construction activities can also have detrimental effects on salmon habitat through the run-off of large quantities of sediment, as well as nutrients, heavy metals, and pesticides. Due to the intermittent nature of rainfall and runoff, the large variety of pollutant source types, and the variable nature of source loadings, urban runoff is difficult to control (Safavi 1996). The National Water Quality Inventory (EPA 2002) reports that runoff from urban areas is the leading source of impairment to surveyed estuaries and the third largest source of impairment to surveyed lakes. Oxygen deficits associated with high biological oxygen demand during and after storms are common (Faulkner et al. 2000; Ometo et al. 2000). Run-off of petroleum products and oils from roads and parking lots and sediment, nutrients, and chemicals from yards as well as discharges from municipal sewage treatment plants and industrial facilities are also associated with urbanization (EPA 1993). Urbanized areas also alter the rate and intensity of stormwater run-off into streams and waterways. Inorganic and organic contaminants in urban runoff can cause acute, chronic and sub-lethal effects in aquatic species.

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

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

### *Potential conservation measures for construction/urbanization*

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

Following are the types of measures that can be undertaken by the action agency on a site-specific basis to conserve salmon EFH in areas that have the potential to be affected by construction and urbanization activities. Not all of these suggested measures are necessarily applicable to any one project or activity that may adversely affect salmon EFH. More specific or different measures based on the best and most current scientific information may be developed prior to, or during, the EFH consultation process, and communicated to the appropriate agency. The EPA (1993) publication "Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters" extensively describes BMPsfor control of runoff from developing areas, construction sites, roads, highways and bridges affecting salmon EFH. In addition to the previous guidelines, the options following represent a short menu of general types of conservation actions that can contribute to the restoration and maintenance of properly functioning salmon habitat. The following suggested measures are adapted from Metro (1997), Oregon Department of Fish and Wildlife (ODFW) (1989), and EPA (1993).

- Protect existing, and wherever practicable, establish new riparian buffer zones of appropriate width on all permanent and ephemeral streams that include or influence EFH. Establish buffers wide enough to support shading, LWD input, leaf litter inputs, sediment and nutrient control, and bank stabilization functions.

- Plan development sites to minimize clearing and grading and cut-and-fill activities.

- During construction, temporarily fence setback areas to avoid disturbance of natural riparian vegetation and maintain riparian functions for EFH.

- Use BMPs in building as well as road construction and maintenance operations such as avoiding ground disturbing activities during the wet season, minimizing the time disturbed lands are left exposed, using erosion prevention and sediment control methods, minimizing vegetation disturbance, maintaining buffers of vegetation around wetlands, streams and drainage ways, and avoiding building activities in areas of steep slopes with highly erodible soils. Use methods such as sediment ponds, sediment traps, or other facilities designed to slow water run-off and trap sediment and nutrients.

- Where feasible, remove impervious surfaces such as abandoned parking lots and buildings from riparian areas, and re-establish wetlands.

- Implement Low Impact Development construction practices to the maximum extent possible.

#### *4.2.2.9 Culvert construction*

Culvert construction, maintenance, and replacement are common activities occurring in Pacific Coast salmon habitat, typically—but not always—associated with roads. Culverts convey water from upslope portions of terrain to downslope areas, thereby minimizing the risk of flooding, erosion, and undesired impacts to infrastructure and habitat. In the past, however, many culverts were constructed too small to convey large flow events, too steep to allow adequate fish passage, or without other physical characteristics to avoid the impacts to habitat and species that are now recognized to be significant problems.

Regulatory requirements under the ESA and MSA, as well as best practices developed by states, counties, tribes, and Federal agencies, have established a suite of construction, maintenance, and replacement actions to minimize adverse impacts to habitats and species. Habitat restoration programs have provided support for installation of "fish friendly" culverts, and the state of the art culvert is typically an open-bottom arched culvert that is designed to better mimic a natural stream bed.

*Potential adverse Effects from culvert construction*

The physical and chemical components to culvert construction that lead to potential adverse habitat impacts include slope, jump height, lack of instream structure, contaminants, and water velocity. These can lead to compromised fish passage, lethal and sublethal effects on individuals, and loss of ecological connectivity (Castro 2003; NMFS 2008b). Culverts may pose significant barriers to migration in salmon habitat. Road crossings are a common bottleneck to migrating adult salmon, as many employ faulty or poorly designed culverts (Chestnut 2002). For example, if a culvert is too small compared to the surrounding river, water velocities will increase rapidly via a Venturi effect. Debris will not readily flow through the culvert, eventually clogging it and making fish passage even more difficult. This blockage also prevents woody debris from reaching lower stretches of the stream, removing valuable fish habitat.

The slope of a culvert can affect fish passage directly by providing conditions that lead to excessive water velocity. This can create a passage barrier to upstream migrating fish. Velocities greater than one foot per second (fps) can create a barrier for juvenile salmon, regardless of the culvert length. For adult passage, velocities can range between two and six fps, depending on culvert length (NMFS 2001).

Excessive water velocity also can cause scouring at the downstream end of a culvert leading to a "perched" culvert requiring migrating fish to jump just to access the culvert. A perched situation can also occur when a culvert is simply placed too high and dries out during periods of low flow, or is placed too far above the stream at the outflow, thereby preventing fish from accessing it or safely exiting (Sylte 2002; Flanders 2000). NMFS (2008a) states that there should ideally be no difference in water height between water inside a culvert and water in the adjacent stream; and offers criteria for maximum jump heights.

Culverts can also impact a stream's geomorphology by trapping sediment above the culvert and increasing erosion below through a process called downcutting (Castro 2003; Wheeler et al. 2005). Downstream scour of stream bed and banks often occurs when large flow events through inadequately- sized culverts create a fire hose effect, mobilizing sediment and potentially eroding stream banks. This situation not only introduces excess sediment into the stream (potentially smothering redds), but also can remove riparian vegetation, a vital component of salmonid habitat. These physical changes can impact the entire lotic system, particularly harming macroinvertebrates that are prey for salmon (Vaughan 2002).

Numerous other effects resulting from the presence of culverts have been identified. These include loss of ecological connectivity, loss of (or excessive) transport of sediment and woody debris downstream, loss of spawning or rearing habitat, and effects on benthic invertebrates and aquatic vegetation (Bates et al. 2003). It is important to remember that various culvert characteristics can act synergistically, even when one factor alone isn’t enough to adversely affect habitat. For example, a too-steep slope can be mitigated by the presence of instream structure that allows for resting pockets and serves to slow water velocity. However, a too-steep slope plus lack of instream structure can make a culvert less passable for fish than if only one of those conditions existed.

The cumulative effects of multiple culverts in a stream system and multiple adverse elements associated with each culvert can increase the physiological stress of migrating salmon and may lower the probability of successful passage and subsequent adult spawning.

*Potential Conservation Recommendations for Culvert Construction*

NMFS (2001), Bates et al. (2003), and NMFS (2008a) offer design criteria that address the effects listed above. These criteria are often incorporated into conservation recommendations for individual projects, in ESA and EFH consultations, and could be used to develop a general suite of conservation recommendations germane to culvert construction.

- In instances where culverts are used to bridge stream crossings, specific engineering care should be given to maintain the stream’s ecological function including use of alternative designs such as Active Channel Design, Stream Simulation Design and Hydraulic Design.
- Where applicable, baffles, weirs, and resting pools should be established to create hydraulic refuges for upstream migrating fish.
- Water velocities and jump heights should not exceed the swimming performance of critical life stages for Pacific salmon (adult or juvenile) or be increased beyond NMFS’s culvert specific passage criteria.
- Regular maintenance should be conducted to ensure culverts remain clear of debris, operable, and have suitable hydraulic conditions.
- Where applicable, alternatives to culverts (such as bridges) should be explored.

#### 4.2.2.10 Dam Construction/Operation

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

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

Dams are also a barrier to downstream passage of juveniles. In general, reservoirs and water diversions (see Section 4.2.2.19 Irrigation Water Withdrawal, Storage, and Management)) reduce water velocities and change current patterns, resulting in increased migration times (Raymond 1979), exposure to less favorable environmental conditions, and increased exposure to predation. At dams, injury and mortality to juveniles occurs as a result of passage through turbines, sluiceways, juvenile bypass systems, and adult fish ladders. Encounters with turbine blades, rough surfaces, or solid objects can cause death or injury. Changes in pressure within turbines or over spillways also can result in death or injury. Juveniles, frequently stunned and disoriented as they are expelled at the base of the dam, are particularly vulnerable to predation (PFMC 1988). Dams also result in changes in concentrations of dissolved oxygen and nitrogen. Above the dams, slow-moving water has lower dissolved oxygen levels than faster, turbulent waters, a factor that may stress fish (Spence et al. 1996). Below hydroelectric facilities, nitrogen supersaturation may also negatively affect migrating as well as incubating or rearing salmon by causing gas-bubble disease. Gas bubble disease increases in years of high flow and high spill.

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

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

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

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

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

*Potential conservation measures for dam construction/operation*

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

- Operate facilities to create flow conditions adequate to provide for passage, water quality, proper timing of life history stages, avoid juvenile stranding and redd dewatering, and maintain and restore properly functioning channel, floodplain, riparian, and estuarine conditions. Specific flow objectives have been developed for the Columbia and Snake river and Sacramento bay/delta river systems and other systems with federally operated facilities where there are species listed under the ESA, through FERC orders, through specific legislative acts (e.g., the Central Valley Water Improvement Act, the Bay-Delta Accord), water quality orders, and through legal settlement agreements. Federal projects are operated within the context of the projects' authorized purposes, applicable state water laws, and contractual commitments.
- Provide adequate designing and screening for all dams, hydroelectric installations, and bypasses to meet specific passage criteria developed by the Columbia Basin fish managers.
- Develop water and energy conservation guidelines and integrate them into dam operation plans and into regional and watershed-based water resource plans.
- Provide mitigation (including monitoring and evaluation) for unavoidable adverse effects on salmon EFH operation.

#### *4.2.2.11 Debris Removal*

Organic Debris

Natural occurring flotsam such as LWD and macrophyte wrack (i.e., kelp) is often removed from streams, estuaries, and coastal shores. This debris is removed for a variety of reasons including dam operations, irrigation levee protection, aesthetic concerns, and commercial and recreational uses. Because the debris affects habitat function and provides habitat for aquatic and terrestrial organisms, removing it may change the ecological balance among riverine, estuarine, and coastal ecosystems.

*Potential Adverse effects from organic debris*

LWD and macrophyte wrack promote habitat complexity and structure to various aquatic and shoreline habitats. The structure provides cover for managed species, creates habitats and microhabitats (e.g., pools, riffles, undercut banks, side channels), and retains gravels and can maintain the underlying channel structure (Abbe and Montgomery 1996; Montgomery et al. 1995; Ralph et al. 1994; Spence et al. 1996) in riverine systems. Its removal reduces these habitat functions. Reductions in LWD input to estuaries have reduced the spatially complex and diverse channel systems that provide for productive salmon habitat (NRC 1996). Woody debris also plays a significant role in salt marsh ecology (Maser and Sedell 1994). Reductions in woody debris input to the estuaries may affect the ecological balance of the estuary. LWD also plays a significant role in benthic ocean ecology, where deep-sea wood borers convert the wood to fecal matter, providing terrestrial based carbon to the ocean food chain (Maser and Sedell 1994). Dams and commercial in-river harvest of LWD have dwindled the supply of wood, jeopardizing the ecological link between the forest and the sea (Collins et al. 2002; Collins et al. 2003; Maser and Sedell 1994).

Species richness, abundance, and biomass of macrofauna (e.g., sand crabs, isopods, amphipods and polychaetes) associated with beach wrack are higher compared to beach areas with lower amounts of wrack or that are groomed (Dugan et al. 2000). The input and maintenance of wrack can strongly influence the structure of macrofauna communities including the abundance of sand crabs (*Emerita analoga*) (Dugan et al. 2000), an important prey species to some EFH managed species. Beach grooming can substantially alter the macrofaunal community structure of exposed sand beaches (Dugan et al. 2000). In addition, there are concerns that beach grooming efforts to remove wrack may also harm the eggs of the grunion (Leuresthes tenuis), an important prey item of EFH managed species.

*Potential conservation measures for organic debris removal*

- Remove woody debris only when it presents a threat to life or property. Leave LWD wherever possible. Reposition, rather than remove woody debris that must be moved.
- Encourage appropriate Federal, state, and local agencies to add secured engineered LWD log jams to river systems that are lacking in LWD and have maintenance constraints.
- Encourage appropriate Federal, state, and local agencies to prohibit or minimize commercial removal of woody debris from rivers, estuaries, and beaches.
- Encourage appropriate Federal, state, and local agencies to aid in the downstream movement of LWD around dams, rather than removing it from the system.
- Educate landowners and recreationalists about the benefits of maintaining LWD.
- Localize beach grooming practices and minimize it whenever possible.
- Conduct beach grooming only above the semilunar high tide as soon as the grunion spawning period begins in the spring, and continue 2 weeks after the last grunion spawning runs are observed in the summer.
- Familiarize beach maintenance staff with the importance of such practices.

#### Inorganic Debris

Marine debris is a problem along much of U.S. coastal waters, littering shorelines, fouling estuaries, and creating hazards in the open ocean. Marine debris consists of a huge variety of man-made materials such as general litter, dredged materials, hazardous wastes, and discarded or lost fishing gear. It enters waterways either indirectly through rivers and storm drains or by direct ocean dumping. Marine debris can have serious negative effects on EFH. Although several legislative laws and regulatory programs exist to prevent or control the problem, marine debris continues to severely impact our waters.

Congress has passed numerous legislative acts intended to prevent the disposal of marine debris in U.S. ocean waters. These include the Marine Protection, Research, and Sanctuaries Act, Titles I and II (also known as the Ocean Dumping Act), The Federal Water Pollution Control Act (Clean Water Act), and the Comprehensive Environmental Response, Compensation, and Liability Act. The International Convention for the Prevention of Pollution from Ships, commonly known as MARPOL Annex V (33 CFR 151), is intended to protect the marine environment from various types of garbage by preventing ocean dumping if the ship is less than 25 nautical miles from shore. Dumping of unground food waste and other garbage is prohibited within 12 nautical miles from shore, and ground non-plastic or food waste may not be dumped within 3 nautical miles of shore. The Ocean Dumping Act implements the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (London Dumping Convention) for the United States. Section 311 of the Federal Water Pollution Control Act makes it unlawful for any person to discharge any pollutant into the waters of the United States except as authorized by law. The Comprehensive Environmental Response, Compensation, and Liability Act stipulates that releases of hazardous substances in reportable quantities must be reported, and the release must be removed by the responsible party. Regulations implementing these acts are intended to control marine debris from ocean sources, including galley waste and other trash from ships, recreational boaters and fishermen, and offshore oil and gas exploration and facilities.

Land-based sources of marine debris account for about 80 percent of the marine debris on beaches and in our waters. Debris from these sources can originate from combined sewer overflows and storm drains, storm-water runoff, landfills, solid waste disposal, poorly maintained garbage bins, floating structures, and general littering of beaches, rivers and open waters. Typical debris from these land-based sources includes raw or partially treated sewage, litter, hazardous materials, and discarded trash. Legislation and programs that address these land-based sources of pollution include the BEACH Act, the National Marine Debris Monitoring Program (NMDMP), the Shore Protection Act of 1989, and the Clean Water Act. The BEACH Act authorizes the EPA to fund state, territorial, Tribal, and local government programs that test and monitor coastal recreational waters near public access sites for microbial contaminants and to assess and monitor floatable debris. The NMDMP is a 5-year study designed to provide statistically valid estimates of marine debris affecting the entire U.S. coastline and to determine the main sources of the debris. The Shore Protection Act contains provisions to ensure that municipal and commercial solid wastes are not deposited in coastal waters during vessel transport from source to the waste receiving station. The Clean Water Act requires the EPA to develop and enforce regulations that treat storm water and combined sewer overflows as point source discharges requiring National Pollution Discharge Elimination System (NPDES) permits that prohibit non-storm water discharges into storm sewers.

### *Potential adverse impacts from inorganic debris*

Land- and ocean-based marine debris is a very diverse problem and adverse effects on EFH are likewise diverse. Floating or suspended trash can directly affect fish that consume or are entangled in the debris. Toxic substances in plastics can kill or impair fish and invertebrates that use habitat polluted by these materials which persist in the environment and can bioaccumulate through the food web. Once floatable debris settles to the bottom of estuaries, coastal, and open ocean areas, it may continue to cause environmental problems. Plastics and other materials with a large surface area can cover and suffocate immobile animals and plants, creating large spaces devoid of life. Currents can carry suspended debris to underwater reef habitats where the debris can become snagged, damaging these sensitive habitats. The typical floatable debris from combined sewer overflows includes street litter, sewage containing viral and bacterial pathogens, pharmaceutical by-products from human excretion, and pet wastes. It may contain condoms, tampons, and contaminated hypodermic syringes, all of which can pose physical and biological threats to EFH. Suspended organic matter has a high biological oxygen demand, and its reduction can cause algal blooms and anoxia that are detrimental to productive marine habitats.

### *Potential conservation measures for inorganic debris*

- Encourage proper trash disposal in coastal and ocean settings.
- Advocate and participate in coastal cleanup activities.
- Encourage enforcement of regulations addressing marine debris pollution and proper disposal.
- Provide resources and technical guidance for development of studies and solutions addressing the problem of marine debris.

- Provide resources to the public on the impact of marine debris and guidance on how to reduce or eliminate the problem.

#### *4.2.2.12 Desalination*

Global population growth continues to place high demand on available supplies of potable water, and areas with limited supplies of this essential resource are turning to desalination (Roberts et al. 2010). Recent estimates suggest that up to 24 million cubic meters of desalinated water are produced daily (Latterman and Hoepner 2008). Expansion of desalination capacity can be found in the U.S., Europe, China, and Australia. California is leading the way in the U.S., with projections that up to 20 new desalination plants, with a capacity of 2 million cubic meters per day, will be constructed by 2030. Desalination plants have a strong potential to detrimentally impact the ecology of marine habitats from water extraction and discharge of effluent. The following discussion is taken, unless otherwise cited, from a recent critical review by Roberts et al. (2010) of the available, peer-reviewed literature on the effects of effluent discharge.

Desalination of seawater to produce potable water uses one of two basic processes: thermal distillation such as multi-stage flash (MSF) distillation, and reverse osmosis (RO). Both of these methods have a saltwater intake and an effluent discharge. The effluent is water remaining after desalination and the concentrated salts from the seawater, commonly referred to as "brine". The brine also may contain various chemicals used in the desalination process, heavy metals from the machinery, and concentrated contaminants that were in the seawater. RO plants are increasingly common compared to the MSF plants.

The potential effects are largely concerned with intake of seawater, which can entrain and impinge marine organisms, and discharge of the brine, which can affect the physiochemistry, and therefore the ecology, at the discharge site and beyond. The effects from intake of seawater are similar to those described under Section 4.2.2.25 Power Plant Intakes, and will not be discussed here.

The discharge of brine can affect the salinity, temperature, and contaminant loading of the receiving body. Changes to salinity have been the most studied of these potential effects. Depending on the desalination method used, the design of the plant, and the salinity of the intake water, the salinity of the brine can range from as low as 37.3 parts per thousand to as high as 75 ppt. In general, for an RO plant, the salinity of the brine will be roughly double that of the intake water. Published research shows that the extent of the brine plume – the area where the salinity is elevated – varies greatly, from 10s of meters, to 100s of meters, or in extreme cases, to several kilometers from the discharge point. The extent of the plume depends on a variety of factors, including the capacity of the plant, the salinity of the brine, the location of the discharge, the design of the diffuser, and local hydrologic conditions. However, in most cases studied, the intensity of the plume diminishes rapidly with distance from the outfall, and is usually no greater than 2 ppt above background salinity within 20 m of the outlet.

Brine is usually denser than seawater and will, therefore, sink to the bottom and extend farther along the seafloor than at the surface. Where prevailing currents carry the plume further alongshore than offshore, the coastal fringe may be especially susceptible to impacts. During times of high tide, the brine may be concentrated around outfalls. Thus, the area impacted by the plume is likely to be both spatially and temporally variable.

A number of studies have shown that discharge of brine can lead to detectable ecological impacts to seagrass habitats, phytoplankton, invertebrate and fish communities. The effects on seagrasses are the most widely studied. However, the results of these studies are highly variable. Several studies on the Mediterranean seagrass *Posidonia oceana* showed clear adverse effects, with significant increases in mortality and leaf necrosis at increases of only 1-2 ppt. Others found no significant effects, even six years after plant operations began. A study on eelgrass (*Zoster marina*) from marine and estuarine waters of the Netherlands found increased mortality at salinities 30 ppt and 25 ppt respectively, which are at the upper end of the salinity range in these habitats (van Katwijk et al. 1999). This suggests that eelgrass, a species of particular importance to Pacific Coast salmon (Fresh 2007), is sensitive to salinity changes and could be at risk if exposed to a brine plume.

Infaunal and epifaunal invertebrate communities were found to be impacted by the brine plume in several studies. Close to the outfall, nematodes dominated the community and reduced diversity of other taxa up to 400 meters from the outfall. The diversity and abundance of benthic diatoms may also be reduced near the outfall. These communities are an important part of the food web upon which juvenile and adult salmon depend, and could be at risk from exposure to brine plumes. In contrast, other studies found no change in the macrobenthic organisms where the brine dissipated within 10 m from the outfall. Some of the studies that showed changes to the benthic community were associated with older plants that discharged excessive levels of copper, an issue that is largely avoidable.

Salinities of 55 ppt or higher were found to be acutely toxic to juvenile sea bream and larval flounder. The implications of this to Pacific Coast salmon are not clear, but suggest that brine discharge could affect their survival, depending on the location of the outfall. Salmon entering the estuarine and marine environment are undergoing smoltification, the adaptation to saltwater. During this time, they gradually adapt to full-strength seawater, and are under considerable physiological stress. Exposure to a concentrated brine plume at this sensitive life stage could increase this already high level of physiological stress and reduce their chances of survival.

Depending on the design of the plant, the brine may be warmer than the receiving waters. This is primarily limited to MSF plants, while RO plants tend to result in ambient temperature plumes. Because RO plants are becoming more common, relative to the MSF plants, this is a lesser problem than in the past. MSF plants can produces brines that are 10-15 degrees C warmer than the receiving waters. However, most studies have found that the thermal impacts dissipate quickly and typically diminish to background levels within tens of meters of the outfalls. The extent and severity of the thermal plume is dependent upon a variety of factors, such as the temperature of the discharge and receiving waters, the plant capacity, and local hydrologic conditions. Given the potentially high water temperatures in the immediate vicinity of the plume, there is a potential for salmon, particularly juveniles, to be affected. Mesa et al. (2002) found that exposure to increased temperature did not increase mortality or predation in juvenile Chinook salmon, but there was clear evidence of increased physiological stress.

Desalination can clearly impact the ecology of the receiving waters, but the extent of those effects depend on a variety of factors, such as plant capacity, discharge location and design, temperature and salinity differences between effluent and receiving water, and hydrologic conditions at the discharge site. Such variables should be considered when assessing the effects of these plants.

### *Potential conservation measures for desalination plants*

The following conservation measures for desalination plants are modified from “Guidelines for Desalination Plants in the Monterrey Bay National Marine Sanctuary” (NOAA 2010).

- Entrainment and Impingement:
  - Desalination plants should be designed and sited to avoid and minimize impingement and entrainment to the extent feasible. Desalination project proponents should investigate the feasibility of using subsurface intakes as an alternative to traditional intake methods. Other options for consideration should include, but may not be limited to: vertical and radial beach wells, horizontal directionally drilled and slant-drilled wells, seabed filtration systems and other sub-seafloor structures. Where feasible and beneficial, subsurface intakes should be used. It must be ensured however, that they will not cause saltwater intrusion to aquifers, negatively impact

    coastal wetlands that may be connected to the same aquifer being used by the intake, and they must address the likelihood of increased coastal erosion in the future. Subsurface intakes have the potential to minimize or eliminate impingement and entrainment impacts and improve the performance and efficiency of a desalination project by providing a certain level of pretreatment.
    - In cases where it has clearly been determined that sub-surface intakes are not feasible and that an open ocean intake is necessary, the use of appropriately sited existing pipelines of acceptable structural integrity should be investigated and if feasible, pursued, to minimize impacts to the seafloor. If a new pipeline is necessary, sub- seafloor placement should be evaluated to minimize disturbances to biological resources and to recreational and commercial activities.
    - When it is necessary to use an open ocean intake, other methods to minimize impingement and entrainment should be evaluated and pursued. These should include design alternatives such as placement of the intake structure to avoid sensitive habitat or highly productive areas, screening the intake ports, if feasible, increasing the number of intake ports, or decreasing the intake velocity. The project proponent should determine expected entrainment and impingement impacts associated with various intake velocities and screen mesh sizes, based upon long-term monitoring data from the area, including diurnal and seasonal variations in planktonic abundance and location.
    - Any impacts to EFH and the biota it supports that cannot be avoided through project design or operations should require mitigation. The necessary level of mitigation should be determined through the use of a biologically based model, such as the habitat production foregone method, in order to account for all “non-use” impacts to affected biota. Mitigation projects should attempt to directly offset the impacted species or habitat (in-place, in-kind mitigation).

- Brine Discharge
    - Desalination project proponents should investigate the feasibility of diluting brine effluent by blending it with other existing discharges. The proponent should evaluate the use of measures to minimize the impacts from desalination plant discharges including discharging to an area with greater circulation or at a greater depth, increasing in the number of diffusers, increasing the velocity while minimizing the volume at each outlet, diluting the brine with seawater or another discharge, or use of a subsurface discharge structure.
    - The project proponent should provide a detailed evaluation of the projected short- term and long-term impacts of the brine plume on marine organisms based on a variety of operational scenarios and oceanographic conditions. Modeling should address different types of seasonal ocean circulation patterns, including consideration of “worst case scenarios”.
    - Results of accepted plume models should be included, to illustrate how the plume will behave during variable oceanographic conditions. The plume model should estimate salinity concentrations at the discharge point, as well as where and when it would reach ambient ocean concentrations. The extent, location, and duration of the plume where the salinity is 10 percent above ambient salinity should also be provided.
    - The project proponent should provide information on the physical and chemical parameters of the brine plume including salinity, temperature, metal concentrations, pH, and oxygen levels. These water quality characteristics of the discharge should conform to California Ocean Plan requirements and should be as close to ambient conditions of the receiving water as feasible.
    - A continuous monitoring program should be implemented to verify the actual extent of the brine plume, and to determine if the plume is impacting EFH. If it is, then mitigation for the EFH impact should be required.

- Use of Chemicals for Treatment and Cleaning
    - The project proponent should provide a complete list of all chemicals that may be used for the desalination plant as well as how these will be stored and disposed. They should also include an evaluation of the potential for these chemicals to cause impacts to local marine organisms.

    - The project proponent should identify and quantify all procedures and chemicals to be used for cleaning and maintaining the outfall and intake structures, filter membranes, and all other aspects of the plant. This should also include a detailed spill prevention and response plan for chemicals stored at project site.
    - The project proponent should evaluate the feasibility of using alternative pretreatment techniques such as ozone pretreatment, subsurface intakes, and membrane filtration, aimed at reducing the use of chemicals.

- Plant Site Selection and Structural and Engineering Considerations:
    - Desalination plant intakes should be sited to avoid sensitive habitats. For open-water intakes, areas of high biological productivity, such as upwelling centers or kelp forests or other dense beds of SAV should be avoided, since the entrainment and impingement impacts of a desalination plant are in large part dictated by the biological productivity in the vicinity of that intake.
    - Desalination plant intakes and discharges should not be located in or near HAPCs.
    - Areas with limited water circulation such as enclosed bays or estuaries, which can “trap” the brine discharge, should be avoided. Instead, brines should be discharged in areas with strong tidal currents to achieve more rapid dilution of the brine by the receiving waters.
    - Intake and discharge pipelines should be placed and configured to avoid sensitive biological areas.

#### *4.2.2.13 Dredging and Dredged Spoil Disposal*

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

<u>*Potential adverse effects from dredging and dredged spoil disposal*</u>

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

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

The suspended sediments dredged from estuarine and coastal marine systems are generally high in organic matter and clay, both of which may be biologically and chemically active. Dredged spoils removed from areas proximate to industrial and urban centers can be contaminated with heavy metals, organochlorine compounds, polyaromatic hydrocarbons, petroleum hydrocarbons, and other substances (Kennish 1997) which may be released into the water column during the dredging operation. Sediments in estuaries downstream from agricultural, or urban/suburban residential, areas may also contain herbicide and pesticide residues (NMFS 1997).

Dredging and subsequent sediment deposition poses a potential threat to the eelgrass and other aquatic vegetation in estuaries and nearshore marine ecosystems, which provide important structural habitat and prey for salmon (see Section 4.2.2.14 Estuarine Alteration). Dredging not only removes plants and reduces water clarity, but can change the entire physical, biological, and chemical structure of the ecosystem (Phillips 1984). Dredging also can reverse the normal oxidation/reduction potential of the sediments of an eelgrass system, which can reverse the entire nutrient-flow mechanics of the ecosystem (Phillips 1984).

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

*Potential conservation measures for dredging and dredged spoil disposal*

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

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

#### 4.2.2.14 Estuarine Alteration

Estuaries represent transitional environments coupling land and sea water. The dominant features of estuarine ecosystems are their salinity variances; typically shallow areas; high biological productivity and diversity; which, in turn are governed by the tides and the amount of freshwater runoff interacting with coastal topography. These systems present a continuum along a fresh-brackish-salt water gradient as a river system empties into the sea. There is a very large range of sizes of estuary systems from the mouth of a small coastal stream to Puget Sound or Chesapeake Bay. The combination of mixed salinity and sediment deposition within shallow coastal waters results in areas of high and uneven advection from winds and currents, forming diverse structures and ecological processes. Estuarine ecosystems, containing a large diversity of species that reflect the great structural diversity and resultant differentiation of niches, may be characterized as:

- Unique hydrological features by which fresh water slows and flows over a wedge of heavier intruding tidal salt water resulting in suspended terrestrial and autochthonous products settling into the inflowing salt water or into bottom sediments.
- Shallow nutrient-rich environments resulting in an enormously productive vegetative habitat and detrital food chain for many organisms, such as crustaceans and juvenile fish.
- Critical nursery habitats for m any aquatic o organisms, particularly anadromous fish and ecotones for shore birds and waterfowl.
- Contributing to the “trapping” and recycling of nutrients: a n area w here an accumulation of nutrients such as potassium and nitrogen are concentrated and recycled – a repeating interactive process by which the incoming tidal water re-suspends nutrients at the fresh-salt water interface while moving them back up the estuary, and the land-based sources of nutrients move towards the sea.
- Depending on the depths, timing and volumes of marine inflows, estuarine conditions may be influenced to a large degree by constituents of the marine waters. For example, more acidic and cooler waters in Puget Sound are mostly the result of marine inflows.
- Accumulating fine sediments transported in by tides and rivers, further enhancing productivity by being adsorptive surfaces for nutrients.

In Oregon where there are relatively few estuarine wetlands because of the steep topography of the shore, it is estimated that between 50 percent and 90 percent of the t tidal marsh s systems in estuaries have been lost in the past century (Frenkel and Morlan 1991). The estuarine environment benefits salmon by providing a food rich environment for rapid growth, physiological transition between fresh and salt water environments, and refugia from predators (Simenstad 1983). Estuarine eelgrass beds, macroalgae, emergent marsh vegetation, marsh channels, and tidal flats provide particularly important estuarine habitats for the production, retention, and transformation of organic matter with in the estuarine food web as well as a direct source of food for salmon and their prey. Additionally, estuarine marsh vegetation, overhanging riparian vegetation, eelgrass beds, and shallow turbid waters of the estuary provide cover for predator avoidance. As noted by Salo (in Groot and Margolis 1991), “the food web supporting juvenile salmonids in the estuarine habitat appears to be detritus-based.” Since estuarine detritus comes from mostly local marine and riparian plants, the food web relies on actions that sustain and protect plant production in-water and along shorelines. Estuaries provide enough habitat variety to allow the numerous species and stocks of salmonids to segregate themselves by niche.

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

For juvenile coho salmon, LWD is an important element of estuarine habitat (McMahon and Holtby 1992).

During their residence time in estuaries, small coho salmon consume large planktonic or small nektonic animals, such as amphipods, insects, mysids, decapod larvae, and larval juvenile fishes (Myers and Horton 1982; Simenstad et al. 1982; Dawley et al. 1986; McDonald et al. 1987). In estuaries, larger salmon smolts prey on fishes that inhabit intertidal and pelagic habitats with deep marine-influenced habitats often preferred (Pearce et al. 1982; Dawley et al. 1986; McDonald et al. 1987). The estuarine residence time of juvenile coho salmon is highly variable, ranging from days to months, and is probably correlated with age of emigration, with younger fish spending more time in the estuary than older fish (Powers et al. 2006).

Although pink salmon generally pass directly through the estuary en route to nearshore areas, populations that do reside in estuaries for one to two months utilize shallow, protected habitats such as tidal channels and consume a variety of prey items, such as copepods, amphipods, and larvae and pupae of various insects (Heard and Salo, in Groot and Margolis, 1991).

There are four general categories of impacts on estuarine ecosystems: *enrichment* with excessive levels of organic materials, inorganic nutrients, or heat; *physical alterations* which include hydrologic changes, removal of natural woody material, dredging to deepen for navigation, and filling to convert marine to uplands; *introduction of toxic materials*; *introduction of exotic species* leading to direct changes in species composition and food web dynamics.

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

Jaworski (1981) discusses sources of nutrients and scale of eutrophication problems in estuaries. Addition of excessive levels of organic matter to estuarine waters results in elevated pathogens and lowered dissolved oxygen concentrations which then results in concomitant changes in community structure and metabolism. Inorganic nutrients from mineralization of the organic matter can stimulate dense algal blooms and lead to another source of excessive organic matter. The source of high levels of organic matter is normally stormwater or sewage waste water, and high levels historically resulted from seafood processing wastes and industrial effluents (Weiss and Wilkes 1974). Impacts from thermal loading include interference with physiological processes, behavioral changes, disease enhancement, and impacts from changing gas solubilities. These impacts may combine to affect entire aquatic systems by changing primary and secondary productivity, community respiration, species composition, biomass, and nutrient dynamics (Hall et al. 1978). (Note the references from 1974 to 1981 refer to conditions common at those times. The seriousness of those conditions does not reflect widespread compliance with NDPES permits etc. in the past 30 years. The degree that eutrophication of estuaries remains a major issue varies widely over the US.)

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

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

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

*Introduction of exotic species* has the potential to change species composition and food web dynamics. See Section 4.2.2.18 Introduction/Spread of Invasive Alien Species for further detail.

Note that predation can also be an issue. Changes to food webs or physical conditions from any of the four general categories of impacts can result in elevated or different risks from predators.

*<u>Potential conservation measures for estuarine alteration</u>*

The following suggested measures are adapted from NMFS (1997), NMFS (1997d), Lockwood (1990), and Meyer, (1997 pers. comm.).

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

- Minimize alteration of shallow estuarine habitat in areas of salmon EFH, including eelgrass beds, tidal channels, and estuarine and tidally-influenced marshes. Minimize effects through appropriate site design, engineering, best management practices, and mitigate all unavoidable adverse effects (See EPA 1993; Metro 1997; SCS Enginners 1989).
- Utilize BMPs for controlling pollution from marina operations, boatyards, and fueling facilities.
- Design appropriate restoration and mitigation performance objectives for properly functioning conditions and values of EFH and monitor achievement of these objectives. Restoration of shallow water habitat is paramount.
- Utilize the placement of woody debris as a part of marsh and estuary enhancement and mitigation work; avoid scavenging logs from estuarine areas; re-position, rather than remove, logs that are hazardous to navigation within river or estuary; and maximize removal of dikes where possible.
- Promote awareness and use of the U.S. Department of Agriculture’s (USDA’s) Wetland Reserve Program to encourage restoration of estuarine habitat.
- Maximize maintenance of freshwater inflow to estuaries. Ideally peak flows could also be provided to sustain and recover natural processes.

- Design culvert replacements and repairs in EFH to increase fish passage for both adult and juvenile fish.

#### *4.2.2.15 Flood control maintenance*

The protection of riverine and estuarine communities from flooding events can result in varying degrees of change in the physical, chemical, and biological characteristics of existing shoreline and riparian habitat. Land surrounding rivers is in high demand for agricultural and developmental purposes, prompting creation of artificial structures that improve flood control (SRSRB 2006). These structures include levees, weirs, channels, and dikes.

*Potential adverse effects from flood control and maintenance*

Managing flood flows with these structures can disconnect a river from its floodplain eliminating off-channel habitat important for salmon (WSCC 2001b) Floodplains serve as a natural buffer to changes in water flow: they retain water during periods of higher flow and release it from the water table during reduced flows (Ziemer and Lisle 2001). These areas are typically well vegetated, lowering water temperatures, regulating nutrient flow and removing toxins. Juvenile salmon use these off channel areas because their reduced flows, greater habitat complexity and shelter from predators may increase growth rates and their chance of survival.

Artificial flood control structures have similar effects on aquatic habitat, as do bank stabilization efforts and woody debris removal. Riverbanks are artificially steepened, eliminating much of the inshore, shallow-water habitat used by larval and juvenile salmonids. Channel complexity is also lost, reducing naturally formed pool-riffle sequences (NMFS 2008c). Pools provide deepwater habitat for larger fish, as well as thermal and spatial refugia during low flow periods. Riffles support benthic invertebrates and juvenile fishes (Thompson 2002). The woody debris that provides shelter and helps structure heterogeneous flows is also lost (USFWS 2000). As a result, water moves at a uniform, increased rate, thereby decreasing spawning habitat and altering sediment dynamics. Sediment size distribution is important for providing habitat to salmonid prey items such as stoneflies and mayflies (NMFS 2009a). In addition, the routing of water through specific flood channels may isolate or strand migrating salmon. Earthen levees can be prone to failure due to cracks caused by rooting plants, and may thus be periodically cleared or stripped of vegetation, leaving denuded banks and barren riparian zones. This leads to decreased shading, higher water temperatures, less LWD recruitment, reduced filtering of overland nutrients, sediment, and toxics, and a loss of bank stability.

The use of dikes and berms can also have long-term adverse effects in tidal marsh and estuarine habitats. Dikes, levees, ditches, or other water controls at the upper end of a tidal marsh can cut off all tributaries feeding the marsh, preventing freshwater flushing and annual flushing, annual renewal of sediments and nutrients, and the formation of new marshes. Water controls within the marsh proper intercept and carry away freshwater drainage, block freshwater from flowing across seaward portions of the marsh, increase the speed of runoff of freshwater to the bay or estuary, lower the water table, permit saltwater intrusion into the marsh, and create migration barriers for aquatic species. In deeper channels where reducing conditions prevail, large quantities of hydrogen sulfide are produced that are toxic to marsh grasses and other aquatic life. Acid conditions of these channels can also result in release of heavy metals from the sediments.

Long-term effects on the tidal marsh include land subsidence (sometimes even submergence), soil compaction, conversion to terrestrial vegetation, greatly reduced invertebrate populations, and general loss of productive wetland characteristics. Loss of these low-salinity environments reduces estuarine fertility, restricts suitable habitat for aquatic species, and creates abnormally high salinity during drought years. Low-salinity environments form a barrier that prevents the entrance of many marine species, including competitors, predators, parasites and pathogens.

*Potential conservation measures for flood control and maintenance*

- Minimize the loss of riparian habitats as much as possible.
- The diking and draining of tidal marshlands and estuaries should not be undertaken unless a satisfactory compensatory mitigation plan is in effect and monitored.
- Wherever possible, "soft" approaches (such as beach nourishment, vegetative plantings, and placement of LWD) to shoreline modifications should be utilized.
- Include efforts to preserve and enhance EFH by providing new gravel for spawning areas; removing barriers to natural fish passage; and using weirs, grade control structures, and low flow channels to provide the proper depth and velocity for fish.
- Construct a low-flow channel to facilitate fish passage and help maintain water temperature in reaches where water velocities require armoring of the riverbed.
- Replace in-stream fish habitat by providing rootwads, deflector logs, boulders, and rock weirs and by planting shaded riverine aquatic cover vegetation.
- Use an adaptive management plan with ecological indicators to oversee monitoring and ensure mitigation objectives are met. Take corrective action as needed.
- Retain trees and other shaded vegetation along earthen levees.
- Screen inappropriate flood control channels.
- Ensure adequate inundation time for floodplain habitat that activates and enhances near-shore habitat for juvenile salmon.
- Ramp and convey flood flows appropriately to reduce stranding events.
- Reconnect wetlands and floodplains to channel/tides.

#### *4.2.2.16 Forestry*

Forest practices can affect salmon habitat in several ways. Construction, reconstruction, maintenance, and use of roads associated with forestry can block fish access to streams, and can increase sediment delivery to streams and reduce stream substrate functions for fish and their prey. Tree felling, yarding, and site preparation, particularly if near the stream or on unstable slopes, can also increase sediment delivery, can cause loss of large wood for stream channel structure, can reduce shade and increase stream temperature, and can alter instream nutrients and hydrology (Beschta et al. 1987; Bisson et al. 1987; Chamberlin et al. 1991; Spence et al. 1996; Grant et al. 2008). The effects of forest practices are summarized below in terms of their effects on these salmon habitat elements: stream substrate, water temperature, other water quality components, wood and stream channel complexity, hydrology, habitat connectivity and beaver habitat.

*Stream Substrate*
Certain forest management activities including tree felling and yarding in riparian areas and on unstable slopes, and particularly road construction, increase sediment delivery to streams through increased surface erosion and mass wasting (Furniss et al. 1991; FEMAT 1993; Spence et al. 1996; Lee et al. 1997; McClelland et al. 1997). Tree felling, log yarding, and site preparation (e.g., prescribed burning and scarification prior to planting) adjacent to streams or with narrow buffers between the activities and streams can deliver sediment directly to streams (Chamberlin et al. 1991; Murphy 1995; Rashin et al. 2006). Streamside buffer strips of 75 to100 feet in width are adequate to filter out most upslope sediment (King 1979; Megahan and Ketcheson 1996); buffers as small as 30 feet in width are adequate in some cases, depending on slope, soil type, amount of disturbance, etc. (Rashin et al. 2006). Road construction, maintenance, and use (particularly during wet weather) deliver sediment to streams mainly through road surfaces, road-side ditches, and road intersections with streams (Reid and Dunne 1984). Those channelized sources are not effectively mitigated by no-cut buffers. Erosion rates decline after completion of road

construction; however, unpaved road surfaces continually erode fine sediments and add significant amounts of sediment to streams (Reid and Dunne 1984; Swanston 1991; Croke and Hairsine 2006; Cover et al. 2008). Also, road construction or improper road maintenance on unstable slopes can greatly increase landslide rates and deliver large pulses of sediment to streams (Swanson and Dryness 1975; Swanston and Swanson 1976; Furniss et al. 1991; McClelland et al. 1997; Robison et al. 1999; Jakob 2000). Road culverts and associated fills can also be a source of sediment pulses, especially if culverts become plugged or fail (Furniss et al. 1991; Murphy 1995; Beechie et al. 2005).

Increased sediment delivery to streams causes sedimentation of stream substrates. This reduces habitat availability for aquatic invertebrates on which juvenile salmon feed, and also reduces exchange of oxygenated water in spawning gravels, which decreases survival of salmon eggs and embryos (Bjornn and Reiser 1991; Murphy 1995). Sedimentation-induced reduction in habitat quality for invertebrates causes reduction in food supply for, and growth rates of juvenile salmonid fishes (Waters 1995; Shaw and Richardson 2001; Suttle et al. 2004). Sedimentation also degrades spawning substrates for eggs and embryos, and reduces the quality of pool habitat and overwintering habitat for juvenile salmonid fishes (Platts et al. 1989; Furniss et al. 1991; Waters 1995; Gucinski et al. 2001; Suttle et al. 2004; Cover et al. 2008).

*Water Temperature*

Forest management can increase stream temperatures by reducing the density of the riparian vegetative canopy and stream shade, and thereby increasing the amount of solar radiation reaching streams (Brown 1970; Brown and Krygier 1970; Brazier and Brown 1973; Steinblums 1977; Steinblums et al. 1984; Brosofske et al. 1997; Johnson and Jones 2000; Kiffney et al. 2003; 2004; Moore et al. 2005a; Pollock et al. 2009; Groom et al. 2011). The amount of stream shade following clearcut tree felling is related to the width of no-cut buffers (Brazier and Brown 1973; Steinblums 1977; Steinblums et al. 1984; Kiffney et al. 2003; Gomi et al. 2005; Moore et al. 2005a; Fleuret 2006), but the relationship is quite variable, depending on site-specific factors such as stream size, stream channel aspect, topography, forest structure and forest species composition (Moore et al. 2005a). The thermal responses of streams to reductions in riparian canopy density also are variable, and are affected by the geomorphic and hydrologic conditions within the subject stream reaches (Story et al. 2003; Johnson 2004; Moore et al. 2005b; Janisch et al. 2012). In some instances (such as narrow streams with dense, overhanging streamside vegetation, or stands on the north sides of streams with an east-west orientation), no-cut buffers as narrow as 30 feet adjacent to clearcut units can maintain stream shade (Brazier and Brown 1973). Other studies indicate that buffers of 100 feet or greater in width are needed in some circumstances to protect streams from temperature increases due to adjacent clearcuts (Steinblums et al. 1984; Kiffney et al. 2003).

Forest thinning can increase the amount of solar radiation penetrating through no-cut buffers, depending on the intensity of thinning (Chan et al. 2004). Although the available published studies on effects of thinning are not sufficient to establish quantitative relationships, reductions in stream shade due to thinning are likely to increase stream temperatures in some situations.

Forest management can also affect stream temperatures by altering factors internal to the stream such as width/depth ratios and the connectivity of streams with floodplains (Beschta et al. 1987; Bisson et al. 1987; Bilby and Bisson 1998; Johnson and Jones 2000; Pollock et al. 2009). Increases in sedimentation generally increase the width and reduce the depth of streams, and such streams are more prone to warming by sunlight (Poole and Berman 2001; Poole et al. 2001a; 2001b). Constructing roads or logging on unstable slopes can increase the rate of landslides that propagate downstream as debris flows, which reduce riparian vegetation, stream shade and the amount of woody material in streams (Johnson and Jones 2000; Pollock et al. 2009). Without this wood, affected streams collect less of the gravel that allows for hyporheic exchange of water, which can exert a significant cooling effect during the warm part of the day (Poole et al. 2001a; Story et al. 2003; Johnson 2004). The construction of road fills and the cutting of road side slopes can intercept groundwater (Furniss et al. 1991) that in some situations otherwise would cool stream segments.

Documented adverse effects on Pacific salmon from warm water temperature include: (1) delay or blockage of adult migration (Sauter et al. 2001); (2) increased adult mortality and reduced gamete survival during pre-spawn holding, and reduced spawning success (Berman 1990; McCullough et al. 2001; Marine 1992); (3) reduced growth of alevins or juveniles (McCullough et al. 2001; Marine 2004); (4) reduced competitive success relative to non-salmonid fishes (Reeves et. al. 1987; Sauter et al. 2001); (5) out-migration from unsuitable areas and truncation of spatial distribution (Dunham et al. 2001); (6) increased disease virulence, and reduced disease resistance (McCullough et al. 2001); and (7) potentially harmful interactions with other habitat stressors (Materna 2001).

*Other Water Quality Components*

**Suspended Sediment** – Increased yield of fine sediments caused by forestry activities (primarily roads but also activity-induced landslides and other sources of erosion) can increase suspended sediment in streams (Reid and Dunne 1984; Beschta 1990; Waters 1995; Hassan et al. 2005). Increases in suspended sediment can kill or injure fish. Exposures to very high concentrations of suspended sediment can kill fish (Newcombe and Jensen 1996). Sublethal effects include physiological stress and reduced feeding and growth (Redding et al. 1987; Gregory and Northcote 1993; Waters 1995; Newcombe and Jensen 1996; Wingfield et al. 1997; Shaw and Richardson 2001; Shrimpton et al. 2007) and reduced resistance to disease or toxicants (Redding et al. 1987; Waters 1995). Concentrations of suspended sediment that are below levels causing physiological harm can, however, provide increased cover and protection from predators (Gregory and Levings 1998).

**Nutrients/Productivity –** Although tree removal can increase water temperature and have the negative effects on salmon habitat noted above, it also can positively affect fish habitat. Decreasing shade increases the amount of photosynthetically active radiation reaching streams (Brosofske et al. 1997; Hetrick et al. 1998; Kiffney et al. 2003), and thereby increases primary (e.g., algal) and secondary (e.g., macroinvertebrate) productivity, provided that nutrients are not limiting (Kiffney et al. 2003; Kiffney et al. 2004; Mallory and Richardson 2005; Kiffney 2008). Tree removal and reduced uptake of soil nutrients by trees may increase nutrient levels in streams (Webster et al. 1990; McClain et al. 1998; Danehy et al. 2007); however, increases in nitrogen and phosphorous concentrations are either very small or short-lived (Megahan 1980; Hicks et al. 1991a; Salminen and Beschta 1991; Brown and Binkley 1994; Gravelle et al. 2009). Application of fertilizers to promote tree growth can result in drift, overland flow, or ephemeral stream transport of nutrients into streams (Norris et al. 1991), which also can increase primary productivity. Increases in primary productivity can increase the biomass of macroinvertebrate organisms, some of which are prey for juvenile salmon, although the diversity of macroinvertebrates may be reduced (Hicks et al. 1991a; Kiffney et al. 2005; Compton et al. 2006; Richardson 2008).

**Dissolved Oxygen/Litter Fall –** Increases in water temperature and primary productivity, and changes in delivery of organic matter due to logging can affect the concentration of dissolved oxygen in salmon habitats. Inputs of leaf litter and other organic matter may reduce dissolved oxygen through respiration by micro-organisms; however, those inputs also provide nutrients and food for aquatic invertebrates. Logging practices that introduce large quantities of organic debris in streams can greatly decrease dissolved oxygen concentration (Hall and Lantz 1969; Brown and Binkley 1994). Keeping logging debris out of stream channels is typically required under current forest practices, and therefore, changes in inputs of organic matter (and by association, dissolved oxygen) mainly relate to changes in riparian vegetation. Logging initially reduces the amount of organic matter input to streams (Webster et al. 1990; Bilby and Bisson 1992; Hetrick et al. 1998; Richardson and Danehy 2007), and then changes the composition of organic matter, as herbaceous plants and broadleaf shrubs replace conifers along the stream (Bonin et al. 2000; Piccolo and Wipfli 2002; Volk et al. 2003; Hart 2006). A recent study found that the effect of logging on total litter input was transient, with litter inputs in logged areas becoming similar after 7 years to unlogged control streams (Kiffney and Richardson 2010).

Increases in stream temperature alone can reduce dissolved oxygen concentrations by lowering saturation levels. However, where forest practices retain shade or allow rapid shade recovery such that temperatures are sufficiently low for oxygen saturation levels to remain above 8 parts per million, there may be little negative effect of temperature increase on dissolved oxygen in streams (Hynes 1960; Leitritz and Lewis 1980; Bjornn and Reiser 1991).

Rivers, estuaries, and bays were the primary means of transporting and storing logs historically in the Pacific Northwest. Log storage within the bays and estuaries remains an issue in several Pacific Northwest bays. Using estuaries, bays, and nearby uplands for storage of logs is common in Alaska, with most of Alaska's log transfer facilities (LTFs) in southeast Alaska, and a few in Prince William Sound.

An LTF is a facility which is constructed in whole or part in waters of the United States and which is utilized for the purpose transferring commercially harvested logs to or from a vessel or log raft, including the formation of a log raft (EPA 2000). LTFs may include a crane, an A-frame structure, conveyor, slide or ramp, and are used move logs into the water. Logs can also be placed in the water by helicopters and barges. The physical adverse effects of these structures on EFH are similar in many ways to those of floating docks and other "over-water" structures. Accumulation of bark debris is unique to LTFs. After the logs have entered the water, they are usually bundled into rafts and hooked to a tugboat for shipment. In the process, bark and other wood debris can pile up on the bottom of the waterway. The piles can smother clams, mussels, and some types of submerged vegetation, with the bark sometimes remaining for decades. Accumulation of bark debris in shallow and deep water environments has resulted in locally decreased richness and abundance of epifaunal macrobenthic invertebrate organisms (Jackson 1986; Kirkpatrick et al. 1998), which can reduce the availability of food for some species and life stages of groundfish.

Stored logs may release soluble, organic compounds. This can degrade groundfish EFH by significantly increasing biological oxygen demand within the area of accumulation (PNPCC 1971). High oxygen demand can lead to an anaerobic zone where toxic sulfide compounds are generated, particularly in brackish and marine waters. Leaching of soluble organic compounds also leads to reduced visibility and predation efficiency for EFH species. Reduced dissolved oxygen concentrations, anaerobic conditions, and the presence of toxic sulfide compounds thereby likely reduce the production of salmon and their forage organisms. Anaerobic areas also reduce available habitat. Soils at onshore facilities where logs are transferred often are contaminated with gasoline, diesel fuel, solvents, etc., from trucks and other machinery. These contaminants can leach into adjacent EFH.

The physical, chemical, and biological impacts of LTF operations can be substantially reduced by adherence to appropriate siting and operational constraints. In 1985, the Alaska Timber Task Force (ATTF) developed guidelines to "delineate the physical requirements necessary to construct a log transfer and associated facilities, and in context with requirements of applicable law and regulations, methods to avoid or control potential impacts from these facilities on water quality, aquatic and other resources." Since 1985, the ATTF Guidelines have been applied to new LTFs in Alaska through the requirements of NPDES permits and other state and Federal programs (EPA 1996). Adherence to guidelines such as the ATTF operational and siting guidelines and BMPs in the NPDES general permit for Alaska is likely to reduce the 1) amount of bark and wood debris that enters estuarine and marine EFH, 2) the potential for displacement or harm to aquatic species, and 3) accumulation of bark and wood debris on the substrate of waterways. The conservation measures for LTFs reflect these documents.

**Toxic Chemicals –** The use of herbicides, insecticides, fire retardants, and spill or leaching of petroleum products from forest roads can kill invertebrates that are food sources for fish can kill or injure fish. Herbicides applied directly to surface waters or entering by wind drift or leaching from near-stream soils can kill aquatic invertebrates (Hartman and Scrivener 1990). Forestry related doses of herbicides that are lethal to salmonid fishes (Reid 1993) would be unlikely except in the case of spills; however, sublethal doses are more likely; related sublethal adverse effects include reduced growth, altered behavior, and reduced resistance to physiological stress (Beschta et al. 1995; Spence et al. 1996). Norris et al. (1991) concluded that insecticides generally have shorter term effects on stream ecosystems than herbicides, but that initial negative effects on aquatic invertebrates can be dramatic. Documentation of the effects of upslope application of fire retardants on streams is scarce; however, when applied directly to streams, fire retardants can kill fish (Hakala et al. 1971; Norris and Webb 1989; Schullery 1989). Petroleum-based products (e.g., fuel, oil, hydraulic fluids) are moderately to highly toxic to fish and other aquatic organisms, depending on concentration and exposure time (Neff 1985). Free oil and emulsions can adhere to gills and interfere with respiration, and heavy concentrations of oil can suffocate fish. Evaporation, sedimentation, microbial degradation, and hydrology determine the fate of fuels entering fresh water (Saha and Konar 1986) and exposures of aquatic invertebrates and fish. Forest practices that avoid fueling near streams and include measures/equipment to avoid and contain spills (e.g., from log hauling and fuel trucks) can minimize the risk of exposure of fish to lethal concentrations of petroleum products. Practices that avoid leakage from logging machinery and transport trucks can reduce chronic inputs of petroleum products from forest road surfaces to streams, and reduce the risk of sublethal adverse effects on fish.

*Synthesis of Effects on Water Quality*

Roads constructed and used for forestry are a source of suspended sediment as well as substrate sedimentation, and thus have mostly detrimental effects on salmon and their habitat (Spence et al. 1996; Shrimpton et al. 2007). Logging that reduces canopy cover sufficiently to increase water temperature can cause physiological, behavioral, and ecological stresses on salmon, but also can increase primary production, invertebrate biomass, and fish biomass (Murphy and Hall 1981; Nislow and Lowe 2006). Increases in stream nutrient levels from tree removal and/or application of fertilizers can add to productivity; however, such increases are typically small and short duration (Salminen and Beschta 1991; Brown and Binkley 1994). Current forest practices tend to reduce organic inputs through litter fall initially, but these effects may also be short-lived (Kiffney and Richardson 2010). Increases in stream temperature, photosynthetically active radiation, primary productivity, and nutrients can reduce dissolved oxygen; however, these effects appear to be counterbalanced by positive effects on food production.

The competing effects of increased temperature on salmon behavior, physiology, and ecological interactions (negative) and increases in their prey base (positive) may be relatively short in duration, especially in small streams, where shade tends to become substantially re-established within a 10 years of logging (Moore et al. 2005a). Temperature increases in streams that have been subject to debris flows may be more persistent due to changes in channel form (Pollock et al. 2009). The overall significance of these changes to individual stream reaches can only be understood by using basin-scale analysis that examines the cumulative effects of short-term, localized temperature increases (Beschta et al. 1987; Brosofke et al. 1997). Loss of shade from logging along larger streams may have more enduring, although somewhat lesser effects on stream temperature, fish, and their food webs due to higher flows and greater dilution of added heat. While it is possible that logging can temporarily stimulate fish production through temperature and light-related mechanisms, chronic sedimentation of substrate from roads and the loss of instream wood (see discussion of channel complexity below) will tend to negate and outlast those potential positive effects and be detrimental to both prey organisms and physical habitat features important for spawning, incubation, and rearing of salmon (Murphy et al. 1986; Spence et al. 1996).

LTFs can reduce water quality through accumulation of bark debris and leaching of soluble organic compounds, which increases biological oxygen demand.

*Wood and Stream Channel Complexity*

In-stream wood regulates sediment and flow routing, influences stream channel complexity and stability; increases pool volume and area; retains non-woody organic matter, allowing it to be biologically processed prior to downstream export as dissolved and particulate nutrients; delays surface water passage, allowing it to be cooled by mixing with ground water; provides a substrate for organic matter development and benthic invertebrates (Coe et al. 2009); and provides hydraulic refugia and cover within streams for fish (Bilby

1984. Bisson et al. 1987; Sullivan et al. 1987; Gregory et al. 1991; Hicks et al. 1991; Ralph et al. 1994; Bilby and Bisson 1998). Instream wood also retains salmon carcasses (Cederholm and Peterson 1985), a major source of nitrogen, phosphorus and carbon in stream ecosystems (Bilby et al. 1996).

Logging near streams reduces the amount of wood that falls into streams over time (Murphy et al. 1986; Bisson et al. 1987; 1992; Ralph et al. 1994). In mature conifer forests in western North America, approximately 50 percent of total wood recruited to streams from streamside areas comes from within 10 to 12 m of the streams, 75 percent of the wood comes from within 17 to 25 m, and 100 percent comes from within 50 to 60 m (McDade et al. 1990; Welty et al. 2002; Meleason et al. 2003). In hardwood riparian forests, the trees are considerably shorter than conifer trees, and more than 50 percent of total wood delivered to streams originates within 5 m of streams and 100 percent originates within 25 m.

Landslides, and debris flows that propagate landslides downstream, sometimes contribute substantial amounts of wood to streams inhabited by salmon. This phenomenon is well documented in the Oregon Coast Range, where wood transported in this manner may constitute one-half or more of the wood recruited to downstream reaches (McGarry 1994; Reeves et al. 1995; May and Gresswell 2003; Reeves et al. 2003). Because of this, logging on unstable slopes and near along debris flow-prone streams likely reduces the potential recruitment of wood to salmon habitat (Reeves et al. 1995; May and Gresswell 2003; Reeves et al. 2003).

Decreased in-stream wood due to logging reduces the number, area, and volume of pools in streams (e.g., Bilby and Ward 1989; Ralph et al. 1994; Montgomery et al. 1995; Beechie and Sibley 1997). Pools are important as rearing and pre-spawning holding habitat for Pacific salmon (Hicks et al. 1991a). Reductions in wood also decrease that retention of gravel that is used for spawning and incubation by Pacific salmon (Bilby and Ward 1989; Buffington and Montgomery 1999).

*Hydrology*

Total water yield typically increases after logging due to reduced evapotranspiration by live trees (Harr et al. 1975; Keppler and Zeimer 1990; Jones 2000), and stream flows appear to respond to the increase in water yield in proportion to the acreage logged (Bosch and Hewlett 1982; Keppler and Zeimer 1990; Stednick 1996). Tree removal generally increases summer low flows for the first 5-10 years after logging; however, this effect may be fairly quickly countered by new plant growth and increased evapotranspiration within a few years after harvest (Hicks et al. 1991b). The projected gains and losses of base flow from tree removal and subsequent plant regrowth will tend to be small percentages of the overall stream flow, except in small watersheds where a substantial portion of the land is logged.

A review of the effects of logging on peak flow showed that peak flow tended to increase as a function of logged area, but also showed that increased peak flow tends to be manifested only for relatively frequent (less than 5-year recurrence interval) flood events (Grant et al. 2008) . However, the ability to detect logging-induced changes in flow becomes more difficult with increasing magnitude of flood events. It is somewhat unclear how much of the peak flow increases for the frequent flood events are attributable to logging and how much to water routing by roads. Roads appear to be either the primary factor (Megahan 1972; Wemple et al. 1996) or at least a demonstrable contributor in proportion to the amount of road network linkages to streams (Grant et al. 2008). While logging and roads may increase peak flows of less than 5-year floods, peak flows that scour stream substrate sufficiently to reduce salmon survival (particularly the egg-to-fry stage) have so far only been documented for greater than 5-year floods (Beamer et al. 2005). Available evidence suggests that forestry-caused changes in peak flow may have little or no effect on salmon habitat and populations.

*Habitat Connectivity*

Forest roads and culverts that eliminate or restrict fish access to streams can have a profound effect on distribution and abundance of salmon at the population scale (Kiffney et al. 2009). For example, in two watersheds in northwestern Washington, impassable culverts reduced juvenile coho salmon rearing capacity by 30-58 percent (Beechie et al. 1994; Roni et al. 2002; Pess et al. 2003). Roads along streams can also reduce or eliminate floodplain habitats such as alcoves, groundwater channels, and side channels. Basin-scale studies examining total habitat losses from all land uses indicate that approximately 40 percent of the losses were attributable to loss of floodplain channels (Beechie et al. 1994; Beechie et al. 2001). Reduction of those off-channel rearing areas caused by roads that constrict floodplains will tend to reduce survival of juvenile fish and thus reduce overall productivity of salmon populations.

*Beaver Habitat*

Beaver feeding may reduce standing woody riparian vegetation, but also increases the input of wood to streams. Beaver ponds often fill with sediments and become wetlands, but they retard erosion upstream and reduce sedimentation downstream. The ponds supplement summer low flows and provide important low-velocity over wintering habitat for salmonid fishes. Beaver ponds may also provide a sink for nutrients from tributary streams, thereby enhancing pond productivity and increasing nutrient retention. Overall, the reduction in beaver populations since European settlement has caused fundamental changes in ecosystem structure and function (Spence et al. 1996; Pollock et al. 2003). Summer habitat for coho salmon in ponds within the Stillaguamish River basin in Washington has been reduced by 88 percent, and winter habitat capacity has been reduced by 93 percent, compared with pre-settlement conditions (Pollock et al. 2004). Where coho salmon production is limited by pool availability and where conditions are suitable, allowing or encouraging beaver to build dams may be more cost-effective and appropriate as a restoration technique than adding wood to streams (Pollock et al. 2004).

Beaver often are removed by land managers to protect culverts from being plugged and to protect roads from flooding. Land managers also sometimes remove beaver dams to reduce the risk of dam break floods. Beavers may also be displaced if riparian vegetation, particularly alders, is removed. Removal or displacement of beaver eliminates the beneficial effects of beaver activity on EFH that are described above.

*Potential Conservation Measures for Forestry*

Forest Roads:

- Avoid construction or reconstruction of roads in riparian areas, and on potentially unstable slopes that can deliver sediment to EFH or tributary streams, unless alternative options for road construction would likely cause greater damage to aquatic habitats or riparian functions.
- Use temporary roads and stream crossings where practicable.
- Mitigate for riparian functions altered by new road segments.
- Ensure that new, reconstructed, and existing roads will not impair hydrological connections between stream channels, ground water, and wetlands; will not increase sedimentation to aquatic systems; will have adequate drainage and surfacing; and will not discharge drainage water into streams or onto potentially unstable land forms (e.g. concave hollows or headwalls on steep hills).
- Require stream crossings to provide adequate fish passage for both adults and juveniles, accommodate a 100-year flood without over-topping the road, and pass adequate woody material. Refer to Chapter 7 (Culverts and Other Road Crossings) in NMFS (2011a), for design criteria and guidelines.
- Apply BMPs for log hauling, recreational use, and seasonal closure to minimize erosion and sediment generation.

Tree Felling and Log Transportation:

- Apply no-cut buffers and limits on tree felling in partial logging zones on all sizes and categories of streams that are adequate to ensure maintenance of wood recruitment, stream shade, stream bank stability, sediment filtration, and connectivity of streams with floodplains and groundwater sources in EFH. Consider both streamside and upstream/upslope sources of wood when designing buffers and limits on tree felling. Use models and published relationships to determine acceptable buffer widths and limits on tree felling.

- Identify potentially unstable slopes and debris flow paths at the plan and project scales using topographic slope stability models and site-specific geologic evaluations. Limit or preclude tree felling on potentially unstable slopes and along debris-flow paths that are likely to deliver wood to EFH.
- Apply buffers on streams and minimize the width of yarding corridors to avoid and minimize sedimentation from machinery use and construction of log yarding corridors.
- Apply seasonal restrictions to avoid and minimize erosion and sedimentation during wet periods.

Toxic Chemicals:

- Develop a fuel transport, storage and spill contingency plan.
- Complete staging, cleaning, maintenance, refueling, and fuel storage for wheeled and tracked machinery in a staging area placed 150 feet or more from any stream or stream-associated wetland, or in areas that are hydrologically disconnected from streams and wetlands.
- Inspect all wheeled and tracked machinery that will be operated within 150 feet of any stream, water body or wetland daily for fluid leaks before leaving the vehicle staging area. Repair any leaks detected in the vehicle staging area before resuming operation.
- Ensure that any forest chemical applications (herbicides, insecticides, fertilizers) comply with EPA label guidelines, and that chemicals are not applied to surface waters, dry ephemeral channels, and other sites where rain would wash them directly or indirectly into streams.

Beaver Habitat:

- Work with state and Federal (i.e., Animal and Plant Health Inspection Service) wildlife agencies to minimize removal of beavers (both commercial and recreational) in areas important to fish.
- Avoid silvicultural activities harmful to beavers (e.g. alder conversion) where it would conflict with beneficial beaver activity.
- Replace culverts with bridges where there are chronic culvert plugging problems that induce beaver removal, or install culvert protective devices that do not impede passage of juvenile and adult salmon.
- Undertake only partial removal of beaver dams using mechanical means, under the guidance of a fishery biologist, where action is necessary due to severe flooding hazards.

Cumulative Effects:

- As part of forest planning, use watershed analysis to analyze the cumulative effects of past and current forest management activities on EFH as indicated in watershed analyses.
- Consider the likely impacts of cumulative effects on EFH when designing future forest management activities.

Log Transfer Facilities and In-water Log Storage:

- Restrict or eliminate storage and handling of logs where the activities are preventing attainment of state or Federal water quality standards.
- Minimize potential impacts of log storage by employing effective bark and wood debris controls, collection, and disposal methods at log dumps, raft building areas, and mill-side handling zones; avoiding the free-fall dumping of logs; using easy let-down devices for placing logs in the water; and bundling logs prior to water storage (bundles should not be broken except on land or at the mill).
- Do not store logs where they will ground at any time or shade aquatic vegetation.
- Avoid siting log storage areas and LTFs in sensitive habitat areas important to species of interest. [not sure if you want make this into EFH language]
- Site log storage areas and LTFs in areas with substantial currents and tidal exchanges.
- Recommend land-based storage sites with the goal of eliminating in-water storage of logs.

#### *4.2.2.17 Grazing*

Livestock grazing represents the second most dominant land use in the Pacific Northwest (after timber production), occupying about 41 percent of the total land base. An aspect of grazing is the impact it imparts on riparian ecosystems.[6]

<u>*Potential adverse effects from grazing*</u>

Numerous symposia and publications have documented the detrimental effects livestock grazing can have on stream and riparian habitats (Johnson et al. 1985; Menke 1977; Meehan and Platts 1978; Cope 1979; AFS 1980; Platts 1981; Peek and Dalke 1982; Ohmart and Anderson 1982; Kauffman and Krueger 1984; Clary and Webster 1989; Gresswell et al. 1989; Kinch 1989; Chaney et al. 1993). These publications describe a series of additive effects that can result when cattle over-graze or impact riparian areas. Over time, woody and hydric herbaceous vegetation along a stream can be reduced or eliminated and livestock trampling causes streambanks to collapse. Without vegetation to slow water velocities, hold the soil, and retain moisture, flooding causes more erosion of streambanks; the stream becomes wider and shallower and in some cases downcut; the water table drops; and hydric, deeply rooted herbaceous vegetation dies out and is replaced by upland species with shallower roots and less ability to bind the soil. The resulting instability in water volume, increased summer water temperature, loss of pools and habitat adjacent and connected to streambanks, and increased substrate fine sediment and cobble-embeddedness.

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

The quality and persistence of the riparian zone is a function of its fragility. A large body of research and monitoring indicates that overgrazing by domestic livestock has damaged riparian and stream ecosystems (Armour et al. 1994; Mosely 1997) resulting in decreased production of salmonids (Platts 1991). An additional threat to EFH from livestock is the trampling of salmon redds when livestock enter salmon spawning habitat (Gregory and Gamett 2009).

Impacts to the riparian zone vary. Livestock grazing can affect the riparian environment by changing, reducing, or eliminating vegetation and actually eliminating riparian areas through channel widening, channel aggrading, or lowering of the water table (Platts 1991). Soil compaction by trampling can result in a reduction in water infiltration by 40-90 percent (Rauzi and Hanson 1966; Berwick 1976). Streams modified by improper livestock grazing are also wider and shallower than normal (Duff 1983) leading to pool loss by elevating sediment delivery (MacDonald and Ritland 1989). In addition, removal of riparian vegetation along rangeland streams can result in increased solar radiation and thus increased summer temperatures (Li et al. 1994).

Livestock presence in the riparian zone can affect bank stability (Beschta et al. 1993), increase sediment transport rates by increasing both surface erosion and mass wasting (Marcus et al. 1990), and shift vegetative growth to less productive, often exotic plants when Kentucky bluegrass, timothy, and orchard grass replace the native sedges, rye and bunch grasses. Streamside shrubs and trees are also eliminated as the sprouts are browsed by livestock. Regeneration is prevented and the even-aged stands of aspen, willow, cottonwood and associates eventually age, die and disappear (Berwick 1978). Increased sediment in aquatic

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

systems can increase turbidity, reduce light penetration, smother fish spawning areas and food supplies, clog the filtering capacity of filter feeders, clog and harm the gills of fish, interfere with feeding behaviors, and significantly lower overall biological productivity.

Because riparian areas are favored by cattle, nutrients consumed elsewhere are often excreted as waste in riparian zones (Heady and Child 1994; Myers and Whited 2010). Pollutants contained in manure and associated bedding materials can be transported into freshwater and marine environments by runoff and process wastewater from rangelands, pastures, or confined animal facilities. These pollutants may include oxygen-demanding substances such as nitrogen, phosphorus, and organic solids; salts; bacteria, viruses, and other microorganisms, as well as sediments that increase organic decomposition. Runoff of animal wastes can cause fish kills due to ammonia, and solids deposited into the aquatic environment and can reduce productivity over extended periods of time due to the accelerated effects of cultural eutrophication. Runoff can be accelerated by grazing processes that remove or disturb riparian vegetation and soils.

