FINAL

ENVIRONMENTAL ASSESSMENT

AND

REGULATORY IMPACT REVIEW

PACIFIC COAST SALMON PLAN AMENDMENT 18: INCORPORATING REVISIONS TO PACIFIC SALMON ESSENTIAL FISH HABITAT

REGULATORY IDENTIFIER NUMBER 0648-BC95

PREPARED BY
THE PACIFIC FISHERY MANAGEMENT COUNCIL
AND
NATIONAL MARINE FISHERIES SERVICE

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LIST OF ACRONYMS

BOR	Bureau of Reclamation
CCA	Cowcod Conservation Area
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
CPS	Coastal pelagic species
DPA	Distinct Population Segment
EA	Environmental Assessment
EEZ	Exclusive Economic Zone
EFH	Essential fish habitat
EIS	Environmental Impact Statement
ESA	Endangered Species Act
ESU	Evolutionarily Significant Unit
FERC	Federal Energy Regulatory Commission
FMP	Fisheries management plan
FMU	Fishery management unit
FONSI	Finding of No Significant Impacts
FPA	Final preferred alternative
FRFA	Final Regulatory Flexibility Analysis
HAPC	Habitat area of particular concern
HC	Habitat Committee
HMS	Highly migratory species
HU	Hydrologic Unit
IRFA	Initial Regulatory Flexibility Analysis
KHSA	Klamath Hydropower Settlement Agreement
LWD	Large woody debris
MBTA	Migratory Bird Treaty Act
MMPA	Marine Mammal Protection Act
MPA	Marine protected area
MSA	Magnuson-Stevens Act
MSRA	Magnuson-Stevens Reauthorization Act
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NPFMC	North Pacific Fishery Management Council
NWFSC	Northwest Fisheries Science Center
NWR	Northwest Region
ODFW	Oregon Department of Fish and Wildlife
OP	Oversight Panel
PCTS	Public Consultation Tracking System
PFMC	Pacific Fishery Management Council (Council)
PS	Puget Sound
PSMFC	Pacific States Marine Fisheries Commission
RCA	Rockfish Conservation Area
RFMC	Regional fishery management council
SAFE	Stock Assessment Fishery Evaluation

SAS	Salmon Advisory Subpanel
SAV	Submerged aquatic vegetation
SBA	Small Business Administration
Secretary	U.S. Secretary of Commerce
SONCC	Southern Oregon/Northern California Coho
SSC	Scientific and Statistical Committee
STT	Salmon Technical Team
SWFSC	Southwest Fisheries Science Center
SWR	Southwest Region
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
WCR	West Coast Region
YRCA	Yelloweye Rockfish Conservation Area

1.0 INTRODUCTION

The 1996 reauthorization of the Magnuson-Stevens Fishery Conservation and Management Act (MSA) included requirements to identify, describe, and protect essential fish habitat (EFH). EFH is defined as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity." The MSA and EFH regulations require Regional Fishery Management Councils (RFMC) to describe and identify EFH by life-stage, evaluate potential adverse impacts to habitat and develop measures to protect EFH, and identify major prey species, among other provisions. These items must be included in all Fishery Management Plans (FMPs).

Pacific salmon EFH is described in Appendix A to the Pacific Coast Salmon FMP (PFMC 1999), and includes "all those streams, lakes, ponds, wetlands, and other currently viable water bodies and most of the habitat historically accessible to salmon in Washington, Oregon, Idaho, and California. In 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 exclusive economic zone (EEZ) offshore of Washington, Oregon, and California north of Point Conception." Pacific Coast salmon EFH also includes those areas off Alaska designated as salmon EFH by the North Pacific Fishery Management Council (NPFMC). Freshwater EFH excludes areas above longstanding naturally impassable barriers and certain man-made barriers representing the current upstream extent of Pacific salmon access. The Pacific Fishery Management Council (Council) and National Marine Fisheries Service (NMFS) made minor revisions during the EFH codification process in 2008 (73 FR 60987).

The regulatory guidelines for implementing the EFH provisions of the MSA state that RFMCs and NMFS should periodically review the EFH provisions of FMPs and revise or amend them as warranted, based on available information (50 CFR 600.815(a)(10)). This review should include evaluating published scientific literature and unpublished reports, soliciting input from interested parties, and searching for previously unavailable information on salmon stocks identified in the FMP. The regulatory guidance states that a complete review should be conducted periodically, but at least once every five years. Pacific Coast salmon EFH was first designated in 1999 by the Council as part of Amendment 14 to the Salmon FMP and was codified in 2008 as a result of the Idaho County versus Commerce court case (Idaho County *et al*. v. Donald Evans *et al.*, United States District Court for the District of Idaho, Case No. CV02-80-C-EJL). Any modifications to EFH should be described in detail and published in the appropriate format. In some cases it may require an FMP amendment, if the FMP does not include provisions for making changes to EFH outside of the amendment process.

The Council and NMFS initiated a review of salmon EFH in 2009[1]. In the years since Pacific Coast salmon EFH was first identified and described in 1999, NMFS has taken steps to clarify the process for identifying, describing, and refining EFH. In 2002, NMFS published a final rule

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[1] As part of the review, Cramer Fish Sciences was contracted to compile an Annotated Bibliography for 2010 Essential Fish Habitat Update; this document will be available to the public on the Council's website (www.pcouncil.org).

to implement the EFH provisions of the MSA (67 FR 2343), and, in 2006, issued a memorandum providing additional guidance to refine the description and identification of EFH (NMFS 2006). This review was guided by these two clarifying documents.

1.1 DOCUMENT ORGANIZATION

This document is intended to present and analyze alternatives that were developed to reflect new and newly-available information generated during the recent periodic review. Section 1 contains background, purpose and need, the Council's FMP amendment schedule, related documents, and a brief summary of alternatives. Section 2 contains the detailed description of the alternatives; Section 3 contains a description of the affected environment; Section 4 is the analysis of alternatives; Section 5 describes consistency with applicable laws; and Section 6 contains literature cited.

Appendix A to this document was adopted in September 2013 by the Council as the Amendment 18 preferred alternative, and is an update of the EFH provisions approved in 2000 as part of Amendment 14 to the Salmon FMP. It provides detailed information regarding the EFH identification and description, and other information contained in the FMP itself. Appendix A includes the detailed description and identification of Pacific salmon EFH, the fishing and non-fishing activities that may adversely affect EFH, and recommended conservation measures.

Appendix B to this document contains proposed amendments to FMP language in strikethrough format. Any changes adopted by the Council and subsequently approved by NMFS will be reflected in Appendix B.

1.2 PURPOSE AND NEED

The purpose of the proposed action is to use the best scientific information available to inform revisions to the description and identification of EFH for Pacific salmon. The purpose is also to use the new information to inform other EFH actions to designate habitat areas of particular concern (HAPC), modify the current information on fishing activities and identify potential measures to minimize its effects on EFH, update the list of non-fishing related activities that may adversely affect EFH, and identify potential conservation and enhancement measures to minimize those effects. The need for the proposed action is to ensure that EFH description and identification in the FMP takes into account new information and data regarding salmon habitat that has become available since EFH was initially identified and described for Pacific Coast salmon in 1999 to continue the protections afforded to Pacific salmon managed under the salmon FMP, by updating EFH designations and related information.

The regulations implementing the EFH requirements in the MSA require that the RFMCs conduct periodic reviews of EFH provisions of their FMPs and revise or amend those provisions, as warranted, based on the available information (50 CFR 600.815(a)(10)). A recent review of the available information on habitat use by Pacific salmon found that revisions to EFH may be necessary to account for new information about salmon habitat.

1.3 PLAN DEVELOPMENT SCHEDULE AND ADVISORY BODY PARTICIPATION

At its April 2011 meeting, the Council initiated an FMP amendment process to address recommended modifications to Pacific salmon EFH. The recommendation to modify EFH was developed by the Pacific salmon EFH Oversight Panel (OP) that consisted of agency and Council staff, and was contained in a final report (Stadler *et al*. 2011) presented to the Council in June 2011.

The Council considered an initial scoping document in March 2012, and considered an alternatives document in September 2012. The alternatives selected for analysis address changes to the geographic extent of EFH, revisions to the list of dams that form the upstream extent of EFH, revisions to the criteria for determining the upstream extent of EFH, the designation of HAPCs, updates to the description of the habitat requirements by species and life-stage, and revisions to the description of fishing and non-fishing activities that may adversely affect salmon EFH, and potential conservation measures to address those effects. At its April 2013 meeting, the Council requested the addition of an alternative to address the situation in which Endangered Species Act (ESA) Section 10(j) experimental population reintroductions may co-occur with proposed EFH.

At its September 2013 meeting, the Council adopted final preferred alternatives for modifying Pacific salmon EFH. This completed the Council's process for the FMP amendment. Council and NMFS staff then made final modifications and transmitted the amendment package (including the Environmental Assessment [EA], FMP language, and other relevant documents) to NMFS for approval by the Secretarial of Commerce. After approval, Amendment 18 will be published on the Council's website, along with Appendix A and other relevant information.

1.4 RELATED DOCUMENTS INCORPORATED BY REFERENCE

Several documents are directly related to Pacific salmon EFH, and are hereby incorporated by reference:

Pacific Coast Salmon Fishery Management Plan (FMP) (PFMC 2012). The FMP forms the basis for Pacific salmon management, including harvest, conservation objectives, consistency with national standards, and EFH. It has been amended 17 times. The Salmon FMP contains the EFH identification, description, and all associated information required by the 1996 revision of the MSA and the subsequent regulations promulgated by NMFS in 2002 (67 FR 2343).

Appendix A to Pacific Coast Salmon FMP (PFMC 1999). This document is referred to as the 1999 Appendix A, and was approved as part of Amendment 14 to the salmon FMP. It contains the detailed identification and description of Pacific salmon EFH, which further defines the overall identification and description, and fishing activities contained in the FMP itself. It also includes information on EFH per life stage, fishing and non-fishing impacts, impassable barriers, conservation measures, maps, figures, and more. Once Amendment 18 is approved by the Secretary, the proposed Appendix A will replace the 1999 Appendix A, and it will reflect the most up-to-date information on Pacific salmon EFH.

Pacific Coast Salmon 5-Year Review of Essential Fish Habitat: Final Report to the Pacific Fishery Management Council (Stadler *et al*. 2011). This report to the Council, written by the OP, summarized the findings of the EFH periodic review, and made broad recommendations regarding whether new and newly-available information warranted moving forward with modifying Pacific salmon EFH.

1.5 CONCLUSION

Detailed descriptions and discussion of the alternatives and the expected environmental impacts resulting from each of the alternatives, as well as any cumulative impacts, are provided in Section 2 and Section 4 of this document, respectively. While there are potential minor negative impacts associated with some of the alternatives, none of the alternatives were found to have significant negative impacts to the biological, socioeconomic, or physical environment. In addition, in some cases, positive insignificant impacts were identified, and are described in Section 4. Based on this, NMFS will make a finding of no significant impact (FONSI), which will be attached to the final EA..

2.0 DESCRIPTION OF ALTERNATIVES

The suite of alternatives described here addresses the potential revisions to salmon EFH identified during the periodic review process. These revisions are based on the required elements of EFH contained in the regulatory guidance (50 CFR 600.815). None of the alternatives are mutually exclusive, with the exception of Alternatives 6C and 6D, which are mutually exclusive with each other; and the No-action Alternatives, which are mutually exclusive with the other alternatives in each category. Therefore, the Council could select more than one action alternative in a given category. For example, the Council could select both Alternatives 3B (add coho EFH to specific hydrologic units [HUs]) *and* 3C (remove EFH designation from one HU).

Selection of any of the action alternatives would modify the existing EFH provisions. The No-action Alternative in each category is equal to status quo. In other words, a decision by the Council to not take action means that the existing EFH provisions would remain in place. Table 2-1 provides an overview of the alternatives, reflecting changes made by the Council at the September 2012 and April 2013 Council meetings.

The Council's selections of final preferred alternatives (FPA) are highlighted in bold font in Table 2-1. The FPAs are Alternatives 1B, 2B, 2D, 3B, 3C, 4B, 5B, 6B, 6D, 7B, 8B, 9B-9F, 10B, 10C, 11B, 11C1-11C10, 12B, and 13B.

Table 2-1: Summary of Alternatives

Subject Area	Alternatives
Identification of Pacific salmon EFH	1A. No-action Alternative **1B. Revise the identification of EFH, clarifying that EFH is designated only for stocks included in the fishery managed by the PFMC.**
Chinook salmon freshwater EFH	2A. No-action Alternative **2B. Add five hydrologic units (HUs) as Chinook salmon EFH: 17060108 (Palouse), 17060308 (Lower NF Clearwater), 18050005 (Tomales-Drakes Bay), 17020009 (Lake Chelan), and 17020015 (Lower Crab Creek); and remove one HU as Chinook salmon EFH: 17100207 (Siltcoos).** 2C. Designate the mainstem Columbia River and side channels as EFH for Chinook salmon, in HU 17070101. **2D. Update EFH designations and maps to be consistent with new USGS California Central Valley 4th field hydrologic units.**
Coho salmon freshwater EFH	3A. No-action Alternative **3B. Add five HUs as coho salmon EFH: 17070103 (Umatilla), 17060305 (South Fork Clearwater), 17060304 (Middle Fork Clearwater), 17060302 (Lower Selway), and 17060301 (Upper Selway)** **3C: Remove coho salmon EFH from one HU: 18060006 (Central California Coast).**
Puget Sound pink salmon freshwater EFH	4A. No-action Alternative **4B. Designate HU 17110013 (Duwamish) and HU 17110017 (Skokomish) as Puget Sound pink salmon EFH.**
ESA Section 10(j) experimental population reintroduction efforts	5A. No-action Alternative **5B. Amend Appendix A to add a statement that efforts to reintroduce Pacific salmon as an experimental population into historically occupied habitats under Section 10(j) of the Endangered Species Act will be considered when designating EFH.**
Impassable barriers	6A. No-action Alternative **6B. Update and correct the list of impassable dams, including correct names, other minor corrections, removing dams from the list that are upstream of other impassable barriers, and removing barriers that are now passable from the list: [Dexter Dam (HU 17090001, Middle Fork Willamette River); Big Cliff Dam (HU 19070005, North Santiam River); Cougar Dam (HU 17090004, McKenzie River); Soda Springs Dam (HU 17100301, North Umpqua River)].** 6C. Revise the criteria for designating a dam as the upstream extent of EFH, and update the list based on the new criteria and new information. **6D. Revise the criteria for designating a dam as the upstream extent of EFH, update the list based on**

	the new criteria and new information, and include consideration of efforts to reintroduce experimental populations of salmon into historically occupied habitats under Section 10(j) of the Endangered Species Act.
Marine and estuarine EFH	7A. No-action Alternative **7B. Clarify that Puget Sound pink salmon marine EFH includes U.S. EEZ waters north of 48° N latitude, Puget Sound/Strait of Juan de Fuca, and Alaskan waters that are designated salmon EFH by the NPFMC.**
EFH descriptions	8A. No-action Alternative **8B. Update the text for EFH summaries and descriptions for each species of Pacific Coast salmon, based on best available science. Provide new references as an appendix to Amendment 18; and update EFH descriptions, life history, and habitats, based on new information including habitat needs and life history.**
HAPCs	9A. No-action Alternative **9B. Designate channels and floodplains as a HAPC.** **9C. Designate thermal refugia as a HAPC.** **9D. Designate spawning habitat as a HAPC.** **9E. Designate estuaries as a HAPC.** **9F. Designate marine and estuarine submerged aquatic vegetation as a HAPC.**
Fishing activities that may adversely affect EFH	10A. No-action Alternative **10B. Revise description of MSA fishing activities.** **10C. Revise description of non-MSA fishing activities.**
Non-fishing activities that may adversely affect EFH	11A. No-action Alternative **11B. Update the information on the existing 21 non-fishing activities that may adversely affect EFH.** **11C. Add new non-fishing activities that may adversely affect EFH:** **11C1. Activities causing high intensity acoustic or pressure waves** **11C2. Over-water structures** **11C3. Alternative energy development** **11C4. Liquefied natural gas projects** **11C5. Desalination** **11C6. Power plant intakes** **11C7. Pesticide use** **11C8. Flood control maintenance** **11C9. Culvert construction** **11C10. Coal export terminal facilities**
Information and research	12A. No-action Alternative **12B. Identify and prioritize new information and research needs.**

Procedures for changing EFH	13A. No-action **13B. Develop process for future changes to EFH.**
Alternatives considered but rejected*	4D. Designate HU 17110021 (Crescent-Hoko) as Puget Sound pink salmon EFH. 4E. Designate HU 17120102 (Queets-Quinault) as Puget Sound pink salmon EFH. 5C. Update the list of dams based on the existing criteria. 10C10. Add “activities that contribute to climate change” to list of non-fishing activities that may adversely affect EFH.

**These alternatives were numbered differently when considered in September 2012, and therefore do not necessarily align with the new numbering.*

2.1 IDENTIFICATION OF EFH FOR PACIFIC COAST SALMON

FMPs are required to identify and describe EFH for all managed species. In very general terms, the Salmon FMP identifies EFH as "those waters and substrate necessary for salmon production needed to support a long-term sustainable salmon fishery and salmon contributions to a healthy ecosystem." It goes on to provide additional factors that the Council uses to identify EFH. Based on the review, the Council considered a minor revision to the general description of salmon EFH, to clarify that EFH can only be designated for salmon species that are federally managed and included in a fishery management unit (FMU).

Alternative 1A: No-action Alternative

This alternative would retain the existing language on identification of Pacific Coast salmon EFH.

Alternative 1B: Revise the identification of EFH (preferred)

This alternative would add language to clarify that EFH may only be designated for federally-managed stocks that are included in an FMU. The alternative language would be modified to avoid confusion about which salmon have EFH; and would provide better clarity regarding the identification of EFH and whether EFH can be designated for a particular stock of Pacific salmon.

2.2 FRESHWATER ESSENTIAL FISH HABITAT

Freshwater EFH for each of the three managed species is currently designated by 4th field HUs[2], and is based on the information available at the time Amendment 14 was developed, in 1999. Continuing to apply an inclusive, watershed-based description of EFH using U.S. Geological Survey (USGS) HUs is appropriate, because it (1) recognizes the species' need to use diverse habitats and underscores the need to account for all of the habitat types supporting the species' freshwater and estuarine life stages, from small headwater streams to migration corridors and estuarine rearing areas, (2) considers the variability of freshwater habitat as affected by environmental conditions (droughts, floods, etc.) that make precise mapping difficult, and (3) reinforces important linkages between aquatic and adjacent upslope areas. Habitat available and utilized by salmon changes frequently in response to floods, landslides, woody debris inputs, sediment delivery, and other natural events. To expect the distribution of salmon within a stream, watershed, province, or region to remain static over time is unrealistic. Furthermore, this watershed-based approach is consistent with other Pacific salmon habitat conservation and recovery efforts such as those implemented under the Endangered Species Act (ESA).

The periodic review noted a number of potential revisions to the freshwater EFH designations for the three species of salmon managed under the Salmon FMP (See Stadler *et al*. 2011). These

[2] The United States is divided into successively smaller hydrologic units based on distinctive features and watershed boundaries. Each hydrologic unit is identified by a unique hydrologic unit code consisting of two to eight digits based on four levels of classification in the hydrologic unit section. 4th field hydrologic units, referred to as "cataloging units", are assigned a unique 8-digit code and cover a geographic area representing part of or all of a surface drainage basin, a combination of drainage basins, or a distinct hydrologic feature.

revisions included changes to the 4th field HUs that are designated as EFH for each species, and changes to the dams that mark the upstream extent of EFH.

2.2.1 Alternatives for revising Chinook salmon Freshwater EFH

As described in Stadler *et al*. (2011), the 4th field HUs were updated by the USGS, resulting in changes to the names, codes, and boundaries of HUs in the California Central Valley and coast(Figure 2-1). The changes, which pertain primarily to the California Central Valley, typically result in larger, consolidated HUs. The EFH designations in this area should be updated to reflect the current classification system.

The alternatives for revising Chinook salmon EFH in fresh water incorporate new distributional data found during the periodic review and revisions to the numbers, names, and boundaries of the 4th field HUs in the California Central Valley and coast. With the exception of Alternative 2A, these are not mutually exclusive. The Council may elect to implement some or all of these alternatives.

Amendment 16 to the Salmon FMP removed the mid-Columbia River spring Chinook salmon stocks from the FMU. The 1999 Appendix A identified EFH for these stocks; however, the action of removing them from federal management means that they are no longer eligible to have EFH identified and described for them. Therefore, Amendment 18 would remove EFH previously identified for mid-Columbia River spring Chinook salmon. However, this action is required as a result of Amendment 16 and the effects of the decision to remove mid-Columbia River spring Chinook stocks from the FMY were analyzed in the EA supporting Amendment 16. As a result, this EA does not further analyze those effects. At the time these alternatives were developed, it was also thought that mid-Columbia River spring Chinook were the only stocks of Chinook salmon to spawn and rear in the Middle Columbia – Lake Wallula HU (17070101), but that stocks of upriver Chinook salmon included in the FMU would use the mainstem and lower reaches of the perennial tributaries as migration routes and refuge from high water events (floods) and high temperatures. As such, the designation of portions of this HU was included in the alternatives. Although there are no options that the Council and NMFS could select or analyze, it nevertheless warrants a brief description here. Several of the 4th field HUs that mid-C Spring Chinook salmon occupy have redundant EFH coverage, in that other Chinook salmon or coho salmon stocks also occupy those HUs. However, there are nine HUs that will have no EFH as a result of removing mid-Columbia Chinook stocks from the FMP, because of the fact that the mid-Columbia Chinook salmon stocks were the only managed salmon stock present in the HU. These are the nine HUs that no longer will have EFH identified for them:

- Walla Walla River (17070102
- Upper John Day River (17070201)
- North Fork John Day River (17070202)
- Middle Fork John Day River (17070203)
- Lower John Day River (17070204)
- Upper Deschutes River (17070301)
- Lower Crooked River (17070305)
- Trout Creek (17070307)
- Willow (17071004)

The alternatives for revising Chinook salmon EFH in fresh water incorporate new distributional data found during the periodic review and revisions to the numbers, names, and boundaries of the 4th field HUs in the California Central Valley and coast. With the exception of Alternative 2A, these are not mutually exclusive. The Council may elect to implement some or all of these alternatives.

Alternative 2A: No-action Alternative

This alternative would retain the existing EFH description and geographic distribution for Chinook salmon. As a result, the EFH designation would not be based on the latest distribution data, and would rely, especially in the California Central Valley, on outdated HU codes, names, and boundaries.