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

*Potential conservation measures for grazing*

- Utilize focused monitoring, management, and grazing regimes or special mitigation activities that allow recovery of degraded areas and maintain streams, wetlands, and riparian areas in properly functioning condition.
- Establish proper streambank alteration move triggers and grazing season of use endpoint indicators to:
  - reduce the amount streambank damage and allow banks to stabilize over time;
  - reduce the amount of the fine sediment introduced into streams; and
  - reduce the amount of damage to streambanks which will also assist in retaining important undercut streambanks, LWD, and overhanging vegetation that provide cover.
- Utilize upland grazing management that minimizes surface erosion and disruption of hydrologic processes. Where range is not in properly functioning condition, forage species composition is altered, productivity reduced, and trends are down, select demonstrably restorative grazing regimes or minimize grazing activity until vegetation has recovered. Once conditions have improved, adjust the grazing strategies to account for all herbivory (e.g., including wildlife) at proper use levels to minimize deterioration of range conditions in the future (Spence et al. 1996).
- Chinook salmon use various stream features such as undercut streambanks, LWD, boulders, and overhanging vegetation to provide cover. The removal of riparian vegetation can reduce overhead cover. Streambank alteration by livestock can eliminate undercut banks and improperly managed grazing can suppress the recruitment of LWD. The introduction of fine sediments can increase substrate embeddedness, reducing the number of hiding places between cobbles and boulders.
- Determine cumulative effects of past and current grazing operations on EFH when designing grazing management strategies.
- Minimize application of chemical treatments within the riparian management zone.
- Utilize innovative grazing practices such as variants of rest-rotation grazing systems, late season riparian grazing systems, winter grazing and management of stocking rates (Heady and Child 1994; Bryant 1985; Davis 1982; Claire and Storch in Kauffman 1982; Hayes 1978; Valentine 1970; and Hedrick in Heady and Child 1994; Pond 1961).
- Minimize livestock access to stream reaches containing salmon redds during spawning and incubation periods (McCullough and Espinosa 1996) by utilizing grazing and vegetation management schemes that promote grazing in other areas and by locating water facilities away from the stream channel and

riparian zone wherever feasible. Excluding livestock from riparian zones has been shown to reduce bank erosion (O'Neal et al. 2010) and decrease salmon redd trampling (Gregory and Gamett 2009).

- Encourage livestock owners to take advantage of The Conservation of Private Grazing Land Program (CPGL) and the Conservation Reserve Enhancement Program (CREP). CPGL and CREP are voluntary programs that help owners and managers of private grazing land address natural resource concerns while enhancing the economic and social stability of grazing land enterprises and the rural communities that depend on them. Technical assistance is provided by the Natural Resource Conservation Service.
- Establish proper streambank alteration move triggers and endpoint indicators in combination with the other management measures intended to reduce the amount of time livestock spend in riparian areas to reduce the amount of the fine sediment introduced into streams.

#### *4.2.2.18 Habitat Restoration Projects*

Habitat loss and degradation are major, long-term threats to the sustainability of fishery resources (NOAA Fisheries 2002). Viable coastal and estuarine habitats are important to maintaining healthy fish stocks. Good water quality and quantity, appropriate substrate, ample food sources and substantial hiding places are needed to sustain fisheries. Restoration and/or enhancement of coastal and riverine habitat that supports managed fisheries and their prey will assist in sustaining and rebuilding fisheries stocks and recovering certain threatened or endangered species by increasing or improving ecological structure and functions. Habitat restoration/enhancement may include, but is not limited, to improvement of coastal wetland tidal exchange or reestablishment of historic hydrology; dam or berm removal; fish passage barrier removal/modification; road related sediment source reduction; natural or artificial reef/substrate/habitat creation; establishment or repair of riparian buffer zones and improvement of freshwater habitats that support anadromous fishes; planting of native coastal wetland and SAV; creation of oyster reefs; and improvements to feeding, shade or refuge, spawning and rearing areas that are essential to fisheries.

It is very important that habitat restoration efforts be developed and designed based on a larger planning effort that initially identifies the causes of habitat impairment at a larger scale and then considers active restoration techniques to accelerate habitat recovery that will provide the greatest benefits to the population under consideration (Bisson et al. 1997; Lawson 1997). Restoration efforts should consider a watershed or basin approach. Each project should be adequately designed, carefully monitored and evaluated, and revised if necessary to meet project goals.

The first step to restoration is setting an appropriate goal based on ecosystem function (Zedler 2005). Restoration efforts undertaken without an understanding of hydrogeological and ecological conditions in the watershed may be unsuccessful. For example, while stabilizing an eroding bank may improve local water quality, if placed incorrectly it may deflect water flow and create erosion. Additionally, habitat restoration activities based solely on an individual species without consideration of the immediate ecosystem may not restore habitat function.

Various documents are available to help those involved in habitat restoration efforts. The Environmental Protection Agency (EPA) has produced a watershed assessment primer (http://water.epa.gov/polwaste/nps/handbook_index.cfm) to meet water quality standards and protect water resources, especially in impaired water systems. The California Department of Fish and Wildlife) salmonid stream habitat restoration manual (http://www.dfg.ca.gov/fish/REsources/HabitatManual.asp ) provides guidance and forms for habitat assessment, monitoring, and restoration. River RAT is a river project development and evaluation tool that was developed by the US Fish and Wildlife Service (USFWS) and NOAA Fisheries to thoroughly evaluate the impacts of proposed projects on river habitat, particularly for Pacific salmon species listed as threatened or endangered under the ESA (http://www.restorationreview.com/).

*Potential adverse effects from restoration projects*

The implementation of restoration/enhancement activities may have localized and temporary adverse impacts on EFH. Possible impacts include 1) localized nonpoint source pollution from substances like petroleum products, sediment, or nutrients, 2) interference with spawning, migration or feeding 3) direct effects like crushing from equipment operation or materials placement, and 5) fish handling. Such concerns should be addressed as part of the planning process. For example in-water projects should be allowed only during times of year that minimize interference with spawning, rearing and migration. Areas for staging, maintaining and fuel equipment and supplies should be located far enough from live water to minimize the chance of petroleum product spills and leaks or disturbed sediment reaching live water.

The use of artificial reefs is a popular form of habitat enhancement, but it can also impact the aquatic environment through the loss of habitat upon which the reef material is placed or the use of inappropriate materials in construction. Usually, reef materials are set upon flat sand bottoms and care must be taken to avoid burying or smothering bottom-dwelling organisms or preventing them from utilizing the area as habitat. Some materials may be inappropriate for the marine environment (e.g., automobile tires; compressed incinerator ash) and can serve as sources of toxic releases or physical damage to existing habitat when breaking free of their anchoring systems (Collins et al. 1994).

*Potential conservation measures for restoration projects*

- Develop and conduct habitat restoration activities on a watershed-scale.
- Design restoration activities as an experiment, using adaptive management to determine project success and modify until the success criteria are achieved.
- Protect habitat-forming processes (e.g., riparian community succession, bedload transport, runoff pattern) that maintain the biophysical structure and function of aquatic ecosystems.
- Use BMPs to minimize and avoid all potential impacts to EFH during restoration activities. This conservation measure requires the use of BMPs during restoration activities to reduce impacts from project implementation. BMPs should include, but are not limited to, the following:
  - Measures to protect the water column such as turbidity curtains, hay bales, and erosion mats should be used.
  - Staging areas should be planned in advance and kept to a minimum size.
  - Buffer areas around sensitive resources such as rare plants, archeological sites, etc., should be flagged and avoided.
  - Invasive species should be removed from the proposed action area prior to commencement of work. Only native plant species should be replanted.
  - Ingress/egress areas should be established prior to restoration activities to minimize adverse impacts from project implementation.
- Avoid restoration work during critical fish windows to reduce direct impacts to important ecological functions such as spawning, nursery, and migration. This conservation measure requires scheduling projects when managed species are not expected in the area. These periods should be determined prior to project implementation to reduce or avoid any potential impacts.
- Provide adequate training and education to volunteers and project contractors to ensure minimal impact to the restoration site. Volunteers should be trained in the use of low-impact techniques for planting, equipment handling, and any other activities associated with the restoration.
- Conduct monitoring before, during, and after project implementation to ensure compliance with project design and restoration criteria. If immediate post-construction monitoring reveals that unavoidable impacts to EFH have occurred, appropriate coordination with NOAA Fisheries should occur to determine appropriate response measures, possibly including mitigation.
- Mitigate fully any unavoidable damage to EFH during project implementation and accomplish within reasonable period of time after the impacts occurred.

- Remove and restore, if necessary, any temporary access pathways and staging areas used in the restoration effort.
- Develop obtainable goals for each restoration project using ecological functions as guidelines.

#### *4.2.2.19 Introduction/Spread of Invasive Alien Species*

(IAS) are any species non-native to an ecosystem whose introduction causes or is likely to cause economic or environmental harm, or harm to human health (Executive Order 13112). Under this broad definition, the socioeconomic and ecological damage to the global environment has been conservatively estimated to exceed $US 1.4 trillion annually, or roughly five percent of the global economy (*see* Pimental D. [ed.], 2002). In the U.S. alone, invasive species have been estimated to annually yield $120 billion in economic damage from control and prevention costs and compromised environmental services (Pimental et al. 2004). This recognition has led to a multitude of international agreements to better coordinate IAS introductions through recognized international pathways of introduction (Fisher 2005), and international guidelines have been developed to address such risks (Orr and Fisher 2009). Executive Order 13112 further details requirements of the Federal government to improve coordination of prevention mechanisms and to establish early detection and rapid response control measures among Federal, state and local government entities within the borders of the U.S.

In the U.S., IAS are reported as the second leading cause for the listing of native species as threatened or endangered under the ESA (Pimental et al. 2000). The introduction of nonnative plant and animal species may be either deliberate (e.g., to enhance sport-fishing or control aquatic weeds) or accidental without thought to the consequences (e.g., the dumping of live bait-fish and the seaweeds in which they are packed, aquaculture escapees, the pumping of bilge or ballast water, or releases from aquariums by individuals). The ecological and economic consequences of non-native species introductions depends, in large measure, on the degree to which such species are subsequently shown to exhibit invasive properties, wherein native species are displaced from habitat previously accessible, or where native species' fitness is otherwise compromised through other mechanisms (e.g., predation, parasitism, etc.).

Although the impacts of non-native species introductions to salmon EFH have not been extensively examined, the spread of many nonnative species into salmon EFH has demonstrated their invasive potential. These introductions can potentially alter habitat processes and functions. Introduced fishes can dominate or displace native fish through predation, reproduction impairment, habitat modification, pathogen and/or parasite infection, and/or hybridization (Spence et al. 1996). In the Columbia Basin, introduced predator species including walleye, channel catfish, and smallmouth bass have high predation rates on emigrating salmon smolts. Boyd (1994) reports that the presence of striped bass in a river system near California's San Francisco Bay region resulted in estimated losses of 11 percent to 28 percent of native run fall Chinook salmon. White bass and northern pike introduced into the inland delta of the Sacramento and San Joaquin Rivers prey on salmon and other species (Cohen 1997). In Oregon's coastal lakes and reservoirs, introduced fish species such as striped bass, largemouth bass, smallmouth bass, crappie, bullheads and yellow perch have become established with obvious predation impacts in some basins and negligible impacts in others. For example, nonendemic Umpqua squawfish are voracious predators of juvenile salmonids in Oregon's Rogue River Basin (Satterwaithe 1998; pers. comm.) and the Coos and Umpqua estuaries contain striped bass that prey on salmonids (OCSRI 1997). Introduced grass carp and common carp can destroy beds of aquatic plants which results in concomitant reductions in cover for juvenile fishes, destruction of substrates supporting diverse invertebrate food chain assemblages, and increases in turbidity (Spence et al. 1996). Displacement of salmonids and other cold water species by such non-native invasive species results in a reduced total usable habitat area for spawning and rearing, and thereby a diminished production capability for salmon (McCullough et al. 1996).

Introduced invertebrates in marine and freshwater environments can also lead to habitat alterations, potentially compromising cover and foraging opportunities for species managed under the MSA for which EFH has been established. For example, the colonial ascidian *Didemnum sp.* can coat substrates to such a heavy degree that other benthic organisms are displaced (Bullard et al. 2007). The outcome of such an invasion in salmon EFH could adversely affect the capacity of such habitats to provide sufficient forage for juvenile salmonids. The food webs of San Francisco Bay have been dramatically altered by non-native invertebrate invasions primarily attributed to the ballast water vector (Carlton 1999). To this end, the arrival of an Asian clam has multiplied to such abundance that it can filter all the water over a significant portion of the bay in less than a day, removing bacteria, phytoplankton, and zooplankton in the process and leaving little behind for other organisms (The Resources Agency of California [RAC] 1997). In this same embayment, the introduction of the green crab has raised significant concerns for intercompetition and predation with the native Dungeness crab, whose larvae represent a significant food source for juvenile salmon, and hence, a component of Chinook salmon and coho salmon EFH. Based on effects observed in the Great Lakes ecosystem and their spread elsewhere (Higgins and Vander Zanden, 2010; Ward and Ricciardi, 2010) the potential introduction and spread of the invasive zebra mussels into the Columbia basin would similarly result in drastic and adverse changes to aquatic substrates of salmon EFH with significant consequences. The high risk potential of the ecological consequences to uninvaded aquatic environments such as the Columbia River system from the zebra mussel has required extreme vigilance and resource agency costs to prevent such introductions (Wu et al. 2010).

Biological invasions of introduced macrophytes are also a worldwide problem with implications to EFH. Mechanisms underlying invasive plant impacts on native fish and macroinvertebrate communities are largely related to increased growth rates, allelopathic chemical production, and phenotypic plasticity that allow for the invasive plants to exhibit greater adaptability to the environmental conditions inherent to the invaded environment than the native plants that are outcompeted (Shultz and Dibble 2012). Introduced plants can also have serious detrimental effects on salmon habitat. The exotic aquatic plant egeria (*Egeria densa*) is known to harm coho salmon rearing in coastal lakes (OCSRI 1997). Similarly, the recognition of the potential harm caused by the invasive algae *Caulerpa taxifolia* (Schaffelke and Hewitt, 2007), resulted in a massive and costly rapid response in order to eradicate it from a southern California embayment and address the risks it posed to nearshore biodiversity through further spread.

The spread in estuaries of various species of cordgrass *Spartina* spp. and another grass, the common reed *Phragmites australis,* is also of concern. *Spartina* spp. may affect salmon habitat in a number of ways, many of which appear to be detrimental to salmon and their prey. *Spartina* forms dense uniform stands in the upper intertidal area, traps sediment and raises the elevation of the mudflat, making them inaccessible to salmonids as foraging habitat. The macroinvertebrate population in areas dominated by *Spartina* a*lterniflora* is somewhat different than that in mudflat areas. Nonnative plant invasions may decrease food for some species such as chum salmon that feed on the mudflats, while it may increase resources for Chinook salmon that feed on invertebrates in the water column or on the surface, though the interactions are complicated and are still being studied (Luiting et al. 1997). Other effects from *Spartina* invasion (as well as from *Phragmites*) results from the meadows serving as filters of nutrients and sediments washing off the land. While this may be beneficial in terms of reducing pollution, it can also have negative effects by raising the elevation of the high intertidal area and sequestering nutrients from the estuarine system.

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

#### *Potential conservation measures for introduction/spread of nonnative species*

Watershed management strategies for enhancement and conservation of salmon EFH in many instances will include restoration of water flows and riparian areas, as well as other habitat conditions. These measures should discourage nonnative IAS from establishing or expanding their territories (e.g., colder water will favor salmonids over centrarchids).

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

- Provide and display educational materials on the potential impacts resulting from the release of nonnative organisms into the natural environment to increase public awareness and engender broad cooperation amongst user groups and stakeholders.
- For the commercial import of plants and animals for aquarium and ornamental plant trades, import those organisms that have been evaluated and determined to be safe for importing through the application of risk assessment guidelines developed through the Aquatic Nuisance Task Force.
- Adopt measures outlined by the International Marine Organization and avoid ballast water exchange in nearshore coastal waters. Use shore-based ballast water treatment systems and ship-board ballast treatment systems as alternatives.
- Inspect all vessels for hull fouling, non-native IAS species prior to introducing the vessels into new waterbodies.
- Conduct vessel hull cleaning outside of water and control run-off from such operations to ensure it does not enter waters not natal to the vessel origin.
- Use native organisms for aquaculture operations whenever possible, and do not transfer native organisms across waterbodies without inspection by qualified agents if the waterbody of export is known to harbor aquatic IAS associated with aquaculture operations that could ‘hitch-hike’ unintentionally with the aquatic species transfer.
- Develop appropriate early detection and rapid response eradication methods for nonnative IAS plant species and predatory animal species, consistent with Federal guidelines as specified by the National Invasive Species Management Plan (NISC 2009).

#### *4.2.2.20 Irrigation Water Withdrawal, Storage, and Management*

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

*Potential adverse effects from irrigation water withdrawal, storage, and management*

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

In addition, the volume of fresh water diverted and stored for agriculture can be substantial and can affect both the total volume of water available to salmon and to form their requisite habitats. The effects of water withdrawals during the irrigation season are likely to grow more pronounced as a result of climate change. Climate and hydrology models project significant reductions in both total snow pack and low-elevation snow pack in the Pacific Northwest over the next 50 years (Mote and Salathe 2009). Such changes may reduce overall habitat productivity and reduce the ability to conserve diverse salmon life histories.

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

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

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

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

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

The physical means of withdrawing water may adversely affect salmon. For major irrigation withdrawals, water is either stored in impoundments or diverted directly from the river channel at pumping facilities. Individual irrigators commonly construct smaller push-up dams from streambed materials, to divert water into irrigation ditches or to create small storage ponds from which water is pumped. In addition, pumps may be submerged directly into rivers and streams to withdraw water. Effects of these irrigation withdrawals and impoundments on aquatic systems include creating impediments or blockages to migration (for both adults and juveniles), diverting juveniles into irrigation ditches or damage to juveniles as a result of impingement on poorly designed fish exclusion screens (Spence et al. 1996).

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

*Potential conservation measures for irrigation water withdrawal, storage, and management*

Water conservation is one of the most promising means of meeting new and expanding needs for additional water (Gillilan and Brown 1997). For example, Washington State's Water Resources Management Trust Water Rights Program, started in 1991, provides a means of enhancing instream flow. The program allows water that is no longer being used for another purpose to be left instream and protected from further appropriation. Participants in the instream flow protection processes in the states of Washington, Idaho, Oregon, and California include:

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

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

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

Washington: Washington Department of Ecology (WDOE) establishes minimum flows either at its own initiative or after request from the Department of Fisheries and Wildlife. However, these instream flows were established long after much of the water from many streams had been appropriated for off-stream purposes and thus flows in many streams are often much lower than the established minimum flows. A significant feature of the Trust Water Rights Program is that the water enrolled through the program is protected as equal in seniority to the water right from which is was gleaned.

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

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

- Apply conservation and enhancement measures for dams (see Section 4.2.2.9 Dam Construction/Operation) to water management activities and facilities, where applicable.
- Establish adequate instream flow conditions for salmon by using, for example, the Instream Flow Incremental Methodology.
- Undertake efforts to purchase or lease, from willing sellers and lessors, water rights necessary to maintain instream flows in accordance with appropriate state and Federal laws.
- Identify and use appropriate water conservation measures in accordance with state law.
- In accordance with state law, install totalizing flow meters at major diversion points and ensure that the diversions do not exceed legally authorized annual or instantaneous quantities. For water withdrawn from reservoirs, install gauges that identify the water surface elevation range from full reservoir elevation to dead pool storage elevation. Additionally, if the reservoir is located in-channel, install gauges upstream and downstream of the reservoir.
- Screen water diversions on all fish-bearing streams.
- Incorporate juvenile and adult salmon passage facilities on all water diversions.
- Where possible, relocate diversions to larger water bodies that would be less severely affected by the reduced flow volume.

#### *4.2.2.21 Liquefied natural gas projects*

Liquefied natural gas (LNG) is expected to provide a large proportion of the future energy needs in the United States. In recent years there has been an increase in proposals for new LNG facilities along the west coast including a number of onshore and offshore facilities in Oregon and California. The LNG process cools natural gas to its liquid form at approximately minus 162 ºC. This reduces the volume of natural gas to approximately 1/600th of its gaseous state volume, making it possible for economical transportation with tankers. Upon arrival at the destination the LNG is either vaporized onshore or offshore and sent out into an existing pipeline infrastructure or transported onshore for storage and future vaporization. The process of vaporization occurs when LNG is heated and converted back to its gaseous state. LNG facilities can utilize open loop, closed loop, combined loop, or ambient air systems for vaporization. Open loop systems utilize warm water for vaporization, and closed loop systems generally utilize a recirculating mixture of ethylene glycol for vaporization. Another type of closed-loop system is submerged combustion vaporization (SCV) which provides a water bath with submerged pipe coils. Combined loop systems utilize a combination of these systems.

Onshore LNG facilities generally include a deepwater access channel, land-based facilities for vaporization and distribution, storage facilities, and a pipeline to move the natural gas. Offshore facilities generally include some type of a deepwater port with a vaporization facility and pipelines to transport natural gas into existing gas distribution pipelines or onshore storage facilities. Deepwater ports and onshore terminals require specific water depths and include an exclusion zone for LNG vessel and/or port facility security.

*Potential adverse effects from liquefied natural gas projects*

Construction and operation of LNG facilities can affect the habitat of salmonids in a variety of ways. Direct conversion and loss of habitat can occur through dredging and filling, construction of overwater structures, placement of pipelines, and shoreline armoring. Construction-related effects on habitat include generation of underwater noise from pile driving and vessel operations, turbidity, and discharge of contaminants. Long-term degradation of habitat can result from impingement and entrainment at water intakes for vaporization water and ballast and engine cooling water for LNG vessels, discharge of contaminants, discharge of cooled water from open-loop systems, and stranding of fishes by vessel wakes. Short- and long-term habitat degradation can result from accidental spills of LNG and other contaminants. With the exception of the discharge of contaminated water, discharge of vaporization water, and accidental spills of

LNG, these effects are covered under other threats described in this document.

Contaminants can enter aquatic habitats through accidental releases associated with onshore and offshore operations, discharge of water containing biocides used to control fouling of piping systems, and discharges of the condensates from heat exchangers. A rapid phase transition can occur when a portion of LNG spilled onto water changes from a liquid to a gas virtually instantaneously. The rapid change from a liquid to vapor state can cause locally large overpressures ranging from a small pop to a blast large enough to potentially damage structures (Luketa et al. 2008). Because rapid phase transition would occur at the surface of the water it would be unlikely to affect fishes that are several feet under the surface. However, any fish present at or near the surface of the water would likely be killed. Effects on the aquatic environment from an LNG spill include thermal shock from the initial release (cold shock from the cryogenic liquid) and thermal shock from ignition of the vapor (Hightower et al. 2004). Condensates from heat exchanger such as SCV systems are generally acidic and require buffering with alkaline chemicals (FERC 2010). The condensate can include a wide range of metals and other contaminants. These contaminants may include copper, a known disruptor of salmonid olfactory function (e.g., Baldwin et al. 2003). The concentration of these chemicals will vary depending on the water source and facility design.

The operation of LNG facilities can result in the alteration of temperature regimes. Water utilized for the purposes of vaporization could be discharged at temperatures that differ significantly from the receiving waters and can be 5-10 ºC below ambient temperature. Changes in water temperatures can alter physiological functions of marine organisms including respiration, metabolism, reproduction, and growth; alter migration pathways; and increase susceptibility to disease and predation. Thermal effluent in inshore habitat can cause severe problems by directly altering the benthic community or adversely affecting marine organisms, especially egg and larval life stages (Pilati 1976, cited in NMFS 2008; Rogers 1976, cited in NMFS 2008).

*Potential conservation measures for liquefied natural gas projects*

- Site LNG facilities in areas that minimize the loss of habitat such as naturally deep waters adjacent to uplands that are not in the floodplain.
- Recommend the vaporization systems that do not rely on surface waters as a heat source, such as an ambient air system. This will avoid impingement and entrainment of living resources. If a water-sourced system must be used, recommend closed loop systems over open loop systems. This will minimize water withdrawals and the associated impingement and entrainment of living marine resources.
- Locate facilities that use surface waters for vaporization and engine cooling purposes away from areas of high biological productivity, such as estuaries.
- Design intake structures to minimize entrainment or impingement.
- Regulate discharge temperatures (both heated and cooled effluent) such that they do not appreciably alter the temperature regimes of the receiving waters. Strategies should be implemented to diffuse this effluent.
- Avoid the use of biocides (e.g., aluminum, copper, chlorine compounds) to prevent fouling where possible. The least damaging antifouling alternatives should be implemented.

#### *4.2.2.22 Mineral Mining*

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

*Potential adverse effects of mineral mining*

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

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

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

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

Commercial operations may also involve road building, tailings disposal, and the leaching of extraction chemicals, all of which may create serious impacts to salmon EFH. Cyanide, sulfuric acid, arsenic, mercury, heavy metals, and reagents associated with such development are a threat to salmonid habitat. Improper or in-water disposal of tailings may cause toxicity to salmon or their prey downstream. On land placement of tailings in unstable or landslide prone areas can cause large quantities of toxic compounds to be released into streams or to contaminate groundwater (NPFMC 1999). Indirectly, the sodium cyanide solution used in heap leach mining is contained in settling ponds from where they might contaminate groundwater and surface waters (Nelson et al. 1991).

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

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

*Potential conservation measures for mineral mining*

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

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

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

#### *4.2.2.23 Offshore Oil and Gas Exploration, Drilling and Transportation Activities*

*Potential adverse effects from offshore oil and gas exploration, drilling, and transportation*

Oil is extracted from offshore platforms in southern California and large amounts of Alaskan crude oil also enter the region on Alaskan tankers bound for refineries. These nearshore oil and gas related activities have the potential to pollute salmon EFH and harm prey resources. Oil exploration/production areas are vulnerable to an assortment of physical, chemical, and biological disturbances resulting from activities used to locate oil and gas deposits such as high energy seismic surveys to actual physical disruptions from anchors, chains, drilling templates, dredging, pipes, platform legs, and the platform jacket. The effects of the underwater sounds produced by seismic surveys are described in Section 4.2.2.1.3 Seismic Surveys. During actual operations, chemical contaminants may also be released into the aquatic environment (NMFS 1997b). Physical alterations in the quality and quantity of local habitats may also occur during the construction and operation of shore-side facilities, tanker terminals, pipelines, and the tankering of oil. These activities may be of concern if they occurred in habitats of special biological importance to salmon stocks or their prey (NPFMC 1999).

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

Although oil is toxic to all marine organisms at high concentrations (parts per million), certain species are more sensitive than others. The type, volume, and properties of the spilled oil (environmental variables such as water density, wave height, currents, wind speed, etc.) and the type of response effort all affect the potential risk to salmon EFH. Oil spills in marine waters probably affect salmon more through their effects on salmon food organisms than on the salmon themselves, because juvenile and adult fish generally are able to avoid oil slicks in open seas. However, if an oil spill reached nearshore areas with productive nursery grounds, such as an estuary, or if a spill occurred at a location where fish were concentrated, a year's production of smolts could be lost (NPFMC 1999).

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

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

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

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

*Potential conservation measures for offshore oil and gas exploration, drilling, and transportation*

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

- Monitor and enforce double hull standards for all oil tankers doing business in U.S. waters, as well as other pollution prevention measures of the Oil Pollution Act of 1990.

- Utilize adequate spill prevention measures such as tug escorts, speed limits, the use of marine pilots, vessel traffic systems, designated areas to be avoided, traffic separation schemes, rescue/salvage tugs, and compliance with international, national, and state spill prevention standards.
- Utilize the agreement between the ten major oil company members of the Western States Petroleum Association as a catalyst to involve other oil carriers and maximize routing of tankers carrying Alaskan North Slope crude to California ports at least 50 miles seaward of the Pacific coast while transiting the coastline after leaving Prince William Sound.
- Route dry cargo vessels and other vessels carrying significant quantities of oil or hazardous cargo at least 50 miles seaward of the Pacific coast while transiting the coast.
- Avoid national marine sanctuaries and areas designated as areas to be avoided and support efforts to re-evaluate and strengthen precautionary and readiness measures in national marine sanctuaries.
- Apply vessel maintenance, inspection programs, and crew training programs, required for oil tank vessels to dry cargo and other vessels carrying significant quantities of oil.
- Monitor and report water and sediment quality around all oil extraction, bunkering, or transfer facilities, and gather other baseline information to assure better natural resource damage assessments after spill events.

#### *4.2.2.24 Overwater structures*

Overwater structures include commercial and residential piers, wharves, marinas, floats and docks, floating breakwaters, barges, rafts, booms, and mooring buoys. In saltwater areas, these structures are typically located in intertidal areas out to about 15 meters below the area exposed by the mean lower low tide (i.e., the shallow subtidal zone). In freshwater areas, they are typically located within 100 feet of ordinary low water. Light, wave energy, substrate type, depth, and water quality are the primary factors controlling the plant and animal assemblages found at a particular site. Overwater structures and associated activities can alter these factors and interfere with key ecological functions such as spawning, rearing, foraging and refugia. Site- specific factors (e.g., water clarity, current, depth) and the type and use of a given overwater structure determine the occurrence and magnitude of these impacts.

Construction and maintenance of overwater structures often involves driving of piles (see Section 4.2.2.1.1 Pile Driving) and dredging of navigation channels (see Section 4.2.2.12 Dredging and Dredged Spoil Disposal). Both activities may also adversely affect EFH. Maintenance also includes the removal of damaged or otherwise unsound piles. Piles can be removed using a variety of methods, including vibratory hammer, direct pull, clam shell grab, or cutting/breaking the pile below the mudline. Vibratory hammers can be used to remove all types of pile, including wood, concrete, and steel. However, old, brittle piles may break under the vibrations and necessitate another method. The direct pull method involves placing a choker around the pile and pulling upward with a crane or other equipment. Broken stubs are often removed with a clam shell and crane. In this method, the clam shell grips the pile near the mudline and pulls it out. In other instances, piles may be cut or broken below the mudline, leaving the buried section in place.

*Potential adverse effects of Overwater Structures*

The following description of the potential impacts of overwater structures and associated activities on EFH, unless otherwise cited, is taken from a recent, comprehensive literature review by Nightingale and Simenstad (2001). For a more detailed discussion, the reader is directed to this review.

Overwater structures and associated developments may adversely affect EFH in a variety of ways, including construction related impacts, changes in ambient light conditions, alteration of the wave and current energy regime, and through activities associated with the use and operation of the facilities, such as increased vessel traffic and pollutants.

Overwater structures create shade which reduces the light levels below the structure. The size, shape and intensity of the shadow cast by a particular structure depend upon its height, width, construction materials, and orientation. High and narrow piers and docks produce narrower and more diffuse shadows than do low and wide structures. Increasing the numbers of pilings used to support a given pier increases the shade cast by pilings on the under-pier environment. In addition, less light is reflected underneath structures built with light-absorbing materials (e.g., wood) than from structures built with materials that allow light transmission (e.g., glass, steel grates). Structures that are oriented north south produce a shadow that moves across bottom substrate throughout the day, resulting in a smaller area of permanent shade than those with an east-west orientation.

The shadow cast by an overwater structure affects both the plant and animal communities below the structure. Distributions of plants, invertebrates, and fishes have been found to be severely limited in under-dock environments when compared to adjacent, unshaded vegetated habitats. Light is the single most important factor affecting aquatic plants. Under-pier light levels have been found to fall below threshold amounts for the photosynthesis of diatoms, benthic algae, eelgrass, and associated epiphytes and other autotrophs. These photosynthesizers are an essential part of nearshore habitat and the estuarine and nearshore foodwebs that support many species of marine and estuarine fishes. Eelgrass and other macrophytes can be reduced or eliminated, even by partial shading of the substrate, and have little chance to recover.

Fishes rely on visual cues for spatial orientation, prey capture, schooling, predator avoidance, and migration. The reduced-light conditions found under an overwater structure limit the ability of fishes, especially juveniles and larvae, to perform these essential activities. Shading from overwater structures may also reduce prey organism abundance and the complexity of the habitat by reducing aquatic vegetation and phytoplankton abundance (Kahler et al. 2000; Haas et al. 2002). Biotic assemblages on pilings have been demonstrated to differ from natural hard substrate (Glasby 1999a) with these differences attributed to shading effects (Glasby 1999b). Other studies have shown shaded epibenthos to be reduced relative to that in open areas. These factors are thought to be responsible for the observed reductions in juvenile fish populations found under piers and the reduced growth and survival of fishes held in cages under piers when compared to open habitats (Able et al. 1998; Duffy-Anderson and Able 1999).

The shadow cast by an overwater structure may increase predation on EFH managed species by creating a light/dark interface that allows ambush predators to remain in a darkened area (barely visible to prey) and watch for prey to swim by against a bright background (high visibility) (Helfman 1981). Prey species moving around the structure are unable to see predators in the dark area under the structure and are more susceptible to predation. Furthermore, the reduced vegetation (i.e., eelgrass) densities associated with overwater structures decrease the available refugia from predators.

In-water structures (e.g., pilings) also provide perching platforms for avian predators such as double-crested cormorants (*Phalacrocorax auritis*), from which they can launch feeding forays or dry their plumage. Because their plumage becomes wet when diving, cormorants spend considerable time drying out feathers (Harrison 1983) on pilings and other structures near feeding grounds (Harrison 1984).

Placement of structures in shallow water may also disrupt migration of smaller juvenile salmonids that use nearshore areas. Boat activity and the physical presence of the structures may result in juvenile salmonid delaying passage or forcing them into deeper water areas in an attempt to go around the structures. Littoral areas are important for juvenile salmonid migration (Ward et al. 1994).

Wave energy and water transport alterations from overwater structures can impact the nearshore detrital foodweb by altering the size, distribution, and abundance of substrate and detrital materials. Disruption of longshore transport can alter substrate composition and can present potential barriers to the natural processes that build spits and beaches and that provide substrates required for plant propagation, fish and shellfish settlement and rearing, and forage fish spawning.

Pilings can alter adjacent substrates by increasing shell deposition from piling communities and changing substrate bathymetry. Changes in substrate type can alter the nature of the flora and fauna native to a given site. In the case of pilings, native dominant communities typically associated with sand, gravel, mud, and eelgrass substrates are replaced by communities associated with shell hash substrates.

The primary adverse effect of removing piles is the suspension of sediments, which may result in harmful levels of turbidity and release of contaminants contained in those sediments. Vibratory pile removal tends to cause the sediments to slough off at the mudline, resulting in relatively low levels of suspended sediments and contaminants. Vibratory removal of piles is gaining popularity because it can be used on all types of piles, providing that they are structurally sound. Breaking or cutting the pile below the mudline may suspend only small amounts of sediment, providing the stub is left in place and little digging is required to access the pile. Direct pull or use of a clamshell to remove broken piles, however, may suspend large amounts of sediment and contaminants. When the piling is pulled from the substrate using these two methods, sediments clinging to the piling will slough off as it is raised through the water column, producing a potentially harmful plume of turbidity and/or contaminants. The use of a clamshell may suspend additional sediment if it penetrates the substrate while grabbing the piling.

While there is a potential to adversely affect EFH during the removal of piles, many of those removed are old creosote-treated timber piles. In some cases, the long-term benefits to EFH obtained by removing a consistent source of contamination may outweigh the temporary adverse effects of turbidity.

Treated wood used for pilings and docks releases contaminants into saltwater environs. Polyaromatic hydrocarbons (PAHs) are commonly released from creosote-treated wood. PAHs can cause a variety of deleterious effects (cancer, reproductive anomalies, immune dysfunction, and growth and development impairment) to exposed fish (Johnson et al. 1999; Johnson 2000; Stehr et al. 2000). Wood also is commonly treated with other copper-based chemicals such as ammoniacal copper zinc arsenate and chromated copper arsenate (Poston 2001). Copper is a common contaminant in salmon habitat and can increase susceptibility to disease, cause hyperactivity, impair respiration, or disrupt osmoregulation. Moreover, salmon use olfactory cues to convey important information about habitat quality, predators, mates, and the animal’s natal stream, and copper can impair olfactory performance. Research has shown that fish behaviors can be disrupted at concentrations of dissolved copper that are at, or slightly above, background concentrations. Therefore, substantial copper-induced loss of olfactory capacity will likely impair behaviors essential for the survival or reproductive success of salmon. These preservatives are known to leach into marine waters for a relatively short period of time after installation, but the rate of leaching is highly variable and dependent on many factors. Concrete or steel, on the other hand, are relatively inert and do not leach contaminants into the water.

Although not the cause of direct introductions, artificial overwater structures and associated substrate may provide increased opportunity for nonnative species colonization and exacerbate the increase in their abundance and distribution (Bulleri and Chapman 2010). Glasby et al. (2007) argue that artificial structures, such as floating docks and pilings, provide entry points for invasion and increase the spread and establishment of non-native species in estuaries. In the San Francisco Estuary, the Smithsonian Institute conducts Rapid Assessment Surveys to determine nonnative species distribution on overwater structures. Of the 294 distinct nonnative taxa observed, 60 percent were found on floating docks, 20 percent on intertidal benthos, and 13 percent from benthic grabs (Cohen et al. 2005). Overwater structures can serve as focal points for nonnative species known to prey on salmon (Kahler et al. 2000) or otherwise alter salmon habitat processes and functions (Nightingale and Simenstad 2001). Given the relative lack of natural hard bottom habitat in estuaries, the addition of artificial hard structures within this type of habitat may prove an invasion opportunity for non-native hard substratum species (Glasby et al. 2007; Wasson et al. 2005; Tyrell and Byers, 2007).

Construction of docks may result in increased vessel traffic. Docks may be built for small marinas (small boats), ferry terminals (ferries), or commercial use. Depending on the size of the boat using the dock, increased vessel traffic may have negligible to significant effects on EFH. Boat traffic creates energy that suspends fine sediments and increases turbidity. Ferry docking and departing may result in multiple propeller wash events per hour (Olson et al. 1997). Ferry propeller wash may cause elevated turbidity, coarsening of sediments underneath ferry terminals (Francisco 1995), and scour pits (Shreffler and Gardiner 1999; Haas et al. 2002). Propeller wash may increase current by up to six times the background current (Olson et al. 1997), which may result in epibenthic meiofauna flushing (Haas et al. 2002). Ferry terminals have been shown to significantly alter epibenthic juvenile salmonid prey during periods of salmon emigration in Washington (Haas et al. 2002).

Wakes from boat traffic may also increase turbidity in shallow waters, uproot aquatic macrophytes in shallow waters, or cause pollution through exhaust, fuel spills, or release of petroleum lubricants (Warrington 1999; McConchie and Tolman 2003). Hilton and Phillips (1982) in their studies on boat traffic and increased turbidity in the River Ant determined that boat traffic definitely had a large effect on turbidity levels in the river. Nordstrom (1989) says that boat wakes may also play a significant role in creating erosion in narrow creeks entering an estuary (areas extensively used by rearing juvenile salmonids). Kahler et al. (2000) indicates that wake erosion results in continuous low level sediment input with episodic large inputs from bank failure.

Dorava (1999) indicates that boat wake erosion was the cause of substantial bank erosion on the Kenaii River, Alaska (whose primary traffic is 10- to 26-foot-long recreational boats) and the reason for substantial bank stabilization measures to arrest that erosion. The result of the erosion in important salmon areas is a reduction in numbers of salmon (Dorava 1999). Dorava (1999) further indicates that juvenile Chinook salmon rearing habitat features are easily altered by boat wake induced streambank erosion and streamside development.

Klein (1997), citing several EPA studies, indicates that boat traffic in waters less than 8.2 feet in depth result in substantial impacts to submerged vegetation and benthic communities. Klein (1997) also indicates that sediment resuspension is substantial if a boat operates in less than 7.2 feet of water and that a slight increase in depth would prevent the resuspension of sediment. Asplund (2000) evaluated the literature on boating effects on the aquatic environment and found that impacts were few in waters greater than 10 feet.

Boating can result in discharges of many pollutants from boats and related facilities, and physical disruption to wetland, riparian and benthic communities and ecosystems through the actions of a boat hull, propeller, anchor, or wakes (USEPA 1993; Carrasquero 2001; Kahler et al. 2000; Mosisch and Arthington 1998). Boats may interact with the aquatic environment by a variety of mechanisms, including emissions and exhaust, propeller contact, turbulence from the propulsion system, waves produced by movement, noise, and movement itself (Asplund 2000). Sediment resuspension, water pollution, disturbance of fish and wildlife, destruction of aquatic plants, and shoreline erosion are the major areas of concern (Asplund 2000).

Boat traffic may adversely affect SAV present in the area. Eelgrass has been shown to be shorter in areas directly affected by boat traffic (Burdick and Short 1999). Propeller wash may erode away the rhizome of seagrasses or cause extensive scarring (Sargent et al. 1995). Boat traffic creates energy that suspends fine sediments and increases turbidity. Ferry docking and departing may result in multiple propeller wash events per hour (Olson et al. 1997). Ferry propeller wash may cause elevated turbidity, coarsening of sediments underneath ferry terminals (Francisco 1995), and scour pits (Shreffler and Gardiner 1999; Haas et al. 2002). Propeller wash may increase current by up to six times the background current (Olson et al. 1997), which may result in epibenthic meiofauna flushing (Haas et al. 2002). Ferry terminals have been shown to significantly alter epibenthic juvenile salmonid prey during periods of salmon emigration in Washington (Haas et al. 2002).

While the effect of some individual overwater structures on EFH may be minimal, the overall impact may be substantial when considered cumulatively. The additive effects of these structures increase the overall magnitude of impact and reduce the ability of the EFH to support native plant and animal communities.

*Potential conservation measures for overwater structures*

- Use upland boat storage whenever possible to minimize need for overwater structures.
- Locate overwater structures in sufficiently deep waters to avoid intertidal and shade impacts, to minimize or preclude dredging, to minimize groundings, and to avoid displacement of SAV, as determined by a pre-construction survey.
- Design piers, docks, and floats to be multi-use facilities in order to reduce the overall number of such structures and the nearshore habitat that is impacted.
- Incorporate measures that increase the ambient light transmission under piers and docks. These measures include, but are not limited to, maximizing the height of the structure and minimizing the width of the structure to decrease shade footprint; grated decking material; using solar tubes to direct light under the structure and glass blocks to direct sunlight under the structure; illuminating the under-structure area with metal halide lamps and use of reflective paint or materials (e.g., concrete or steel instead of materials that absorb light such as wood) on the underside of the dock to reflect ambient light; using the fewest number of pilings necessary to support the structures to allow light into under-pier areas and minimize impacts to the substrate; and aligning piers, docks and floats in north-south orientation to allow arc of sun to cross perpendicular to structure and reduce duration of light limitation.
- Use floating breakwaters whenever possible and remove them during periods of low dock use.
- Encourage seasonal use of docks and off-season haul-out.
- Use waveboards to minimize effects on littoral drift and benthic habitats.
- Locate floats in water far enough offshore as to not impede juvenile fish migration past the structures
- Use mid-water floats or other technology to keep anchor chains from contacting the substrate.
- Conduct in-water work during the time of year when EFH-managed species and prey species are least likely to be impacted.
- Avoid use of treated wood timbers or pilings to the extent practicable. Use of alternative materials such as untreated wood, concrete, or steel is recommended.
- Fit all pilings and navigational aids, such as moorings and channel markers, with devices to prevent perching by piscivorous bird species.
- Orient night lighting such that illumination of the surrounding waters is avoided.
- Mitigate for unavoidable impacts to benthic habitats that is adequately provided, properly monitored, and adaptively managed.
- Elevated turbidity during construction may be avoided with the use of a silt curtain if site conditions allow.
- When removing piles:
  - Remove piles completely rather than cutting or breaking off if the pile is structurally sound.
  - Minimize the suspension of sediments and disturbance of the substrate when removing piles. Measures to help accomplish this include, but are not limited to, the following:
    - When practicable, remove piles with a vibratory hammer, rather than the direct pull or clamshell method.
    - Remove the pile slowly to allow sediment to slough off at, or near, the mudline.
    - The operator should first shake or vibrate the pile to break the bond between the sediment and pile. Doing so causes much of the sediment to slough off the pile at the mudline, thereby minimizing the amount of suspended sediment.
    - Place a ring of clean sand around the base of the pile. This ring will contain some of the sediment that would normally be suspended.

        - Encircle the pile, or piles, with a silt curtain that extends from the surface of the water to the substrate.
    - Complete each pass of the clamshell to minimize suspension of sediment if pile stubs are removed with a clamshell.
    - Fill all holes left by the piles with clean, native sediments if possible.
    - Place old piles on a barge equipped with a basin to contain all attached sediment and runoff water after removal. Creosote-treated timber piles should be cut into short lengths to prevent reuse, and all debris, including attached, contaminated sediments, should be disposed of in an approved upland facility.

#### *4.2.2.25 Pesticide use*

Pesticides are a diverse group of chemicals that are broadly used to control unwanted organisms in agriculture and a range of non-agricultural uses (e.g., forestry, rights-of-way, horticulture, outdoor solid waste containers, irrigation ditches, stagnant water, households and domestic dwellings). They include fungicides, herbicides, insecticides, nematicides, molluscicides, rodenticides, fumigants, disinfectants, repellents, wood preservatives, and antifoulants among others. In Willapa Bay and Grays Harbor, two estuaries in Washington State, the insecticide carbaryl is often sprayed into the aquatic habitat to control burrowing shrimps that interfere with shellfish culture. Given this wide-spread use, pesticides are ubiquitous contaminants in the aquatic environment, and are known to adversely affect many types of organisms, including salmonids by either injuring or killing them, or by degrading the habitats upon which they depend.

Pesticides contain “active” ingredients that kill or otherwise affect targeted organisms (listed on the label). There are more than 900 active ingredients, and they must be registered under the Federal Insecticide, Fungicide, and Rodenticide Act. Registered pesticide products, known as formulations, typically contain active ingredients and a variety of “inert” or other ingredients which are generally not assessed for toxicity, although they are released into the environment. Examples may include chemical adjuvants to make pesticide products more efficacious, surfactants to reduce the interfacial, surface tension and increase uptake by the target, solvents, or other chemicals. Many of these ingredients have their own toxic properties that may result in adverse effects on salmon or their prey. Beginning in 2008, NMFS has issued six biological opinions (NMFS 2008b; 2009b; 2010, NMFS 2011b, NMFS 2012a, 2012b) to the EPA on the registration of 27 pesticides, a draft biological opinion on 3 pesticides (NMFS 2013) is scheduled to complete consultation on 7 others. These biological opinions determined that when applied according to the label instructions, many of these pesticides can have severe effects on individual and populations of threatened and endangered Pacific salmonids under NMFS’ jurisdiction. The biological opinions concluded that many of the pesticides analyzed present a limiting factor to the recovery of at least some of the 27 ESUs of Pacific Coast salmonids, and that application according to the labels would jeopardize the continued existence as well as adversely modify designated critical habitats of many of them. The following summary is drawn from the first two biological opinions (NMFS 2008b; 2009b), which covered a total of six of the pesticides: chlorpyrifos, diazinon, malathion, carbaryl, carbofuran, and methomyl.

The risk analyses in the Opinions used existing literature to evaluate the effects of these pesticides on a number of important endpoints (survival, growth, reproduction, swimming, olfactory-mediated behaviors, and prey survival) and found strong evidence of adverse responses at concentrations that would be expected to occur in the habitats used by salmon. In off-channel habitats that are very important to juvenile salmonids, estimates of pesticide concentrations appeared to be especially high. The Opinions concluded the following:

- Direct, acute exposure to pesticides can kill salmonids. Monitoring data and modeling estimates show that some pesticides can reach lethal concentrations in some of the habitats used by salmon, especially in off-channel habitats.

- Acute or chronic exposure to sublethal concentrations of some active ingredients can lead to lower feeding success and likely results in reduced growth. Survival of juvenile salmonids has been correlated with growth rates, where lower growth rates result in lower survival.
- Salmonid prey are highly sensitive and affected by real-world exposures to many of the pesticides and mixtures of pesticides, particularly, neurotoxic insecticides. Aquatic habitats that are routinely exposed to certain pesticides showed reductions in the abundance and species diversity of the prey community, and reduced growth rates in juvenile salmon have been associated with low prey abundance.
- Exposure to real-world sublethal concentrations of some pesticides has been shown to impair swimming behavior in salmonids. Swimming speed, distance swam, and acceleration can be reduced after such exposure. The ecological consequences of aberrant swimming behavior are impaired feeding that translates into reduced growth, interrupted migratory patterns, survival, and reproduction.
- Definitive evidence supports that olfaction can be impaired by some pesticides at concentrations that are expected to occur in salmon habitats. Juveniles with impaired olfactory functions have been shown to more susceptible to predation, while adult spawning migration and mate detection can be affected by impaired olfaction.
- Mixtures of pesticides, including the ”inert/other” ingredients, can act in combination to increase the potential adverse effects on salmon and salmon habitat compared to exposure to a single ingredient

It is important to note that the potential for pesticides to adversely affect EFH depends on a variety of factors, and not every application will result in an adverse effect. The specific pesticide being applied, the application method and concentration, the distance from salmon habitat that the pesticide is applied, and the general pattern of pesticide use in the area will all affect the pesticide concentrations in the aquatic habitat. In addition the time of year and the species and life stages present are important considerations.

*Potential conservation measures for pesticide use*

The conservation measure implemented will vary depending on the specific pesticide being applied, the species and life stage in the area, and the time of year. In general, they include:

- Avoid the use of pesticides near aquatic habitats, if possible.
- Implement measures that reduce the need to apply pesticides, such as planting pest-resistant crops.
- Use less toxic alternatives to pesticides.
- Establish a minimum no-application buffer width.
- Install or establish a minimum non-crop vegetative buffer where no pesticides are applied.
- Maintain healthy riparian zones alongside salmon-bearing waters.
- Restrict applications under certain environmental conditions, such as during periods of high wind, rain, or wet soils.

#### *4.2.2.26 Power plant intakes*

The withdrawal of water for power plant cooling purposes is termed once-through cooling (OTC). Withdrawal of cooling water removes billions of aquatic organisms every year (CEC 2005). Discharges of heated and/or chemically-treated discharge water may also occur. Adverse impacts to EFH from OTC and subsequent discharges may adversely affect EFH in the source or receiving waters via 1) entrainment, 2) impingement, 3) discharge, 4) operation and maintenance, and 5) construction-related impacts.

*Potential adverse effects from power plant intakes*

Entrainment is the withdrawal of aquatic organisms along with the cooling water into the cooling system. OTC indiscriminately entrains phytoplankton, zooplankton, and the eggs and larval stages of fish and shellfish. These entrained organisms are subjected to mechanical stress, heated water, and occasionally biocides. Of primary concern is the entrainment of early life history stages of fish and shellfish. Entrainment of larval stages can have a greater on fish and shellfish species than to phytoplankton or zooplankton due to a shorter spawning season, a more restricted habitat range, and greater likelihood of mortality. Long-term water withdrawal may adversely affect fish and shellfish populations by adding another source of mortality to the early life stage, which often determines recruitment and year-class strength (Travnichek et al. 1993). OTC units utilizing estuarine or marine waters are unlikely to entrain larval Chinook salmon or coho salmon given that spawning and larval development for these species occur in freshwater environments. Pink salmon are likely to be more susceptible to impingement and entrainment than the other two species because they typically enter the estuarine and marine habitats immediately after emergence and are, therefore, much smaller. Entrainment studies at power plants located in coastal lagoons and embayments have demonstrated that a large percentage of entrained larvae are composed of resident fishes that serve as a forage base for other species (EPRI 2007). Thus, entrainment may reduce the forage base for salmon species that may utilize the various coastal lagoons and embayments in which OTC units operate. Power plants utilizing OTC in open coastal environments have far less potential for population-level effects on fish populations than power plants located in coastal lagoons and embayments (EPRI 2007). However, localized reductions in forage opportunities may still occur near open coast OTC units.

Impingement occurs to organisms that are too large to pass through in-plant screening devices and instead become stuck or impinged against the screening device or remain in the forebay sections of the system until they are removed by other means (Grimes 1975; Hanson et al. 1977; Moazzam and Rizvi 1980; Helvey 1985; Helvey and Dorn 1987). The organisms cannot escape due to the water flow that either pushes them against the screen or prevents them from exiting the intake tunnel. Similar to entrainment, the withdrawal of water can entrapped particular species especially when visibility is reduced (Helvey 1985). This condition reduces the suitability of the source waters to provide normal EFH functions necessary for subadult and adult life stages of salmon and/or their prey. Population level impacts have not been observed for individual species.

The ecological implications of entrainment and impingement are complex and difficult to assess. Although population level impacts are not consistently observed, the use of OTC may significantly decrease biological productivity in estuarine and marine systems. With modern entrainment sampling and analyses, a more scientifically robust method of determining appropriate compensation may be done through the use of habitat production foregone analyses. A combined habitat foregone estimate for 13 power plants using OTC in California bays and estuaries was approximately 10,800 acres of wetlands (CEC 2005).

Thermal effluents in inshore habitat may alter the benthic community or kill marine organisms, especially larval fish. Temperature influences biochemical processes of the environment and the behavior (e.g., migration) and physiology (e.g., metabolism) of marine organisms (Blaxter 1969). Thermal impacts are generally site-specific and depend upon the type of habitat and circulation at the discharge site. The thermal impacts of some West Coast plants have been large when discharge occurs either into bays and estuaries with reduced mixing or into the open coast where heated water quickly contacts rocky habitats (Duke 2004; Schiel et al. 2004; Foster 2005). Significant impacts to sensitive habitats, such as eelgrass and kelp, have been observed with some California power plants. However, heated water discharged offshore on the open coast experiences rapid mixing before touching benthic habitat, which likely results in little impact (CEC 2005). The water clarity of the receiving waters may also be diminished if the intake water is more turbid than that around the discharge structure. Water clarity and quality may also be altered by the increased dead organic matter in the discharge, as well as by scour if discharge occurs on shore (CEC 2005).

Other impacts to aquatic habitats may result from construction related activities, such as dewatering or dredging, as well as routine operation and maintenance activities. The effects of some of these activities are discussed elsewhere. There is a broad range of impacts associated with these activities depending on the specific design and needs of the system. For example, dredging activities may cause turbidity, degraded water quality, noise, and substrate alterations. Power plants using OTC may also periodically use biocides such as sodium hypochlorite and sodium bisulfate to clean the intake and discharge structures. Chlorine is extremely toxic to aquatic life. In addition, heat treatments are frequently used to control fouling organisms in the forebay area of OTC units. This kills the fish that remain in the forebay and the fouling invertebrate organisms along the tunnels and racks.

*Potential conservation measures for power plant intakes*

- To the extent feasible, power plants should utilize cooling alternatives that avoid or minimize the use of river, estuary, or ocean water for cooling purposes. Alternatives such as dry cooling, closed- cycle wet cooling, utilizing recycled water for cooling water are more benign to EFH.
- Locate facilities that rely on surface waters for cooling in areas other than estuaries, inlets, heads of submarine canyons, rock reefs, or small coastal embayments where EFH species or their prey concentrate. Discharge points should be located in areas that have low concentrations of living marine resources.
- Design intake structures to minimize entrainment or impingement. Velocity caps that produce horizontal intake/discharge currents should be employed, and intake velocities across the intake screen should not exceed 0.5 foot per second.
- Design power plant cooling structures to meet the "best technology available" requirements (BTAs) as developed pursuant to Section 316(b) of the Clean Water Act. Use of alternative cooling strategies, such as closed cooling systems (e.g., dry cooling) should be used to completely avoid entrainment/impingement impacts in all industries that require cooling water. When alternative cooling strategies prove infeasible, other BTAs may include but are not limited to fish diversion or avoidance systems, fish return systems that convey organisms away from the intake, and mechanical screen systems that prevent organisms from entering the intake system, and habitat restoration measures.
- Regulate discharge temperatures (both heated and cooled effluent) such that they do not appreciably alter the temperature in a way that could cause a change in species assemblages and ecosystem function in the receiving waters. Strategies should be implemented to diffuse the heated effluent.
- Avoid the use of biocides (e.g., chlorine) to prevent fouling where possible. The least damaging antifouling alternatives should be implemented.
- Mitigate for impacts related to power plants and other industries requiring cooling water. Mitigation should compensate for the net loss of EFH habitat functions from placement and operation of the intake and discharge structures. Mitigation should be provided for the loss of habitat from placement of the intake structure and delivery pipeline, the loss of fish larvae and eggs that may be entrained by large intake systems, and the degradation or loss of habitat from placement of the outfall structure and pipeline as well as the treated water plume. A habitat production foregone approach or equivalent habitat equivalency analysis should be used for determining mitigation.
- Treat all discharge water from outfall structures to meet state water quality water standards at the terminus of the pipe. Pipes should extend a substantial distance offshore and be buried deep enough to not affect shoreline processes. Buildings and associated structures should be set well back from the shoreline to preclude the need for bank armoring.

#### 4.2.2.27 Road Building and Maintenance

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

In urban areas, extensive road and pavement can effectively double the frequency of hydrologic events that are capable of mobilizing stream substrates (NRC 1996) (also see Section 4.2.2.7 Construction/Urbanization). This increased scour of gravel and cobble in areas where salmon eggs, alevins, or fry reside can kill salmon directly or indirectly increase mortality by carrying them downstream and away from stream cover. Urban roads can be a major source of sediment input during construction as can the installation of bridges, culverts, and diversions with coffer dams. However, these project impacts seem to be more temporary and less pervasive on sediment input than forest roads (Waters 1995).

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

Road culverts can block both adult and juvenile salmon migrations. Blockage can result from the culvert becoming perched above stream bed level, lack of pools that could allow salmon to reach the culvert, or from high water flow velocities in the culvert. The effect of logging roads on erosion and sedimentation has been well studied. Furniss et al. (1991) concluded that forest roads contribute more sediment than all other forest activities combined on a per-unit basis. Road surfaces can break down with repeated heavy wheel loads of hauling trucks, particularly under wet conditions, resulting in a continual source of fine sediment input (Murphy 1995). However, improvements in road-construction and logging methods can reduce erosion rates (NRC 1996). For additional detail, see Section 4.2.2.15 Forestry.

### *Conservation Measures for Road Building and Maintenance*

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

- Revegetate cut banks, road fills, bare shoulders, disturbed streambanks, etc. after construction to prevent erosion. Check and maintain sediment control and retention structures throughout the rainy season.
- Minimize riparian corridor damage during construction of roads (and bridges, culverts, and other crossings) and avoid locating roads in floodplains.
- Rehabilitate roads by upgrading problem culverts or replacing with bridges, outsloping road surfaces to drain properly without maintenance, revegetating bare surfaces, and other measures as necessary for stability.
- At a minimum, use state or Federal culvert design guidelines (e.g., NMFS 1996b) for design and installations of culverts.
- Road maintenance practices should be conducted according to the requirements of existing NMFS rules such as the July 2000 ESA 4(d) rule (Protective Regulations) for listed West Coast salmon and steelhead (65 FR 42422; July 10, 2000), Limit 10, covering road maintenance. NMFS has found that doing maintenance under these programs not only avoids causing existing problems to worsen, but protects salmonid habitat to the extent that it contributes to the conservation of the species.

#### *4.2.2.28 Sand and Gravel Mining*

Mining of sand and gravel in the region's watersheds is extensive. Mining occurs by several methods. Most common is bar scalping or skimming operations, which use bulldozers, scrapers, and loaders to remove the tops of river gravel bars without excavating below the summer water. The bars are almost always attached to the stream banks and are frequently located on the inside of meander bends. Excavation of floodplain and river terrace deposits adjacent to an active or former channel is another common method for gravel extraction. Gravel extraction in these locations may occur to the level of seasonal flow, or may excavate below the adjacent water level, and require pumping of seepage water or underwater extraction from a pond. As active channels naturally move, the channel may migrate into the excavated area. The chance of this occurring is increased in the event of a flood.

*Potential adverse effects of sand and gravel mining*

The potential effects of gravel extraction activities on anadromous fishes and their habitats are summarized in NMFS' National Gravel Extraction Policy (Packer et al. 2005) with the following categories of effects:

- Extraction of bed material in excess of natural replenishment by upstream transport causes bed degradation.
- Gravel extraction increases suspended sediment, sediment transport, water turbidity and gravel siltation.
- Bed degradation changes the morphology of the channel.
- Gravel bar skimming significantly impacts aquatic habitat.
- Operation of heavy equipment in the channel bed can directly destroy spawning habitat, and produce increased suspended sediment downstream.
- Stockpiles and overburden left in the floodplain can alter channel hydraulics during high flows.
- Removal or disturbance of instream roughness elements during gravel extraction activities negatively affects both quality and quantity of anadromous fish habitat.
- Destruction of the riparian zone during gravel extraction operations can have multiple deleterious effects on anadromous fish habitat.

The culmination of these effects make the stream channels wider, shallower, and less complex, resulting in decreased suitability as rearing habitat for juveniles. During summer low-flow periods deep complex waters are important for survival. During winter high-flow events slow water on the margins of streams created by complex channels are most important for juvenile survival. Similarly a reduction in pool frequency may adversely affect migrating adults that require holding pools (Spence et al. 1996). Changes in the frequency and extent of bedload movement and increased erosion and turbidity can also remove spawning substrates, scour redds (resulting in a direct loss of eggs and young), or reduce their quality by deposition of increased amounts of fine sediments. Other effects that may result from sand and gravel mining include increased temperatures (from reduction in summer base flows and decreases in riparian vegetation), decreased nutrients (from loss of floodplain connection and riparian vegetation), and decreased food production (loss of invertebrates) (Spence et al. 1996).

*Potential conservation measures for sand and gravel mining*

The following suggested measures are adapted from the Oregon Sediment Removal Considerations (Federal Interagency Working Group 2006), NMFS National Gravel Policy (NMFS 2005), and OWRRI (1995).

- In all sand and gravel removal projects, include restoration, mitigation, and monitoring plans.
- For in-stream sand and gravel removal:
    - Complete all in-water work during the summer low flow period.

  - Require implementation of a spill prevention and response plan to minimize the potential of a contaminant spill and the size of a spill if one were to occur
  - Avoid reach level impacts on channel morphology by strictly limiting the cumulative gravel removal quantities to ensure gravel recruitment and accumulation rates are sufficient. To achieve this, an estimate of the volume of sand and gravel recruiting to the reach will be required from a qualified hydrologist or fluvial geomorphologist. Only a portion of that estimate will be available for removal.
  - Minimize site level impacts by retaining the hydraulic control exerted by bars on the stream channel using the following restrictions:
    - <u>Head of bar buffer</u>. The operators will protect the upstream third of the bar from any excavation activities.
    - <u>Lateral buffer</u>. An undisturbed setback area between the low flow channel and the active mining area will be no less than 20 percent of the active channel width.
    - <u>Excavated backwater length</u>. Not greater than two-thirds of the bar feature, and will include the head slope and side slope of the backwater.
    - <u>Excavated backwater depth</u>. The maximum depth will be equal to the low flow elevation at the downstream end. The backwater area will be sloped to prevent fish entrapment.
    - <u>Excavated backwater head slope</u>. No steeper than 10 to 1 (horizontal to vertical).
    - <u>Excavated backwater side slopes</u>. No steeper than 4 to 1 (horizontal to vertical).
- For floodplain sand and gravel removal:
  - To minimize the occurrence of juvenile entrapment, floodplain pits should be located outside the 50-year flood elevation.
  - To minimize the probability of pit capture, floodplain pits should be located outside of the 100-year channel migration belt of all streams.

#### *4.2.2.29 Vessel Operations*

Population and income drive the demand for trade, and trade drives the demand for transportation services (COE 2012a). The United States is a maritime nation, with its networks of highways, railways and inland waters connecting America's heartland to inland and coastal ports. The U.S. population is expected to increase from 313.4 million in 2011 to 412.2 million in 2042, an increase of 32 percent (COE 2012a). Populations in west coast states of Washington, Oregon and California are expected to grow by 12.8, 10.5 and 24.3 percent, respectively. Forecasts for bulk and containerized trade expect imports to increase from 17 million in 2011 to 60 million in 2037 and exports to increase from 13 to 52 million over the same time period. As coastal and inland waterway communities grow, so does the demand for increased capacity of marine transportation vessels, facilities, and infrastructure for cargo handling activities, water transportation services, and recreational opportunities. By 2030 post-Panamax vessels will make up 62 percent of total container ship capacity. These ships have the capacity to transport 12,000 containers, have 50-foot drafts, 16-foot beams, and 1,200-foot lengths (COE 2012b).

*<u>Potential adverse effects from vessel operations/transportation/navigation</u>*

While investments to maintain, improve and expand navigation and intermodal transportation infrastructure are necessary for the US to remain globally competitive, these investments come at a significant environmental and resource cost. The growth of the marine transportation industry is accompanied by land-use changes, including over-water or in-water construction, and loss and degradation of aquatic habitat and wetlands through actions such as filling, dredging, channelization, and diking and damming. Wetlands and open-water environments are disproportionately impacted by ports and waterways, and wetland losses have outdistanced gains (Dahl 2011). Freshwater environments have been significantly impacted by physical, chemical and biological changes (COE 2012a). Although some habitat impacts resulting from some site-specific activities may be minimal, the cumulative effects of these activities over time can have substantial impacts on habitat. Impacts to EFH from navigation infrastructure include: (1) loss, conversion, or impairment of benthic, shoreline, and pelagic habitats; (2) altered light and temperature regimes; (3) contaminant and debris releases; (4) altered tidal, current, and hydrologic regimes; and (5) introduction of invasive or nonnative species. Navigation and transportation infrastructure can also directly and indirectly alter aquatic organism assemblages; alter rearing, spawning, and migration behavior; alter predator-prey relationships and interactions; and result in the mortality or injury through entrainment and propeller strikes. For additional information, refer to the Sections on the Construction and Urbanization, Dredging and Dredge Spoils, Wetland and Floodplain Alteration, Wastewater and Pollutant Discharge, Estuarine Alteration, Overwater Structures, Introduction and Spread of Invasive Species, and Bank Stabilization.

### Operation and Maintenance of Vessels

Activities associated with the operation and maintenance of commercial, industrial and recreational vessels can directly and indirectly impact EFH. Impacts from vessel operation can result from hydrodynamics due to vessel-induce wake and wave generation, anchor chain and propeller scour; noise and chemical pollution due to vessel operation and waste discharge; and the inadvertent transport of invasive plant and animal species. Impacts can also result from vessel abandonment and dereliction. The severity of vessel-induced impacts on coastal and inland waterway habitats depends on the geomorphology of the impacted area, current velocity, sediment composition, vegetation type and extent of vegetative cover, as well as vessel type and dimensions, number of vessels, speed, vessel direction, proximity to the shoreline, and timing (Yousef 1974; Holland 1987; Garrad and Hey 1988; Barr 1993; Mazumder et al. 1993). Projected population growth and associated demand for improved and expanded waterborne transportation services that include increased vessel traffic and faster, larger vessels will likely exacerbate vessel-induced impacts (Cook 1985; Holland 1987).

Direct and indirect vessel-induced EFH impacts include: (1) loss or impairment of benthic, shoreline and pelagic habitats; (2) contaminant and debris releases, including vessel abandonment and dereliction; (3) underwater noise pollution; and (4) introduction of invasive or nonnative species. Vessel operations can also directly and indirectly alter aquatic organism assemblages; alter rearing, spawning, migration, and recruitment behaviors; and result in the mortality or injury through stranding, entrainment, and propeller strikes.

#### Loss or impairment of benthic, shoreline and pelagic habitat

Vessel movement creates wakes/waves and energy, which causes altered velocity and pressure regimes, drawdowns, waves along the shoreline, and increases in turbidity due to erosion and resuspended sediments (Bhowmik et al. 1982; Maynord 1990; Bhowmik 1991; Bhowmik et al. 1991; Bhowmik et al. 1993; Mazumder et al. 1993; Maynord 1996). These disturbances can result in shoreline erosion, disturbed substrate, increased turbidity, damaged aquatic vegetation, and impacts to aquatic organisms (Bouwmeester et al. 1977; Hilton and Phillips 1982; Cook 1985; Nielsen et al. 1986; Garrad and Hey 1988; Bhowmik et al. 1991; Bhowmik et al. 1993; Barr 1993; Johnson 1994; Maynord 2005; Hammack et al. 2008; Kelpšaite et al. 2009; Nagrodski et al. 2012).

The degree of sediment resuspension and entrainment into the water column by vessel activity is complex (Anthony and Downing 2003), but is generally dependent upon the wave energy and surge produced by the vessel, as well as the size of the sediment particles, the water depth, and the number of vessels passing through an area (Barr 1993). Heavy recreational vessel traffic can generate substantial wave activity with detrimental results to shoreline vegetation and bank stability (Johnson 1994; Bhowmik et al. 1991). Wave activity also influences the distribution and species composition of aquatic plant communities (Vermaat and de Bruyne 1993; Stewart et al. 1997). Maynord et al. (2008) noted that the persistent nature of wake erosion during the peak boating season may prevent the colonization of some plant species and may induce elevated turbidity levels in the zone near the bank. Wave activity washes away finer clays and silts, leaving coarser, less fertile sediments behind, and can tear or up-root plants. Chambers (1987) study demonstrated that the minimum depth of macrophyte occurrence is related to the depth of surface wave mixing. Doyle's (2001) study on the effects of vessel-induced waves on submerged plant growth concluded that plants exposed to even modest wave energy grew more slowly and were less resilient to recovery from other forms of disturbance.

Substrate and macrophyte disturbance can also occur through propeller wash resuspension of bottom sediments and direct contact with propellers or vessel hulls through grounding (Barr 1993). Benthic disturbance can also occur from anchor scour. As reported in NMFS (2011c), mooring buoys, when anchored in shallow nearshore waters, can drag the anchor chain across the bottom, destroying submerged vegetation and creating a circular scour hole (Walker et al. 1989 as cited in Shafer 2002). A study by Hastings et al. (1995 as cited in Shafer 2002) in Australia found that up to 18 percent of total seagrass cover was lost to mooring buoy scour.

Vessel-induced sedimentation can lead to persistently- poor water quality; altered phytoplankton productivity through reduced photosynthetic efficiency and macrophyte biomass (Kirk 1985; Asplund and Cook 1997; Uhrin and Holmquist 2003); and suppression of benthic, macrophyte and fish communities (Murphy and Eaton 1983; Anthony and Downing 2003; Wolter and Arlinghaus 2003; Eriksson et al. 2004). Both propeller-induced turbulence and vessel-induced wakes from recreational boat traffic have been correlated to rapid increases in total dissolved solids, soluble reactive phosphorus, total phosphorus (Yousef et al. 1980), and turbidity (Yousef 1974; Yousef et al.1980; Garrad and Hey 1988). Turbidity results in poor light conditions which impacts plant growth (Doyle 1999). Water clarity is important in determining the depth-of-penetration of sunlight within a given water body, and light penetration is especially important for submerged aquatic plants such as seagrasses for photosynthesis (Wilson 2010). Benthic diatoms and other microflora can also experience a significant decrease in primary production as a result of increases in turbidity and sediment from resuspension. Shaffer (1984) found that a thin layer of sediment deposited over a sandflat resulted in a 6.5 fold decrease in net primary productivity. Studies investigating sedimentation impacts on eelgrass have found that experimental burial of 25 percent of the plant height can result in greater than 50 percent mortality (Mills and Fonseca 2003).

The value of nearshore habitats to fish and shellfish is well documented (Bjornn and Reiser 1991; Dethier 2006; Fresh 2006; Gelfenbaum et al. 2006; Mumford 2007; Penttila 2007; AHGP 2010; Tabor et al. 2011). The disturbance of sediments and rooted vegetation decreases habitat suitability for fish and shellfish resources and can affect the spatial distribution and abundance of fauna (Soria et al. 1996; Uhrin and Holmquist 2003; Eriksson et al. 2004; Fullerton et al. 2011; Fresh et al. 2011). Declines in SAV, which provides food, shelter, and protection for many aquatic invertebrate and vertebrate species, will indirectly affect populations of species that depend on it.