Alternate 2B: Add five HUs and remove one as Chinook salmon EFH (preferred)

- Current distribution data show that Chinook salmon occupy five 4th field HUs that are not currently designated as EFH for this species. These HUs are:
    - 17020009 (Lake Chelan)
    - 17060108 (Palouse)
    - 17060308 (Lower North Fork Clearwater)
    - 18050005 (Tomales-Drakes Bay)
    - 17020015 (Lower Crab Creek)
- Current and historic distribution data show that Chinook salmon have not occupied one HU that is currently designated as Chinook salmon EFH:
    - 17100207 (Siltcoos)

The presence of anadromous Chinook salmon in Lake Chelan (17020009) is limited to the lower reaches of the Chelan River, below a naturally impassable stream reach. Although Chinook salmon are present in the lake, these are non-anadromous fish and are not managed by the Council. In the lower north fork of the Clearwater River (17060308), Chinook salmon are limited to the relatively short portion of river that is below Dworshak Dam. Within the Tomales-Drakes Bay HU (18050005), Chinook salmon have been observed in Lagunitas Creek 12 of the last 16 years (Ettlinger *et al*. 2012). Streamnet data show fall Chinook migration and spawning in some parts of Lower Crab Creek (17020015).

Although the 1999 Appendix A identifies the Siltcoos (17100207) as both current and historic habitat for Chinook salmon, this was not supported upon a review of the available information on Chinook salmon distribution.

This alternative would designate these four HUs as EFH for Chinook salmon, and therefore follow the regulatory guidelines for designating EFH based on presence/absence data. Additional 4th field HUs may be designated as EFH for Chinook salmon under Alternatives 6C and 6D (impassable dams). This alternative would also remove EFH from HU 17100207 (Siltcoos).

Alternative 2C: Designate the mainstem Columbia River and side channels as EFH for Chinook salmon, in HU 17070101

Amendment 16 removed the mid-Columbia spring-run Chinook salmon stocks from the management unit. Originally, it was thought that these were the only stocks of Council-managed Chinook salmon to spawn in the Mid-Columbia-Lake Wallula HU (17070101), but that the mainstem Columbia River and the lower reaches of the perennial tributaries in this HU function as migratory corridors, rearing habitat, and thermal refugia for upstream stocks of Council-managed Chinook salmon. This alternative was intended to ensure that these habitats retained their designation as EFH for Chinook salmon. However, it is now understood that Council-managed fall-run Chinook salmon spawn in several of the tributaries to this HU and, therefore, this alternative would not designate some important habitat as EFH for Chinook salmon.

Alternative 2D: Update EFH identification and maps to be consistent with new USGS HU designations (preferred)

As described in Stadler *et al*. (2011), the 4th field HUs were updated by the USGS, resulting in changes to the names, codes, and boundaries of several HUs in the California Central Valley and coast (Figure 2-1). Most of the changes result in larger, consolidated HUs.

This alternative would update the tables and maps of the 4th field HUs designated as EFH for Pacific salmon to reflect the changes in the California Central Valley and coast HU classifications. In some cases, this would result in expansion of EFH into some areas that were not previously designated as EFH. However, much of the new area encompassed by the revised HUs is above impassable barriers, and therefore is excluded from EFH on that basis. In addition, all but the lower reaches of western tributaries to the San Joaquin River would be excluded because of a lack of current or historical salmon distribution. These changes to the HU codes and names are documented in Table 2-2 and Figure 2-1.

Table 2-2. Changes to HUs in the California Central Valley and Coast Based on USGS Data Revisions and Necessary Updates to EFH Designations as a Result.

Current HUs to Designate as EFH	Previous HU(s) Designated as EFH with Boundary Overlap	FMP Species
18010109 (Gualala-Salmon)	18010109 (Gualala-Salmon), 18010111 (Bodega Bay)	Chinook, coho
18020104 (Sacramento-Stone Corral)	18020104 (Sacramento-Stone Corral)	Chinook
18020111 (Lower American)	18020111 (Lower American), 18020109 (Lower Sacramento)	Chinook
18020115 (Upper Stony)	18020103 (Sacramento-Lower Thomes)	Chinook
18020116 (Upper Cache)	18020109 (Lower Sacramento), 18020110 (Lower Cache)	Chinook
18020125 (Upper Yuba)	18020107 (Lower Yuba),	Chinook

	18020125 (Upper Yuba)	
18020126 (Upper Bear)	18020108 (Lower Bear), 18020126 (Upper Bear)	Chinook
18020151 (Cow Creek)	18020101 (Sacramento-Lower Cow-Lower Clear), 18020118 (Upper Cow-Battle)	Chinook
18020152 (Cottonwood Creek)	18020102 (Lower Cottonwood), 18020113 (Cottonwood Headwaters)	Chinook
18020153 (Battle Creek)	18020101 (Sacramento-Lower Cow-Lower Clear), 18020118 (Upper Cow-Battle)	Chinook
18020154 (Clear Creek-Sacramento River)	18020101 (Sacramento-Lower Cow-Lower Clear), 18020112 (Sacramento-Upper Clear), 18020118 (Upper Cow-Battle)	Chinook
18020155 (Paynes Creek-Sacramento River)	18020101 (Sacramento-Lower Cow-Lower Clear), 18020103 (Sacramento-Lower Thomes), 18020114 (Upper Elder-Upper Thomes), 18020118 (Upper Cow-Battle), 18020119 (Mill-Big Chico)	Chinook
18020156 (Thomes Creek-Sacramento River)	18020103 (Sacramento-Lower Thomes), 18020114 (Upper Elder-Upper Thomes), 18020119 (Mill-Big Chico)	Chinook
18020157 (Big Chico Creek-Sacramento River)	18020103 (Sacramento-Lower Thomes), 18020119 (Mill-Big Chico)	Chinook
18020158 (Butte Creek)	18020105 (Lower Butte), 18020120 (Upper Butte)	Chinook
18020159 (Honcut Headwaters-Lower Feather)	18020106 (Lower Feather)	Chinook
18020161 (Upper Coon-Upper Auburn)	18020109 (Lower Sacramento)	Chinook
18020162 (Upper Putah)	18020109 (Lower Sacramento)	Chinook

18020163 (Lower Sacramento)	18020109 (Lower Sacramento)	Chinook
18040001 (Middle San Joaquin-Lower Chowchilla)*	18040002 (Middle San Joaquin-Lower Merced-Lower Stanislaus); 18040001 (Middle San Joaquin-Lower Chowchilla)	Chinook
18040002 (Lower San Joaquin River)*	18040002 (Middle San Joaquin-Lower Merced-Lower Stanislaus)	Chinook
18040003 (San Joaquin Delta)	18040002 (Middle San Joaquin-Lower Merced-Lower Stanislaus), 18040003 (San Joaquin Delta), 18040004 (Lower Calaveras-Mormon Slough), 18040005 (Lower Cosumnes-Lower Mokelumne)	Chinook
18040007 (Fresno River)	18040001 (Middle San Joaquin-Lower Chowchilla)	Chinook
18040008 (Upper Merced)	18040001 (Middle San Joaquin-Lower Chowchilla), 18040002 (Middle San Joaquin-Lower Merced-Lower Stanislaus)	Chinook
18040009 (Upper Tuolumne)	18040002 (Middle San Joaquin-Lower Merced-Lower Stanislaus)	Chinook
18040010 (Upper Stanislaus)	18040002 (Middle San Joaquin-Lower Merced-Lower Stanislaus)	Chinook
18040011 (Upper Calaveras)	18040003 (San Joaquin Delta); 18040004 (Lower Calaveras-Mormon Slough), 18040011 (Upper Calaveras)	Chinook
18040012 (Upper Mokelumne)	18040003 (San Joaquin Delta), 18040005 (Lower Cosumnes-Lower Mokelumne), 18020109 (Lower Sacramento)	Chinook
18040013 (Upper Cosumnes)	18040003 (San Joaquin Delta), 18040005 (Lower Cosumnes-Lower Mokelumne), 18040013 (Upper Cosumnes)	Chinook
18060015 (Monterey Bay)		Coho

** 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, 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*

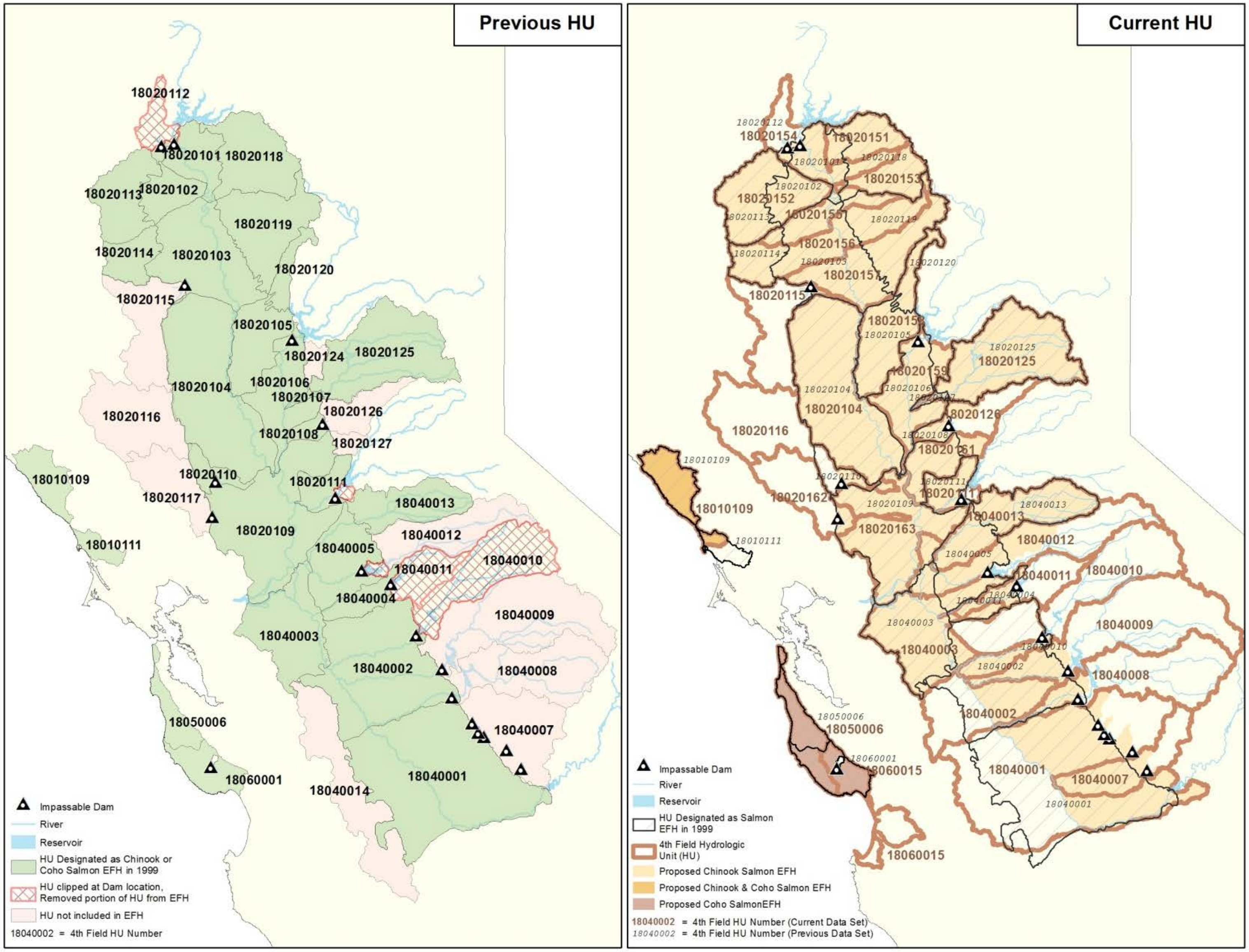

Figure 2-1. Changes in USGS 4th field hydrologic unit number, names, and boundaries between 1999 and 2013.

2.2.2 ALTERNATIVES FOR REVISING COHO SALMON FRESHWATER EFH

The alternatives to revise the designations of coho salmon EFH in fresh water incorporate new distributional data found during the periodic review and recognize that some historical data may not be accurate. With the exception of Alternative 3A, these are not mutually exclusive. The Council may elect to implement some or all of these alternatives.

Alternative 3A. No-action Alternative

This alternative would retain the existing EFH description and geographic distribution for coho salmon. As a result, the EFH designation would not be based on the latest distribution data, and some HUs with coho salmon would not be designated as EFH.

Alternative 3B. Add six HUs as coho salmon EFH (preferred)

This alternative would designate six HUs as EFH for coho salmon, and therefore follow the regulatory guidelines for designating EFH based on presence/absence data. Additional 4th field HUs may be designated as EFH for coho salmon under Alternatives 6C and 6D (impassable dams).

Current distributional data show that coho salmon occupy six 4th field HUs that are not currently designated as EFH for this species. These HUs are:

- 17070103 (Umatilla)
- 17060305 (South Fork Clearwater)
- 17060304 (Middle Fork Clearwater)
- 17060302 (Lower Selway)
- 17060301 (Upper Selway)
- 18060002 (Pajaro River)[3]

Alternative 3C: Remove coho salmon EFH from HU 18060006 (Central California Coast) (preferred)

The EFH review found that inclusion of this HU as EFH was based on sparse, unsubstantiated information that suggested presence only in the extreme northern portion of that HU. The report cited in Brown and Moyle (1991) contains no direct evidence for coho occurrence. In addition, the California Cooperative Anadromous Fish and Habitat Data Program (Calfish) indicates no current coho salmon distribution in that HU. Therefore, given that HU 18060006 encompasses a significant amount of California coastline which has never been known to be coho salmon habitat, the Council could consider removing EFH coverage from that HU. This alternative would remove the designation of coho salmon EFH from this HU. This HU is not designated as Chinook or Puget Sound (PS) pink salmon.

[3] Spence *et al*. (2011) concluded that although habitat in Pajaro River tributaries may have been suitable for coho salmon, there was no historical or recent evidence of naturally occurring coho salmon in this watershed. As a result of this lack of demonstrated occupancy, the Pajaro River system was not included in the Central California Coastal Coho Salmon ESU, and should also not be included as coho EFH.

2.2.3 Alternatives for Revising Puget Sound Pink Salmon Freshwater EFH

There are two 4th field HUs that indicate presence of pink salmon but are not currently designated as EFH. The Duwamish (17110013) has experienced dramatic returns of pink salmon in recent years (Stadler *et al*. 2011). The Washington Department of Fish and Wildlife estimated that 2.875 million pink salmon returned to the Duwamish system in 2009, and the 2011 escapement was approximately 864,000 (A. Bosworth, pers comm 2012). Despite the lack of data on presence in the Duwamish in 1999, there is no question that PS pink salmon now occupy this system. The Skokomish (17110017) is shown in StreamNet (2012) as being occupied by pink salmon. However, their distribution in this system is more limited than in the Duwamish. Based on current distribution information, the Council should consider designating those two HUs as EFH for PS pink salmon.

The alternatives to revise PS pink salmon EFH in fresh water incorporate new distribution data found during the five-year review. Alternatives 4A and 4B are mutually exclusive.

Alternative 4A: No-action

The No-action Alternative would retain the existing EFH designation for PS pink salmon. As a result, the EFH designation would not be based on the most up-to-date information on historical and current distribution.

Alternative 4B: Add HU 17110013 (Duwamish) and HU 17110017 (Skokomish) to Puget Sound pink salmon EFH (preferred)

Current distributional data show that PS pink salmon occupy HU 17110013 (Duwamish) and HU 17110017 (Skokomish), but these HUs are not currently designated as EFH for this species (Figure 2-2). This alternative would designate these HUs as EFH for PS pink salmon, and therefore follow the regulatory guidelines for designating EFH based on presence/absence data.

2.2.4 Alternatives for considering ESA Section 10(j) experimental population reintroductions

Throughout their historical range, salmon have been extirpated from many freshwater habitats that once supported self-sustaining populations. Construction of impassable barriers, such as dams and culverts, blocked access to a significant portion of the 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 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 with an experimental population designation into historical habitats. In such cases, 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 requirements and potential 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, the possibility exists that EFH designations could jeopardize ongoing and future efforts to reestablish listed salmon populations in these areas. Therefore, the Council and NMFS intend to consider these areas, on a case-by-case basis, to determine whether it is ultimately beneficial to the conservation and management of the population to designate EFH in areas where those experimental populations have been, or are proposed to be, reintroduced.

Alternative 5A: No-action Alternative

The No-action Alternative would retain the existing approach to designating EFH, and would not accommodate consideration of ESA Section 10(j) experimental reintroduction efforts in determining the extent of EFH.

Alternative 5B: Consider ESA Section 10(j) reintroductions in determining EFH identification (preferred)

This alternative would amend the 1999 Appendix A to state that efforts to reintroduce Pacific salmon under Section 10(j) of the ESA into historically occupied habitats will be considered when designating EFH. This Alternative would allow the Council and NMFS to include consideration of reintroduction of an experimental population when making a decision to designate EFH in such areas.

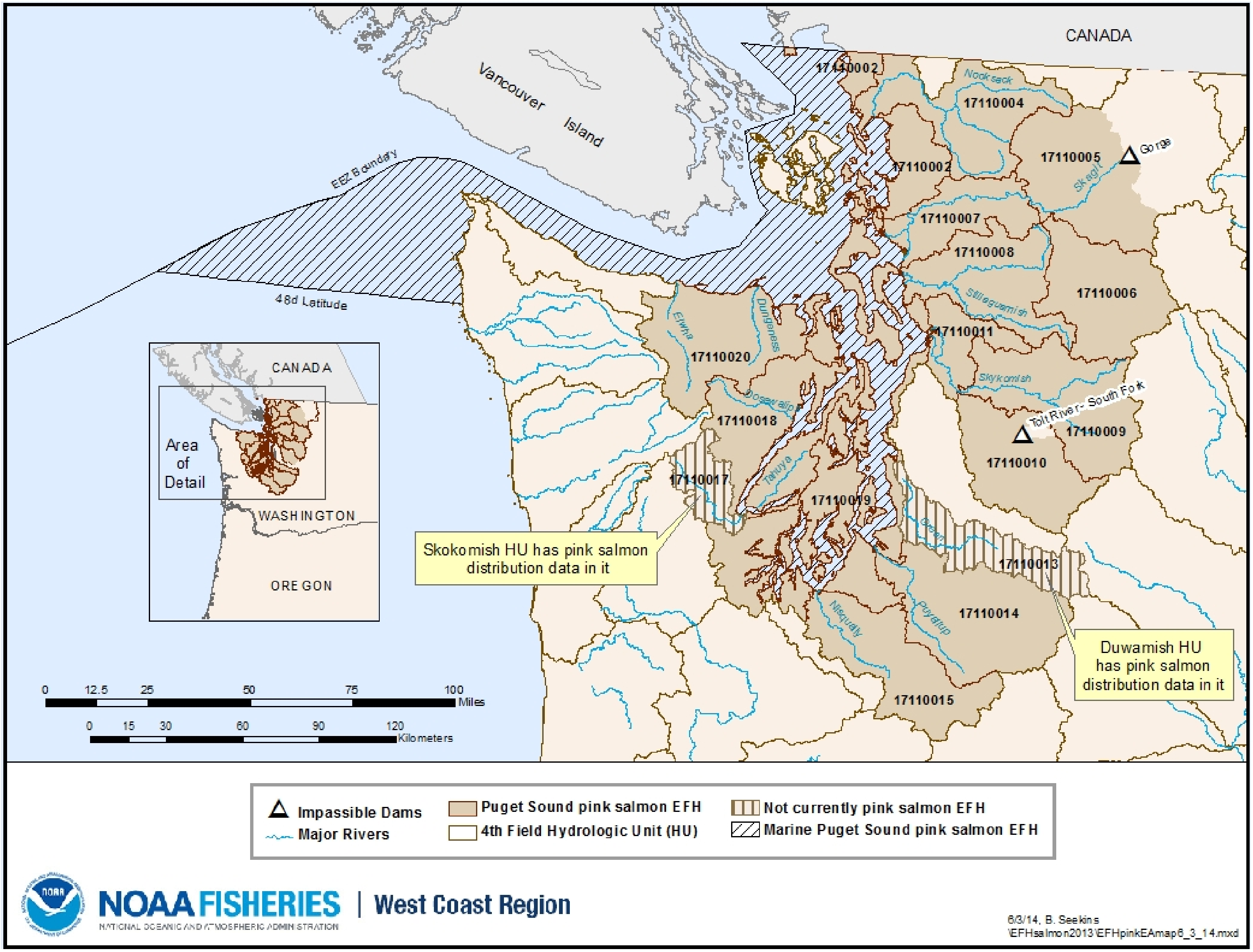

Figure 2-2. Proposed changes to EFH for Puget Sound pink salmon.

2.3 IMPASSABLE BARRIERS DESIGNATED AS THE UPSTREAM EXTENT OF EFH

The geographic extent of freshwater EFH includes all currently occupied waters and most of the habitat historically accessible to salmon. It excludes areas above longstanding naturally impassable barriers, but includes areas above all artificial barriers, except those specifically listed as the upstream extent of EFH in Table A-2 in the 1999 Appendix A. Both the EFH regulations and the 1999 Appendix A include justification for designating EFH above impassable barriers. The regulations state that if degraded or inaccessible aquatic habitats have contributed to reduced yields, and if those conditions can be ameliorated through fish passage or other technologically and economically feasible measures that improve water quality or quantity, then EFH should include those habitats needed to obtain increased yields [50 CFR 600.815(a)(1)(iv)(F)].

The 1999 Appendix A includes criteria for determining whether a dam should mark the upstream extent of EFH. The four criteria address whether: 1) the dam is of sufficient size, permanence, and impassability to be considered; 2) the dam is upstream of another impassable dam; 3) fish passage is under consideration or construction at the facility; and 4) NMFS has determined the dam blocks access to habitat that is key for the conservation of the species. This section also notes that currently accessible habitat may not be sufficient to support sustainable salmon fisheries and a healthy ecosystem, and that subsequent analyses may conclude that inaccessible habitat should be made available to the species. Recovery planning, ESA consultations, and hydropower relicensing proceedings are examples of the types of analyses that may be used to make this determination, especially when evaluating a dam using criterion 4. Emphasis is placed on the Federal Energy Regulatory Commission (FERC) relicensing process and the determination whether fish passage facilities will be required to provide access above currently impassable barriers. The section concludes that EFH would be designated above an impassable barrier if salmon access or reintroduction above that barrier became feasible.

2.3.1 ALTERNATIVES FOR DESIGNATING IMPASSABLE BARRIERS AS THE UPSTREAM EXTENT OF EFH

Alternative 6A: No-action Alternative

The status quo alternative would retain the existing list of dams that represent the upstream extent of EFH as contained in the 2008 Final Rule. The current list contains errors, including unintentionally omitted and misnamed dams, and is based on outdated and incomplete data. This Alternative would not provide for updates to the list of barriers, based on new and corrected information.

Alternative 6B: Update and correct the list of impassable barriers (preferred)

This alternative would make necessary updates, including correcting misnamed dams, adding erroneously omitted dams, and removing dams from the list that are no longer impassable to salmon. As described above, the 1999 Appendix A includes four criteria for determining whether an artificial barrier should mark the upstream extent of EFH, and states that when an impassable dam is removed or fish passage is implemented, that dam will be removed from the list. In addition, as a result of the list of HUs designated as EFH being updated to reflect the revised USGS 4th field HU names, boundaries, and codes in Alternative 2D, some of the dams marking the upstream extent of EFH in those areas are now located in an HU with a different number and/or name. Those dams and the new HU information, along with the other proposed changes under this alternative, are detailed below.

The following dams were inadvertently omitted from the 2008 Final Rule and should be included on the list of dams marking the upstream extent of EFH unless otherwise noted.

- Bull Run Dam #2 (HU 17080001, Lower Columbia-Sandy River).
- Dwinnell Dam (HU 18010207, Shasta).
- Camp Far West Dam (HU 18020126, Upper Bear). However, Camp Far West Dam is upstream of the impassable Camp Far West Diversion Dam, also called the South Sutter Water District Diversion Dam, which should be considered the upstream extent of EFH in the Upper Bear (HU 18020126).
- Oroville Dam (HU 18020159, Honcut Headwaters-Lower Feather). However, Oroville Dam is upstream of the impassable Feather River Fish Barrier Dam, which should be considered the upstream extent of EFH.
- Friant Dam (HU 18040006, Upper San Joaquin). However, Friant Dam is on the border between 18040001 and 18040006, and therefore, designating Friant Dam as the upstream extent of EFH is unnecessary because upstream of Friant Dam would not be EFH regardless of whether or not Friant Dam has passage.

Remove from the list, the following dams that have been removed or which now have fish passage:

- Dexter Dam (HU 17090001, Middle Fork Willamette River). A trap and haul facility to transport spring-run Chinook salmon above this dam has been in operation since 1993 (Beidler and Knapp 2005). Critical habitat[4] was designated above this dam in 2005. There are no other impassable dams and no additional HUs upstream of Dexter Dam and, therefore, the rest of the HU would be included as EFH.
- Cougar Dam (HU 17090004, McKenzie River). A trap and haul facility to transport Chinook salmon above this dam has been in operation since 1996 (Beidler and Knapp 2005). There are no other dams and no additional HUs upstream of Cougar Dam, and therefore, the rest of the HU would be included as EFH.
- Big Cliff Dam (HU 19070005, North Santiam River). A trap and haul operation to transport spring-run Chinook salmon above this dam and Detroit Dam has been in operation since 2000 (Beidler and Knapp 2005). There are no dams or additional HUs upstream of Detroit Dam, and, therefore, the rest of the HU would be included as EFH.
- Soda Springs Dam (HU 17100301, North Umpqua River). A fish ladder to provide passage above this dam was constructed in 2012. The next impassable barrier upstream of Soda Springs Dam is Toketee Falls, a naturally impassable barrier three miles upstream. There are no other impassable dams, and no additional HUs, upstream of Soda Springs Dam, and therefore, the rest of the HU would be included as EFH.

[4] The ESA requires the Federal government to designate "critical habitat" for any species it lists under the ESA. Critical habitat is defined as specific areas within the geographical area occupied by the species at the time of listing, if they contain physical or biological features essential to conservation, and those features may require special management considerations or protection; and outside the geographical area occupied by the species if the agency determines that the area itself is essential for conservation

In accordance with existing criterion 2, delete those dams that are upstream of other impassable barriers. Three dams are identified as meeting this criterion. Both Brownlee and Oxbow Dams on the Snake River Complex are upstream of Hells Canyon Dam in Hells Canyon (HU 17060101) and would be removed from the list. Hells Canyon Dam would represent the upstream extent of EFH in that HU. The Oak Grove Dam is above some naturally impassable falls on the Oak Grove Fork, a tributary of the Clackamas River (HU 17090011), and would be removed from the list.

In addition to the dams described above, the Opal Springs Dam on the Lower Crooked River (HU 17070305) is designated as the upstream extent of EFH in the 1999 Appendix A. However, with the removal of mid-Columbia spring-run Chinook salmon stocks from the FMU, this HU is no longer occupied by salmon that are managed under the FMP. Therefore, it is no longer designated as EFH, and the dam should be removed from the list.

Finally, there are some impassable dams that have been, and should continue to be, identified as the upstream extent of EFH, but that are now located in an HU of a different number and/or name due to the updating of the USGS HU data in California's Central Valley.

The following impassable dams are located in an HU in which the current HU number and name are different from the previous HU number and name. These dams should be identified as follows:

- Keswick and Whiskeytown Dams (HU 18020154, Clear Creek-Sacramento River).
- La Grange Dam (HU 18040009, Upper Tuolumne).
- Camanche Dam (HU 18040012, Upper Mokelumne).

The following impassable dams are located in an HU in which the current HU number is the same as the previous HU number, but the HU name has changed. These dams should be identified as follows:

- Black Butte Dam (HU 18020115, Upper Stony).
- Crocker Diversion Dam (HU 18040008, Upper Merced).
- Goodwin Dam (HU 18040010, Upper Stanislaus).
- New Hogan Dam (HU 18040011, Upper Calaveras).

Alternative 6C: Revise the criteria for designating a dam as the upstream extent of EFH and update the list based on the new criteria and new information

The criteria for determining whether a dam should be designated as the upstream extent of EFH can be interpreted in different ways. This alternative would revise the criteria into a sequential list of "yes" or "no" questions to provide clearer guidance when making that determination. This revision is not a substantive change to the criteria, but is meant to avoid differing interpretation of how to apply the criteria. New information would then be used to update the list of barriers using the revised criteria. The revised criteria are:

1. Is the dam federally owned or operated, licensed by 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 to both questions, go to 2.

- If no, then the dam is not the upstream extent, and the habitat above the dam should be designated as EFH.

2. Is the dam upstream of any other impassable dam that is designated as the upstream extent of EFH?
   - If yes, then the upstream extent of EFH is, by definition, downstream of the dam, and it should not be included in the list of impassable barriers.
   - If no, then go to 3.
3. Is fish passage 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.

Criteria 1 and 2 under this alternative are the same as those in the 1999 Appendix A. Therefore, the changes associated with these criteria would be the same as those described in Alternative 6B above.

Criterion 3 asks whether fish passage is in the construction or planning phase, while criterion 4 determines whether conservation of habitat above an impassable dam is necessary for the long-term survival of the species and sustainability of the fishery. In some cases, evaluating a dam using these criteria and determining that it should mark the upstream extent of EFH is straightforward. These dams, for which the answers to the questions in criteria 3 and 4 are “no,” are addressed first under this alternative. Other dams require a more thorough evaluation and are discussed in more detail later in this section.

In addition, if EFH is expanded above a dam that currently marks the upstream extent of EFH, any additional dams and 4th field HUs upstream of that dam must be evaluated to determine the new extent of EFH. Identifying a new upstream extent can be complicated for several reasons, including a lack of specific information on historical salmon distribution, equivocal data on upstream barriers, complex stream networks in upper watersheds, and the vast geographic range being evaluated. The data used to designate salmon EFH is appropriate at a regional or watershed level, but not necessarily for identifying EFH down to specific stream reaches. Therefore, despite efforts to identify an appropriate upstream extent based on the revised criteria, it will often still be necessary to rely on individual scientific expertise (e.g., NMFS biologists with first-hand knowledge of these systems) to determine the extent of EFH in these watersheds.

Two impassable dams not listed as the upstream extent of EFH were evaluated using these criteria based on comments received by the Bureau of Reclamation (BOR) in 2007. These dams include McKay Dam on McKay Creek in the Umatilla HU (17070103) and Emigrant Dam in the Middle Rogue HU (17100308). The evaluation showed these dams are of sufficient size and permanence, are not upstream of any other impassable dams, do not have fish passage being constructed or planned, and do not have habitat above them that was determined to be necessary for the long-term survival of the species and sustainability of the fishery. As a result, these dams warrant inclusion on the list of impassable dams marking the upstream extent of EFH.

In addition, under Alternative 2D, changes were made to some of the HUs designating EFH in California's Central Valley as a result of updates the USGS made to their HU data. Because these updates resulted in changes to watershed boundaries in some areas, impassable dams had to be evaluated in these new or modified HUs. For the same reasons noted previously regarding McKay and Emigrant Dams, the following dams should be added to the list of impassable dams marking the upstream extent of EFH:

- Capay Dam (HU 18020116, Upper Cache).
- Monticello Dam (HU 18020162, Upper Putah).
- Buchanan Dam, Bear Dam, Owens Dam, Mariposa Dam (HU 18040001, Middle San Joaquin-Lower Chowchilla).
- Hidden Dam (HU 18040007, Fresno River).

As noted in the paragraph, to implement criterion 3, it is necessary to identify which dams on the list of barriers marking the upstream extent of EFH have fish passage in the construction or planning phase by a state or Federal agency or facility operator. The Cle Elum Dam on the Upper Yakima River (HU 107030001), where BOR has approved a fish passage plan (BOR 2011) and thus fish passage is currently in the planning stage, clearly meets this criterion. As such, this dam would be removed from the list. There are no additional dams or 4th field HUs upstream of Cle Elum Dam.

Evaluating the status of fish passage for the five dams operated by PacifiCorp under the Klamath Hydroelectric Project on the mainstem Klamath River is more complicated. Moving in order upstream, these dams include Iron Gate, Copco 2, Copco 1, J.C. Boyle, and Keno. The next upstream dam, also operated by PacifiCorp, is Link River Dam at the mouth of Upper Klamath Lake. Iron Gate Dam currently marks the upstream extent of EFH for coho and Chinook salmon in the Upper Klamath Basin. NMFS and the U.S. Fish and Wildlife Service (USFWS) filed joint preliminary (March 29, 2006) and modified (January 29, 2007) fishway prescriptions under the Federal Power Act to provide passage above the five mainstem dams operated under the Klamath Hydroelectric Project. Issues of material fact that formed the basis of these prescriptions were affirmed in an administrative trial-type hearing under the Federal Power Act (September 27, 2006) and modified fishway prescriptions must be included in any new FERC license for the Klamath Hydroelectric Project. In addition, among other things, the modified fishway prescriptions led to the Klamath Hydropower Settlement Agreement (KHSA) (2010), which, instead of relicensing the Klamath Hydroelectric Project, provides for four dams on the mainstem Klamath River (Iron Gate, Copco 2 and 1, and J. C. Boyle) being removed if the Secretary of the Interior makes a determination under the agreement that removal of these facilities will advance restoration of the salmonid fisheries of the Klamath Basin and is in the public interest. Given the assurance that the fishway prescriptions would be a requirement of any new FERC license, and the KHSA provides for removal of the lower four mainstem dams if the Secretary of the Interior makes the determination described above, Iron Gate Dam warrants removal from the list of artificial barriers marking the upstream extent of EFH under criterion 3.

Expanding EFH above Iron Gate Dam under criterion 3 would require the identification of a new upstream extent of EFH for both coho and Chinook salmon in the Upper Klamath Basin. Coho salmon historically reached at least as far as Spencer Creek, which enters the Klamath River downstream of Keno Dam (Hamilton *et al*. 2005, Draft Recovery Plan for SONCC Coho). Historical distribution of Chinook salmon extended farther upstream and included areas above Upper Klamath Lake (Hamilton *et al*. 2005). Keno Dam currently lacks sufficient fishways for safe, effective and timely passage of anadromous fish despite having a fish ladder. In addition, water quality issues exist upstream of Keno Dam that complicate fish passage past that facility. Keno Dam is upstream of the four mainstem dams proposed for removal under the KHSA. Although the KHSA provides that Keno Dam would be transferred to the Federal government subject to conditions provided in the KHSA, and fish passage at Keno Dam would be studied, it does not provide specific plans for fish passage improvements at Keno Dam. Moreover, specific plans for fish passage improvements at Keno Dam have not yet been fully developed in the event that the four lower dams are removed under the KHSA.

Given that the KHSA is currently being implemented, and specific plans for fish passage improvements at Keno Dam have not yet been fully developed in the event that Iron Gate Dam is removed under the KHSA, should Iron Gate Dam be removed from the list of dams marking the upstream extent of EFH under criterion 3, EFH for coho and Chinook in the Upper Klamath Basin should extend to Keno Dam. There were no other dams identified on tributaries within this stretch of the Klamath River that meet the criteria for identifying them as the upstream extent of EFH. Also, Keno Dam is located at the upstream extent of HU 18010206, a portion of which is already identified as salmon EFH. Thus, the EFH designation would be expanded to include the entire HU, but no additional HUs would be added at this time. As implementation of the KHSA and specific plans for fish passage improvements at Keno Dam progress or a new FERC license for the Klamath Hydroelectric Project is resolved, the identification of Keno Dam as the upstream extent of EFH should be reassessed in a future EFH review.

Applying criterion 4 requires an evaluation of whether habitat above an impassable barrier is necessary for the long-term survival of the species and sustainability of the fishery. The evaluation for criterion 4 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. These NMFS documents are often focused on ESA-listed species. However, these species must be recovered before they can achieve the EFH objectives of supporting a sustainable fishery and contributing to a healthy ecosystem. Therefore, the habitats identified as being necessary to recover these species or to prevent their extinction should be designated as EFH.

The available information relevant to this criterion varies by basin, and even among individual barriers within a basin. After reviewing newly available information on the dams that currently mark the upstream extent of EFH, two dams were identified under this alternative as warranting removal from that list and designating EFH above them based on criterion 4. That information is summarized below.

<u>Summary of Information in NMFS Documents Relevant to Criterion 4</u>

Upper Klamath Basin - Iron Gate Dam
As mentioned previously, PacifiCorp operates five dams (Iron Gate, Copco 2, Copco 1, J.C. Boyle, and Keno) under the Klamath Hydroelectric Project on the mainstem Klamath River. PacifiCorp also operates the next upstream dam, Link River, at the mouth of Upper Klamath Lake. Iron Gate Dam currently marks the upstream extent of EFH for coho and Chinook salmon in the Upper Klamath Basin.

Preliminary (2006) and Modified Final (2007) Fishway Prescriptions, filed jointly with the USFWS, for the Klamath Hydroelectric Project under the Federal Power Act:

- Determined that fish passage was warranted for the project to regain access to historical and currently suitable habitat above Iron Gate Dam.
- Regaining access to this habitat would increase the reproductive potential of coho by expanding the range and distribution of the species.
- Passage above Iron Gate Dam would also increase the population and genetic diversity of coho stocks, and decrease vulnerability to impacts from habitat degradation.
- Additional benefits shared by coho and Chinook salmon would include restored access to miles of historical habitat and cool water refugia areas, and inclusion of a drought-resistant genetic source to help these stocks withstand extreme drought or flood events.
- Providing passage above Iron Gate Dam and into the upper basin “above project reach” would allow Chinook populations to regain access to approximately 49 important tributaries of historical habitat; the resulting increase in Chinook abundance would benefit ocean salmon fisheries by limiting the likelihood that fishing effort in the mixed-stock fishery would be restricted to protect Klamath Chinook.

Biological Opinion on the Operation of the Klamath Project between 2013 and 2023:

- Dams are listed as one of the “major factors” responsible for the decline of Southern Oregon Northern California Coast (SONCC) coho salmon ESU.
- Coho salmon occupy a small fraction of their historical area due to migration barriers and habitat degradation.
- Coho salmon are currently spatially restricted to habitat below Iron Gate Dam; the Upper Klamath River coho salmon population is at a high risk of extinction because its abundance, spatial structure, and diversity are substantially limited compared to historical conditions

Draft Recovery Plan for the SONCC ESU of Coho Salmon:

- Access to high quality spawning, rearing and migratory habitat above Iron Gate Dam will be important to recover the species, especially for the Upper Klamath River population.
- When discussing the loss of habitat upstream of Iron Gate Dam, the Draft Recovery Plan concludes that the Upper Klamath River coho population is at an elevated risk of extinction because its spatial structure and diversity are substantially limited compared to historical conditions.
- PacifiCorp's five mainstem dams preclude upstream passage of coho into approximately 58 miles of historic habitat, and will remain a major threat in the Upper Klamath River watershed until fish passage or dam removal occurs.
- Implementing a fish passage strategy is a Priority 2 action. Priority 2 actions are the highest priority actions identified in the Draft Recovery Plan and are deemed necessary to prevent a significant decline in population numbers, habitat quality, or some other significant impact short of extinction.

Based on this information, there is a demonstrated need for access to habitat in the Upper Klamath Basin to support healthy salmon (both Chinook and coho) populations, and expanding the EFH designations for coho and Chinook salmon above Iron Gate Dam under criterion 4 is warranted.

As noted under criterion 3, expanding EFH above Iron Gate Dam would require identification of a new upstream extent of EFH for both coho and Chinook salmon in the Upper Klamath Basin. The same rationale for identifying Keno Dam as the upstream extent of EFH under criterion 3 would apply here under criterion 4.

California's Central Valley, Upper Sacramento Basin - Shasta-Keswick Dam Complex

Keswick and Shasta Dams are located on the Sacramento River in the northern end of California's Central Valley. They are both part of BOR's Central Valley Project. Keswick Dam is used to regulate releases from Shasta Dam, located just upstream. The original salmon EFH designation identified Keswick Dam as the upstream extent of EFH on the Sacramento River.

Biological Opinion and Conference Opinion on the Long-Term Operations of the Central Valley Project and State Water Project (CVP/SWP)

- Regarding species managed under the Salmon FMP, concluded that CVP/SWP operations are likely to jeopardize the continued existence of, and destroy or adversely modify the designated critical habitats of, federally-listed Sacramento River winter-run Chinook salmon (endangered) and Central Valley spring-run Chinook salmon (threatened).
- Effects analysis shows that even when all discretionary actions are taken to reduce adverse effects of water operations, the risk of temperature-related mortality of fish and eggs persists, especially in critically dry years which are expected to increase in frequency due to climate change. This mortality can be significant at the population level.
- Reasonable and prudent alternative includes long-term passage prescriptions above Shasta Dam and reintroduction of winter-run Chinook salmon to McCloud and/or Upper Sacramento River (using a stepped approach).

Public Draft Recovery Plan for the ESUs of Sacramento River Winter-Run Chinook Salmon and Central Valley Spring-Run Chinook Salmon and the Distinct Population Segment of Central Valley Steelhead (Central Valley Draft Recovery Plan)

- Barriers to historic habitat are listed as one of four of the more important stressors, and every extant population is viewed as necessary for the recovery of the Chinook salmon ESUs.
- Priority 1 recovery actions identified in the Upper Sacramento River and McCloud River include developing and implementing a phased approach to salmon reintroduction planning to recolonize historic habitats, including a long-term fish passage program, above Keswick and Shasta Dams in the Upper Sacramento and McCloud Rivers. Priority 1 are the highest priority actions and are defined as those critical actions that must be taken to prevent extinction or to prevent the species from declining irreversibly.
- Identifies reestablishment of viable winter-run and spring-run Chinook salmon populations in both the Upper Sacramento and McCloud Rivers as critical to the recovery of the winter-run ESU and Basalt and Porous Lava Diversity Group within the spring-run ESU, respectively.

Based on this information, an expansion of Chinook salmon EFH above Keswick and Shasta Dams seems warranted. However, this alternative does not consider potential efforts to reintroduce salmon into historically occupied habitats in this watershed under Section 10(j) of the ESA. Those actions are addressed in Alternative 6D.

If EFH were to be expanded above Keswick and Shasta Dams, a new upstream extent in the Upper Sacramento Basin would need to be identified. Chinook salmon historically occupied the Upper Sacramento, McCloud, and Pit Rivers upstream of where Shasta Dam is currently located (NMFS 2009a, NMFS 2009b). Suitable habitat still exists within the Upper Sacramento and McCloud Rivers. Therefore, if EFH is expanded above Shasta Dam, it should extend into the Upper Sacramento (HU 18020005) and McCloud (HU 18020004) hydrologic units. Box Canyon Dam, an impassable dam licensed by FERC that blocks Chinook salmon passage, would mark the upstream extent of EFH in the Upper Sacramento River (HU 18020005). Within the McCloud River, EFH would extend to McCloud Dam, a 235-foot high FERC-licensed dam blocking access to upstream habitats (HU 18020004).

Other Basins

Information within the Central Valley Draft Recovery Plan identifies habitats above other artificial barriers within the Central Valley (i.e., “rim dams”) as important for recovering salmonids. However, there is less certainty regarding this habitat being necessary for the long-term survival of the species. For instance, the reintroduction of spring-run Chinook salmon is being considered in the Stanislaus, Tuolumne, and the Merced River Basins. But when identifying Priority 1 actions to recover the Southern Sierra Diversity Group within the Central Valley spring-run Chinook salmon ESU, only one of these three populations was deemed critical for recovery, and which one is not specified. In addition, although there are other Priority 1 actions regarding restoring passage above specific artificial barriers within the Yuba, Mokelumne, Stanislaus, and Tuolumne River Basins, those areas are either already designated as

EFH (Yuba), or the actions are specific to steelhead trout (all others). Therefore, although there is evidence demonstrating these areas above artificial barriers as important habitat for Chinook salmon, there seems to be insufficient justification within existing NMFS documents for designating these areas as EFH. These dams should be reevaluated during the next EFH periodic review.

Potential changes to the upstream extent of EFH for coho salmon and Chinook salmon under Alternative 6C, as well as Alternative 6D, are summarized in Table 2-3.

Alternative 6D: Revise the criteria for designating a dam as the upstream extent of EFH, update the list based on the new criteria and new information, and include consideration of efforts to reintroduce experimental populations of salmon into historically occupied habitats under Section 10(j) of the ESA (preferred)

Alternative 6D would include language specifying that efforts to designate experimental populations under Section 10(j) of the ESA should be considered as part of the criteria for determining whether a dam should mark the upstream extent of EFH. Otherwise, the criteria in this Alternative are identical to those in Alternative 6C. Section 10(j) of the ESA provides for authorizing the reintroduction of a listed species to historic, but currently unoccupied, habitat by designating them as an experimental population. This designation is done through rulemaking and is contingent upon NMFS determining, among other things, that it would further the conservation of the species. The success of an effort to reintroduce salmon into historical habitat depends, in part, on the support of involved stakeholders, including government agencies and private citizens. Congress specifically added Section 10(j) to the ESA in 1982 to encourage cooperative reintroduction efforts where reintroduction of listed species is perceived to conflict with human activities. The intent is to encourage stakeholders to support these efforts by easing certain potential ESA liabilities within the reintroduction area. Under some specific circumstances, the EFH consultation requirement could create a perceived regulatory burden that may cause both Federal and private stakeholders to oppose the reintroduction.

As mentioned previously, the objective of designating EFH is to support a sustainable fishery and the managed species' contribution to a healthy ecosystem. Apart from the ESA goals, reintroducing fish into their historical habitats will be necessary to achieve this objective in some areas, especially when impacts associated with climate change are considered. In fact, the intent of designating EFH above dams and other currently unoccupied areas that were historic habitat is to conserve these habitats, which have been identified as necessary to support a sustainable fishery. The designation is meant to support the possibility of salmon having access those habitats in the future. This alternative would ensure that current and future reintroduction efforts under Section 10(j) of the ESA are considered prior to designating EFH above dams to better integrate the two processes.