Increased suspended sediment levels can also affect predator-prey relationships, food availability, and feeding behavior (Barrett et al. 1992; Lloyd 1987; Bash et al. 2001; Meager et al. 2006; Harvey and White 2008; Carter et al. 2010; Huenemann et al. 2012) and cause physical damage or mortality to eggs, larvae, and older fish (Newcombe and Jensen 1996; Bash et al. 2001) The egg and larval stages of marine and estuarine fish are generally highly sensitive to suspended sediment exposures (Morgan and Levings 1989; Wilber and Clark 2001), and juvenile fish may be susceptible to gill injury when suspended sediment levels are high (Servizi and Martens 1991; Bash et al. 2001).

As fish assemblages in inland navigational waterways become exposed to vessel-induced physical forces such as shear stress, wave turbulence, drawdown, dewatering, backwash, and return currents, susceptibility to stranding in littoral areas increases (Bauersfeld 1977; Adams et al. 1999; Ackerman 2002; Wolter and Arlinghaus 2003; Pearson et al. 2006; Pearson et al. 2008; Pearson and Skalski 2011; Nagrodski et al. 2012). Fish stranding, a function of fish size and swimming performance, tends to be a problem for smolts less than 60 to 70 millimeters fork length (Bauersfeld 1977; Ackerman 2002). The risk of stranding increases as the distance from the drawdown to run-up increases. The risk of stranding also increases with increasing salmon density in the nearshore. Using spatial analysis and sequential screen criteria on how the channel morphology influences ship wake characteristics, Pearson et al. (2008) estimated the number of shoreline reaches in the lower Columbia River that could potentially strand juvenile salmonids. They also concluded that stranding was a function of ship characteristics (mainly size and speed), channel and shoreline geomorphology, and the presence and composition of fish fauna.

Contaminant releases

A variety of substances can be discharged or accidentally spilled into the aquatic environment from vessel operations, maintenance, and repair, such as gray water (i.e., sink, laundry effluent), raw sewage, engine cooling water, fuel and oil, vessel exhaust, sloughed bottom paint, boat wash-down water, that may degrade water quality and contaminate bottom sediments (Stammerjohn et al. 1991; EPA 2001; EPA and MA 2006; WDOE 2009). Boat waste discharges result in local increases in nutrient loading and biological oxygen demand and further impact water quality through the release of disease causing organisms and toxic substances (Thom and Shreffler 1996 as cited in NMFS 2011c; Klein 1997; EPA 1985). Despite laws prohibiting the discharge of untreated wastes into coastal waters, many vessels may not be equipped with marine sanitation devices and on-shore pump-out stations are not common (Amaral et al. 2005). Impacts from vessel waste discharges may be exacerbated in small, poorly flushed waterways where pollutant concentrations can reach unusually high levels (Klein 1997). For additional information, refer to the discussion on Wastewater and Pollutant Discharge.

Metals and metal-containing compounds known to have toxic effects on marine organisms such as arsenic, cadmium, copper, lead, zinc and mercury (EPA 2001; EPA 2006) are released into the environment through various vessel maintenance activities such as bottom washing, paint scraping, and application of antifouling paints (Amaral et al. 2005). Sediment disturbance through physical or biological means can reintroduce toxic compounds into the water column, where they can be ingested by fish or other aquatic organisms and in turn by people (EPA 2001; EPA 2006; Jones and Turner 2010; Turner 2010; Berto et al. 2012). Metals are known to have toxic effects on marine organisms (Tierney et al. 2010). Considerable information is available regarding the effects of copper on aquatic organisms (Eisler 1998; Hecht et al. 2007; EPA 2007; Tierney et al. 2010; Tilton et al. 2011). Hecht et al. (2007) concluded benchmark concentrations (BMC) of dissolved copper ranging from 0.18 ($BMC_{10}$) to 2.1 ($BMC_{50}$) micrograms per liter (µg/L) corresponded to an approximately 50 percent reduction in olfactory function of juvenile salmon and a 47 percent reduction in alarm response. Copper may also bioaccumulate in bacteria and phytoplankton (Milliken and Lee 1990; Turner et al. 2009). Bao et al. (2013) determined that at least one of the new generation antifouling booster biocides, Irgarol 1051; works synergistically with copper in antifouling paints.

In addition to biocides, herbicides are also used in some antifouling paints to inhibit the colonization of algae and the growth of seaweeds on boat hulls and intake pipes (Readman et al. 1993). The leaching of these chemicals into the marine environment could affect community structure and phytoplankton abundance (Readman et al. 1993).

Other chemicals used in vessel maintenance, repair, and cleaning that can enter the water column and sediment include solvents used in degreasing agents, varnishes, and paint removers; antifreeze; and acids such as battery acid, cleaning compounds, and detergents (EPA 2001). Solvents, many of which are carcinogens, are insoluble and accumulate on the bottom. Detergents and cleaning agents accumulate at the water surface, creating a barrier to the transfer of dissolved oxygen at the air-surface interface. This results in lowered dissolved oxygen concentrations.

The air-surface microlayer is a sink and source for a range of other pollutants including chlorinated hydrocarbons, organotin compounds, petroleum hydrocarbons and polycyclic aromatic hydrocarbons (PAHs) (Wurl and Obbard 2004). Pollutants in this layer can be enriched by up to 500 times relative to concentrations in the underlying water column. Wurl and Obbard (2004) concluded that the total concentration of PAHs in the microlayer generally increases with the size of the port and intensity of shipping traffic. Mastran et al. (1994) concluded that recreational boating was a source of PAHs during periods of high boating activity. Outboard engine pollution, particularly from two-cycle engines, can contribute to the concentrations of hydrocarbons in the water column and sediment.

The presence and effects of PAHs in sediment and aquatic organisms is well studied (Meador et al. 1995; Poston 2001; Johnson et al. 2002; Lebow et al. 2004; Stratus Consulting 2006). Polycyclic aromatic hydrocarbons can cause acute and chronic toxicity in marine organisms (Neff 1985), and can bioaccumulate in the tissue of organisms (Meador et al. 1995; Arkoosh et al. 1998). Because PAHs tend to attach to suspended particles and sediment, they can be ingested by shellfish and other bottom dwelling organisms for years (EPA 2001). Arkoosh et al. (1998) concluded that juvenile Chinook salmon bioaccumulate significant concentrations of chemical contaminants during their relatively short residence time in the estuary, primarily through exposure from their diet. Exposure to PAHs can lead to immunosuppression and increased disease susceptibility in juvenile salmon (Arkoosh et al. 1998). Effects on fish from low-level chronic exposure may increase embryo mortality or reduce growth (Heintz et al. 2000).

### Debris releases

Solid waste is also a significant source of contaminants in marine and freshwater (Barnes 2005; UNEP 2005; Barnes et al. 2009; Gregory 2009), and billions of pounds of debris are dumped into the oceans each year (Milliken and Lee 1990; UNEP 2005). Commercial fishing, merchant vessel, cruise ship, and recreational boats are major contributors to marine debris because of accidental loss, routine practices of dumping waste, and illegal dumping activities. Plastics are an especially persistent form of solid waste as the longevity of plastic is estimated to be hundreds to thousands of years (Barnes et al. 2009). They tend to concentrate along coastal areas because they float on the surface and can be transported by ocean currents (Barnes 2005; UNEP 2005; Milliken and Lee 1990; Barnes et al. 2009). Entanglement in or ingestion of this debris can cause fish, marine mammals, and sea birds to become impaired or incapacitated, leading to starvation, drowning, increased vulnerability to predators, and physical wounds (UNEP 2004; Gregory 2009). Marine debris can also cause direct physical damage to habitat features through smothering or physical disturbance, and introduction of aggressive invasive species (UNEP 2005; Gregory 2009).

### Vessel Abandonment and dereliction

Also considered marine debris, are the hundreds of thousands of sunken, derelict, abandoned, grounded, or wrecked vessels that can be found in US waters (Zelo et al. 2005). These vessels can cause a variety of environmental impacts, including the release of pollutants and hazardous materials, the physical destruction of habitats, and becoming sources for clandestine dumping, nutrient enrichment, and impediments to navigation (Helton 2003). The most obvious environmental threat of a derelict, abandoned, grounded, or wrecked vessel is the release of oil or other pollutants. These hazardous materials may be part of a vessel’s cargo, fuel and oil related to vessel operations, or chemicals contained within the vessel’s structure which may be released through decay and corrosion over time (Marshall et al. 2002; Negri et al. 2002; Turner 2010). Abandoned, derelict, and grounded vessels may physically damage, smother, or reduce the complexity of benthic habitats; increase shading effects; and create changes in wave energy and sedimentation patterns leading to increased erosion and bed scour (Precht et al. 2001; Zelo and Helton 2005; Zelo et al. 2005).

### Introduction of Invasive or Nonnative Species

Industrial and commercial shipping and recreational boating are significant vectors for the introduction of non-native and invasive species. Vectors include hull and sea chest fouling, and ballast water (Ruiz et al. 2000; Clarke Murray 2012). Invasive and non-native species attached to vessel hulls and sea chests are transported between water bodies or through the release of ballast water from large commercial vessels.

Modern ships can carry 10 to 200 thousand tons of ballast water at a time and transport marine organisms across long distances and in relatively short time periods (Hofer 1998 in NMFS 2008). A 2009 International Union for Conservation of Nature report estimated that 7,000 species are carried around the world in ballast water every day and 10 billion tons of ballast water are transferred globally each year. Arrival of zebra mussels in the Great Lakes in the late 1980s focused initial attention on ballast water as a source of invasive species (Buck 2010). A key vector for zebra mussels is now via recreational boat trailers (Buck 2010; Clarke Murray 2012). Recreational vessels can act as both a primary vector and a secondary vector for the spread of invasive and non-native species (Davidson et al. 2010; Clarke Murray 2011; Clarke Murray 2012). See Section 4.2.2.18 Introduction/Spread of Invasive Alien Species for a description of the potential effects of invasive species and measures to minimize those effects.

*Potential conservation measures for vessel operation*

- Encourage recreational boats to be equipped with marine sanitation devices (MSDs) to prevent untreated sewage to be pumped overboard.
- Establish no discharge zones to prevent any boat sewage from entering boating waters.
- Utilize appropriate methods for containment of waste water, surface water collection, and recycling to avoid the discharge of pollution during the maintenance and operation of vessels.
- Provide and maintain appropriate storage, transfer, containment, and disposal facilities for liquid material, such as oil, harmful solvents, antifreeze, and paints, and encourage recycling of these materials.
- Dispose of wastes, both solid and liquid, produced by the operation, cleaning, maintenance, and repair of boats in a manner that prevents contamination of surface waters. Proper disposal of these materials can be encouraged through public outreach and education.
- Ensure that commercial ships have oil-spill response plans and all necessary equipment in place to improve response and recovery in the case of accidental spillage.
- Use dispersants that remove oils from the environment rather than dispersants that simply move them from the surface to the ocean bottom.
- Promote the use of oil-absorbing materials in the bilge areas of all boats with inboard engines.
- Promote the use of fuel/air separators on air vents or tank stems of inboard fuel tanks to reduce the amount of fuel and oil spilled into surface waters during fueling of boats.
- Avoid overfilling fuel tanks and provide “doughnuts” or small petroleum absorption pads to patrons to use while fueling.
- Keep engines properly maintained for efficient fuel consumption, clean exhaust, and fuel economy. Follow the manufacturer’s specifications and routinely check for engine fuel leaks.
- Avoid pumping any bilge water that is oily or has a sheen. Promote the use of materials that capture or digest oil in bilges. Examine these materials frequently and replace as necessary.
- Avoid in-the-water hull scraping or any abrasive process done underwater that could remove paint from the boat hull.
- Incorporate BMPs to prevent or minimize contamination from ship bilge waters, antifouling paints, shipboard accidents, shipyard work, maintenance dredging and disposal, and nonpoint source contaminants from upland facilities related to vessel operations and navigation.
- Promote education and signage on all vessels to encourage proper disposal of solid debris at sea.
- Avoid ballast water exchange in nearshore coastal waters. Use shore-based ballast water treatment systems and ship-board ballast treatment systems as alternatives.
- Wash recreational boats and watercraft off after use and before trailering it to other waters to avoid spreading exotic, nonnative species to uninfected waters.
- Locate mooring buoys in deep water to avoid grounding and minimize the effects of propeller wash. Use subsurface floats or other methods to prevent contact of the anchor line with the substrate.

- Minimize ship speeds on rivers to those that do not create ship wakes and drawdowns which strand fish or damage shorelines.
- Vessels should be operated at sufficiently low speeds, especially near the shoreline, to reduce wake energy, and no-wake zones should be designated near sensitive habitats.
- Avoid shallow water areas to avoid stirring bottom sediments. In coastal areas, be aware of low tides when seagrass beds, other delicate vegetation, and bottom organisms are more exposed. Restrict boater traffic in shallow-water and sensitive areas.
- Minimize additional seafloor damage when a derelict vessel has to be dragged across the seafloor to deep water by following the same ingress path. Alternatively, identify the least sensitive, operationally feasible towpath. Dismantling derelict vessels in place when stranded close to shore may cause less environmental impact than dredging or dragging a vessel across an extensive shallow habitat.
- Reduce the risk of a sudden release of the entire cargo when a submerged derelict vessel contains hazardous aqueous solutions that pose limited environmental risks, such as mild acids and bases, by allowing the release of the cargo under controlled conditions. The controlled release plan can include water-quality monitoring to validate the calculated dilution rates and plume distance assumptions. All applicable state and Federal laws and regulations regarding the release of chemicals into the water should be followed.
- Develop a contingency plan for uncontrolled releases during vessel salvage operations. The salvage plan should include a risk assessment to determine the most likely release scenarios and use the best practices of the industry.
- Schedule nonemergency salvage operations while including environmental considerations to minimize potential impacts on natural resources. Environmental considerations include periods when few sensitive species are present, avoidance of critical reproductive periods, and weather patterns that influence the trajectory of potential releases during operations.

#### *4.2.2.30 Wastewater/Pollutant Discharge*

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

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

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

Indirect sources of water pollution in salmon habitat results from run-off from streets, yards, construction sites, gravel or rock crushing operations, or agricultural and forestry lands. This run-off can carry oil and other hydrocarbons, lead and other heavy metals, pesticides, herbicides, sediment, nutrients, bacteria, and pathogens into salmon habitat. Water pollution can also result from the resuspension of buried contaminated sediments (e.g., from dredging operations). (See Sections 4.2.2.2 Agriculture; 4.2.2.7 Construction/Urbanization; 4.2.2.13 Dredging and Dredged Spoil Disposal; 4.2.2.15 Forestry; 4.2.2.16 Grazing; and 4.2.2.21 Mineral Mining).

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

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

*Potential conservation measures for wastewater/pollutant discharge*

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

Some pollutant discharges are regulated through discharge permits which set effluent discharge limitations and/or specify operation procedures, performance standards, or BMPs. Additional effort to improve water quality is also being fostered by states under the guidance of the Coastal Zone Management Reauthorization Act. These efforts rely on the implementation of BMPs to control polluted run-off (EPA 1993). Although not yet a consistently applied mechanism to improve water quality, vegetated buffers along streams have been shown to be effective in providing such functions as sediment trapping, removal of nutrients and metals, moderation of water temperatures, increasing stream and channel stability and allowing recruitment of woody debris.

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

- Monitor water quality discharges following National Pollutant Discharge Elimination System requirements from all discharge points (including municipal stormwater systems, and desalinization plants). , and irrigation ditches).

- Apply the management measures developed for controlling pollution from run-off in coastal areas to all watersheds affecting salmon EFH.
- For those water bodies that are defined as water quality limited in salmon EFH (303(d) list), establish total maximum daily loads (TMDLs)and develop appropriate management plans to attain management goals.
- Allocate more resources to complete existing and future TMDLs established on waterbodies designated as water quality limited in salmon EFH habitat.
- Where in-stream flows are insufficient for water quality maintenance, establish conservation guidelines for water use permits, encourage the purchase or lease of water rights and the use of water to conserve or augment instream flows in accordance with state and Federal water law.
- Establish and update, as necessary, pollution prevention plans, spill control practices, and spill control equipment for the handling or transporting toxic substances in salmon EFH. Consider bonds or other damage compensation mechanisms to cover clean-up, restoration, and mitigation costs.
- Actively reduce the size of mixing zones that discharge to coastal areas and watersheds.
- Utilize biological effects thresholds, for example those recently established for dissolved copper, for transportation facilities that discharge to salmon EFH habitat.

#### *4.2.2.31 Wetland and Floodplain Alteration*

*Potential adverse effects from wetland and floodplain alteration*

Many river valleys in the west were once marshy and well vegetated, filled with mazes of floodplain sloughs, beaver ponds, and wetlands. Salmon evolved within these systems. Juvenile salmon, especially coho salmon, can spend large portions of their fresh water residence rearing and over-wintering in floodplain environments and riverine wetlands. Spring Chinook salmon also will spend up to a year rearing in freshwater and will rely on floodplains for refuge during flood conditions, and access to such floodplain refuge improves their overall growth and fitness (Sommer et al. 2001). Salmon survival and growth are often better in floodplain channels, oxbow lakes, and other river-adjacent waters than in mainstream systems (NRC 1996). Additionally floodplains and wetlands provide other ecosystem functions important to salmonids such as regulation of stream flow, stormwater storage and filtration, and often provide key habitat for beavers (that in turn may provide instream habitat benefits to coho salmon from their active and continual placement of wood in streams) (OCSRI 1997).

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

The construction of dikes, levees, roads, and other structural development in the floodplain that confine the river have further effects on salmon habitat. These structures prevent the connections between the rivers and floodplain, and frequently prevent or reduce lateral channel movement. Historically, unconfined river reaches often provided the highest quality and most diverse freshwater and estuarine habitats available for salmonid use (see, e.g. Junk et al. 1989). Channels that are free to move across the floodplain also provide more aquatic habitat per linear river mile than confined river reaches. This natural geomorphic process of channel migration is particularly important in providing a dynamic mosaic of complex habitats. Lateral channel migration creates, modifies, and maintains a diverse assemblage of complex habitats and provides numerous beneficial functions crucial to successful salmon rearing, migration, and spawning. In part, these functions provide velocity reduction, off-channel areas, groundwater recharge, base flows, reduced summer water temperatures, floodplain access, sediment sorting and storage, large wood production and recruitment, and undercut banks.

A river confined by adjacent development and/or flood control and erosion control structures, can no longer move across the floodplain and support the natural processes that 1) maintain floodplain connectivity and fish access that provide velocity refugia for juvenile salmon during high flows; 2) reduce flow velocities that reduce streambed erosion, channel incision, and spawning redd scour; 3) create side channels and off-channel areas that shelter rearing juvenile salmon; 4) allow fine sediment deposition on the floodplain and sediment sorting in the channel that enhance the substrate suitability for spawning salmon; 5) maintain riparian vegetation patterns that provide shade, large wood, and prey items to the channel; 6) provide the recruitment of large wood and spawning gravels to the channel; 7) create conditions that support hyporheic flow pathways that provide thermal refugia during low water periods; and 8) contribute to the nutrient regime and food web that support rearing and migrating juvenile salmon in the associated mainstem river channels.

Structures that confine and deprive the river of a place to deposit sediment also transport more sediment downstream causing stream channel aggradation and estuary filling, which increases the need for future episodes of dredging. Dredging itself has a host of consequences to suitability of spawning and rearing habitat for salmonids. Additional indirect effects of development in floodplains adjacent to rivers and wetlands include the pollutant load from runoff and stormwater generated in an urbanizing environment, which discharges into these aquatic habitats.

### *Potential conservation measures for wetland and floodplain alteration*

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

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

- Minimize alteration of floodplains and wetlands for nonwater-dependent uses in areas of salmon EFH.
- Minimize adverse effects on floodplains and wetlands from water-dependent uses.
- Wherever possible avoid floodplain development, and mitigate for unavoidable floodplain losses to existing floodplain functions and processes, including water quality, water storage capacity and lateral channel movement.
- Wherever possible complete compensation mitigation for unavoidable floodplain or wetland loss prior to conducting activities that may adversely affect floodplains or wetlands, and perform such mitigation only in areas that have been identified as having long term viability and functionality.
- Design floodplain and wetland mitigation to meet specific performance objectives for function and value, and monitor to assure achievement of these objectives. Use mitigation and enhancement ratios that are sufficient to attain a net gain in acreage as well as function and value.

- Determine cumulative effects of all past and current floodplain and wetland alterations before planning activities that further alter wetlands and floodplains.
- Promote awareness and use of the USDA's wetland and conservation reserve programs to conserve and restore wetland and floodplain habitat.
- Promote restoration of degraded floodplains and wetlands, including in part reconnecting rivers with their associated floodplains and wetlands and invasive species management.

# 5. ADDITIONAL INFORMATION AND RESEARCH NEEDS

The EFH regulatory guidance states that each FMP should contain recommendations for research efforts that the Councils and NMFS view as necessary to improve upon the description and identification of EFH, the identification of threats to EFH from fishing and other activities, and the development of conservation and enhancement measures for EFH. The lack of specific and comprehensive information on distribution prevented detailed delineation and fine-scale mappings of EFH in both freshwater and marine habitats. While far more research has been conducted on Pacific salmon life history and habitat requirements than most other marine fishes, significant research gaps still exist, particularly with regard to distribution and marine life history and habitat requirements. The following information and research needs were identified in Amendment 14 and/or during the 2011 EFH review process.

1. Improve fine scale mapping of salmon distribution to inform future reviews of EFH for Pacific Coast salmon and aid in a more precise and accurate designation of EFH. The lack of specific and comprehensive distribution data prevented detailed delineation and fine-scale mapping of EFH More refined EFH designations would facilitate the consultation process by clarifying which Federal actions warranted an EFH consultation and could lead to more effective Conservation Recommendations. It should be noted, however, that more detailed and precise freshwater distribution data will not eliminate the need for a watershed-based approach for recovery and protection of Pacific salmon EFH Potential approaches to address this information need include, but are not limited to:
    a. Develop freshwater distribution data at the 5th or 6th field HUs, across the geographic range of these species
    b. Develop habitat models that can be used to predict suitable habitat, both current and historical, across the geographic range of these species.
    c. Develop seasonal distribution data at a 1:24,000 or finer scale, particularly in freshwater.

2. Improve data on habitat conditions, including how they affect salmon survival, across the geographic range of Pacific Coast salmon to help refine EFH in future reviews and focus restoration efforts. A detailed analysis of salmon production and watershed condition throughout the Pacific Northwest is needed to determine the characteristics of productive watersheds and stream reaches for Pacific salmon. Incorporating physical variables, such as water quality, riparian vegetation, land-use, etc. into a watershed framework could help determine the potential productivity of a watershed and help to identify those in need of restoration. A better understanding of watershed productivity could inform future EFH reviews.

3. Improve data on marine distribution of Pacific Coast salmon, especially during early ocean residence, and develop models that incorporate oceanic conditions to predict marine distribution to inform revisions to EFH in future reviews. Fine scale seasonal information is needed to better understand the marine distribution of juvenile and adult Pacific salmon, which is thought to change depending upon ocean conditions. Early ocean residence is believed to be a critical period for salmon survival and better data on habitat utilization, feeding, and survival during this stage would allow a more precise description of marine EFH,

4. Improve data on the possibility of adverse effects of fishing gear on the EFH of Pacific Coast salmon. Impacts to salmon EFH from fishing gear can include removal of prey species, smothering or damage to benthic habitats utilized by salmon and their prey, removal of salmon carcasses that supply nutrients that enhance salmonid growth and survival, and derelict fishing gear effects. Although these potential effects have been identified, the extent to which they impact salmon EFH is poorly understood.

5. Advance the understanding of how a changing climate can affect Pacific Coast salmon EFH. Attempts to predict future climate conditions are based on mathematical models, and the results of these models vary substantially, making it difficult to determine what salmon habitat conditions will be like in the future. However, anticipated effects associated with climate change, including increased freshwater temperatures, changes in precipitation patterns and reduced snowpacks that can alter the seasonal hydrograph, and ocean acidification, have the potential for widespread impacts on Pacific salmon EFH. Therefore, as new information becomes available, it will be important to try to understand how climate change will affect salmon EFH, and what steps can be taken to minimize or mitigate these effects.

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# 7. TABLES

Table 1. 4th field hydrologic units designated as EFH for each of the three species of Pacific Coast salmon and the impassable dams that form the upstream extent of EFH in those units.

| 4th Field Hydrologic Unit Code | Hydrologic Unit Name | State(s) | Chinook | Coho | PS Pink | Impassable Dam(s) |
|---|---|---|---|---|---|---|
| 17020005 | Chief Joseph | WA | X | X | | Chief Joseph Dam |
| 17020006 | Okanogan | WA | X | | | |
| 17020007 | Similkameen | WA | X | | | |
| 17020008 | Methow | WA | X | X | | |
| 17020009 | Lake Chelan | WA | X | | | |
| 17020010 | Upper Columbia- Entiat | WA | X | X | | |
| 17020011 | Wenatchee | WA | X | X | | |
| 17020012 | Moses Coulee | WA | X | X | | |
| 17020015 | Lower Crab | WA | X | | | |
| 17020016 | Upper Columbia-Priest Rapids | WA | X | X | | |
| 17030001 | Upper Yakima | WA | X | X | | Keechelus Dam<br>Kachess Dam (Kachess River) |
| 17030002 | Naches | WA | X | X | | Rimrock Dam (Tieton River) |
| 17030003 | Lower Yakima | WA | X | X | | |
| 17060101 | Hells Canyon | OR/ID | X | | | Hells Canyon Dam |
| 17060102 | Imnaha River | OR/ID | X | | | |
| 17060103 | Lower Snake-Asotin | OR/WA/ID | X | X | | |
| 17060104 | Upper Grande Ronde River | OR | X | X | | |
| 17060105 | Wallowa River | OR | X | X | | |
| 17060106 | Lower Grande Ronde | OR/WA | X | X | | |
| 17060107 | Lower Snake-Tucannon | WA | X | X | | |
| 17060108 | Palouse River | WA | X | | | |
| 17060110 | Lower Snake River | WA | X | X | | |
| 17060201 | Upper Salmon | ID | X | | | |
| 17060202 | Pahsimeroi | ID | X | | | |

| 4th Field Hydrologic Unit Code | Hydrologic Unit Name | State(s) | Chinook | Coho | PS Pink | Impassable Dam(s) |
|---|---|---|---|---|---|---|
| 17060203 | Middle Salmon-Panther | ID | X | | | |
| 17060204 | Lemhi | ID | X | | | |
| 17060205 | Upper Middle Fork Salmon | ID | X | | | |
| 17060206 | Lower Middle Fork Salmon | ID | X | | | |
| 17060207 | Middle Salmon-Chamberlain | ID | X | | | |
| 17060208 | South Fork Salmon | ID | X | | | |
| 17060209 | Lower Salmon | ID | X | | | |
| 17060210 | Little Salmon | ID | X | | | |
| 17060301 | Upper Selway | ID | X | X | | |
| 17060302 | Lower Selway | ID | X | X | | |
| 17060303 | Lochsa | ID | X | | | |
| 17060304 | Middle Fork Clearwater | ID | X | X | | |
| 17060305 | South Fork Clearwater | ID | X | X | | |
| 17060306 | Clearwater | WA/ID | X | X | | |
| 17060308 | Lower North Fork Clearwater | ID | X | | | Dworshak Dam |
| 17070101 | Middle Columbia-Lake Wallula | OR/WA | X | X | | |
| 17070103 | Umatilla | OR | X | X | | McKay Dam (McKay Creek) |
| 17070105 | Middle Columbia-Hood | OR/WA | X | X | | |
| 17070106 | Klickitat | WA | X | X | | |
| 17070306 | Lower Deschutes | OR | X | X | | |
| 17080001 | Lower Columbia-Sandy | OR/WA | X | X | | Bull Run Dam #2 |
| 17080002 | Lewis | WA | X | X | | |
| 17080003 | Lower Columbia-Clatskanie | OR/WA | X | X | | |
| 17080004 | Upper Cowlitz | WA | X | X | | |
| 17080005 | Cowlitz | WA | X | X | | |
| 17080006 | Lower Columbia | OR/WA | X | X | | |
| 17090001 | Middle Fork Willamette | OR | X | | | |

| 4th Field Hydrologic Unit Code | Hydrologic Unit Name | State(s) | Chinook | Coho | PS Pink | Impassable Dam(s) |
|---|---|---|---|---|---|---|
| 17090002 | Coast Fork Willamette | OR | X | | | Dorena Dam |
| 17090003 | Upper Willamette | OR | X | X | | |
| 17090004 | McKenzie | OR | X | X | | Cougar Dam[1] |
| 17090005 | North Santiam | OR | X | X | | Big Cliff Dam[2] |
| 17090006 | South Santiam | OR | X | X | | |
| 17090007 | Middle Willamette | OR | X | X | | |
| 17090008 | Yamhill | OR | X | X | | |
| 17090009 | Molalla-Pudding | OR | X | X | | |
| 17090010 | Tualatin | OR | X | X | | |
| 17090011 | Clackamas | OR | X | X | | |
| 17090012 | Lower Willamette | OR | X | X | | |
| 17100101 | Hoh-Quillayute | WA | X | X | | |
| 17100102 | Queets-Quinault | WA | X | X | | |
| 17100103 | Upper Chehalis | WA | X | X | | |
| 17100104 | Lower Chehalis | WA | X | X | | |
| 17100105 | Grays Harbor | WA | X | X | | |
| 17100106 | Willapa | WA | X | X | | |
| 17100201 | Necanicum | OR | X | X | | |
| 17100202 | Nehalem | OR | X | X | | |
| 17100203 | Wilson-Trask-Nestucca | OR | X | X | | |
| 17100204 | Siletz-Yaquina | OR | X | X | | |
| 17100205 | Alsea | OR | X | X | | |
| 17100206 | Siuslaw | OR | X | X | | |
| 17100207 | Siltcoos | OR | | X | | |

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[1] Cougar Dam is a barrier to coho salmon only. Chinook salmon are trapped and hauled above the dam.

[2] Big Cliff Dam is a barrier to coho salmon only. Chinook salmon are trapped and hauled above the dam.

| 4th Field Hydrologic Unit Code | Hydrologic Unit Name | State(s) | Chinook | Coho | PS Pink | Impassable Dam(s) |
|---|---|---|---|---|---|---|
| 17100301 | North Umpqua | OR | X | X | | |
| 17100302 | South Umpqua | OR | X | X | | |
| 17100303 | Umpqua | OR | X | X | | |
| 17100304 | Coos | OR | X | X | | |
| 17100305 | Coquille | OR | X | X | | |
| 17100306 | Sixes | OR | X | X | | |
| 17100307 | Upper Rogue | OR | X | X | | Lost Creek Dam |
| 17100308 | Middle Rogue | OR | X | X | | Emigrant Dam |
| 17100309 | Applegate | CA/OR | X | X | | Applegate Dam |
| 17100310 | Lower Rogue | OR | X | X | | |
| 17100311 | Illinois | CA/OR | X | X | | |
| 17100312 | Chetco | CA/OR | X | X | | |
| 17110001 | Fraser | WA | X | X | | |
| 17110002 | Strait Of Georgia | WA | X | X | X | |
| 17110003 | San Juan Islands | WA | | X | | |
| 17110004 | Nooksack | WA | X | X | X | |
| 17110005 | Upper Skagit | WA | X | X | X | Gorge Lake Dam |
| 17110006 | Sauk | WA | X | X | X | |
| 17110007 | Lower Skagit | WA | X | X | X | |
| 17110008 | Stillaguamish | WA | X | X | X | |
| 17110009 | Skykomish | WA | X | X | X | |
| 17110010 | Snoqualmie | WA | X | X | X | Tolt Dam (S. Fork Tolt River) |
| 17110011 | Snohomish | WA | X | X | X | |
| 17110012 | Lake Washington | WA | X | X | | Cedar Falls (Masonry) Dam (Cedar River) |
| 17110013 | Duwamish | WA | X | X | X | |
| 17110014 | Puyallup | WA | X | X | X | |
| 17110015 | Nisqually | WA | X | X | X | |

| 4th Field Hydrologic Unit Code | Hydrologic Unit Name | State(s) | Chinook | Coho | PS Pink | Impassable Dam(s) |
|---|---|---|---|---|---|---|
| 17110016 | Deschutes | WA | X | X | | |
| 17110017 | Skokomish | WA | X | X | X | |
| 17110018 | Hood Canal | WA | X | X | X | |
| 17110019 | Puget Sound | WA | X | X | X | |
| 17110020 | Dungeness-Elwha | WA | X | X | X | |
| 17110021 | Crescent-Hoko | WA | X | X | | |
| 18010101 | Smith River | CA/OR | X | X | | |
| 18010102 | Mad-Redwood | CA | X | X | | Robert W. Matthews Dam |
| 18010103 | Upper Eel | CA | X | X | | Scott Dam |
| 18010104 | Middle Fork Eel | CA | X | X | | |
| 18010105 | Lower Eel | CA | X | X | | |
| 18010106 | South Fork Eel | CA | X | X | | |
| 18010107 | Mattole | CA | X | X | | |
| 18010108 | Big-Navarro-Garcia | CA | X | X | | |
| 18010109 | Gualala-Salmon | CA | X | X | | |
| 18010110 | Russian | CA | X | X | | Coyote Valley Dam (E. Fork Russian R.)<br>Warm Springs Dam (Dry Cr.) |
| 18010206 | Upper Klamath | CA/OR | X | X | | Keno Dam |
| 18010207 | Shasta | CA | X | X | | Dwinnell Dam |
| 18010208 | Scott | CA | X | X | | |
| 18010209 | Lower Klamath | CA/OR | X | X | | |
| 18010210 | Salmon | CA | X | X | | |
| 18010211 | Trinity | CA | X | X | | Lewiston Dam |
| 18010212 | South Fork Trinity | CA | X | X | | |
| 18020104 | Sacramento-Stone Corral | CA | X | | | |
| 18020111 | Lower American | CA | X | | | Nimbus Dam |
| 18020115 | Upper Stony | CA | X | | | Black Butte Dam |

| 4th Field Hydrologic Unit Code | Hydrologic Unit Name | State(s) | Chinook | Coho | PS Pink | Impassable Dam(s) |
|---|---|---|---|---|---|---|
| 18020116 | Upper Cache | CA | X | | | Capay Dam[3] |
| 18020125 | Upper Yuba | CA | X | | | |
| 18020126 | Upper Bear | CA | X | | | Camp Far West Dam |
| 18020151 | Cow Creek | CA | X | | | |
| 18020152 | Cottonwood Creek | CA | X | | | |
| 18020153 | Battle Creek | CA | X | | | |
| 18020154 | Clear Creek-Sacramento River | CA | X | | | Keswick Dam (Sacramento R.),<br>Whiskeytown Dam (Clear Creek) |
| 18020155 | Paynes Creek-Sacramento River | CA | X | | | |
| 18020156 | Thomes Creek-Sacramento River | CA | X | | | |
| 18020157 | Big Chico Creek-Sacramento River | CA | X | | | |
| 18020158 | Butte Creek | CA | X | | | |
| 18020159 | Honcut Headwaters-Lower Feather | CA | X | | | Feather River Fish Barrier Dam |
| 18020161 | Upper Coon-Upper Auburn[4] | CA | X | | | |
| 18020162 | Upper Putah | CA | X | | | Monticello Dam |
| 18020163 | Lower Sacramento | CA | X | | | |
| 18040001 | Middle San Joaquin-Lower Chowchilla[5] | CA | X | | | Buchanan Dam (Chowchilla River),<br>Bear Dam (Bear Creek),<br>Owens Dam (Owens Creek)<br>Mariposa Dam |

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[3] Capay Dam was selected as the upstream extent of EFH because it was identified as a complete barrier by NMFS biologists and is located in the vicinity of the historical upstream extent of Chinook salmon distribution.

[4] Natural “lower falls” are downstream of any artificial barriers that would meet the criteria for designating them as the upstream extent of EFH; therefore, the upstream extent of EFH within this HU is at the “lower falls”.

[5] EFH for Chinook salmon in the Middle San Joaquin- Lower Chowchilla HU (18040001) and Lower San Joaquin River HU (18040002) includes the San Joaquin River,

| 4th Field Hydrologic Unit Code | Hydrologic Unit Name | State(s) | Chinook | Coho | PS Pink | Impassable Dam(s) |
|---|---|---|---|---|---|---|
| 18040002 | Lower San Joaquin River[5] | CA | X | | | |
| 18040003 | San Joaquin Delta | CA | X | | | |
| 18040007 | Fresno River | CA | X | | | Hidden Dam |
| 18040008 | Upper Merced | CA | X | | | Crocker-Huffman Diversion Dam |
| 18040009 | Upper Tuolumne | CA | X | | | La Grange Dam (Tuolumne R.) |
| 18040010 | Upper Stanislaus | CA | X | | | Goodwin Dam |
| 18040011 | Upper Calaveras | CA | X | | | New Hogan Dam |
| 18040012 | Upper Mokelumne | CA | X | | | Camanche Dam |
| 18040013 | Upper Cosumnes | CA | X | | | |
| 18050001 | Suisun Bay | CA | X | | | |
| 18050002 | San Pablo Bay | CA | X | X | | San Pablo Dam (San Pablo Cr.) |
| 18050003 | Coyote | CA | X | X | | LeRoy Anderson Dam |
| 18050004 | San Francisco Bay | CA | X | X | | |
| 18050005 | Tomales-Drake Bays | CA | X | X | | Nicasio Dam (Nicasio Cr.)<br>Peters Dam (Lagunitas Cr.) |
| 18050006 | San Francisco Coastal South | CA | | X | | |
| 18060015 | Monterey Bay[6] | CA | | X | | Newell Dam (Newell Cr.) |

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its eastern tributaries, and the lower reaches of the western tributaries. Although there is no evidence of current or historical Chinook salmon distribution in the western tributaries (Yoshiyama et al. 2001), the lower reaches of these tributaries could provide juvenile rearing habitat or refugia from high flows during floods as salmon migrate along the mainstem in this area.

[6] EFH for coho salmon in the Monterey Bay HU does not include the sections south of the Pajaro HU (18060002).

Table 2. 4th field hydrologic units where salmon distribution was not based on Streamnet (2013), Calfish (2013) or NOAA (2005a; 2005b).

| 4th Field HU Code | Hydrologic Unit Name | Source | |
|---|---|---|---|
| | | Chinook | Coho |
| 17020008 | Methow | N/A | Fulton 1970 |
| 17020011 | Wenatchee | N/A | Fulton 1970 |
| 17060103 | Lower Snake-Asotin | N/A | Fulton 1970 |
| 17060104 | Upper Grande Ronde River | N/A | Fulton 1970;<br>Childs 2003 |
| 17060105 | Wallowa River | N/A | Fulton 1970;<br>Childs 2003 |
| 17070306 | Lower Deschutes | N/A | Seals and French 2012 |
| 17090004 | McKenzie | N/A | Fulton 1970:<br>Williams 1981 |
| 17090006 | South Santiam | N/A | Fulton 1970;<br>Williams 1981 |
| 18010104 | Middle Fork Eel | Williams et al. 2006 | Brown and Moyle 1991;<br>Williams et al. 2006 |
| 18010108 | Big-Navarro-Garcia | NMFS 2005 | N/A |
| 18010109 | Gualala-Salmon | Bjorkstedt et al. 2005 | N/A |
| 18050002 | San Pablo Bay | Leidy et al. 2005 | Leidy et al. 2005 |
| 18050003 | Coyote | NMFS 1998; Leidy et al. 2007 | Leidy et al. 2005;<br>Spence et al. 2005 |
| 18050004 | San Francisco Bay | NMFS 1998; Leidy et al. 2007 | Brown and Moyle 1991;<br>Leidy et al. 2005;<br>Spence et al. 2005 |
| 18050005 | Tomales-Drake Bays | Ettlinger et al. 2012 | N/A |
| 18060001 | San Lorenzo-Soquel | N/A | Brown and Moyle 1991;<br>Spence et al. 2011;<br>April 2, 2012 77 FR 19552 |
| 18060002 | Pajaro River | N/A | No reliable data to support current or historical use by coho salmon |

Table 3. Major prey items for Chinook salmon, coho salmon, and PS pink salmon by life stage and habitat. Prey type is highly dependent on fish size, micro- and macro-habitat, season and year. See text for more detailed information on diets.

| Species | Juvenile - freshwater | Juvenile- estuarine | Juvenile- marine | Sub-adult/Adult |
|---|---|---|---|---|
| Chinook salmon | insects (Diptera, Ephemeroptera) | insects (Diptera, psocoptera), epibenthic crustaceans (copepods), planktonic crustaceans (decapod larvae, euphausiids. gammarid amphipods, copepods), annelid worms (polychaetes), fish (clupeids, osmerids) | fish, planktonic crustaceans, insects | fish, planktonic crustaceans |
| Coho salmon | insects (Diptera, Ephemeroptera) | insects, epibenthic crustaceans, planktonic crustaceans, polychaetes, fish | fish, planktonic crustaceans | fish, planktonic crustaceans |
| Puget Sound pink salmon | insects, epibenthic crustaceans, planktonic crustaceans | epibenthic crustaceans, planktonic crustaceans, insects | planktonic crustaceans, planktonic molluscs | fish, planktonic crustaceans |

Key References: Fresh et al. 1981; Higgs et al. 1995; Wipfli 1997; Schabetsberger et al. 2003; Gonzales 2006; Olegario 2006; Sweeting et al. 2007; Macneale et al. 2010; Bollens et al. 2010; Duffy et al. 2010; Sanderson et al. in preparation.

Table 4. Chinook salmon habitat use by life-history stage. See key to abbreviations and EFH data levels on the next page.

| **Stage - EFH Data Level[1]** | **Duration or Age** | **Diet/Prey** | **Season/Time** | **Location** | **Water Column** | **Bottom Type** | **Oceanographic Features** | **Other** |
|---|---|---|---|---|---|---|---|---|
| **Eggs**<br>EFH Data Level 0-4 | 50-130 d | Non-feeding stage; eggs consumed by birds, fish, and mammals. | Late summer, fall, and winter | Intragravel in stream beds | 20-80 cm gravel depth; 15-700 cm water depth | Medium to course gravel | NA | DO < 2 mg/l lethal, optimum > 8 mg/l; Temperature 0-17 °C, optimum 5-14 °C; Water velocity 15-190 cm/s |
| **Larvae (alevins)**<br>EFH Data Level 0-4 | 50-125 d until fry emerge from gravel | Non-feeding stage; Alevins consumed by birds, fish and mammals | Fall, winter, and early spring | Intragravel until fry emergence | 20-80 cm gravel depth; 15-700 cm water depth | Medium to course gravel | NA | DO < 2 mg/l lethal, optimum > 8 mg/l; Temperature 0-17 °C, optimum 5-14 °C; Water velocity 15-190 cm/s |
| **Juveniles (freshwater)**<br>EFH Data level 0-4 | days-yrs | Insect larvae and adults, plankton (e.g., Daphnia) | Year-round, depending on race | Streams, lakes, sloughs, rivers | 0-120 cm | Varied | NA | DO lethal at <2 mg/l, optimum at saturation; Temperature 0-25 °C, optimum 12-14 °C; Salinity < 29 ppt |
| **Juveniles (estuary and oceanic)**<br>EFH Data Level 0-3 | 6-months to 2 yrs | Estuary: insects, copepods, polychaetes euphausiids, amphipods decapod larvae, fish, squid, crabs, | Estuary and Ocean: year-round | BCH BAY, IP, ICS, OCS | P, N, SD/SP 30-80 m preferred depth | All bottom types | Estuarine, littoral then more open water, UP, F, CL, G | DO lethal at <2 mg/l, optimum at saturation; Temperature 0-26 °C, optimum 12-14 °C; Salinity sea water |
| **Adults**<br>EFH Data Level 0-2 | 2-8 yrs of age from egg to mature adult | Fish, squid, euphausiids, amphipods, and copepods, decapods | Spawning: July-Feb.<br>Non-spawning: Year round | Oceanic to nearshore migrations, spawn in freshwater | P, N, SD/SP | NA | Different stock groups have specific oceanic migratory patterns | DO Preferred >5 mg/l, optimum at saturation; Temperature 0-26 °C; optimum <14 °C |

Primary sources: Healey 1991. Bjornn and Reiser 1991. Myers *et al*. 1998. NOAA 1990. Fisher and Pearcy 1995. Spence *et al*. 1996. Aitkin 1998. McCullough et al. 2001; Kaeriyama et al. 2004. Beamer et al. 2005. Brennan et al. 2004. Sweeting et al. 2007. Daly et al. 2009. Duffy et al. 2010.

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[1] Not all habitats have been sampled

## KEY FOR TABLES 2, 3, AND 4.

### EFH Data Level

0 No systematic sampling has been conducted for this species and life stage; may have been caught opportunistically in small numbers during other surveys.
1 Presence/absence distribution data are available for some or all portions of the geographic range.
2 Habitat-related densities are available. Density data should reflect habitat utilization, and the degree that a habitat is utilized is assumed to be indicative of habitat value.
3 Habitat-related growth, reproduction, or survival rates are available. The habitats contributing the most to productivity should be those that support the highest growth, reproduction, and survival of the species (or life-history stage).
4 Habitat-related production rates are available. Essential habitats are those necessary to maintain fish production consistent with a sustainable fishery and a healthy ecosystem.

### Location where found (in waters of these depths)

BAY - nearshore bays, give depth if appropriate (e.g., fjords)
BCH - beach (intertidal)
BSN - basin (>3,000 m)
IP - island passes (areas of high current), give depth if appropriate
ICS - inner continental shelf (1-50 m)
LSP - lower slope (1,000-3,000 m)
MCS - middle continental shelf (50-100 m)
OCS - outer continental shelf (100-200 m)
USP - upper slope (200-1,000 m)

### Where found in water column

D - demersal (found on bottom)
N - neustonic (found near surface)
P - pelagic (found off bottom, not necessarily associated with a particular bottom type)
SD/SP - semi-demersal or semi-pelagic if slightly greater or less than 50 percent on or off bottom

### Bottom Types

M - mud
SM - sandy mud
MS - muddy sand
S - sand
CB - cobble
G - gravel
R - rock
C - coral
K - kelp
SAV - subaquatic vegetation other than kelp (e.g., eelgrass).

### Oceanographic Features

UP - upwelling
CL - thermo-or pycnocline
G - gyres
E – edges
F - fronts

### Other

U=Unknown
NA=not applicable

Table 5. Coho salmon habitat use by life-history stage. See key to abbreviations and EFH data levels at Table 4.

| Stage - EFH Data Level[1] | Duration or Age | Diet/Prey | Season/Time | Location | Water Column | Oceanographic Features | Other |
|---|---|---|---|---|---|---|---|
| **Eggs**<br>EFH Data Level 0-4 | 50 days at optimum temperatures | Non-feeding stage; eggs consumed by birds, fish and mammals | Fall/winter | Streambeds | Intragravel; water depth 4-35 cm | NA | DO < 2 mg/l lethal, optimum > 8 mg/l;<br>Temperature 0-17 °C; optimum 4.4-13.3 °C; Substrate 2-10 cm with < 12% fines (<3.3 mm),<br>optimum <5% fines;<br>Water velocity 25-90 cm/s |
| **Larvae (alevins).**<br>EFH Data Level 0-4 | 100 days at optimum temperatures | Non-feeding stage; Alevins consumed by birds, fish and mammals | Winter/spring | Streambeds | Intragravel; water depth 4-35 cm | NA | DO < 3 mg/l lethal, optimum > 8 mg/l;<br>Temperature 0-17 °C; optimum 4.4-13.3 °C;<br>Substrate 2-10 cm with < 12% fines (<3.3 mm),<br>optimum <5% fines;<br>Water velocity 25-90 cm/s |
| **Juveniles (freshwater)**<br>EFH Data Level 0-4 | 1-2 yrs, most (>90%) 1 yrs | Aquatic, terrestrial, and estuarine invertebrates, eggs, fish | Rearing - all year<br>Migration - spring and fall | Streams, lakes, BAY (estuaries) | Water depth 0-122 cm in streams | NA | DO lethal at <2 mg/l, optimum at saturation;<br>Temperature 0-25 °C; optimum 12-14 °C;<br>Salinity < 29 ppt;<br>Water velocity 5-30 cm/s |
| **Juveniles (estuarine)**<br>EFH Data Level 0-3 | 0-2 yrs | Insects, copepods, euphausiids, amphipods, crab larvae, fish | Rearing – winter, spring, summer,<br>Migration - all year | BCH, BAY | Pelagic | NA | Temperature <15 °C |
| **Juveniles and adults (marine)**<br>EFH Data Level 0- | 16 months (except precocious males) | Epipelagic fish (herring, sand lance) and marine invertebrates (copepods, euphausiids, amphipods, crab larvae) | Rearing – winter, spring, summer<br>Migration - all year | BCH, ICS, MCS, OCS, USP, BAY, IP | Pelagic | UP, CL, F; migration influenced by currents, salinity, and temperature | Temperature <15 °C |

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[1] Not all habitats have been sampled

| Stage - EFH Data Level[1] | Duration or Age | Diet/Prey | Season/Time | Location | Water Column | Oceanographic Features | Other |
|---|---|---|---|---|---|---|---|
| **Adults (freshwater)**<br>EFH Data Level 1-2 | up to 2 months | Little or none | Migration - fall<br>Spawning - fall, winter | Rivers, streams, lakes |  | NA |  |

Primary Sources: Shapovalov and Taft 1954; Sandercock 1991; Bjorrn and Reiser 1991; Weitkamp *et al*. 1995; Spence *et al*. 1996; Aitkin 1998; McCullough et al. 2001; Brodeur et al. 2007; Weitkamp et al. 2008; Daly et al. 2009.

Table 6. Pink salmon habitat use by life stage. See key to abbreviations and EFH data levels with Table 4.

| **Stage - EFH Data Level**[1] | **Duration or Age** | **Diet/Prey** | **Season/Time** | **Location** | **Water Column** | **Bottom Type** | **Oceanographic Features** | **Other** |
|---|---|---|---|---|---|---|---|---|
| **Eggs**<br>EFH Data Level 0-4 | 90-100 d | Non-feeding stage; eggs consumed by birds, fish and mammals | Late summer, fall, and winter | Intragravel in stream beds | 15-50 cm depth in gravel; water depth 10-15 cm | Medium to course gravel | NA | DO < 2 mg/l lethal, optimum > 8 mg/l; Temperature 0-17 °C, optimum 4.4-13.3 °C; Water velocity 20-140 cm/s |
| **Larvae (alevins)**<br>EFH Data Level 0-4; | 100-125 d, fry emerge and migrate quickly from stream | Non-feeding stage; alevins consumed by birds, fish, and mammals | Fall, winter, and early spring | Intragravel until fry emergence | 15-50 cm depth in gravel; water depth 10-15 cm | Medium to course gravel | NA | DO < 3 mg/l lethal, optimum > 8 mg/l; Temperature 0-17 °C, optimum 4.4-13.3 °C; Water velocity 20-140 cm/s |
| **Juveniles**<br>EFH Data Level 0-3 | 2 yrs | Pteropods, amphipods, crab larvae,, euphausiids, copepods, , amphipods, fish squid | Estuary: spring, summer<br>Ocean: year-round | BCH BAY, IP | P, N; migration influenced by currents, salinity, and temperature | All bottom types | Estuarine, littoral then open water; UP, F, CL, E; migration may be influenced by surface currents, salinities and temperatures | DO <2 mg/l lethal, optimum at saturation; Temperature 0-26 °C, optimum 12-14 °C; Salinity sea water; School with other salmon and Pacific sandfish |
| **Adults**<br>EFH Data Level 0-2 | 2 yrs of age from egg to mature adult | Fish, squid, euphausiids, amphipods, and copepods | Spawning: Aug-Dec | Oceanic to nearshore migrations | P, N | NA | Different regional stock groups have specific oceanic migratory patterns | DO lethal at <3 mg/l, optimum at saturation; Temperature 0-26 °C, optimum <14 °C; Migration timing for different regional stock groups varies; earlier in the north, later in the south |

Primary sources: NOAA 1990; Bjornn and Rieser 1991; Heard 1991; Higgs et al. 1995; Spence *et al*. 1996; Aitken 1998; Boldt and Haldorson 2003; Cross et al. 2005; Bollens et al. 2010.

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[1] Not all habitats have been sampled

Table 7. Summary of fishing activities that potentially affect EFH. CK=Chinook salmon; CO=coho salmon; P=PS pink salmon.

| | Habitat Type | | |
|---|---|---|---|
| **Fishing Activity** | **Freshwater** | **Estuarine** | **Marine** |
| Roundhaul gear | | CK, CO, P | CK |
| Pot/trap | | CK, CO, P | CK |
| Bottom trawl | | | CK |
| Mid-water trawl | | | CK |
| Long lines | | | CK |
| Carcass removal | CK, CO, P | | |
| Vessel impacts | CK, CO, P | CK, CO, P | CK, CO, P |
| Harvest of prey species | | CK, CO, P | CK, CO, P |
| Marine debris | CK, CO, P | CK, CO, P | CK |
| Derelict gear | CK, CO, P | CK, CO, P | CK |
| Shellfish harvest | | CK, CO, P | |
| Recreational fishing | CK, CO, P | CK, CO, P | CK, CO, P |

# 8. FIGURES

Figure 1. Overall geographic extent of EFH for Chinook salmon, coho salmon, and Puget Sound pink salmon

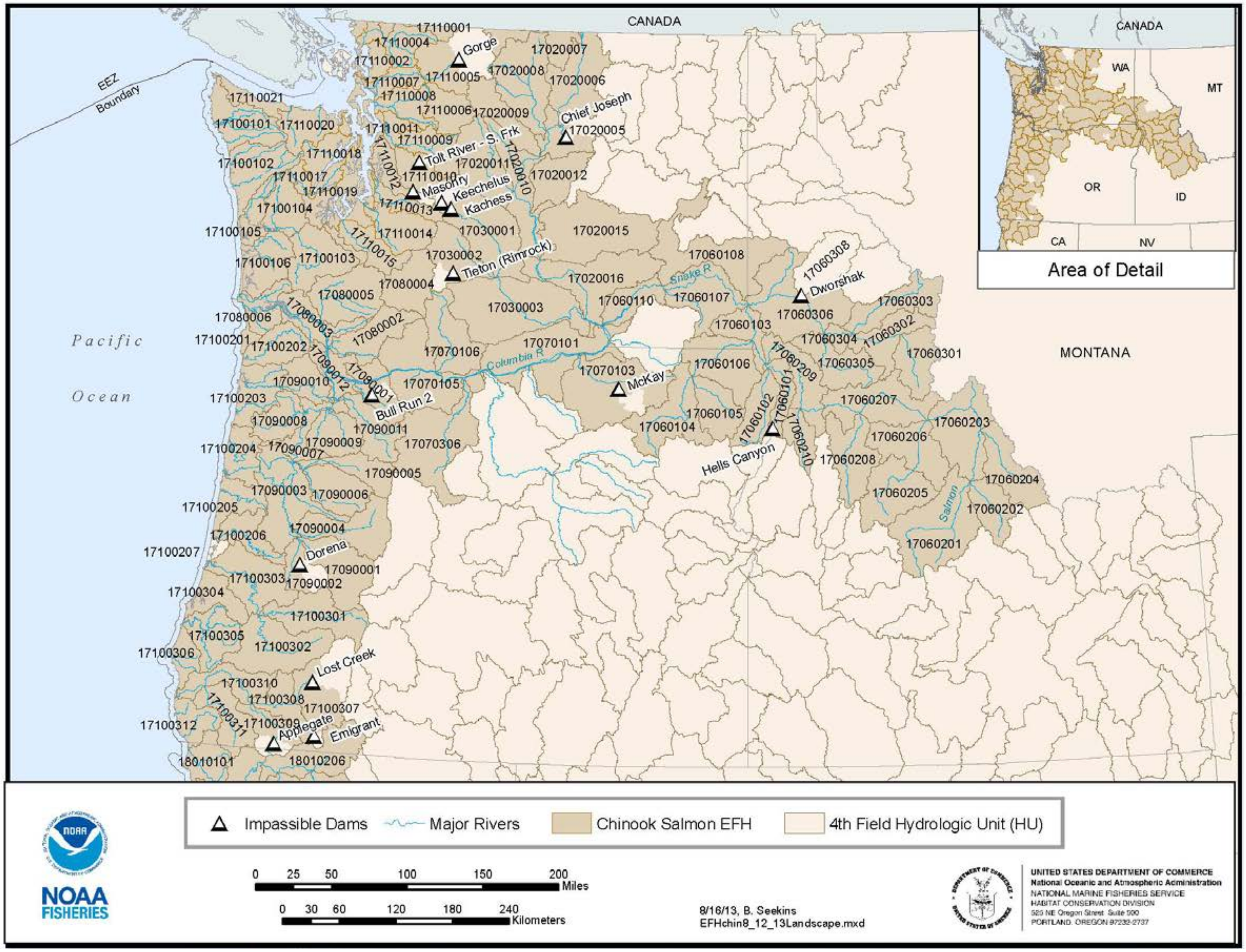

Figure 2. Chinook salmon EFH in Washington, Oregon, and Idaho. EFH designations are based on the USGS 4th field hydrologic units.

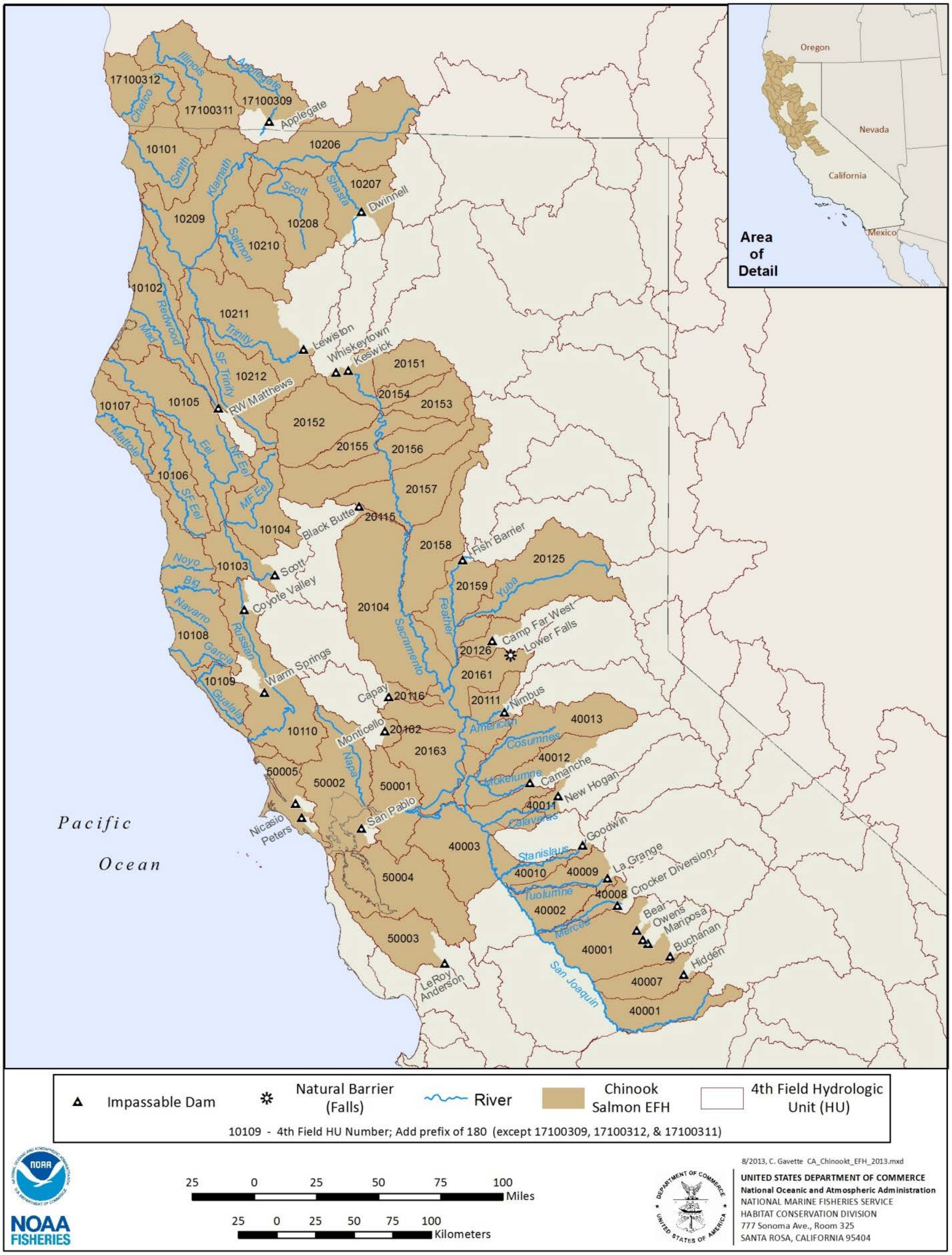

Figure 3. Chinook salmon EFH in California. EFH designations are based on the USGS 4th field hydrologic units.

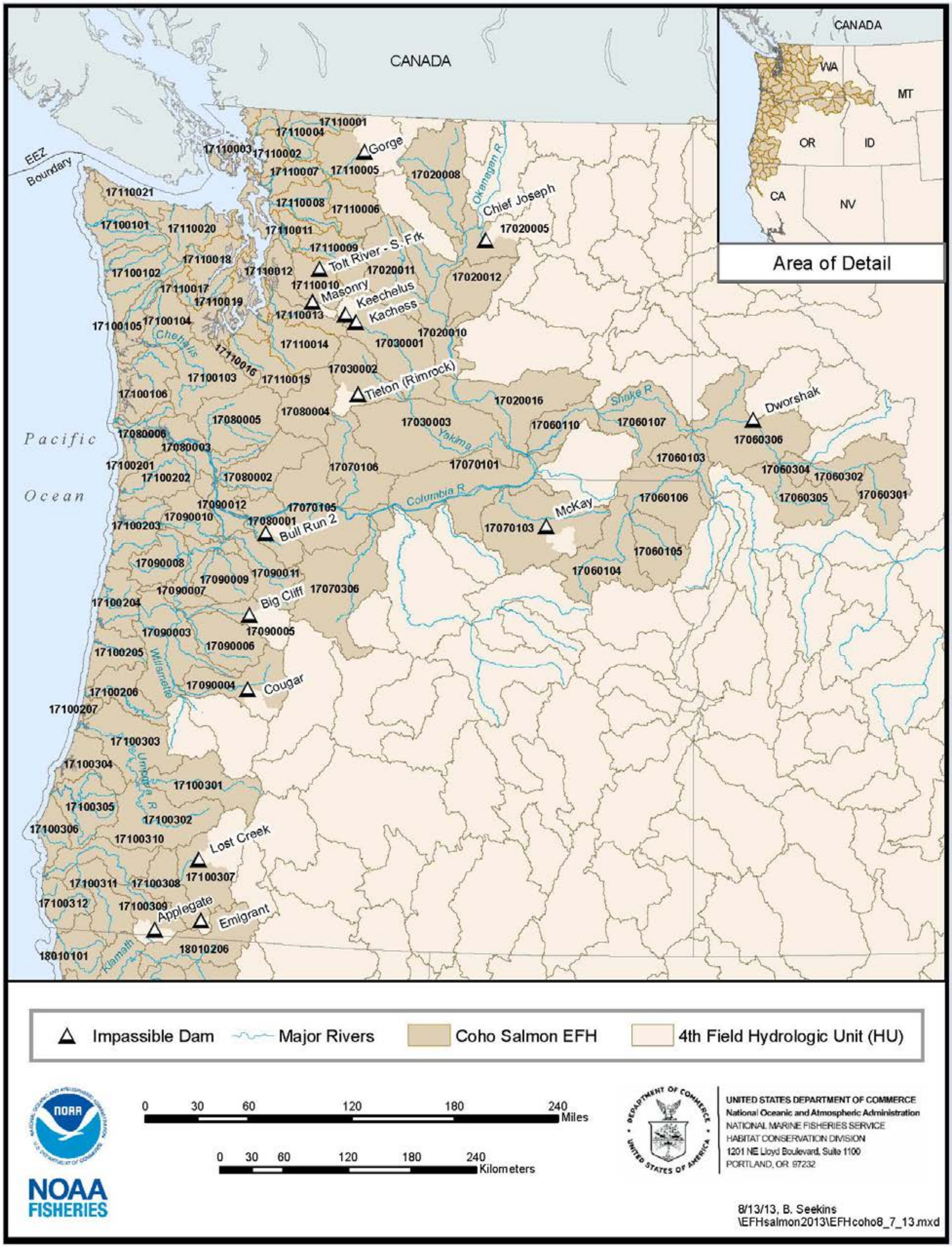

Figure 4. Coho salmon EFH in Washington, Oregon, and Idaho. EFH designations are based on the USGS 4th field hydrologic units.

Figure 5. Coho salmon EFH in California. EFH designations are based on the USGS 4th field hydrologic units.

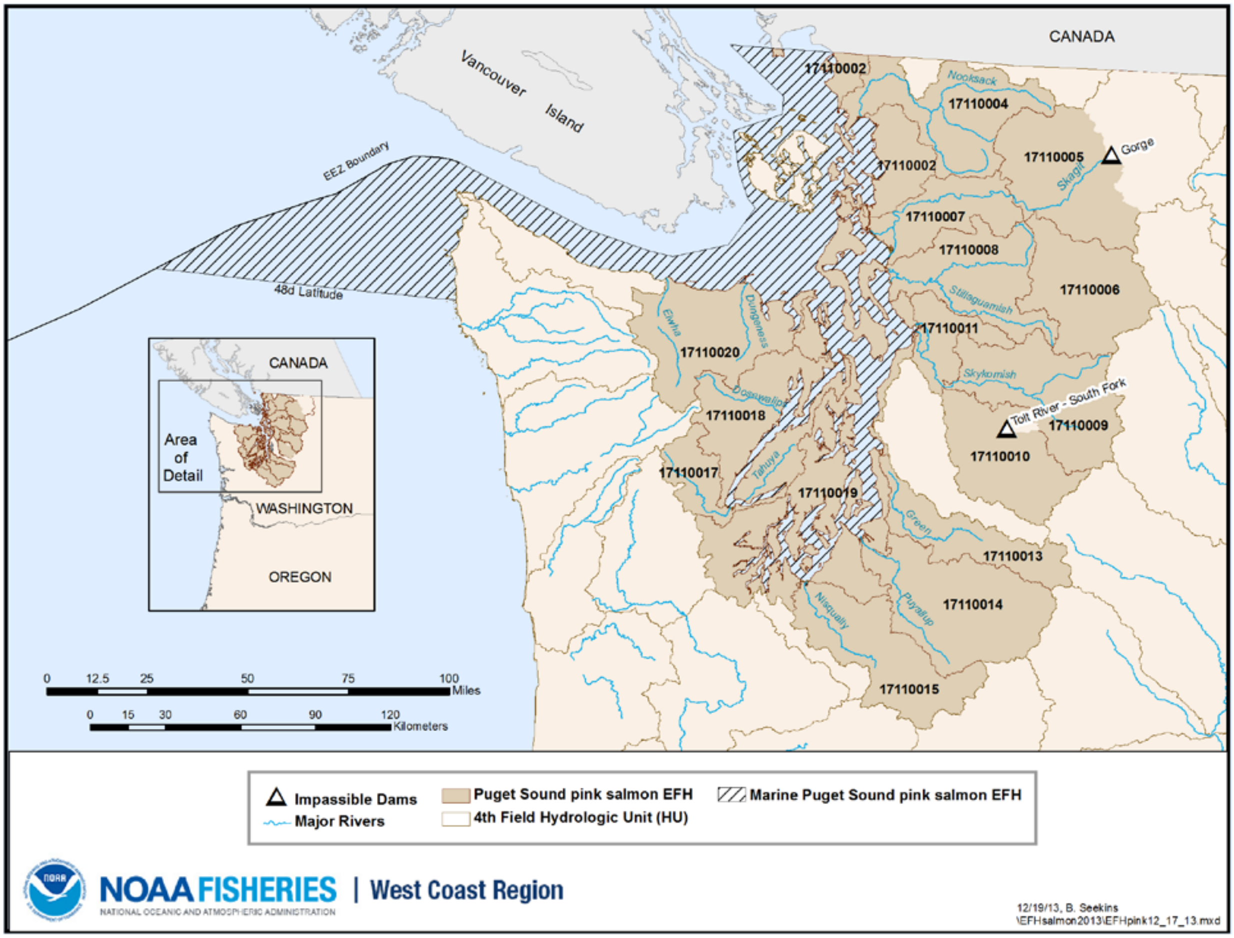

Figure 6. Puget Sound pink salmon EFH. EFH designations are based on the USGS 4th field hydrologic units.

# APPENDIX B

# DESCRIPTION OF THE OCEAN SALMON FISHERY AND ITS SOCIAL AND ECONOMIC CHARACTERISTICS

## AMENDMENT 14 TO THE PACIFIC COAST SALMON PLAN

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August 1999

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# TABLE OF CONTENTS

# LIST OF ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| BIA | Bureau of Indian Affairs |
| CDFG | California Department of Fish and Game |
| CPFV | Commercial Passenger Fishing Vessel |
| CRITFC | Columbia River Inter-Tribal Fish Commission |
| EIS | Environmental Impact Statement |
| ESA | Endangered Species Act |
| FMP | fishery management plan |
| KFMC | Klamath Fishery Management Council |
| KMZ | Klamath Management Zone |
| NOAA | National Oceanic and Atmospheric Administration |
| NRC | Natural Resource Consultants |
| NWIFC | Northwest Indian Fisheries Commission |
| ODFW | Oregon Department of Fish and Wildlife |
| PacFIN | Pacific Fishery Information Network |
| PFMC | Pacific Fishery Management Council |
| PSC | Pacific Salmon Commission |
| STT | Salmon Technical Team |
| USCG | U.S. Coast Guard |
| WDFW | Washington Department of Fish and Wildlife |

# INTRODUCTION

This appendix provides an economic and social description of the West Coast ocean salmon fishery in the context of local and world markets, the West Coast fishing industries and communities, and the larger management regime of which the West Coast ocean salmon fishery is only one part. It serves as a description of the fishery for the salmon fishery management plan (FMP) and a description of the human environment for the environmental impact statement (EIS).

Chinook, or king salmon (*Oncorhynchus tshawytscha*), and coho, or silver salmon (*O. kisutch*), are the main species caught in PFMC-managed ocean salmon fisheries. In odd-numbered years, catches of pink salmon (*O. gorbuscha*) can also be significant, primarily off Washington and Oregon (Salmon Technical Team [STT] 1998a). Therefore, while all species of salmon fall under PFMC's jurisdiction, the primary focus of management is on chinook, coho, pink (odd-numbered years only), and any salmon species listed under the Endangered Species Act (ESA) that is measurably impacted by PFMC fisheries. To the extent practicable, PFMC has partitioned this coastwide aggregate of chinook, coho, and pink salmon into various stock components with specific conservation objectives. A detailed listing of the individual stocks or stock complexes managed by PFMC, along with pertinent stock information and conservation objectives, is provided in Chapter 3.

In this appendix, where inflation-adjusted economic information is provided, the gross domestic product implicit price deflator, developed by the Bureau of Economic Analysis, has been used to adjust nominal to real values (Table B-1).

# 1.0 MARKETS

## 1.1 COMMERCIAL

### 1.1.1 The World Market and Production

West Coast salmon products compete in a global salmon market. Chinook and coho off the West Coast compete not only with the same species produced in other regions of the world, but also with other salmon species such as sockeye, chum, pink, and Atlantic. Nonsalmon fish species and other meat protein sources also compete with salmon and act as substitutes in the market place. One such example particularly relevant to the West Coast is sablefish. Studies have shown a relationship between sablefish prices and salmon prices in the Tokyo central wholesale market (Hastie, 1989 and Jacobson 1982 as cited by Hastie 1989). Japan is the world's largest importer of fish, and Japanese demand for salmon drives much of the trade patterns in the world salmon market (Wessells and Wilen, 1992). Rainbow trout (*Oncorhynchus mykiss)* might be considered another example (Anon., 1998). This fish is not included in most of the quantitative information below on world salmon production, though it has recently been reclassified as a salmon species.

With the introduction of farm-raised salmon, and most recently trout, world salmon markets have undergone rapid changes in recent years. World salmon supply has tripled since 1980 (based on estimated production for 1997, Figure B-1a). The estimated 1997 world harvest of salmon from commercial fisheries is near the 1980-1997 average while farmed production continues to increase. The farmed salmon share of the market has gone from one percent in 1980 to 59% in 1997 (Figure B-1b). Increasing production of farmed salmon has had major impacts on salmon prices and is likely responsible for a continuing slump in West Coast chinook and coho prices (Figure B-2). Rainbow trout pen culture has been slower to take off than the culture of other salmon species though recent growth in this activity has been rapid. In 1997, farmed rainbow trout production was about one fifth the size of farmed salmon production (Anon., 1998).

The West Coast ocean salmon fisheries contribute chinook, coho, and pink salmon to North American salmon production. The West Coast chinook harvest is comparable to Alaskan and Canadian production (Table B-2). West Coast coho and pink salmon harvests are less than Canadas and minor compared to Alaska (Table B-3 and Table B-4).

In fisheries such as the salmon fishery, where there is a brief harvest period followed by a longer marketing period during which product is sold out of inventories, there are two types of markets operating. One market distributes all its product during or shortly after the harvest period and determines what product form the raw fish will go to (e.g., fresh, frozen, canned, or cured). It is this market that also establishes the exvessel price that fishers will receive. The other market operates during the remainder of the year and determines the rate at which product flow into wholesale and retail markets over time (Wessels and Wilen, 1992). Salmon cannot be held in cold storage for much longer than a year, thus U.S. cold storage holdings fluctuate widely (Figure B-3). Since the mid-1990s peak inventories of salmon have been generally been higher than what was observed in the late 1980s and early 1990s. The generally higher U.S. cold storage holdings correlate with a period of increased world supply, increased U.S. salmon consumption rates, and decreased exvessel prices.

### 1.1.2 Trade

In 1997, the U.S. went from being a net exporter of fresh and frozen salmon to being a net importer on a dollar-value basis (Table B-5). This was primarily the result of a decline in sockeye exports and a corresponding increase in Atlantic salmon imports. The U.S. is a net exporter of fresh and frozen coho and a net importer of fresh and frozen chinook.

#### 1.1.2.1 Imports

Fresh and frozen salmon comprise about 95% of the U.S. salmon imports as measured by value (Table B-5). U.S. imports of fresh and frozen chinook and coho declined from 17% of all fresh and frozen salmon imports by value in 1993 to between 10% and 13% from 1994 to 1996, and then down to about five percent in 1997.

The decline is due primarily to an increase in the volume of imports of other species of salmon and some reduction in chinook imports (Figure B-4 and Figure B-5). The value and volume of fresh and frozen chinook imports is generally substantially greater than the value and volume of fresh and frozen coho imports. The Atlantic salmon proportion of the total value of fresh and frozen salmon imports has risen steadily from 69% in 1993 to 86% in 1997. The U.S. has imported salmon products of all types from 65 different countries over the last five years. Many of the countries from which the U.S. imports small amount of salmon are locations for intermediate handlers of the salmon. In these intermediary countries, salmon may undergo additional processing before being re-exported to the U.S. From 1993 to 1997, Canada, Chile, Norway, and the United Kingdom, accounted for 96% of the value of U.S. salmon imports (Table B-6).

#### 1.1.2.2 Exports

About 65% of the U.S. salmon exports are fresh and frozen (on a dollar value basis), though that ratio declined to 60% in 1997 (Table B-5). From 1993 to 1997, U.S. exports of chinook and coho accounted for between 8% and 13% of the value of all exports of fresh and frozen exports (Figure B-6 and B-7). The value of the coho exports has been generally greater than the value of chinook exports though the ratios have evened out more in recent years. In 1993, sockeye accounted for 75% of the value of U.S. fresh and frozen salmon exports. The sockeye contribution to export values has been on a downward trend, and in 1997 sockeye contributed only 65% of the value of U.S. fresh and frozen salmon exports. The U.S. has exported salmon products of all types to 93 different countries over the last five years. From 1993-1997, Japan, Canada, the United Kingdom, and France received 90% of the value of U.S. salmon imports (Table B-7).

In 1997, even with the drop in sockeye production and exports, the U.S. supplied nearly one-third of the dollar value of Japan's salmon imports. Of that one-third, 88% of the U.S. supply to Japan was fresh and frozen sockeye (Table B-8). The U.S. export of all other salmon species combined amounts to only four percent of the Japanese imports of all salmon. The main market for West Coast salmon has been domestic with some chinook going to the smoking market in Europe (Radtke and Jensen, 1991).

### 1.1.3 Domestic Demand

From 1910 through the early 1970s, per-capita fish consumption in the U.S. generally ran between 10 and 12 pounds, except during the depression and World War II, at which times consumption dropped. In the early 1970s, per-capita consumption increased to a 12 to 13 pound range. In the mid 1980s, it shifted upward again to the 15 to 16 pound range it has been in since 1985 (U.S. Department of Commerce, 1996). Consumption of salmon has steadily increased over the last 18 years. Per-capita consumption of salmon in 1996 is 3.65 times what it was in 1979, while the U.S. population has increased 18% (Figure B-8 and Table B-9). Most of the increased demand is for fresh and frozen salmon as opposed to canned salmon.

### 1.1.4 Exvessel Prices

Exvessel prices for West Coast ocean-caught non-Indian chinook and coho have been on a steady downward trend in the 1990s (Figure B-2). In real terms, 1996-1997 chinook and coho prices are less than half what they were at the start of the decade. Within the year, West Coast exvessel prices appear to dip when harvest increases (Figures B-9 and B-10). West Coast exvessel prices are generally lowest in July and August. Given the small size of the West Coast harvest relative to world production, the cause of this correlation between West Coast harvest and exvessel prices is uncertain. It might be a function of localized markets or a correlation of West Coast harvest with harvest in other parts of the world.

### 1.1.5 Exprocessor and Wholesale Prices

Information on the exprocessor values of salmon products is very limited. A Natural Resource Consultants (NRC) report from 1986 estimated that the wholesale value of salmon products in Washington was twice the exvessel value (NRC, 1986). Some more recent information for a broader geographic area is available from the NMFS processed products survey and Urner Barry Publications, Inc.

Usefulness of the processed product survey information for purposes here is limited, because response to the survey by processors is relatively low; the processed products covered include fish from Canada, Alaska, and other nonWest Coast sources; and the product forms for which there are the best response rates in the survey tend to be in general categories (e.g., "salmon chinook dressed") as opposed to more specific categories (e.g., "salmon chinook dressed head-on"). This makes it difficult to interpret price trends and difficult to compare exprocessor and exvessel prices. Table B-10 shows exprocessor prices for products for which the number of processors and pounds on which prices are reported in the processed product survey are substantial. Prices appear to be lower in recent years, though there are exceptions.

Urner Barry Publications, Inc. reports wholesale market prices for certain categories of salmon. The only wild salmon for which Urner Barry reports prices are chum. However, price trends for farm raised salmon may be indicative of the market situation for wild salmon as well. In general, Urner Barry wholesale prices indicate a downward trend in recent years for wild chums and farmed Atlantic salmon (Table B-11). While prices for Canadian farmed chinook prices also exhibit a downward trend they appear to be a little more stable in recent years. This relative price stability may reflect decreased supply due to falling production since Canadian farmed chinook production reached a peak in 1991.

CanadaFarmed Chinook Production (mt)

| 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 |
|---|---|---|---|---|---|---|
| 10,396 | 14,245 | 13,409 | 8,295 | 7,148 | 8,068 | 7,194 |

(Salmon Market Information Service, 1998)

## 1.2 RECREATIONAL

Just as the West Coast supply of salmon for food markets is only one segment of a broader food market, the supply of salmon for recreational harvest opportunities is only one segment of a broader recreational market. The substitutes for marine recreational ocean salmon fishing experiences are not as accessible and of greater difference in quality than substitutes in the food markets. For example, substituting an alternative ocean salmon harvest experience for a West Coast experience (e.g., traveling to Alaska or Canada for such an experience) involves a much greater increase in time and money expenditures than substituting an Alaska caught salmon for a West Coast caught salmon at the supermarket. At the same time, for northern areas of the coast in particular, newspaper advertising reveals that there is a real competition with the British Columbia recreational industry for the dollars of West Coast (U.S.) marine recreational anglers. Alaska and British Columbia tend to offer longer more stable ocean seasons than have been offered north of Horse Mountain California under the restrictive seasons of recent years, (Tables B-12 and B-13).

Other types of marine recreational angler trips, fresh water angling, and other recreational activities are, to varying degrees, potential substitutes in the market place for ocean salmon fishing. West Coast salmon angling opportunities, including those in marine fisheries such as Puget Sound and the Columbia River Buoy-10 fishery are discussed in more detail in Section 3.4.

Demand for recreational trips and measures of the breadth of social and economic impacts related to the salmon fishery are related to numbers of anglers. Data is not available on the number of salmon anglers on the West Coast. However, data is available on the number of saltwater anglers. In the U.S., 9.4 million anglers took part in 86.5 million saltwater fishing trips in 1996. The following are the numbers of marine anglers by West Coast state and number of marine angling trips (USFWS, 1997).

| 1996 | Marine Anglers (Thousands) | | | | Marine Trips (Thousands) | | | |
|---|---|---|---|---|---|---|---|---|
| | Total | Resident | NonResident | Percent NonResident | Total | Resident | NonResident | Percent NonResident |
| Washington | 378 | 316 | 62 | 16 | 2,134 | 1,773 | 361 | 17 |
| Oregon | 162 | 129 | 33 | 20 | 870 | 818 | 53 | 6 |
| California | 1,049 | 937 | 112 | 11 | 7,302 | 6,992 | 310 | 4 |

# 2.0 THE SALMON FISHERIES MANAGEMENT SYSTEM

PFMC is responsible only for the West Coast ocean area commercial and recreational salmon harvests. Non-Indian commercial salmon fisheries also occur in Puget Sound, Grays Harbor, Willapa Bay, and the Columbia River. Nonocean Indian commercial salmon fisheries occur in the same areas (except Willapa Bay) as well as the Klamath River, Quinault River, Queets River, Hoh River, and Quillayute River. Nonocean recreational salmon fisheries occur in Puget Sound and other coastal and inland rivers, streams and estuaries including the Columbia River and Klamath River Basins. PFMC manages the ocean fisheries for ocean and expected spawning escapement, taking into account expected abundances and inside harvests. Expected abundances for north migrating fish are affected by harvests in Alaska and Canadian waters, which in some years have been negotiated under the Pacific Salmon Treaty.

## 2.1 HARVEST MANAGERS AND MANAGEMENT FORUMS

Because of the transboundary migratory nature of salmon, numerous U.S. management agencies take part in a number of different forums for the coordinated management of West Coast salmon stocks.

### 2.1.1 The Harvest Managers

The parties that implement management regulations affecting the West Coast ocean salmon fisheries include California, Oregon, Washington, Idaho, Alaska, Canada, NMFS, and the tribes. The California tribes involved in management and harvest of salmon are the Hoopa and Yurok. The Columbia River tribes involved in management and harvest of salmon are the Yakima, Warm Springs, Umatilla, Nez Perce, and Shoshone-Bannock tribes. The states of Oregon, Washington, and the Columbia River tribes manage according to court orders and plans arising from U.S. v. Oregon. The western Washington tribes involved in management and harvest of salmon are the Hoh, Jamestown S'Klallam, Lower Elwha Klallam, Port Gamble S'Klallam, Lummi, Makah, Muckleshoot, Nisqually, Nooksack, Puyallup, Quileute, Quinault, Sauk-Suiattle, Skokomish, Squaxin Island, Stillaquamish, Suquamish, Swinomish, Tulalip, and Upper Skagit. In Western Washington, the State of Washington and tribes are co-managers according to court orders arising from U.S. v. Washington and Hoh v. Baldrige utilizing the Puget Sound Salmon Management Plan and the Hoh v. Baldrige Framework Management Plan to guide annual management planning activities. Other tribes in the northwest also fish for salmon, but do not have fishery rights adjudicated under a treaty.

### 2.1.2 Northwest Tribal Management Organizations

The treaty tribes of the northwest utilize the services of two technical service organizations. These are the Columbia River Inter-Tribal Fish Commission (CRITFC) and the Northwest Indian Fisheries Commission (NWIFC).

#### 2.1.2.1 Columbia River Inter-Tribal Fish Commission

The CRITFC was formed in 1977 by resolutions of the Yakama, Warm Springs, Umatilla, and Nez Perce tribes-Columbia Basin Indian tribes that signed treaties in 1855 securing to them certain reserved rights to take fish in the Columbia River and its tributaries. The CRITFC is composed of the fish and wildlife committees of its member tribes and supplies technical expertise and enforcement resources. CRITFC provides support to the tribal governments during their negotiation on fish issues with the relevant state governments.[1/]

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[1/] The Shoshone-Bannock tribe has fishery rights established under a separate treaty and is not a member of the CRITFC.

### 2.1.2.2 Northwest Indian Fisheries Commission

The NWIFC was established to coordinate the activities of the tribes for implementation of orders arising from U.S. v. Washington. It is composed of 19 of the tribes in western Washington that are party to the U.S. v. Washington litigation: Jamestown S'Klallam, Lower Elwha S'Klallam, Port Gamble S'Klallam, Lummi Makah, Muckleshoot, Nisqually, Nooksack, Puyallup, Quileute, Quinault, Sauk-Suiattle, Skokomish, Squaxin Island, Stillaquamish, Suquamish, Swinomish, Tulalip, and Upper Skagit. Members' tribes manage their own fisheries and negotiate directly with the state. The NWIFC provides technical support to Puget Sound and coastal tribes and assists in intertribal coordination on harvest policy.

### 2.1.3 Pacific Salmon Treaty and Pacific Salmon Commission

Allowable impact levels established under agreements made within the Pacific Salmon Commission (PSC) or, in the absence of such agreements, independently by Canada affect the amount of fish available for harvest and spawning in U.S. waters. The PSC was established under the Pacific Salmon Treaty.

Canada and the U.S. signed the Pacific Salmon Treaty in 1985, after 15 years of negotiation. The Treaty was negotiated to ensure conservation and an equitable harvest of salmon stocks. It covers five species of Pacific salmon and steelhead; and applies to fisheries in southeast Alaska, British Columbia, Washington, and Oregon.

The treaty recognizes that each country is most interested in the conservation and harvest of salmon stocks that originate in its own waters. However, it also recognizes that salmon migrate through the waters of both countries and are inevitably intercepted in large numbers by each country's fisheries. The treaty was designed, therefore, to establish a forum for consultation and negotiation between Canada and the U.S. on Pacific salmon issues and to facilitate co-operation on research and enhancement of Pacific salmon stocks.

The two principles on which the treaty rests are conservation and equity.

- The conservation principle obliges the two parties to prevent overfishing and provide for optimum production.
- The equity principle provides for each country to receive benefits equivalent to the production of salmon from its own rivers.

Representatives from the two countries meet annually to review the past year's fishery and to negotiate fishing regimes for future years. Negotiations on implementation of the equity principle within the Pacific Salmon Commission as well as U.S.-government-to-Canadian-government negotiations on the issue have been unsuccessful. Since 1994, U.S. and Canadian negotiators have been unable to agree on catch limits.

### 2.1.4 Pacific Fishery Management Council

Each year PFMC[2] follows a specified preseason management process to develop the annual salmon management recommendations. Public involvement in the process begins in late February with the release of reports documenting the previous ocean salmon fishing season and providing estimates of the expected salmon abundance for the coming season. The reports are followed by a Council meeting in early March to propose season options for public comment, public hearings on the options in late March, and an early April Council meeting to adopt the final recommendations on time for implementation on May 1.

### 2.1.5 Columbia River Compact

The U.S. congress ratified a compact agreement between Oregon and Washington in 1918 (the Compact). The Compact's charge is to manage commercial fishing seasons for salmon, sturgeon and other commercial food fish caught in the Columbia River. The Columbia River Compact is made up of delegates from the Oregon and Washington fish and wildlife commissions. The Columbia River treaty tribes have authority to regulate Treaty-Indian ceremonial and subsistence fisheries. All commercial fisheries regulations are established by the Compact. In developing commercial seasons, the Compact considers the effect of the commercial fishery on escapement, treaty rights and sports fisheries for species such as salmon, steehead and shad. Options for management of the commercial Treaty fisheries are developed in consultation with the tribes in a co-management process. While the Compact has no authority to adopt sport regulations, allocation between sport, commercial and tribal users is considered an inherent part of the Compact's responsibility. Additionally, particular attention is paid to conservation of species listed under the ESA. Hearings are held periodically to adopt or review seasonal commercial regulation (Columbia River Compact, 1997 and 1998).

### 2.1.6 North of Cape Falcon Forum

The North of Cape Falcon Forum provides an opportunity for co-managers of the ocean and inside fisheries and representatives of commercial and recreational harvesting groups to resolve complex management issues which constrain management of the ocean and inside salmon fisheries north of Cape Falcon, Oregon. Co-managers participating in the forum include the states of Oregon and Washington, the Columbia River tribes, the Puget Sound and Washington coastal tribes and NMFS. The fishing groups represented include Oregon and Washington inside and ocean recreational fishers, Oregon and Washington non-Indian Columbia River, Willapa Bay and Grays Harbor gillnetters, Oregon and Washington non-Indian trollers, and Puget Sound non-Indian commercial fishers. In this forum, participants try to reach harvest agreements taking into account conservation needs, anticipated impacts from fish passing through Alaska and Canadian fisheries, court orders and harvest sharing between Indian and non-Indian users, harvest sharing between inside and outside fisheries, and harvest sharing and formal allocations between non-Indian commercial and recreational fishers.

In the Puget Sound and the Washington coastal areas, the entire package of pre-terminal and terminal fishing agreements are not always fully completed in the North of Cape Falcon Forum. In the event this occurs, the affected co-managers continue negotiations utilizing court orders and plans arising from the U.S.

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2/ PFMC is one of eight regional fishery management councils in the nation, all with similar missions, but covering different areas. Congress created councils when it passed the Magnuson-Stevens Fishery Conservation and Management Act in 1976. Fish and fishers often move between the waters of different states and between federal and state waters. Consequently, a regional management body can more easily control harvests of all fishers throughout the range of the fish. Councils prepare, monitor, and revise FMPs for fisheries requiring conservation and management, such as this salmon FMP. Councils are not federal agencies, but a combination of federal, state, and private interests. Councils are planning bodies that make recommendations, but have no rule making authority. The U.S. Secretary of Commerce is the federal rule making authority for fishery management. The Secretary approves/disapproves and implements PFMC plans and regulations.

v. Washington and Hoh v. Baldrige litigation including the Puget Sound Salmon Management Plan and the Hoh v. Baldrige Framework Management Plan.

### 2.1.7 Klamath River Fishery Management Council

The Klamath Fishery Management Council (KFMC) was created by Congress under the Klamath Basin Restoration Act in October 1986 (PL 99-552, 1986). The Klamath Basin Restoration Act created an 11 member KFMC to supercede a management group originally convened under the auspices of PFMC. The KFMC is comprised of representatives of California Department of Fish and Game (CDFG), Oregon Department of Fish and Wildlife (ODFW), PFMC, NMFS, the Department of Interior, the Yurok and Hoopa Tribes, California and Oregon commercial fishers, California ocean recreational fishers, and inland recreational fishers. The KFMC's advisory function is to make harvest management recommendations to the various management agencies including PFMC. All recommendations passed forward to agencies or to PFMC must be with the consensus of all members.

## 2.2 ACCESS TO THE COMMERCIAL AND RECREATIONAL SALMON FISHERIES

How our society determines who should be allowed access to the salmon fishery reflects social, political, and economic attitudes about the salmon resource. For example, the license limitation programs for the commercial fishery firmly establishes the resource is publicly owned, while at the same time establishing what is often construed as a private (tradable) right to access. The characteristics of this system and how it was established reflect attitudes about the fishery and fish resource and our relationship to it. License requirements and fees for recreational angling also reflect values placed on the opportunity to participate in the fishery, as do rules that provide exemptions for veterans, handicapped individuals, and senior citizens.

This section documents the commercial license limitation programs established by the states, including how they were established, and licensing requirements for recreational fisheries. The emphasis on the license limitation programs is particularly relevant given the recent federal funding of salmon license buyback programs in Washington and the potential for future buyback programs as a response to diminishing harvest opportunities. Information included on license fees may become out-dated over a relatively short period of time. It is included here to document and provide a baseline for the costs of access as of this moment in time. This section does not cover tribal rules for member access to tribal fisheries.

### 2.2.1 Commercial and Charter Vessels

State license limitation programs are used to control participation in the West Coast salmon fisheries. The non-Indian commercial salmon fisheries in all three states are operated under license limitation programs, and there is a license limitation program in effect in Washington for salmon recreational charter operations.

In August 1978, PFMC adopted a resolution encouraging the coastal states to implement moratoria on new participation in the ocean salmon troll and charter boat fleets. This action was taken in lieu of establishing a Federal permit, in recognition that the coastal states had existing vessel licensing programs and could most efficiently implement their own moratoria, responsive to the needs of the states and industry. The following are the general principles the states were encouraged to follow (1) cap not only participation, but also total effort; (2) use 1974-1977 as a base period for qualifying; (3) adhere as closely as possible to definitions of "active vessel participation," "contracted for construction," etc., as adopted and publicized by PFMC; (4) establish appeals boards; (5) recognize the regional nature of fisheries, but do not discriminate among fishers of the states within the region; (6) seek to ultimately maintain approximately the number of vessels in the 1977 fishery (or less) recognizing that the qualifying period may result in an initial increase in number of participants.

#### 2.2.1.1 California

### Ocean Commercial Troll

In California, ocean troll salmon vessel limited entry permits were first required for participation in the ocean troll salmon fishery beginning in 1982. There is no recipricol recognition of the salmon limited entry permits of other states.

#### Initial Qualification

California implemented its first moratorium on new entry to the salmon fishery in 1980 (SB 755, 1979). California's first moratorium was based on the individual rather than the vessel. The two-year moratorium required licensed fishers hold a personal salmon permit when fishing commercially for salmon. The permit was in the form of a stamp to be affixed to the commercial fishing license. A person with a salmon stamp could fish for salmon from any commercially licensed vessel. To acquire a stamp, the person (1) needed a commercial fish dealer receipt showing that he or she had sold at last one salmon in at least one year from 1974 through 1979; or (2) needed to show that he or she had a commercial license and while acting under that license had assisted in the capture and sale of at least one salmon from 1974 through 1979; or (3) needed to show proof of investment in becoming a commercial salmon fisherman such as by having a vessel under construction or contract for purchase prior to December 16, 1977. A notarized statement signed by the applicant and providing the registration number of the vessel delivering the fish was sufficient demonstration that the second of the listed requirements was met. To qualify based on investment, applications had to be reviewed by an appeals board dominated by commercial salmon fishers. Fishers in Oregon and Washington that qualified under the limited entry laws in those states were qualified to purchase a commercial license and salmon stamp in California. Because the limited entry programs in other states were vessel based rather than crew based, out of state vessels were allowed to use out of state crew without having commercial licenses for those crew. The initial moratorium permits were nontransferable except that they could be transferred to a different individual for one 15-day period during the calendar year. The fees for the stamp and salmon validation fee were $15. The initial moratorium was in place through the end of 1981.

In 1982, the fisher based moratorium was modified to a vessel owner based license limitation system. Permits were issued to (1) owners of vessels that had been used to take salmon commercially from 1980 through August 11, 1982, (2) to natural persons with personal salmon permits under the moratorium who had constructed or purchased a vessel prior to August 11, 1982 in anticipation of entering the salmon fishery, (3) natural persons owning a commercial vessel with salmon landings who due to a personal illness, disability, or other circumstance outside their control were unable to fish from 1980-1982, (4) individuals licensed to fish commercially for at least 20 years who had participated in the salmon fishery in at least one of those 20 years (Senate Bill 1917, 1982).[3/] New permits could only go to natural persons who did not already own a commercial salmon fishing permit.[4/] The vessel based moratorium did not provide recipricol recognition for Oregon and Washington salmon limited entry permits. This moratorium was initially set to expire at the end of 1986, unless renewed (SB 1917). After a series of renewals, the moratoreum became a permanent license limitation system in 1988 (Assembly Bill 2366).

#### Numbers of Permits and Provisions for Expanding the Number of Permits

The California legislation establishing a permanent salmon license limitation program authorized the issuance of new permits only when the total number of permits falls below 2,500. When the total number of permits falls below 2,500, CDFG is to consult with the review board to determine the number and vessel

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3/ If new permits were to be issued, they were first issued as interim permits. Interim permits had to be used in two consecutive seasons before a permanent permit could be issued.

4/ Permits were transferable with, but not separable from, the vessel except in the case of a lost, destroyed, or retired vessel. An owner could replace a lost, destroyed, or retired vessel within one year with a vessel found by the review board to be of equal or lessor capacity.

classification for the new permits to be issued. New permits would be issued by a drawing. There have been fewer than 2,500 California permits since 1994; however, because of the depressed condition of the resource, to date, no additional permits have been issued. The number of permits issued was highest in 1984 at 5,964. In 1997, there were 2,069 vessels with California permits.

### Permit Transferability and Vessel Capacity Limitation

Permits are issued to the vessel owner and may only be transferred to a new owner with the vessel. The owner may transfer the permit to a replacement vessel that has the same or less fishing potential than the vessel being replaced, however, the owner must own the permitted boat at least 18 months before the permit can be transferred to a new vessel. Permits may be transferred to new vessels if the vessel was accidentally lost and the necessary steps to secure a replacement are taken within one year of the loss. There is a $200 fee for transferring a permit to a different vessel. If a permitted vessel has a lien holder or mortgage holder, the lien or mortgage holder must approve the transfer of the permit to a different vessel.

Fishing vessel potential is evaluated by a commercial salmon review board. In considering the capacity of permits, the review board first groups vessels into two groups: vessels less than 25 feet, and vessels more than 25 feet. The following seven factors are evaluated by the board in determining vessel capacity (they are listed here in order of importance), (1) the vessel's size in terms of length, beam, and depth; (2) the vessel's "seakeeping ability" as determined by the size and design of the hull; (3) the new vessel's ability to function as a salmon troller in comparison to the vessel being replaced; (4) previous use of the vessel; (5) fish holding capacity; (6) hull shape (open deck, closed deck, displacement, semidisplacement, and planing) and materials (wood, fiberglass, aluminum, steel, other); (7) propulsion. Seakeeping ability is the board's assessment of the ability of the vessel to stay at sea and continue to fish during inclement weather. Amounts of salmon landed may be considered as part of the boards evaluation of the vessel's capacity. The boards final determination is based on its aggregate assessment of these factors. For vessels less than 25 feet in length the size of the vessels is not compared. Where one or both vessels involved in the transfer are greater than 25 feet all seven factors are considered. (CDFG, Guidelines for Commercial Salmon Vessel Permit Transfers, March 18, 1997).

### Permit Renewal and Revocation

Salmon permits must be renewed prior to April 1 each year and will become void if not renewed. The fee for renewing the salmon permit is $30 (Bennett, 1998). Permits not renewed by April 1, may be renewed prior to the end of April with payment of a $100 late fee. Salmon landings are not required for renewal of the permit. The permits can only be reinstated if an extenuating circumstance prevented renewal and there was not a reasonable opportunity for an agent to renew the permit on behalf of the owner. Permits will be voided if a vessel is purposefully sunk prior to the transfer of the permit from the vessel or if a vessel was accidentally lost but not replaced within one year (Fish and Game Code, Article 4.5).

### Other State Permits Required for Participation in the Commercial Salmon Fishery

In California, all commercial fishing vessels are required to have a commercial fishing vessel registration. Additionally, salmon conservation stamps are required for anyone on the vessel assisting in the salmon harvest. As of 1998, the fee for the vessel registration was $200 for residents and $400 for nonresidents. Everyone working on board the vessel must hold a commercial license to which the salmon conservation stamps are affixed. The 1998 fees for the commercial licenses were $50 for crew members, $90 for operators, and $400 for nonresidents. The vessel may hold a permit for one crew member that may be assigned to any crew member working on the vessel. The fee for the salmon conservation stamps fluctuate between $85 and $285 on an annual basis, depending on the total tonnage of salmon landed in the state in the previous year. For 1998 the fee was $260 (Bennett,1998).

Commercial fishers who wish to sell to the public or directly to restaurants and retail outlets must acquire special licenses. To sell to restaurants and retail outlets a commercial fish receivers license is required, the fee for which is $400 for 1998. To sell directly to the public a commercial fish retailers license is required, the fee for which is $50 for 1998 (CDFG, 1998b).

### Recreational Charter Vessels

There is no license limitation system for California commercial passenger fishing vessels charter vessels. Such vessels are required to obtain commercial passenger fishing vessel licenses from CDFG for $200 ($150 if the vessel has a commercial salmon vessel permit). These vessels must also hold commercial boat registrations from the California Department of Motor Vehicles. In addition, north of Point Arguello, charter vessels participating in the salmon fishery must hold commercial fishing salmon stamps for the operator and an additional salmon stamp for each crew member required to be on board under USCG rules (CDFG, 1998).

### Limited Entry Permit Buyback Programs

There have been no buyback programs for California ocean troll permits.

## 2.2.1.2 Oregon

### Ocean Commercial Troll

Ocean troll salmon limited entry permits were first required for participation in the ocean troll salmon fishery beginning in 1980 (ORS 508.801). In an emergency and with the approval of ODFW, ocean troll salmon may be landed by vessels without limited entry permits if a single delivery license is purchased for the vessel. Vessels operating under the California salmon license limitation program may land in Oregon using such a single delivery permit.

#### Initial Qualification

Initial issuance of the ocean troll salmon limited entry permits was based on vessel history. In order to qualify, a vessel must have been commercially licensed and have landed in Oregon at least one ocean troll caught salmon from 1974-1978, or, during 1974-1978 must have been under construction or a contract for construction as a commercial fishing vessel designed to be used in the ocean troll salmon fishery. No applications for new permits were accepted after May 15, 1989.

#### Numbers of Permits and Provisions for Expanding the Number of Permits

ODFW is required to issue a minimum of 1,200 limited entry ocean troll salmon permits. If the number of renewed permits falls below this level then a lottery may be used to achieve the minimum. The Oregon Fish and Wildlife Commission is allowed to suspend the lottery for up to two years if it determines the action appropriate in consideration of the condition of the resource. When the program was first established the minimum was set at the number of vessels participating in the ocean troll salmon fishery during the calendar year 1978 (3,158 vessels). Since initially establishing the program, the state legislature has reduced this minimum on several occasions. A lottery has never been held to issue more permits. The greatest number of permits issued was 4,314 in 1980. In 1997 there were 1,286 permits issued.

#### Permit Transferability and Vessel Capacity Limitation

Limited entry troll permits may be transferred to new owners with the transfer of the vessel. Such permits may also be transferred to a replacement vessel of the holder of the permit or, if authorized by ODFW, to a different vessel owned by a different individual. The language of the initial legislation placed some limits on the transfers based on vessel "capability".[5/][6/] The replacement vessels could not be of greater capability than the vessel from which the permit was being transferred with three exceptions. The permit could go to a greater capability vessel if (1) prior to August 8, 1983 the person owning the vessel to which the permit was being transferred also owned a limited entry troll permit; (2) prior to August 8, 1983 there was a limited entry troll permit issued for the vessel to which the permit was being transferred; or (3) the vessel was newly constructed and had never been used in any commercial fishery. The agency issued rules giving this legislation the following interpretation: all vessels less than or equal to 30 feet in length were considered to have the same capability; and the limit on transfer to vessels of "greater capability" was interpreted as a limit on transferring a permit to a vessel more than 5 feet longer than the vessel from which the permit was being transferred (where the vessel to which the permit was being transferred was longer than 30 feet). Through a series of transfers, permits could be moved to progressively longer vessels without limit, except permits could be transferred only once per year. In 1995, legislation abandoned the "capability" language and specified transfer restrictions in terms of length. The rules were liberalized to remove all capability limitations for permit transfers where both vessels involved were in the same length class. Three length classes were established, (1) less than 30 feet,[7/] (2) greater than 30 feet and less than or equal to 42 feet, and (3) greater than 42 feet. Additionally, permits could be moved between vessels in different categories so long as the change in length was no greater than 5 feet.

A vessel operating under a permit must land more than 100 pounds of salmon in the year prior to a transfer if the permit is to be transferred to a vessel longer than 30 feet owned by a different person. The required salmon landings may be made in any West Coast or Alaska ocean troll fishery. This requirement to land 100 pounds in order to transfer the permit will not be effective in a calendar year in which the number of permits issued is less than 1,200.

Permits may be transferred only once per year unless the Commercial Fishery Permit Review Board finds that such a restriction would create undue hardship. In response to an appeal, the board may waive eligibility requirements for transfer of permits if the board finds the individual fails to meet the requirements as the result of illness, accident, or other circumstances beyond the individual's control.

There are no fees for the transfer of a permit.

### Permit Renewal and Revocation

Limited entry permits must be renewed each year prior to the end of the year. A limited entry permit will expire and not be renewed if the permit holder fails to apply and pay the required fees for the limited entry permit prior to the end of the calendar year or fails to acquire the state's general boat license for commercial harvest prior to the end of the calendar year, except in the following situations:

- A person who permanently loses a vessel through capsizing, fire, or collision has a period of two years from the date of the loss to replace the vessel without losing eligibility to renew the limited entry permit.
- Renewal requirements are waived if in the year prior to the renewal application there was no federally established salmon season of 20 or more days in length between May 1 and July 31 off the Oregon port in which the vessel lands; and if, during the three most recent years in which there was a season of 20 or more days off that Oregon port, the vessel has landed troll-caught salmon in at least one of those years and did not land salmon in any other port during those three years.

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[5/] Oregon regulations use the word "capability" rather than "capacity".

[6/] During the early phase of the program, legislation authorized consideration of the following factors in determining vessel capability. Vessel size, horsepower, ability to operate under adverse weather, electronic and other gear with which the vessel is equipped, and fish hold capacity.

[7/] Based on the previous rules and the pattern established by the remaining categories, it was probably intended that the bottom category be vessels less than **or equal to** 30 feet.

As of 1998, the renewal fee for a salmon troll permit was $75 (including a $65 surcharge in place for 1998 through 2003). Permit fees may be refunded for vessels qualifying for the exemption from renewal specified in the second bullet. When the program was first established, in addition to keeping the permit up-to-date (renewed prior to the end of the calendar year) sometime during the year the vessel had to have landed salmon in Alaska, Washington, Oregon, or California in order to be eligible to have its permit renewed in a subsequent year. This provision was eliminated, effective in 1988.

If issuance of a permit is denied because of failure to renew, the denial may be appealed to the Commercial Fishery Permit Review Board. The board may waive eligibility requirements for renewal of permits if the board finds the individual fails to meet the requirements as the result of illness, accident, or other circumstances beyond the individual's control.

Permits may be revoked by the Commercial Fishery Permit Review Board on conviction of violation of the state's commercial fishing or game fishing laws or rules or on forfeiture of bail on account of such an offense. Additionally, permits may be revoked based on convictions in the State of Washington on an offense in violation of Columbia River commercial fishing rules adopted pursuant to the Columbia River Compact, provided the action on which the conviction was based would have also been considered an offense subject to permit revocation in the State of Oregon. After a first revocation, a permit may be revoked for up to two years for the commission of a second offense.

### Columbia River Commercial Gill Net

Columbia River commercial gill net permits are required to participate in the Columbia River troll gill net fishery and land fish in Oregon (ORS 508.775). Vessels with permits for this fishery licensed by Washington are also allowed to make landings in Oregon.

### Initial Qualification

The initial qualifying requirements for the Columbia River gill net permits (landings and construction) were similar to those for the troll fishery except with respect to the fishery in which participation was required (the Columbia River gill net fishery) and the years of the qualifying period (1977-1978).

### Numbers of Permits and Provisions for Expanding the Number of Permits

Similar to the troll permit system, there is a minimum number of gill net permits that ODFW is required to issue and if necessary, that minimum number may be maintained through a lottery. However, the lottery may be delayed for two years for resource conservation reasons. Since 1995, the minimum number has been 200.

### Permit Transferability and Vessel Capacity Limitation

Limited entry gill net permits may be transferred to new owners with the transfer of the vessel. Such permits may also be transferred to a replacement vessel of the holder of the permit or, if authorized by ODFW, to a different vessel owned by a different individual. There are no vessel capacity restrictions on the transfer of Columbia River gill net permits. Until 1995, there was a provision specifying that if a permit was not used during a calendar year and a waiver of renewal requirements was issued (see below), it could not be transferred for two years.

### Permit Renewal and Revocation

Permit renewal requirements and revocation provisions are similar to those described for the troll permit system. Through mid-1995, in addition to keeping the permit up-to-date (renewed prior to the end of the calendar year) the vessel operating under the permit must have made at least one landing in the Columbia River gill net fishery during the calendar year. The renewal requirement can be waived if the Commercial

Fishery Permit Board finds that (1) the individual, for personal or economic reasons, chose to actively commercially fish in some other fishery during the Columbia River gill net salmon seasons, or (2) the individual failed to meet the requirements as a result of illness, accident, or other circumstances beyond the individuals control. These exceptions also applied to the use requirement when it was in place.

As of 1998, the renewal fee for the permits was $75 (including a $74 surcharge in place for 1998 through 2003).

### Commercial Fishery Permit Board

The Commercial Fishery Permit Board is comprised of representatives of the fishing industry. Additionally, two members are appointed to represent the public. Members of the board serve without compensation (with the exception of travel and other expenses incurred as part of their official duties).

### Other State Permits Required for Participation in the Commercial Salmon Fishery

The owner or operator of any boat harvesting fish or shellfish for commercial use must hold a boat license for the vessel (ORS 507.260). These licenses constitute registration for the purpose of Section 306(a) of the Magnuson-Stevens Fishery Conservation and Management Act. Such registration gives the state authority to regulate the fishing vessel outside the boundaries of the state so long as there is no FMP or other applicable federal fishing regulations, or so long as the state's laws and regulations are consistent with such FMPs or other federal fishing regulations. Vessel licenses cost $200 for residents and $400 for nonresidents.

Crew members assisting in the fish harvest must hold licenses. The crewmember fees are $50 for residents over 18, $25 for residents 18 and younger, and $100 for nonresidents. The vessel may purchase "Commercial Crewmember Fishing Licenses" for $85 and assign such licenses to the individuals working on the vessel.

### Recreational Charter Vessels

There is no license limitation system for Oregon recreational charter vessels. Such vessels are required to obtain permits from the state Marine Board. The current permit fees for residents are $50 for an Oregon titled vessel and $100 for a United States Coast Guard (USCG) documented vessel. For nonresidents the fees are $50 for Alaska residents, $250 for California residents, $550 for Washington residents, and $100 for residents of other states. In addition to the vessel licensing requirements, the vessel operator must have a vessel operators license from the USCG. Outfitter guides may also take recreational fishers out for hire, however, they may not go further than three miles out without a charter vessel license (Oregon State Marine Board, 1998).

### Limited Entry Permit Buyback Programs

There has not been a buyback program for Oregon troll vessel permits, however, there has been such a program for Columbia River gill net vessels. The Salmon and Steelhead Conservation Act of 1980 provided guidance on fleet reduction in the Washington conservation area, including the Columbia River gill net salmon fishery. A separate public law authorized a National Oceanic and Atmospheric Administration (NOAA) grant to the Washington Department of Fisheries in 1981 for fleet reduction in the Washington conservation area. This appropriation included a provision for funding an Oregon Columbia River fleet reduction program. The Oregon program began in April 1983, operating with federal grant funds made available through a cooperative agreement with Washington. The program ended with the end of federal funding in December of 1986. Permits were purchased in four rounds under a reverse auction bidding procedure. In each round, offers to sell were solicited from permit holders. The offers were placed in order from lowest to highest, and the Oregon Fish and Wildlife Commission determined how many of the permits they would buy, buying the lowest offers first (Carter, 1998). During the program, 133 gill net permits were purchased for $645,000. Between attrition and the buyback program, the number of permits declined from 572 in 1980 to 355 in 1986. The administrative costs of the program were $71,000.

### 2.2.1.3 Washington

#### Ocean Commercial Troll and Other Washington Commercial Salmon Fisheries

The ocean troll salmon limited entry program was created as part of a program that created commercial licenses for all of Washington's commercial salmon fisheries. The first legislation creating this system was passed in 1974. Washington recognizes Oregon Columbia River gill net permits, but does not provide recipricol recognition for the troll limited entry licenses issued by other states.

#### Initial Qualification

Initial issuance of the ocean troll salmon limited entry licenses and delivery permits was based on vessel history. In order to qualify, a vessel must have been commercially licensed for salmon and landed at least one ocean troll caught salmon between January 1, 1970 and May 6, 1974. The licenses issued were specific to the gear type and area in which the vessel fished.[8/] Additionally, commercial fishing vessels under construction or purchased in good faith between April 16, 1973 and May 6, 1974 were eligible for licenses. A provision in the law would have allowed recreational charter vessels to be licensed for commercial trolling if it were found that the charter industry was suffering economic hardship due to the national fuel crisis. However, the fuel crisis provision was never invoked (Edie, 1998). As a result of the consideration of the moratorium law, many individuals applied for licenses early in 1974. However, because most fishing seasons did not start until after May 6, 1974 and landings were required prior to that date, these permits were not eligible for renewal in 1975. Extenuating hardship circumstances did not play a role in the initial permit issuance criteria.

An advisory review board was convened to hear disputes on the issuance of permits. The board was comprised of three members nominated by the commercial salmon fishing industry.

The initial program was set to expire at the end of 1977. In 1977 the commercial troll program was extended through 1980 and in 1979 it was made permanent.

#### Numbers of Permits and Provisions for Expanding the Number of Permits

Unlike Oregon and California, there was no minimum set on the number of permits to be issued. A committee, convened to evaluate the moratorium, was in consensus agreement the number of vessels in the fishery should not be increased, but there was not an agreement on whether or not a decrease was warranted (Benson and Longman, 1980). In 1978, 3,291 permits were issued. The number of permits issued declined to 323 in 1997.

#### Permit Transferability and Vessel Capacity Limitation

Washington commercial salmon limited entry permits are transferable between vessels. There has never been a limit on the size or capacity of the vessels to which the permits can be transferred. There is nothing in the program that restricts the transfer of permits from lost vessels. The fee to transfer a permit is $50.

The permit off any vessel which is subject to a government confiscation may be transferred to the individual named on the permit with the approval of the director of Washington Department of Fish and Wildlife (WDFW).

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[8/] The fishing area/gear type combinations for which permits were issued were Puget Sound purse seine, Puget Sound gill net, Willapa Bay gill net, Grays Harbor gill net, Columbia River gill net, Ocean troll, and Puget Sound reef net.

### Permit Renewal and Revocation

The annual fee for renewing a salmon troll license is $380 for Washington residents and $685 for nonresidents. There is an additional $100 enhancement surcharge which must be paid. The WDFW directory may wave renewal requirements or refund permit renewal fees if there is no salmon season in a particular year (Edie, 1998).

Beginning in 1979, salmon limited entry permits could be renewed so long as the permit had been renewed in the previous year, and the vessel with which the permit had been registered was used to take food fish. Previous to 1979, permit renewal was contingent only on a vessel having met the original qualifying requirements. Some vessels did not renew their permit every year or had not applied for a permit. The requirement a permit be held in the previous year in order to acquire a permit in a subsequent year resulted in an increase in the number of permits issued in 1978. Beginning in 1994, the provision was dropped that required the vessel to have been used to take food fish in order to renew. Beginning in April 1997, a provision was created that allowed permit holder's to declare an intent not to renew their permit for the year, but reserve the right to renew the permit in a future year. Such declarations must be made by May 1, and the standard enhancement surcharge must be paid along with a $15 handling fee (RCW 75.28.110, Edie, 1998). Extenuating circumstances beyond the control of the vessel owner may be considered by an administrative hearings officer if someone fails to renew their permit. However, because permit holders have until the end of the year to renew a permit, the circumstances under which hardship exceptions are granted have been quite limited.

The director may revoke a permit for up to one year for violation of state fishing laws. Such revocation is allowed in response to two or more gross misdemeanors within a 5-year period or one Class C felony (RCW 75.10.120).

### Other State Permits Required for Participation in the Commercial Salmon Fishery

In Washington, licenses for all commercial fisheries are species and gear specific. No vessel licenses are required from the state other than a salmon limited entry or delivery permit. Each permit allows the designation of one of the vessel owners as a primary vessel operator. If someone else is to operate the vessel, they must acquire an alternative operator license for $35. The operator license is a one-time license assigned to the individual that may be used by that person on any vessel. Licenses are not required for crew members.

## Recreational Charter Vessels

A moratorium on the entry of new recreational salmon charter vessels was imposed on May 28, 1977. Oregon permits are recognized for Oregon charter vessels fishing as far north as Point Leadbetter Washington, so long as Oregon extends similar reciprocity to Washington charter vessels.

### Initial Qualification

To qualify under the initial moratorium, a charter vessel had to have been licensed in at least one year from 1974 to 1976 (RCW 75.28.095, 1975). The charter licenses required were not specific to salmon. In addition, licenses were issued to any vessel under construction or purchased in good faith between April 15, 1976 and May 28, 1977. The initial moratorium was set to expire at the end of 1980 (SB 2104). Recreational charter vessel licenses are not area specific (vessels may make trips in the ocean as well as interior marine waters such as Puget Sound [Edie, 1998]). Extenuating hardship circumstances did not play a role in the initial permit issuance criteria.

In 1979, the moratorium was revised and renewed through the end of 1981, and it was established as a permanent program in 1981. The 1979 revisions included the addition of a requirement for "yearly angler permits," in addition to the charter vessel permit. The yearly angler permit specified the maximum number of anglers that may fish from a charter vessel at any one time. The maximum number of anglers that could be carried was based on vessel size as specified in a USCG certificate of inspection. The schedule for number of anglers started out at 8 for a 31.5' vessel and ended at 34 for a 64.5' vessel. Vessels without USCG inspection documents were issued permits for 6 passengers. Vessels with hulls substantially wider than conventional hulls were issued permits to carry up to 25 anglers (Benson and Longman, 1979; RCW 75.30, 1980).

An advisory review board was convened to hear disputes on the issuance of permits. The board was comprised of three members nominated by the charter industry.

### Numbers of Permits and Provisions for Expanding the Number of Permits

No provisions have been made to allow an expansion in the number of permits or yearly angler permits issued if the fleet size or number of yearly angler permits falls below a certain threshold.

### Permit Transferability and Vessel Capacity Limitation

All charter vessel licenses are transferrable between owners and among vessels. There is a $50 fee for the transfer of a license. Angler permits are also transferable and may be transferred in single angler units, so the authorized carrying capacity of any vessel may be increased or decreased with the purchase or sale of additional angler permits. There is a $10 fee for the transfer of angler permits. The fee is paid by all parties in the transfer (both "sellers" and "buyers"). There must be at least one angler permit left with the vessel license. If all angler permits are transferred from the vessel license then the vessel license expires.

### Permit Renewal and Revocation

A license for which no application was made or which is not renewed in any given year is considered to have expired. Angler permits expire if the charter permits are not renewed. The permit renewal fee is $380 for residents and $685 for nonresidents. There is an additional $100 enhancement surcharge which must be paid. The WDFW directory may wave renewal requirements or refund permit renewal fees if there is no salmon season in a particular year (Edie, 1998). The rules for considering hardship and permit revocation are similar to those discussed above for the commercial fishery.

### Other State Permits Required for Participation in the Commercial Salmon Fishery

There are no state permits required for charter vessel operations, other than the limited entry license. Vessel operators are required to have the proper USCG certification, no additional state licenses are required. There are no licensing requirements for crew members.

## Limited Entry Permit Buyback Programs

Laws creating a buyback program for the Washington fleet were implemented in 1975. The funds for the program were federal, and the initial funds were used for the purchase of Puget Sound commercial permits and vessels. Vessels bought out were not allowed to participate in any Washington fisheries. The buyback program was changed in 1979 to include recreational charter, ocean troll vessels, and gill net vessels in Grays Harbor, Willapa Bay, and the Columbia River. First priority was given to those who wanted to sell their permit only and second priority to those willing to sell both their permits and vessels. Within these two categories a ranking system was developed based on length of time in the fishery, with higher priority going to those with a longer history. A random drawing was held among those within a similar category for length of participation. In 1980 the program was modified to allow only the purchase of licenses (not vessels). In October 1981, the program was modified to allow the purchase of the license or the license and a promise not to participate in Washington fisheries for ten years (WDFW, 1991) . Prices were based on a set offer from the state.

In 1978, there were 3,291 ocean troll permits and 535 recreational charter permits. The number of troll and charter vessels purchased under the buyback program were as follows:

Number of permits bought back.

| | 1975-1978 | 1979 | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| Troll | 0 | 213 | 215 | 15 | 44 | 39 | 162 | 324 | 143 | 1,155 |
| Charter | 0 | 0 | 16 | 3 | 25 | 19 | 21 | 19 | 15 | 118 |

Since 1986 no funds have been available for this program. In 1987, due to the buyback program and attrition, there were 1,401 troll permits and 280 charter permits.

In 1994, the federal government declared a fishery disaster for West Coast salmon fisheries off northern California, Oregon, and Washington. Disaster relief funds were used to fund a buyback program in 1995 and 1996. In 1995, the lowest bids were purchased first and program rules prohibited acceptance of bids over $100,000. In 1996, offers to sell permits were ranked based on the salmon decline impact ratio. The salmon decline impact was calculated as the vessel's best year of salmon-related revenue from 1986 through 1991 minus the vessel's worst year of salmon related revenue from 1991 through 1995 multiplied by 2.5. The ratio was the permit holders offering price divided by the salmon decline impact. Maximum payments were limited to the lessor of the salmon decline impact and $75,000 in 1996. Those selling their permits had to agree not to purchase or operate a commercially licensed vessel in any of the fisheries under the buyback program for ten years beginning January 1, 1997. Over the two years of the program, $4.0 million was spent buying troll permits and $800,000 on recreational charter permits (WDFW, 1997). Washington gill net permits for Grays Harbor, Willapa Bay, and the Columbia River were also purchased. The following are the number of permits purchased in 1995 and 1996.

Number of permits bought back.

| | 1995 | 1996 | Total |
|---|---|---|---|
| Ocean Troll | 190 | 72 | 262 |
| Charter | 23 | 18 | 41 |

Following on the buyback program funded under the fishery disaster declaration, a second program was funded using a federal appropriation of disaster relief funds made in response to the 1996-1997 winter floods. The second program required state matching funds. In 1998, the Washington legislature appropriated $1.7 million as 25% matching funds. This most recent buyback program will cover Puget Sound fisheries in addition to the coastal and Columbia River fisheries covered under the 1995-1996 program. The new buyback program will pay the same amount for all permits.

### 2.2.2 Recreational Fisher Licensing

#### 2.2.2.1 California

In California, anyone over the age of 16 participating in recreational fishing in ocean waters is required to have a license. However, no license is required for pier fishing in ocean waters, including, but not limited to, San Francisco and San Pablo Bays. Licenses may be lifetime, annual, or short term (10-day or daily). Recreational licenses in California fall into different classes. There are general fishing licenses covering all areas, ocean fishing licenses, and ocean finfish licenses. The annual licenses are general fishing licenses except that residents may acquire Pacific-Ocean-only licenses. In 1998, the annual licenses cost $27.05 for residents, $16 for resident Pacific-Ocean-only licenses and $73 for nonresidents (there is no nonresident Pacific-Ocean-only license). Ten-day nonresident general licenses can be acquired for $27.05 and one-day resident and nonresident general licenses for $9.70. One-day Pacific Ocean finfish only licenses run $6.05 for residents and nonresidents. For those fishing south of Point Arguello, an additional $0.50 must be paid for an ocean enhancement stamp. Salmon fishers in the ocean north of Point Delgada or in the Klamath

River system must also acquire salmon punch cards for $1.05. Lifetime permits can be acquired for fees which range from $300 to $495 depending on the age of the applicant. Reduced fee and free annual permits are available to disabled veterans and the elderly poor. Free licenses are available to those with mobility restricting disabilities, low-income American Indians, wards of the state residing in state hospitals, and certain developmentally disabled individuals (California, 1998)

#### 2.2.2.2 Oregon

In Oregon, anyone recreational fishing over the age of 13 is required to have an Oregon fishing license with the exception of those taking smelt or shellfish and Washington residents fishing in the ocean under a Washington license between Cape Falcon, Oregon and Point Leadbetter, Washington. In 1998, annual licenses for residents were $20.50 for adults and $6.25 for juveniles age 14-17. The fee for an annual license for nonresidents is $48 for all ages required to have licenses. In addition to the general fishing license, salmon tags must be held for each salmon landed. These tags cost $10.50 each. Single-day and seven-day general fishing licenses include salmon tags and may be purchased for $8.75 and $34.25, respectively. For no charge or a small fee; the blind, wheelchair bound, disabled war veterans, senior citizens over 70 years old, and 50-year residents over 65 years old may acquire permanent licenses. Annual fishing licenses may also be purchased together with hunting privileges for $32.50 or as part of a $101 "Sportpak License" (ODFW, 1998).

#### 2.2.2.3 Washington

For 1998, a Washington recreational fishing license is required for recreational fishing by any resident over the age of 14 and any nonresident. There are "Food Fish," "Game Fish," "Steelhead," and "Shellfish/Seaweed" licenses. A "Food Fish" license is required to fish for salmon. These licenses are $8.00 for residents and $20.00 for nonresidents. Catch record cards for salmon, halibut, and sturgeon are provided with the license. A maximum of 15 salmon may be landed on each salmon catch record card. Three- day licenses for residents and nonresidents are $5.00. A "Puget Sound Enhancement License" must be purchased to fish for any marine species in Puget Sound. Annual enhancement licenses run $10.00 and three-day enhancement licenses are $5.00. Beginning in 1999, the license structure will change, and there will be licenses for saltwater, freshwater, and shellfish/seawead. The charge for marine water licenses will be $18.00 for residents and $36.00 for nonresidents. Enhancement fees are included in the license fees. There are, and will be, reduced fee licenses for individuals over 70 and free licenses for certain handicapped, blind, developmentally, and otherwise disabled fishers. Washington recognizes Oregon fishing permits for anglers fishing in Washington waters when the fishing trips depart from and return to Oregon ports. There are no lifetime permits available in Washington (WDFW, 1998a and 1998b).

## 2.3 LANDINGS TAXES FOR COMMERCIAL SALMON

### 2.3.1 California

Fees for the landing of salmon are generally paid by the fish processor, but may be paid by the vessel if the vessel sells its fish under commercial fish receivers or a fish retailers licenses. The California fish and game code is silent on the treatment of take-home fish. Beginning in 1998, a policy was implemented to require that fish taken home for personal use be recorded on the official state fishticket of a commercial fish business, licensed fish receiver, or licensed fish retailer. These licensed fish recipients would then be responsible for paying the taxes. The landings fees total $0.05 per pound with $0.02 of the amount going to the state Salmon Council (a salmon marketing board) and the remainder going to CDFG. Fees must be paid on all salmon landed, included that taken by the commercial fishers for personal use. (Blakely, 1998)

### 2.3.2 Oregon

There are two components to landings fees for salmon landed in Oregon. One is an ad valorem fee of 3.15% of the landed value; the second is a $0.05 per-pound (round weight equivalent) surcharge that goes to the Fish Restoration and Enhancement Program. The processor pays the fee in most cases. The exception is for those fishermen who have limited salmon fish seller licenses (limited to 40 per year) who sell directly to consumers from their vessel. They would submit fishtickets and pay the landings fee. (Note: the ad valorem rate for other species is 1.09%.) Fishers who wish to take salmon home must first sell it to a licensed fish receiver then buy it back at an agreed upon price (e.g., the exvessel price plus the fees paid by the processor [Carter, 1998]).

### 2.3.3 Washington

Excise taxes are paid on salmon by the first fish buyer. Washington legislation specifically authorized the buyer to deduct one half the excise tax from the price paid for the raw product. The excise tax is based on the value of the fish landed and is 0.0525% for chinook coho and chum salmon, and 0.0315% for pink and sockeye salmon (RCW 82.27). Fish taken home by the fishers are supposed to be recorded on fishtickets along with a zero price. Tickets are recorded as "Takehome," and no landings taxes are paid.

# 3.0 THE SALMON HARVEST AND HARVESTERS

## 3.1 ALASKA AND CANADA

West Coast salmon stocks are among those harvested in Alaska and Canadian salmon fisheries. The amount of fish available for harvest in PFMC management areas depends, in part, on harvest in Canada and Alaska. In turn, management of West Coast fisheries affects the amount of West Coast production and amount of fish available in these northern fisheries. For some chinook stocks, the impacts of PFMC fisheries are significant as well as those of Alaska and/or Canada (e.g., Stayton Pond fall chinook on the Columbia River, Table B-14). For other stocks the level of PFMC impacts rounds to zero and most of the impacts occur in Alaska and Canada (e.g., Queets fall fingerlings). Information on the impacts of fisheries in different areas, for example coho stocks, is provided in Table B-15. Production from Alaskan and Canadian commercial fisheries is discussed in Section 2 of this appendix.

## 3.2 WEST COAST INDIAN FISHERIES

West Coast harvest is allocated between Indian and non-Indian fishers in accordance with judicial interpretations of U. S. treaty obligations. These obligations are reviewed in Chapter 5 of the FMP. Tribal harvest is taken in commercial fisheries and in ceremonial and substance fisheries. This section covers tribes with federally recognized harvest rights. Not included are tribes that harvest salmon, but do not have federally recognized fishing rights, such as the Karuks on the Klamath River.

### 3.2.1 Tribal Ceremonial and Subsistence Fisheries

The amounts of salmon used for ceremonial and subsistence purposes are documented in Appendix B of the PFMC's annual *Review of Ocean Salmon Fisheries*.

The following reflects some of the tribal perspective on the cultural importance of salmon to tribes:

> The First Salmon Ceremony is general to tribes throughout Northwest Indian Country, from the Pacific Coast to Puget Sound to the Inland Northwest. It is a rite to ensure the continued return of salmon and it has been performed for thousands of years. The symbolic acts, attitudes of respect and reverence, and concern for the salmon reflect a conception of the interdependence and relatedness of all living things which is a dominant feature of Indian world view.
>
> The importance of the First Salmon Ceremony has to do with the celebration of life, of the salmon as subsistence. The annual celebration is an appreciation that the salmon are returning. It is the natural law; the cycle of life.
>
> As an example of ceremony, the Washat service, the longhouse and the Seven Drums are all part of the traditional religion of the Columbia River tribes. Before tribal celebrations, commemorative or memorial services, Washat prayers are offered. Water is the most essential part of all longhouse rituals and has a deep symbolic significance for tribal people. One of the most important services is the First Food Feast. This ceremony must occur before hunting, fishing, root digging, or gathering can take place. Salmon are also used in naming and burial ceremonies.
>
> Designated subsistence fisheries provide food for a fisherman's family, and often for many other tribal members. All of the subsistence fisheries count against the yearly tribal allocation of fish.

(Provided by Stuart Ellis, NWIFC)

#### 3.2.1.1 Washington Coast and Puget Sound Tribes

##### Washington Coast-Ocean Fishery

Indian regulations have restricted ceremonial and subsistence harvest since 1983. Since 1989, treaty Indian troll regulations for the Quinault, Quileute, and Hoh tribes have restricted ceremonial and subsistence harvest to no more than two chinook over 24 inches per day per person with no limit on smaller fish. Since 1985, no more than eight fixed lines have been allowed per boat, with the additional restriction for the Makah tribe there be no more than four hand-held lines (PFMC, 1998).

##### Washington Coast-Inside Fisheries

There are ceremonial and subsistence fisheries in most drainages from the Grays Harbor system north. The Quinault Nation has ceremonial and subsistence fisheries in the Grays Harbor system and its tributaries as well as the Quinault and Queets River systems. The Hoh tribe has ceremonial and subsistence fisheries in the Hoh River system. The Quileute tribe has ceremonial and subsistence fisheries in the Quillayute River and its tributaries. The Makah tribe has ceremonial and subsistence fisheries in the Soooes River. These fisheries use primarily gill nets, but other gears can be used, as regulated by the tribe. These fisheries can occur at any time year round when harvestable fish are present. Tribes consider it desirable to have subsistence opportunity throughout the year. Catch limits on the fisheries are determined by the status of the individual run and are typically one or two fish per day of a certain size (Ellis, 1998).

##### Puget Sound

Regulations for the harvest of ceremonial and subsistence fish generally allow fishing year round. Under such regulations fishers are usually allowed to take one or two fish per day of a certain size. Harvest under these regulations tends to be more for substance purposes. Ceremonial salmon are generally taken in special fisheries that allow a certain number of salmon (e.g., 50) to be taken by a group for use in a particular ceremony (Ellis, 1998)

On the White River, the Muckleshoot have a traditional fish drive and ceremonial and subsistence hook-and-line fishing for spring chinook. There is a ceremonial and subsistence hook-and-line fishery for seniors to catch coho, chum, and steelhead.

#### 3.2.1.2 Columbia River Tribes

Treaty Indian fisheries on the Columbia River are managed under the Columbia River Fish Management Plan adopted by the federal district court as part of its continuing jurisdiction under U.S. v. Oregon. The tribes adopt regulations for their fisheries. The states of Oregon and Washington also adopt fishing regulations for the tribal fisheries as part of the co-management process. The Nez Perce tribe, the Confederated Tribes of the Umatilla Indian Reservation, the Confederated Tribes of the Warm Springs Reservation of Oregon, and the Confederated Tribes and Bands of the Yakima Indian Nation are the only tribes in the Columbia Basin to have adjudicated reserved rights to anadromous fish pursuant to 1,855 treaties with the United States. These are the tribes that are members of CRITFC. The Shoshone-Bannock tribe has asserted tribal fishing rights under a separate treaty. The Shoshone-Bannock Tribe harvests spring and summer chinook, on which the PFMC fisheries have little impact. The Coville and Spokane tribes have also asserted such rights, however, dams prevent salmon from returning to the usual and accustomed fishing areas for these tribes.

Subsistence fish are generally taken with dipnets, hoopnets, setnets, and hook-and-line gear from platforms primarily in the areas below the Dalles at Lone Pine and above Bonneville in the Cascade Locks area. Spears and gaffs are also used in specific tributary areas. Fish taken from platforms can be used personally or sold or traded to other Indians, but may not be sold or traded to non-Indians. The subsistence platform fishery is generally open year round, however the harvest is monitored and must remain within catch guidelines. Harvest controls of subsistence fisheries sometimes include restrictions on the amount of gear used. Ceremonial and some subsistence fish are taken under tribal permits using gill nets in the spring and fall (Lumley, 1998; WDFW/ODFW, 1997).

#### 3.2.1.3 Siletz Tribe

The Confederated Tribes of Siletz Indians have harvest rights agreed to in 1980 with the State of Oregon and the United States. These rights allow the harvest of 200 salmon for cultural fishery purposes only at sites on the Siletz River and its tributaries. Dipnets, spears, and gaffhooks are used in these fisheries at specific sites in October and November (Oregon, 1997).

#### 3.2.1.4 Klamath River Basin Tribes

The Hoopa and Yurok tribes have federally recognized fishery rights on the Klamath River Basin. Members of the Karuk tribe also fish salmon in the basin. The following excerpt reflects one tribal perspective on the importance of salmon to the tribes:

> The Native People of the Klamath River Basin have depended on the salmon of the River since time immemorial. The awesome cyclical nature of the salmon's yearly migrations over the centuries influenced almost every aspect of their lives. Religion, lore, law, and technology all evolved from the Indian's relationship with the salmon and other fish of the Basin. The Supreme Court recognized the importance of salmon to the Northwest Tribes such as these, when it concluded that access to the fisheries was "not much less necessary to the existence of the Indians than the air they breathed." (Pierce, 1998)

Hoopa Valley and Yurok tribal subsistence and ceremonial fisheries are prosecuted under the regulatory authority of each respective tribe. Each respective tribe determines the level of fishing opportunity that will be provided to its respective tribal members based on estimates of preseason abundance.

Traditional fishing methods for salmon fishing have included the use of gill nets, dipnets, triggernets, spears, and communal fish dams. Currently the primary gears used are gill nets, dipnets, and triggernets. Construction of temporary communal fishing dams was at one time used to ensure adequate subsistence for all tribal members (Pierce, 1998). Such dams are still used on occasion (Orcutt, 1998). Fishing sites were, and to some extent still are, considered privately owned (Pierce, 1998). Indian fishers in the Klamath River fish steelhead from November through the spring, spring chinook as early as late March and April and continuing to mid-July and early August, fall chinook from July through November, and coho beginning in mid-September and peaking in October (Orcutt, 1998).

### 3.2.2 Tribal Commercial Fisheries

Historically, the tribal commercial fish harvest was exchanged through barter and trade. In the modern tribal commercial fishery, fish are generally sold to processors. Puget Sound, Washington coastal, and Columbia River Indian commercial fishery harvest of chinook, coho, and pink salmon, as recorded on state fishtickets is reported in (Tables B-16 through B-21). The fishticket data on which these tables are based do not include Klamath River Indian commercial harvest or direct sales by Indian fishers to consumers. It has been reported that on the Columbia River there are fairly substantial sales of Indian salmon directly to consumers.

#### 3.2.2.1 Washington Coast-Ocean Troll Fishery

In the ocean fisheries along the Washington coast (Areas 2, 3, 3N, 4, and 4A), troll gear is used by the Quinault, Quileute, Hoh, and Makah tribes. In the ocean areas out to 200 miles, tribal regulations generally allow all-except-coho fisheries in May and June and all-salmon fisheries for portions of the summer, depending on stock abundance, since 1983. The duration of the summer all-salmon fisheries has varied from 12 days to 92 days with most years running between 20 days and 42 days. From 1977 through 1983, the seasons were open for all salmon from May through October.

In Area 4B, the Makah and S'Kallam tribes have troll fisheries. The Area 4B Indian troll fisheries are considered part of the ocean fisheries from May through October. The Area 4B fisheries generally ran for more than 300 days through 1990 and were open for all salmon species. Chinook-only openings became a regular feature of the fishery beginning in 1991 (May and June of each year). In the mid 1990s ocean fisheries were reduced due to stock status. The precice timing of fisheries is variable and is determined each year in responce to the status of various stocks. Beginning in 1995, chinook-only fishing regulations dominated the season with coho retention allowed only in August, September, and December. All Area 4B catch is counted as ocean catch in Tables B-16 through B-21.

### 3.2.2.2 Washington Coast-Inside Fisheries

In Grays Harbor, the Quinault Nation fishes primarily with gill nets on fall chinook and coho in late summer through early winter. Additionally, the Chehalis Tribe uses gill nets to take fall chinook that pass through its reservation.

On the Quinault and Queets Rivers, the Quinault Nation fishes primarily with gill nets on spring, summer, and fall chinook, chum, sockeye, and coho. The fisheries generally occur in spring through early winter.

The Hoh tribe on the Hoh River and the Quileute tribe on the Quillayute River take coho and spring, summer, and fall chinook in commercial gill net fisheries. These fisheries typically occur in spring through early winter.

The precise timing and harvest levels of these fisheries vary and are determined by the status of the stocks and through agreements with the State of Washington.

### 3.2.2.3 Puget Sound Area-Strait of Juan de Fuca

In Puget Sound, the Strait of Juan de Fuca, Hood Canal, and related terminal areas, the primary means of harvest by Indian fishers are drift gill net, marine setnet, stakenet, purse seine, troll, and beach seine. Gears typically vary by tribe and location. In the Strait of Juan de Fuca the primary species targeted are sockeye, coho, chum, chinook, and pink salmon. In the north Puget Sound, the primary species targeted are sockeye, chum, and pink salmon. In central Puget Sound, south Puget Sound, and the Hood Canal the primary target species are coho, chum, and chinook. The tribes fish in Puget Sound primarily from summer through late fall, but in the Strait of Juan de Fuca fisheries can extend through the winter months. In freshwater and terminal areas, fisheries can occur in any month year round when harvestable salmon are present. Timing and duration of fisheries change according to the status of impacted stocks. In some cases fisheries change according to inseason updates. Each tribe regulates its fisheries, including allowable gears and locations, individually within its usual and accustomed area. In many cases these areas partially overlap the usual and accustomed areas of other tribes, and a coordinated management approach is dictated. A detailed listing of agreed to treaty and non-treaty fisheries including dates, areas, and target species is published annually by the NWIFC and the WDFW.

### 3.2.2.4 Columbia River Tribal Fisheries

Prior to 1957, the primary Indian fishery occurring in Zone 6 (the area from above Bonneville Dam to McNary Dam) was the Indian platform-dipnet fishery located at Celilo Falls. This area was permanently inundated in 1957 by the Dalles Dam and fishing switched to other gears and areas regulated under tribal authority. The Columbia River Fish Management Plan establishes commercial fisheries in Zone 6 exclusively for the Indians. The treaty Indian commercial fishery is now conducted primarily with set gill nets in the main stem of the Columbia. In recent years, treaty Indian commercial seasons in Zone 6 above Bonneville Dam have opened in February and March, then again from mid-August through mid-October. The current tribal February-March fishery is primarily for sturgeon and steelhead (WDFW/ODFW, 1997). In the fall fishery, fall chinook and steelhead dominate the catch, however, the catch can include substantial numbers of sturgeon and coho. In recent years, the sale of sturgeon during fall commercial fisheries has been prohibited. Gill net mesh size regulations, time of the fishery, and zoning have been used to keep wild steelhead harvest rates down and to increase escapement of some runs (Columbia River Compact, 1998).

Falling processor/wholesale prices for commercially caught salmon have spurred efforts by Columbia River tribes to increase their direct sales to the public. These direct sales to the public are included in catch estimates, but not reported on the state fishtickets used to produce Tables B-16 through B-21. In the 1980s, over $2.00 per pound was received for bright fall chinook. In 1996, the wholesale price was only about $0.30 per pound. In 1996 about one-third of the commercial fall chinook harvest and one-half of the steelhead harvest went home with the tribal fishers or was sold to the general public. The estimated total value of sales to the general public is $330,000 (WDFW/ODFW, 1997). Part way through 1997, it was reported about half the Indian chinook caught were sold to the public at an average price of about $1.75 per pound. On this basis it was estimated that total sales would run about $1,375. If the 1996 price to buyers/processors had been received, the total sale value would have been only about $585,000 (CRITFC, 1998).

#### 3.2.2.5 Klamath River Basin Tribal Fisheries

Since the late 1980s, Yurok and Hoopa Valley tribal commercial fisheries have been prosecuted under the regulatory authority of each respective tribe. From 1934-1976, there were no Indian commercial or subsistence fisheries on the lower 20 miles of the Klamath River. In 1977, the Bureau of Indian Affairs (BIA) reopened the fishery for one year. It was then closed again until restablished in 1987 pursuant to the settlement of People v. McCovey. Members of the Hoopa Valley and Yurok tribes participated in commercial harvests of fall chinook in 1987, 1988, 1989, and 1996 (PFMC, 1998 and Pierce, 1998). The Hoopa Valley tribe also had some minor commercial fisheries in 1990 and 1991 (Orcutt, 1998). There have been some commercial test fisheries on spring chinook. Gill nets are the primary gears used in the commercial fisheries. There was no commercial Indian gill net fishery in the Klamath River in 1997. The 1996 Yurok harvest was 43,277 chinook. The value at first sale for the harvest is estimated at $525,000. The average weight of fish landed was 13.5 pounds. The 1989 Yurok harvest of 27,504 chinook had an average weight of 15.4 pounds and was sold for $852,000 (the equivalent of $1.1 million in 1997 dollars; PFMC, 1998).