The only case in which this alternative would currently apply would be if EFH was designated above the Shasta-Keswick dam complex, where the Section 10(j) process was recently initiated (See Table 2-3). Reintroduction of an experimental population is being pursued there with the understanding that there would be no additional regulatory burden. Expanding EFH designations above those dams could weaken stakeholder support of the reintroduction efforts. Under Alternative 6C, criterion 4, this dam would be deleted from the list of dams forming the upstream extent of EFH, and the habitat above it would be designated as EFH. However, using the revised criteria and consideration of 10(j) populations under this Alternative, Keswick Dam would remain on the list, and the habitat above it would not be designated as EFH.

Table 2-3. Potential changes to the upstream extent of EFH under Alternatives 6C and 6D.

State	4th Field HUC	Dam(s)	Action under Alternative 6C	Action under Alternative 6D	Next upstream dam(s) that meet the criteria	Addl. HU(s) to be designated as Chinook salmon EFH	Addl. HU(s) to be designated as coho salmon EFH
CA	18010206	Iron Gate Dam	Remove from list	Remove from list	Keno Dam	None	None
CA	18020154	Keswick Dam	Remove from list	Retain on list	Box Canyon Dam (Upper Sacramento River); McCloud Dam (McCloud River)	18020005; 18020004	None
OR	17070103	McKay (on McKay Creek)	Add to list	Add to list	N/A	N/A	N/A
OR	17100308	Emigrant	Add to list	Add to list	N/A	N/A	N/A

2.4 MARINE AND ESTUARINE ESSENTIAL FISH HABITAT

Current EFH for Pacific Coast salmon includes all estuarine and marine waters from the nearshore and tidal submerged environments within state territorial waters out to the U.S. EEZ north of Point Conception, California, to the U.S. – Canada border (Figure 2-3). EFH also includes the marine areas of Alaska that are designated as salmon EFH by the NPFMC. Marine EFH for Pacific Coast salmon is necessarily broad and based on presence/absence data, as provided in the regulatory guidelines, because the data that was available in 1999 was not sufficient to allow for a more narrowly-defined description of marine EFH. Some recent information was described in Stadler *et al*. (2011). However, there remains a paucity of definitive information on ocean distribution and habitat associations. Because of this lack of information, the OP concluded that it would be better to continue to rely on the presence/absence data, and wait to refine marine EFH until more information becomes available. Therefore, both the potential for re-visiting the inclusion of marine waters off Alaska, as well as the possibility of refining specific marine EFH descriptions, were not included as alternatives. For PS pink salmon, the 1999 Appendix A defines marine EFH as "all nearshore marine waters north and east of Cape Flattery, Washington, including Puget Sound, the Strait of Juan de Fuca, and the Strait of Georgia." This is slightly inconsistent with the general description of marine EFH for Pacific salmon that includes the marine waters beyond Cape Flattery, as described above. The Council should clarify the extent of PS pink salmon marine EFH.

2.4.1 ALTERNATIVES FOR REVISING MARINE EFH

These alternatives are mutually exclusive.

Alternative 7A: No-action Alternative

The No-action Alternative would retain the existing description of marine EFH for Pacific Coast salmon, including marine waters off Alaska as designated by the NPFMC. It would not clarify the extent of marine EFH for PS pink salmon.

Alternative 7B: Clarify Puget Sound pink salmon marine EFH (preferred)

This alternative would clarify the extent of EFH for PS pink salmon in the West Coast EEZ and the waters off Alaska. The result would be better clarity regarding the extent of PS pink salmon marine EFH. Selection of this alternative implies that the Council's intent regarding marine EFH for PS pink salmon was to include the U.S. EEZ off northern Washington State and the Strait of Juan de Fuca, in addition to Puget Sound. This alternative describes PS pink salmon marine EFH as 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 offshore waters of the U.S. EEZ north of 48° N latitude. If the Council does not clarify the designation of PS pink salmon EFH, the ambiguity will remain. This alternative would not alter the extent of marine EFH for either Chinook salmon or coho salmon.

2.5 ESSENTIAL FISH HABITAT DESCRIPTIONS

According to the EFH regulatory guidelines [50 CFR 600.815 (a)(1)]:

> *FMPs must describe and identify EFH in text that clearly states the habitats or habitat types determined to be EFH for each life stage of the managed species. FMPs should*

> *explain the physical, biological, and chemical characteristics of EFH and, if known, how these characteristics influence the use of EFH by the species/life stage.*

This information can then be used to evaluate the potential effects of proposed actions on EFH.

The descriptions of the habitats by life stage determined to be EFH in the 1999 Appendix A were developed through an extensive review and synthesis of the literature available in 1999. While much of that information remains accurate and relevant today, this review compiled a significant amount of new and newly-available information that needs to be used to refine, and improve upon, the life history characteristics and habitat parameters.

Figure 2-3. Proposed coast-wide geographical extent of EFH for Pacific Coast salmon.

2.5.1 Alternatives for updating EFH descriptions

Alternative 8A: No change

This alternative would retain the existing EFH descriptions and would not expand upon the body of literature that was available in 1999. As a result, the analysis of Federal actions that may adversely affect EFH could be based on outdated or incomplete information.

Alternative 8B: Update the EFH summaries for each species of Pacific Coast salmon (preferred)

This alternative would update the existing EFH descriptions using the new information, which can be used by the public, consultants, and state and Federal agencies to assess the potential effects on EFH from a proposed action. As a result, the analysis of Federal actions during the EFH consultation process would be based on more up-to-date information, which will result in improved EFH Conservation Recommendations.

2.6 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 HAPCs based on one or more of the following considerations: (1) the importance of the ecological function provided by the habitat; (2) the extent to which the habitat is sensitive to human-induced environmental degradation; (3) whether, and to what extent, development activities are, or will be, stressing the habitat type; and (4) the rarity of the habitat type. The intended goal of identifying such habitats as HAPCs is to provide additional focus for conservation efforts, although it does not require any additional regulatory activity during the EFH consultation process.

As part of the periodic review, the OP developed five potential HAPCs (Stadler *et al*. 2011). Habitat types were initially identified using the best available information and the collective professional knowledge and experience gained by the OP through scientific research and conducting EFH and ESA consultations. These habitats were then evaluated according to the four considerations listed above. The five potential HAPCs for Pacific Coast salmon are discussed below. For a more detailed discussion of how these habitats met the four considerations defined above, see Stadler *et al*. (2011).

Complex channels and floodplain habitats. Meandering, island-braided, pool-riffle, and forced pool-riffle channels. Complex floodplain habitats, including wetlands, oxbows, side channels, sloughs, and beaver ponds, and steeper, more constrained channels with high levels of large woody debris (LWD), provide valuable habitat for all Pacific Coast salmon species.

Thermal refugia. Thermal refugia typically include cool water tributaries, lateral seeps, side channels, tributary junctions, deep pools, areas of groundwater upwelling and other mainstem river habitats that are cooler than surrounding waters (≥2° C cooler) (Torgersen *et al*. 1999; Ebersole *et al*. 2003). As such, refugia can occur at spatial scales ranging from entire tributaries (e.g., spring-fed streams), to stream reaches (e.g., alluvial reaches with high hyporheic flow), to highly localized pockets of water only a few square meters in size embedded within larger rivers.

Spawning habitat. Salmon spawning habitat is typically defined as low gradient stream reaches (<3 percent), containing clean gravel with low levels of fine sediment and high intergravel flow. Many spawning areas have been well-defined by historical and current spawner surveys, and detailed maps exist for some hydrologic units.

Estuaries. Estuaries include nearshore areas such as bays, sounds, inlets, river mouths and deltas, pocket estuaries, and lagoons influenced by ocean and fresh water. Because of tidal cycles and freshwater runoff, salinity varies within estuaries and results in great diversity of habitats, offering freshwater, brackish, and marine habitats within close proximity (Haertel and Osterberg 1967). This HAPC also includes those estuary-influenced offshore areas of continuously diluted seawater.

Marine and estuarine submerged aquatic vegetation. Submerged aquatic vegetation (SAV) includes the kelps and seagrasses. The kelps are brown macroalgae and include those that float to form canopies and those that do not, such as *Laminaria* species. Canopy-forming kelps of the eastern Pacific Coast are dominated by two species, giant kelp (*Macrocystis pyrifera*) and bull kelp (*Nereocystis leutkeana*). Kelp plants, besides requiring moderate to high water movement and energy levels, are most likely limited by the availability of suitable substrate (Mumford 2007). Eelgrass (*Zostera marina* and *Z. pacifica*) is prevalent in many west coast estuaries and nearshore areas, forms dense beds of leafy shoots year-round in the soft sediments of the lower intertidal and shallow subtidal zone, and forms a three-dimensional structure in an otherwise two-dimensional (sand or mud) environment (Mumford 2007).

2.6.1 Alternatives for considering HAPCs for Pacific salmon

Each potential HAPC is presented as an independent alternative for consideration by the Council. As a result, Alternative 9A (No-action Alternative) is mutually exclusive with the other alternatives, but Alternatives 9B through 9F are not mutually exclusive with each other, and the Council may decide to proceed with some or all of them.

Alternative 9A: No change

This alternative would maintain the current status of having no HAPCs designated as part of Pacific Coast salmon EFH. As a result, these important habitats would not receive any special focus during the EFH consultation process.

Alternatives 9B through 9F. Designate HAPCs (preferred)

This suite of alternatives would each designate one type of habitat as a HAPC. The Council considered the following alternatives in selecting the final preferred alternative.

Alternative 9B: Designate complex channels and floodplain habitat as a HAPC

Alternative 9C: Designate thermal refugia as a HAPC

Alternative 9D: Designate spawning habitat as a HAPC

Alternative 9E: Designate estuaries as a HAPC

Alternative 9F: Designate marine and estuarine SAV as a HAPC

2.7 ACTIVITIES THAT MAY ADVERSELY AFFECT EFH

FMPs are required to identify and describe three categories of activities that may adversely affect EFH: fishing activities managed under the MSA, fishing activities not managed under the MSA (typically managed by states), and human activities not associated with fishing.

2.7.1 ALTERNATIVES FOR UPDATING FISHING ACTIVITIES THAT MAY ADVERSELY AFFECT PACIFIC SALMON EFH

There are no known new fishing activities that could potentially adversely affect Pacific salmon EFH. However, the Council may wish to update the descriptions of the fishing activities and gear contained in the 1999 Appendix A. With the exception of Alternative 10A, the alternatives described below are not mutually exclusive.

Alternative 10A: No Change

This alternative would retain the description of the effects from fishing activities. Doing so would disregard the new information on the potential effects of fishing activity on EFH as well as the measures that the Council has taken that have reduced the level of these effects.

Alternative 10B: Revise the description of the potential adverse effects of fishing managed under the MSA (preferred)

This alternative would incorporate the new information into the description of the fishing activities and potential adverse effects on Pacific Coast salmon EFH from fishing activities. It does not imply a determination of adverse effects and would not include measures to minimize any adverse effects on salmon habitat (minimization measures).

Alternative 10C: Revise the description of the potential adverse effects of fishing not managed under the MSA (preferred)

This alternative would incorporate new information into the identification of non-MSA fishing activities that may adversely affect Pacific salmon EFH.

2.7.2 ALTERNATIVES FOR REVISING NON-FISHING ACTIVITIES THAT MAY ADVERSELY AFFECT PACIFIC SALMON EFH

The 1999 Appendix A identified 21 non-fishing activities (Table 2-4) that may adversely affect EFH; and potential conservation recommendations to avoid, minimize, mitigate, or otherwise offset those adverse impacts. However, new information indicates that some of these descriptions and conservation measures are out of date and should be updated. During the periodic review of EFH, 10 additional activities that may adversely affect EFH were identified (Table 2-4).

The utility of describing the non-fishing activities and associated conservation recommendations is that the public and NMFS staff can efficiently reference the adverse effects as well as minimization measures associated with these effects. In many cases (e.g., culvert construction and over-water structures), best practices are already established and in use. In those cases, there would be little, if any, change to current practices. It is important to note that while the list of non-fishing activities provides guidance, it does not preclude NMFS from including conservation recommendations for activities not on the list and does not preclude NMFS from recommending additional or different conservation measures from those included in the FMP. It is also important to note that most projects consist of multiple activities, and the cumulative effects of those activities should be considered when making EFH conservation recommendations.

Table 2-4. Non-fishing activities that may adversely affect Pacific Coast salmon EFH.

Activities Identified in the 1999 Appendix A	New Activities Identified During EFH Review
Agriculture	Activities causing high intensity acoustic or pressure waves
Artificial Propagation of Fish and Shellfish	Over-water structures
Bank Stabilization	Alternative energy development
Beaver removal and Habitat Alteration	Liquefied natural gas projects
Construction/Urbanization	Desalination
Dam Construction/Operation/Removal	Power plant intakes
Dredging and Dredged Spoil Disposal	Pesticide use
Estuarine Alteration	Flood control maintenance
Forestry	Culvert construction
Grazing	Coal terminal export facilities
Habitat Restoration Projects	
Irrigation/Water Management	
Mineral Mining	
Introduction/Spread of Nonnative Species	
Offshore Oil and Gas Drilling	
Road Building and Maintenance	
Sand and Gravel Mining	
Vessel Operation	
Wastewater/Pollutant Discharge	
Wetland and Floodplain Alteration	
Woody Debris/Structure Removal	

Alternative 11A is mutually exclusive with the other two alternatives, but Alternatives 11B and 11C are not mutually exclusive of each other.

Alternative 11A: No-action Alternative

This alternative would retain the current descriptions and potential conservation measures for non-fishing activities that may adversely affect EFH. The descriptions of the existing 21 activities would not be updated, and the 10 new activities would not be described. EFH consultations would be conducted as they are now, without the benefit to consulting agencies, the public, and NMFS for additional information on these activities. However, NMFS would still be able to provide EFH Conservation Recommendations for any activities that may adversely affect EFH, regardless of whether the activity is on the list.

Alternative 11B: Update the existing 21 non-fishing activities that may adversely affect EFH (preferred)

By updating the description of non-fishing activities that may adversely affect Pacific Coast salmon EFH, as well as updating the potential conservation recommendations, Amendment 18 would be providing relevant new information to assist consulting agencies, the public, and NMFS staff when considering these activities. These updates to the FMP would not represent any net change in the consultation process. However, there would be an increased level of consistency in how those activities are evaluated during the consultation process.

Alternative 11C: Add new non-fishing activities that may adversely affect EFH (preferred)

This alternative includes options to include any or all of the 10 new non-fishing activities, and associated conservation measures, identified by the periodic review. The options under this alternative are:

- **11C1: Activities causing high intensity acoustic or pressure waves (e.g., pile driving, ordnance detonation, seismic surveys)**
- **11C2: Over-water structures**
- **11C3: Alternative energy development**
- **11C4: Liquefied natural gas projects**
- **11C5: Desalination**
- **11C6: Power plant intakes**
- **11C7: Pesticide use**
- **11C8: Flood control maintenance**
- **11C9: Culvert construction**
- **11C10: Coal export terminal facilities**

2.8 INFORMATION AND RESEARCH NEEDS

The EFH regulatory guidance states that each FMP should contain recommendations, preferably in priority order, for research efforts that the RFMCs and NMFS view as necessary to improve upon the description and identification of EFH, the identification of threats to EFH, and the development of conservation recommendations. Numbers 1 through 3 (below) are summaries of those contained in the 1999 Appendix A, and numbers 4 and 5 are new, as identified by the OP. The priority order has not been established.

1. Improve fine scale mapping of salmon distribution to inform future reviews of EFH for Pacific Coast salmon and aid in more precise and accurate designation of EFH and the consultation process. Potential approaches include, but are not limited to:
    a. Develop freshwater distribution data at the 5^{th} or 6^{th} field HUs, across the geographic range of these species.

    b. Develop habitat models that can be used to predict suitable habitat, both current and historical, across the geographic range of these species.
    c. Develop seasonal distribution data at a 1:24,000 or finer scale.
2. Improve data on habitat conditions, 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.
3. Improve data on marine (seasonal) 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.
4. Improve data on the possibility of adverse effects of fishing gear on the EFH of Pacific Coast salmon.
5. Advance the understanding of how a changing climate can affect Pacific Coast salmon EFH.

2.8.1 ALTERNATIVES FOR UPDATING INFORMATION AND RESEARCH NEEDS

Alternative 12A: No-action Alternative

This No-action Alternative would retain the three information and research needs identified in the 1999 Appendix A. The two new information and research needs identified by the five-year review would not be added.

Alternative 12B: Identify and prioritize new information and research needs (preferred)

This alternative would include the existing information and research needs and would add two more, related to improving information on the adverse effects of fishing gear and climate change on salmon EFH. By establishing the Council's information and research needs priorities, this alternative would meet the requirements of the MSA.

2.9 PROCEDURES FOR CHANGING EFH

The EFH regulations state that the EFH provisions of FMPs should be reviewed and updated periodically, based on available information, and at least once every five years. The regulations also state that FMPs should outline the procedures they will use to update the EFH information. Currently, EFH updates are done through an FMP amendment. However, there are many types of changes that could be made periodically, and this may warrant consideration for a mechanism to update EFH outside of an FMP amendment process.

2.9.1 ALTERNATIVES FOR CHANGING EFH

13A: No-action Alternative

This alternative would maintain the status quo and require that all changes to Pacific Coast salmon EFH be accomplished through an FMP amendment.

13B: Develop procedures to address future changes to EFH (preferred)

The EFH regulations require periodic review and update of EFH provisions, as appropriate. The regulations also require FMPs to outline the procedures the Council will follow to review and update EFH information. The Pacific Salmon FMP does not currently describe a process for reviewing and updating EFH provisions, meaning that any changes to Pacific Salmon EFH, no matter how minor, can only be accomplished via an FMP amendment.

This alternative would provide 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. 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 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 activities, both fishing and non-fishing, that may adversely affect EFH; and the conservation measures to avoid, minimize, mitigate, or otherwise avoid those adverse effects; and
7. 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 description and identification 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.

Process for Making Framework Changes to EFH

Revisions to Pacific salmon EFH could be made when the Council determines that such action is warranted by new information, including during the periodic review. The process would be as follows, and could typically be accomplished via a three-meeting Council process:

1. Council advisory bodies, particularly the Habitat Committee (HC) should develop proposals to revise EFH provisions 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.

3. The Council will review the report and, if appropriate, direct staff to revise the EFH Appendix.
4. 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.

3.0 AFFECTED ENVIRONMENT

For the purposes of this action, the general action area consists of U.S. marine and estuarine waters between Point Conception and the U.S./Canada border, and freshwater and terrestrial areas comprising salmon distribution of the states of Washington, Oregon, Idaho, and California. Based on NOAA Administrative Order (NAO) 216-6 Section 6.02, the affected environment described here consists of the following components:

- Fish resources
- Protected resources
    - Endangered Species Act
    - Marine mammals
    - Sea birds
- Habitat, biodiversity, and ecosystem functions
    - California Current Large Marine Ecosystem
    - Physical/biological
    - Marine Protected Areas
    - West Coast biogeography
- Socioeconomic environment

Target and non-target species are typically included as part of the affected environment in NEPA analyses for FMP amendments. However, the action covered by this EA does not involve harvest management, open or closed seasons, or any other fisheries management actions. Nonetheless, because the stated intent of Pacific salmon EFH identification and description is to support a long term sustainable salmon fishery and salmon contributions to a healthy ecosystem, this section includes a description of ocean salmon fishing management, fishery management areas, and socioeconomics. Freshwater salmon fisheries are dominated by the recreational fishing sector, and fishery information is much less developed. As a result, more information on ocean salmon fishing is presented here, as compared with freshwater fishery information.

In this EA several of these components have been combined into categories to reduce duplication in the descriptions and to facilitate analyses of environmental effects. In addition, because this FMP amendment does not involve harvest issues, fish are generally not described in terms of target and non-target stocks.

The identification and description, spatial extent, and other elements of EFH are described in Section 2 and in the 1999 Appendix A; and the reader should refer to those resources for information on the EFH portions of the affected environment. ESA-listed Chinook salmon and coho salmon are covered in the Fish Resources Section; while marine mammals, seabirds, and other ESA-listed species are covered in the Protected Resources Section. Biodiversity, ecosystem function and EFH are covered in the Habitat Section; and social and economic environment is described in the Socioeconomic Section. Much of the information contained in this section is derived from PFMC 2011.

There are four components specified under NAO 216-6 Section 6.02 that are not affected by the proposed action and, therefore, are not analyzed in this EA:

- Public health or safety

  The proposed activity is not expected to adversely affect public health or safety, either directly or indirectly because it will not result in any activities that would have any effect on public health or safety. The proposed activity revises the description and identification of EFH for Pacific salmon, designates HAPC, updates identification of fishing and non-fishing related activities that may adversely affect EFH, and identifies potential measures to minimize those effects.
- Cultural or historical resources

  The proposed activity is not expected to adversely affect cultural or historic resources, including objects listed or eligible for listing in the National Register for Historic Places, because the proposed activity will not result in any activities that would have any effect on such resources. There are no ground disturbing aspects to the proposed activity, and any projects that require EFH consultation as a result of the EFH definitions and identifications implemented by the proposed activity would undergo a permitting procedure and NEPA analysis.
- Introduction or spread of non-indigenous species

  The proposed activity does not involve the introduction or spread of non-indigenous species.
- Federal, state, or local law

  The proposed activity is not expected to violate any Federal, state, or local law. The proposed activity is being conducted in accordance with Federal law to comply with the MSA.

3.1 FISH RESOURCES

Fish resources include all those finfish and shellfish resources that occur in the same environment with Pacific salmon managed by the Council. In some cases (notably Pacific salmon stocks) fish species are protected under the ESA. However, ESA-listed Pacific salmon commonly co-occur with non-listed stocks. Both may be managed by the Council, and at least some ESA-listed stocks are targeted. For this reason, we describe all salmonid stocks under the Fish Resources section, and describe non-salmonid ESA-listed fish (e.g., eulachon) under the Protected Resources section. Table 3-1 includes the ESA status for all listed west coast salmonid stocks.

Fish stocks targeted in Council-managed salmon fisheries include Chinook salmon, coho salmon, and PS pink salmon stocks identified in Tables 3-2, 3-3, and 3-4 of this EA, including ESA-listed Chinook salmon and coho salmon stocks. A description of the historical baseline for affected salmon stocks is presented in the Review of 2010 Ocean Salmon Fisheries (PFMC 2011a).

Additional background information on salmon life history and habitat is presented in PFMC (2000), Stadler (2011), and PFMC (2012).

Many other fish species, managed and unmanaged, co-occur with Pacific salmon in the marine, estuarine and freshwater environments. In the marine environment, species managed under the groundfish FMP, the Highly Migratory Species (HMS) FMP, and Coastal Pelagic Species (CPS) FMP are present. Over 90 species of finfish are managed under the groundfish FMP. These include numerous species of rockfish, Pacific whiting, and flatfish species. The HMS FMP includes species such as tuna, swordfish, and sharks; and the CPS FMP includes species such as Pacific sardine, Pacific mackerel, and northern anchovy. Several state-managed species such as Dungeness crab, pink shrimp, and California halibut also occupy Pacific salmon marine and estuarine environment; and there are numerous unmanaged fish species that occur in the marine environment, including sculpins, wolffishes, myctophids, ratfish, and surfperches. In many cases, other fish species (e.g., shrimp, herring, Pacific sardine) serve as prey species for Pacific salmon.

In the freshwater environment, species that co-occur with Pacific salmon EFH include sockeye salmon (*O. nerka*), chum salmon (*O. keta*), steelhead (*O. mykiss*), and various species of trout (e.g., bull trout, *Salvelinus confluentus*), including a number of populations that are listed as "threatened" or "endangered" under the ESA. All are in the Family Salmonidae, with relatively similar habitat requirements. Other freshwater species include anadromous fish such as white sturgeon and Pacific lamprey; as well as resident freshwater fish such as sculpins, threespine stickleback, and smallmouth bass.

3.2 PROTECTED RESOURCES

Protected species include those protected by three Federal laws: the ESA, the Marine Mammal Protection Act (MMPA), and the Migratory Bird Treaty Act (MBTA). This section describes the affected environment relative to protected resources. In some cases there are overlapping regulatory jurisdictions and mechanisms, and in some cases (e.g., salmonids) there are some stocks listed as protected resources and others that are not.

3.2.1 ENDANGERED SPECIES ACT AND CRITICAL HABITAT

Critical Habitat

The ESA requires that NMFS establish critical habitat for listed salmonids. Critical habitat is designated on a more refined level than EFH, i.e., on a water body by water body basis. As a result, EFH has a much broader distribution than critical habitat. Because EFH includes water bodies that have current or historic presence, it will include all critical habitat. For this reason, consultations conducted by NMFS are typically integrated, to include both EFH and ESA consultation requirements. In areas of EFH where critical habitat is not designated, the conservation recommendations resulting from an EFH consultation would be the primary mechanism for NMFS to implement minimization measures.

ESA-listed Salmon

Pacific salmon from twenty eight evolutionarily significant units (ESUs) in the area covered by the proposed actions are listed under the ESA as either "threatened" or "endangered." These include: nine Chinook salmon ESUs (59 FR 440, January 4, 1994; 64 FR 50394, September 16, 1999; 70 FR 37160, June 28, 2005); four coho salmon ESUs (70 FR 37160, June 28, 2005; 76 FR 35755, June 20, 2011); two chum salmon ESUs (70 FR 37160, June 28, 2005; 77 FR 19552, April 2, 2012); two sockeye salmon ESUs (70 FR 37160, June 28, 2005); and 11 steelhead ESUs (71 FR 834, January 5, 2006; 72 FR 26722, May 11, 2007; 74 FR 42605, August 24, 2009). In addition, bull trout are listed as "threatened" throughout their range (64 FR 58909, November 1, 1999). The distribution and critical habitat for these listed-species overlap extensively with salmon EFH, but are not completely coincident. Federal actions in areas designated as critical habitat are subject to the consultation requirements of ESA Section 7 which, like the MSA EFH provisions, are also designed to protect habitat. In areas where critical habitat of species under NMFS jurisdiction overlaps with salmon EFH, the ESA and EFH consultations are often combined.

Eulachon

The southern Distinct Population Segment (DPS) of eulachon was listed as threatened under the ESA in 2010 (75 FR 13012, March 18, 2010). Eulachon are found in the eastern north Pacific Ocean from northern California to southwest Alaska and into the southeastern Bering Sea. The eulachon southern DPS is defined from the Mad River in northern California, north to the Skeena River in British Columbia. Eulachon are an anadromous fish, and the adults migrate from the ocean to freshwater streams where they spawn from late winter through early summer. The offspring hatch and migrate back to the ocean to forage until maturity. Once juvenile eulachon enter marine waters, they move from shallow nearshore areas to deeper areas over the continental shelf. There is little information available about eulachon movements in nearshore marine areas and the open ocean (PFMC 2012)

Green Sturgeon

The southern DPS of North American green sturgeon was listed as threatened under the ESA in 2006 (71 FR 17757, April 7, 2006). The North American green sturgeon southern DPS is defined as coastal and Central Valley populations, south of the Eel River in California, and therefore co-occurs with Pacific salmon fisheries.

Sea Turtles

Four species of sea turtles are known to be present in the west coast EEZ: leatherback, loggerhead, olive ridley, and green. All four are listed as Endangered under the ESA. Leatherbacks and loggerheads are regular visitors to areas coincident with the Pacific Coast salmon fishery, but olive ridley and green turtles are less predictably present (PFMC 2013).

3.2.2 Marine Mammals

ESA-listed marine mammal species that co-occur with Pacific salmon EFH include Guadalupe fur seal, southern sea otter, northern sea otter, and Southern Resident killer whale. Among the ESA-listed marine mammals, only the Southern Resident killer whale is known to interact with Pacific salmon. There is evidence suggesting salmon abundance in Puget Sound may correlate with killer whale population growth rate (PFMC 2011). Table 3-1 displays ESA-listed marine mammals and their listing status that occur in west coast marine waters.

Table 3-1. ESA-listed marine mammals that occur in the action area.

	Species	ESA listing
Whales	Humpback (*Megaptera novaeangliae*)	Endangered
	Sei (*Balaenoptera borealis*)	Endangered
	North Pacific Right (*Eubalaena japonica*)	Endangered
	Blue whale (*Balaenoptera musculus*)	Endangered
	Fin whale (*Balaenoptera physalus)*	Endangered
	Sperm whale (*Physter macrocephalus*)	Endangered
	Southern Resident Killer whale (*Orcinus orca*)	Endangered
Other marine mammals	Guadalupe Fur Seal (*Arctocephalus townsendi*)	Threatened
	Southern sea otter (*Enhydra lutris nereis*)	Threatened
	Northern sea otter (*Enhydra lutris kenyoni*)	Threatened

A number of non-ESA-listed marine mammals may also occur in the affected area, these include: northern fur seal, California sea lion, Steller sea lion, harbor seal, northern elephant seal, bottlenose dolphin, Pacific white-sided dolphin, common dolphin, harbor porpoise, Dall's porpoise, and minke whale. These species, like all marine mammals, are protected under the MMPA. The non-ESA-listed marine mammal species that are known to interact with ocean salmon fisheries are California sea lion and harbor seals. All are protected under the MMPA. Ocean salmon fisheries are classified under the MMPA as Category III (79 FR 14418, March 14, 2014), indicating there is no record of substantive impacts to marine mammals [MMPA 118(c)(1)].

3.2.3 Seabirds

Numerous seabird species, as well as raptors, are protected under the MBTA, including several that are present in areas coincident with Pacific salmon. These seabirds include grebes, loons, petrels, albatrosses, pelicans, double-crested cormorants, gulls, terns, auks, and auklets (PFMC 2011). ESA-listed bird species include short-tailed albatross (endangered) and marbled murrelet (threatened).

Interactions with the Pacific salmon fishery typically occur in two ways: when seabirds feed on outmigrating juvenile salmon, and when seabirds are entangled or otherwise interact with fishing gear or activities. Predation on juvenile salmon occurs in the lower Columbia River, as salmon smolts migrate downstream and into marine waters. Two man-made islands, East Sand Island and Rice Island were created using dredge spoils from the Columbia River. The Islands have since become occupied by colonies of Caspian terns and double-crested cormorants. In 2010 and 2011, an estimated 19.2 million and 20.5 million (respectively) juvenile salmon were consumed by the double-crested cormorant colony on East Sand Island. These numbers are approximately equal to 18 percent of the entire Columbia River out-migrating salmon for those years (BRNW 2011). Caspian Terns nesting on East Sand and Rice Islands also consume outmigrating salmonids: 8.1 million salmon smolts in 1997 and 12.4 million in 1998. Although these numbers include steelhead smolts, they represent a minority of all salmonids consumed by Caspian terns (Roby *et al*. 2003).

Bycatch of seabirds occurs in west coast salmon fisheries, primarily in gillnet fisheries in Puget Sound, Willapa Bay, and Gray's Harbor. According the Washington Sea Grant (WSG 1996) the two species most frequently entangled were rhinoceros auklets (*Cerorhinca monocerata*) and common murres (*Uria aalge*). Although there are data available related to seabird bycatch in the sockeye gillnet fishery in Puget Sound, data are more sparse on gillnet fisheries targeting Council-managed salmon stocks.

3.3 HABITAT, BIODIVERSITY, AND ECOSYSTEM FUNCTION

Salmon FMP stocks interact with a number of ecosystems along the Pacific Coast, including the California Current Large Marine Ecosystem, numerous estuary and freshwater areas and associated riparian habitats. Salmon contribute to ecosystem function as predators on lower trophic level species, as prey for higher trophic level species, and as nutrient transportation from marine ecosystems to inland ecosystems. Because of their wide distribution in both the freshwater and marine environments, Pacific salmon interact with a great variety of habitats and other species of fish, mammals, and birds. An extensive description can be found in the EIS for groundfish harvest specifications (PFMC 2012). This section summarizes the habitats and ecosystem functions that Pacific salmon encounter, and draws primarily from PFMC 2012.

3.3.1 CALIFORNIA CURRENT LARGE MARINE ECOSYSTEM

The California Current (CC) is formed when the North Pacific Current splits, approximately at Vancouver Island, Canada. It varies seasonally, but generally flows southward along the West Coast to mid-Baja, Mexico. The California Current flows in a southern direction year-round off shore from the shelf break to approximately 200 miles offshore. Other coastal currents dominate along the continental shelf. These include the Davidson Current and California Undercurrent, the Southern California Countercurrent, as well as many eddies and smaller shelf currents (PFMC 2012).

The California Current also defines the outer boundary of the California Current Large Marine Ecosystem (CCLME) that is delineated by bathymetry, productivity, and trophic interactions. The LME is an organizational unit to facilitate management of an entire ecosystem, and recognizes the complex dynamics between the biological and physical components. NOAA's ecosystem-based management approach uses the LME concept to define ecosystem boundaries.

Several Council and NMFS documents describe the prevailing marine ecosystem functions, variations, and drivers. The CPS SAFE document (PFMC 2011a) and the Groundfish SAFE document (PFMC 2008b) summarize stock assessment information as well as fishery statistics for all groundfish and CPS species. These typically include ecosystem information, bycatch, management strategies, and other fishery-related information.

3.3.2 PHYSICAL AND BIOLOGICAL OCEANOGRAPHY

The California Current is essentially the eastern limb of the Central Pacific Gyre, and begins where the west wind drift (or the North Pacific Current) reaches the North American Continent. This occurs near the northern end of Vancouver Island, roughly between 45° and 50° N latitude and 130° to 150° W longitude (Ware and McFarlane 1989). A divergence in the prevailing wind patterns causes the west wind drift to split into two broad coastal currents, the California Current to the south and the Alaska Current to the north. As there are really several dominant currents in the region, all of which vary in geographical location, intensity, and direction with the seasons, this region is often referred to as the California Current System (Hickey 1979).

3.3.3 MARINE PROTECTED AREAS

There are numerous Federal and state-managed MPAs distributed throughout the project area. The EIS for Pacific Coast Groundfish EFH contains a complete analysis of these sites. Federally-managed areas include National Wildlife Refuges, National Parks, National Marine Sanctuaries, and National Estuarine Research Reserves. In addition, there are navigation-related managed areas, weather and scientific buoys, and hazardous and danger areas. Finally, there are federally-managed fishing areas such as the Rockfish Conservation Areas (RCAs), Cowcod Conservation Areas (CCA), and Yelloweye Rockfish Conservation Areas (YRCA) used to reduce fisheries impacts on groundfish species, and Pacific Whiting Salmon Conservation Zones off the Klamath and Columbia Rivers, designed to minimize impacts to Pacific salmon from the whiting fishery in those areas.

Many state-managed MPAs are under varying degrees of management, ranging from no-take marine reserves to designations allowing more intensive or extractive uses. The California Marine Life Protection Act guides a system of MPAs to increase coherence and effectiveness in protecting the state's marine life and habitats, marine ecosystems, and marine natural heritage, as well as to improve recreational, educational and study opportunities provided by marine ecosystems subject to minimal human disturbance. Oregon MPAs include marine gardens, research reserves, and two pilot marine reserves. Washington State manages marine reserves, conservation easements, state parks, and other areas, all with varying levels of regulation covering passive and extractive uses.

3.3.4 WEST COAST BIOGEOGRAPHY

The U.S. west coast contains a wide range of ecosystems and habitats, ranging from arid inland climates to alpine-dominated climates, to coastal rain forest-dominated areas. This section draws primarily from NMFS (2003). The Pacific Northwest coastal region is dominated by medium to high rainfall resulting from the interaction between marine weather systems and the coastal mountains, which reach up to 4,000 feet in elevation. Most coastal streams have relatively steep gradients with a shallow coastal plain. Forested lands are dominated by Sitka spruce, Douglas fir, western redcedar, and western hemlock. Numerous shrubs and herbaceous plants dominate the undergrowth. The southern Oregon and California coastal region typically experiences less rainfall than the Pacific Northwest, although is still influenced by marine weather.

Major inland river systems include the Columbia Basin, Klamath Basin, and the Sacramento/San Joaquin system (California Central Valley). These river basins provide spawning and rearing habitat for much of the Pacific Coast salmon managed under the Salmon FMP, and many smaller coastal watersheds contribute to both local and regional fisheries.

The West Coast oceanographic ecosystem is dominated by the California Current Large Marine Ecosystem (CCLME), which is characterized by very high biological productivity. The California Current (CC) is formed by the bifurcation of the North Pacific Current as it approaches the West Coast. The California Current flows southward year round off shore from the shelf break to ~200 miles. Other coastal currents generally dominate along the continental shelf including the northward Davidson Current and California Undercurrent, the Southern California Countercurrent, as well as many eddies and smaller shelf currents. The biological productivity is reflected in the extensive nearshore kelp beds, large schools of CPS (e.g., sardine, anchovy, squid, etc.) and groundfish (Pacific hake) that, in turn, support large populations of marine mammals, seabirds and highly migratory species such as tuna, sharks, billfish (PFMC 2011b).

Table 3-2. Coho salmon stocks listed in the Pacific salmon FMP (revised through Amendment 17).

Coho salmon stock complexes and stocks		ESA-Status
No coho stock complexes		
	Central California Coast	Threatened
	Southern Oregon/Northern California Coast	Threatened
	Oregon Coast Natural	Threatened
	Lower Columbia Natural	Threatened
	Oregon Coast Hatchery	Not listed
	Columbia River Late Hatchery	Not listed
	Columbia River Early Hatchery	Not listed
	Willapa Bay Hatchery	Not listed
	Willapa Bay Natural	Not listed
	Grays Harbor	Not listed
	Quinault – Hatchery	Not listed
	Queets	Not listed
	Quillayute – Summer Hatchery	Not listed
	Quillayute – Fall	Not listed
	Hoh	Not listed
	Strait of Juan de Fuca	Not listed
	Hood Canal	Not listed
	Skagit	Not listed
	Stillaguamish	Not listed
	Snohomish	Not listed
	South Puget Sound Hatchery	Not listed
Coho Totals	21 stocks	4 ESA-listed stocks

Table 3-3. Chinook salmon stocks listed in the Pacific salmon FMP (revised through Amendment 17).

Chinook salmon stock complexes and stocks		ESA-Status
Central Valley Fall Chinook Stock Complex		
	Sacramento River Fall	Not listed
	Sacramento River Late Fall	Not listed
	San Joaquin River Fall	Not listed
Southern Oregon Northern California Chinook Stock Complex		
	Klamath River Fall	Not listed
	Klamath River Spring	Not listed
	Smith River	Not listed
	Southern Oregon Coast	Not listed
Far-North-Migrating Coastal Chinook Stock Complex		
	Central and Northern Oregon Coast	Not listed
	Willapa Bay Fall (natural)	Not listed
	Willapa Bay Fall (hatchery)	Not listed
	Grays Harbor Fall	Not listed
	Grays Harbor Spring	Not listed
	Quinault Fall	Not listed

Chinook salmon stock complexes and stocks		ESA-Status
	Queets Fall	Not listed
	Queets Spring/Summer	Not listed
	Hoh Fall	Not listed
	Hoh Spring/Summer	Not listed
	Quillayute Fall	Not listed
	Quillayute Spring/Summer	Not listed
	Hoko Summer/Fall	Not listed
Chinook Stocks not included in a stock complex		
	Sacramento River Spring	Threatened
	Sacramento River Winter	Endangered
	California Coastal Chinook (Eel, Mattole, Mad Rivers fall and spring stocks)	Threatened
	North Lewis River Fall	Threatened
	Columbia Lower River Hatchery Fall	Not listed
	Columbia Lower River Hatchery Spring	Not listed
	Upper Willamette Spring	Threatened
	Columbia Mid-River Bright Hatchery Fall	Not listed
	Columbia Spring Creek Hatchery Fall	Not listed
	Snake River Fall	Threatened
	Snake River Spring/Summer	Threatened
	Columbia Upper River Bright Fall	Not listed
	Columbia Upper River Summer	Not listed
	Columbia Upper River Spring	Endangered
	Eastern Strait of Juan de Fuca Summer/Fall	Threatened
	Skokomish Summer/Fall	Threatened
	Nooksack Spring Early	Threatened
	Skagit Summer/Fall	Threatened
	Skagit Spring	Threatened
	Stillaguamish Summer/Fall	Threatened
	Snohomish Summer/Fall	Threatened
	Cedar River Summer/Fall	Threatened
	White River Spring	Threatened
	Green River Summer/Fall	Threatened
	Nisqually River Summer/Fall	Threatened
Chinook Totals	45 stocks	19 ESA-listed stocks

Table 3-4. Pink salmon stocks listed in the Pacific salmon FMP **(revised through Amendment 17).**

Pink salmon stock		ESA Status
Puget Sound		Not listed
Pink salmon Totals	1 stock	0 ESA-listed stocks

3.4 SOCIOECONOMIC ENVIRONMENT

This Section describes the socioeconomic conditions of the 2010 fishing year, with comparisons to the other recent fishing years and recent historical averages. It is based largely on Amendment 16 to the Pacific salmon FMP (PFMC 2011). It describes the harvests of Chinook salmon and coho salmon, ex-vessel revenues, price, fishing effort and recreational trip information for the commercial and recreational ocean salmon fishery. These estimates are stratified by state, management zone, and/or port of landing. Commercial fishing activities are unaffected by current EFH-based management measures, and therefore could be considered not part of the affected environment. However, there is potential in the future that the Council and NMFS could implement management measures to minimize impacts to EFH. Therefore, this section includes descriptions of ocean and inland fishing activities.

Chapter IV in the *Review of 2010 Ocean Salmon Fisheries Review* (PFMC 2011a) provides information on the socioeconomic impacts of the ocean salmon fisheries. More extensive information on the ocean salmon fisheries and social and economic characteristics is provided in Appendix B to the Salmon FMP (PFMC 2007). Information on fishing communities and recommended conservation measures is provided in Appendices A and B to the Council's description of West Coast fishing communities (PFMC 2007).

3.4.1 STATE-LEVEL TRENDS: COMMERCIAL OCEAN SALMON FISHERY

Coastwide, the number of commercial vessels landing salmon has drastically declined since 1990 (from Tables D-4, D-5, and D-6 in the *Review*). In 2010, there was a decline in the number of vessels landing salmon (216 vessels) in California compared to 2007 (601 vessels), and a 66 percent decline compared to the 2001-2007 average (640 vessels) (Table 3-5). In Oregon, there was a 15 percent decline in vessels landing salmon in 2010 (369 vessels) compared to 2007 (436 vessels), and a 23 percent decline compared to the 2001-2007 average (481 vessels). In Washington, there was a 20 percent increase in vessels landing salmon in 2010 (116 vessels) compared to 2009 (97 vessels), and a 41 percent increase compared to the 2001-2009 average (82 vessels). Similar trends were apparent for the number of vessels landing 90 percent of total pounds of salmon troll catch by state (Table 3-5, from Tables D-12, D-13, and D-14 in the *Review*).

Table 3-5. Number of registered vessels making troll commercial salmon landings.

Year or Period	California			Oregon			Washington		
	Total vessels	Vessels landing 90% of catch		Total vessels	Vessels landing 90% of catch		Total vessels	Vessels landing 90% of catch	
		No. of Vessels	Percent of Fleet		No. of Vessels	Percent of Fleet		No. of Vessels	Percent of Fleet
2010	216	84	39%	369	139	38%	116	73	63%
Previous fishing year (2007 for CA & OR; 2009 for WA)	601	293	49%	436	232	53%	97	61	63%
Average (2001-2007 for CA & OR; 2001-2009 for WA)	640	299	47%	481	252	52%	82	49	60%

3.4.2 State-Level Trends: Recreational Ocean Salmon Fishery

Recreational ocean salmon fishing estimates include mainly private vessels and charter boats. Some shore-based fishing occurs, although this component accounts for a low amount of the recreational ocean salmon catch. In 2010, a combined total of 48,800 estimated recreational trips occurred in California, and 27 percent of these trips were charter boat trips (13,100) (Table 3-6; Tables IV-11, IV-12, IV-13 in the *Review*). The total number of estimated recreational trips in 2010 (48,800 trips) reflects a 70 percent decline, compared to the 2001-2007 average in California (161,900 trips). The 2010 trip estimate is also substantially less than the number of trips in California in 2007 (105,900 trips).

In 2010, a combined total of 53,300 estimated recreational trips occurred in Oregon, and about nine percent of these trips were charter boat trips (5,000 trips) (Table 3-6; Table IV-12 in the *Review*). The trips in 2010 represented a 50 percent decrease from the 2001-2007 average (106,400 trips), and substantially less than 2007 (88,300 trips).

In 2010, a combined total of 80,800 estimated recreational trips occurred in Washington, and 33 percent of these trips were charter boat trips (26,500 trips) (Table 3-6; Table IV-13 in the *Review*). In Washington, the decline was less pronounced than in California and Oregon; the combined number of estimated recreational trips in 2010 (80,800 trips) experienced a 9 percent decline from the 2001-2009 average (88,900 trips), and was less than the previous year (98,900 trips). In recent years, recreational ocean trips have been supported in Washington and Oregon by the implementation of mark-selective fisheries for coho salmon. Council-area wide, the number of charter trips was estimated to be about 44,600 trips in 2010, and the number of private vessel trips was estimated to be about 138,300 trips (a total of about 182,900 trips).

Table 3-6. Estimated number of recreational ocean salmon angler trips by state.