## 3.3 All Citizens Commercial Fisheries

### 3.3.1 Ocean Troll Fishery

In the ocean fishery only salmon taken with commercial troll gear may be retained and sold. Salmon taken under special permits in the trawl whiting fishery may be retained for donation to charity, but may not be sold.

Season maps reveal increasing restrictions in the ocean troll fisheries (Tables B-22 through B-26). Some of the major changes in seasons in recent years as compared to the 1980s include the elimination of coho fishing south of Cape Falcon and increasing closures in the Klamath management zone (KMZ). Season maps for recent years also show increasing closures in the south of Cape Falcon fisheries close to the KMZ as compared to those further away. North of Cape Falcon, the change in season durations is not very apparent when season maps are compared, however, season length has decreased by close to 50%, comparing the last three years to 1981-1988.

The following discussion and accompanying tables refer to the non-Indian commercial troll fishery in PFMC management areas and associated state territorial ocean area waters.

#### 3.3.1.1 Trends in Aggregate Harvest Volume and Value

The total value of the ocean commercial salmon harvest is affected by trends in prices, number of salmon caught, and average weight of salmon caught. In general, the value of commercial harvest has been at depressed levels for most of the 1990s (Figure B-13 and Table B-27). Fishing opportunity in the ocean commercial salmon fisheries has declined resulting in decreased harvests, both in terms of total number of fish harvested and pounds of harvest (Figure B-14 and Tables B-16, B-18, and B-20). At the same time exvessel prices have been on a downward trend. Average weight per fish has varied (Table B-28). In the most recent five years (1993-1997) total exvessel value has averaged about $10.3 million, adjusted for inflation. This is 79% below the 1976-1992 average of $48.5 million and below the depressed values associated with the 1983-1984 *El Niño* years.

### 3.3.1.2 Geographic Distribution of Harvest

#### By State

The 1997 California commercial troll catch was 64% below its 1976-1996 average exvessel value, the 1997 value for the Oregon commercial troll catch was 81% below the 1976-1996 average, and the 1997 value for the Washington non-Indian ocean commercial troll catch was 98% below the 1976-1996 average (all values adjusted for inflation, Tables B-29, B-30, and B-31).

#### By Management Area and Community

In the 1990s, due to declining fisheries in the north, there has been southward shift in harvest concentration by area of harvest (Table B-27).

In 1997, about 75% of the coastwide chinook harvest (by weight) was landed in California, from the San Francisco area south, as compared to 59% in 1996 (Table B-32, B-33, and B-34). Landings in the San Francisco and Monterey areas increased substantially from 1996 levels while decreases were observed in Crescent City, Eureka, and Fort Bragg. In Oregon, chinook landings were down coastwide (by weight), with the bulk of the landings continuing to come into Newport. In Washington, there are generally some small landings of chinook from other areas of the coast every year. However, 1997 was the first year in which there was a chinook directed non-Indian commercial troll fishery of some significance since 1993. The amounts landed were substantially below the levels of previous chinook fisheries (nearly 80% below the 1993 landings). Coho have not been landed south of Cape Falcon in any significant quantities since 1992.

### 3.3.1.3 The Ocean Troll Fleet

#### Numbers of Participants

Coastwide, 1,286 vessels participated in the 1997 salmon troll fishery, down about 14% to from 1996 and about 75% below the average number of vessels participating from 1986-1990.[9/] The active fleet in Oregon decreased by 22 vessels (five percent), the active fleet in Washington decreased by 39 vessels (43%), and the active fleet in California decreased by 153 vessels (16%), all comparisons to 1996. Coastwide, the number of salmon limited entry permits issued decreased by 254 (six percent) to 3,678 permits. From 1995 to 1997, a federally funded permit buyback program purchased 262 Washington troll licenses and delivery permits. There had been 667 Washington non-Indian ocean troll permits issued in 1993, and 323 such permits were issued in 1997. Thirty-six percent of all permits made salmon landings in 1997 (Tables B-35).

#### Average Vessel Harvest and Concentration of Harvest

Average per vessel exvessel value increased 29% in 1997, as compared to 1996 (adjusted for inflation), to approximately $7,700. Per vessel average exvessel values increased in California and Washington, while decreasing in Oregon (Table B-35). The averages are generally at the higher end of the typical range seen over the last 15 years. However, caution needs to be exercised in interpreting the average. The averages may increase as much from small producers dropping out at a higher rate relative to larger producers as from an increase in revenue earned by remaining vessels.

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9/ Based on state fishtickets submitted to Pacific Fishery Information Network (PacFIN). The vessel counts listed in Table B-35 sum to more than 1,286 vessels, because of the double counting of vessels participating in more than one state.

### Geographic Distribution of Participants

In recent years the majority of the commercial salmon fleet participated in fisheries south of Point Arena, California. The other area in which harvesters concentrate is off the central Oregon coast (Cape Falcon to Cape Blanco). Restricted seasons have resulted in more dramatic declines in the numbers of vessels participating in other areas (Table B-36).

### Bycatch in the Salmon Troll Fishery

Salmon fishers may retain any species of fish caught on their gear, subject to the harvest limits governing those species, except steelhead and halibut. For halibut, regulations have been established to allow salmon trollers to choose between participation in a directed halibut fishery or taking halibut as bycatch in the ocean troll fishery. Retained bycatch rates for halibut taken in the troll fishery are subject to a ratio limit that specifies a number of salmon which must be harvested for every halibut taken as bycatch. For most other species, troll vessels do not typically have bycatch that exceed the landing limits for those species.

### 3.3.1.4 Other Ocean Fisheries Taking Salmon as Bycatch

Trawlers are the primary group encountering salmon as bycatch. Other groundfish and shrimp trawl gear types do not have substantial salmon bycatch (NMFS, 1992). In 1992, NMFS estimated that 6,000 to 9,000 chinook would be taken annually in the bottom trawl fishery and a comparable number in the midwater trawl fishery. Trawl vessels participating under special permits in the whiting fishery are allowed to land salmon bycatch, however, this bycatch may not be sold and is donated to food charities. These bycatch levels will have changed with declining groundfish harvests and declining salmon abundance. In the Eureka and Monterey areas, salmon bycatch in the whiting fishery declined from between about 3,000 and 6,000 fish from 1988 to 1991 to 100 or less in 1992 and 1993 (PFMC, 1994).

### 3.3.2 Inside Commercial Fisheries

Inside commercial fisheries occur in Puget Sound, the Washington Coast (Grays Harbor and Willapa Bay), and the Columbia River. Gill nets are used in Grays Harbor, Willapa Bay, and the Columbia River. In Puget Sound, gill nets and purse sein and reef nets are used in the non-Indian commercial fisheries. Total non-Indian salmon revenue from these fisheries is provided in Table B-27. Numbers of vessels participating in these fisheries is provided in Table B-36.

## 3.4 ALL CITIZEN FISHERIES RECREATIONAL FISHERIES

Season maps reveal increasing restrictions in the ocean recreational fisheries (Tables B-37 though B-41). In the recent period the seasons in northern areas have been reduced substantially more than in southern areas. For the north of Cape Falcon area, the 1984 and 1988 example years do not illustrate well the range of seasons observed during early and mid 1980s. The number of days in the 1984 and 1988 seasons are within the range and below the average for the 1993 through 1997 period, with the exception of Neah Bay. However, in the 1993 through 1997 recent period the average season durations have declined between one third and two thirds compared to 1981 through 1988.[10/]

### 3.4.1 Ocean

Ocean recreational anglers use poles and generally troll or mooch for salmon from vessels. Recreational salmon fishing takes place primarily in one of two modes, (1) anglers fishing from privately owned pleasure crafts and (2) anglers employing the services of the charter boat fleet. In general, success rates on charter

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[10/] Off Neah Bay, Area 4B is considered part of the ocean area when ocean fisheries are open, but is managed under separate state regulations when the ocean fishery is closed. State managed seasons provided to Area 4B are not reflected in this discussion.

vessels tend to be higher than success rates on private vessels. In marine areas, there are small amounts of shore based effort directed toward salmon, primarily fishing occurring off jetties and piers.

### 3.4.1.1 Harvest and Effort

In general, the recreational fishery has tended to have a more stable harvest than the troll fishery (in both absolute and relative terms); the majority of the annual variation in available ocean harvest is usually taken up in the troll fishery (Figures B-14 and B-15). However, like the troll fishery, the recreational fishery has suffered substantial declines in recent years, the effects of which are amplified when specific geographic areas are considered.

From 1979 through 1990, total angler effort on the West Coast ranged from about 500,000 to 750,000 trips. After a decline from 1990 to 1992, total angler effort appears to have leveled off with effort in four out of the last six years of between about 300,000 and 400,000 trips.

Number of West Coast charter and private vessel recreational angler trips (thousands).

| | ‘81-85 | ‘86-‘90 | ‘79 | ‘80 | ‘81 | ‘82 | ‘83 | ‘84 | ‘85 | ‘86’ | ‘87 | ‘88 | ‘89 | ‘90 | ‘91 | ‘92 | ‘93 | ‘94 | ‘95 | ‘96 | ‘97 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Chart | 217 | 206 | 373 | 342 | 289 | 255 | 222 | 116 | 201 | 188 | 220 | 197 | 227 | 199 | 153 | 116 | 120 | 74 | 175 | 106 | 119 |
| Priv | 336 | 389 | 363 | 384 | 381 | 361 | 340 | 241 | 355 | 304 | 406 | 366 | 409 | 459 | 347 | 272 | 245 | 143 | 287 | 203 | 173 |
| TOT | 552 | 595 | 736 | 726 | 670 | 616 | 562 | 357 | 556 | 492 | 625 | 563 | 636 | 658 | 500 | 388 | 364 | 217 | 462 | 308 | 292 |

From 1983-1996 the proportion of trips taken on charter vessels varied between 30% and 40%. In 1997 and prior to 1983, more than 40% of the trips were taken on charter vessels.

### 3.4.1.2 Geographic Distribution

Effort in California has remained relatively high compared to historic levels while season restrictions have caused declines in effort in Oregon and Washington (Figure B-16). The areas of the coast experiencing the greatest reduction are north of Cape Falcon and the KMZ. The reduction in seasons on the central Oregon coast has not been as severe as in the areas directly to the north and south, however, the prohibition of coho retention has significantly reduced angler retained catch rates.

The proportion of trips taken on charter vessels has declined in Washington and Oregon, while remaining relatively stable in California (Figure B-16).

### 3.4.1.3 The Charter Vessel Fleet

The historic charter vessel counts available for each state are different in terms of what is counted. The count for Washington is a count of charter vessels licensed for salmon (including vessels that operate in Puget Sound), the count for Oregon is a count of all ocean recreational charter vessel regardless of whether or not they target on salmon in a particular year, the count for California is a count of only those vessels that are licensed and participate in the ocean salmon fishery each year (Table B-43).

An attempt was made to characterize the recent charter fleet by area based on information obtained from state sampling programs and the California commercial passenger fishing vessel (CPFV) logbooks. The information provided for each state is for a different recent period.

In central and northern California, 92 charter vessels fished for salmon, rockfish/lingcod, nearshore species, and offshore species in the 1995-1997 period. Tables B-44 and B-45 show the various targeting strategies of charter vessels by region. Over 85% of the charter vessels in central and northern California target on salmon. In central California, 50% of the trips targeted on salmon and in northern California, 40% of the trips targeted on salmon.

In Oregon, 83 charter vessels operated in 1998. Table B-46 shows the various targeting strategies of charter vessels. Vessels which land salmon predominate the charter vessel fleet in Astoria and Newport.

Those with a strategy that includes bottomfish predominate in Garibaldi and Depoe Bay. Brookings vessels combine salmon and bottom fish while Gold Beach vessels target only on salmon.

In Washington, a total of 70 charter vessels operated in 1995-1996 out of 3 major ports: Ilwaco, Neah Bay, and Westport. The most common fishing strategy is fishing for a combination of salmon, bottomfish, halibut, and tuna. Table B-47 shows the different strategies by charter vessels by port.

### 3.4.2 Inside

The same stocks caught in the ocean are also subject to recreational harvest in inside marine and freshwater salmon fisheries. These fisheries occur in estuaries and rivers along the coast and Puget Sound as well as major river basins such as the Columbia, Klamath, and Sacramento River Basins. In addition to the West Coast states, some freshwater salmon fishing occurs in Idaho. Two of the larger inside marine recreational fisheries for salmon are those in Puget Sound and the Columbia River estuary (Table B-48).

# 4.0 PROCESSORS/BUYERS

A relatively small number of large processor/buyer firms handle most of the ocean salmon catch on the West Coast. There were 1,927 firms with state processor/buyer licenses for the period of this descriptive analysis (1995-1997).[11/] These firms include both operators of processing plants and buyers that may do little more than hold the fish prior to their shipment to a processor or market. In some cases, the buyers may be owners of vessels who also own licenses allowing them to sell fish directly to the public or retail markets. Of these processor/buyers (here after referred to as "buyers"), 442 received salmon from the West Coast Indian and non-Indian ocean troll fisheries (including vessels that acted as "buyers," receiving the fish from themselves, Table B-49). The top 24 state licensed buyer firms each received over $3,000,000 worth of fish (exvessel value) from West Coast fisheries. These 24 firms handled 50% of the exvessel value of all West Coast fishery landings and 50% of the exvessel value of all landings of ocean caught salmon. Top ocean caught salmon buying firms include some firms that are not among the top fish buyers when all species are counted. The top 5% of the salmon buying firms (top 22 firms) buy 73% of all ocean caught salmon in terms of exvessel value. The bottom 80% of these firms buy 6.4% of all ocean caught salmon (Table B-50). Larger processing firms are more likely to handle ocean caught salmon than smaller firms. Of the top 24 fish buyers (all species) 80% handled salmon (19 of 24). The proportion of smaller buyers handling salmon was substantially less, about 20% for buyers purchasing less than $500,000 of product (Table B-51).

There are many small buyers that specialize in salmon, only handle small amounts of product, and receive product from two or fewer vessels. Ocean caught salmon comprised more than 95% of all purchases for about 25% of all salmon buyers. The vast majority of those expending more than 95% of their fish purchases on salmon are small operations handling less than $10,000 exvessel value (Table B-49). It is likely that most of these buyers are vessels that also have licenses allowing them to sell directly to the public or other retail outlets (e.g., restaurants). Sixty-three percent of all buyers of ocean caught salmon received deliveries from an average of two or fewer vessels and handled 4.1% of the exvessel value of the ocean catch (Table B-52). Four percent of all such buyers received deliveries from over 64 vessels and handled 65% of the exvessel value of all ocean caught salmon.

Most larger salmon buying firms acquire fish from sites in more than one port (Table B-53). The largest salmon buyers tend buy salmon from over 64 vessels landing and buy fish in 4-8 ports. Of the 199 processors that bought fish in only one port, 174 received salmon from only one or two vessels (Table B-54). Instances where a buyer purchases from one to two vessels, but buys fish at over eight ports, are explained as either large firms with buying stations in multiple ports that acquire only a few salmon at one or two of their locations, or as vessels with buyer licenses that take fish to different ports to sell.

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11/ This estimate was developed using cross ownership of processing plant information from Radtke and Davis (1997) and an exact match of names from processor/buyer license files containing 15,611 records (individual person names were excluded from the match). Ownership of processing plants changes frequently, therefore, analysis based on ownership information collected at a point in time may not be applicable over a longer period of time. The results presented here should be considered an approximation for the period of the descriptive analysis (1995-1997). Exact name matches will tend to miss matches between licenses held by the same firm when the firm's name differs between the license records due to typographical errors or data entry choices (e.g., entering "&" or "and"). It is also likely that Radtke and Davis (1997) did not detect all instances of cross ownership between firms with different names. For these reasons, the actual number of processors/buyers is likely to be lower, and the concentration of processing/buying activities greater than represented in this analysis.

# 5.0 WEST COAST HATCHERIES AND SALMON AQUACULTURE

## 5.1 HATCHERIES

Hatchery production plays a significant role in West Coast salmon management. Fish are released from hatcheries to rear in the ocean and return to be harvested by recreational and commercial fishers. Many of the hatchery programs were created to mitigate for lost production due to the construction of dams. The mass marking of hatchery salmon to allow harvesters to retain hatchery salmon and release wild salmon is one of the most recent developments in salmon management and one of the subjects of Amendment 14 to the salmon FMP.

## 5.2 RANCHING

Salmon ranching is an acquaculture practice similar to that of hatcheries except that fish are harvested when they return to the hatcheries rather than in fisheries. Salmon ranching has not proven to be an economically successful way of producing salmon.

## 5.3 PENS

Salmon pens are used to produce fish directly for food markets, for enhancement of fisheries, and for preservation of genetic material for endangered species. Pen culture depends on hatcheries for rearing stock. Salmon reared in pens are never released to the wild. In Puget Sound about six million pounds a year of Atlantic salmon have been produced for direct marketing for the last three or four years. Salmon are raised in pens to enhance commercial fisheries in Willapa Bay and at two locations in the Columbia River estuary. Pen operations to preserve the genetic material of endangered species are occurring in south Puget Sound (for White River spring chinook).

# 6.0 COMMUNITIES

Communities are affected by most aspects of salmon harvest and management. Fishers, processors, association employees, fishery managers, fishery data collectors, and hatchery workers live and spend money in communities which, because of the presence of these individuals, are in one manner or another and to varying degrees, dependent on the salmon fishery. Most general economic data available on ports is county level data. Table B-55 lists ports in which salmon were landed from 1995-1997 and the corresponding county.

## 6.1 LOCAL LEVEL COMMERCIAL AND RECREATIONAL FISHERY DATA

Information on commercial harvest by port area is provided in Tables B-32 through B-34. Numbers of vessels landing salmon and total number of vessels landing by county are provided in Table B-56. Recreational effort levels for charter and private vessel salmon trips is provided by port area in Tables B-57 through B-59. Charter vessel counts by port area (geographic region for California) are provided in Tables B-43 through B-47.

## 6.2 INCOME IMPACTS

Coastal community impacts are presented in order to address concerns about the effects of regulations on local economies and small businesses. Income impact estimates per commercial pound and per recreational day were generated using the Fishery Economic Assessment Model. Reference information on the model is available from PFMC.

### 6.2.1 Interpretation of State and Coastal Community Income Impacts

Estimated state and community income impacts of commercial and recreational ocean salmon fisheries and selected state-managed fisheries are shown in Tables B-60 through B-62. The impacts presented are estimates of total personal income associated with activity in the commercial and recreational salmon fisheries in counties and states. Income impact estimates are based on the landings in the area, an inventory of the fleet and processors, estimates of fleet and processor expenditures, surveys of the expenditure patterns of recreational fishers, and income coefficients from the U.S. Forest Service IMPLAN model. Commercial ocean harvest not landed in the coastal areas (e.g., landed in Puget Sound ports) is not included in the estimates of coastal community impacts, but is included in the estimate of state impacts.

The numbers presented here are estimates of annual trends and the possible redirection of money between nonfishing-dependent and fishing-dependent sectors; they are likely an upper bounds on the local community and state income impacts which may have been generated by West Coast ocean salmon fisheries as well as some selected inside fisheries. All income impact estimates in this review are reported in real (inflation adjusted) 1997 dollars.

### 6.2.2 West Coast Ocean Fishery Income Impacts

From 1976-1996 the total state level income impact associated with the recreational and troll ocean fisheries for all three states combined averaged $138.1 million (adjusted for inflation). In 1997 state level impacts were $50.5 million, up five percent compared to 1996, but still 63% below the 1976-1996 average (adjusted for inflation). State level income impacts related to the commercial troll fishery were up nine percent compared to 1996, but were still 73% below the 1976-1996 average; and those impacts related to the recreational fishery were up one percent, but were 45% below the 1976-1996 average (all comparisons are adjusted for inflation). These coastwide values, while low compared to historic averages, do not reveal the greater reductions which have occurred in particular communities such as those in the KMZ (Eureka, Crescent City, and Brookings) and north of Cape Falcon (Astoria, Ilwaco, Westport, La Push, and Neah Bay).

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TABLE B-1. Price index[a] and Canadian to U.S. dollar exchange rate.

| Year | Price Index | $Candian: $U.S.[b] |
|---|---|---|
| 1960 | 20.7 | |
| 1961 | 20.9 | |
| 1962 | 21.2 | |
| 1963 | 21.5 | |
| 1964 | 21.8 | |
| 1965 | 22.2 | |
| 1966 | 22.8 | |
| 1967 | 23.6 | |
| 1968 | 24.6 | |
| 1969 | 25.7 | |
| 1970 | 27.1 | |
| 1971 | 28.5 | |
| 1972 | 29.7 | |
| 1973 | 31.4 | |
| 1974 | 34.2 | |
| 1975 | 37.4 | |
| 1976 | 39.6 | |
| 1977 | 42.2 | |
| 1978 | 45.3 | |
| 1979 | 49.1 | |
| 1980 | 53.7 | |
| 1981 | 58.7 | 1.19 |
| 1982 | 62.4 | 1.23 |
| 1983 | 65.1 | 1.24 |
| 1984 | 67.5 | 1.32 |
| 1985 | 69.9 | 1.40 |
| 1986 | 71.7 | 1.39 |
| 1987 | 73.9 | 1.33 |
| 1988 | 76.6 | 1.23 |
| 1989 | 79.8 | 1.18 |
| 1990 | 83.3 | 1.17 |
| 1991 | 86.6 | 1.15 |
| 1992 | 89.0 | 1.21 |
| 1993 | 91.3 | 1.29 |
| 1994 | 93.5 | 1.35 |
| 1995 | 95.9 | 1.37 |
| 1996 | 98.1 | 1.36 |
| 1997 | 100.0 | 1.38 |

a/ Based on gross domestic product implicit price deflator.

b/ Rates for 1981 through 1984 from *World Currency Yearbook* published by International Currency Analysis, rates for 1986 through 1997 from U.S. Bank, July 6, 1998.

TABLE B-2. North American commercial **chinook** salmon landings (pounds and value) by major harvest area, 1981-1997.

| Year | Puget Sound | Inside Washington Coast | Columbia River | West Coast Ocean | U.S. West Coast Total[a/] | Alaska[b/c/] | U.S. Total | Canada[d/] | North America Total |
|---|---|---|---|---|---|---|---|---|---|
| **Thousands of Round Pounds** | | | | | | | | | |
| 1981 | 3,016 | 759 | 1,748 | 9,600 | 15,124 | 15,738 | 30,862 | N/A | 30,862 |
| 1982 | 2,988 | 722 | 3,051 | 13,143 | 19,905 | 16,904 | 36,809 | N/A | 36,809 |
| 1983 | 2,235 | 324 | 1,049 | 4,045 | 7,654 | 15,684 | 23,338 | 10,440 | 33,778 |
| 1984 | 2,731 | 353 | 2,069 | 3,859 | 9,012 | 12,524 | 21,536 | 12,120 | 33,656 |
| 1985 | 3,315 | 543 | 2,661 | 8,127 | 14,647 | 13,477 | 28,124 | 10,670 | 38,794 |
| 1986 | 2,916 | 664 | 4,764 | 13,012 | 21,356 | 11,712 | 33,068 | 9,750 | 42,818 |
| 1987 | 2,639 | 1,250 | 9,087 | 17,348 | 30,325 | 13,282 | 43,607 | 10,040 | 53,647 |
| 1988 | 2,392 | 1,610 | 10,617 | 23,022 | 37,642 | 10,913 | 48,555 | 11,330 | 59,885 |
| 1989 | 2,555 | 2,006 | 6,363 | 11,428 | 22,351 | 11,314 | 33,666 | 10,230 | 43,896 |
| 1990 | 2,896 | 1,365 | 3,291 | 8,043 | 15,596 | 11,482 | 27,078 | 10,120 | 37,198 |
| 1991 | 1,571 | 1,146 | 2,169 | 5,126 | 10,013 | 10,728 | 20,741 | 9,890 | 30,631 |
| 1992 | 1,160 | 1,290 | 1,108 | 3,873 | 7,431 | 10,763 | 18,194 | 10,220 | 28,414 |
| 1993 | 926 | 1,087 | 896 | 4,453 | 7,362 | 11,070 | 18,432 | 9,300 | 27,732 |
| 1994 | 1,127 | 912 | 766 | 3,970 | 6,775 | 11,790 | 18,565 | 6,880 | 25,445 |
| 1995 | 890 | 932 | 613 | 9,989 | 12,424 | 12,862 | 25,286 | 2,910 | 28,196 |
| 1996 | 903 | 1,074 | 1,030 | 7,064 | 10,071 | 9,350 | 19,421 | 990 | 20,411 |
| 1997 | 1,077 | 613 | 958 | 8,027 | 10,675 | 11,580 | 22,255 | N/A | N/A |
| **Nominal Exvessel Value (Thousands of U.S. Dollars)** | | | | | | | | | |
| 1981 | 5,124 | 1,156 | 1,853 | 21,626 | 29,759 | 23,700 | 53,459 | N/A | 53,459 |
| 1982 | 4,898 | 867 | 2,731 | 29,550 | 38,046 | 27,000 | 65,046 | N/A | 65,046 |
| 1983 | 2,474 | 397 | 1,167 | 7,092 | 11,130 | 18,200 | 29,330 | 8,392 | 37,722 |
| 1984 | 4,741 | 518 | 2,767 | 9,320 | 17,347 | 21,800 | 39,147 | 9,175 | 48,322 |
| 1985 | 4,306 | 453 | 2,871 | 17,931 | 25,561 | 20,800 | 46,361 | 7,638 | 53,999 |
| 1986 | 3,466 | 494 | 4,203 | 22,113 | 30,276 | 17,800 | 48,076 | 14,151 | 62,227 |
| 1987 | 4,309 | 1,877 | 13,449 | 41,123 | 60,758 | 26,800 | 87,558 | 23,029 | 110,587 |
| 1988 | 5,324 | 2,885 | 20,621 | 58,894 | 87,724 | 29,600 | 117,324 | 35,595 | 152,920 |
| 1989 | 2,655 | 1,670 | 5,392 | 23,085 | 32,801 | 20,848 | 53,650 | 17,034 | 70,684 |
| 1990 | 3,724 | 1,655 | 4,788 | 18,802 | 28,969 | 21,526 | 50,495 | 17,557 | 68,051 |
| 1991 | 1,732 | 1,376 | 2,525 | 11,323 | 16,957 | 22,167 | 39,124 | 17,145 | 56,269 |
| 1992 | 1,418 | 1,651 | 1,379 | 8,580 | 13,028 | 24,579 | 37,607 | 20,238 | 57,845 |
| 1993 | 914 | 1,082 | 724 | 8,543 | 11,262 | 18,037 | 29,299 | 11,314 | 40,614 |
| 1994 | 1,270 | 1,161 | 663 | 7,257 | 10,352 | 15,800 | 26,152 | 9,660 | 35,811 |
| 1995 | 777 | 851 | 231 | 15,158 | 17,017 | 18,021 | 35,038 | 3,753 | 38,791 |
| 1996 | 756 | 906 | 355 | 9,094 | 11,111 | 13,350 | 24,461 | 895 | 25,356 |
| 1997 | 944 | 589 | 476 | 9,991 | 12,001 | 17,990 | 29,991 | N/A | N/A |

a/ All West Coast data are derived from PacFIN vessel summary files.

b/ Alaska values for 1996 and 1997 are preliminary.

c/ Historic data are from the Salmon Market Information Service (1994), and preliminary data are from the Alaska Department of Fish and Game Blue Sheet.

d/ Canadian data from Canadian Department of Fisheries and Oceans web page.

TABLE B-3. North American commercial **coho** salmon landings (pounds and value) by major harvest area, 1981-1997.

| Year | Puget Sound | Inside Washington Coast | Columbia River | West Coast Ocean | U.S. West Coast Total[a/] | Alaska[b/c/] | U.S. Total | Canada[d/] | North America Total |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | **Thousands of Round Pounds** | | | | |
| 1981 | 4,267 | 765 | 477 | 6,407 | 11,916 | 25,847 | 37,763 | N/A | N/A |
| 1982 | 7,621 | 1,399 | 1,604 | 6,142 | 16,766 | 46,541 | 63,307 | N/A | N/A |
| 1983 | 5,059 | 286 | 48 | 1,907 | 7,300 | 26,793 | 34,093 | 20,230 | 54,323 |
| 1984 | 4,062 | 851 | 1,619 | 879 | 7,411 | 44,515 | 51,926 | 19,360 | 71,286 |
| 1985 | 7,524 | 648 | 1,674 | 1,956 | 11,802 | 47,263 | 59,065 | 17,570 | 76,635 |
| 1986 | 7,848 | 1,838 | 6,927 | 3,195 | 19,808 | 46,603 | 66,411 | 25,720 | 92,131 |
| 1987 | 9,976 | 1,592 | 1,314 | 3,181 | 16,064 | 25,312 | 41,376 | 16,220 | 57,596 |
| 1988 | 6,582 | 869 | 2,721 | 4,555 | 14,728 | 35,455 | 50,183 | 13,570 | 63,753 |
| 1989 | 5,602 | 938 | 2,710 | 3,347 | 12,597 | 33,177 | 45,774 | 16,980 | 62,754 |
| 1990 | 6,320 | 1,091 | 512 | 2,262 | 10,184 | 40,022 | 50,206 | 20,330 | 70,536 |
| 1991 | 3,277 | 2,319 | 2,752 | 2,899 | 11,246 | 43,827 | 55,073 | 19,250 | 74,323 |
| 1992 | 1,918 | 379 | 305 | 640 | 3,242 | 53,759 | 57,002 | 14,040 | 71,042 |
| 1993 | 763 | 491 | 275 | 404 | 1,932 | 36,620 | 38,553 | 8,300 | 46,853 |
| 1994 | 2,414 | 315 | 520 | 0 | 3,249 | 75,241 | 78,490 | 14,910 | 93,400 |
| 1995 | 1,582 | 1,020 | 200 | 296 | 3,097 | 47,239 | 50,336 | 9,260 | 59,596 |
| 1996 | 772 | 1,533 | 235 | 189 | 2,729 | 46,420 | 49,149 | 7,380 | 56,529 |
| 1997 | 630 | 115 | 162 | 65 | 972 | 22,830 | 23,802 | N/A | N/A |
| | | | | | **Nominal Exvessel Value (Thousands of U.S. Dollars)** | | | | |
| 1981 | 4,930 | 862 | 525 | 8,996 | 15,313 | 23,700 | 39,013 | N/A | N/A |
| 1982 | 6,421 | 1,097 | 1,379 | 7,492 | 16,390 | 40,000 | 56,390 | N/A | N/A |
| 1983 | 4,413 | 308 | 51 | 1,680 | 6,451 | 16,200 | 22,651 | 16,262 | 38,913 |
| 1984 | 4,095 | 1,017 | 1,871 | 1,308 | 8,291 | 42,700 | 50,991 | 14,656 | 65,647 |
| 1985 | 6,621 | 456 | 1,392 | 2,310 | 10,780 | 42,600 | 53,380 | 12,577 | 65,957 |
| 1986 | 8,394 | 1,809 | 6,870 | 2,979 | 20,052 | 42,000 | 62,052 | 28,259 | 90,311 |
| 1987 | 18,614 | 3,059 | 2,501 | 4,803 | 28,976 | 28,800 | 57,776 | 25,458 | 83,234 |
| 1988 | 14,997 | 1,770 | 5,974 | 9,088 | 31,828 | 61,800 | 93,628 | 30,630 | 124,258 |
| 1989 | 5,719 | 972 | 2,409 | 3,367 | 12,466 | 27,091 | 39,558 | 16,341 | 55,899 |
| 1990 | 8,180 | 1,438 | 612 | 3,128 | 13,357 | 40,413 | 53,769 | 24,063 | 77,833 |
| 1991 | 2,846 | 1,850 | 2,194 | 2,790 | 9,679 | 34,527 | 44,207 | 22,060 | 66,267 |
| 1992 | 1,922 | 335 | 275 | 688 | 3,220 | 49,350 | 52,570 | 17,060 | 69,630 |
| 1993 | 620 | 419 | 223 | 376 | 1,638 | 32,454 | 34,092 | 8,461 | 42,552 |
| 1994 | 1,776 | 267 | 423 | 0 | 2,466 | 66,252 | 68,718 | 15,677 | 84,395 |
| 1995 | 964 | 610 | 123 | 215 | 1,912 | 29,519 | 31,431 | 9,269 | 40,700 |
| 1996 | 398 | 897 | 144 | 148 | 1,586 | N/A | N/A | 7,042 | 8,628 |
| 1997 | 394 | 89 | 118 | 56 | 658 | N/A | N/A | N/A | N/A |

a/ All West Coast data are derived from PacFIN vessel summary files.

b/ Alaska values for 1996 and 1997 are preliminary.

c/ Historic data are from the Salmon Market Information Service (1994), and preliminary data are from the Alaska Department of Fish and Game Blue Sheet.

d/ Canadian data from Canadian Department of Fisheries and Oceans web page.

TABLE B-4. North American commercial **pink** salmon landings (pounds and value) by major harvest area, 1981-1997.

| Year | Puget Sound | Inside Washington Coast | Columbia River | West Coast Ocean | U.S. West Coast Total[a/] | Alaska[b/c/] | U.S. Total | Canada[d/] | North America Total |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | **Thousands of Round Pounds** | | | | |
| 1981 | 18,834 | 0 | 0 | 1,481 | 20,314 | 244,970 | 265,285 | N/A | N/A |
| 1982 | 0 | 0 | 0 | 0 | 1 | 219,149 | 219,150 | N/A | N/A |
| 1983 | 7,958 | 0 | 0 | 448 | 8,407 | 194,083 | 202,489 | 85,370 | 287,859 |
| 1984 | 0 | 0 | 0 | 0 | 0 | 276,684 | 276,684 | 25,780 | 302,464 |
| 1985 | 21,437 | 0 | 0 | 968 | 22,405 | 304,261 | 326,666 | 80,570 | 407,236 |
| 1986 | 0 | 0 | 0 | 0 | 1 | 259,257 | 259,258 | 64,520 | 323,778 |
| 1987 | 9,518 | 0 | 0 | 198 | 9,716 | 164,813 | 174,529 | 57,020 | 231,549 |
| 1988 | 0 | 0 | 0 | 0 | 1 | 177,904 | 177,904 | 69,370 | 247,274 |
| 1989 | 14,962 | 0 | 0 | 247 | 15,208 | 331,469 | 346,677 | 65,240 | 411,917 |
| 1990 | 1 | 0 | 0 | 0 | 2 | 271,909 | 271,911 | 56,470 | 328,381 |
| 1991 | 13,313 | 0 | 0 | 198 | 13,512 | 338,845 | 352,357 | 75,240 | 427,597 |
| 1992 | 1 | 0 | 0 | 0 | 1 | 203,402 | 203,402 | 32,110 | 235,512 |
| 1993 | 8,150 | 0 | 0 | 23 | 8,173 | 335,233 | 343,406 | 33,790 | 377,196 |
| 1994 | 1 | 0 | 0 | 0 | 1 | 364,683 | 364,684 | 7,220 | 371,904 |
| 1995 | 10,009 | 0 | 0 | 169 | 10,179 | 431,701 | 441,880 | 41,510 | 483,390 |
| 1996 | 0 | 0 | 0 | 0 | 1 | 325,160 | 325,161 | 18,080 | 343,240 |
| 1997 | 7,057 | 0 | 0 | 7 | 7,064 | 271,530 | 285,658 | N/A | N/A |
| | | | | | **Nominal Exvessel Value (Thousands of U.S. Dollars)** | | | | |
| 1981 | 8,779 | 0 | 0 | 973 | 9,753 | 106,000 | 115,753 | N/A | N/A |
| 1982 | 0 | 0 | 0 | 0 | 0 | 47,500 | 47,500 | N/A | N/A |
| 1983 | 2,725 | 0 | 0 | 204 | 2,930 | 48,000 | 50,930 | 68,625 | 119,555 |
| 1984 | 0 | 0 | 0 | 0 | 0 | 70,500 | 70,500 | 19,516 | 90,016 |
| 1985 | 5,508 | 0 | 0 | 508 | 6,016 | 71,900 | 77,916 | 57,674 | 135,590 |
| 1986 | 0 | 0 | 0 | 0 | 0 | 62,000 | 62,000 | 18,491 | 80,492 |
| 1987 | 4,705 | 0 | 0 | 119 | 4,824 | 69,100 | 73,924 | 25,255 | 99,179 |
| 1988 | 0 | 0 | 0 | 0 | 0 | 141,300 | 141,300 | 40,065 | 181,365 |
| 1989 | 5,947 | 0 | 0 | 145 | 6,092 | 144,599 | 150,691 | 28,289 | 178,980 |
| 1990 | 0 | 0 | 0 | 0 | 1 | 90,807 | 90,808 | 23,129 | 113,937 |
| 1991 | 2,683 | 0 | 0 | 80 | 2,763 | 49,413 | 52,177 | 26,163 | 78,340 |
| 1992 | 0 | 0 | 0 | 0 | 0 | 41,658 | 41,658 | 8,948 | 50,606 |
| 1993 | 1,310 | 0 | 0 | 9 | 1,319 | 54,301 | 55,620 | 8,949 | 64,570 |
| 1994 | 0 | 0 | 0 | 0 | 0 | 70,281 | 70,281 | 1,776 | 72,058 |
| 1995 | 1,718 | 0 | 0 | 39 | 1,757 | 80,031 | 81,788 | 10,005 | 91,793 |
| 1996 | 0 | 0 | 0 | 0 | 0 | 31,620 | 31,620 | 3,624 | 35,244 |
| 1997 | 1,291 | 0 | 0 | 2 | 1,293 | 36,630 | 37,923 | N/A | N/A |

a/ All West Coast data are derived from PacFIN vessel summary files.

b/ Alaska values for 1996 and 1997 are preliminary.

c/ Historic data are from the Salmon Market Information Service (1994), and preliminary data are from the Alaska Department of Fish and Game Blue Sheet.

d/ Canadian data from Canadian Department of Fisheries and Oceans web page.

TABLE B-5. U.S. salmon trade, proportions fresh and frozen and export/import balance.

| | 1993 | 1994 | 1995 | 1996 | 1997 |
|---|---|---|---|---|---|
| **Imports** | | | | | |
| Fresh and Frozen | $249,467,463 | $260,258,209 | $339,042,725 | $392,503,642 | $503,549,473 |
| All Salmon Products | $266,310,980 | $277,911,756 | $359,084,988 | $411,813,956 | $522,279,670 |
| Percent Fresh and Frozen | 94% | 94% | 94% | 95% | 96% |
| **Exports** | | | | | |
| Fresh and Frozen | $583,059,930 | $518,482,529 | $545,283,012 | $462,981,812 | $300,021,421 |
| All Salmon Products | $867,664,718 | $797,693,669 | $850,162,050 | $715,003,751 | $499,693,017 |
| Percent Fresh and Frozen | 67% | 65% | 64% | 65% | 60% |
| **Exports/Imports Ratio** | | | | | |
| Fresh and Frozen | 2.34 | 1.99 | 1.61 | 1.18 | 0.60 |
| All Salmon Products | 3.26 | 2.87 | 2.37 | 1.74 | 0.96 |

TABLE B-6. Value of imported salmon from top 15 countries (U.S., millions).

| | 1993 | 1994 | 1995 | 1996 | 1997 | Average | Cumulative Percent[a/] |
|---|---|---|---|---|---|---|---|
| Canada | 162.7 | 182.9 | 206.2 | 204.6 | 274.2 | 206.1 | 56.1% |
| Chile | 65.7 | 57.4 | 111.3 | 161.6 | 192.9 | 117.8 | 88.1% |
| Norway | 17.8 | 18.6 | 22.8 | 17.6 | 17.5 | 18.9 | 93.3% |
| United Kingdom | 4.5 | 7.5 | 9.5 | 13.5 | 13.5 | 9.7 | 95.9% |
| Iceland | 4.8 | 4.6 | 2.9 | 5.8 | 5.0 | 4.6 | 97.2% |
| Denmark | 2.8 | 2.7 | 2.7 | 1.1 | 2.8 | 2.4 | 97.8% |
| Faroe Is. | 4.1 | 1.1 | 0.1 | 1.6 | 3.7 | 2.1 | 98.4% |
| Japan | 0.6 | 0.1 | 0.2 | 0.1 | 7.0 | 1.6 | 98.8% |
| Russia | 0.7 | 0.5 | 0.5 | 2.1 | 0.5 | 0.9 | 99.1% |
| New Zealand | 0.1 | 0.4 | 0.7 | 0.8 | 0.4 | 0.5 | 99.2% |
| Ireland | 1.0 | 0.3 | 0.2 | 0.2 | 0.2 | 0.4 | 99.3% |
| Australia | 0.6 | 0.6 | 0.2 | 0.1 | 0.0 | 0.3 | 99.4% |
| China | 0.0 | 0.1 | 0.1 | 0.2 | 0.9 | 0.3 | 99.5% |
| Netherlands | 0.0 | 0.1 | 0.1 | 0.4 | 0.4 | 0.2 | 99.5% |
| Sweden | 0.2 | 0.2 | 0.2 | 0.3 | 0.0 | 0.2 | 99.6% |
| Ecuador | 0.1 | 0.0 | 0.0 | 0.0 | 0.8 | 0.2 | 99.6% |
| Total (all countries) | 266.3 | 277.9 | 359.1 | 411.8 | 522.3 | 367.5 | 100% |

a/ Cumulative percent based on 1993-1997 average.

TABLE B-7. Value of salmon exported to top 25 recipients of U.S. salmon ($U.S. millions).

| | 1993 | 1994 | 1995 | 1996 | 1997 | Average | Cumulative Percent[a] |
|---|---|---|---|---|---|---|---|
| Japan | 604.2 | 543.1 | 543.1 | 437.5 | 265.1 | 478.6 | 64.2% |
| Canada | 81.8 | 83.2 | 122.0 | 113.2 | 77.9 | 95.6 | 77.0% |
| United Kingdom | 93.7 | 80.8 | 89.5 | 75.4 | 69.0 | 81.7 | 87.9% |
| France | 26.1 | 18.4 | 21.3 | 13.1 | 14.5 | 18.7 | 90.4% |
| Australia | 14.9 | 17.4 | 15.5 | 18.1 | 18.4 | 16.9 | 92.7% |
| Netherlands | 11.7 | 17.9 | 14.9 | 11.5 | 11.4 | 13.5 | 94.5% |
| Belgium | 6.2 | 6.0 | 7.8 | 7.2 | 6.6 | 6.8 | 95.4% |
| Denmark | 5.0 | 5.6 | 5.3 | 6.2 | 4.1 | 5.3 | 96.1% |
| Germany | 3.4 | 4.0 | 3.7 | 3.9 | 4.1 | 3.8 | 96.6% |
| Sweden | 4.2 | 3.6 | 3.3 | 3.5 | 1.5 | 3.2 | 97.0% |
| Taiwan | 0.6 | 1.5 | 3.7 | 4.5 | 3.4 | 2.7 | 97.4% |
| China | 0.8 | 2.1 | 4.3 | 3.3 | 2.6 | 2.6 | 97.8% |
| Spain | 2.0 | 0.9 | 3.0 | 1.8 | 3.2 | 2.2 | 98.0% |
| South Korea | 2.1 | 2.8 | 1.4 | 2.3 | 1.2 | 1.9 | 98.3% |
| New Zealand | 1.7 | 0.9 | 1.1 | 0.9 | 2.1 | 1.3 | 98.5% |
| Mexico | 1.2 | 2.2 | 0.5 | 0.5 | 1.8 | 1.2 | 98.7% |
| Italy | 0.6 | 0.8 | 1.6 | 1.1 | 2.0 | 1.2 | 98.8% |
| Switzerland | 1.0 | 0.7 | 1.2 | 1.0 | 1.1 | 1.0 | 98.9% |
| Ireland | 1.0 | 1.2 | 1.2 | 1.0 | 0.7 | 1.0 | 99.1% |
| Israel | 0.3 | 0.4 | 0.5 | 1.5 | 2.1 | 1.0 | 99.2% |
| Hong Kong | 1.0 | 0.7 | 0.6 | 1.4 | 0.7 | 0.9 | 99.3% |
| South Africa | 0.5 | 0.4 | 1.4 | 1.0 | 0.7 | 0.8 | 99.4% |
| Russia | 0.0 | 0.1 | 0.1 | 0.6 | 1.6 | 0.5 | 99.5% |
| Thailand | 1.0 | 0.3 | 0.1 | 0.3 | 0.1 | 0.3 | 99.5% |
| Portugal | 0.2 | 0.3 | 0.1 | 0.1 | 0.7 | 0.3 | 99.6% |
| Total (all countries) | 867.7 | 797.7 | 850.2 | 715.0 | 499.7 | 746.0 | 100% |

[a] Cumulative percent based on 1993-1997 average.

TABLE B-8. Japanese salmon imports from the U.S.

| | Value ($U.S.) | Percent of Japanese Imports |
|---|---|---|
| Japanese Salmon Imports | $796,745,317 | 100% |
| Salmon Imports from the U.S. | $260,000,726 | 33% |
| Sockeye Imports from the U.S. | $228,562,478 | 29% |
| Other Salmon Imports from the U.S. | $31,438,248 | 4% |

TABLE B-9. U.S. per capita consumption (pounds per person) and population.[a/]

| | Fresh & Frozen | Canned | Total | US Population (millions) |
|---|---|---|---|---|
| 1979 | 0.39 | 0.44 | 0.84 | 223 |
| 1980 | 0.52 | 0.56 | 1.08 | 226 |
| 1981 | 0.18 | 0.66 | 0.85 | 228 |
| 1982 | 0.21 | 0.31 | 0.52 | 230 |
| 1983 | 0.23 | 0.55 | 0.77 | 232 |
| 1984 | 0.32 | 0.56 | 0.88 | 234 |
| 1985 | 0.34 | 0.53 | 0.87 | 236 |
| 1986 | 0.39 | 0.52 | 0.91 | 238 |
| 1987 | 0.31 | 0.44 | 0.75 | 241 |
| 1988 | 0.36 | 0.29 | 0.64 | 243 |
| 1989 | 0.49 | 0.30 | 0.79 | 245 |
| 1990 | 0.50 | 0.44 | 0.94 | 248 |
| 1991 | 0.79 | 0.54 | 1.33 | 251 |
| 1992 | 0.63 | 0.49 | 1.11 | 254 |
| 1993 | 0.81 | 0.51 | 1.32 | 256 |
| 1994 | 0.97 | 0.47 | 1.44 | 259 |
| 1995 | 1.15 | 0.52 | 1.67 | 261 |
| 1996 | 1.43 | 0.62 | 2.05 | 264 |

a/ Data from the Salmon Market Information Service, 1997.

TABLE B-10. Exprocessor prices (nominal) for selected West Coast salmon products together with number of processors and total pounds on which the prices are based (from the NMFS Processed Product Survey).

| Product Group | | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 |
|---|---|---|---|---|---|---|---|
| **Chinook** | | | | **Average Prices** | | | |
| Salmon Chinook Dressed | Fresh | $2.41 | $2.66 | $2.37 | $2.57 | $2.05 | $1.83 |
| | Frozen | $3.20 | $3.20 | $1.83 | $2.28 | $1.74 | $1.76 |
| Salmon Chinook Fillet | Fresh | $3.61 | $3.53 | $3.63 | $3.94 | $3.71 | $3.42 |
| | Frozen | $4.83 | $3.58 | $3.57 | $3.74 | $2.23 | $3.97 |
| Salmon Chinook Head on | Fresh | $2.56 | $2.76 | $2.36 | $2.28 | $2.38 | $2.16 |
| Salmon Chinook Smoked | Cured | $6.51 | $5.84 | $7.74 | $8.87 | $7.07 | $8.42 |
| **Coho** | | | | | | | |
| Salmon Coho Dressed | Fresh | $1.87 | $2.01 | $1.84 | $1.78 | $1.43 | $2.08 |
| | Frozen | $1.96 | $2.01 | $0.91 | $1.63 | $1.32 | $1.25 |
| Salmon Coho Fillet | Fresh | $4.42 | $3.94 | $3.89 | $3.07 | $2.91 | $3.09 |
| | | | | **Number of Processors Reporting Price** | | | |
| **Chinook** | | | | | | | |
| Salmon Chinook Dressed | Fresh | 44 | 36 | 25 | 14 | 10 | 6 |
| | Frozen | 81 | 68 | 12 | 11 | 13 | 11 |
| Salmon Chinook Fillet | Fresh | 12 | 9 | 10 | 7 | 7 | 5 |
| | Frozen | 6 | 6 | 4 | 3 | 3 | 7 |
| Salmon Chinook Head on | Fresh | 15 | 13 | 12 | 8 | 5 | 4 |
| Salmon Chinook Smoked | Cured | 13 | 13 | 12 | 9 | 10 | 10 |
| **Coho** | | | | | | | |
| Salmon Coho Dressed | Fresh | 38 | 34 | 23 | 13 | 9 | 6 |
| | Frozen | 76 | 61 | 14 | 11 | 11 | 10 |
| Salmon Coho Fillet | Frozen | 4 | 6 | 3 | 5 | 5 | 6 |
| | | | | **Total Pounds for Which Price Was Reported** | | | |
| **Chinook** | | | | | | | |
| Salmon Chinook Dressed | Fresh | 2,704,533 | 1,357,639 | 942,682 | 422,967 | 545,301 | 453,988 |
| | Frozen | 5,074,068 | 4,379,066 | 1,513,989 | 1,124,553 | 1,155,324 | 1,797,697 |
| Salmon Chinook Fillet | Fresh | 574,883 | 492,807 | 327,347 | 347,245 | 217,579 | 172,127 |
| | Frozen | 202,930 | 370,865 | 359,147 | 410,000 | 99,821 | 351,045 |
| Salmon Chinook Head on | Fresh | 1,315,518 | 1,350,007 | 474,683 | 516,524 | 437,288 | 869,991 |
| Salmon Chinook Smoked | Cured | 337,497 | 142,313 | 83,625 | 142,850 | 188,928 | 65,860 |
| **Coho** | | | | | | | |
| Salmon Coho Dressed | Fresh | 3,157,259 | 2,124,198 | 660,437 | 531,113 | 675,851 | 618,209 |
| | Frozen | 16,853,211 | 25,278,830 | 3,870,284 | 4,847,136 | 4,909,645 | 1,857,838 |
| Salmon Coho Fillet | Frozen | 359,465 | 319,931 | 175,200 | 294,338 | 883,202 | 1,510,759 |

TABLE B-11. Annual wholesale market price trends for selected salmon products (nominal dollars per pound).[a/]

| | Year | | | | | | |
|---|---|---|---|---|---|---|---|
| Product | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 |
| Chum, Seattle | - | - | 1.50 | 1.43 | 1.13 | 1.00 | 0.86 |
| West Coast Atlantic, Seattle, 10-12 Pounds | - | - | - | 3.39 | 3.00 | 2.86 | 2.53 |
| West Coast Atlantic, Seattle, 8-10 Pounds | - | - | - | 3.23 | 2.91 | 2.74 | 2.43 |
| West Coast Atlantic, Seattle, 6-8 Pounds | - | - | - | 3.06 | 2.70 | 2.57 | 2.35 |
| Canadian Farmed King, Fresh, Seattle, 4-6 Pounds | 2.22 | 2.37 | 2.52 | 2.63 | 2.42 | 2.33 | 2.43 |
| Canadian Farmed King, Fresh, FOB Seattle, 4-6 Pounds | 2.22 | 2.37 | 2.52 | 2.67 | 2.61 | - | - |
| Canadian Farmed King, Fresh, Seattle, 4-6 Pounds | 3.31 | 3.36 | 2.91 | 2.98 | 2.62 | 2.53 | 2.51 |

a/ As reported by Urner Barry Publications, Inc.

TABLE B-12. Generalized summary of Canadian recreational salt water regulations for chinook, coho, chum, pink, and sockeye salmon.[a]

| Species | Fishing Season[b] | Daily Limits[c/d] | Possession Limit | Yearly Limits |
|---|---|---|---|---|
| Chinook | Year-round w/ partial summer & early fall month closures. | 2 | 4 | from: 15-30 |
| Sockeye | Year-round w/ partial summer & early fall month closures. | 4 | 8 | None |
| Pink | Year-round w/ partial summer & early fall month closures. | 4 | 8 | None |
| Chum | Year-round w/ partial summer & early fall month closures. | 4 | 8 | None |
| Coho | Non-retention of coho | N/A | N/A | N/A |

a/ Based on information from BC Online Tidal Waters Sport Fishing Guide 1998/99 (July 21, 1998)

b/ Salmon closure times in the North Coast, for most salmon, fall between June 29 and Aug. 27. Salmon closure times in the South Coast, for most salmon, fall between July 1 to Oct. 15.

c/ Minimum size limit ranges from 30 in. to 62 in.

d/ Aggregate daily limit for all species of Pacific salmon from tidal and non-tidal waters combined is 4.

TABLE B-13. Generalized summary of Alaskan salt water regulations for king, coho, chum, pink, and sockeye salmon.[a/]

| Species | Fishing Season | Daily Limits | Possession Limits | Yearly Limits |
|---|---|---|---|---|
| Chinook | Year-round | From: 2-3 daily w/ minimum of 2 fish greater than 28 inches. | 2-3 in possession (2 must be a minimum of 28 inches) | • 4 fish yearly limit for fish 28 inches or larger for <u>non-residents only</u> between Cape Suckling and the Int'l Boundary at Dixon entrance.<br>• No yearly limits for resident and non-resident in Alaska Peninsula, Aleutian Islands & Kodiak.<br>• 5 fish yearly limit in Bristol Bay area for residents & non-residents. |
| Coho, Chum, Pink, and Sockeye | Year-round | From: 5-6 daily w/ size limits for areas between Cape Suckling and the International Boundary at Dixon entrance. | • Kodiak, Alaska Pen., Aleutian Is., & Bristol bay: 5 in possession w/ no size limits.<br>• Between Cape Suckling & the Int'l Boundary at Dixon Entrance: 12 of each species in possession. | None |

a/ Based on information in 1998 Sport Fishing Regulations Summary from Alaska's Department of Fish and Game.

TABLE B-14. Distribution of total average chinook mortalities for selected stocks, 1984-1994 in adult equivalent impacts.

|  |  | Fisheries with Ceilings |  |  |  | Other Fisheries |  |  |  |  |
|---|---|---|---|---|---|---|---|---|---|---|
| Location | Stock | All Alaska | All North/Central British Columbia | West Coast Vancouver Island Troll | All Strait of Georgia | Canada Net | Canada Sport | U.S. Troll | U.S. Net | U.S. Sport |
| Puget Sound | Stillaguamish Fall Fingerling | 3.9% | 2.6% | 29.8% | 22.7% | 2.2% | 2.9% | 6.1% | 2.7% | 22.2% |
| Puget Sound | South Puget Sound Fall Fingerling | 0.3% | 1.0% | 27.0% | 14.8% | 1.4% | 0.7% | 11.7% | 11.3% | 31.2% |
| Washington Coast | Queets Fall Fingerling | 21.1% | 41.8% | 25.6% | 0.0% | 0.0% | 0.0% | 0.0% | 4.8% | 1.9% |
| Columbia River | Stayton Pond Tule | 0.0% | 1.1% | 47.5% | 2.5% | 0.4% | 0.7% | 28.1% | 2.7% | 16.2% |
| Columbia River | Columbia River Upriver Bright | 29.8% | 22.3% | 26.1% | 0.0% | 0.1% | 0.4% | 2.5% | 13.6% | 5.1% |
| Columbia River | Lyons Ferry | 12.5% | 12.6% | 24.8% | 0.3% | 2.1% | 0.8% | 12.6% | 28.8% | 5.3% |

TABLE B-15. Base fishery (1979-1981) coho impacts for selected stocks by fishery area.

| Region | Nooksack-Samish | Stillaguamish-Snohomish | Hood Canal | Grays Harbor | Columbia River Early | Columbia River Late | Robertson Creek | Fraser River |
|---|---|---|---|---|---|---|---|---|
| Alaska | 0 | 0 | 0 | 331 | 105 | 0 | 378 | 0 |
| W. Coast Ocean | 36,564 | 94,331 | 55,853 | 39,425 | 435,813 | 181,610 | 3,971 | 8,352 |
| Puget Sound | 140,125 | 176,527 | 91,552 | 210 | 649 | 1,932 | 192 | 19,143 |
| Canada | 224,203 | 293,770 | 134,731 | 77,237 | 16,424 | 18,317 | 243,594 | 195,190 |
| Total | 400,892 | 564,628 | 282,145 | 117,227 | 454,039 | 202,349 | 248,135 | 222,685 |
| | | | | | | | | |
| Alaska | 0.0% | 0.0% | 0.0% | 0.3% | 0.0% | 0.0% | 0.2% | 0.0% |
| W Coast Ocean | 9.1% | 16.7% | 19.8% | 33.6% | 96.0% | 89.8% | 1.6% | 3.8% |
| Puget Sound | 35.0% | 31.3% | 32.4% | 0.2% | 0.1% | 1.0% | 0.1% | 8.6% |
| Canada | 55.9% | 52.0% | 47.8% | 65.9% | 3.6% | 9.1% | 98.2% | 87.7% |

TABLE B-16. Commercial non-Indian and Indian **chinook** salmon landings **(thousands of round pounds)** by major **West Coast** harvest area, 1981-1997.[a]

| Year | Puget Sound [b] | Washington Inside Coast | Columbia River | West Coast Ocean | U.S. West Coast |
|---|---|---|---|---|---|
| | | | **Non-Indian** | | |
| 1981 | 1,086 | 368 | 773 | 9,370 | 11,597 |
| 1982 | 1,241 | 274 | 1,938 | 12,791 | 16,244 |
| 1983 | 613 | 46 | 635 | 3,790 | 5,084 |
| 1984 | 890 | 95 | 1,212 | 3,734 | 5,930 |
| 1985 | 1,097 | 182 | 1,308 | 7,925 | 10,512 |
| 1986 | 1,137 | 233 | 2,752 | 12,783 | 16,905 |
| 1987 | 899 | 232 | 6,215 | 16,998 | 24,343 |
| 1988 | 580 | 869 | 7,233 | 22,546 | 31,228 |
| 1989 | 671 | 794 | 3,265 | 11,010 | 15,740 |
| 1990 | 734 | 586 | 1,301 | 7,656 | 10,276 |
| 1991 | 273 | 653 | 1,000 | 4,880 | 6,806 |
| 1992 | 247 | 833 | 430 | 3,628 | 5,138 |
| 1993 | 254 | 662 | 344 | 4,181 | 5,441 |
| 1994 | 328 | 470 | 64 | 3,910 | 4,772 |
| 1995 | 94 | 581 | 12 | 9,891 | 10,578 |
| 1996 | 120 | 712 | 283 | 6,947 | 8,062 |
| 1997 | 350 | 296 | 189 | 7,903 | 8,739 |
| | | | **Indian** | | |
| 1981 | 1,930 | 391 | 975 | 231 | 3,527 |
| 1982 | 1,747 | 449 | 1,113 | 352 | 3,660 |
| 1983 | 1,622 | 278 | 414 | 255 | 2,570 |
| 1984 | 1,841 | 258 | 857 | 125 | 3,081 |
| 1985 | 2,218 | 361 | 1,353 | 203 | 4,135 |
| 1986 | 1,779 | 431 | 2,012 | 229 | 4,452 |
| 1987 | 1,740 | 1,018 | 2,872 | 351 | 5,982 |
| 1988 | 1,812 | 741 | 3,384 | 477 | 6,414 |
| 1989 | 1,884 | 1,211 | 3,098 | 418 | 6,612 |
| 1990 | 2,163 | 779 | 1,990 | 387 | 5,319 |
| 1991 | 1,298 | 493 | 1,169 | 246 | 3,207 |
| 1992 | 913 | 457 | 677 | 245 | 2,293 |
| 1993 | 672 | 425 | 552 | 271 | 1,921 |
| 1994 | 799 | 443 | 702 | 60 | 2,003 |
| 1995 | 796 | 351 | 602 | 98 | 1,847 |
| 1996 | 782 | 362 | 747 | 117 | 2,008 |
| 1997 | 727 | 317 | 768 | 123 | 1,936 |

a/ All West Coast data is derived from PacFIN vessel summary files.

b/ All Area 4B catch is included with the West Coast ocean harvest.

TABLE B-17. Commercial non-Indian and Indian **chinook** salmon landings **(exvessel values, thousands of dollars)** by major **West Coast** harvest area, 1981-1997.[a]

| Year | Puget Sound [b] | Washington Inside Coast | Columbia River | West Coast Ocean | U.S. West Coast |
|---|---|---|---|---|---|
| | | | **Non-Indian** | | |
| 1981 | 1,799 | 659 | 1,054 | 21,123 | 24,635 |
| 1982 | 2,122 | 375 | 1,968 | 28,837 | 33,302 |
| 1983 | 675 | 65 | 808 | 6,574 | 8,121 |
| 1984 | 1,596 | 171 | 1,760 | 9,029 | 12,556 |
| 1985 | 1,524 | 201 | 1,700 | 17,515 | 20,939 |
| 1986 | 1,360 | 233 | 2,544 | 21,684 | 25,821 |
| 1987 | 1,579 | 463 | 8,856 | 40,301 | 51,199 |
| 1988 | 1,312 | 1,972 | 14,042 | 57,546 | 74,872 |
| 1989 | 700 | 689 | 2,920 | 22,245 | 26,553 |
| 1990 | 990 | 857 | 2,273 | 17,976 | 22,096 |
| 1991 | 314 | 838 | 1,590 | 10,860 | 13,602 |
| 1992 | 315 | 1,100 | 638 | 8,170 | 10,223 |
| 1993 | 256 | 670 | 365 | 8,114 | 9,406 |
| 1994 | 427 | 641 | 145 | 7,142 | 8,355 |
| 1995 | 100 | 538 | 19 | 15,018 | 15,675 |
| 1996 | 111 | 638 | 124 | 8,933 | 9,806 |
| 1997 | 322 | 291 | 154 | 9,873 | 10,639 |
| | | | **Indian** | | |
| 1981 | 3,325 | 497 | 799 | 503 | 5,124 |
| 1982 | 2,776 | 492 | 763 | 713 | 4,744 |
| 1983 | 1,799 | 332 | 360 | 518 | 3,008 |
| 1984 | 3,145 | 347 | 1,008 | 291 | 4,791 |
| 1985 | 2,783 | 253 | 1,171 | 415 | 4,622 |
| 1986 | 2,105 | 261 | 1,659 | 429 | 4,455 |
| 1987 | 2,730 | 1,414 | 4,592 | 823 | 9,559 |
| 1988 | 4,012 | 913 | 6,579 | 1,348 | 12,852 |
| 1989 | 1,955 | 981 | 2,472 | 840 | 6,248 |
| 1990 | 2,734 | 798 | 2,515 | 826 | 6,873 |
| 1991 | 1,418 | 538 | 935 | 463 | 3,355 |
| 1992 | 1,103 | 550 | 742 | 410 | 2,805 |
| 1993 | 657 | 412 | 359 | 429 | 1,857 |
| 1994 | 843 | 521 | 518 | 115 | 1,997 |
| 1995 | 677 | 313 | 212 | 140 | 1,343 |
| 1996 | 645 | 268 | 231 | 161 | 1,305 |
| 1997 | 622 | 299 | 322 | 118 | 1,361 |

a/ All West Coast data is derived from PacFIN vessel summary files.
b/ All Area 4B catch is included with the West Coast ocean harvest.

TABLE B-18. Commercial non-Indian and Indian **coho** salmon landings (**thousands of round pounds**) by major **West Coast** harvest area, 1981-1997.[a/]

| Year | Puget Sound [b/] | Washington Inside Coast | Columbia River | West Coast Ocean | U.S. West Coast |
|---|---|---|---|---|---|
| **Non-Indian** | | | | | |
| 1981 | 1,560 | 273 | 465 | 6,219 | 8,518 |
| 1982 | 2,551 | 770 | 1,577 | 5,280 | 10,179 |
| 1983 | 1,814 | 90 | 47 | 1,690 | 3,640 |
| 1984 | 1,516 | 471 | 1,610 | 602 | 4,200 |
| 1985 | 2,808 | 304 | 1,628 | 1,348 | 6,088 |
| 1986 | 2,869 | 1,005 | 6,703 | 2,799 | 13,376 |
| 1987 | 3,737 | 726 | 1,298 | 2,732 | 8,493 |
| 1988 | 2,486 | 435 | 2,641 | 4,232 | 9,795 |
| 1989 | 2,049 | 527 | 2,668 | 2,846 | 8,089 |
| 1990 | 2,444 | 414 | 494 | 1,667 | 5,019 |
| 1991 | 1,120 | 1,142 | 2,676 | 2,486 | 7,423 |
| 1992 | 498 | 73 | 300 | 335 | 1,206 |
| 1993 | 115 | 183 | 264 | 89 | 651 |
| 1994 | 129 | 120 | 498 | 0 | 747 |
| 1995 | 126 | 387 | 190 | 128 | 831 |
| 1996 | 109 | 450 | 230 | 81 | 870 |
| 1997 | 43 | 14 | 158 | 2 | 217 |
| **Indian** | | | | | |
| 1981 | 2,707 | 492 | 11 | 187 | 3,398 |
| 1982 | 5,070 | 629 | 26 | 862 | 6,587 |
| 1983 | 3,246 | 197 | 1 | 216 | 3,660 |
| 1984 | 2,546 | 380 | 9 | 277 | 3,211 |
| 1985 | 4,717 | 344 | 46 | 607 | 5,714 |
| 1986 | 4,979 | 833 | 224 | 396 | 6,431 |
| 1987 | 6,239 | 866 | 17 | 450 | 7,571 |
| 1988 | 4,096 | 434 | 80 | 323 | 4,933 |
| 1989 | 3,553 | 411 | 42 | 501 | 4,508 |
| 1990 | 3,876 | 677 | 18 | 595 | 5,165 |
| 1991 | 2,157 | 1,177 | 77 | 413 | 3,823 |
| 1992 | 1,420 | 306 | 5 | 305 | 2,036 |
| 1993 | 648 | 308 | 10 | 315 | 1,281 |
| 1994 | 2,285 | 196 | 21 | 0 | 2,502 |
| 1995 | 1,455 | 632 | 10 | 168 | 2,266 |
| 1996 | 663 | 1,083 | 6 | 108 | 1,859 |
| 1997 | 588 | 101 | 3 | 63 | 756 |

a/ All West Coast data is derived from PacFIN vessel summary files.

b/ All Area 4B catch is included with the West Coast ocean harvest.

TABLE B-19. Commercial non-Indian and Indian **coho** salmon landings (exvessel values, **thousands of dollars**) by major **West Coast** harvest area, 1981-1997.[a/]

| Year | Puget Sound [b/] | Washington Inside Coast | Columbia River | West Coast Ocean | U.S. West Coast |
|---|---|---|---|---|---|
| | | | **Non-Indian** | | |
| 1981 | 1,818 | 287 | 513 | 8,755 | 11,372 |
| 1982 | 2,256 | 634 | 1,355 | 6,455 | 10,700 |
| 1983 | 1,607 | 99 | 50 | 1,486 | 3,242 |
| 1984 | 1,585 | 606 | 1,863 | 988 | 5,041 |
| 1985 | 2,611 | 241 | 1,358 | 1,653 | 5,863 |
| 1986 | 3,265 | 1,099 | 6,708 | 2,595 | 13,668 |
| 1987 | 7,434 | 1,537 | 2,478 | 4,150 | 15,599 |
| 1988 | 5,853 | 956 | 5,839 | 8,380 | 21,029 |
| 1989 | 2,158 | 544 | 2,379 | 2,847 | 7,928 |
| 1990 | 3,281 | 513 | 594 | 2,401 | 6,790 |
| 1991 | 1,038 | 1,007 | 2,148 | 2,424 | 6,617 |
| 1992 | 526 | 67 | 271 | 339 | 1,204 |
| 1993 | 91 | 156 | 216 | 79 | 543 |
| 1994 | 101 | 103 | 413 | 0 | 618 |
| 1995 | 82 | 255 | 120 | 95 | 552 |
| 1996 | 60 | 267 | 142 | 63 | 532 |
| 1997 | 27 | 11 | 117 | 7 | 162 |
| | | | **Indian** | | |
| 1981 | 3,113 | 575 | 12 | 241 | 3,940 |
| 1982 | 4,165 | 463 | 24 | 1,037 | 5,690 |
| 1983 | 2,805 | 209 | 1 | 194 | 3,210 |
| 1984 | 2,510 | 411 | 9 | 320 | 3,250 |
| 1985 | 4,010 | 215 | 34 | 657 | 4,917 |
| 1986 | 5,129 | 710 | 161 | 384 | 6,385 |
| 1987 | 11,180 | 1,522 | 22 | 653 | 13,376 |
| 1988 | 9,143 | 814 | 135 | 708 | 10,799 |
| 1989 | 3,561 | 428 | 30 | 520 | 4,539 |
| 1990 | 4,898 | 925 | 17 | 726 | 6,567 |
| 1991 | 1,808 | 843 | 46 | 366 | 3,063 |
| 1992 | 1,396 | 267 | 4 | 349 | 2,016 |
| 1993 | 529 | 263 | 7 | 296 | 1,095 |
| 1994 | 1,674 | 163 | 10 | 0 | 1,848 |
| 1995 | 882 | 355 | 3 | 120 | 1,360 |
| 1996 | 338 | 631 | 2 | 84 | 1,055 |
| 1997 | 367 | 79 | 1 | 49 | 496 |

a/ All West Coast data is derived from PacFIN vessel summary files.

b/ All Area 4B catch is included with the West Coast ocean harvest.

TABLE B-20. Commercial non-Indian and Indian **pink** salmon landings (**thousands of round pounds**) by major **West Coast** harvest area, 1981-1997.[a/]

| Year | Puget Sound [b/] | Washington Inside Coast | Columbia River | West Coast Ocean | U.S. West Coast |
|---|---|---|---|---|---|
| | | | **Non-Indian** | | |
| 1981 | 13,176 | 0 | 0 | 1,453 | 14,629 |
| 1982 | 0 | 0 | 0 | 0 | 0 |
| 1983 | 4,531 | 0 | 0 | 349 | 4,881 |
| 1984 | 0 | 0 | 0 | 0 | 0 |
| 1985 | 10,409 | 0 | 0 | 874 | 11,283 |
| 1986 | 0 | 0 | 0 | 0 | 0 |
| 1987 | 4,436 | 0 | 0 | 117 | 4,553 |
| 1988 | 0 | 0 | 0 | 0 | 0 |
| 1989 | 6,857 | 0 | 0 | 177 | 7,034 |
| 1990 | 0 | 0 | 0 | 0 | 0 |
| 1991 | 6,376 | 0 | 0 | 175 | 6,551 |
| 1992 | 0 | 0 | 0 | 0 | 0 |
| 1993 | 3,831 | 0 | 0 | 10 | 3,841 |
| 1994 | 0 | 0 | 0 | 0 | 0 |
| 1995 | 5,029 | 0 | 0 | 116 | 5,145 |
| 1996 | 0 | 0 | 0 | 0 | 0 |
| 1997 | 3,246 | 0 | 0 | 0 | 3,246 |
| | | | **Indian** | | |
| 1981 | 5,658 | 0 | 0 | 27 | 5,686 |
| 1982 | 0 | 0 | 0 | 0 | 0 |
| 1983 | 3,427 | 0 | 0 | 99 | 3,526 |
| 1984 | 0 | 0 | 0 | 0 | 0 |
| 1985 | 11,028 | 0 | 0 | 94 | 11,122 |
| 1986 | 0 | 0 | 0 | 0 | 0 |
| 1987 | 5,081 | 0 | 0 | 81 | 5,163 |
| 1988 | 0 | 0 | 0 | 0 | 0 |
| 1989 | 8,105 | 0 | 0 | 69 | 8,174 |
| 1990 | 1 | 0 | 0 | 0 | 1 |
| 1991 | 6,937 | 0 | 0 | 23 | 6,961 |
| 1992 | 0 | 0 | 0 | 0 | 0 |
| 1993 | 4,319 | 0 | 0 | 13 | 4,332 |
| 1994 | 1 | 0 | 0 | 0 | 1 |
| 1995 | 4,980 | 0 | 0 | 53 | 5,034 |
| 1996 | 0 | 0 | 0 | 0 | 0 |
| 1997 | 3,811 | 0 | 0 | 7 | 3,818 |

a/ All West Coast data is derived from PacFIN vessel summary files.

b/ All Area 4B catch is included with the West Coast ocean harvest.