Year or Period	California	Oregon	Washington
2010	48,800	53,300	80,800
Previous fishing year (2007 for CA & OR; 2009 for WA)	105,900	88,300	98,900
Average (2001-2007 for CA & OR; 2001-2009 for WA)	161,900	106,400	88,900

While fishing impacts are calculated on a stock-specific basis, the social dimension, including management measures, is organized around ocean management areas, as described in the Salmon FMP. These areas also correspond to some extent with the ocean distribution of salmon stocks, although stocks are mixed in offshore waters. Broadly, from north to south these areas are:

(a) From the U.S./Canada border to Cape Falcon (45°46' N. lat.), which is on the Oregon coast south of the Columbia River mouth;
(b) Between Cape Falcon and Humbug Mountain (42°40' 30" N. lat.) on Oregon's north and central coast;
(c) The Klamath Management Zone (KMZ), which covers ocean waters from Humbug Mountain in southern Oregon to Horse Mountain (40°05' N. lat.) in northern California;
(d) From Horse Mountain to Point Arena; and
(e) From Point Arena to the U.S./Mexico border.
There are also numerous subdivisions within these areas used to further balance stock conservation and harvest allocation considerations (Figure 3-1).

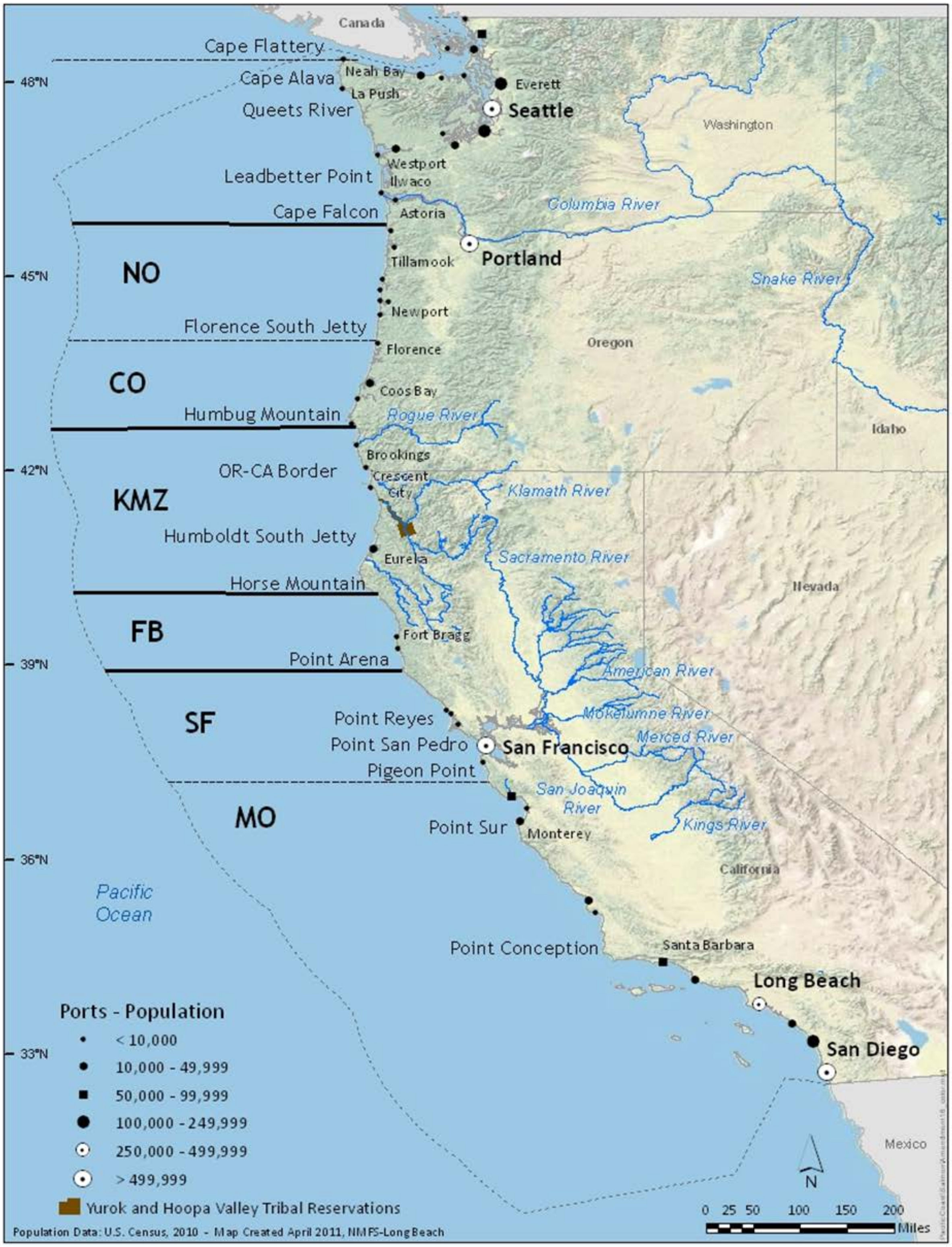

Figure 3-1. Map of West Coast ocean salmon fishery management areas.

3.4.3 Inside Commercial and Recreational Fisheries

Recreational fisheries occur in nearly all inside waters, in Washington, Oregon, Idaho, and California. These account for substantial economic expenditures, from personal and guided trips. Recreational fishing activities are unaffected by EFH overlays and therefore should not be considered part of the affected environment. Non-Indian commercial fisheries operate in Puget Sound (seine and gillnet) Grays Harbor, Willapa Bay, and the lower Columbia River (gillnet). Inland recreational fisheries are widely distributed across Washington, Oregon, Idaho, and California. These represent a considerable amount of economic activity, although economic data is sparse as compared with marine and coastal fishing.

3.4.4 Inside Tribal Fisheries

Tribal fisheries operate in Puget Sound, Washington coastal rivers from Grays Harbor north, and the mid-Columbia River; these include commercial (gillnet, and dipnet), and ceremonial and subsistence (all gear types) fisheries. The only tribal fishery along the Oregon coast is conducted and regulated by the Siletz Tribe, which allows no more than 200 Chinook salmon or coho salmon annually (USPL 96-340 1980). In California, commercial fisheries are conducted by the Yurok and Hoopa Valley tribes in the Klamath Basin in their respective reservations. The Yurok, Hoopa Valley, Kurok, and Resighini Rancheria tribes also conduct important, but minor ceremonial and subsistence fisheries in their usual and accustomed fishing areas. The Karuk tribal dipnet fisheries and fishing conducted by members of the Resighini Rancheria are conducted under state regulations (15 CCR §7.50(b)(91.1)), and are subject to the same season and bag limit restrictions as the in-river non-Indian recreational fisheries. There are no non-Indian commercial fisheries in this area.

3.4.5 Catch, Effort and Economic Impact Data for Ocean Salmon Fisheries

Catch and effort data for 2010 and average landings and effort during 2000-2007 or 2000-2009 were used to describe and compare commercial troll and recreational ocean salmon fisheries off Washington, Oregon, and California. In 2010, catch per unit of effort (CPUE) was highest in fisheries from the U.S./Canada border to Cape Falcon in the treaty commercial troll ocean salmon fisheries (35 Chinook salmon per fishing day) (Table 3-7; from Table I-5 in the 2010 *Review;* CPUE calculated manually based on table contents). The Chinook salmon CPUEs in the recent year have declined substantially compared to the recent past average CPUEs except for the North of Cape Falcon (non-treaty) zone for both commercial and recreational fisheries. Non-treaty troll catch was limited in 2010 by landing limits and possession limits. The estimates of Chinook salmon dressed pounds were taken from Tables IV-6, IV-7, and IV-8 in the *Review* (PFMC 2010).

During the 2000s, average Chinook salmon effort and landings were highest from Horse Mountain south to the U.S. border, before widespread fishery closures in that area during 2008 and 2009. The least average commercial troll catch and effort during the 2000s occurred from Humbug Mountain to Horse Mountain.

Table 3-7. Commercial troll ocean salmon fishing effort and number of Chinook salmon and coho salmon landed by management area.

Management area	In 2010				Average[5]			
	No. of days fished	No. of Chinook salmon landed	Chinook salmon CPUE	No. of Coho salmon landed	No. of days fished	No. of Chinook salmon landed	Chinook salmon CPUE	No. of coho salmon landed
U.S./Canada Border to Cape Falcon (treaty)	1,000	33,400	35.1	11,500	600	30,500	50.8	34,800
U.S./Canada Border to Cape Falcon (non-treaty)	3,100	56,200	18.3	3,100	2,000	31,500	15.8	13,800
Cape Falcon to Humbug Mountain	3,500	27,400	7.9	0	8,500	169,600	20.0	1,100
Humbug Mountain to Horse Mountain	200	900	4.8	0	700	14,500	20.7	0
Horse Mountain south to U.S. Border	2,000	15,100	7.6	0	14,500	293,400	20.2	0

Table 3-8. Recreational ocean salmon fishing effort and catch of Chinook salmon and coho salmon landed by management area.

Management Zones	In 2010				Average[6]			
	No. of angler trips	No. of Chinook salmon landed	No. of coho salmon landed	Chinook salmon CPUE (Chinook/trip)	No. of angler trips	No. of Chinook salmon landed	No. of coho salmon landed	Chinook salmon CPUE (Chinook/trip)
U.S./Canada border to Cape Falcon (non-	91,200	38,700	42,400	0.42	99,000	21,900	98,400	0.22

[5] Averages include years 2003-2009 north of Cape Falcon (treaty and non-treaty), and years 2003-2007 south of Cape Falcon to exclude years of widespread fishery closures off California in 2008 and 2009.
[6] Averages include years 2003-2009 north of Cape Falcon, and years 2003-2007 south of Cape Falcon to exclude years of widespread fishery closures off California in 2008 and 2009.

treaty)								
Cape Falcon to Humbug Mountain	37,100	2,300	12,100	0.06	75,500	22,300	37,100	0.30
Humbug Mountain to Horse Mountain	10,200	1,500	100	0.15	32,600	21,500	1,000	0.66
Horse Mountain south to U.S. Border	44,500	14,000	100	0.32	132,500	103,700	700	0.78

Coastal community and state personal income impacts of the non-Indian commercial troll and recreational ocean salmon fishery were compared coast-wide (Table 3-9; from Tables IV-16, IV-17, and IV-18 in the *Review*). Economic impact estimate averages in the 2000s indicate the most economic activity occurred in ports south of Horse Mountain ($12,800,000 in San Francisco alone), while the least amount of activity occurred in ports from Humbug Mountain to Horse Mountain.

Table 3-9. Coastal community and personal income impacts (in real, inflation-adjusted 2010 dollars) of the commercial troll and recreational ocean salmon fishery for major port areas[7].

Management Areas or Ports	Ocean Commercial Troll		Ocean Recreational	
	2010	**Average**	**2010**	**Average**
U.S./Canada Border to Cape Falcon	**$5,593,000**	**$2,391,000**	**$7,412,000**	**$8,731,000**
Neah Bay	319,000	528,700	428,000	672,300
La Push	502,000	229,600	214,000	198,700
Westport	3,792,000	854,900	4,183,000	4,331,200
Ilwaco	82,000	130,800	2,001,000	2,708,100
Astoria	898,000	647,900	586,000	821,000
Cape Falcon to Humbug Mountain	**2,449,000**	**8,962,000**	**1,666,000**	**3,918,000**
Tillamook	260,000	781,100	522,000	902,400
Newport	1,304,000	4,320,400	819,000	1,595,400
Coos Bay	885,000	3,860,600	325,000	1,420,300
Humbug Mountain to Horse Mountain	**383,000**	**1,580,100**	**424,000**	**1,537,600**

[7] Averages include the years 2001-2009 north of Cape Falcon, and 2001-2007 south of Cape Falcon.

Crescent City	0	401,000	8,000	136,700
Eureka	34,000	350,700	185,000	776,000
Brookings	349,000	828,400	220,000	624,900
South of Horse Mountain	**1,977,000**	**21,363,000**	**3,037,000**	**11,904,000**
Fort Bragg	1,689,000	5,288,100	410,000	1,723,000
San Francisco	135,000	12,799,700	1,540,000	7,311,100
Monterey	153,000	3,274,700	1,087,000	2,869,900

Non-Indian ocean troll exvessel revenue information is presented in Table 3-10 (from Tables IV-16, IV-17, IV-18, IV-2, IV-3, and IV-4 in the *Review*). Except for Washington, the income impacts for 2010 were lower than average (2001-2010) for both California and Oregon.

Table 3-10. Estimates of ex-vessel value (in real dollars) and state personal income impacts both in thousands of real (inflation adjusted, 2010) dollars for the Non-Indian ocean troll Chinook salmon and coho salmon fishery.

	California		Oregon		Washington	
Year or Period	Ex-vessel value	Income impact	Ex-vessel value	Income impact	Ex-vessel value	Income impact
2001	$5,832	$14,477	$5,769	$12,615	$468	$1,056
2002	9,350	24,705	6,482	14,347	911	2,191
2003	14,338	35,939	8,501	17,648	1,167	2,784
2004	20,483	37,573	11,353	17,183	1,356	2,588
2005	14,303	26,064	9,418	14,429	1,428	2,570
2006	5,739	9,693	2,897	4,126	1,121	1,870
2007	8,235	13,910	2,941	4,206	993	1,663
2008	0	0	504	691	723	1,167
2009	0	0	348	537	1,181	1,981
2010	1,246	2,090	2,790	3,968	3,115	4,904
Average (2001-2010)	$7,953	$16,445	$5,100	$8,975	$1,246	$2,277

The number of recreational trips and the resulting state personal income impact are listed in Table 3-11 (from Tables IV-11, IV-12, IV-13, IV-16, IV-17, and IV-18 in the *Review*). The income impacts for the year 2010 have remained below the average (2001-2010) for all states.

Table 3-11. Ocean recreational trips (in thousands) and resulting state personal income impacts (in thousands of real 2010 dollars)

Year or Period	California				Oregon				Washington			
	Charter boat trips	Private boat trips	Total trips	Income impact	Charter boat trips	Private boat trips	Total trips	Income impact	Charter boat trips	Private boat trips	Total trips	Income impact
2001	69.9	95.2	165.1	$14,330	18.2	102.4	120.6	$7,699	41.2	72.4	113.6	$11,932
2002	86.6	123.4	210.1	18,008	15.7	91.9	107.6	6,805	37.0	57.4	94.4	10,429
2003	59.4	75.3	134.6	11,908	23.4	121.1	144.5	9,416	44.5	75.5	120.0	12,793
2004	97.7	121.0	218.7	19,469	21.1	124.6	145.7	9,189	36.5	73.1	109.5	10,920
2005	69.1	103.0	172.1	14,571	9.9	66.1	76.0	4,653	31.7	58.9	90.6	9,306
2006	44.9	81.6	126.5	10,151	8.0	54.4	62.3	3,799	24.5	39.1	63.6	6,951
2007	31.4	74.5	105.9	7,909	11.4	76.9	88.3	5,395	26.7	45.9	72.7	7,712
2008	0.1	0.3	0.4	30	1.9	28.5	30.4	1,607	14.2	22.2	36.4	4,011
2009	0.6	4.7	5.4	310	12.6	71.9	84.5	5,377	29.4	69.5	98.9	9,229
2010	13.1	35.6	48.8	3,515	5.0	48.3	53.3	3,033	26.5	54.4	80.8	7,976
Average (2001-2010)	47.3	71.5	118.8	$10,020	12.7	78.6	91.3	$5,697	31.2	56.8	88.0	$9,126

3.4.6 Inside Consultation Requirements

Any federal agency undertaking an action that may adversely affect salmon EFH must consult with NMFS to identify potential adverse effects, and to develop conservation recommendations for the project. EFH consultations are conducted by NMFS biologists, are typically combined with ESA consultations, and reported on the Public Consultation Tracking System (PCTS), a national database with public access via a website (https://pcts.nmfs.noaa.gov/pcts-web/homepage.pcts).

Between 2008 and 2012, the NMFS NWR and SWR conducted over 1000 consultations each year (NMFS 2013). The vast majority were combined ESA/EFH consultations. In some cases there were stand-alone ESA or stand-alone EFH consultations, but these are relatively rare. In many cases, NMFS develops programmatic consultations, especially with agencies such as the U.S. Forest Service, which conducts multiple similar projects requiring EFH consultation. Logging operations and sales, road building, bridge construction and maintenance, pesticide application, and other activities can be the subjects of such programmatic consultations. However, most consultations are single-project consultations.

4.0 ENVIRONMENTAL IMPACTS OF ALTERNATIVES

This chapter analyzes the effects of the alternatives under consideration on the four categories of the affected environment described in Chapter 3 of this document: fish resources, protected resources, habitat, and socioeconomics.

The U.S. Congress, in establishing the EFH mandate in the MSA, recognized the link between healthy habitats and sustainable fisheries and noted that habitat degradation was a major factor in the decline of many fisheries. The proposed alternatives to revise and update the salmon EFH provisions of the salmon FMP would affect the habitat of the three species of salmon managed under the salmon FMP. The intent of developing the salmon EFH provisions is to conserve the habitats upon which the three species of Council-managed salmon depend for spawning, breeding, feeding, or growth to maturity. These habitats play a vital role in maintaining a sustainable salmon fishery and their conservation will directly benefit the three species of salmon managed by the Council under the Pacific Salmon FMP. The habitats used by Pacific salmon and the functions they provide (e.g., prey resources, shelter, clean water) are shared by, and are important to, the other fish resources (both salmon and non-salmon) and protected resources (both fish and non-fish). When the effects of an alternative on habitat are positive they are also positive on fish resources and protected resources, and when the effects on habitat are negative they are also negative on fish resources and protected resources. As such, throughout this document the analysis of the effects of each alternative on fish resources and protected resources parallels the analysis of the effects of that alternative on habitat.

It is noted that none of the preferred alternatives are expected to affect public health or safety, or cultural or historic resources, or to involve introduction or spread of non-indigenous species. The preferred alternatives do not threaten violation of Federal, state, or local law. Because the proposed action does not affect these situations, they are not analyzed in this document.

4.1 IDENTIFICATION OF SALMON EFH

The EFH review team recommended minor language changes to clarify that EFH can be designated only for Federally-managed stocks that are included in an FMU. The intent is to provide better clarity regarding whether EFH can be designated for a particular stock of Pacific salmon. The two mutually exclusive alternatives under consideration are: 1A: No-action Alternative and 1B (preferred): Revise the identification of EFH to clarify that EFH is designated only for stocks included in the fishery managed by the PFMC. Revisions to this language would not represent a change in regulation or policy, but would simply clarify existing regulation and policy. As such, the selection of either of these two alternatives would not have any effect on fish resources, protected resources, habitat, or socioeconomics, and would not contribute to any cumulative effects from the remaining suite of alternatives.

4.2 CHINOOK SALMON FRESHWATER EFH

There are three alternatives under consideration for Chinook salmon freshwater EFH, the No-action Alternative and three action alternatives. Of these alternatives, the No-action Alternative is mutually exclusive with the others, but the action alternatives are not mutually exclusive with each other.

Alternative 2A: No-action Alternative

This alternative would retain the existing EFH description and geographic distribution for Chinook salmon. As such, the EFH description for Chinook salmon would not be based on the best scientific information available and would, therefore, not meet the purpose and need for the action.

Effects on Habitat

The No-action Alternative would maintain the existing designations of EFH for Chinook salmon and would not designate those new areas that, based on new information, are currently occupied by Chinook salmon. Actions that adversely affect habitat in those areas would not go through the EFH consultation process and NMFS would not provide the Federal agency with EFH Conservation Recommendations to avoid, minimize, mitigate, or otherwise offset the adverse effects. As such, actions in these areas would likely continue to affect habitat at their current levels.

Effects on Fish Resources

The No-action Alternative would maintain the existing designations of EFH for Chinook salmon and would not designate those new areas that, based on new information, are currently occupied by Chinook salmon and meet the description of EFH in the FMP. Actions that adversely affect habitat in those areas would not go through the EFH consultation process and NMFS would not provide the Federal agency with EFH Conservation Recommendations to avoid, minimize, mitigate, or otherwise offset the adverse effects. Adverse effects to habitat could result in reduced productivity for salmon and other fish resources. Under the No-Action Alternative, however, effects to fish resources would likely continue at current levels.

Effects on Protected Resources

The No-action Alternative would maintain the existing designations of EFH for Chinook salmon and would not designate those new areas that, based on new information, are currently occupied by Chinook salmon. Actions that adversely affect habitat in those areas would not go through the EFH consultation process and NMFS would not provide the Federal agency with EFH Conservation Recommendations to avoid, minimize, mitigate, or otherwise offset the adverse effects. Adverse effects to Chinook salmon habitat could result in adverse effects to protected resources that share that habitat, and to protected resources that prey on salmon, such as marine mammals and seabirds. Under the No-action Alternative, however, effects to protected resources would likely continue to affect protected resources at current levels.

Effects on Socioeconomics

The No-action Alternative would maintain the existing designations of EFH for Chinook salmon and the EFH consultation requirements would not change, and effects to fishery-dependent communities from Chinook salmon productivity affected by EFH designations would also not change. Therefore, the socioeconomic effects of EFH designation in these areas would likely continue at their current levels.

Alternative 2B: Designate five additional hydrologic units as Chinook salmon EFH and remove one (preferred)

This alternative would expand the designation of EFH for Chinook salmon into five 4th field HUs that are currently not designated as EFH, and would eliminate one HU from EFH for Chinook salmon.

Effects on Habitat

This alternative could have positive effects on habitat. It would expand the current designation of EFH for Chinook salmon into some areas that, based on new information, meet the description of EFH in the FMP. Actions in those areas that may adversely affect EFH would require consultation with NMFS, and could result in EFH Conservation Recommendations to the Federal agency to avoid, minimize, mitigate, or otherwise offset any adverse effects. The recommendations, if implemented, would promote the conservation of the aquatic habitats in these areas. However, the newly designated areas would be relatively small when compared to the overall geographic extent of salmon EFH. In addition, these HUs are either designated as critical habitat for, or are occupied, at least seasonally, by ESA-listed salmon. Tomales-Drakes Bay is designated as critical habitat for Central California steelhead; the Palouse is occupied by Snake River fall-run Chinook salmon; the lower reaches of the Chelan River are occupied by Upper Columbia spring-run Chinook salmon and Upper Columbia steelhead; and the Lower North Fork Clearwater is occupied by Snake River fall Chinook salmon and Snake River steelhead. The habitat needs of Chinook salmon are the same, or very similar to those of the ESA-listed species of salmon in these HUs, and the protections to the salmon habitat afforded by the ESA could provide sufficient protection to salmon habitat. Therefore, while designating EFH might produce some positive effects on aquatic habitat, including the habitat of species not managed by the Council, the magnitude of those effects is expected to be minimal.

Effects on Fish Resources

This alternative could have positive effects on fish resources. It would expand the current designation of EFH for Chinook salmon into some areas that, based on new information, meet the description of EFH in the FMP. Actions in those areas that may adversely affect EFH would require consultation with NMFS, and could result in EFH Conservation Recommendations to the Federal agency to avoid, minimize, mitigate, or otherwise offset any adverse effects to EFH. The recommendations, if implemented, would promote the conservation of the aquatic habitats in these areas and, therefore, the fish resources that rely on those habitats. However, the newly designated areas would be relatively small when compared to the overall geographic extent of salmon EFH. In addition, these HUs are either designated as critical habitat for, or are occupied, at least seasonally, by ESA-listed salmon. Tomales-Drakes Bay is designated as critical habitat for Central California steelhead; the Palouse is occupied by Snake River fall-run Chinook salmon; the lower reaches of the Chelan River are occupied by Upper Columbia spring-run Chinook salmon and Upper Columbia steelhead; and the Lower North Fork Clearwater is occupied by Snake River fall Chinook salmon and Snake River steelhead. The habitat needs of Chinook salmon are the same as, or similar to, the ESA-listed species of salmon in these HUs, and the protections to the salmon habitat afforded by the ESA could provide sufficient protection to salmon habitat. Therefore, while designating EFH might produce some positive effects on aquatic habitat and the productivity of fish resources, including non-salmon species, that rely on those habitats, the magnitude of those effects is expected to be minimal.

Effects on Protected Resources

This alternative could have positive effects on protected resources. It would expand the current designation of EFH for Chinook salmon into some areas that, based on new information, meet the description of EFH in the FMP. Actions in those areas that may adversely affect EFH would require consultation with NMFS, and could result in EFH Conservation Recommendations the Federal agency to avoid, minimize, mitigate, or otherwise offset any adverse effects. The recommendations, if implemented, would promote the conservation of the aquatic habitats in these areas and, therefore, the protected resources that rely on those habitats. However, the newly designated areas would be relatively small when compared to the overall geographic extent of salmon EFH. In addition, these HUs are either designated as critical habitat for, or are occupied, at least seasonally, by ESA-listed salmon. Tomales-Drakes Bay is designated as critical habitat for Central California steelhead; the Palouse is occupied by Snake River fall-run Chinook salmon; the lower reaches of the Chelan River are occupied by Upper Columbia spring-run Chinook salmon and Upper Columbia steelhead; and the Lower North Fork Clearwater is occupied by Snake River fall Chinook salmon and Snake River steelhead. The habitat needs of Chinook salmon are the same as, or very similar to, those of the ESA-listed species of salmon in these HUs, and the protections to the salmon habitat afforded by the ESA could provide sufficient protection to salmon habitat. Therefore, while designating EFH might produce some positive effects on aquatic habitat and the protected resources, including non-salmon species, that rely on those habitats, or that prey on salmon, the magnitude of those effects is expected to be minimal.

Effects on Socioeconomics

This alternative could expand the geographic extent of EFH and could, therefore, trigger an unknown increase in the number of EFH consultations on Federal actions that may adversely affect EFH. These additional consultations would not otherwise be required if EFH were not expanded. The additional consultation requirement could negatively, but no more than minimally, affect the costs and timelines of permitting for projects that may adversely affect EFH in these new areas because EFH consultation can be combined with other environmental processes, such as NEPA and ESA Section 7 consultation. Effects to fishery-dependent communities from Chinook salmon productivity affected by EFH designations could be positive, but such effects would be expected to be minimal.

ALTERNATIVE 2C: DESIGNATE THE MAINSTEM COLUMBIA RIVER AND SIDE CHANNELS AS EFH FOR CHINOOK SALMON

This alternative would designate EFH for Chinook salmon in the mainstem Columbia River of the Middle Columbia-Lake Wallula 4th field HU, and the lower reaches of the perennial tributaries flowing into that HU. This entire HU is currently designated as EFH for Chinook salmon. When this alternative was being developed, it was thought that only the mainstem Columbia River and the lower reaches of the tributaries were occupied by Chinook salmon other than spring-run fish. However, Streamnet (2012a) shows that at least two of the tributaries of this HU are used by fall-fun Chinook salmon for spawning, rearing, or migration. Therefore, limiting EFH to just the mainstem Columbia and lower reaches of the tributaries would not be using the best information available and would, therefore, not meet the purpose and need of the action.

Effects on Habitat

This alternative could have negative effects on habitat. It would expand the current designation of EFH for Chinook salmon in this HU to the mainstem Columbia River and lower reaches of the tributaries. The areas of the HU above the lower reaches of the perennial tributaries would lose the protections afforded by EFH designation and Federal actions occurring in those areas would no longer require EFH consultation, unless the effects of that action extended to the sections designated as EFH. The loss of EFH designation in parts of this HU would mean that habitats in those areas would receive less protection than they currently receive. As a result, the aquatic habitats in this HU could be negatively affected. However, this HU is occupied by the Middle-Columbia steelhead ESU, which is listed as "threatened" under the ESA, and some of the tributaries have been designated as critical habitat. Consultation under the ESA is required for any action that may adversely affect ESA-listed species or their critical habitat and is expected to provide equal or greater protection to the aquatic habitats and the fish resources that rely on them than would designation as EFH. Therefore, the potential effects on habitat, including the habitats of species not managed under the MSA, are not expected to be significant.

Effects on Fish Resources

This alternative could have negative effects on fish resources. It would limit the extent of EFH for Chinook in this HU to the mainstem Columbia River and lower reaches of the tributaries. The areas of the HU above the lower reaches of the perennial tributaries would lose the protections afforded by EFH designation and Federal actions occurring in those areas would no longer require EFH consultation unless the effects of that action extended to the downstream areas designated as EFH. The loss of EFH designation in parts of this HU would mean that habitats in those areas lose the EFH protections that they currently receive. As a result, the aquatic habitats in this HU and the fish resources that rely on them, could be negatively affected. However, this HU is occupied by the Middle-Columbia steelhead ESU, which is listed as "threatened" under the ESA, and some of the tributaries have been designated as critical habitat. Consultation under the ESA is required for any action that may adversely affect ESA-listed species or their critical habitat and is expected to provide equal or greater protection to the aquatic habitats and the fish resources that rely on them than would designation as EFH. Therefore, the potential negative effects of this alternative on the productivity of fish resources, including non-salmon species, are not expected to be significant.

Effects on Protected Resources

This alternative could have negative effects on protected resources. It would limit the extent of EFH for Chinook salmon in this HU to the mainstem Columbia River and lower reaches of the tributaries. The areas of the HU above the lower reaches of the perennial tributaries would lose the protections afforded by EFH designation and Federal actions occurring in those areas would no longer require EFH consultation, unless the effects of that action extended to the sections designated as EFH. The loss of EFH designation in parts of this HU would mean that habitats in those areas would receive less protection than they currently receive. As a result, the aquatic habitats in this HU and the protected resources that rely on them, would be negatively affected. However, this HU is occupied by the Middle-Columbia steelhead ESU, which is listed as "threatened" under the ESA, and some of the tributaries have been designated as critical habitat. Consultation under the ESA is required for any action that may adversely affect ESA-listed species or their critical habitat, and is expected to provide equal or greater protection to the aquatic habitats and the fish resources that rely on those habitats, or that prey on affected salmon, than would designation as EFH. Therefore, the potential negative effects on protected resources, including non-salmon species, are not expected to be significant.

Effects on Socioeconomics

This alternative would reduce the geographic extent of EFH and would, therefore, trigger an unknown decrease in the number of EFH consultations on Federal actions that may adversely affect EFH. These actions would require consultations if the extent of EFH were not reduced by this alternative. The reduced consultation requirement could positively, but no more than minimally, affect the costs and timelines of permitting for projects that may adversely affect EFH in these new areas, because those actions would likely require ESA consultation for Middle-Columbia steelhead, regardless of the EFH designations. Effects to fishery-dependent communities from Chinook salmon productivity affected under this alternative could be negative, but such effects would be expected to be minimal.

ALTERNATIVE 2D: UPDATE EFH DESIGNATIONS AND MAPS TO BE CONSISTENT WITH THE NEW (REORGANIZED) USGS CENTRAL CALIFORNIA VALLEY 4TH FIELD HYDROLOGIC UNITS (PREFERRED)

This alternative would update the EFH designations to reflect recent changes to the USGS California Central Valley and coast 4th field HUs.

Effects on Habitat

This alternative could have positive effects on habitat resources. Most of the revised USGS watershed boundaries resulted in larger, consolidated HUs. As a result, using the updated USGS data would expand EFH designations into some areas that were not previously designated as EFH. Actions in those areas that may adversely affect EFH would require consultation with NMFS, and could result in EFH Conservation Recommendations to the Federal agency to avoid, minimize, mitigate, or otherwise offset any adverse effects to EFH. The recommendations, if implemented, would promote the conservation of the aquatic habitats in these areas. However, much of the new area encompassed by the revised HUs is above impassable dams, and therefore would be excluded from EFH on that basis. In addition, all but the lower reaches of western tributaries to the San Joaquin River would be excluded because of a lack of current or historical salmon distribution. Therefore, because the changes to the spatial extent of EFH in the Central Valley and coast are minimal, the corresponding positive effects from expansion of EFH on habitat, including the habitat of species not managed under the MSA, are not expected to be significant.

Effects on Fish Resources

This alternative could have positive effects on fish resources. Most of the revised USGS watershed boundaries resulted in larger, consolidated HUs. As a result, using the updated USGS data would expand EFH designations into some areas that were not previously designated as EFH. Actions in those areas that may adversely affect EFH would require consultation with NMFS, and could result in EFH Conservation Recommendations to the Federal agency to avoid, minimize, mitigate, or otherwise offset any adverse effects to EFH. The recommendations, if implemented, would promote the conservation of the aquatic habitats in these areas and, therefore, the productivity of fish resources that rely on those habitats. However, much of the new area encompassed by the revised HUs is above impassable dams, and therefore would be excluded from EFH on that basis. In addition, all but the lower reaches of western tributaries to the San Joaquin River would be excluded because of a lack of current or historical salmon distribution. Therefore, because the changes to the spatial extent of EFH in the Central Valley and coast are minimal, the corresponding positive effects from expansion of EFH on fish resources, including non-salmon species, are not expected to be significant.

Effects on Protected Resources

This alternative could have positive effects on protected resources. Most of the revised USGS watershed boundaries resulted in larger, consolidated HUs. As a result, using the updated USGS data would expand EFH designations into some areas that were not previously designated as EFH. Actions in those areas that may adversely affect EFH would require consultation with NMFS, and could result in EFH Conservation Recommendations to the Federal agency to avoid, minimize, mitigate, or otherwise offset any adverse effects to EFH. The recommendations, if implemented, would promote the conservation of the aquatic habitats in these areas and, therefore, the protected resources that rely on those habitats or that prey on affected salmon stocks. However, much of the new area encompassed by the revised HUs is above impassable dams, and therefore would be excluded from EFH on that basis. In addition, all but the lower reaches of western tributaries to the San Joaquin River would be excluded because of a lack of current or historical salmon distribution. Therefore, because the changes to the spatial extent of EFH in the Central Valley and coast are minimal, the corresponding positive effects from expansion of EFH on protected resources, including non-salmon species, are not expected to be significant.

Effects on Socioeconomics

This alternative could expand the geographic extent of EFH and could, therefore, trigger an unquantifiable increase in the number of EFH consultations on Federal actions that may adversely affect EFH. These additional consultations would not otherwise be required if EFH were not expanded. The additional consultation requirement could negatively, but no more than minimally, affect the costs and timelines of permitting for projects that may adversely affect EFH in these new areas because the changes to the spatial extent of EFH in the Central Valley and coast would be minimal and EFH consultation can be combined with other environmental processes, such as NEPA. Effects to fishery-dependent communities from salmon productivity affected by EFH consultations could be positive, but such effects would be expected to be minimal.

4.3 Coho Salmon Freshwater EFH

There are three alternatives under consideration for coho salmon freshwater EFH, the No-action Alternative and two action alternatives. The No-action Alternative is mutually exclusive with the action alternatives, but the action alternatives are not mutually exclusive of each other.

Alternative 3A: No-action Alternative

This alternative would retain the existing EFH description and geographic distribution for coho salmon. As such, the EFH description for coho salmon would not be based on the best scientific information available and would, therefore, not meet the purpose and need for the action.

Effects on Habitat

The No-action Alternative would maintain the existing designations of EFH for coho salmon and would not designate those new areas that, based on new information, are currently occupied by coho salmon. Actions that adversely affect habitat in those areas would not go through the EFH consultation process and NMFS would not provide the Federal agency with EFH Conservation Recommendations to avoid, minimize, mitigate, or otherwise offset the adverse effects. It would also not remove EFH designation from areas that do not meet the description of EFH. Actions that adversely affect EFH in these areas would still be required to go through the consultation process and NMFS would continue to provide the Federal agency with EFH Conservation Recommendations. As such, actions in these areas would likely continue to affect habitat at their current levels.

Effects on Fish Resources

The No-action Alternative would maintain the existing designations of EFH for coho salmon and would not designate those new areas that, based on new information, are currently occupied by coho salmon and meet the description of EFH in the FMP. Actions that adversely affect habitat in those areas would not go through the EFH consultation process and NMFS would not provide the Federal agency with EFH Conservation Recommendations to avoid, minimize, mitigate, or otherwise offset the adverse effects. Adverse effects to habitat could result in reduced productivity for salmon and other fish resources. It would also not remove EFH designation from areas that do not meet the description of EFH. Actions that adversely affect EFH in these areas would still be required to go through the consultation process and NMFS would continue to provide the Federal agency with EFH Conservation Recommendations. As such, actions in these areas would likely continue to affect the aquatic habitats and the fish resources, including non-salmonids that rely on them at their current levels.

Effects on Protected Resources

The No-action Alternative would maintain the existing designations of EFH for coho salmon and would not designate those new areas that, based on new information, are currently occupied by coho salmon. Actions that adversely affect habitat in those areas would not go through the EFH consultation process and NMFS would not provide the Federal agency with EFH Conservation Recommendations to avoid, minimize, mitigate, or otherwise offset the adverse effects. Adverse effects to salmon habitat could result in adverse effects to protected resources that share that habitat, and to protected resources that prey on salmon, such as marine mammals and seabirds. It would also not remove EFH designation from areas that do not meet the description of EFH. Actions that adversely affect EFH in these areas would still be required to go through the consultation process and NMFS would continue to provide the Federal agency with EFH Conservation Recommendations. As such, actions in these areas would likely continue to affect protected resources at their current levels.

Effects on Socioeconomics

The No-action Alternative would maintain the existing designations of EFH for coho salmon and the EFH consultation requirements would not change; effects to fishery-dependent communities from affected salmon productivity would also not change under the No-action Alternative. Therefore, the socioeconomic effects of EFH designation in these areas would likely continue at their current levels.

ALTERNATIVE 3B: ADD FIVE HUS AS COHO SALMON EFH (PREFERRED)

This alternative would designate five additional 4th field HUs as EFH for coho salmon.

Effects on Habitat
This alternative could have positive effects on habitat. It would expand the current designation of EFH for coho salmon into some areas that, based on new information, meet the description of EFH in the FMP. However, the aquatic habitats in these 4th field HUs are already designated as EFH for Chinook salmon, and because the habitat needs of coho salmon are very similar to those of Chinook salmon, designation as coho salmon EFH would no more than minimally alter the effect of existing EFH protections. As a result, the positive effects on habitat, including the habitat of species not managed under the MSA, are not expected to be significant.

Effects on Fish Resources
This alternative could have positive effects on fish resources. It would expand the current designation of EFH for coho salmon into some areas that, based on new information, meet the description of EFH in the FMP. However, the aquatic habitats in these 4th field HUs are already designated as EFH for Chinook salmon, and because the habitat needs of coho salmon are very similar to those of Chinook salmon, designation as coho salmon EFH would no more than minimally alter the effects of existing EFH protections on the productivity of fish resources. As a result, the positive effects on aquatic habitat, and therefore on the fish resources that rely on that habitat, are expected to be minimal.

Effects on Protected Resources
This alternative could have positive effects on protected resources. It would expand the current designation of EFH for coho salmon into some areas that, based on new information, meet the description of EFH in the FMP. However, the aquatic habitats in these 4th field HUs are already designated as EFH for Chinook salmon. Because the habitat needs of coho salmon are very similar to those of Chinook salmon, designation as coho salmon EFH would no more than minimally alter the effects of existing EFH protections. As a result, the positive effects of this alternative on aquatic habitat, and therefore on the protected resources that rely on that habitat, or that prey on affected salmon stocks, are expected to be minimal.

Effects on Socioeconomics
This alternative could expand the geographic extent of coho salmon EFH. However, these five HUs are currently designated as EFH for Chinook salmon and actions in these areas are already subject to the EFHP consultation requirement. Therefore, this alternative is unlikely to trigger any additional EFH consultations. In addition, because the habitat requirements of coho salmon are similar to those of Chinook salmon, EFH consultations in these areas are not likely to result in any additional EFH Conservation Recommendations from NMFS. Fishery-dependent communities would likely have little effect from this alternative due to the minimal affect to fish resources. As a result, there would be no discernible socioeconomic effects from this alternative.

ALTERNATIVE 3C: REMOVE COHO SALMON EFH FROM ONE HU: 18060006 (CENTRAL CALIFORNIA COAST) (PREFERRED)
This alternative would eliminate the coho salmon EFH designation from the Central California Coast HU (18060006).

Effects on Habitat
This alternative would remove the habitat protections afforded by EFH designation for this HU. However, this HU is designated as critical habitat for South-Central California Coast steelhead

(*O. mykiss*), and the habitat protections afforded by critical habitat designation would remain in effect. Because the habitats used by coho salmon and steelhead are similar, the mandatory measures to protect steelhead critical habitat would likely provide similar protection to the aquatic habitats in this HU. Therefore, while the loss of coho salmon EFH designation in this HU might produce some negative effects on aquatic habitats, including the habitats of species not managed under the MSA, the magnitude of those effects is expected to be minimal.

Effects on Fish Resources

This alternative would remove the habitat protections afforded by EFH designation for this HU. However, this HU is designated as critical habitat for ESA-listed South-Central California Coast steelhead (*O. mykiss*) (50 CFR 226.211), and the mandatory habitat protections afforded by critical habitat designation would remain in effect. Because the habitats used by coho salmon and steelhead are similar, the mandatory measures to protect steelhead critical habitat would likely provide similar protection to the habitats used by fish resources in this HU. Therefore, while the loss of coho salmon EFH designation in this HU might produce some negative effects on aquatic habitats and the fish resources, including non-salmon species that rely on those habitats, the magnitude of those effects is expected to be minimal. There would be no expected effects on coho salmon stocks, as coho do not occupy the Central California Coast HU.

Effects on Protected Resources

This alternative would remove the habitat protections afforded by EFH designation for this HU. However, this HU is designated as critical habitat for South-Central California Coast steelhead, and the habitat protections afforded by critical habitat designation would remain in effect. Because the habitats used by coho salmon and steelhead are similar, the mandatory measures to protect steelhead critical habitat will likely provide similar protection to the habitats used by protected resources in this HU. For this reason, effects on aquatic habitats and the protected resources, including non-salmon species that rely on those habitats, are expected to be minimal. There would be no expected effects on protected resources that prey on salmon, e.g., marine mammals and seabirds, from this alternative, as coho salmon do not occupy this HU.

Effects on Socioeconomics

This alternative could have some positive socioeconomic effects because EFH consultations would no longer be required in this HU. The benefits include reduced permitting costs and timelines for projects in this HU that would otherwise adversely affect EFH compared to the No-action Alternative. The extent of these benefits would depend on future activities in the area and are impossible to estimate at this time, but are expected to be minimal and insignificant because of the overlap with ESA consultations on South-Central California Coast steelhead. There would be no expected effects on fishery dependent communities from this alternative, as coho salmon do not occupy this HU.

4.4 Puget Sound Pink Salmon Freshwater EFH

The two alternatives under consideration for PS pink salmon freshwater EFH are mutually exclusive.

Alternative 4A: No-action Alternative

This alternative would retain the existing EFH descriptions and geographic distribution for PS pink salmon. As such, the EFH description for PS pink salmon would not be based on the best scientific information available and would, therefore, not meet the purpose and need for the action.

Effects on Habitat
The No-action Alternative would maintain the existing designations of EFH for PS pink salmon and would not designate those 4th field HUs that, based on new information, are currently occupied by PS pink salmon and meet the description of EFH in the FMP. However, the aquatic habitats in these 4th field HUs are already designated as EFH for both Chinook salmon and coho salmon. Because the habitat needs of PS pink salmon are similar to those of these other species, the addition of PS pink salmon EFH would not alter the effect of the existing EFH protections. Therefore, there would be no significant beneficial or adverse effects on habitat from this No-action Alternative.

Effects on Fish Resources
The No-action Alternative would maintain the existing designations of EFH for PS pink salmon and would not designate those new areas that, based on new information, are currently occupied by PS pink salmon and meet the description of EFH in the FMP. However, the aquatic habitats in these 4th field HUs are already designated as EFH for both Chinook salmon and coho salmon. Because the habitat needs of PS pink salmon are very similar to those of these other species, the addition of PS pink salmon EFH would not alter the effect of the existing EFH protections. Therefore, there would be no significant beneficial or adverse effects on aquatic habitats and the fish resources, including non-salmonid species, that use them from, this No-action Alternative

Effects on Protected Resources
The No-action Alternative would maintain the existing designations of EFH for Chinook salmon and would not designate those new areas that, based on new information, are currently occupied by PS pink salmon and meet the description of EFH in the FMP. However, the aquatic habitats in these 4th field HUs are already designated as EFH for both Chinook salmon and coho salmon. Because the habitat needs of PS pink salmon are very similar to those of these other species, the addition of PS pink salmon EFH would not alter the effect of the existing EFH protections. Therefore, there would be no significant beneficial or adverse effects on habitat and the protected resources, including non-salmonid species, that use them, from this No-action Alternative

Effects on Socioeconomics
The No-action Alternative would maintain the existing designations of EFH for PS pink salmon and the EFH consultation requirements would not change, and effects to fishery-dependent communities would also not change. Therefore, the socioeconomic effects of EFH designation in these areas would likely continue at their current levels.

ALTERNATIVE 4B: DESIGNATE HU 17110013 (DUWAMISH) AND HU 17110017 (SKOKOMISH) AS PUGET SOUND PINK SALMON EFH (PREFERRED)
This alternative would expand the designation of PS pink salmon EFH to include HU 17110013 (Duwamish) and HU 17110017 (Skokomish).

Effects on Habitat
This alternative could have positive effects on habitat. It would expand the current designation of EFH for PS pink salmon into some areas that, based on new information, meet the description of EFH in the FMP. However, the aquatic habitat in the Duwamish and Skokomish HUs is

already designated as EFH for Chinook salmon and coho salmon, and because the basic habitat needs of PS pink salmon are similar to those of these other salmon species, designation as PS pink salmon EFH would no more than minimally alter the existing EFH protections. Therefore, while this alternative could produce positive effects on habitat, including the habitat of species not managed under the MSA, the magnitude of those effects is expected to be minimal.