TABLE B-21. Commercial non-Indian and Indian **pink** salmon landings (**exvessel values, thousands of dollars**) by major **West Coast** harvest area, 1981-1997.[a/]

| Year | Puget Sound [b/] | Washington Inside Coast | Columbia River | West Coast Ocean | U.S. West Coast |
|---|---|---|---|---|---|
| | | | **Non-Indian** | | |
| 1981 | 6,182 | 0 | 0 | 958 | 7,139 |
| 1982 | 0 | 0 | 0 | 0 | 0 |
| 1983 | 1,511 | 0 | 0 | 162 | 1,672 |
| 1984 | 0 | 0 | 0 | 0 | 0 |
| 1985 | 2,710 | 0 | 0 | 472 | 3,181 |
| 1986 | 0 | 0 | 0 | 0 | 0 |
| 1987 | 2,221 | 0 | 0 | 78 | 2,299 |
| 1988 | 0 | 0 | 0 | 0 | 0 |
| 1989 | 2,781 | 0 | 0 | 109 | 2,891 |
| 1990 | 0 | 0 | 0 | 0 | 0 |
| 1991 | 1,290 | 0 | 0 | 73 | 1,363 |
| 1992 | 0 | 0 | 0 | 0 | 0 |
| 1993 | 639 | 0 | 0 | 5 | 644 |
| 1994 | 0 | 0 | 0 | 0 | 0 |
| 1995 | 844 | 0 | 0 | 27 | 871 |
| 1996 | 0 | 0 | 0 | 0 | 0 |
| 1997 | 625 | 0 | 0 | 0 | 625 |
| | | | **Indian** | | |
| 1981 | 2,598 | 0 | 0 | 16 | 2,613 |
| 1982 | 0 | 0 | 0 | 0 | 0 |
| 1983 | 1,215 | 0 | 0 | 43 | 1,257 |
| 1984 | 0 | 0 | 0 | 0 | 0 |
| 1985 | 2,798 | 0 | 0 | 37 | 2,835 |
| 1986 | 0 | 0 | 0 | 0 | 0 |
| 1987 | 2,484 | 0 | 0 | 41 | 2,525 |
| 1988 | 0 | 0 | 0 | 0 | 0 |
| 1989 | 3,166 | 0 | 0 | 35 | 3,201 |
| 1990 | 0 | 0 | 0 | 0 | 0 |
| 1991 | 1,393 | 0 | 0 | 7 | 1,400 |
| 1992 | 0 | 0 | 0 | 0 | 0 |
| 1993 | 671 | 0 | 0 | 4 | 675 |
| 1994 | 0 | 0 | 0 | 0 | 0 |
| 1995 | 874 | 0 | 0 | 12 | 886 |
| 1996 | 0 | 0 | 0 | 0 | 0 |
| 1997 | 667 | 0 | 0 | 2 | 668 |

a/ All West Coast data is derived from PacFIN vessel summary files.

b/ All Area 4B catch is included with the West Coast ocean harvest.

TABLE B-22. Geographic outline of West Coast commercial ocean troll seasons, 1978.

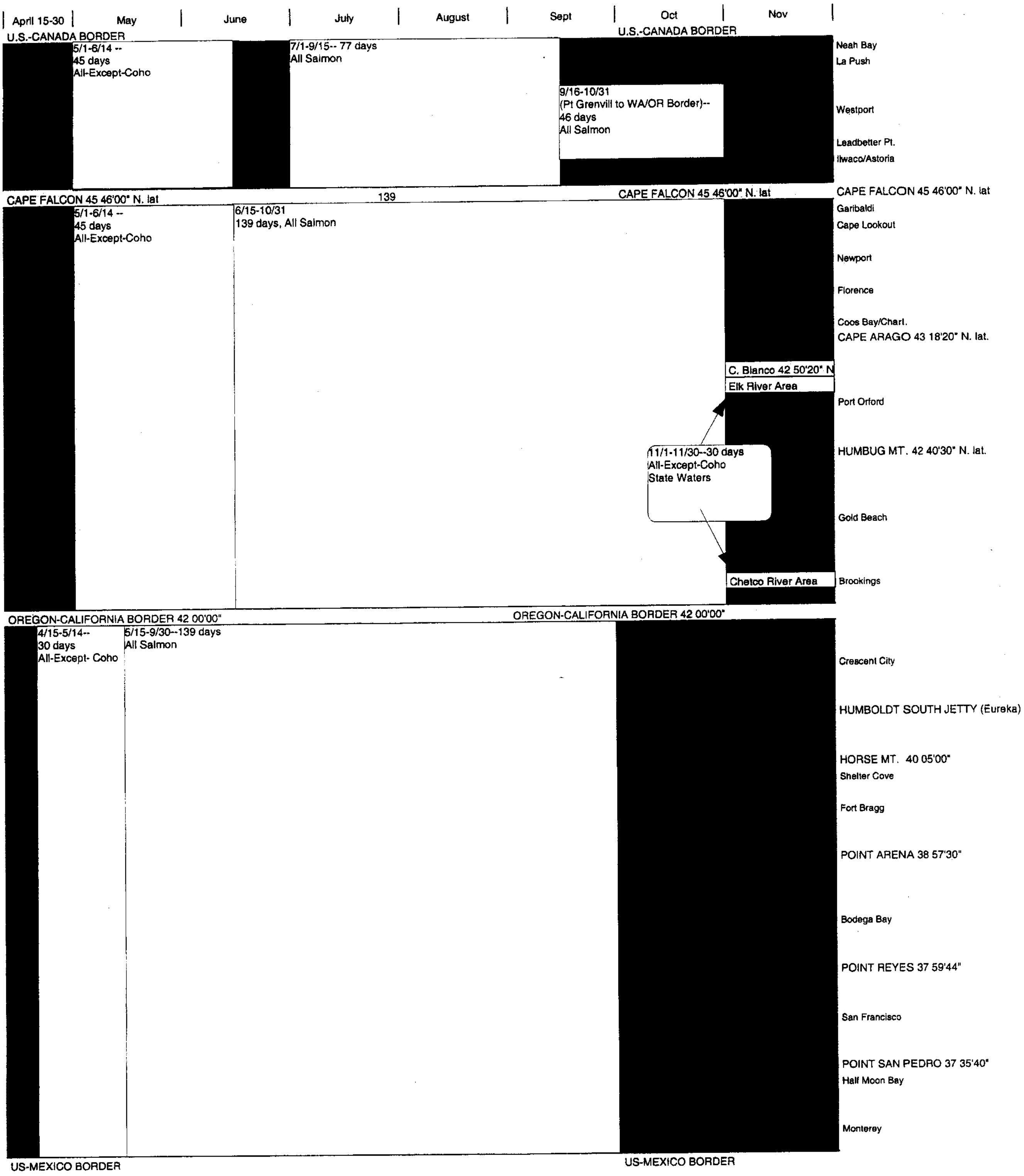


TABLE B-23. Geographic outline of West Coast commercial ocean troll seasons, 1984.

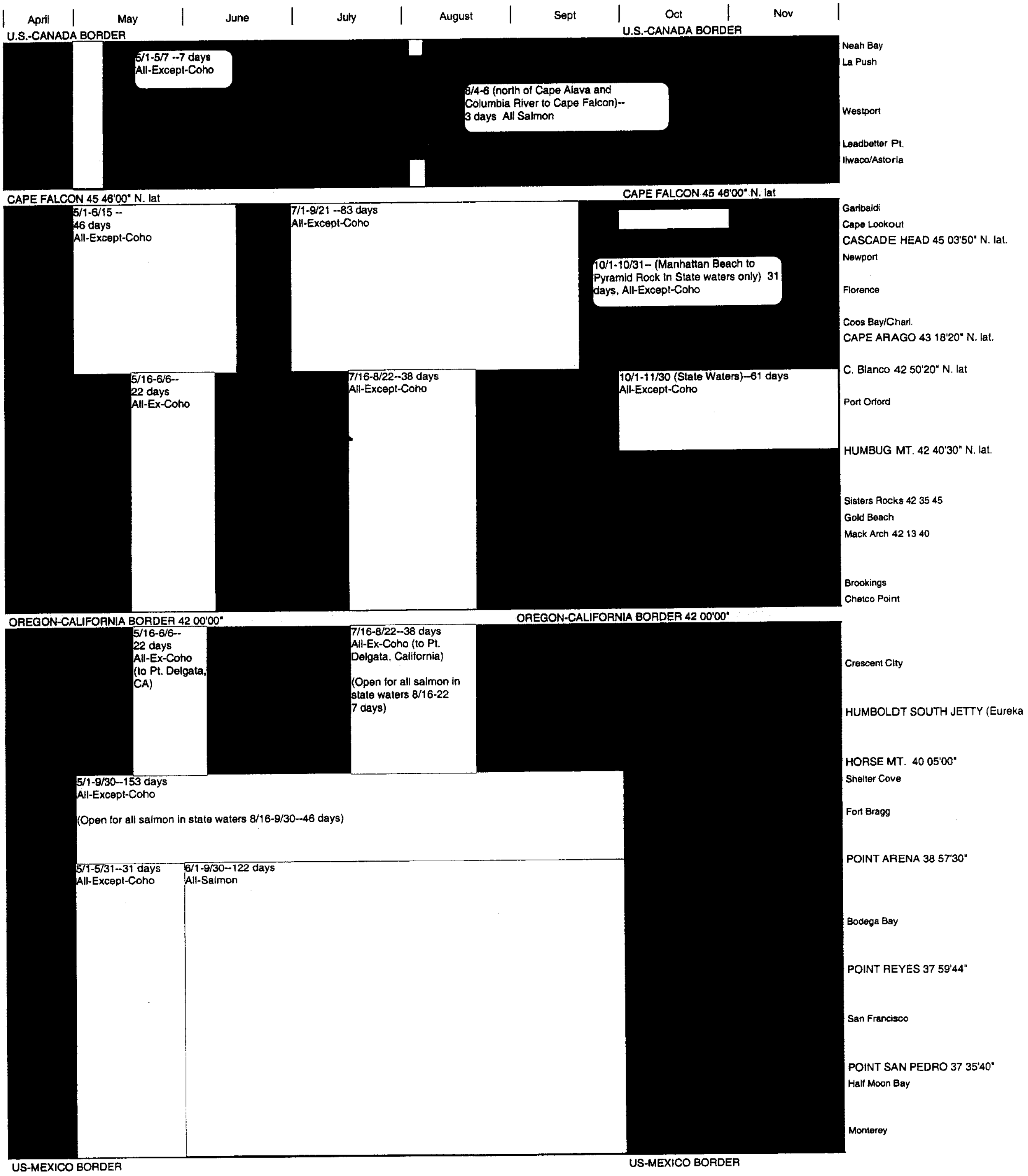


TABLE B-24. Geographic outline of West Coast commercial ocean troll seasons, 1988.

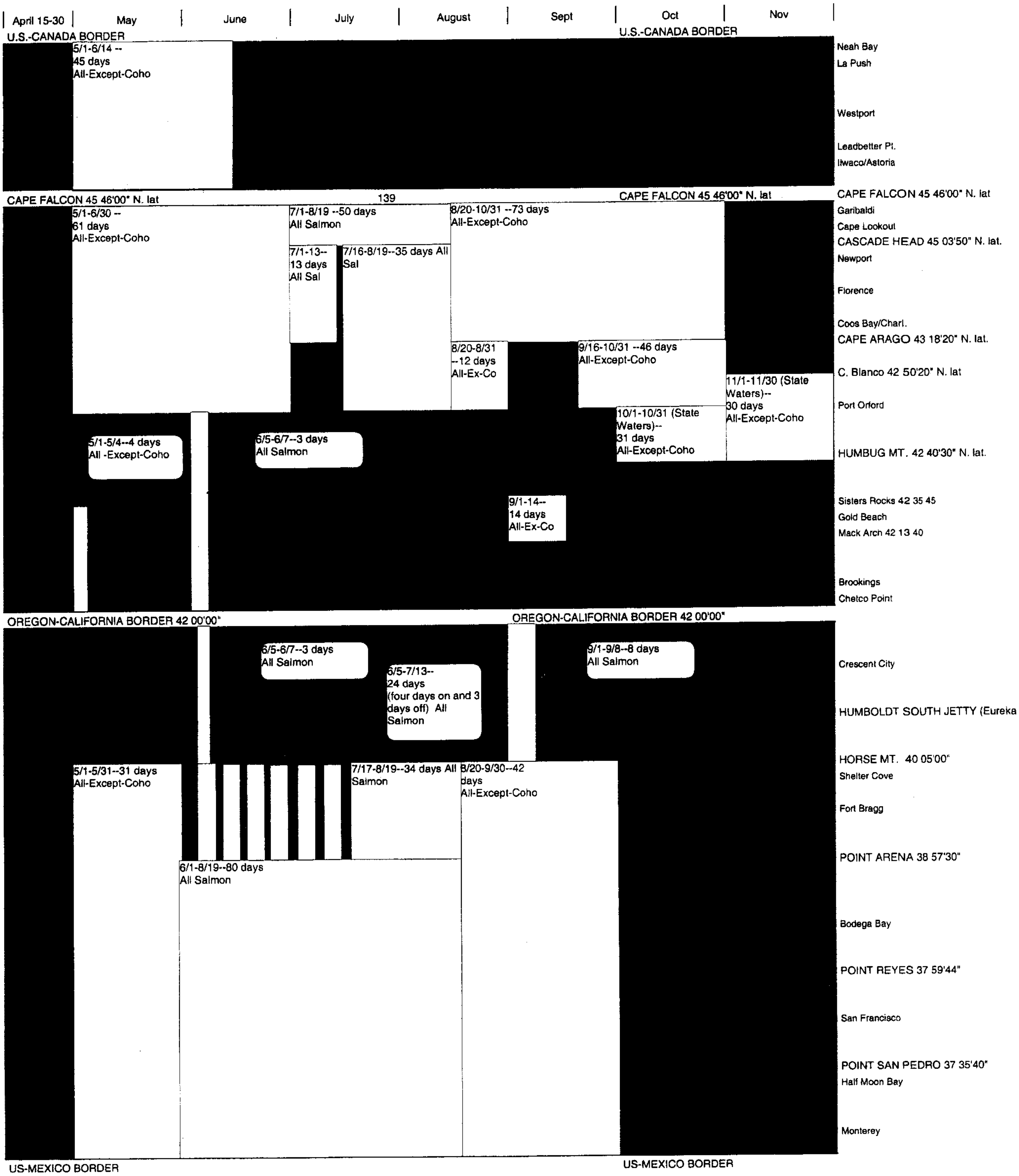


TABLE B-25. Geographic outline of West Coast commercial ocean troll seasons, 1994.

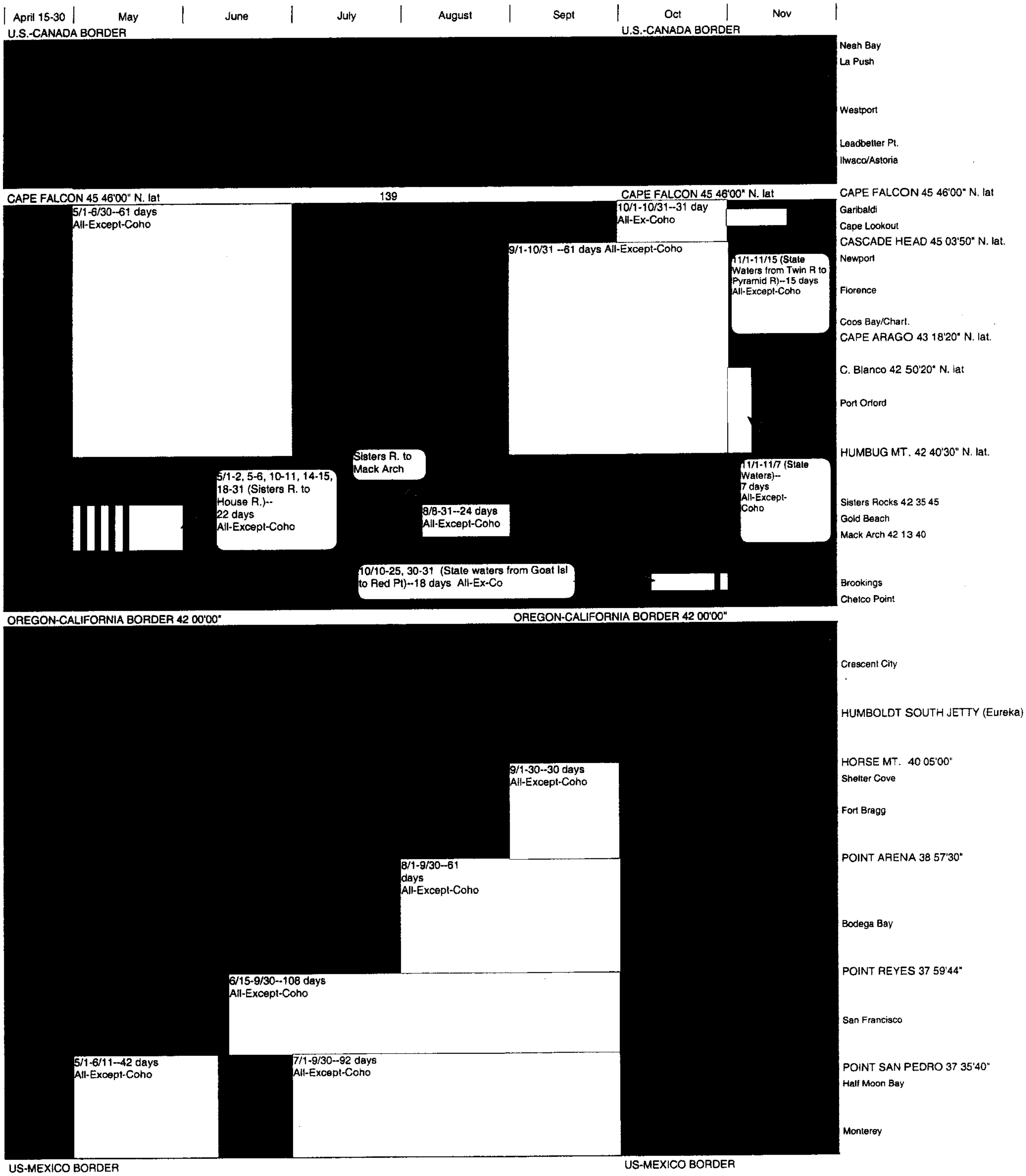
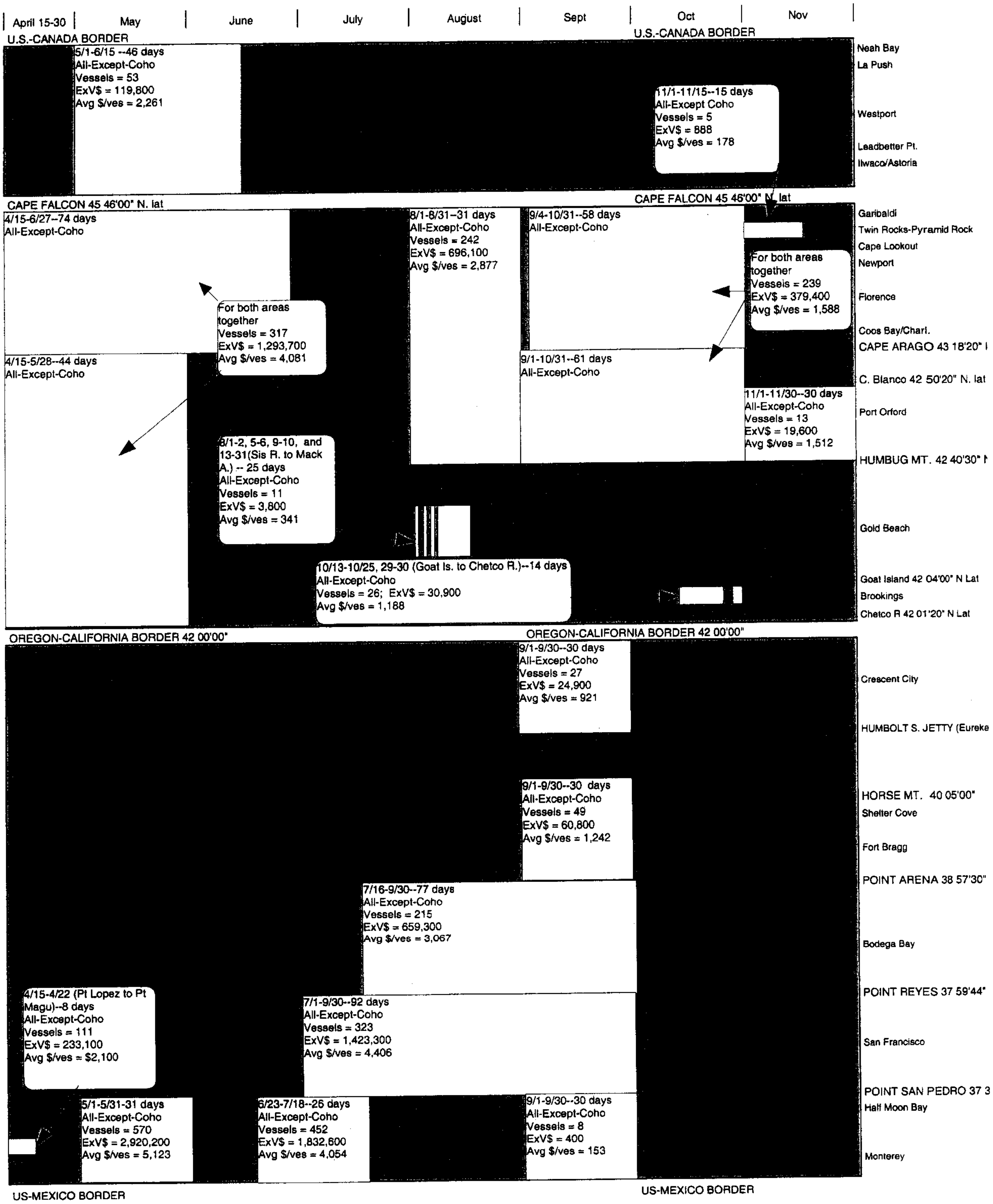


TABLE B-26. Geographic outline of West Coast commercial ocean troll seasons, 1997. a/ b/



5/1-6/15 --46 days
All-Except-Coho
Vessels = 53
ExV$ = 119,800
Avg $/ves = 2,261

11/1-11/15--15 days
All-Except Coho
Vessels = 5
ExV$ = 888
Avg $/ves = 178

4/15-6/27--74 days
All-Except-Coho

8/1-8/31--31 days
All-Except-Coho
Vessels = 242
ExV$ = 696,100
Avg $/ves = 2,877

9/4-10/31--58 days
All-Except-Coho

For both areas together
Vessels = 239
ExV$ = 379,400
Avg $/ves = 1,588

For both areas together
Vessels = 317
ExV$ = 1,293,700
Avg $/ves = 4,081

4/15-5/28--44 days
All-Except-Coho

9/1-10/31--61 days
All-Except-Coho

11/1-11/30--30 days
All-Except-Coho
Vessels = 13
ExV$ = 19,600
Avg $/ves = 1,512

8/1-2, 5-6, 9-10, and 13-31(Sis R. to Mack A.) -- 25 days
All-Except-Coho
Vessels = 11
ExV$ = 3,800
Avg $/ves = 341

10/13-10/25, 29-30 (Goat Is. to Chetco R.)--14 days
All-Except-Coho
Vessels = 26; ExV$ = 30,900
Avg $/ves = 1,188

9/1-9/30--30 days
All-Except-Coho
Vessels = 27
ExV$ = 24,900
Avg $/ves = 921

9/1-9/30--30 days
All-Except-Coho
Vessels = 49
ExV$ = 60,800
Avg $/ves = 1,242

7/16-9/30--77 days
All-Except-Coho
Vessels = 215
ExV$ = 659,300
Avg $/ves = 3,067

4/15-4/22 (Pt Lopez to Pt Magu)--8 days
All-Except-Coho
Vessels = 111
ExV$ = 233,100
Avg $/ves = $2,100

7/1-9/30--92 days
All-Except-Coho
Vessels = 323
ExV$ = 1,423,300
Avg $/ves = 4,406

5/1-5/31-31 days
All-Except-Coho
Vessels = 570
ExV$ = 2,920,200
Avg $/ves = 5,123

6/23-7/18--26 days
All-Except-Coho
Vessels = 452
ExV$ = 1,832,600
Avg $/ves = 4,054

9/1-9/30--30 days
All-Except-Coho
Vessels = 8
ExV$ = 400
Avg $/ves = 153

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a/ The information source for this table is state fish ticket data maintained in the redefined PacFIN database. The data were retrieved January 13, 1998 and may vary somewhat from summary information presented elsewhere in the review. Catch area recorded on tickets is sometimes based on the point of landing. When there is no opening in an area for which catch is reported it was assumed that landings made during a closure came from the nearest open area.

b/ Excludes information on 53,900 pounds of landings for which West Coast catch area was unknown. Total revenue for these landings was $79,500.

TABLE B-27. Exvessel revenue (thousands of dollars, not adjusted for inflation) by management area of catch (non-tribal) all species of salmon.

| | Inside Fisheries | | | Ocean Fisheries | | | | |
|---|---|---|---|---|---|---|---|---|
| | Puget Sound | Washington Coast | Columbia River | North of Cape Falcon[a/] | Cape Falcon to Cape Blanco | Cape Blanco to Horse Mountain | Horse Mountain to Point Arena | South of Point Arena |
| 1981 | 18,693 | 1,132 | 1,579 | 6,253 | 5,917 | 6,606 | 3,034 | 7,540 |
| 1982 | 19,730 | 1,574 | 3,334 | 5,985 | 6,376 | 6,043 | 4,893 | 10,852 |
| 1983 | 6,470 | 582 | 859 | 1,393 | 1,524 | 1,492 | 798 | 2,747 |
| 1984 | 12,595 | 1,040 | 3,672 | 605 | 766 | 1,188 | 1,216 | 5,980 |
| 1985 | 20,552 | 540 | 3,188 | 2,549 | 4,647 | 313 | 3,770 | 6,921 |
| 1986 | 21,299 | 1,523 | 9,267 | 1,470 | 6,528 | 2,036 | 3,553 | 9,899 |
| 1987 | 29,213 | 2,907 | 11,515 | 2,211 | 14,909 | 4,294 | 7,076 | 14,176 |
| 1988 | 21,078 | 4,258 | 20,019 | 2,361 | 20,326 | 3,284 | 10,724 | 27,457 |
| 1989 | 21,462 | 1,381 | 5,307 | 1,559 | 9,194 | 1,239 | 2,736 | 9,654 |
| 1990 | 19,199 | 1,414 | 2,873 | 1,837 | 6,281 | 507 | 1,741 | 9,560 |
| 1991 | 11,700 | 2,022 | 3,740 | 1,334 | 2,910 | 228 | 1,218 | 7,604 |
| 1992 | 7,195 | 1,435 | 911 | 1,371 | 2,619 | 2 | 55 | 4,434 |
| 1993 | 10,664 | 891 | 581 | 821 | 1,604 | 28 | 457 | 5,236 |
| 1994 | 10,416 | 753 | 559 | 0 | 637 | 62 | 174 | 6,244 |
| 1995 | 3,316 | 810 | 140 | 119 | 3,118 | 121 | 229 | 11,406 |
| 1996 | 1,604 | 909 | 266 | 61 | 2,737 | 368 | 377 | 5,310 |
| 1997 | 5,612 | 302 | 271 | 110 | 2,337 | 113 | 92 | 7,155 |

a/ Includes all catch from Area 4B.

TABLE B-28. Troll chinook and coho average dressed weights (pounds) by area of landing (PFMC, 1998).

| | Chinook | | | Coho | | |
|---|---|---|---|---|---|---|
| Year | California | Oregon | Washington | California | Oregon | Washington |
| 1981 | 9.4 | 9.8 | 11.4 | 5.7 | 5.4 | 4.3 |
| 1982 | 9.7 | 10.1 | 11.2 | 6.0 | 5.2 | 5.0 |
| 1983 | 7.3 | 8.2 | 10.5 | 4.4 | 3.4 | 4.2 |
| 1984 | 8.7 | 8.5 | 9.4 | 7.4 | 5.1 | 4.5 |
| 1985 | 12.3 | 9.4 | 10.4 | 7.3 | 5.8 | 4.6 |
| 1986 | 9.0 | 8.4 | 10.2 | 5.5 | 4.3 | 4.1 |
| 1987 | 10.3 | 9.8 | 9.5 | 5.6 | 5.4 | 4.3 |
| 1988 | 11.0 | 10.1 | 10.6 | 6.3 | 5.4 | - |
| 1989 | 10.3 | 10.0 | 10.6 | 5.5 | 4.4 | 3.9 |
| 1990 | 9.7 | 9.4 | 11.1 | 5.1 | 5.2 | 5.6 |
| 1991 | 11.0 | 9.3 | 10.6 | 5.6 | 4.6 | 5.1 |
| 1992 | 10.0 | 9.2 | 11.6 | 4.5 | 4.2 | 4.1 |
| 1993 | 9.1 | 9.3 | 11.0 | - | 5.4 | 4.8 |
| 1994 | 10.5 | 11.3 | 9.3 | - | - | - |
| 1995 | 9.8 | 9.0 | 8.4 | - | - | 4.4 |
| 1996 | 10.8 | 10.9 | 12.4 | - | - | 4.0 |
| 1997 | 10.7 | 10.3 | 10.6 | - | - | - |

TABLE B-29. **Troll** salmon landed in **California**, estimates of **exvessel value and average price** (dollars per dressed pound).

| | Chinook | | | | Coho | | | | Total[a/] | |
|---|---|---|---|---|---|---|---|---|---|---|
| Year | Nominal Value (thousands of dollars) | Real Value[b/] (thousands of dollars) | Nominal Price Per Pound (dollars) | Real Price Per Pound[b/] (dollars) | Nominal Value (thousands of dollars) | Real Value[b/] (thousands of dollars) | Nominal Price Per Pound (dollars) | Real Price Per Pound[b/] (dollars) | Nominal Value (thousands of dollars) | Real Value[b/] (thousands of dollars) |
| 1979 | 17,356 | 35,334 | 2.53 | 5.15 | 2,303 | 4,689 | 2.19 | 4.46 | 19,659 | 40,023 |
| 1980 | 12,741 | 23,746 | 2.27 | 4.23 | 408 | 760 | 1.36 | 2.53 | 13,149 | 24,506 |
| 1981 | 13,417 | 22,854 | 2.25 | 3.83 | 905 | 1,542 | 1.94 | 3.30 | 14,322 | 24,396 |
| 1982 | 18,754 | 30,051 | 2.55 | 4.09 | 735 | 1,178 | 1.36 | 2.18 | 19,489 | 31,229 |
| 1983 | 4,290 | 6,593 | 2.09 | 3.21 | 318 | 489 | 1.25 | 1.92 | 4,608 | 7,082 |
| 1984 | 6,875 | 10,182 | 2.67 | 3.95 | 687 | 1,017 | 1.99 | 2.95 | 7,562 | 11,200 |
| 1985 | 11,390 | 16,308 | 2.56 | 3.67 | 125 | 179 | 1.57 | 2.25 | 11,515 | 16,487 |
| 1986 | 14,874 | 20,755 | 2.01 | 2.80 | 238 | 332 | 1.18 | 1.65 | 15,112 | 21,087 |
| 1987 | 25,130 | 34,019 | 2.78 | 3.76 | 493 | 667 | 2.00 | 2.71 | 25,623 | 34,686 |
| 1988 | 41,221 | 53,838 | 2.86 | 3.74 | 706 | 922 | 2.21 | 2.89 | 41,927 | 54,760 |
| 1989 | 13,095 | 16,411 | 2.39 | 3.00 | 390 | 489 | 1.69 | 2.12 | 13,485 | 16,900 |
| 1990 | 11,434 | 13,735 | 2.77 | 3.33 | 622 | 747 | 1.98 | 2.38 | 12,056 | 14,483 |
| 1991 | 8,351 | 9,648 | 2.58 | 2.98 | 696 | 804 | 1.52 | 1.76 | 9,047 | 10,453 |
| 1992 | 4,487 | 5,045 | 2.74 | 3.08 | 18 | 20 | 1.63 | 1.83 | 4,505 | 5,065 |
| 1993 | 5,707 | 6,252 | 2.25 | 2.46 | - | - | - | - | 5,707 | 6,252 |
| 1994 | 6,437 | 6,887 | 2.07 | 2.21 | - | - | - | - | 6,437 | 6,887 |
| 1995 | 11,693 | 12,201 | 1.76 | 1.84 | - | - | - | - | 11,693 | 12,201 |
| 1996 | 5,984 | 6,105 | 1.44 | 1.47 | - | - | - | - | 5,984 | 6,105 |
| 1997[c/] | 7,200 | 7,200 | 1.38 | 1.38 | - | - | - | - | 7,200 | 7,200 |

a/ Does not include pink landings.
b/ Expressed in 1997 dollars.
c/ Preliminary.

TABLE B-30. **Troll** salmon landed in **Oregon**, estimates of **exvessel value and average price** (dollars per dressed pound).

| | Chinook | | | | Coho | | | | Total[a] | |
|---|---|---|---|---|---|---|---|---|---|---|
| Year | Nominal Value (thousands of dollars) | Real Value[b] (thousands of dollars) | Nominal Price Per Pound (dollars) | Real Price Per Pound[b] (dollars) | Nominal Value (thousands of dollars) | Real Value[b] (thousands of dollars) | Nominal Price Per Pound (dollars) | Real Price Per Pound[b] (dollars) | Nominal Value (thousands of dollars) | Real Value[b] (thousands of dollars) |
| 1971-1975 | 2,036 | 6,157 | 0.89 | 2.74 | 3,658 | 11,331 | 0.64 | 1.95 | 5,694 | 17,488 |
| 1976-1980 | 5,366 | 11,732 | 2.16 | 4.71 | 6,407 | 14,430 | 1.51 | 3.29 | 11,773 | 26,162 |
| 1981 | 4,039 | 6,880 | 2.57 | 4.38 | 5,534 | 9,426 | 1.66 | 2.83 | 9,573 | 16,306 |
| 1982 | 6,094 | 9,765 | 2.59 | 4.15 | 3,801 | 6,091 | 1.40 | 2.24 | 9,895 | 15,856 |
| 1983 | 1,244 | 1,912 | 1.90 | 2.92 | 1,052 | 1,617 | 0.96 | 1.48 | 2,296 | 3,529 |
| 1984 | 1,477 | 2,187 | 2.74 | 4.06 | 118 | 175 | 1.66 | 2.46 | 1,595 | 2,362 |
| 1985 | 5,045 | 7,223 | 2.48 | 3.55 | 729 | 1,044 | 1.51 | 2.16 | 5,774 | 8,267 |
| 1986 | 5,976 | 8,339 | 1.77 | 2.47 | 1,978 | 2,760 | 1.04 | 1.45 | 7,954 | 11,099 |
| 1987 | 13,467 | 18,231 | 2.60 | 3.52 | 3,296 | 4,462 | 1.72 | 2.33 | 16,763 | 22,692 |
| 1988 | 13,940 | 18,207 | 3.19 | 4.17 | 7,596 | 9,921 | 2.28 | 2.98 | 21,536 | 28,128 |
| 1989 | 7,894 | 9,893 | 2.23 | 2.79 | 2,131 | 2,671 | 1.07 | 1.34 | 10,025 | 12,564 |
| 1990 | 5,627 | 6,760 | 2.58 | 3.10 | 1,014 | 1,218 | 1.60 | 1.92 | 6,641 | 7,978 |
| 1991 | 1,721 | 1,988 | 2.47 | 2.85 | 1,399 | 1,616 | 0.99 | 1.14 | 3,120 | 3,605 |
| 1992 | 2,490 | 2,800 | 2.46 | 2.77 | 222 | 250 | 1.08 | 1.21 | 2,712 | 3,049 |
| 1993 | 1,661 | 1,820 | 2.18 | 2.39 | 10 | 11 | 1.13 | 1.24 | 1,671 | 1,831 |
| 1994 | 690 | 738 | 2.40 | 2.57 | - | - | - | - | 690 | 738 |
| 1995 | 3,294 | 3,437 | 1.70 | 1.77 | - | - | - | - | 3,294 | 3,437 |
| 1996 | 3,007 | 3,068 | 1.56 | 1.59 | - | - | - | - | 3,007 | 3,068 |
| 1997[c] | 2,469 | 2,469 | 1.60 | 1.60 | - | - | - | - | 2,469 | 2,469 |

a/ Does not include pink landings.
b/ Expressed in 1997 dollars.
c/ Preliminary.

TABLE B-31. **Non-Indian troll** salmon landed in **Washington**, estimates of **exvessel value and average price** (dollars per dressed pound).[a]

| Year or Average | Chinook: Nominal Value (thousands of dollars) | Chinook: Real Value[c] (thousands of dollars) | Chinook: Nominal Price Per Pound (dollars) | Chinook: Real Price Per Pound[c] (dollars) | Coho: Nominal Value (thousands of dollars) | Coho: Real Value[c] (thousands of dollars) | Coho: Nominal Price Per Pound (dollars) | Coho: Real Price Per Pound[c] (dollars) | Total[b]: Nominal Value (thousands of dollars) | Total[b]: Real Value[c] (thousands of dollars) |
|---|---|---|---|---|---|---|---|---|---|---|
| 1971-1975 | 2,714 | 8,313 | 0.89 | 2.74 | 3,060 | 9,395 | 0.66 | 2.04 | 5,775 | 17,708 |
| 1976-1980 | 5,313 | 11,851 | 2.39 | 5.17 | 6,086 | 13,541 | 1.67 | 3.62 | 11,399 | 25,391 |
| 1981 | 3,279 | 5,585 | 2.66 | 4.53 | 2,642 | 4,500 | 1.52 | 2.59 | 5,921 | 10,086 |
| 1982 | 4,246 | 6,804 | 2.57 | 4.12 | 2,484 | 3,980 | 1.34 | 2.15 | 6,730 | 10,784 |
| 1983 | 1,152 | 1,771 | 1.72 | 2.64 | 313 | 481 | 0.93 | 1.43 | 1,465 | 2,252 |
| 1984 | 255 | 378 | 2.78 | 4.12 | 155 | 230 | 1.48 | 2.19 | 410 | 607 |
| 1985 | 837 | 1,198 | 2.57 | 3.68 | 764 | 1,094 | 1.32 | 1.89 | 1,601[d] | 2,292 |
| 1986 | 808 | 1,127 | 2.35 | 3.28 | 367 | 512 | 1.16 | 1.62 | 1,175 | 1,640 |
| 1987 | 1,606 | 2,173 | 2.97 | 4.02 | 354 | 480 | 1.67 | 2.26 | 1,960[e] | 2,653 |
| 1988 | 2,289 | 2,990 | 2.95 | 3.85 | 48[f] | 63 | 2.45 | 3.20 | 2,337 | 3,052 |
| 1989 | 955 | 1,197 | 2.22 | 2.78 | 275 | 345 | 1.31 | 1.64 | 1,230[g] | 1,541 |
| 1990 | 890 | 1,069 | 2.57 | 3.09 | 758 | 911 | 1.52 | 1.83 | 1,648 | 1,980 |
| 1991 | 783 | 905 | 2.54 | 2.93 | 343 | 396 | 1.13 | 1.31 | 1,126[h] | 1,301 |
| 1992 | 1,200 | 1,349 | 2.41 | 2.71 | 99 | 111 | 1.33 | 1.50 | 1,299 | 1,461 |
| 1993 | 728 | 798 | 2.21 | 2.42 | 67 | 73 | 1.02 | 1.12 | 795[i] | 871 |
| 1994 | j/ | j/ | j/ | j/ | - | - | - | - | j/ | j/ |
| 1995 | j/ | j/ | j/ | j/ | 91 | 95 | 0.83 | 0.87 | 91[k] | 95 |
| 1996 | j/ | j/ | j/ | j/ | 59 | 60 | 0.86 | 0.88 | 59 | 60 |
| 1997 | 125 | 125 | 1.55 | 1.55 | - | - | - | - | 125[l] | 125 |

a/ All values in this table are based on preliminary information available at the start of each year's salmon review.
b/ Does not include pink landings.
c/ Expressed in 1997 dollars.
d/ Pink landings nominal exvessel value was $308,000. Nominal pink price per pound was $0.55.
e/ Pink landings nominal exvessel value was $6,500. Nominal pink price per pound was $0.62.
f/ There was no legal coho fishery in 1988. This value is for landings of fish caught south of Cape Falcon and seizures of illegal fish.
g/ Pink landings nominal exvessel value was $91,000. Nominal pink price per pound was $0.70.
h/ Pink landings nominal exvessel value was $69,600. Nominal pink price per pound was $0.47.
i/ Pink landings nominal exvessel value was $4,700. Nominal pink price per pound was $0.54.
j/ Chinook were caught off Oregon and landed in Washington. Value information is not provided in order to preserve confidentiality.
k/ Pink landings nominal exvessel value was $26,000. Nominal pink price per pound was $0.20.
l/ Pink landings nominal exvessel value was $3. Nominal pink price per pound was $0.31.

TABLE B-32. **Pounds** of salmon **landed** by the commercial **troll** ocean fishery for major **California** port areas.[a/]

| Year or Average | Crescent City | Eureka | Fort Bragg | San Francisco | Monterey | State Total |
|---|---|---|---|---|---|---|
| | | | **CHINOOK (thousands of pounds)** | | | |
| 1976-1980 | 393 | 1,403 | 1,449 | 1,733 | 889 | 5,867 |
| 1981-1985 | 350 | 428 | 1,128 | 1,806 | 742 | 4,454 |
| 1986 | 151 | 457 | 2,147 | 2,751 | 1,891 | 7,397 |
| 1987 | 313 | 656 | 3,115 | 3,874 | 1,090 | 9,047 |
| 1988 | 188 | 557 | 4,201 | 7,177 | 2,307 | 14,431 |
| 1989 | 103 | 220 | 1,359 | 2,545 | 1,263 | 5,490 |
| 1990 | 20 | 133 | 671 | 1,892 | 1,407 | 4,122 |
| 1991 | 4 | 79 | 467 | 1,685 | 1,004 | 3,238 |
| 1992 | b/ | 1 | 21 | 996 | 613 | 1,632 |
| 1993 | 3 | 11 | 220 | 1,316 | 987 | 2,537 |
| 1994 | b/ | 6 | 77 | 2,189 | 831 | 3,103 |
| 1995 | 5 | 26 | 130 | 3,277 | 3,197 | 6,633 |
| 1996 | 3 | 92 | 278 | 1,695 | 2,046 | 4,113 |
| 1997[c/] | 1 | 16 | 54 | 2,644 | 2,485 | 5,200 |
| | | | **COHO (thousands of pounds)** | | | |
| 1976-1980 | 360 | 391 | 277 | 109 | 48 | 1,184 |
| 1981-1985 | 89 | 104 | 89 | 54 | 9 | 345 |
| 1986 | 30 | 30 | 103 | 30 | 8 | 202 |
| 1987 | 32 | 67 | 140 | 7 | 1 | 246 |
| 1988 | 19 | 78 | 174 | 46 | 2 | 320 |
| 1989 | 29 | 24 | 137 | 38 | 3 | 231 |
| 1990 | - | 15 | 125 | 142 | 32 | 314 |
| 1991 | 1 | 19 | 55 | 270 | 115 | 459 |
| 1992 | - | b/ | b/ | 10 | 1 | 11 |
| 1993 | - | - | - | - | - | - |
| 1994 | - | - | - | - | - | - |
| 1995 | - | - | - | - | - | - |
| 1996 | - | - | - | - | - | - |
| 1997 | - | - | - | - | - | - |

a/ The major port areas listed include the following ports: Crescent City includes only Crescent City; Eureka also includes Trinidad and Humboldt Bay locations; Fort Bragg also includes Shelter Cove, Noyo Harbor, Mendocino, and Pt. Arena; San Francisco also includes Bodega Bay, San Francisco Bay, and Half Moon Bay; Monterey also includes Santa Cruz, Moss Landing, Monterey, Morro Bay, and Santa Barbara.

b/ Less than 500 pounds.

c/ Preliminary.

TABLE B-33. **Pounds** of salmon **landed** by the commercial **troll** ocean salmon fishery for major **Oregon** port areas.[a]

| Year or Average | Astoria | Tillamook | Newport | Coos Bay | Brookings | State Total |
|---|---|---|---|---|---|---|
| | | | **CHINOOK (thousands of pounds)** | | | |
| 1976-1980 | 171 | 118 | 530 | 908 | 700 | 2,427 |
| 1981-1985 | 92 | 45 | 271 | 638 | 386 | 1,432 |
| 1986 | 61 | 119 | 751 | 1,990 | 449 | 3,370 |
| 1987 | 83 | 419 | 997 | 2,997 | 685 | 5,182 |
| 1988 | 37 | 341 | 1,231 | 2,198 | 580 | 4,387 |
| 1989 | 50 | 302 | 777 | 1,945 | 449 | 3,532 |
| 1990 | 28 | 139 | 388 | 1,452 | 174 | 2,181 |
| 1991 | 9 | 110 | 267 | 292 | 18 | 695 |
| 1992 | 17 | 108 | 676 | 206 | 7 | 1,013 |
| 1993 | 5 | 86 | 460 | 182 | 28 | 761 |
| 1994 | b/ | 29 | 165 | 45 | 47 | 287 |
| 1995 | 6 | 96 | 1,330 | 453 | 55 | 1,941 |
| 1996 | 21 | 125 | 1,219 | 417 | 142 | 1,926 |
| 1997[c] | 3 | 32 | 1,053 | 381 | 73 | 1,542 |
| | | | **COHO (thousands of pounds)** | | | |
| 1976-1980 | 385 | 660 | 1,190 | 1,661 | 357 | 4,252 |
| 1981-1985 | 133 | 293 | 451 | 550 | 111 | 1,537 |
| 1986 | 109 | 418 | 885 | 393 | 101 | 1,905 |
| 1987 | 57 | 380 | 517 | 894 | 67 | 1,916 |
| 1988 | 17 | 766 | 1,375 | 1,087 | 91 | 3,336 |
| 1989 | 115 | 530 | 615 | 672 | 63 | 1,996 |
| 1990 | 69 | 272 | 73 | 197 | 24 | 634 |
| 1991 | 69 | 431 | 440 | 464 | 7 | 1,411 |
| 1992 | 6 | 33 | 112 | 55 | b/ | 206 |
| 1993 | 8 | 1 | - | - | - | 9 |
| 1994 | - | - | - | - | - | - |
| 1995 | - | - | - | - | - | - |
| 1996 | - | - | - | - | - | - |
| 1997 | - | - | - | - | - | - |

a/ The port areas listed include landings in the following ports: Astoria also includes Gearhart/Seaside and Cannon Beach; Tillamook also includes Garibaldi, Netarts, Pacific City, and Nehalem Bay; Newport also includes Depoe Bay, Siletz Bay, Salmon River, and Waldport; Coos Bay also includes Florence, Winchester Bay, Charleston, and Bandon; Brookings also includes Port Orford and Gold Beach.

b/ Less than 500.

c/ Preliminary.

TABLE B-34. **Pounds** of salmon **landed** by the **non-Indian commercial troll** ocean salmon fishery for major **Washington** port areas.[a/b/]

| Year | Neah Bay | La Push | Westport | Ilwaco | Coastal Community Total | Puget Sound | State Total |
|---|---|---|---|---|---|---|---|
| **CHINOOK (thousands of pounds)** | | | | | | | |
| 1976-1980 | 288 | 421 | 919 | 261 | 1,889 | 426 | 1,543 |
| 1981-1985 | 88 | 32 | 370 | 74 | 564 | 124 | 689 |
| 1986 | 50 | 21 | 141 | 75 | 286 | 55 | 342 |
| 1987 | 42 | 20 | 367 | 65 | 494 | 51 | 545 |
| 1988 | 94 | 30 | 250 | 57 | 430 | 348 | 778 |
| 1989 | 20 | 2 | 277 | 28 | 327 | 124 | 451 |
| 1990 | 149 | 15 | 135 | 17 | 315 | 34 | 349 |
| 1991 | 128 | 7 | 127 | 14 | 276 | 32 | 308 |
| 1992 | 160 | 46 | 232 | 10 | 447 | 58 | 507 |
| 1993 | 122 | 35 | 132 | 2 | 291 | 41 | 332 |
| 1994[c/] | - | - | - | - | - | 7 | 7 |
| 1995[c/] | - | - | 3 | - | 3 | 12 | 15 |
| 1996[c/] | - | - | 4 | 1 | 5 | 13 | 19 |
| 1997 | 20 | d/ | 45 | 0 | 66 | 15 | 80 |
| **COHO (thousands of pounds)** | | | | | | | |
| 1976-1980 | 600 | 786 | 1,066 | 678 | 3,130 | 496 | 3,626 |
| 1981-1985 | 133 | 63 | 277 | 142 | 616 | 128 | 744 |
| 1986 | 58 | 30 | 118 | 72 | 279 | 38 | 317 |
| 1987 | 9 | 15 | 135 | 47 | 206 | 7 | 213 |
| 1988 | 1 | 0 | 2 | 8 | 11 | 9 | 20 |
| 1989 | 121 | 2 | 19 | 79 | 221 | 24 | 245 |
| 1990 | 159 | 46 | 214 | 61 | 480 | 20 | 501 |
| 1991 | 87 | 16 | 126 | 45 | 274 | 31 | 304 |
| 1992 | 25 | 13 | 21 | 4 | 63 | 12 | 75 |
| 1993 | 11 | 7 | 43 | 2 | 63 | 3 | 66 |
| 1994 | - | - | - | - | - | - | - |
| 1995 | 84 | 18 | 7 | - | 109 | 2 | 111 |
| 1996 | 45 | 1 | 23 | 0 | 68 | d/ | 68 |
| 1997 | - | - | - | - | - | - | - |

a/ All values in this table are based on preliminary information available at the start of each year's review.

b/ The major port areas listed may include smaller ports as follows: Neah Bay includes only Neah Bay; La Push also includes Kalaloch; Westport also includes Aberdeen, Bay City, Copalis Beach, Hoquiam, Moclips, Taholah, Bay Center, Grayland Beach, Raymond, South Bend, and Tokeland; Ilwaco also includes Long Beach, Nahcotta, Naselle, and all Columbia River Ports; Puget Sound includes all Puget Sound ports east of Neah Bay.

c/ There was no ocean commercial fishery for chinook north of Cape Falcon, however, chinook were caught off Oregon and landed in Washington.

d/ Less than 500.

TABLE B-35. West Coast troll salmon landings[a/] in dressed weight, value of landings and number of registered vessels making commercial salmon landings, by state.[b/]

| | California | | | | Oregon | | | | Washington | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | Vessels Landing Salmon | Vessels with Permits | Nominal Average Exvessel Value/Vessel (dollars) | Real Average Exvessel Value/Vessel (dollars)[c/] | Vessels Landing Salmon | Vessels with Permits | Nominal Average Exvessel Value/Vessel (dollars) | Real Average Exvessel Value/Vessel (dollars) | Vessels Landing Salmon | Vessels with Permits | Nominal Average Exvessel Value/Vessel (dollars) | Real Average Exvessel Value/Vessel (dollars) |
| 1974 | 3,185 | - | 2,516 | 7,353 | 2,253 | - | 3,523 | 10,297 | | | | |
| 1975 | 3,150 | - | 2,213 | 5,913 | 2,304 | - | 2,521 | 6,734 | | | | |
| 1976 | 3,526 | - | 3,037 | 7,664 | 2,770 | - | 5,368 | 13,547 | | | | |
| 1977 | 3,797 | - | 3,180 | 7,538 | 3,108 | - | 3,695 | 8,760 | | | | |
| 1978 | 4,919 | - | 2,236 | 4,941 | 3,158 | - | 2,324 | 5,135 | 3,041 | 3,291 | 3,297 | 7,284 |
| 1979 | 4,593 | - | 4,280 | 8,714 | 3,114 | - | 5,456 | 11,107 | 2,778 | 3,068 | 5,432 | 11,059 |
| 1980 | 4,738 | - | 2,775 | 5,172 | 3,875[d/] | 4,314 | 2,112 | 3,937 | 2,626 | 2,797 | 2,709 | 5,049 |
| 1981 | 4,102 | - | 3,491 | 5,947 | 3,615 | 3,926 | 2,648 | 4,511 | 2,439 | 2,603 | 2,428 | 4,135 |
| 1982 | 4,013 | 5,964 | 4,856 | 7,782 | 3,269 | 3,646 | 3,027 | 4,850 | 2,253 | 2,512 | 2,987 | 4,787 |
| 1983 | 3,223 | 4,617 | 1,430 | 2,197 | 2,951 | 3,439 | 778 | 1,196 | 2,045 | 2,328 | 716 | 1,101 |
| 1984 | 2,569 | 4,180 | 2,944 | 4,360 | 771 | 3,203[e/] | 2,069 | 3,064 | 381 | 2,071[f/] | 1,076 | 1,594 |
| 1985 | 2,308 | 3,869 | 4,989 | 7,144 | 2,050 | 2,993[g/] | 2,817 | 4,033 | 1,259 | 1,650[h/] | 1,272 | 1,821 |
| 1986 | 2,582 | 3,753 | 5,853 | 8,167 | 2,288 | 2,739 | 3,476 | 4,851 | 1,252 | 1,531 | 938 | 1,310 |
| 1987 | 2,442 | 3,533 | 10,493 | 14,204 | 2,111 | 2,626 | 7,941 | 10,750 | 883 | 1,401 | 2,220 | 3,005 |
| 1988 | 2,571 | 3,493 | 16,308 | 21,299 | 2,061 | 2,597 | 10,449 | 13,648 | 650 | 1,337 | 3,596 | 4,696 |
| 1989 | 2,534 | 3,464 | 5,322 | 6,669 | 1,937 | 2,569 | 5,176 | 6,486 | 883 | 1,306 | 1,393 | 1,746 |
| 1990 | 2,115 | 3,372 | 5,700 | 6,848 | 1,557 | 2,528 | 4,265 | 5,124 | 897 | 1,170 | 1,837 | 2,207 |
| 1991 | 1,769 | 3,242 | 5,114 | 5,909 | 1,217 | 2,044[i/] | 2,564 | 2,962 | 811 | 1,013 | 1,388 | 1,604 |
| 1992 | 1,085 | 2,974 | 4,152 | 4,669 | 649 | 2,111 | 4,179 | 4,699 | 604 | 806 | 2,151 | 2,418 |
| 1993 | 1,240 | 2,740 | 4,602 | 5,042 | 612 | 1,814 | 2,735 | 2,991 | 474 | 668 | 1,677 | 1,837 |
| 1994 | 1,024 | 2,470 | 6,286 | 6,726 | 371 | 1,569 | 1,859 | 1,990 | 1 | 7[j/] | f/ | f/ |
| 1995 | 1,104 | 2,333 | 10,591 | 11,051 | 476 | 1,465 | 6,920 | 7,221 | 96 | 435[k/] | 948 | 989 |
| 1996 | 985 | 2,222 | 6,075 | 6,198 | 455 | 1,377 | 6,609 | 6,743 | 90 | 333 | 943 | 963 |
| 1997[l/] | 832 | 2,069 | 8,654 | 8,654 | 433 | 1,286 | 5,701 | 5,701 | 51 | 323[m/] | 2,470 | 2,470 |

a/ Includes only chinook and coho salmon landings.

b/ Derived from vessel registrations and fish landing tickets.

c/ Expressed in 1997 dollars.

d/ The establishment of a restricted vessel permit system drew a number of historically active vessels back into the fishery in 1980.

e/ Vessels were not required to land one salmon in 1984 to be eligible for a permit in 1985. The Oregon Fish and Wildlife Commission waived this requirement, because of the elimination of the coho fishery south of Cape Falcon.

f/ 312 licenses and delivery permits purchased by buyback program.

g/ Vessels traditionally landing salmon south of Cape Blanco and north of Cape Falcon were not required to land one salmon in 1985 to be eligible for a permit in 1986. The Oregon Fish and Wildlife Commission waived this requirement, because of the complete salmon closure south of Cape Blanco and a limited one-day coho season between the Columbia River and Cape Blanco.

h/ 118 licenses and delivery permits purchased by buyback program.

i/ Legislation passed during the 1991 season of the Oregon Legislature **waived** the requirement that troll permit holders must buy a 1991 permit to be able to renew for 1992. This was a **one-time** exemption for 1991 only.

j/ Vessels were not required to purchase a permit in 1994 to maintain their eligibility for a permit in 1995.

k/ 190 licenses and delivery permits purchased by buyback program.

l/ Preliminary.

m/ 72 licenses and delivery permits purchased by buyback program at the end of 1996 and early 1997.

TABLE B-36. Number of commercial salmon vessels by fishery area.[a/]

|  | Inside Fisheries |  |  | Ocean Fisheries |  |  |  |  |  |
|---|---|---|---|---|---|---|---|---|---|
| Year | Puget Sound | Washington Coast | Columbia River | North of Cape Falcon | Cape Falcon to Cape Blanco | Cape Blanco to Horse Mountain | Horse Mountain to Point Arena | South of Point Arena | All Ocean Fisheries[b/] |
| 1981 | 1,868 | 366 | 825 | 2,812 | 2,706 | 1,916 | 906 | 2,260 | 9,037 |
| 1982 | 1,812 | 370 | 806 | 2,464 | 2,567 | 1,818 | 1,064 | 2,345 | 8,539 |
| 1983 | 1,746 | 328 | 746 | 2,224 | 2,312 | 1,317 | 620 | 1,848 | 7,492 |
| 1984 | 1,532 | 289 | 750 | 572 | 488 | 800 | 519 | 1,689 | 3,447 |
| 1985 | 1,645 | 251 | 621 | 1,713 | 1,808 | 204 | 749 | 1,706 | 5,379 |
| 1986 | 1,519 | 234 | 669 | 1,618 | 1,975 | 893 | 769 | 1,653 | 5,665 |
| 1987 | 1,567 | 302 | 755 | 1,032 | 1,980 | 753 | 832 | 1,646 | 4,920 |
| 1988 | 1,619 | 315 | 856 | 684 | 2,001 | 723 | 849 | 1,830 | 4,710 |
| 1989 | 1,514 | 258 | 695 | 1,009 | 1,849 | 644 | 789 | 1,943 | 4,921 |
| 1990 | 1,482 | 266 | 640 | 1,024 | 1,466 | 300 | 560 | 1,631 | 4,216 |
| 1991 | 1,392 | 265 | 655 | 1,056 | 1,153 | 176 | 444 | 1,494 | 3,601 |
| 1992 | 1,241 | 273 | 519 | 678 | 629 | 6 | 41 | 1,065 | 2,261 |
| 1993 | 1,277 | 273 | 463 | 521 | 587 | 29 | 225 | 1,110 | 2,226 |
| 1994 | 1,024 | 218 | 390 | - | 348 | 54 | 151 | 934 | 1,346 |
| 1995 | 809 | 189 | 227 | 93 | 455 | 75 | 118 | 1,106 | 1,683 |
| 1996 | 518 | 196 | 230 | 86 | 427 | 125 | 129 | 881 | 1,477 |
| 1997 | 719 | 164 | 196 | 57 | 404 | 75 | 58 | 788 | 1,286 |

a/ Based on PacFIN annual vessel summary files retrieved from system July 9, 1998.

b/ Vessels with unspecified West Coast ocean catch areas are excluded from this total.

TABLE B-37. Geographic outline of West Coast recreational ocean seasons, 1978.

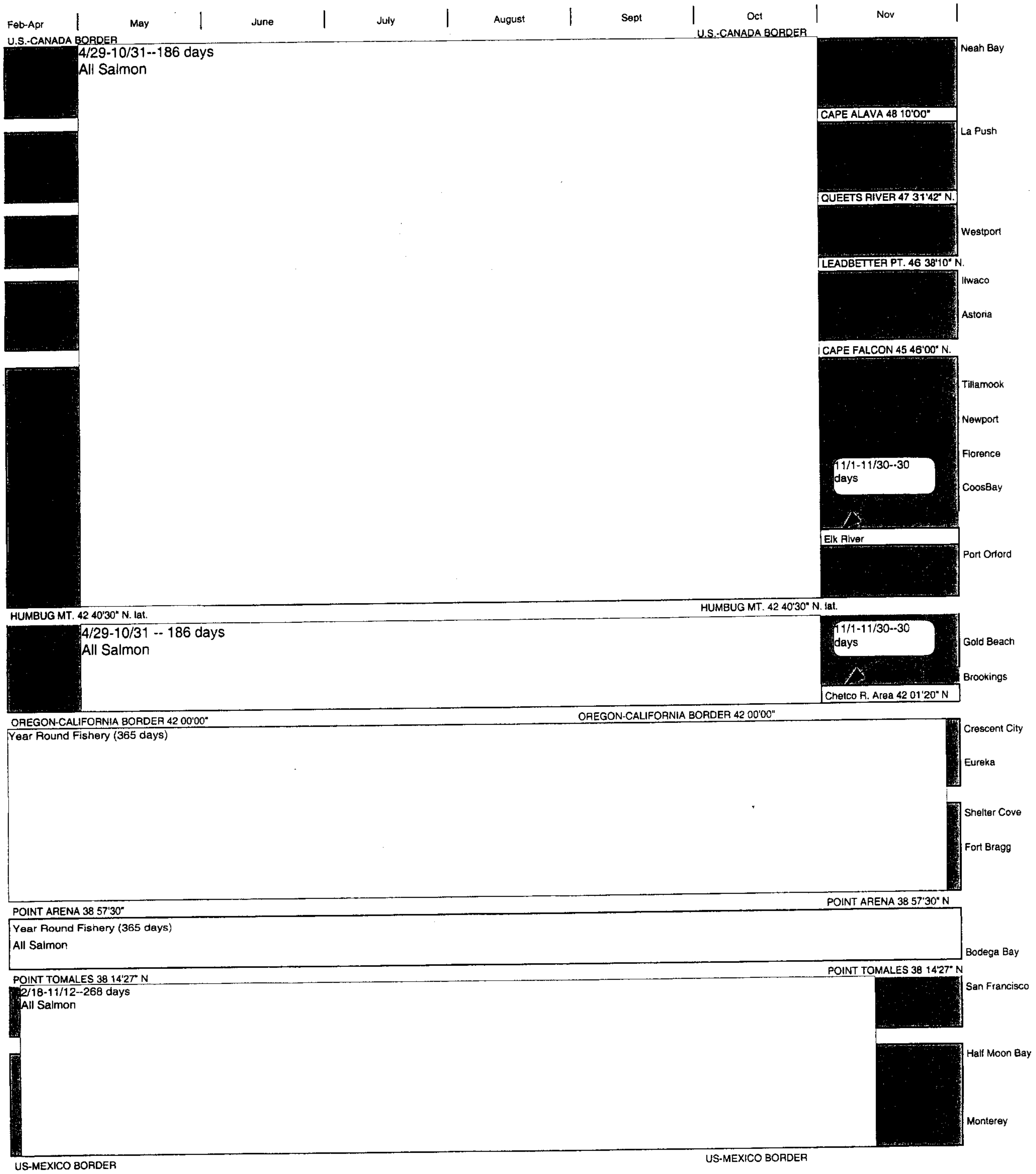


TABLE B-38. Geographic outline of West Coast recreational ocean seasons, 1984.

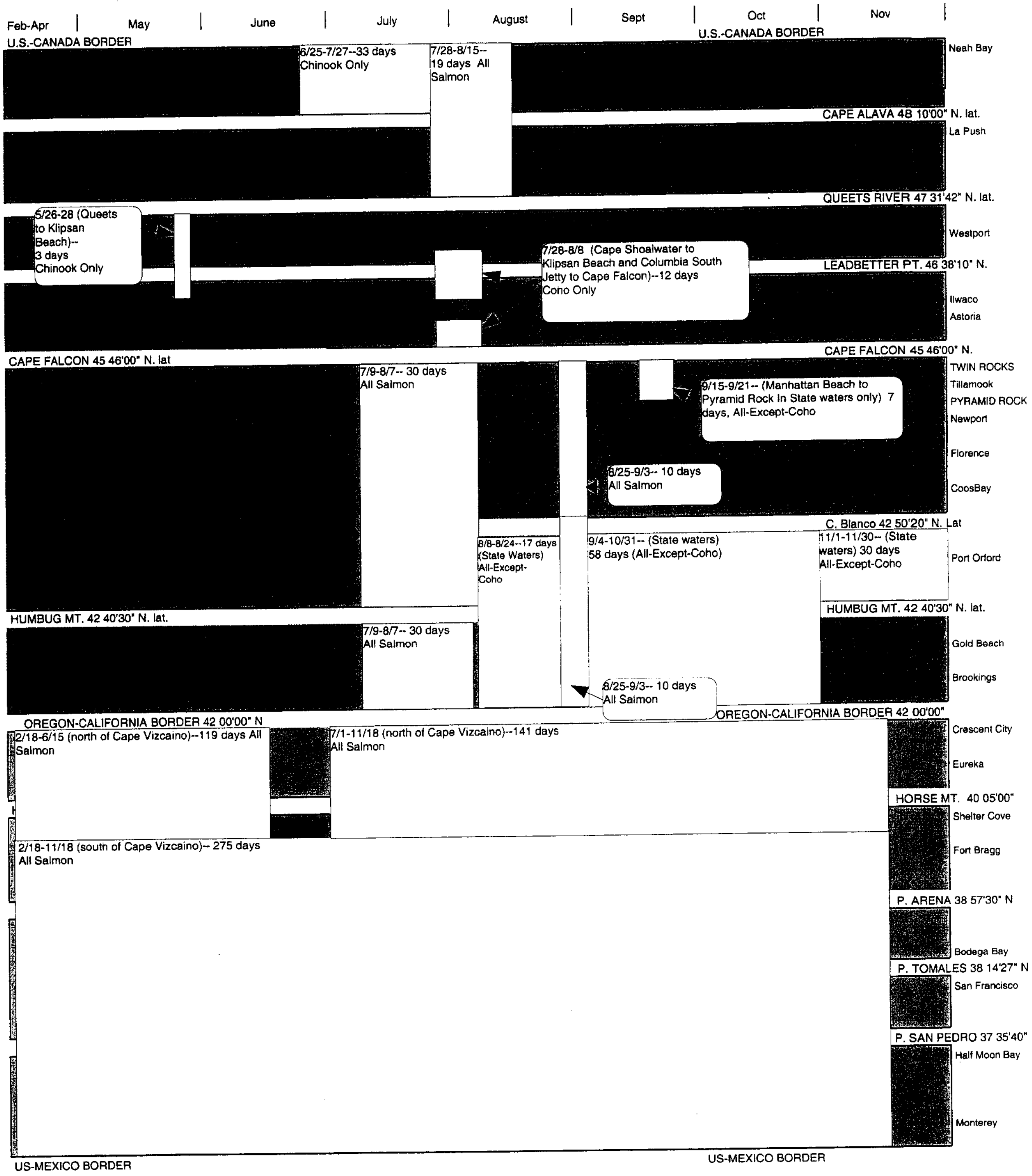


TABLE B-39. Geographic outline of West Coast recreational ocean seasons, 1988.

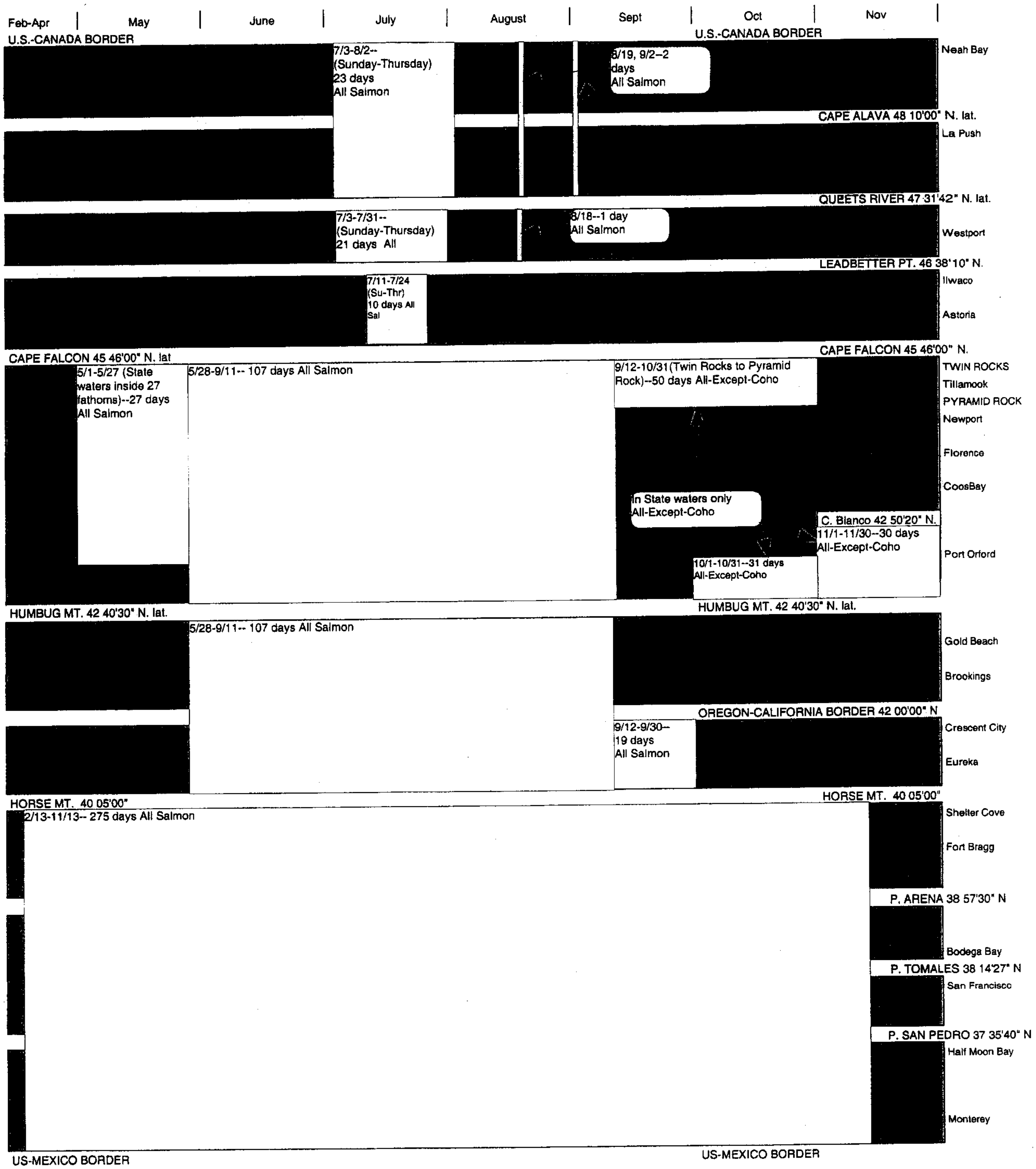


TABLE B-40. Geographic outline of West Coast recreational ocean seasons, 1994.

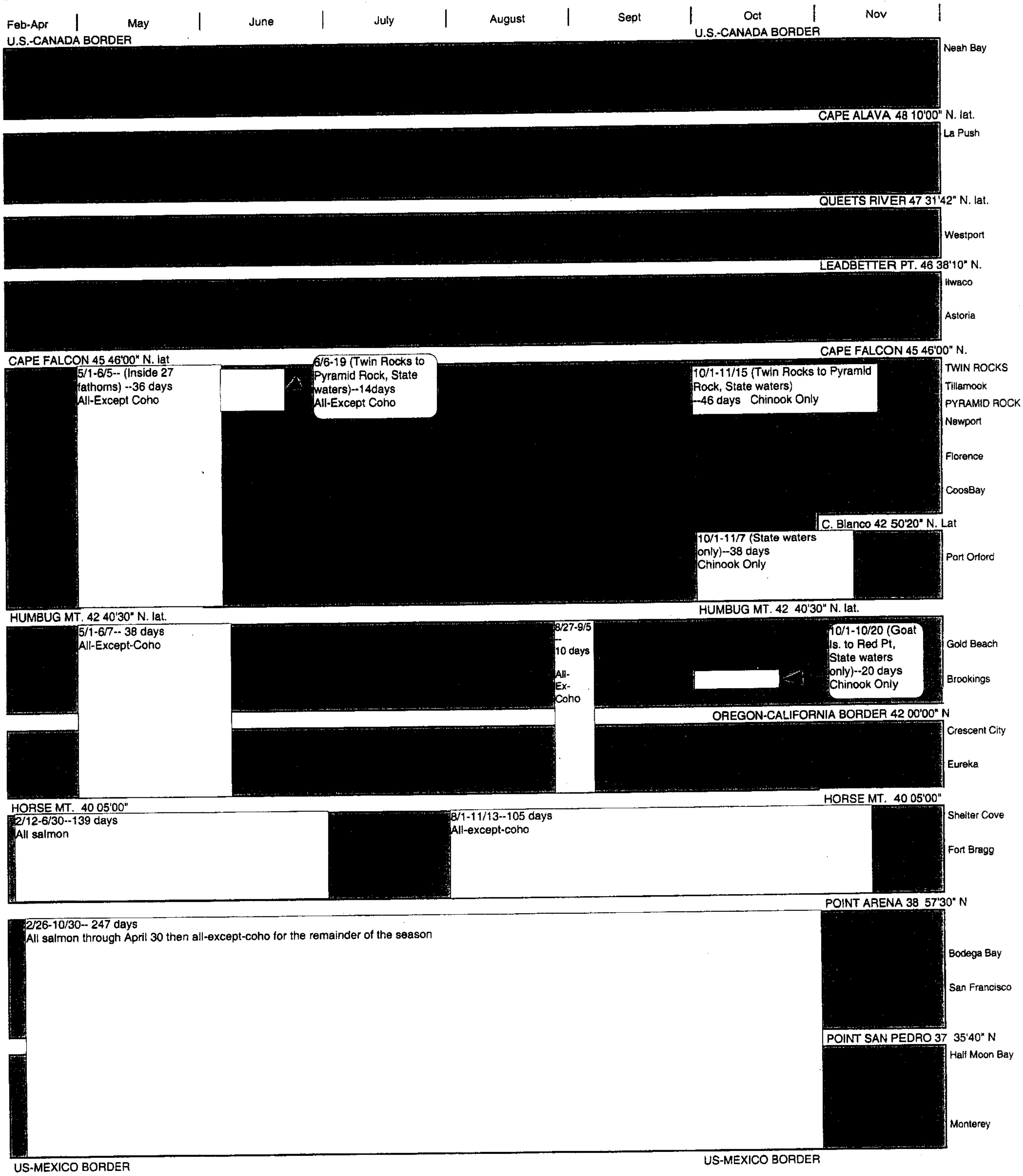
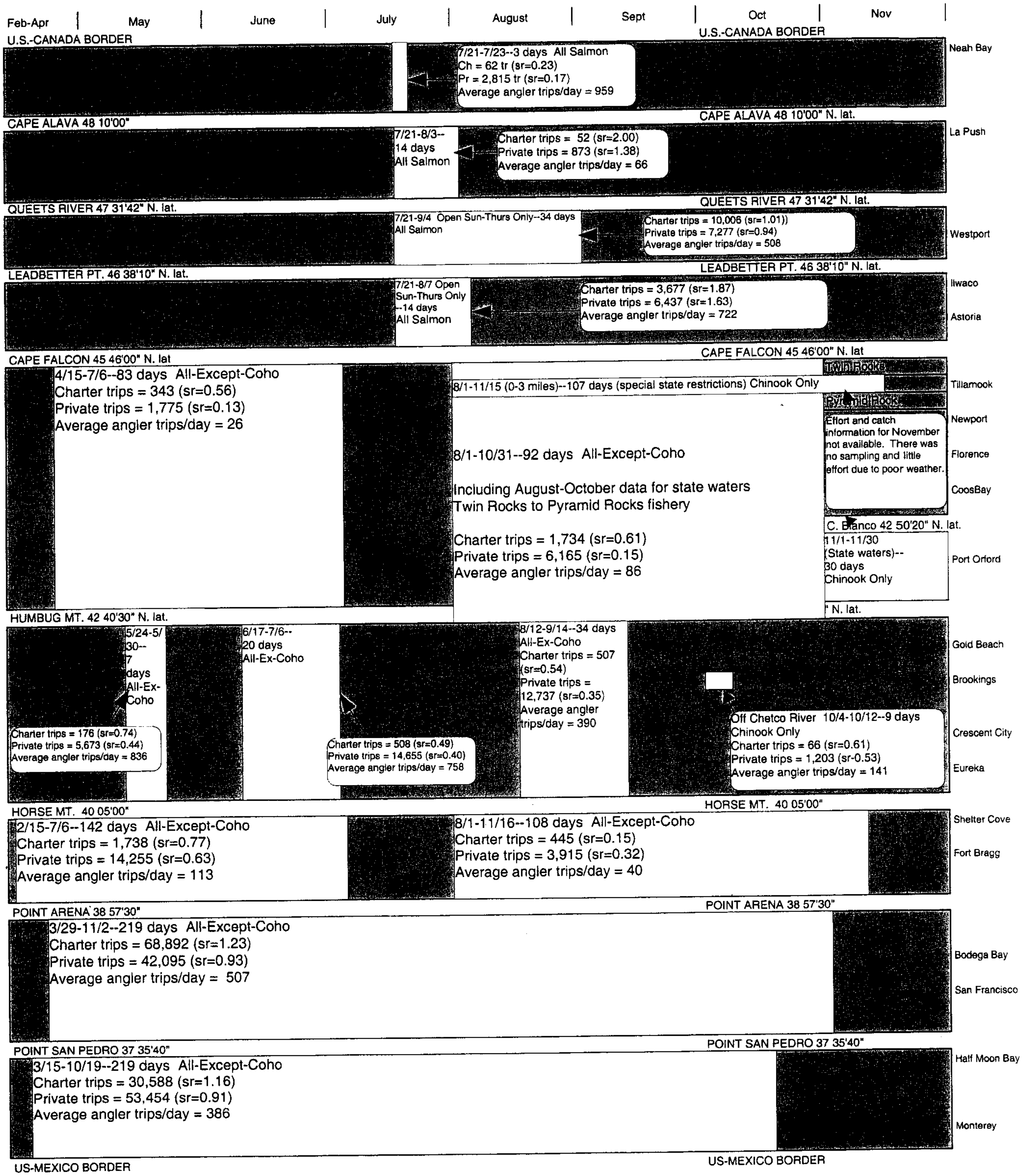


TABLE B-41. Geographic outline of West Coast recreational ocean seasons, 1997.



U.S.-Canada Border – Cape Alava:

7/21-7/23--3 days All Salmon
Ch = 62 tr (sr=0.23)
Pr = 2,815 tr (sr=0.17)
Average angler trips/day = 959

Cape Alava – Queets River:

7/21-8/3--
14 days
All Salmon

Charter trips = 52 (sr=2.00)
Private trips = 873 (sr=1.38)
Average angler trips/day = 66

Queets River – Leadbetter Pt.:

7/21-9/4 Open Sun-Thurs Only--34 days
All Salmon

Charter trips = 10,006 (sr=1.01))
Private trips = 7,277 (sr=0.94)
Average angler trips/day = 508

Leadbetter Pt. – Cape Falcon:

7/21-8/7 Open
Sun-Thurs Only
--14 days
All Salmon

Charter trips = 3,677 (sr=1.87)
Private trips = 6,437 (sr=1.63)
Average angler trips/day = 722

Cape Falcon – Humbug Mt.:

4/15-7/6--83 days All-Except-Coho
Charter trips = 343 (sr=0.56)
Private trips = 1,775 (sr=0.13)
Average angler trips/day = 26

8/1-11/15 (0-3 miles)--107 days (special state restrictions) Chinook Only

8/1-10/31--92 days All-Except-Coho

Including August-October data for state waters
Twin Rocks to Pyramid Rocks fishery

Charter trips = 1,734 (sr=0.61)
Private trips = 6,165 (sr=0.15)
Average angler trips/day = 86

Effort and catch
information for November
not available. There was
no sampling and little
effort due to poor weather.

11/1-11/30
(State waters)--
30 days
Chinook Only

Humbug Mt. – Horse Mt.:

5/24-5/30--
7
days
All-Ex-
Coho

Charter trips = 176 (sr=0.74)
Private trips = 5,673 (sr=0.44)
Average angler trips/day = 836

6/17-7/6--
20 days
All-Ex-Coho

Charter trips = 508 (sr=0.49)
Private trips = 14,655 (sr=0.40)
Average angler trips/day = 758

8/12-9/14--34 days
All-Ex-Coho
Charter trips = 507
(sr=0.54)
Private trips =
12,737 (sr=0.35)
Average angler
trips/day = 390

Off Chetco River 10/4-10/12--9 days
Chinook Only
Charter trips = 66 (sr=0.61)
Private trips = 1,203 (sr-0.53)
Average angler trips/day = 141

Horse Mt. – Point Arena:

2/15-7/6--142 days All-Except-Coho
Charter trips = 1,738 (sr=0.77)
Private trips = 14,255 (sr=0.63)
Average angler trips/day = 113

8/1-11/16--108 days All-Except-Coho
Charter trips = 445 (sr=0.15)
Private trips = 3,915 (sr=0.32)
Average angler trips/day = 40

Point Arena – Point San Pedro:

3/29-11/2--219 days All-Except-Coho
Charter trips = 68,892 (sr=1.23)
Private trips = 42,095 (sr=0.93)
Average angler trips/day = 507

Point San Pedro – US-Mexico Border:

3/15-10/19--219 days All-Except-Coho
Charter trips = 30,588 (sr=1.16)
Private trips = 53,454 (sr=0.91)
Average angler trips/day = 386

TABLE B-42. **California, Oregon, and Washington** ocean **recreational** salmon **effort** in thousands of angler trips and **catch** in thousands of fish by boat type.

| Year or Average | Angler Trips | | Chinook Catch[a/] | | Coho Catch[a/] | |
|---|---|---|---|---|---|---|
| | Charter | Private | Charter | Private | Charter | Private |
| | | | **WASHINGTON**[f/g/] | | | |
| 1981-1990 | 77.8 | 64.7 | 29.3 | 11.9 | 95.7 | 73.3 |
| 1979 | 220.8 | 89.8 | 61.1 | 15.7 | 227.9 | 62.4 |
| 1980 | 193.9 | 86.2 | 41.1 | 12.5 | 288.4 | 73.1 |
| 1981 | 162.2 | 74.6 | 62.8 | 21.7 | 182.4 | 55.5 |
| 1982 | 131.9 | 86.8 | 85.8 | 21.0 | 124.0 | 82.5 |
| 1983 | 123.0 | 90.4 | 39.1 | 9.5 | 122.6 | 89.2 |
| 1984 | 29.9 | 46.8 | 7.7 | 7.4 | 38.5 | 49.6 |
| 1985 | 62.9 | 49.8 | 17.4 | 9.2 | 99.0 | 69.0 |
| 1986 | 58.1 | 51.4 | 13.3 | 7.9 | 98.0 | 77.7 |
| 1987 | 53.7 | 48.3 | 27.7 | 12.9 | 59.9 | 58.6 |
| 1988 | 32.4 | 37.1 | 11.2 | 7.8 | 46.1 | 43.7 |
| 1989 | 58.5 | 65.9 | 11.2 | 8.1 | 95.2 | 94.5 |
| 1990 | 65.0 | 94.4 | 16.6 | 13.0 | 90.9 | 113.6 |
| 1991 | 43.7 | 69.6 | 5.0 | 7.3 | 80.2 | 111.6 |
| 1992 | 38.2 | 56.8 | 11.8 | 6.6 | 48.5 | 62.6 |
| 1993 | 40.2 | 68.9 | 5.8 | 6.9 | 52.8 | 62.3 |
| 1994 | - | - | - | - | - | - |
| 1995 | 17.9 | 30.0 | b/ | 0.4 | 26.1 | 37.4 |
| 1996 | 15.3 | 23.5 | b/ | 0.2 | 24.5 | 24.4 |
| 1997[c/] | 12.5 | 15.1 | 1.7 | 2.3 | 12.5 | 12.8 |

a/ Catch numbers may include some illegal harvest.

b/ Less than 50 fish.

c/ Preliminary.

d/ Salmon data from surveyed ports only. These generally include Astoria, Garibaldi, Depoe Bay, Newport, Winchester Bay, Coos Bay, and Brookings. Since 1981, Pacific City and Florence have also been included. Gold Beach data are included from 1981-1987. Astoria was not included in 1994.

e/ Numbers do not include angling from the Columbia River jetty.

f/ Numbers do not include angling from the Columbia River jetty or from the late-season state waters Area 4B fishery.

g/ Values for 1982-1985 include some inriver Columbia River fishing after closure of the ocean fishery.

TABLE B-43. Numbers of recreational charter vessels by state.

| | California (Charter Vessels Catching Salmon) | | | Oregon (All Charter Vessels) | Washington (Licensed Salmon Charter Vessels) |
|---|---|---|---|---|---|
| Year | Active[a/] | Casual | Total | | |
| 1980 | | | | 194 | 510 |
| 1981 | | | | 248 | 478 |
| 1982 | | | | 253 | 415 |
| 1983 | | | | 255 | 375 |
| 1984 | | | | 218 | 334 |
| 1985 | | | | 226 | 288 |
| 1986 | | | | 247 | 308 |
| 1987 | 96 | 53 | 149 | 254 | 280 |
| 1988 | 95 | 71 | 166 | 313 | 281 |
| 1989 | 89 | 93 | 182 | 322 | 276 |
| 1990 | 93 | 67 | 160 | 170 | 273 |
| 1991 | 78 | 108 | 186 | 171 | 267 |
| 1992 | 49 | 91 | 140 | 157 | 269 |
| 1993 | 66 | 61 | 127 | 148 | 265 |
| 1994 | 60 | 42 | 102 | 145 | 260 |
| 1995 | 93 | 71 | 164 | 134 | 231 |
| 1996 | 75 | 51 | 126 | 127 | 210 |
| 1997 | 82 | 38 | 120 | 122 | 209 |

a/ Active vessels land over 100 salmon, casual vessels land 1 to 100 salmon.

TABLE B-44. Central California charter vessel targeting strategies[a/]

| Target Fishing Strategy | | | | | # of Boat Trips Associated with each Target Species Combination | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Rockfish/ Lingcod | Salmon | Potluck | Other | # of boats | Rockfish/ Lingcod | Salmon | Potluck | Other | Total |
| x | | | | 1 | - | - | - | - | - |
| | x | | | 9 | 0 | 164 | 0 | 0 | 164 |
| | | x | | 0 | 0 | 0 | 0 | 0 | 0 |
| | | | x | 5 | 0 | 0 | 0 | 95 | 95 |
| x | x | | | 4 | 0 | 0 | 0 | 0 | 0 |
| x | | x | | 0 | 0 | 0 | 0 | 0 | 0 |
| x | | | x | 2 | - | - | - | - | - |
| | x | x | | 3 | - | - | - | - | - |
| | x | | x | 0 | 0 | 0 | 0 | 0 | 0 |
| | | x | x | 5 | 0 | 0 | 214 | 176 | 390 |
| x | x | x | | 4 | 14 | 313 | 26 | 0 | 354 |
| x | x | | x | 28 | 1,299 | 1,824 | 0 | 277 | 3,400 |
| x | | x | x | 1 | - | - | - | - | - |
| | x | x | x | 10 | 0 | 438 | 113 | 165 | 717 |
| x | x | x | x | 22 | 683 | 1,295 | 446 | 366 | 2,790 |
| | | | Total | 94 | 2,105 | 4,097 | 804 | 1,099 | 8,105 |
| | | Total For Salmon Vessels | | 80 | 1,996 | 4,034 | 585 | 808 | 7,425 |

a/ Based on data from 1995-1997 CPFV logbooks, provided courtesy of California Department of Fish and Game. The central California region is defined to include: Monterey, Santa Cruz, San Mateo, San Francisco, Marin, Sonoma, Solano, Alameda, and Contra Costa counties. Distribution of boat trips across target species combinations not provided when the number of boats associated with a given combination is less than or equal to three (denoted "–" in the table).

TABLE B-45. Northern California charter vessel targeting strategies.[a/]

| Target Fishing Strategy | | | | # of Boat Trips Associated with each Target Species Combination | | | |
|---|---|---|---|---|---|---|---|
| Rockfish/ Lingcod | Salmon | Other | # of boats | Rockfish/ Lingcod | Salmon | Other | Total |
| x | | | 1 | - | - | - | - |
| | x | | 1 | - | - | - | - |
| | | x | 0 | 0 | 0 | 0 | 0 |
| x | x | | 1 | - | - | - | - |
| x | | x | 0 | 0 | 0 | 0 | 0 |
| | x | x | 0 | 0 | 0 | 0 | 0 |
| x | x | x | 10 | 328 | 282 | 88 | 698 |
| | | Total | 13 | 352 | 303 | 95 | 751 |
| Total For Salmon Vessels | | | 12 | 328 | 282 | 88 | 698 |

[a/] Based on data from 1995-1997 CPFV logbooks, provided courtesy of California Department of Fish and Game. The northern California region is defined to include: Mendocino, Humboldt, and Del Norte counties. Distribution of boat trips across target species combinations not provided when the number of boats associated with a given combination is less than or equal to three (denoted "–" in the table).

TABLE B-46. Oregon charter vessels targeting strategies by port, 1998 (ODFW Ocean Salmon Management Program).

| Target Fishing Strategy | | | | | Number of Boats by Port | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Salmon | Bottomfish | Halibut | Tuna | #boats | Astoria[a] | Nehalem | Garibaldi | Pacific City | Depoe Bay | Newport | Winchester Bay | Coos Bay | Bandon | Gold Beach | Brookings |
| | X | | | 14 | | | 1 | 1 | 8 | 1 | | | | 3 | |
| | | X | | 4 | | | 2 | | | 2 | | | | | |
| | X | X | | 8 | | | 6 | | | | | 1 | 1 | | |
| | X | | X | 2 | | | | | 2 | | | | | | |
| | X | X | X | 9 | | | 2 | | 6 | | | | 1 | | |
| X | | | | 5 | 5 | | | | | | | | | | |
| X | X | | | 17 | 6 | | | | 1 | 2 | 1 | | | | 7 |
| X | X | X | | 10 | | 1 | 2 | | 2 | 5 | | | | | |
| X | X | | X | 1 | 1 | | | | | | | | | | |
| X | X | X | X | 13 | 1 | | 1 | | 1 | 9 | | 1 | | | |
| | | | Total: | 83 | 13 | 1 | 14 | 1 | 20 | 19 | 1 | 2 | 2 | 3 | 7 |
| | | | Total Salmon | 46 | 13 | 1 | 3 | 0 | 4 | 16 | 1 | 1 | 0 | 0 | 7 |

a/ All 13 of the Astoria vessels also target sturgeon.

TABLE B-47. Washington charter vessels targeting strategies by port, 1995-1996 (Washington Ocean Sampling Program).

| Target Fishing Strategy | | | | | Number of Boats by Port | | |
|---|---|---|---|---|---|---|---|
| Salmon | Bottomfish | Halibut | Tuna | # boats | Ilwaco[a/] | Westport | Neah Bay |
| | | | x | 1 | 0 | 1 | 0 |
| | | x | | 7 | | | 7 |
| | x | x | | 4 | | 1 | 3 |
| x | | | | 11 | 8 | 3 | |
| x | | | x | 1 | 1 | | |
| x | | x | x | 1 | | 1 | |
| x | x | | | 7 | 5 | 2 | |
| x | x | | x | 3 | 1 | 2 | |
| x | x | x | | 16 | 2 | 8 | 6 |
| x | x | x | x | 18 | 3 | 15 | |
| | | | Total | 69 | 20 | 33 | 16 |
| | | | Total Salmon | 57 | 20 | 31 | 6 |

a/ 14 of the 16 vessels in Ilwaco also target sturgeon.

TABLE B-48. Recreational trips (thousands) in two of the major inside marine water salmon fisheries on the West Coast.

| | Puget Sound | Buoy-10 |
|---|---|---|
| 1985 | 882 | n/a |
| 1986 | 972 | 102 |
| 1987 | 1,180 | 125 |
| 1988 | 927 | 183 |
| 1989 | 1,027 | 148 |
| 1990 | 1,016 | 76 |
| 1991 | 924 | 169 |
| 1992 | 726 | 115 |
| 1993 | 809 | 76 |
| 1994 | 353 | 9 |
| 1995 | 514 | 25 |
| 1996 | n/a | 18 |
| 1997 | n/a | 56 |
| Average | 848 | 92 |

TABLE B-49. Salmon processors/buyers, by total volume purchased of all West Coast salmon species and by percent of total purchases comprised of ocean caught salmon, 1995-1997 average for known processors/buyers (West Coast commercial ocean troll Indian and non-Indian salmon).

| Purchases (all species) | Ocean Salmon as a Percent of Purchases of All Species (1995 through 1997 Average) < 5% | 5%-20% | 20%-50% | 50%-80% | 80%-95% | >95% | Row Total | Cumulative Row Total |
|---|---|---|---|---|---|---|---|---|
| **Number of Processors** | | | | | | | | |
| ≤$10,000 | 21 | 29 | 31 | 37 | 20 | 102 | 240 | 240 |
| $10,000-$150,000 | 40 | 19 | 33 | 12 | 6 | 7 | 117 | 357 |
| $150,000-$500,000 | 12 | 8 | 8 | | | | 28 | 385 |
| $500,000-$3,000,000 | 25 | 8 | 3 | 1 | | 1 | 38 | 423 |
| >$3,000,000 | 11 | 7 | 1 | | | | 19 | 442 |
| Column Total | 109 | 71 | 76 | 50 | 26 | 110 | 442 | |
| Cumulative Column Total | 109 | 180 | 256 | 306 | 332 | 442 | | |
| **Percent of Total Number of Processors** | | | | | | | | |
| ≤$10,000 | 4.8 | 6.6 | 7.0 | 8.4 | 4.5 | 23.1 | 54.3 | 54 |
| $10,000-$150,000 | 9.0 | 4.3 | 7.5 | 2.7 | 1.4 | 1.6 | 26.5 | 81 |
| $150,000-$500,000 | 2.7 | 1.8 | 1.8 | 0.0 | 0.0 | 0.0 | 6.3 | 87 |
| $500,000-$3,000,000 | 5.7 | 1.8 | 0.7 | 0.2 | 0.0 | 0.2 | 8.6 | 96 |
| >$3,000,000 | 2.5 | 1.6 | 0.2 | 0.0 | 0.0 | 0.0 | 4.3 | 100 |
| Column Total | 24.7 | 16.1 | 17.2 | 11.3 | 5.9 | 24.9 | 100.0 | |
| Cumulative Column Total | 24.7 | 40.7 | 57.9 | 69.2 | 75.1 | 100 | | |
| **Exvessel Value of Purchases** | | | | | | | | |
| ≤$10,000 | 3,199 | 16,357 | 45,226 | 87,226 | 51,797 | 192,054 | 395,858 | 395,858 |
| $10,000-$150,000 | 42,824 | 121,803 | 715,268 | 237,167 | 209,100 | 149,093 | 1,475,256 | 1,871,114 |
| $150,000-$500,000 | 92,601 | 392,301 | 684,284 | | | | 1,169,186 | 3,040,300 |
| $500,000-$3,000,000 | 255,116 | 991,753 | 1,422,760 | 277,930 | | 853,023 | 3,800,582 | 6,840,882 |
| >$3,000,000 | 2,136,973 | 3,657,614 | 961,111 | | | | 6,755,699 | 13,596,580 |
| Column Total | 2,530,713 | 5,179,828 | 3,828,649 | 602,324 | 260,897 | 1,194,171 | 13,596,580 | |
| Cumulative Colomn Total | 2,530,713 | 7,710,541 | 11,539,189 | 12,141,513 | 12,402,410 | 13,596,580 | | |
| **Salmon Purchases By Group as a Percent of Total Salmon Purchases** | | | | | | | | |
| ≤$10,000 | 0.0 | 0.1 | 0.3 | 0.6 | 0.4 | 1.4 | 2.9 | 2.9 |
| $10,000-$150,000 | 0.3 | 0.9 | 5.3 | 1.7 | 1.5 | 1.1 | 10.9 | 13.8 |
| $150,000-$500,000 | 0.7 | 2.9 | 5.0 | 0.0 | 0.0 | 0.0 | 9 | 22.4 |
| $500,000-$3,000,000 | 1.9 | 7.3 | 10.5 | 2.0 | 0.0 | 6.3 | 28 | 50.3 |
| >$3,000,000 | 15.7 | 26.9 | 7.1 | 0.0 | 0.0 | 0.0 | 50 | 100.0 |
| Column Total | 18.6 | 38.1 | 28.2 | 4.4 | 1.9 | 8.8 | 100 | |
| Cumulative Column Total | 18.6 | 56.7 | 84.9 | 89.3 | 91.2 | 100.0 | | |

TABLE B-50. Number of salmon processors/buyers and purchases by processor/buyer rank (based on value of ocean caught salmon purchases) and grouped by level of ocean caught salmon purchases, 1995 through 1997 average for known processors/buyers (West Coast commercial ocean troll Indian and non-Indian salmon).

| | Total Ocean Caught Salmon Purchases (1995 through 1997) | | | | | |
|---|---|---|---|---|---|---|
| Processor/Buyer Percentile Rank | ≤$1,000 | $1,000-10,000 | $10,000-100,000 | $>100,000 | Row Total | Cumulative Row Total |
| **Number of Processors/Buyers** | | | | | | |
| ≤50 | 160 | 61 | | | 221 | 221 |
| 50-80 | | 110 | 22 | | 132 | 353 |
| 80-90 | | | 44 | | 44 | 397 |
| 90-95 | | | 18 | 4 | 22 | 419 |
| 95-100 | | | | 23 | 23 | 442 |
| Column Total | 160 | 171 | 84 | 27 | 442 | |
| Cumulative Column Total | 160 | 331 | 415 | 442 | | |
| **Percent of Total Processors** | | | | | | |
| ≤50 | 36.2 | 13.8 | | | 50.0 | 50.0 |
| 50-80 | | 24.9 | 5.0 | | 29.9 | 79.9 |
| 80-90 | | | 10.0 | | 10.0 | 89.8 |
| 90-95 | | | 4.1 | 0.9 | 5.0 | 94.8 |
| 95-100 | | | | 5.2 | 5.2 | 100.0 |
| Column Total | 36.2 | 38.7 | 19.0 | 6.1 | 100.0 | |
| Cumulative Column Total | 36.2 | 74.9 | 93.9 | 100.0 | | |
| **Exvessel Value of Salmon Purchases ($)** | | | | | | |
| ≤50 | 56,370 | 91,638 | | | 148,008 | 148,008 |
| 50-80 | | 477,491 | 255,808 | | 733,299 | 881,306 |
| 80-90 | | | 1,051,286 | | 1,051,286 | 1,932,593 |
| 90-95 | | | 1,171,845 | 499,840 | 1,671,684 | 3,604,277 |
| 95-100 | | | | 9,992,304 | 9,992,304 | 13,596,580 |
| Column Total | 56,370 | 569,128 | 2,478,939 | 10,492,143 | 13,596,580 | |
| Cumulative Column Total | 56,370 | 625,498 | 3,104,437 | 13,596,580 | | |
| **Salmon Purchases By Group as a Percent of Total Salmon Purchases** | | | | | | |
| ≤50 | 0.4 | 0.7 | | | 1.1 | 1.1 |
| 50-80 | | 3.5 | 1.9 | | 5.4 | 6.5 |
| 80-90 | | | 7.7 | | 7.7 | 14.2 |
| 90-95 | | | 8.6 | 3.7 | 12.3 | 26.5 |
| 95-100 | | | | 73.0 | 73.0 | .100.0 |
| Column Total | 0.4 | 4.2 | 17.7 | 77.7 | 100.0 | |
| Cumulative Column Total | 0.4 | 4.6 | 22.3 | 100.0 | | |

TABLE B-51. Number of state licensed buyers and processors receiving fish landed on the West Coast.

| Purchases (All West Coast Species) | Number of Buyers and Processors Handling All Species | Number of Buyers and Processors Handling Ocean Caught Salmon | Percent Handling Ocean Caught Salmon |
|---|---|---|---|
| <$10,000 | 1,101 | 240 | 21.8 |
| $10,000-$150,000 | 557 | 117 | 21.0 |
| $150,000-$500,000 | 123 | 28 | 22.8 |
| $500,000-$3,000,000 | 122 | 38 | 31.1 |
| >$3,000,000 | 24 | 19 | 79.2 |
| Column Total | 1,927 | 442 | 22.3 |

TABLE B-52. Numbers of processors/buyers and purchases, by processor/buyer rank (based on value of ocean-caught salmon purchases) and by number of vessels from which deliveries are received, 1995 through 1997 average for known processors/buyers (West Coast commercial ocean troll Indian and non-Indian salmon).

| Processor/Buyer Percentile Rank | Number of Vessels from Which Deliveries are Received (1995 through 1997 Average) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1-2 | >2-8 | >8-16 | >16-64 | >64 | Row Total | Cum Row Tot |
| | | | | **Number of Processor/Buyers** | | | |
| ≤50 | 197 | 17 | | | | 214 | 214 |
| 50-80 | 69 | 45 | 16 | | | 130 | 344 |
| 80-90 | 5 | 15 | 11 | 10 | | 41 | 385 |
| 90-95 | | 2 | 3 | 17 | | 22 | 407 |
| 95-100 | | | | 6 | 17 | 23 | 430 |
| Column Total | 271 | 79 | 30 | 33 | 17 | 430 | |
| Cumulative Column Total | 271 | 350 | 380 | 413 | 430 | | |
| | | | | **Percent of Processors/Buyers** | | | |
| ≤50 | 45.8 | 4.0 | | | | 49.8 | 49.8 |
| 50-80 | 16.0 | 10.5 | 3.7 | | | 30.2 | 80.0 |
| 80-90 | 1.2 | 3.5 | 2.6 | 2.3 | | 9.5 | 89.5 |
| 90-95 | | 0.5 | 0.7 | 4.0 | | 5.1 | 94.7 |
| 95-100 | | | | 1.4 | 4.0 | 5.3 | 100.0 |
| Column Total | 63.0 | 18.4 | 7.0 | 7.7 | 4.0 | 100.0 | |
| Cumulative Column Total | 63.0 | 81.4 | 88.4 | 96.0 | 100.0 | | |
| | | | | **Exvessel Value of Salmon Purchases ($)** | | | |
| ≤50 | 124,156 | 21,990 | | | | 146,146 | 146,146 |
| 50-80 | 302,431 | 286,572 | 138,735 | | | 727,738 | 873,883 |
| 80-90 | 124,847 | 316,500 | 268,328 | 256,688 | | 966,362 | 1,840,245 |
| 90-95 | | 132,189 | 176,151 | 1,363,344 | | 1,671,684 | 3,511,929 |
| 95-100 | | | | 1,214,885 | 8,777,418 | 9,992,304 | 13,504,233 |
| Column Total | 551,433 | 757,251 | 583,213 | 2,834,917 | 8,777,418 | 13,504,233 | |
| Cumulative Column Total | 551,433 | 1,308,684 | 1,891,897 | 4,726,815 | 13,504,233 | | |
| | | | | **Salmon Purchases By Group as a Percent of Total Salmon Purchases** | | | |
| ≤50 | 0.9 | 0.2 | 0.0 | 0.0 | 0.0 | 1.1 | 1.1 |
| 50-80 | 2.2 | 2.1 | 1.0 | 0.0 | 0.0 | 5.4 | 6.5 |
| 80-90 | 0.9 | 2.3 | 2.0 | 1.9 | 0.0 | 7.2 | 13.6 |
| 90-95 | 0.0 | 1.0 | 1.3 | 10.1 | 0.0 | 12.4 | 26.0 |
| 95-100 | 0.0 | 0.0 | 0.0 | 9.0 | 65.0 | 74.0 | 100.0 |
| Column Total | 5.6 | 4.3 | 21.0 | 65.0 | 100.0 | 100.0 | |
| Cumulative Column Total | 9.7 | 14.0 | 35.0 | 100.0 | | | |
| | | | | **Average Salmon Purchases Per Processor/Buyer** | | | |
| | | | | | | Row Average (Weighted) | |
| ≤50 | 630 | 1,294 | | | | 683 | |
| 50-80 | 4,383 | 6,368 | 8,671 | | | 5,598 | |
| 80-90 | 24,969 | 21,100 | 24,393 | 25,669 | | 23,570 | |
| 90-95 | | 66,095 | 58,717 | 80,197 | | 75,986 | |
| 95-100 | | | | 202,481 | 516,319 | 434,448 | |
| Column Average (Weighted) | 2,035 | 9,585 | 19,440 | 85,907 | 516,319 | | |

TABLE B-53. Numbers of processors/buyers and salmon purchases, by processor rank (based on value of ocean-caught salmon purchases) and by number of processing/buying sites (all species), 1995 through 1997 average for known processors/buyers (West Coast commercial ocean troll Indian and non-Indian salmon).

| | Number of Processing/Buying Sites (1995 through 1997 Average) | | | | | | |
|---|---|---|---|---|---|---|---|
| Processor/Buyer Percentile Rank | 1 | >1-2 | >2-4 | >4-8 | >8 | Row Total | Cumulative Row Total |
| **Number of Processors/Buyers** | | | | | | | |
| ≤50 | 142 | 51 | 12 | 12 | 4 | 221 | 221 |
| 50-80 | 54 | 37 | 29 | 9 | 3 | 132 | 353 |
| 80-90 | 9 | 8 | 18 | 6 | 3 | 44 | 397 |
| 90-95 | 2 | 2 | 10 | 7 | 1 | 22 | 419 |
| 95-100 | 1 | 2 | 7 | 6 | 7 | 23 | 442 |
| Column Total | 208 | 100 | 76 | 40 | 18 | 442 | |
| Cumulative Column Total | 208 | 308 | 384 | 424 | 442 | | |
| **Percent of Total Processors/Buyers** | | | | | | | |
| ≤50 | 32.1 | 11.5 | 2.7 | 2.7 | 0.9 | 50.0 | 50.0 |
| 50-80 | 12.2 | 8.4 | 6.6 | 2.0 | 0.7 | 29.9 | 79.9 |
| 80-90 | 2.0 | 1.8 | 4.1 | 1.4 | 0.7 | 10.0 | 89.8 |
| 90-95 | 0.5 | 0.5 | 2.3 | 1.6 | 0.2 | 5.0 | 94.8 |
| 95-100 | 0.2 | 0.5 | 1.6 | 1.4 | 1.6 | 5.2 | 100.0 |
| Column Total | 47.1 | 22.6 | 17.2 | 9.0 | 4.1 | 100.0 | |
| Cumulative Column Total | 47.1 | 69.7 | 86.9 | 95.9 | 100.0 | | |
| **Exvessel Value of Salmon Purchases ($)** | | | | | | | |
| ≤50 | 80,444 | 45,712 | 10,042 | 8,157 | 3,652 | 148,008 | 148,008 |
| 50-80 | 271,495 | 208,508 | 164,723 | 66,923 | 21,650 | 733,299 | 881,306 |
| 80-90 | 235,996 | 154,627 | 438,902 | 133,082 | 88,680 | 1,051,286 | 1,932,593 |
| 90-95 | 123,874 | 110,870 | 773,266 | 544,888 | 118,787 | 1,671,684 | 3,604,277 |
| 95-100 | 140,628 | 596,134 | 1,983,398 | 3,820,828 | 3,451,316 | 9,992,304 | 13,596,580 |
| Column Total | 852,436 | 1,115,852 | 3,370,331 | 4,573,877 | 3,684,084 | 13,596,580 | |
| Cumulative Column Total | 852,436 | 1,968,288 | 5,338,619 | 9,912,496 | 13,596,580 | | |
| **Salmon Purchases By Group as a Percent of Total Salmon Purchases** | | | | | | | |
| ≤50 | 0.6 | 0.3 | 0.1 | 0.1 | 0.0 | 1.1 | 1.1 |
| 50-80 | 2.0 | 1.5 | 1.2 | 0.5 | 0.2 | 5.4 | 6.5 |
| 80-90 | 1.7 | 1.1 | 3.2 | 1.0 | 0.7 | 7.7 | 14.2 |
| 90-95 | 0.9 | 0.8 | 5.7 | 4.0 | 0.9 | 12.3 | 26.5 |
| 95-100 | 1.0 | 4.4 | 14.6 | 28.1 | 25.4 | 73.5 | 100.0 |
| Column Total | 6.3 | 8.2 | 24.8 | 33.6 | 27.1 | 100.0 | |
| Cumulative Column Total | 6.3 | 14.5 | 39.3 | 72.9 | 100.0 | | |

TABLE B-54. Numbers of processors/buyers and salmon purchases, by number of vessels from which ocean-caught salmon are received and by number of processing/buying sites (all species), 1995 through 1997 average for known processors/buyers (West Coast commercial ocean troll Indian and non-Indian salmon).

| Number of Vessels from Which Deliveries are Received | Processor/Buyer Number of Processing/Buying Sites (1995 through 1997 Average). | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | >1-2 | >2-4 | >4-8 | >8 | Row Total | Cumulative Row Total |
| | | | **Number of Processors/Buyers** | | | | |
| 1-2 | 174 | 59 | 22 | 12 | 4 | 271 | 271 |
| >2-8 | 15 | 28 | 22 | 11 | 3 | 79 | 350 |
| >8-16 | 8 | 5 | 10 | 4 | 3 | 30 | 380 |
| >16-64 | 2 | 4 | 19 | 7 | 1 | 33 | 413 |
| >64 | | 1 | 3 | 6 | 7 | 17 | 430 |
| Column Total | 199 | 97 | 76 | 40 | 18 | 430 | |
| Cumulative Column Total | 199 | 296 | 372 | 412 | 430 | | |
| | | | **Percent of Total Processors/Buyers** | | | | |
| 1-2 | 40.5 | 13.7 | 5.1 | 2.8 | 0.9 | 63.0 | 63.0 |
| >2-8 | 3.5 | 6.5 | 5.1 | 2.6 | 0.7 | 18.4 | 81.4 |
| >8-16 | 1.9 | 1.2 | 2.3 | 0.9 | 0.7 | 7.0 | 88.4 |
| >16-64 | 0.5 | 0.9 | 4.4 | 1.6 | 0.2 | 7.7 | 96.0 |
| >64 | 0.0 | 0.2 | 0.7 | 1.4 | 1.6 | 4.0 | 100.0 |
| Column Total | 46.3 | 22.6 | 17.7 | 9.3 | 4.2 | 100.0 | |
| Cumulative Column Total | 46.3 | 68.8 | 86.5 | 95.8 | 100.0 | | |
| | | | **Exvessel Value of Salmon Purchases ($)** | | | | |
| 1-2 | 343,921 | 117,106 | 77,864 | 8,891 | 3,652 | 551,433 | 551,433 |
| >2-8 | 103,479 | 206,721 | 307,713 | 117,689 | 21,650 | 757,251 | 1,308,684 |
| >8-16 | 130,946 | 43,495 | 174,753 | 145,340 | 88,680 | 583,213 | 1,891,897 |
| >16-64 | 206,984 | 279,206 | 1,748,811 | 481,130 | 118,787 | 2,834,917 | 4,726,815 |
| >64 | | 444,084 | 1,061,190 | 3,820,828 | 3,451,316 | 8,777,418 | 13,504,233 |
| Column Total | 785,330 | 1,090,611 | 3,370,331 | 4,573,877 | 3,684,084 | 13,504,233 | |
| Cumulative Column Total | 785,330 | 1,875,941 | 5,246,271 | 9,820,149 | 13,504,233 | | |
| | | | **Salmon Purchases By Group as a Percent of Total Salmon Purchases** | | | | |
| 1-2 | 2.5 | 0.9 | 0.6 | 0.1 | 0.0 | 4.1 | 4.1 |
| >2-8 | 0.8 | 1.5 | 2.3 | 0.9 | 0.2 | 5.6 | 9.7 |
| >8-16 | 1.0 | 0.3 | 1.3 | 1.1 | 0.7 | 4.3 | 14.0 |
| >16-64 | 1.5 | 2.1 | 13.0 | 3.6 | 0.9 | 21.0 | 35.0 |
| >64 | 0.0 | 3.3 | 7.9 | 28.3 | 25.6 | 65.0 | 100.0 |
| Column Total | 5.8 | 8.1 | 25.0 | 33.9 | 27.3 | 100.0 | |
| Cumulative Column Total | 5.8 | 13.9 | 38.8 | 72.7 | 100.0 | | |
| | | | **Average Salmon Purchases Per Processor/Buyer** | | | | |
| | | | | | | Row Average (Wtd) | |
| 1-2 | 1,977 | 1,985 | 3,539 | 741 | 913 | 2,035 | |
| >2-8 | 6,899 | 7,383 | 13,987 | 10,699 | 7,217 | 9,585 | |
| >8-16 | 16,368 | 8,699 | 17,475 | 36,335 | 29,560 | 19,440 | |
| >16-64 | 103,492 | 69,801 | 92,043 | 68,733 | 118,787 | 85,907 | |
| >64 | | 444,084 | 353,730 | 636,805 | 493,045 | 516,319 | |
| Column Average (Wtd) | 3,946 | 11,243 | 44,346 | 114,347 | 204,671 | 31,405 | |

TABLE B-55. West Coast ports with more than $10,000 exvessel value of salmon landings for a three-year period (1995-1997) for all areas of catch.

| Washington | | Oregon | | California | |
|---|---|---|---|---|---|
| Port | County | Port | County | Port | County |
| Blaine | Whatcom | Columbia River | Oregon Upriver Counties | Cresent City | Del Norte |
| Bellingham | Whatcom | Astoria | Clatsop | Fields Landing | Humboldt |
| Point Roberts | Whatcom | Garibaldi (Tillamook) | Tillamook | Eureka | Humboldt |
| Friday Harbor | San Juan | Pacific City | Tillamook | Trinidad | Humboldt |
| Anacortes | Skagit | Depoe Bay | Lincoln | Shelter Cove | Humboldt |
| LaConner | Skagit | Newport | Lincoln | Fort Bragg | Mendocino |
| Whidbey Island | Island | Florence | Lane | Albion | Mendocino |
| Everett | Snohomish | Winchester | Douglas | Point Arena | Mendocino |
| Seattle | King | Charleston (Coos Bay) | Coos | Bodega Bay | Sonoma |
| Tacoma | Pierce | Bandon | Coos | Jenner | Sonoma |
| Olympia | Thurston | Port Orford | Curry | Dillon Beach | Marin |
| Shelton | Mason | Brookings | Curry | Bolinas | Marin |
| Port Townsend | Jefferson | | | Sausilito | Marin |
| Queets | Jefferson | | | San Francisco | San Francisco |
| Poulsbo | Kitsap | | | Berkeley | Alameda |
| Bremmerton | Kitsap | | | Richmond | Contra Costa |
| Port Angeles | Clallam | | | Princeton | San Mateo |
| Neah Bay | Clallam | | | Pigeon Point | San Mateo |
| La Push | Clallam | | | Santa Cruz | Santa Cruz |
| Taholah | Grays Harbor | | | Monterey | Monterey |
| Aberdeen | Grays Harbor | | | Moss Landing | Monterey |
| Hoquiam | Grays Harbor | | | Morro Bay | San Luis Obispo |
| Westport | Grays Harbor | | | Avila | San Luis Obispo |
| Grayland | Grays Harbor | | | Santa Barbara | Santa Barbara |
| Tokeland | Pacific | | | Ventura | Ventura |
| Raymond | Pacific | | | San Pedro | Los Angeles |
| South Bend | Pacific | | | | |
| Bay Center | Pacific | | | | |
| Naselle | Pacific | | | | |
| Long Beach | Pacific | | | | |
| Ilwaco | Pacific | | | | |
| Chinook | Pacific | | | | |
| Cathlamet | Wahkiakum | | | | |
| Skamania | Skamania | | | | |
| The Dalles | Klickitat | | | | |

TABLE B-56. Numbers of nonIndian vessels landing, total non-Indian revenue and non-Indian ocean salmon revenue by county, for vessels with valid identification numbers.[a]

| | | Vessels Landing | | | | | | Primary Port[b] Vessels Based on | | | | | | Exvessel Revenue ($ thousands) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | All Vessels | | | Salmon Vessels | | | All Species | | | Ocean Salmon | | | All Species | | | Salmon[c] | | |
| Region | County | 1988 | 1989 | 1997 | 1988 | 1989 | 1997 | 1988 | 1989 | 1997 | 1988 | 1989 | 1997 | 1988 | 1989 | 1997 | 1988 | 1989 | 1997 |
| St. of Geo. | Whatcom | 1,496 | 1,436 | 806 | 1 | 25 | 0 | 804 | 762 | 563 | 0 | 19 | 0 | 23,513 | 24,256 | 18,178 | conf | 89 | 0 |
| San Juan | San Juan | 322 | 197 | 23 | 11 | 2 | 0 | 78 | 59 | 3 | 2 | 1 | 0 | 1,311 | 758 | 42 | 20 | conf | 0 |
| | Skagit | 1,078 | 856 | 276 | 38 | 3 | 0 | 350 | 312 | 136 | 17 | 2 | 0 | 5,887 | 5,718 | 2,799 | 364 | conf | 0 |
| Metro Puget | Snohomish | 806 | 790 | 173 | 178 | 166 | 0 | 189 | 219 | 64 | 52 | 73 | 0 | 5,501 | 5,948 | 1,461 | 115 | 54 | 0 |
| Sound | King | 1,516 | 1,186 | 318 | 180 | 50 | 2 | 558 | 493 | 127 | 48 | 22 | 2 | 11,015 | 9,822 | 8,103 | 416 | 73 | conf |
| | Pierce | 223 | 267 | 142 | 6 | 14 | 0 | 85 | 106 | 60 | 1 | 10 | 0 | 1,363 | 1,765 | 1,835 | conf | 3 | 0 |
| South Puget | Thurston | 36 | 27 | 5 | 17 | 6 | 0 | 10 | 13 | 2 | 2 | 5 | 0 | 23 | 24 | conf | 8 | conf | 0 |
| Sound | Mason | 44 | 75 | 7 | 0 | 1 | 0 | 20 | 12 | 4 | 0 | 1 | 0 | 62 | 75 | 38 | 0 | conf | 0 |
| NE Olympic & | Jefferson | 308 | 307 | 90 | 19 | 14 | 0 | 92 | 74 | 40 | 12 | 6 | 0 | 1,328 | 1,416 | 1,779 | 141 | 61 | 0 |
| NW Olympic | Clallam | 842 | 993 | 272 | 162 | 271 | 25 | 341 | 536 | 145 | 77 | 203 | 20 | 3,795 | 4,535 | 3,451 | 413 | 314 | 48 |
| Central WA | Grays Harbor | 776 | 803 | 369 | 351 | 457 | 26 | 371 | 521 | 258 | 175 | 334 | 23 | 20,943 | 16,780 | 20,456 | 662 | 651 | 70 |
| WA S. Coast & | Pacific | 1,000 | 887 | 342 | 224 | 194 | 0 | 604 | 622 | 253 | 81 | 125 | 0 | 25,366 | 18,704 | 9,863 | 200 | 156 | 0 |
| OR Col. Upriver | Not Identified | 700 | 536 | 192 | 0 | 0 | 0 | 483 | 395 | 158 | 0 | 0 | 0 | 13,560 | 3,300 | 558 | 0 | 0 | 0 |
| Astoria- | Clatsop | 295 | 374 | 246 | 91 | 185 | 5 | 131 | 162 | 155 | 32 | 63 | 2 | 17,559 | 19,626 | 22,489 | 137 | 261 | conf |
| Tillamook | Tillamook | 587 | 593 | 132 | 542 | 547 | 69 | 409 | 385 | 106 | 402 | 365 | 58 | 5,897 | 3,989 | 1,603 | 2,864 | 1,281 | 61 |
| Newport | Lincoln | 975 | 890 | 417 | 758 | 711 | 212 | 640 | 519 | 286 | 532 | 419 | 180 | 25,195 | 19,319 | 21,238 | 7,201 | 2,369 | 1,645 |
| Coos Bay | Lane | 245 | 215 | 45 | 227 | 202 | 34 | 96 | 82 | 28 | 98 | 80 | 26 | 2,196 | 1,004 | 798 | 1,252 | 377 | 139 |
| | Douglas | 362 | 397 | 55 | 332 | 369 | 34 | 237 | 226 | 36 | 221 | 214 | 22 | 2,881 | 2,018 | 1,041 | 1,498 | 917 | 41 |
| | Coos | 925 | 909 | 219 | 829 | 771 | 104 | 458 | 506 | 137 | 455 | 497 | 80 | 18,674 | 16,563 | 12,134 | 6,625 | 3,721 | 436 |
| Brookings | Curry | 471 | 464 | 226 | 382 | 358 | 63 | 184 | 205 | 155 | 129 | 138 | 40 | 6,885 | 9,679 | 8,895 | 2,034 | 1,110 | 140 |
| Cresc. City | Del Norte | 401 | 390 | 275 | 127 | 148 | 5 | 214 | 231 | 175 | 31 | 60 | 0 | 15,824 | 13,143 | 14,274 | 559 | 294 | conf |
| Eureka | Humboldt | 460 | 420 | 259 | 329 | 281 | 28 | 212 | 213 | 181 | 100 | 100 | 20 | 12,774 | 8,819 | 14,271 | 1,774 | 557 | 29 |
| Fort Bragg | Mendocino | 1,059 | 1,016 | 303 | 842 | 777 | 57 | 666 | 607 | 201 | 583 | 508 | 32 | 22,825 | 13,544 | 11,538 | 10,713 | 2,719 | 92 |
| San Fran | Sonoma | 1,033 | 935 | 371 | 877 | 784 | 199 | 565 | 493 | 211 | 527 | 430 | 110 | 15,674 | 6,973 | 5,801 | 10,468 | 2,176 | 734 |
| | Marin | 426 | 357 | 144 | 274 | 234 | 58 | 164 | 111 | 52 | 118 | 87 | 31 | 4,281 | 1,610 | 3,064 | 2,322 | 612 | 329 |
| | San Fran | 656 | 679 | 421 | 261 | 318 | 132 | 307 | 325 | 269 | 108 | 115 | 73 | 9,263 | 8,377 | 19,737 | 1,894 | 865 | 1,089 |
| | Alameda | 227 | 276 | 156 | 127 | 154 | 48 | 112 | 158 | 73 | 82 | 101 | 23 | 3,076 | 3,133 | 2,068 | 1,598 | 674 | 75 |
| | San Mateo | 610 | 740 | 411 | 497 | 620 | 270 | 302 | 331 | 226 | 246 | 292 | 175 | 7,194 | 5,010 | 6,427 | 4,295 | 2,079 | 1,772 |
| | Marin | 426 | 357 | 144 | 274 | 234 | 58 | 164 | 111 | 52 | 118 | 87 | 31 | 4,281 | 1,610 | 3,064 | 2,322 | 612 | 329 |
| Monterey | Monterey | 564 | 574 | 559 | 377 | 397 | 297 | 387 | 391 | 328 | 281 | 304 | 220 | 9,340 | 8,207 | 14,564 | 3,315 | 1,626 | 2,006 |
| | Santa Cruz | 304 | 376 | 188 | 247 | 299 | 131 | 132 | 171 | 85 | 107 | 139 | 56 | 3,079 | 1,942 | 1,619 | 2,002 | 799 | 594 |
| S.L. Obispo | S.L. Obispo | 445 | 441 | 426 | 222 | 214 | 134 | 255 | 301 | 275 | 131 | 161 | 81 | 8,213 | 7,467 | 6,783 | 1,488 | 746 | 533 |
| S. Barbara | S. Barbara | 307 | 351 | 308 | 15 | 12 | 15 | 194 | 223 | 206 | 5 | 6 | 9 | 5,691 | 8,759 | 8,778 | 27 | 46 | 20 |
| | Ventura | 315 | 404 | 317 | 9 | 4 | 4 | 168 | 219 | 194 | 0 | 2 | 2 | 13,390 | 12,562 | 21,679 | conf | conf | conf |
| Los Angeles | Los Angeles | 587 | 538 | 444 | 0 | 4 | 1 | 390 | 383 | 289 | 0 | 1 | 0 | 59,130 | 44,442 | 32,084 | 0 | conf | conf |
| | Orange | 110 | 107 | 94 | 2 | 3 | 2 | 69 | 75 | 67 | 1 | 2 | 2 | 1,118 | 1,286 | 1,887 | conf | conf | conf |
| San Diego | San Diego | 375 | 376 | 236 | 6 | 6 | 0 | 275 | 287 | 170 | 0 | 2 | 0 | 6,982 | 9,565 | 6,456 | conf | conf | 0 |
| Inland Californ | Not Identified | 245 | 210 | 25 | 221 | 188 | 1 | 120 | 103 | 14 | 116 | 97 | 0 | 1,525 | 599 | 122 | 1,436 | 519 | conf |
| Total | | | | | | | | 10,836 | 10,942 | 5,784 | 4,890 | 5,071 | 1,318 | 396,612 | 322,346 | 310,981 | 68,192 | 25,808 | 10,200 |
| Total Confidential Exvessel Value Excluded | | | | | | | | | | | | | | 0 | 0 | 6 | 29 | 45 | 19 |

a/ Revenue is not reported where less than 10 vessels made landings in a county, indicated as "conf". Total of landings exvessel value with held for individual counties is reported at the end of the table.

b/ The primary port is the port where a majority of the value of all landings were made. Primary ports were assigned based on all species and on ocean caught salmon landings of chinook, pink and coho salmon.

c/ Ocean caught, chinook, coho and pink salmon only.

TABLE B-57. Estimates of **California recreational** ocean salmon angler **trips** by port area and boat type. (Page 1 of 2)

| Year | Crescent City | Eureka | Fort Bragg | San Francisco | Monterey | State Total |
|---|---|---|---|---|---|---|
| | | | **CHARTER TRIPS (thousands)** | | | |
| 1976 | 0.8 | 2.2 | 4.1 | 66.2 | 7.9 | 81.2 |
| 1977 | 1.0 | 1.2 | 1.7 | 72.0 | 4.8 | 80.7 |
| 1978 | 2.4 | 1.3 | 0.9 | 47.3 | 1.3 | 53.2 |
| 1979 | 2.2 | 0.7 | 3.3 | 69.6 | 3.1 | 79.0 |
| 1980 | 1.4 | 0.6 | 2.0 | 62.4 | 2.9 | 69.3 |
| 1981 | 0.6 | 0.5 | 1.3 | 56.1 | 2.7 | 61.1 |
| 1982 | 0.5 | 0.4 | 2.4 | 72.2 | 4.4 | 79.9 |
| 1983 | 0.5 | 1.4 | 1.6 | 50.8 | 2.7 | 56.9 |
| 1984 | 0.5 | 0.9 | 1.4 | 56.8 | 1.9 | 61.5 |
| 1985 | 1.6 | 3.5 | 2.3 | 74.6 | 3.2 | 85.1 |
| 1986 | 1.1 | 2.8 | 2.8 | 69.6 | 10.1 | 86.4 |
| 1987 | 1.5 | 3.8 | 4.6 | 82.9 | 12.3 | 105.0 |
| 1988 | 0.9 | 2.5 | 5.6 | 81.1 | 11.7 | 101.7 |
| 1989 | 0.6 | 5.4 | 4.5 | 83.5 | 14.0 | 108.0 |
| 1990 | 0.8 | 3.2 | 2.7 | 54.3 | 17.4 | 78.4 |
| 1991 | 1.0 | 2.1 | 5.4 | 43.7 | 17.0 | 69.2 |
| 1992 | 0.1 | 0.2 | 1.5 | 38.6 | 7.3 | 47.7 |
| 1993 | 0.4 | 1.0 | 2.0 | 53.2 | 9.4 | 66.0 |
| 1994 | 0.2 | 0.2 | 1.3 | 63.9 | 7.2 | 72.8 |
| 1995 | 0.1 | 0.7 | 3.8 | 79.2 | 68.9 | 152.9 |
| 1996 | a/ | 0.6 | 5.0 | 57.6 | 21.4 | 84.6 |
| 1997[b/] | a/ | 0.8 | 2.2 | 68.9 | 30.6 | 102.4 |
| | | | **PRIVATE TRIPS (thousands)** | | | |
| 1976 | 27.9 | 28.2 | 13.0 | 30.5 | 6.3 | 106.0 |
| 1977 | 21.8 | 25.5 | 14.0 | 34.2 | 5.1 | 100.7 |
| 1978 | 15.0 | 19.8 | 8.5 | 48.7 | 5.4 | 97.5 |
| 1979 | 9.6 | 17.3 | 6.5 | 34.7 | 6.7 | 74.8 |
| 1980 | 17.8 | 22.5 | 4.4 | 23.7 | 6.7 | 75.1 |
| 1981 | 13.4 | 15.8 | 6.8 | 19.0 | 5.7 | 60.8 |
| 1982 | 24.6 | 22.3 | 8.0 | 28.7 | 7.7 | 91.4 |
| 1983 | 21.2 | 21.5 | 6.8 | 9.5 | 6.8 | 65.8 |
| 1984 | 23.3 | 17.9 | 4.6 | 8.2 | 11.4 | 65.5 |
| 1985 | 29.5 | 31.4 | 12.6 | 18.7 | 14.6 | 106.8 |
| 1986 | 24.5 | 26.1 | 10.4 | 22.1 | 26.1 | 109.2 |
| 1987 | 50.6 | 42.4 | 9.4 | 25.5 | 35.4 | 163.3 |
| 1988 | 43.0 | 30.3 | 12.2 | 27.0 | 28.2 | 140.7 |
| 1989 | 33.0 | 37.7 | 13.0 | 11.5 | 41.7 | 137.0 |
| 1990 | 41.9 | 35.4 | 11.9 | 35.4 | 49.0 | 173.7 |
| 1991 | 24.5 | 25.3 | 17.2 | 26.5 | 33.8 | 127.4 |
| 1992 | 9.0 | 8.9 | 9.7 | 23.4 | 29.1 | 80.2 |
| 1993 | 15.0 | 17.3 | 17.4 | 29.6 | 29.7 | 108.9 |
| 1994 | 9.4 | 6.3 | 18.1 | 43.7 | 39.6 | 117.1 |
| 1995 | 11.8 | 12.0 | 25.4 | 62.2 | 114.2 | 225.6 |
| 1996 | 11.3 | 13.6 | 26.2 | 46.6 | 43.2 | 140.9 |
| 1997[b/] | 6.6 | 11.6 | 18.2 | 42.1 | 53.5 | 131.9 |

TABLE B-57. Estimates of **California recreational** ocean salmon angler **trips** by port area and boat type. (Page 2 of 2)

| Year | Crescent City | Eureka | Fort Bragg | San Francisco | Monterey | State Total |
|---|---|---|---|---|---|---|
| | | | **TOTAL TRIPS (thousands)** | | | |
| 1976 | 28.7 | 30.5 | 17.0 | 96.8 | 14.2 | 187.2 |
| 1977 | 22.8 | 26.7 | 15.7 | 106.2 | 9.9 | 181.3 |
| 1978 | 17.4 | 21.2 | 9.5 | 96.1 | 6.6 | 150.7 |
| 1979 | 11.7 | 18.0 | 9.8 | 104.3 | 9.9 | 153.7 |
| 1980 | 19.2 | 23.1 | 6.4 | 86.1 | 9.6 | 144.4 |
| 1981 | 14.1 | 16.3 | 8.1 | 75.1 | 8.4 | 122.0 |
| 1982 | 25.1 | 22.8 | 10.4 | 100.9 | 12.1 | 171.3 |
| 1983 | 21.7 | 22.8 | 8.4 | 60.3 | 9.5 | 122.7 |
| 1984 | 23.8 | 18.8 | 6.0 | 65.0 | 13.3 | 127.0 |
| 1985 | 31.0 | 34.9 | 15.0 | 93.3 | 17.8 | 191.9 |
| 1986 | 25.6 | 28.9 | 13.2 | 91.7 | 36.2 | 195.6 |
| 1987 | 52.1 | 46.1 | 14.0 | 108.4 | 47.7 | 268.3 |
| 1988 | 43.9 | 32.8 | 17.8 | 108.1 | 39.9 | 242.4 |
| 1989 | 33.6 | 43.0 | 17.5 | 95.0 | 55.7 | 244.9 |
| 1990 | 42.7 | 38.7 | 14.6 | 89.7 | 66.5 | 252.1 |
| 1991 | 25.6 | 27.4 | 22.6 | 70.2 | 50.8 | 196.6 |
| 1992 | 9.1 | 9.1 | 11.2 | 62.0 | 36.4 | 127.9 |
| 1993 | 15.4 | 18.3 | 19.3 | 82.8 | 39.1 | 174.9 |
| 1994 | 9.7 | 6.4 | 19.4 | 107.6 | 46.8 | 189.9 |
| 1995 | 11.9 | 12.8 | 29.3 | 141.5 | 183.1 | 378.5 |
| 1996 | 11.3 | 14.2 | 31.3 | 104.2 | 64.5 | 225.4 |
| 1997[b/] | 6.6 | 12.4 | 20.4 | 111.0 | 84.0 | 234.3 |

a/ Less than 50.
b/ Preliminary.

TABLE B-58. Estimates of **Oregon recreational** ocean salmon angler **trips** by port area and boat type. (Page 1 of 2)

| Year | Astoria | Tillamook | Newport | Coos Bay | Brookings | State Total |
|---|---|---|---|---|---|---|
| **CHARTER TRIPS (thousands)** | | | | | | |
| 1979 | 18.5 | 2.8 | 26.7 | 22.7 | 3.0 | 73.7 |
| 1980 | 26.3 | 3.7 | 26.7 | 19.6 | 2.8 | 79.1 |
| 1981 | 16.0 | 3.1 | 25.5 | 17.6 | 3.2 | 65.4 |
| 1982 | 11.8 | 2.1 | 14.6 | 11.4 | 3.4 | 43.3 |
| 1983 | 12.9 | 1.8 | 11.5 | 12.1 | 3.6 | 41.9 |
| 1984 | 2.7 | 2.5 | 11.1 | 5.9 | 2.1 | 24.3 |
| 1985 | 8.3 | 5.3 | 23.1 | 12.5 | 4.2 | 53.4 |
| 1986 | 7.7 | 3.0 | 20.0 | 9.6 | 3.4 | 43.7 |
| 1987 | 8.0 | 5.5 | 28.4 | 14.4 | 4.6 | 60.9 |
| 1988 | 2.4 | 7.3 | 34.2 | 15.6 | 3.0 | 62.5 |
| 1989 | 9.1 | 5.2 | 28.3 | 13.1 | 4.4 | 60.2 |
| 1990 | 8.5 | 5.5 | 26.6 | 12.2 | 2.5 | 55.3 |
| 1991 | 8.1 | 2.5 | 19.2 | 8.4 | 2.1 | 40.3 |
| 1992 | 4.6 | 2.7 | 14.8 | 7.4 | 0.5 | 30.0 |
| 1993 | 5.8 | 0.5 | 4.7 | 1.8 | 0.6 | 13.4 |
| 1994 | 0.0[a/] | 1.2 | b/ | b/ | 0.2 | 1.4 |
| 1995 | 2.5 | 1.2 | 0.6 | b/ | 0.3 | 4.6 |
| 1996 | 1.9 | 0.8 | 2.1 | 0.1 | 0.6 | 5.6 |
| 1997[c/] | 1.3 | 0.3 | 1.8 | 0.0 | 0.5 | 3.9 |
| **PRIVATE TRIPS (thousands)** | | | | | | |
| 1979 | 24.3 | 16.3 | 45.4 | 52.9 | 48.8 | 187.7 |
| 1980 | 20.1 | 29.3 | 56.6 | 65.2 | 47.7 | 218.9 |
| 1981 | 28.7 | 34.9 | 51.8 | 66.3 | 64.0 | 245.8 |
| 1982 | 15.4 | 22.5 | 38.8 | 47.9 | 58.0 | 182.7 |
| 1983 | 18.0 | 23.5 | 31.0 | 59.6 | 52.1 | 184.1 |
| 1984 | 4.4 | 21.3 | 32.8 | 34.3 | 35.9 | 128.7 |
| 1985 | 11.7 | 33.2 | 47.4 | 51.0 | 54.8 | 198.2 |
| 1986 | 12.8 | 15.0 | 32.2 | 34.0 | 49.3 | 143.3 |
| 1987 | 9.1 | 23.6 | 48.6 | 48.1 | 64.8 | 194.2 |
| 1988 | 3.2 | 26.0 | 55.5 | 53.5 | 50.0 | 188.2 |
| 1989 | 10.7 | 26.1 | 54.4 | 53.5 | 61.3 | 206.1 |
| 1990 | 17.0 | 28.0 | 44.8 | 52.8 | 48.6 | 191.2 |
| 1991 | 13.6 | 18.5 | 34.0 | 49.3 | 34.4 | 149.7 |
| 1992 | 8.3 | 23.4 | 38.3 | 48.2 | 17.2 | 135.4 |
| 1993 | 12.7 | 5.1 | 12.4 | 13.6 | 23.2 | 66.9 |
| 1994 | 0.0[a/] | 9.1 | 0.1 | 0.4 | 16.0 | 25.5 |
| 1995 | 7.2 | 3.9 | 0.4 | 0.7 | 19.1 | 31.2 |
| 1996 | 3.7 | 7.5 | 0.6 | 3.8 | 22.7 | 38.3 |
| 1997[c/] | 2.3 | 3.4 | 0.6 | 3.9 | 16.1 | 26.4 |

TABLE B-58. Estimates of **Oregon recreational** ocean salmon angler **trips** by port area and boat type. (Page 2 of 2)

| Year | Astoria | Tillamook | Newport | Coos Bay | Brookings | State Total |
|---|---|---|---|---|---|---|
| | | | **TOTAL TRIPS (thousands)** | | | |
| 1979 | 43.3 | 31.0 | 72.4 | 94.7 | 60.0 | 301.3 |
| 1980 | 46.3 | 47.8 | 83.9 | 97.4 | 56.0 | 331.4 |
| 1981 | 44.7 | 38.0 | 77.3 | 83.9 | 67.1 | 311.0 |
| 1982 | 27.2 | 24.6 | 53.5 | 59.4 | 61.4 | 226.0 |
| 1983 | 30.9 | 25.3 | 42.6 | 71.6 | 55.7 | 226.0 |
| 1984 | 8.3 | 25.0 | 41.5 | 40.2 | 38.0 | 153.1 |
| 1985 | 20.0 | 38.6 | 70.6 | 63.5 | 59.0 | 251.6 |
| 1986 | 20.5 | 17.9 | 52.2 | 43.6 | 52.7 | 187.0 |
| 1987 | 17.1 | 29.1 | 76.9 | 62.6 | 69.4 | 255.1 |
| 1988 | 5.7 | 33.3 | 89.6 | 69.0 | 53.1 | 250.7 |
| 1989 | 19.8 | 31.3 | 82.8 | 66.6 | 65.8 | 266.3 |
| 1990 | 25.5 | 33.5 | 71.4 | 65.0 | 51.1 | 246.6 |
| 1991 | 21.7 | 21.0 | 53.3 | 57.7 | 36.4 | 190.1 |
| 1992 | 12.9 | 26.1 | 53.1 | 55.6 | 17.7 | 165.3 |
| 1993 | 17.8 | 5.6 | 17.1 | 15.3 | 23.8 | 79.6 |
| 1994 | 0.0[a/] | 10.3 | 0.1 | 0.4 | 16.2 | 26.9 |
| 1995 | 9.6 | 5.1 | 0.9 | 0.7 | 19.4 | 35.8 |
| 1996 | 5.6 | 8.3 | 2.8 | 3.9 | 23.3 | 44.0 |
| 1997[c/] | 3.6 | 3.7 | 2.4 | 3.9 | 16.6 | 30.2 |

a/ The fishery north of Cape Falcon was closed and it is assumed that no trips were taken out of Astoria to the south of Cape Falcon area. No samplers were stationed in Astoria.

b/ Less than 50.

c/ Preliminary.

TABLE B-59. Estimates of **Washington recreational** ocean salmon angler **trips** by port area.

| Year | Neah Bay[a] | La Push | Westport | Ilwaco[b] | Coastal Area Total |
|---|---|---|---|---|---|
| | | | **CHARTER TRIPS (thousands)** | | |
| 1984[c] | 0.3 | 0.0 | 11.6 | 18.0 | 29.9 |
| 1985[c] | 2.0 | 0.0 | 42.2 | 20.7 | 62.9 |
| 1986 | 2.4 | 0.0 | 36.6 | 19.1 | 58.1 |
| 1987 | 1.9 | 0.0 | 34.1 | 17.7 | 53.7 |
| 1988 | 2.0 | 0.0 | 23.5 | 6.9 | 32.4 |
| 1989 | 1.5 | 0.0 | 40.8 | 16.2 | 58.5 |
| 1990 | 2.1 | 0.0 | 43.4 | 19.5 | 65.0 |
| 1991 | 1.4 | 0.2 | 28.6 | 13.5 | 43.7 |
| 1992 | 0.7 | 0.2 | 28.1 | 9.2 | 38.2 |
| 1993 | 1.0 | 0.1 | 27.4 | 11.7 | 40.2 |
| 1994 | - | - | - | - | - |
| 1995 | 0.2 | 0.1 | 12.7 | 5.0 | 17.9 |
| 1996 | 0.2 | d/ | 10.3 | 4.8 | 15.3 |
| 1997[e] | 0.1 | 0.1 | 10.0 | 2.4 | 12.5 |
| | | | **PRIVATE TRIPS (thousands)** | | |
| 1984[c] | 8.3 | 0.2 | 2.3 | 36.0 | 46.8 |
| 1985[c] | 15.2 | 1.5 | 13.7 | 19.4 | 49.8 |
| 1986 | 17.4 | 1.7 | 14.8 | 17.5 | 51.4 |
| 1987 | 17.9 | 2.0 | 9.8 | 18.6 | 48.3 |
| 1988 | 14.8 | 2.8 | 13.9 | 5.6 | 37.1 |
| 1989 | 15.0 | 1.6 | 18.7 | 30.6 | 65.9 |
| 1990 | 19.5 | 4.2 | 25.9 | 44.8 | 94.4 |
| 1991 | 14.8 | 3.3 | 24.2 | 27.3 | 69.6 |
| 1992 | 11.0 | 2.3 | 25.6 | 17.9 | 56.8 |
| 1993 | 18.4 | 2.8 | 23.5 | 24.2 | 68.9 |
| 1994 | - | - | - | - | - |
| 1995 | 5.3 | 1.4 | 9.0 | 14.2 | 30.0 |
| 1996 | 9.1 | 1.3 | 5.2 | 7.9 | 23.5 |
| 1997[e] | 2.8 | 0.9 | 7.3 | 4.1 | 15.1 |
| | | | **TOTAL TRIPS (thousands)** | | |
| 1984[c] | 8.6 | 0.2 | 13.9 | 54.0 | 76.7 |
| 1985[c] | 17.2 | 1.5 | 55.9 | 40.1 | 114.7 |
| 1986 | 19.8 | 1.7 | 51.4 | 36.6 | 109.5 |
| 1987 | 19.8 | 2.0 | 43.9 | 36.3 | 102.0 |
| 1988 | 16.8 | 2.8 | 37.4 | 12.5 | 69.5 |
| 1989 | 16.5 | 1.6 | 59.5 | 46.8 | 124.4 |
| 1990 | 21.6 | 4.2 | 69.3 | 64.3 | 159.4 |
| 1991 | 16.2 | 3.5 | 52.8 | 40.8 | 113.3 |
| 1992 | 11.7 | 2.5 | 53.7 | 27.1 | 95.0 |
| 1993 | 19.4 | 2.9 | 50.9 | 35.9 | 109.1 |
| 1994 | - | - | - | - | - |
| 1995 | 5.5 | 1.5 | 21.7 | 19.2 | 47.9 |
| 1996 | 9.3 | 1.3 | 15.5 | 12.7 | 38.8 |
| 1997[e] | 2.9 | 0.9 | 17.3 | 6.5 | 27.6 |

a/ Does not include effort from the late-season state-water Area 4B fishery.

b/ Does not include effort from the Columbia River Jetty.

c/ Values for 1984 and 1985 include some Columbia River fishing after closure of the ocean fishery.

d/ Less than 50.

e/ Preliminary.

TABLE B-60. Estimates of **California coastal community and state personal income** impacts[a] of the troll and recreational ocean salmon fishery for major port areas.

| Year or Average | Crescent City | Eureka | Fort Bragg | San Francisco | Monterey | Coastal Community Total[b] | State Total |
|---|---|---|---|---|---|---|---|
| | | | **OCEAN TROLL (thousands of dollars)[c]** | | | | |
| 1976-1980 | 5,495 | 13,882 | 13,561 | 17,795 | 7,732 | 58,465 | 75,063 |
| 1981-1985 | 2,696 | 3,252 | 7,592 | 14,337 | 4,887 | 32,763 | 40,793 |
| 1986 | 771 | 2,146 | 9,831 | 16,247 | 10,424 | 39,421 | 49,730 |
| 1987 | 2,289 | 4,495 | 18,815 | 29,413 | 7,268 | 62,281 | 76,645 |
| 1988 | 1,203 | 3,793 | 26,102 | 53,100 | 14,945 | 99,143 | 120,355 |
| 1989 | 623 | 1,148 | 6,915 | 15,646 | 6,915 | 31,247 | 38,374 |
| 1990 | 111 | 782 | 4,098 | 13,202 | 8,147 | 26,341 | 32,073 |
| 1991 | 17 | 421 | 2,365 | 11,074 | 5,620 | 19,497 | 23,594 |
| 1992 | 2 | 3 | 100 | 6,160 | 3,166 | 9,432 | 11,174 |
| 1993 | 7 | 43 | 858 | 6,565 | 4,330 | 11,803 | 14,341 |
| 1994 | 0 | 25 | 317 | 9,931 | 3,253 | 13,527 | 15,997 |
| 1995 | 11 | 26 | 276 | 11,315 | 10,300 | 21,927 | 26,853 |
| 1996 | 9 | 381 | 685 | 4,921 | 5,743 | 11,739 | 14,749 |
| 1997[d] | 3 | 48 | 163 | 8,582 | 6,347 | 15,142 | 18,533 |
| | | | **RECREATIONAL (thousands of dollars)** | | | | |
| 1976-1980 | 1,013 | 1,174 | 684 | 10,278 | 688 | 13,838 | 15,522 |
| 1981-1985 | 1,109 | 1,143 | 548 | 9,102 | 727 | 12,630 | 14,216 |
| 1986 | 1,243 | 1,502 | 782 | 10,385 | 2,227 | 16,138 | 18,535 |
| 1987 | 2,487 | 2,353 | 921 | 12,325 | 2,872 | 20,958 | 24,421 |
| 1988 | 2,072 | 1,661 | 1,153 | 12,172 | 2,488 | 19,546 | 22,570 |
| 1989 | 1,583 | 2,304 | 1,081 | 11,618 | 3,336 | 19,922 | 23,190 |
| 1990 | 2,014 | 1,974 | 840 | 9,122 | 4,023 | 17,973 | 21,456 |
| 1991 | 1,241 | 1,391 | 1,368 | 7,230 | 3,295 | 14,525 | 17,329 |
| 1992 | 421 | 432 | 608 | 6,389 | 2,066 | 9,917 | 11,472 |
| 1993 | 733 | 903 | 1,014 | 8,656 | 2,315 | 13,622 | 15,740 |
| 1994 | 454 | 311 | 972 | 10,856 | 2,529 | 15,123 | 17,174 |
| 1995 | 559 | 632 | 1,579 | 13,916 | 12,326 | 29,011 | 34,804 |
| 1996 | 521 | 686 | 1,746 | 10,190 | 4,170 | 17,313 | 20,252 |
| 1997[d] | 304 | 619 | 1,072 | 11,423 | 5,599 | 19,018 | 22,138 |

a/ Expressed in 1997 dollars. Per pound and per day estimates of income impacts provided from output of the Fishery Economic Assessment Model. These are the income impacts associated with expenditures in the troll or recreational sectors. There is no differentiation between money new to the area and money which would otherwise have been expended in other sectors.

b/ Income impacts on the coastal economy. Totals do not include impacts of one coastal community on another.

c/ Excluding pink salmon.

d/ Preliminary.

TABLE B-61. Estimates of **Oregon coastal community and state personal income** impacts of the troll and recreational ocean salmon fishery for major port areas.[a]

| Year or Average | Astoria | Tillamook | Newport | Coos Bay | Brookings[b] | Coastal Community Total[c] | State Total |
|---|---|---|---|---|---|---|---|
| | | | **OCEAN TROLL (thousands of dollars)**[d] | | | | |
| 1976-1980 | 3,438 | 4,426 | 10,377 | 15,968 | 6,636 | 40,845 | 55,384 |
| 1981-1985 | 1,105 | 1,426 | 3,336 | 5,871 | 2,556 | 14,293 | 19,425 |
| 1986 | 598 | 1,568 | 5,308 | 8,692 | 1,822 | 17,989 | 24,368 |
| 1987 | 707 | 3,534 | 7,037 | 19,063 | 3,800 | 34,142 | 46,107 |
| 1988 | 306 | 5,470 | 13,620 | 18,279 | 3,529 | 41,205 | 55,469 |
| 1989 | 544 | 2,615 | 4,686 | 9,746 | 1,936 | 19,526 | 26,408 |
| 1990 | 361 | 1,481 | 2,014 | 7,157 | 846 | 11,859 | 15,998 |
| 1991 | 194 | 1,383 | 2,001 | 2,241 | 89 | 5,908 | 7,980 |
| 1992 | 91 | 561 | 2,984 | 992 | 27 | 4,656 | 6,279 |
| 1993 | 39 | 331 | 1,659 | 663 | 97 | 2,788 | 3,738 |
| 1994 | 1 | 124 | 615 | 175 | 180 | 1,094 | 1,499 |
| 1995 | 21 | 293 | 3,725 | 1,274 | 150 | 5,462 | 7,352 |
| 1996 | 55 | 350 | 3,112 | 1,055 | 372 | 4,944 | 6,712 |
| 1997[e] | 9 | 96 | 2,665 | 1,001 | 198 | 3,969 | 5,370 |
| | | | **RECREATIONAL (thousands of dollars)** | | | | |
| 1976-1980 | 2,912 | 2,221 | 4,129 | 5,461 | 3,599 | 18,322 | 23,719 |
| 1981-1985 | 1,656 | 1,335 | 3,190 | 3,253 | 2,263 | 11,697 | 15,188 |
| 1986 | 1,281 | 864 | 3,128 | 2,305 | 2,136 | 9,715 | 12,650 |
| 1987 | 1,156 | 1,431 | 4,557 | 3,339 | 2,818 | 13,301 | 17,345 |
| 1988 | 366 | 1,690 | 5,367 | 3,674 | 2,127 | 13,225 | 17,228 |
| 1989 | 1,330 | 1,502 | 4,778 | 3,436 | 2,670 | 13,716 | 17,875 |
| 1990 | 1,534 | 1,604 | 4,239 | 3,321 | 2,031 | 12,730 | 16,517 |
| 1991 | 1,354 | 956 | 3,126 | 2,816 | 1,466 | 9,718 | 12,572 |
| 1992 | 793 | 1,167 | 2,890 | 2,676 | 685 | 8,211 | 10,595 |
| 1993 | 1,093 | 246 | 927 | 728 | 918 | 3,912 | 5,064 |
| 1994 | 0 | 468 | 4 | 16 | 615 | 1,102 | 1,484 |
| 1995 | 543 | 263 | 71 | 29 | 739 | 1,645 | 2,175 |
| 1996 | 339 | 368 | 218 | 165 | 899 | 1,989 | 2,650 |
| 1997[e] | 222 | 161 | 190 | 159 | 644 | 1,377 | 1,357 |

a/ Expressed in 1997 dollars. Per pound and per day estimates of income impacts provided by the Fishery Economic Assessment Model. These are the income impacts associated with expenditures in the troll or recreational sectors. There is no differentiation between money new to the area and money which would otherwise have been expended in other sectors.

b/ On average, between 1976-1991 over 50% of the troll fishery community income impacts for the Brookings port area originated from landings in Brookings and Gold Beach. For 1986-1990 an average of about 40% of the impacts for the Brookings port area originated in landings made through Brookings and Gold Beach. In 1992 and 1993, impacts originating through these two ports averaged less than 18% and 11%, respectively, of the total for the Brookings port area. Since 1994, the average has been 61%. Port Orford is the other port included in the Brookings port area.

c/ Income impacts on the coastal economy. Totals do not include impacts of one coastal community on another.

d/ Excludes pink salmon.

e/ Preliminary.

TABLE B-62. Estimates of **Washington coastal community and state personal income** impacts of the non-Indian troll and recreational ocean salmon fishery for major port areas.[a/]

| Year or Average | Neah Bay | La Push | Westport | Ilwaco[b/] | Coastal Community Total[c/d/] | Puget Sound | State Total |
|---|---|---|---|---|---|---|---|
| **OCEAN TROLL (thousands of dollars)**[e/f/] | | | | | | | |
| 1976-1980 | 4,964 | 6,781 | 14,959 | 4,813 | 31,517 | 6,673 | 46,699 |
| 1981-1985 | 969 | 392 | 4,080 | 875 | 6,317 | 1,416 | 9,089 |
| 1986 | 385 | 170 | 1,269 | 489 | 2,314 | 448 | 3,393 |
| 1987 | 269 | 171 | 3,221 | 479 | 4,141 | 389 | 5,142 |
| 1988 | 526 | 147 | 1,627 | 307 | 2,607 | 2,323 | 5,829 |
| 1989 | 410 | 13 | 1,528 | 289 | 2,239 | 629 | 3,370 |
| 1990 | 1,042 | 191 | 1,593 | 236 | 3,063 | 249 | 4,020 |
| 1991 | 703 | 63 | 1,063 | 140 | 1,968 | 230 | 2,695 |
| 1992 | 646 | 201 | 1,235 | 46 | 2,127 | 295 | 2,928 |
| 1993 | 439 | 131 | 712 | 10 | 1,292 | 172 | 1,783 |
| 1994 | - | - | - | - | - | 26 | 32 |
| 1995 | 124 | 27 | 29 | 0 | 180 | 42 | 304 |
| 1996 | 63 | 2 | 64 | 2 | 131 | 35 | 209 |
| 1997 | 49 | 1 | 138 | 0 | 188 | 39 | 265 |
| **RECREATIONAL (thousands of dollars)** | | | | | | | |
| 1976-1980 | 1,749 | 1,528 | 12,253 | 4,843 | 20,374 | - | 27,672 |
| 1981-1985 | 1,771 | 410 | 8,474 | 3,935 | 14,590 | - | 19,853 |
| 1986 | 884 | 65 | 3,973 | 2,191 | 7,113 | - | 9,639 |
| 1987 | 858 | 77 | 3,543 | 2,114 | 6,593 | - | 8,950 |
| 1988 | 748 | 108 | 2,726 | 766 | 4,347 | - | 5,811 |
| 1989 | 711 | 61 | 4,516 | 2,415 | 7,704 | - | 10,435 |
| 1990 | 937 | 161 | 5,043 | 3,189 | 9,330 | - | 12,688 |
| 1991 | 694 | 145 | 3,606 | 2,076 | 6,521 | - | 8,847 |
| 1992 | 485 | 106 | 3,616 | 1,390 | 5,597 | - | 7,525 |
| 1993 | 797 | 117 | 3,468 | 1,818 | 6,199 | - | 8,390 |
| 1994 | - | - | - | - | - | - | - |
| 1995 | 222 | 63 | 1,532 | 913 | 2,730 | - | 3,696 |
| 1996 | 371 | 50 | 1,157 | 674 | 2,252 | - | 3,054 |
| 1997[g/] | 117 | 40 | 1,215 | 342 | 1,714 | - | 2,278 |

a/ Expressed in 1997 dollars. Per pound and per recreational day estimates of income impacts provided by the fishery economic assessment model. These are the income impacts associated with expenditures in the troll or recreational sectors. There is no differentiation between money new to the area and money which would otherwise have been expended in other sectors.

b/ Excludes recreational shorebased effort from the north side of the Columbia River jetty.

c/ Income impacts on the coastal economy. Totals do not include impacts of one coastal community on another.

d/ Includes a very small amount of fish landed in other coastal Washington areas.

e/ Excludes pink salmon.

f/ All commercial values in this table are based on preliminary information available at the start of each year's salmon review.

g/ Preliminary.

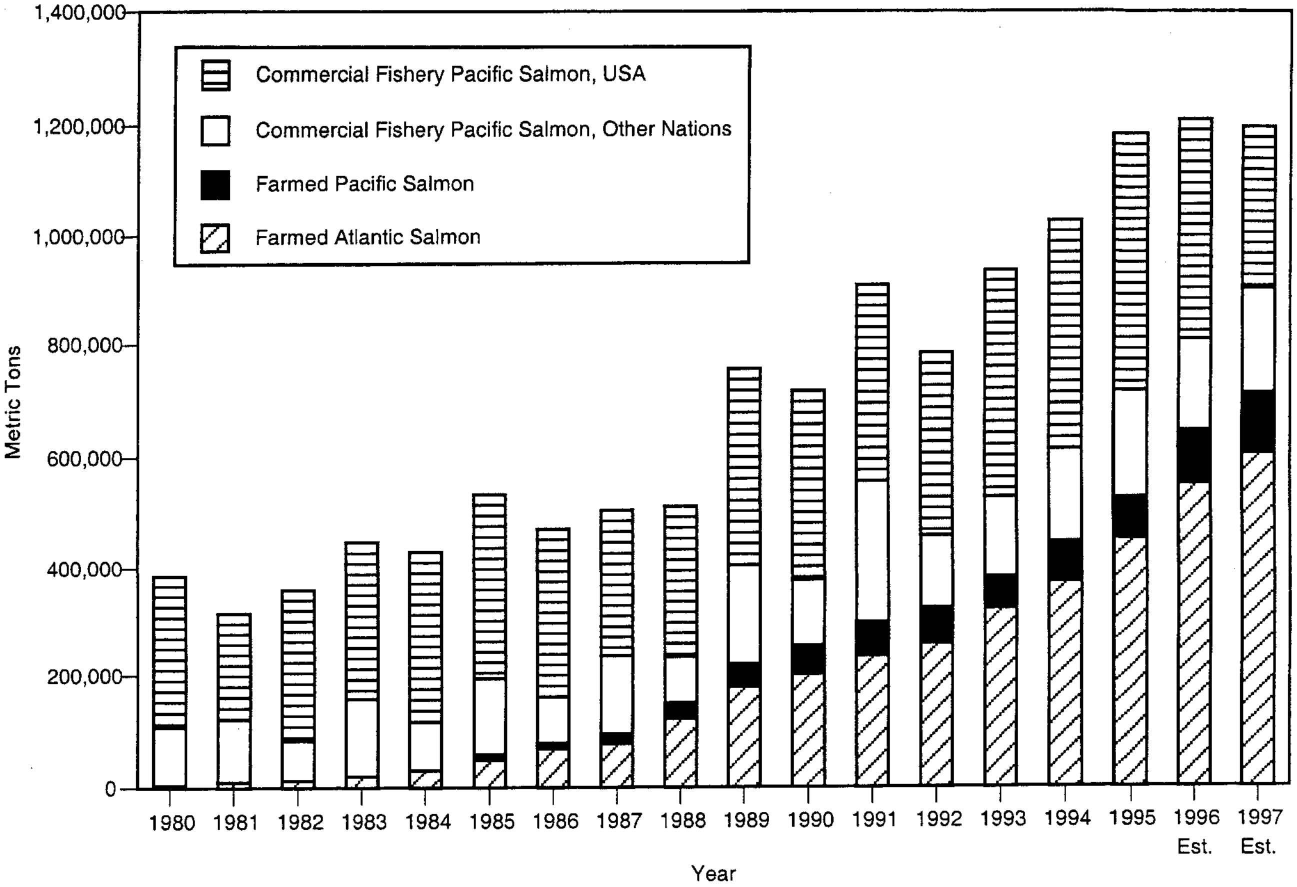


FIGURE B-1a. Estimated world salmon production; comercial fishery harvest includes natural and hatchery produced fish. (World salmon supply estimates prepared by the Salmon Market Information Service, University of Alaska, Anchorage, May 1988).

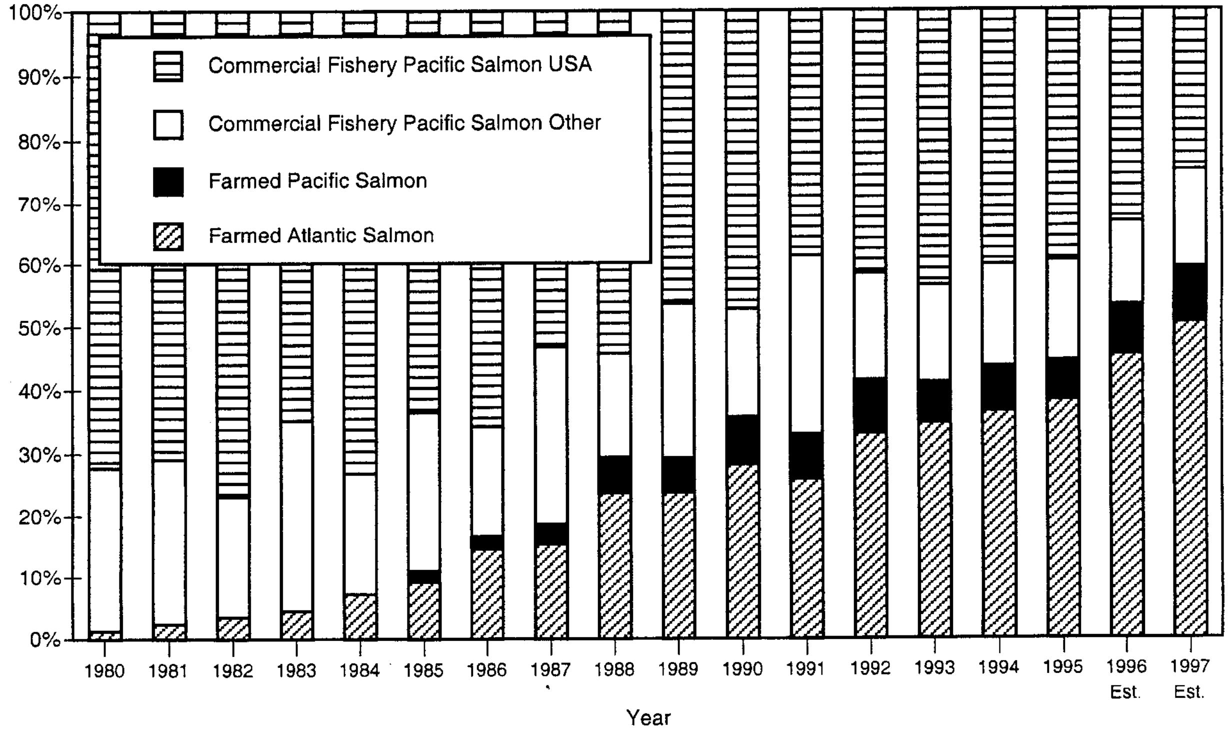


FIGURE B-1b. Percent world salmon production by type. (World salmon supply estimates prepared by the Salmon Market Information Service, University of Alaska, Anchorage, May 1988).

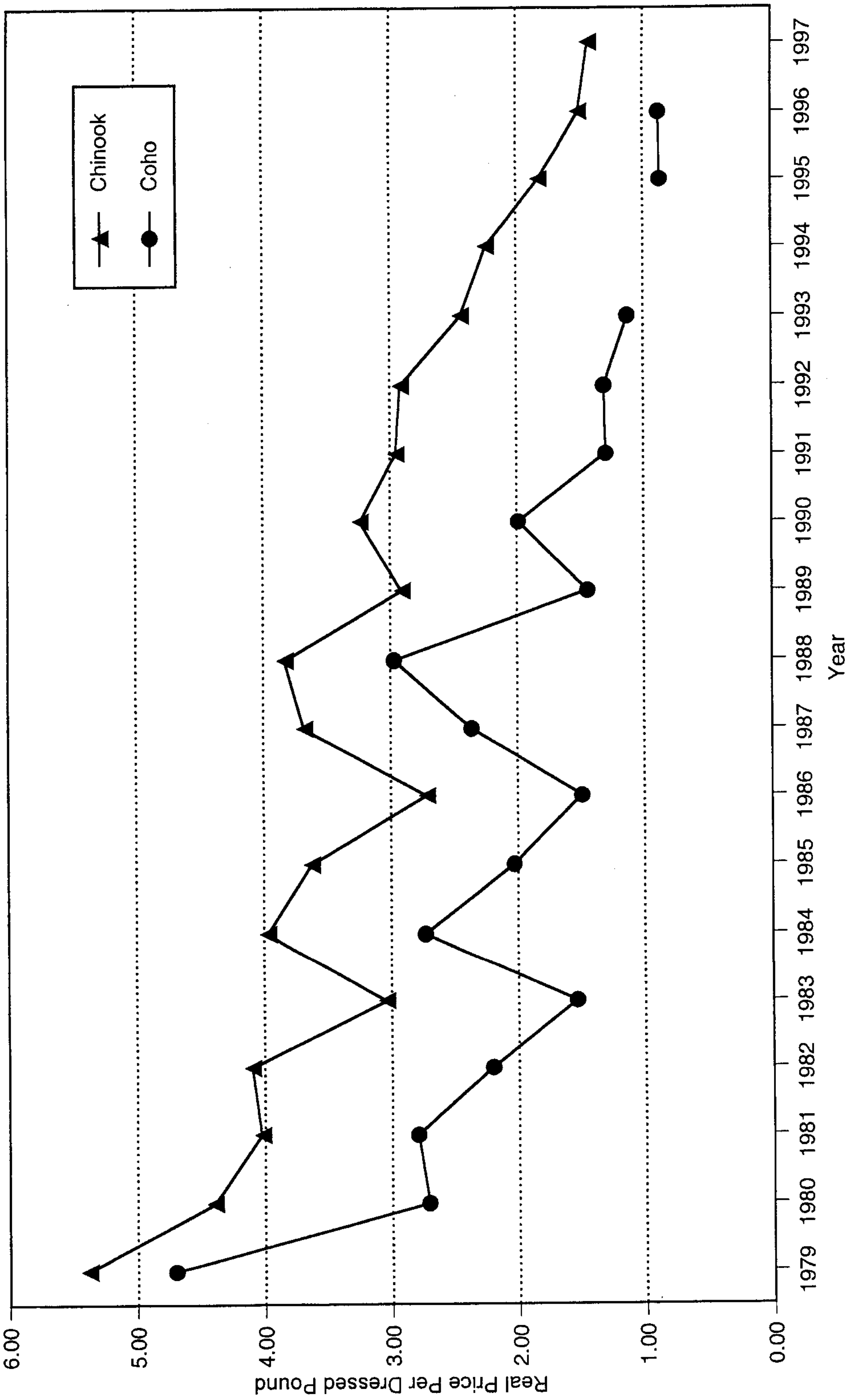


FIGURE B-2. West Coast non-Indian ocean troll exvessel salmon price trends.

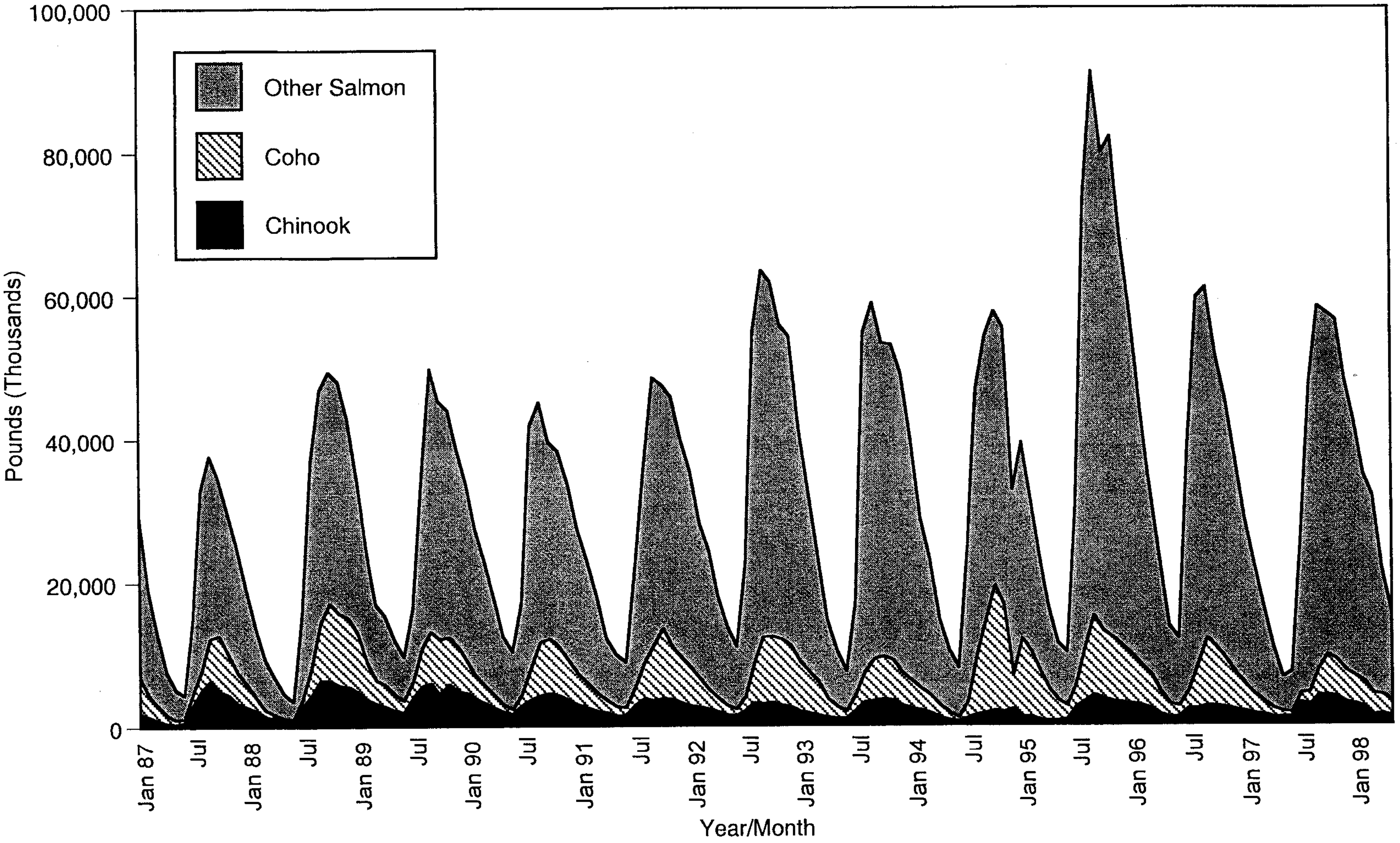


FIGURE B-3. U.S. cold storage holding of dressed and round salmon.

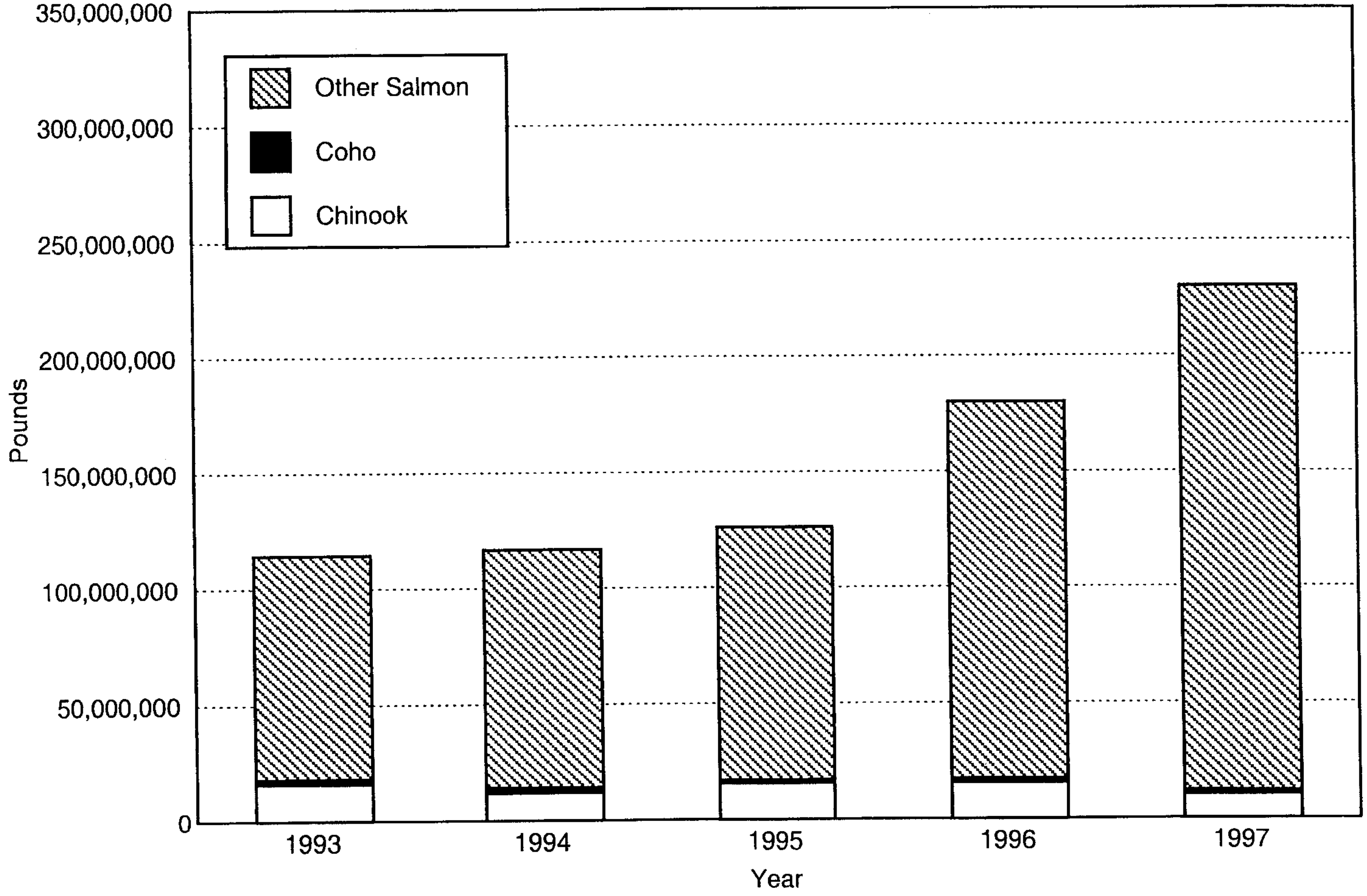


FIGURE B-4. U.S. salmon imports, annual volume of fresh and frozen salmon.

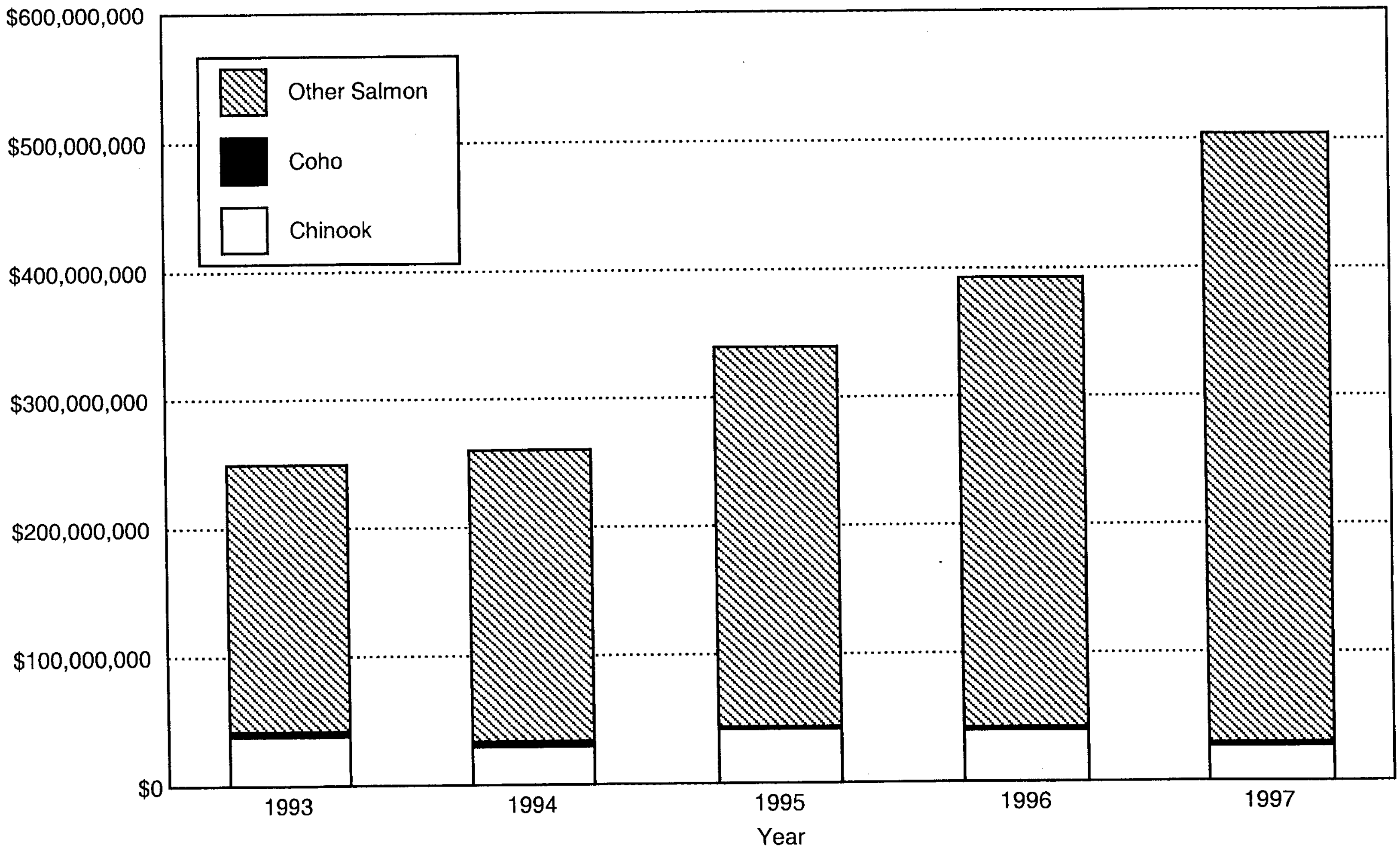


FIGURE B-5. U.S. salmon imports, annual value of fresh and frozen salmon.

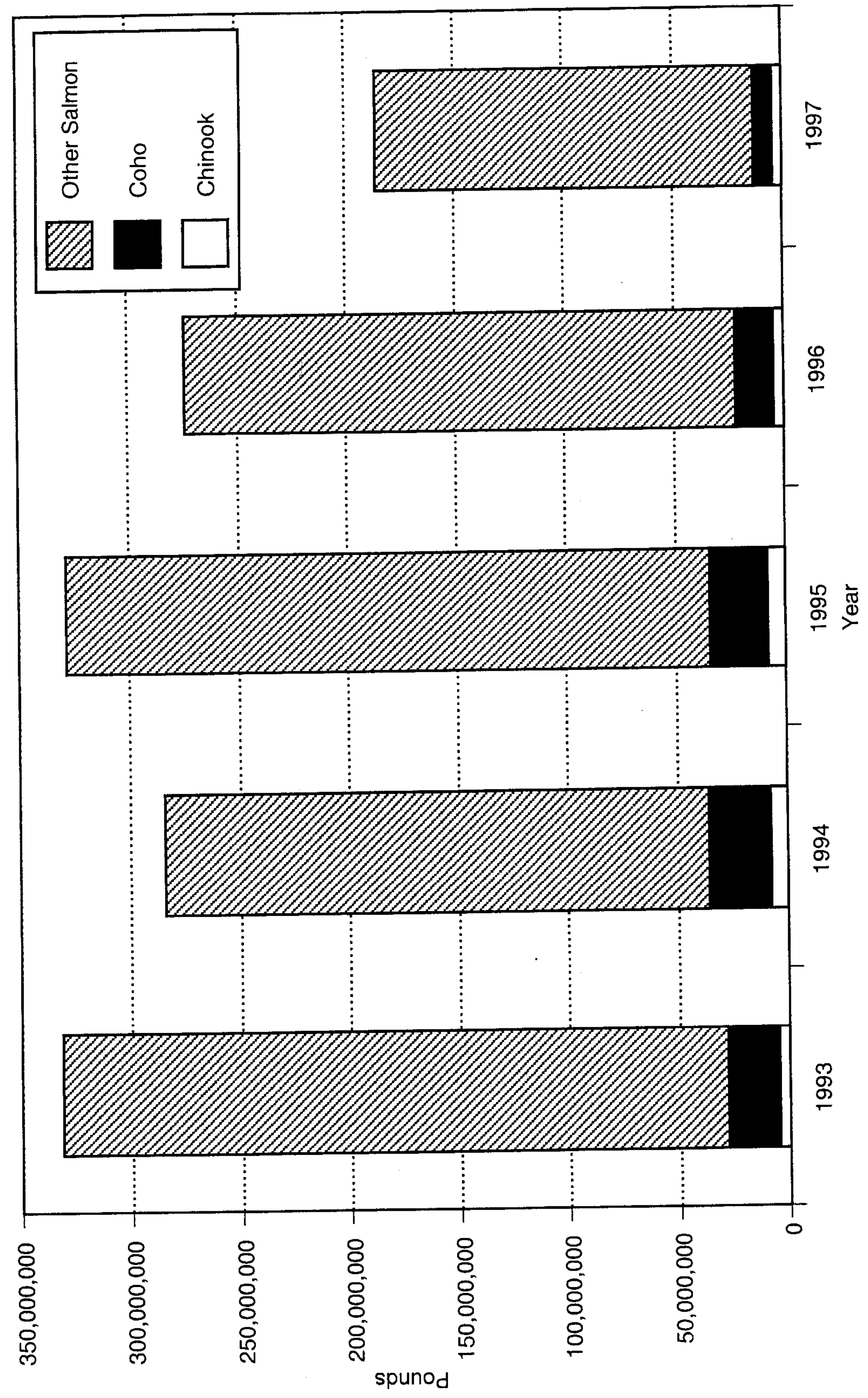


FIGURE B-6. U.S. salmon exports annual volume of fresh and frozen salmon.

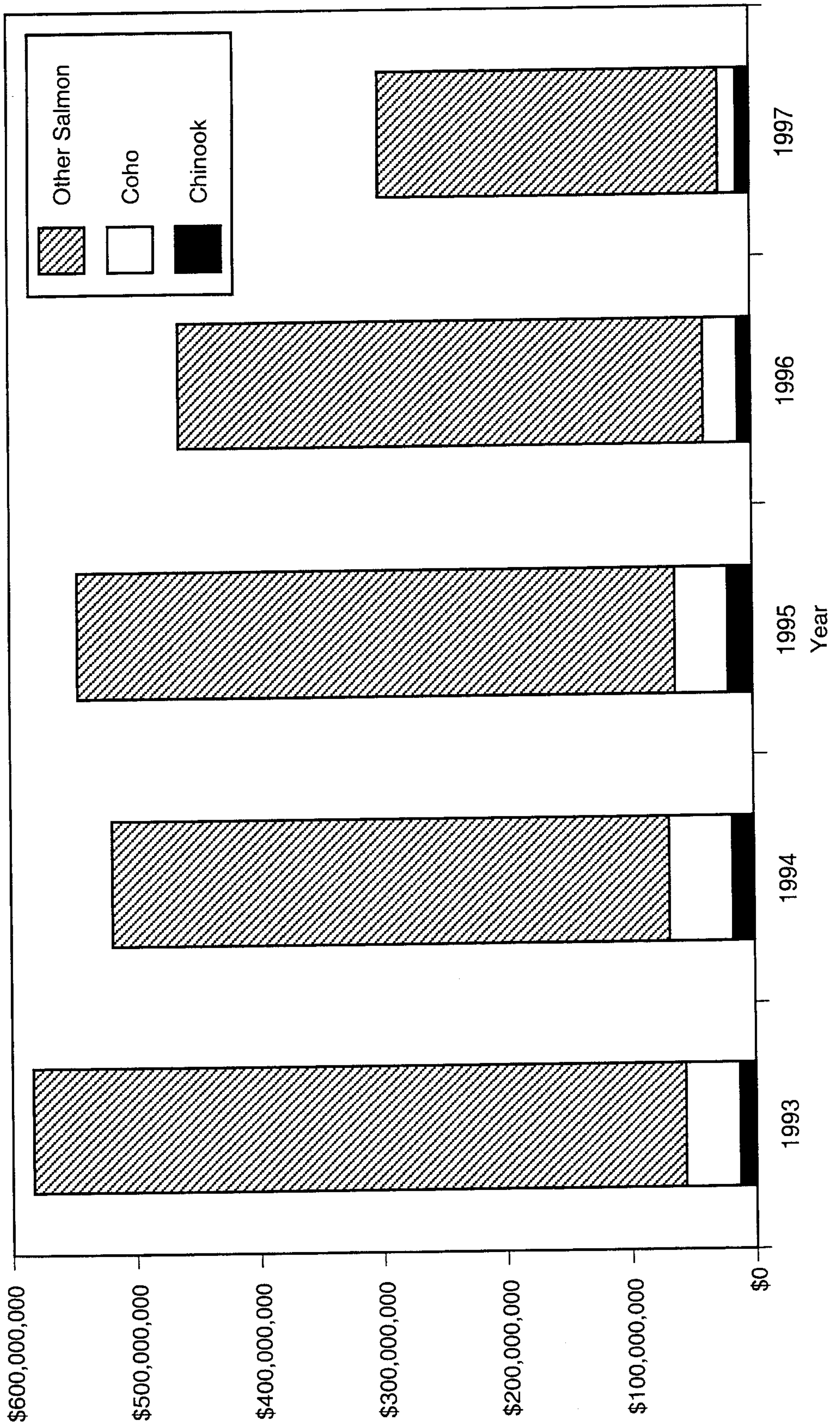


FIGURE B-7. U.S. salmon exports annual value of fresh and frozen salmon.

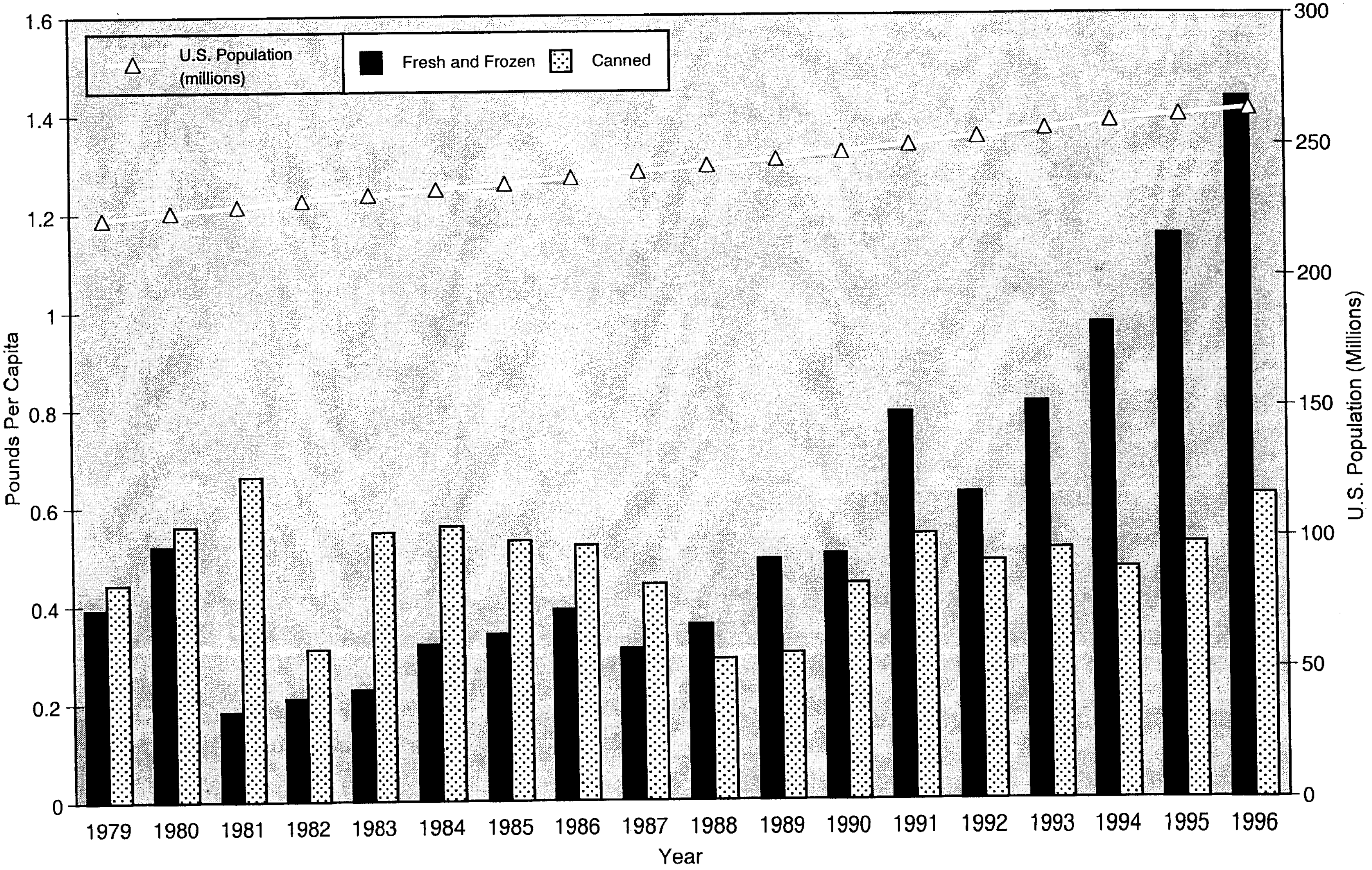


FIGURE B-8. U.S. per capita salmon consumption and population trends.

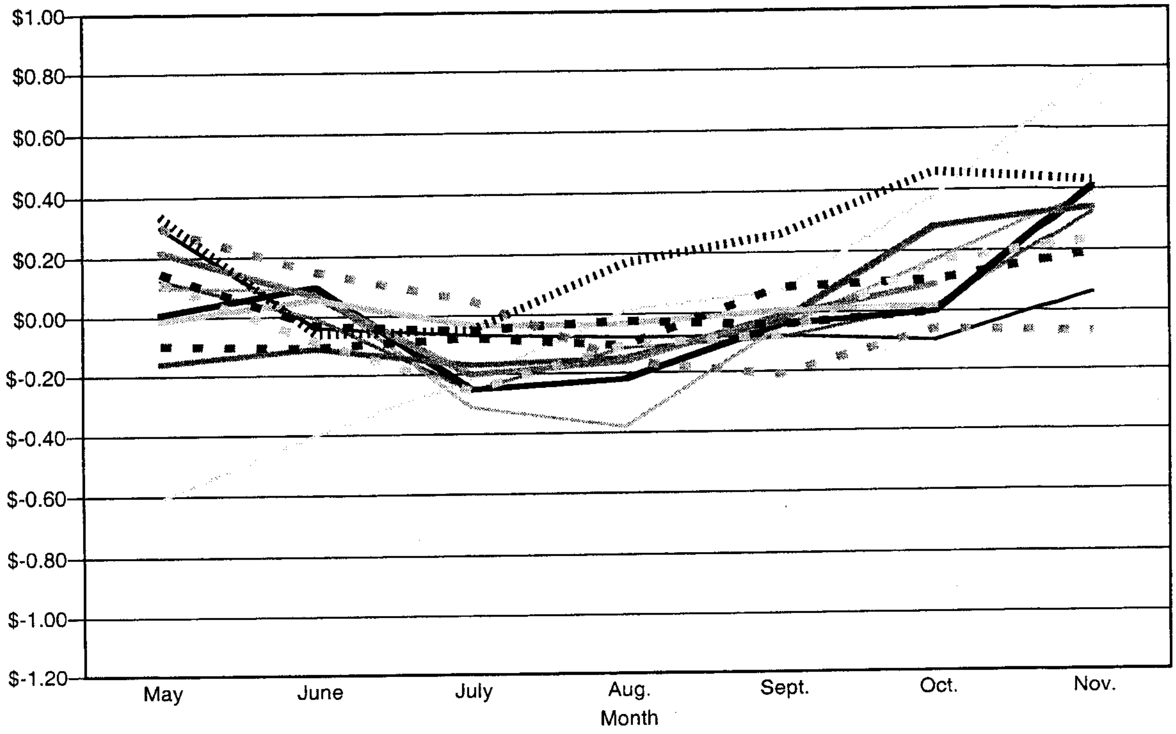
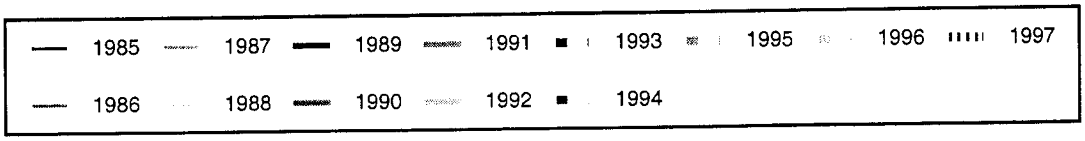


FIGURE B-9. Inseason exvessel price fluctuations for large chinook (Oregon).



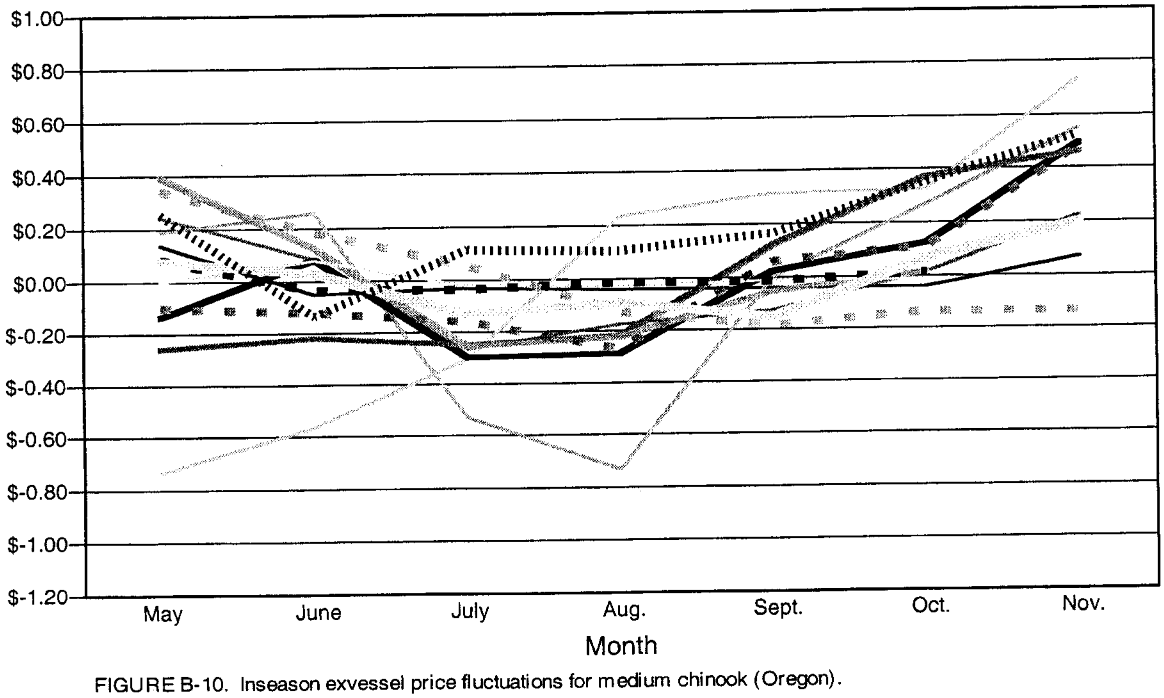


FIGURE B-10. Inseason exvessel price fluctuations for medium chinook (Oregon).

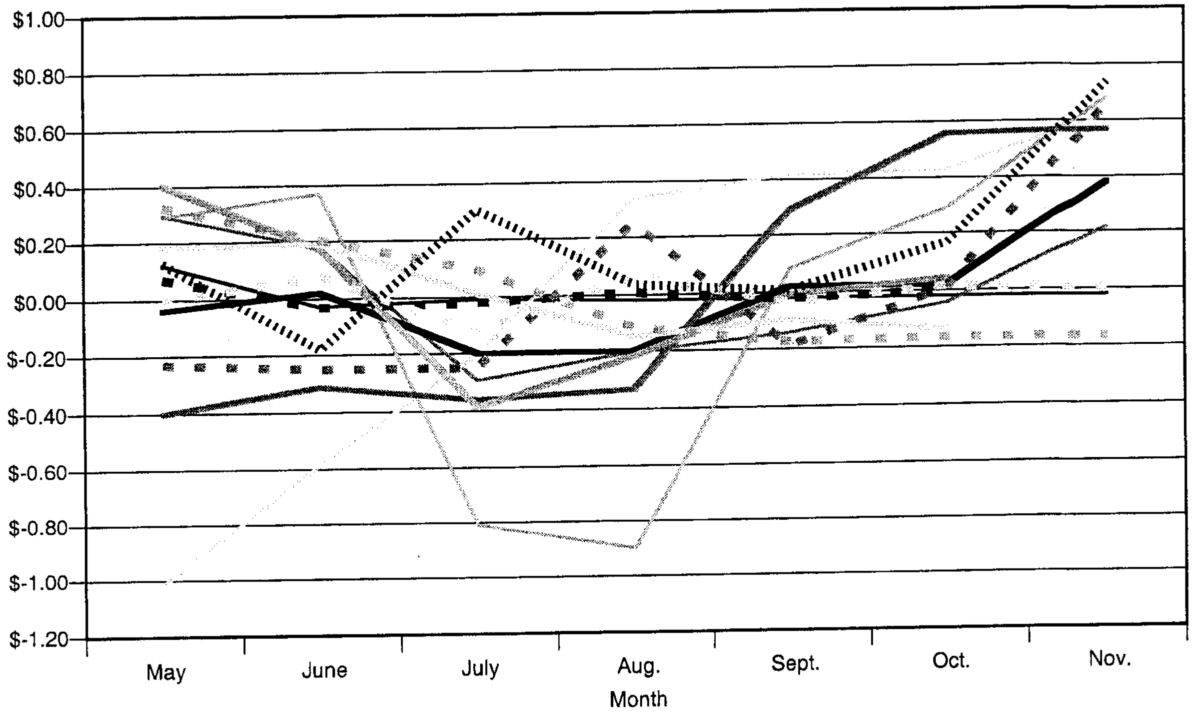


FIGURE B-11. Inseason exvessel price fluctuations for small chinook (Oregon).

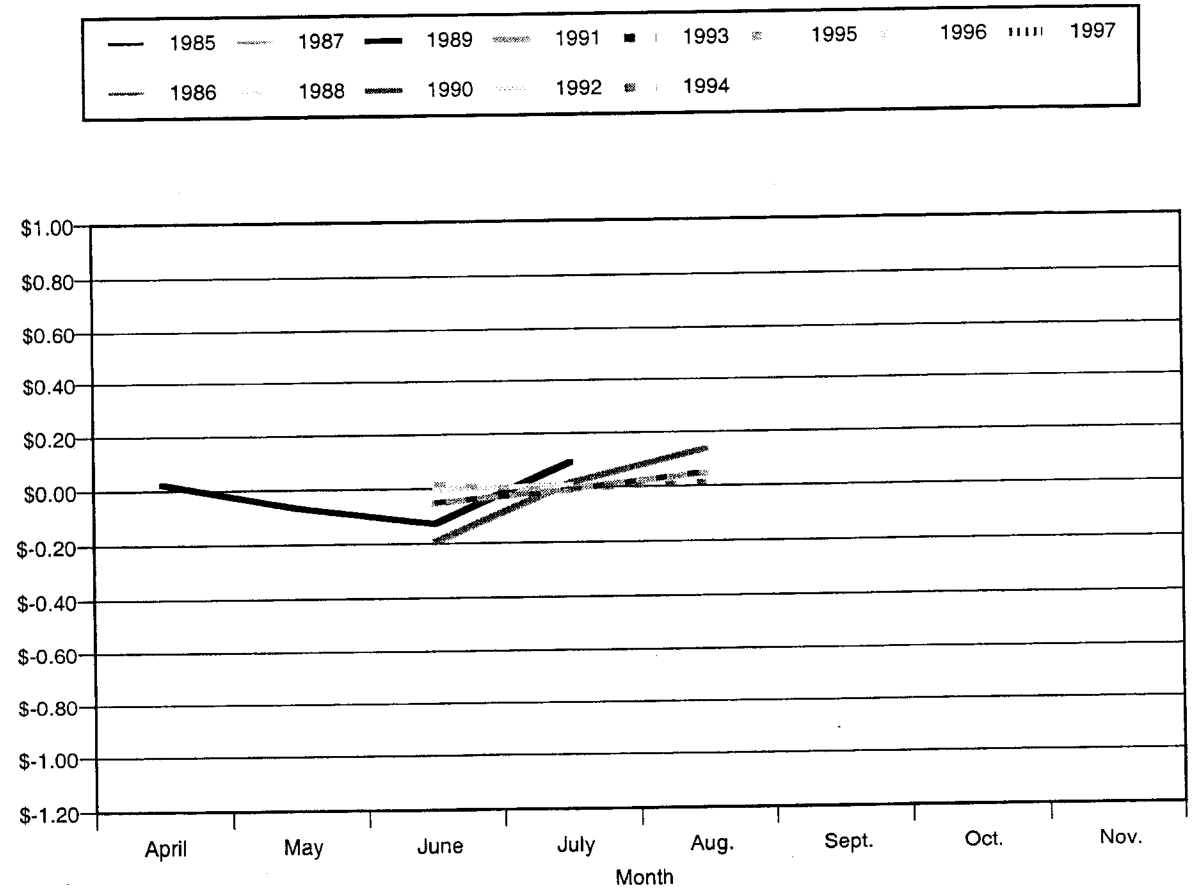


FIGURE B-12. Inseason exvessel price fluctuations for mixed coho (Washington).

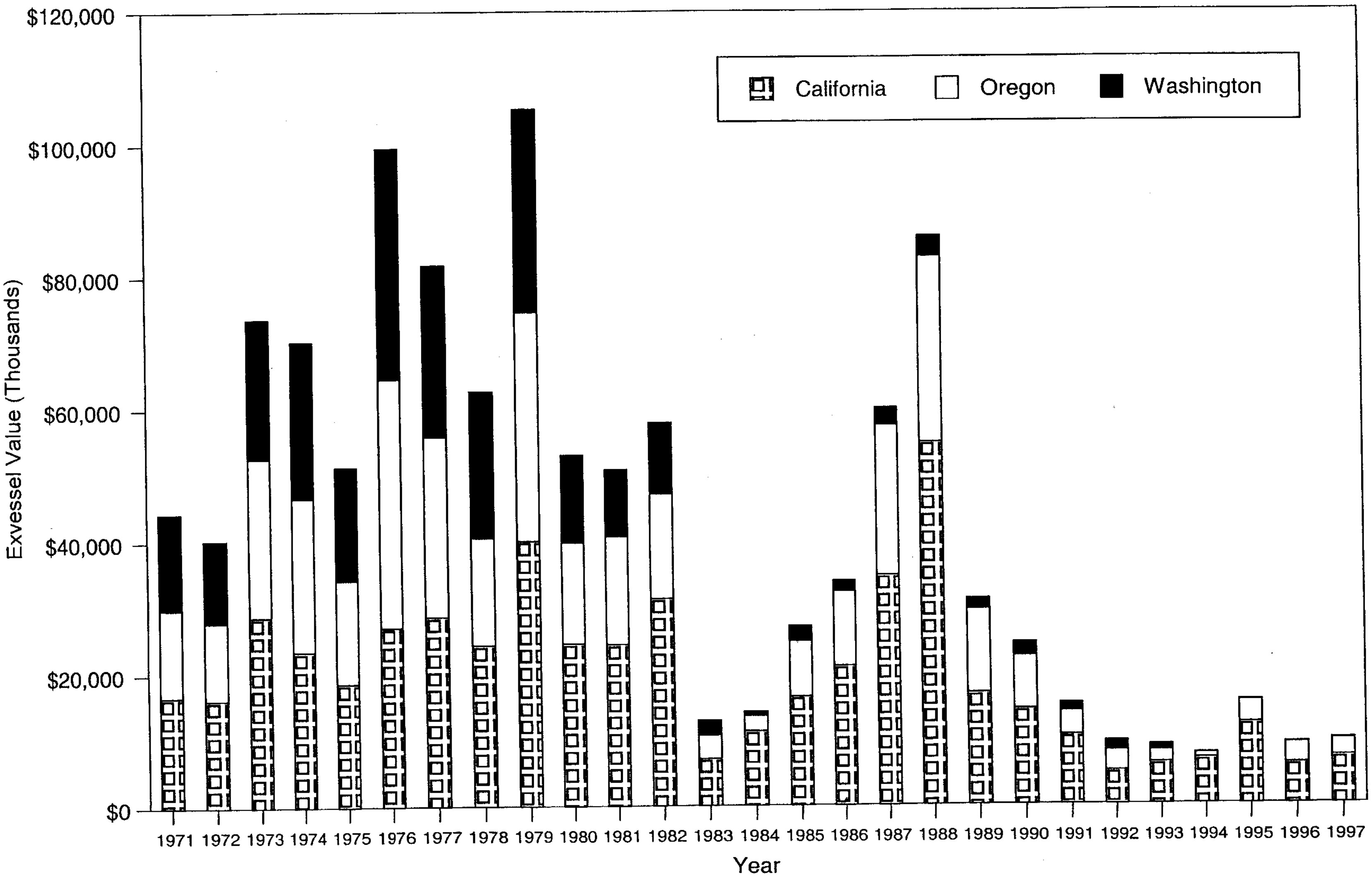


FIGURE B-13. Exvessel value of troll chinook and coho landings by state of landing (1997 dollars).

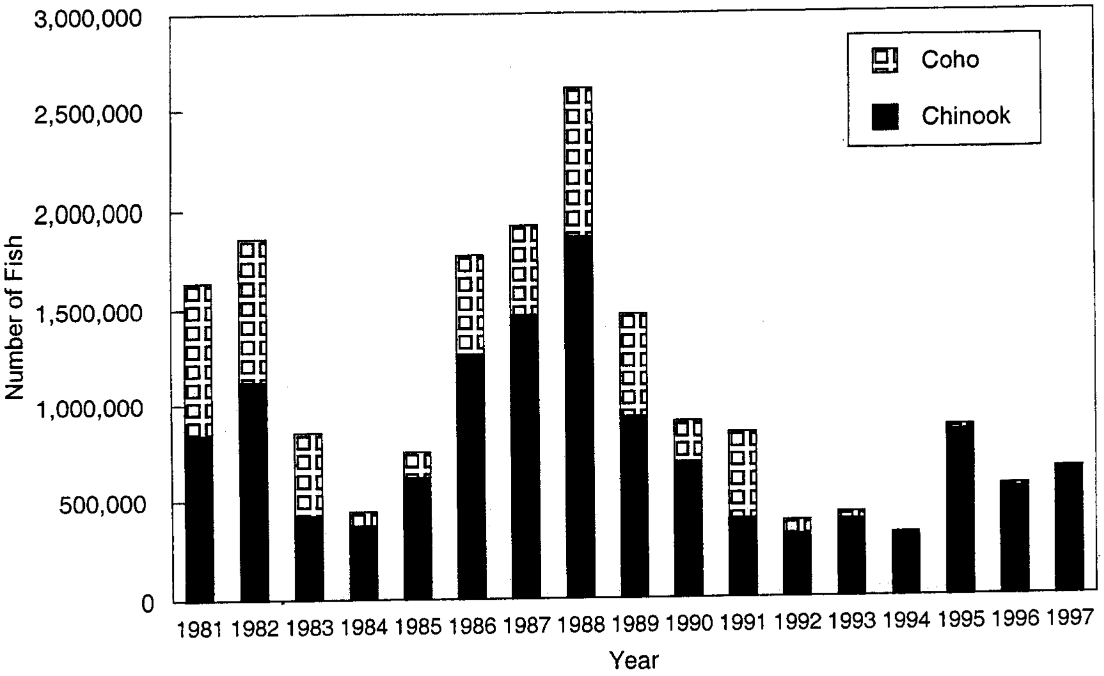


FIGURE B-14. West Coast non-Indian ocean commercial troll chinook and coho harvest.

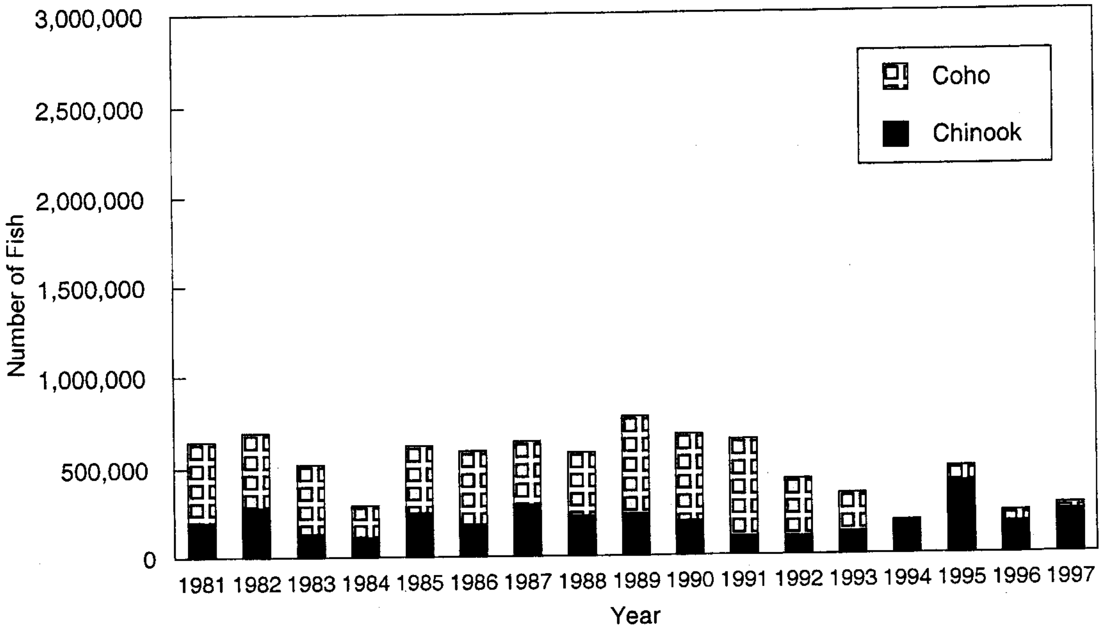


FIGURE B-15. West Coast recreational ocean chinook and coho harvest.

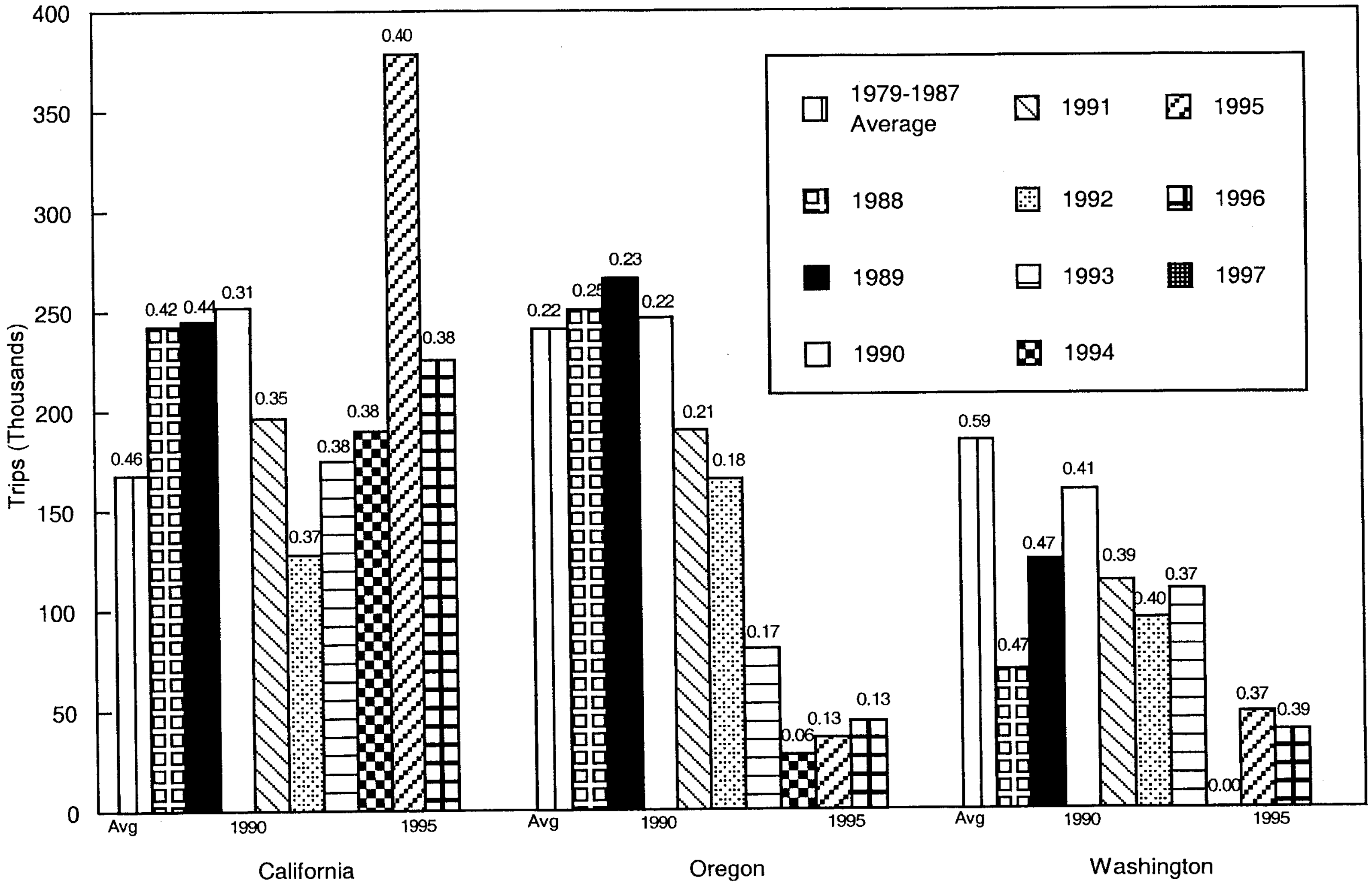


FIGURE B-16. Total recreational ocean salmon trips by state (with proportion of charter trips shown above each bar).