Effects on Fish Resources

This alternative could have positive effects on fish resources. It would expand the current designation of EFH for PS pink salmon into some areas that, based on new information, meet the description of EFH in the FMP. However, the aquatic habitat in these two HUs is already designated as EFH for Chinook salmon and coho salmon. Because the basic habitat needs of PS pink salmon are similar to those of these other species, designation as PS pink salmon EFH would not significantly alter the existing EFH protections. Therefore, while this alternative would produce some positive effects on aquatic habitat and the fish resources, including non-salmon species, that rely on those habitats, the magnitude of those effects is expected to be minimal.

Effects on Protected Resources

This alternative could have positive effects on protected resources. It would expand the current designation of EFH for PS pink salmon into some areas that, based on new information, meet the description of EFH in the FMP. Because the basic habitat needs of PS pink salmon are similar to those of other FMP species, designation of PS pink salmon EFH would not significantly alter the existing EFH protections. Therefore, while this alternative could produce positive effects on aquatic habitat and the protected resources, including non-salmon species that rely on those habitats, and those that prey on salmon, the magnitude of those effects is expected to be minimal.

Effects on Socioeconomics

This alternative would expand the geographic extent of PS pink salmon EFH. However, these HUs are currently designated as EFH for Chinook salmon and coho salmon and actions in these HUs are already subject to the EFH consultation requirement. Therefore, this alternative is unlikely to trigger any additional EFH consultations. In addition, because the habitat requirements of PS pink salmon are similar to those of Chinook salmon and coho salmon, EFH consultations in these areas are not likely to result in any additional EFH Conservation Recommendations from NMFS. This alternative would likely not affect fishery-dependent communities. As a result, there would be no discernible socioeconomic effects from this alternative.

4.5 Consideration of ESA Section 10(j) Experimental Populations When Designating EFH

As described in Chapter 4, the designation of EFH can, in some cases, complicate efforts to reintroduce salmon, as experimental populations under Section 10(j) of the ESA, into historically occupied habitats. This set of alternatives addresses the consideration of these experimental populations when designating EFH. The two mutually exclusive alternatives are: 5A: No-action Alternative and 5B (preferred): Amend Appendix A to clarify that efforts to reintroduce Pacific salmon as an experimental population into historically occupied habitats under section 10(j) of the ESA will be considered when designating EFH.

Restoring ESA-listed salmon populations into historically occupied habitats benefits the species being restored by expanding their geographic range. In addition, protected resources and habitat, both aquatic and terrestrial, and other fish resources would benefit from the marine-derived nutrients contained in the carcasses of the returning salmon from the experimental population. However, these benefits would result directly from the 10(j) process, not from the EFH designation process. These resources will not be affected by either of these alternatives because they change neither regulations nor policy. Rather, they simply address the consideration of experimental populations under Section 10(j) of the ESA when designating EFH to better integrate the two processes. As such, the selection of either of these two alternatives would not have any effect on fish resources, protected resources, habitat, or socioeconomics.

4.6 IMPASSABLE DAMS

There are four alternatives under consideration for impassable dams that form the upstream extent of salmon EFH: the No-action Alternative and three action alternatives. The No-action Alternative is mutually exclusive with the others, and Alternative 6C is mutually exclusive with Alternative 6D.

Alternative 6A: No-action Alternative

This alternative would maintain the existing list of dams that represent the upstream extent of EFH. As such, the EFH descriptions for Chinook salmon and coho salmon would not be based on the best information available and would, therefore, not meet the purpose and need for the action.

Effects on Habitat

The No-action Alternative would maintain the existing list of dams that represent the upstream extent of EFH. It would not correct errors on the list, such as mistakenly omitted or misnamed dams, would not update the list of dams using the revised USGS 4th field HU names, boundaries, and codes would not update the list using the current or revised criteria, would not evaluate additional dams using the current or revised criteria, and would not consider ESA section 10(j) populations when evaluating those dams. As such, the extent of EFH above dams designated as the upstream extent of EFH would not change, and the requirement to consult on actions that may adversely affect aquatic habitat in those areas would not change. Therefore, actions in these areas would likely continue to affect aquatic habitats, including the habitats of species not managed under the MSA that rely on them, at current levels.

Effects on Fish Resources

The No-action Alternative would maintain the existing list of dams that represent the upstream extent of EFH. It would not correct errors on the list, such as mistakenly omitted or misnamed dams, would not update to the list of dams using the revised USGS 4th field HU names, boundaries, and codes, would not update the list using the current or revised criteria, would not evaluate additional dams using the current or revised criteria, and would not consider ESA section 10(j) populations when evaluating those dams. As such, the extent of EFH above dams designated as the upstream extent of EFH would not change, and the requirement to consult on actions that may adversely affect fish habitat in those areas would not change. Therefore, actions in these areas would likely continue to affect aquatic habitats and the fish resources, including non-salmonids, that rely on them at current levels.

Effects on Protected Resources

The No-action Alternative would maintain the existing list of dams that represent the upstream extent of EFH. It would not correct errors on the list, such as mistakenly omitted or misnamed dams, would not update the list of dams using the revised USGS 4th field HU names, boundaries, and codes, would not update the list using the current or revised criteria, would not evaluate additional dams using the current or revised criteria, and would not consider ESA section 10(j) populations when evaluating those dams. As such, the extent of EFH above dams designated as the upstream extent of EFH would not change, and the requirement to consult on actions that may adversely affect aquatic habitat in those areas would not change. Therefore, actions in these areas would likely continue to affect aquatic habitats and the protected resources, including non-salmonids, that rely on them, or that prey on salmon, at current levels.

Effects on Socioeconomics

The No-action Alternative would not alter the dams designated as the upstream extent of EFH and would therefore not alter the EFH consultation requirements in the area above these dams. This No-action Alternative would likely not affect fishery-dependent communities. Therefore, the socioeconomic effects of EFH designation in these areas would likely continue at their current levels.

ALTERNATIVE 6B: UPDATE AND CORRECT THE LIST OF IMPASSABLE DAMS (PREFERRED)

This alternative would make necessary updates to the list of impassable dams including adding erroneously omitted dams, correcting misnamed dams, and removing dams from the list that are no longer impassable to salmon. Some of the updates under this alternative are based on an evaluation of impassable dams (50 CFR 600.412) using criteria 1 and 2 included within the 1999 Appendix A for identifying artificial barriers that mark the upstream extent of EFH. Other updates are associated with Alternative 2D, which associate the revised USGS 4th field HU names, boundaries, and codes with the impassable dams in these areas. Potential changes based on criteria 3 and 4 in the 1999 Appendix A, some of which required a thorough evaluation of new information, are addressed in Alternatives 6C and 6D below. Some of the updates under this alternative would expand the designation of EFH for Chinook and coho salmon into areas that are currently not designated as EFH.

Effects on Habitat

This alternative could have positive effects on habitat resources. It would correct errors and update the list of impassable dams marking the upstream extent of EFH using updated information. The updated and more accurate information should help avoid confusion regarding where EFH consultations are required. In some cases, it would also expand the current designation of EFH for Chinook and coho salmon into some areas that, based on new information, meet the description of EFH in the FMP. Actions in those areas that may adversely affect EFH would require consultation with NMFS, and could result in EFH Conservation Recommendations to the Federal agency to avoid, minimize, mitigate, or otherwise offset any adverse effects to EFH. The recommendations, if implemented, would promote the conservation of the aquatic habitats in these areas, including the habitats used by species that are not managed under the MSA. However, because the newly designated areas would be relatively small when compared to the overall geographic extent of salmon EFH, the positive effects of this alternative on habitat are not expected to be significant.

Effects on Fish Resources

This alternative could have positive effects on productivity of fish resources. It would correct errors and update the list of impassable dams marking the upstream extent of EFH using updated information. The updated and more accurate information should help avoid confusion regarding where EFH consultations are required. In some cases, it would also expand the current designation of EFH for Chinook and coho salmon into some areas that, based on new information, meet the description of EFH in the FMP. Actions in those areas that may adversely affect EFH would require consultation with NMFS, and could result in EFH Conservation Recommendations to the Federal agency to avoid, minimize, mitigate, or otherwise offset any adverse effects to EFH. The recommendations, if implemented, would promote the conservation of the aquatic habitats in these areas and, therefore, the fish resources, including non-salmon species that rely on those habitats. However, because the newly designated areas would be relatively small when compared to the overall geographic extent of salmon EFH, the positive effects of this alternative on fish resources is not expected to be significant.

Effects on Protected Resources

This alternative could have positive effects on protected resources. It would correct errors and update the list of impassable dams marking the upstream extent of EFH using updated information. The updated and more accurate information should help avoid confusion regarding where EFH consultations are required. In some cases, it would also expand the current designation of EFH for Chinook and coho salmon into some areas that, based on new information, meet the description of EFH in the FMP. Actions in those areas that may adversely affect EFH would require consultation with NMFS, and could result in EFH Conservation Recommendations to the Federal agency to avoid, minimize, mitigate, or otherwise offset any adverse effects to EFH. The recommendations, if implemented, would promote the conservation of the aquatic habitats in these areas and, therefore, the protected resources that rely on those habitats, and protected resources that prey on affected salmon (e.g., marine mammals and seabirds). However, because the newly designated areas would be relatively small when compared to the overall geographic extent of salmon EFH, the positive effects of this alternative on protected resources, including those that prey on salmon, are not expected to be significant.

Effects on Socioeconomics

This alternative could expand the geographic extent of EFH and could, therefore, trigger an unknown increase in the number of EFH consultations on Federal actions that may adversely affect EFH. These additional consultations would not otherwise be required if EFH were not expanded. The additional consultation requirement could negatively, but no more than minimally, affect the costs and timelines of permitting for projects that may adversely affect EFH in these new areas because EFH consultation can be combined with other environmental processes, such as NEPA. The positive effects of this alternative on fish resources could have a minimally positive effect to fishery-dependent communities.

ALTERNATIVE 6C: REVISE THE CRITERIA FOR DESIGNATING A DAM AS THE UPSTREAM EXTENT OF EFH AND UPDATE THE LIST BASED ON THE NEW CRITERIA AND NEW INFORMATION

This alternative would revise the criteria to provide clearer guidance on determining when a dam should mark the upstream extent of EFH, and then evaluate new information using those criteria. In some of the options under this alternative, using the revised criteria and new information would result in changes to the upstream extent of EFH (as noted in Table 2-3) and would expand the current designation of EFH for Chinook and coho salmon into some areas that, based on new information, meet the description of EFH in the FMP. For instance, some dams would be removed from the list of dams marking the upstream extent of EFH because they have fish passage in the planning or construction phase (Cle Elum Dam, Iron Gate Dam) and/or because the habitat above the dam has been determined to be necessary for the long-term survival of the species and sustainability of the fishery (Iron Gate Dam, Keswick Dam). This alternative would also result in some dams being added to that list, such as McKay Dam on McKay Creek, Emigrant Dam in the Middle Rogue, and those newly identified dams in the Central Valley resulting from the updates made to the USGS HU data. However, there would be a relatively modest overall expansion in salmon EFH associated with this alternative. Moreover, the dams marking the upstream extent of EFH, and the EFH designations themselves, would be based on the best available scientific information, consistent with the purpose and need for the proposed action.

Effects on Habitat

This alternative could have positive effects on habitat resources. It would expand the current designation of EFH for Chinook and coho salmon into some areas that, based on new information, meet the description of EFH in the FMP. Actions in those areas that may adversely affect EFH would require consultation with NMFS, and could result in EFH Conservation Recommendations to the Federal agency to avoid, minimize, mitigate, or otherwise offset any adverse effects to EFH. The recommendations, if implemented, would promote the conservation of the aquatic habitats in these areas. However, because the newly designated areas would be relatively small when compared to the overall geographic extent of salmon EFH, the corresponding effects from expansion of EFH on habitat, including the habitat of species not managed under the MSA, are not expected to be significant.

Effects on Fish Resources

This alternative could have positive effects on fish resources. It would expand the current designation of EFH for Chinook and coho salmon into some areas that, based on new information, meet the description of EFH in the FMP. Actions in those areas that may adversely affect EFH would require consultation with NMFS, and could result in EFH Conservation Recommendations to the Federal agency to avoid, minimize, mitigate, or otherwise offset any adverse effects to EFH. The recommendations, if implemented, would promote the conservation of the aquatic habitats in these areas and, therefore, the productivity of fish resources that rely on those habitats. However, because the newly designated areas would be relatively small when compared to the overall geographic extent of salmon EFH, the corresponding effects from expansion of EFH on fish resources, including non-salmon species, are not expected to be significant.

Effects on Protected Resources

This alternative could have positive effects on protected resources. It would expand the current designation of EFH for Chinook and coho salmon into some areas that, based on new information, meet the description of EFH in the FMP. Actions in those areas that may adversely affect EFH would require consultation with NMFS, and could result in EFH Conservation Recommendations to the Federal agency to avoid, minimize, mitigate, or otherwise offset any adverse effects to EFH. The recommendations, if implemented, would promote the conservation of the aquatic habitats in these areas and, therefore, the protected resources that rely on those habitats. Increased productivity of salmon stocks could have a positive effect on protected resources that prey on salmon, such as marine mammals and seabirds. However, because the newly designated areas would be relatively small when compared to the overall geographic extent of salmon EFH, the corresponding effects from expansion of EFH on protected resources, including non-salmon species, are not expected to be significant.

Effects on Socioeconomics

This alternative could expand the geographic extent of EFH and could, therefore, trigger an unknown increase in the number of EFH consultations on Federal actions that may adversely affect EFH. These additional consultations would not otherwise be required if EFH were not expanded. The additional consultation requirement could negatively, but no more than minimally, affect the costs and timelines of permitting for projects that may adversely affect EFH in these new areas because the newly designated areas would be relatively small when compared to the overall geographic extent of salmon EFH and EFH consultation can be combined with other environmental processes, such as NEPA. Fishery-dependent communities could benefit from increased salmon productivity under this alternative, but likely not significantly.

ALTERNATIVE 6D: REVISE THE CRITERIA FOR DESIGNATING A DAM AS THE UPSTREAM EXTENT OF EFH, INCLUDE CONSIDERATION OF EFFORTS TO REINTRODUCE EXPERIMENTAL POPULATIONS OF SALMON INTO HISTORICALLY OCCUPIED HABITATS UNDER SECTION 10(J) OF THE ENDANGERED SPECIES ACT, AND UPDATE THE LIST BASED ON THE NEW CRITERIA AND NEW INFORMATION (PREFERRED)

This alternative would have the same effects on fish resources, protected resources, habitat, and socioeconomics described under Alternative 6C, with the potential exception of areas where EFH may not be expanded due to consideration of efforts to reintroduce experimental populations of salmon under Section 10(j) of the ESA. Currently, the one area in which this may apply is above Keswick and Shasta Dams in the Upper Sacramento River. If EFH was not expanded in these areas, this alternative would have the same effects as those described under Alternative 6B.

4.7 ESTUARINE AND MARINE EFH

Marine and estuarine EFH for Pacific salmon is described in the 1999 Appendix A. However, PS pink salmon do not occur in marine waters south of 48° N latitude, off the coast of Washington State. Therefore, minor language changes are needed to clarify the extent of marine EFH for PS pink salmon. The two mutually exclusive alternatives under consideration are: 7A: No-action Alternative and 7B (preferred): Clarify that PS pink salmon marine EFH includes U.S. EEZ waters west of Cape Flattery, north of 48° N latitude, Puget Sound/Strait of Juan de Fuca, and Alaskan waters that are designated salmon EFH by the NPFMC. Revisions to this language would not represent a substantial change in regulation or policy. As such, the selection of either of these two alternatives would not have any effect on fish resources, protected resources, habitat, or socioeconomics, and would not contribute to any cumulative effects from the remaining suite of alternatives.

4.8 Revisions to EFH Descriptions by Species and Life-History Stage

The two alternatives under consideration for revising the EFH descriptions by species and life-history stage are mutually exclusive.

Alternative 8A: No-action Alternative

This alternative would not update the EFH descriptions for each species and life-history stage, and would not incorporate information that has become available since 1999. Because the descriptions would not be based on the best scientific information available, this alternative does not meet the purpose and need for the proposed action.

Effects on Habitat

The No-action Alternative could result in the use of outdated EFH descriptions, which could lead to an erroneous effects analysis during the EFH consultation process and EFH Conservation Recommendations that are not protective of EFH. However, because EFH consultations are not based solely on the EFH summaries in Appendix A, the negative effects on habitat, including the habitats of species not managed under the MSA, are not expected to be significant.

Effects on Fish Resources

The No-action Alternative could result in the use of outdated EFH descriptions, which could lead to an erroneous effects analysis during the EFH consultation process and EFH Conservation Recommendations that are not protective of EFH and the fish resources that occupy the affected habitat. However, because EFH consultations are not based solely on the EFH summaries in Appendix A, the negative effects on aquatic habitats and the fish resources, including non-salmon species that use them are not expected to be significant.

Effects on Protected Resources

The No-action Alternative could result in the use of outdated EFH descriptions, which could lead to an erroneous effects analysis during the EFH consultation process and EFH Conservation Recommendations that are not protective of EFH. However, because EFH consultations are not based solely on the EFH summaries in Appendix A, the negative effects on the aquatic habitat and the protected resources, including non-salmon species that use those habitats (e.g., eulachon and green sturgeon), and species that prey on salmon (e.g., marine mammals and seabirds) are not expected to be significant.

Effects on Socioeconomics

The No-action Alternative would have insignificant positive or negative socioeconomic effects. The use of outdated EFH descriptions would not affect the need for consultation on projects that may adversely affect EFH. However, if the EFH consultation is based solely on the outdated information in Appendix A, this could lead to an erroneous effects analysis during the EFH consultation process and EFH Conservation Recommendations that are not different from those that would be made using updated information. The socioeconomic effects of these recommendations could be either positive or negative, in terms of costs and timelines for permitting. Fishery-dependent communities could be adversely affected by any reduced productivity of salmon stocks under this alternative. However, because EFH consultations are not based solely on the EFH descriptions in Appendix A, any positive or negative socioeconomic effects of this alternative are not expected to be significant.

Alternative 8B: Update the EFH summaries and descriptions for each species and life stage using the best available science (preferred)

This alternative would revise and update the EFH summaries and descriptions, by species and life stage .

Effects on Habitat

This alternative could have positive effects on habitat because the EFH summaries would be based on current information and could contribute to a more accurate effects analysis during the EFH consultation process, including the effects on major prey species, and result in EFH Conservation Recommendations that more effectively protect EFH. However, EFH consultations are not based solely on the EFH summaries, so while this alternative would produce some positive effects on habitat, including the habitats of species not managed under the MSA, the magnitude of those effects is expected to be minimal.

Effects on Fish Resources

This alternative could have positive effects on the productivity of fish resources because the EFH summaries would be based on current information and could contribute to a more accurate effects analysis during the EFH consultation process, including the analysis of effects on major prey species and result in EFH Conservation Recommendations that more effectively protect EFH. However, EFH consultations are not based solely on the information in Appendix A, so while this alternative would produce some positive effects on aquatic habitat and the fish resources, including non-salmon species, the magnitude of those effects is expected to be minimal.

Effects on Protected Resources

This alternative could have positive effects on protected resources because the EFH summaries would be based on current information and could contribute to a more accurate effects analysis during the EFH consultation process, including the effects on major prey species, and result in EFH Conservation Recommendations that more effectively protect EFH. However, EFH consultations are not based solely on the information in Appendix A, so while this alternative would produce some positive effects on aquatic habitat and the protected resources including non-salmon species that use those habitats (e.g., eulachon and green sturgeon), and species that prey on salmon (e.g., marine mammals and seabirds), the magnitude of those effects are expected to be minimal.

Effects on Socioeconomics

This alternative could have insignificant positive or negative socioeconomic effects. The use of updated descriptions of the activities that may adversely affect EFH would not affect the need for consultation on projects that may adversely affect EFH. However, if the EFH consultation is based on the updated information, this alternative could affect the EFH effects analysis and result in different EFH Conservation Recommendations than would occur under the No-action Alternative. The socioeconomic effects of these different recommendations could be either positive or negative, in terms of costs of implementing the recommendations and timelines for permitting. Fishery-dependent communities could be positively affected by any increased salmon productivity under this alternative. However, because EFH consultations are not based solely on the EFH summaries, any positive or negative socioeconomic effects of this alternative are not expected to be significant.

4.9 Habitat Areas of Particular Concern

The alternatives under consideration for HAPCs are the No-action Alternative and five alternatives to designate a HAPC. The No-action Alternative is mutually exclusive with the other five alternatives, but they are not mutually exclusive of each other.

Alternative 9A: No-action Action

This No-action Alternative would maintain the status quo, where no HAPCs are designated for Pacific Coast salmon EFH. However, the best available information indicates that several specific types of habitat provide important functions to salmon and are essential to maintaining a sustainable fishery. As such, this alternative does not meet the purpose and need for the proposed action.

Effects on Habitat

The No-action Action would not designate any HAPCs and these areas would not get special scrutiny during the EFH consultation process. As a result, NMFS might provide EFH Conservation Recommendations that are less protective than would occur if HAPCs were designated and actions in these areas would likely continue to affect habitat at their current level.

Effects on Fish Resources

The No-action Alternative would not designate any HAPCs and these areas would not get special scrutiny during the EFH consultation process. As a result, NMFS might provide EFH Conservation Recommendations that are less protective than would occur if HAPCs were designated, and actions in these areas would likely continue to affect productivity of fish resources at their current level.

Effects on Protected Resources

The No-action Alternative would not designate any HAPCs and these areas would not get special scrutiny during the EFH consultation process. As a result, NMFS might provide EFH Conservation Recommendations that are less protective than would occur if HAPCs were designated and actions in these areas would likely continue to affect protected resources, including non-salmon species that use those habitats (e.g., eulachon and green sturgeon), and species that prey on salmon (e.g., marine mammals and seabirds), at their current level.

Effects on Socioeconomics

The No-action Alternative would not designate any HAPCs and these areas would not get special scrutiny during the EFH consultation process. As a result, NMFS might provide EFH Conservation Recommendations that are less conservative than would occur if HAPCs were designated, and actions in these areas would likely continue to affect socioeconomics, in terms of timelines and permit costs, as well as fishery-dependent communities, at their current level.

ALTERNATIVES 9B, 9C, 9D, 9E, AND 9F: DESIGNATE HAPCS FOR PACIFIC COAST SALMON (PREFERRED)

Although the designations of the five HAPCs are separate alternatives, the effects on the relevant resources and socioeconomics do not differ among them. Therefore, all five of the HAPCs are covered by the following analysis. The HAPC alternatives are:

9B: Designate complex channels and floodplain habitats as HAPC
9C: Designate thermal refugia as HAPC.
9D: Designate spawning habitat as HAPC
9E: Designate estuaries as HAPC
9F: Designate marine and estuarine submerged aquatic vegetation as HAPC

Effects on Habitat

Each of these alternatives could have positive effects on habitat because they could lead to EFH Conservation Recommendations that are more protective of the habitat than would occur without this designation. However, even without designation as an HAPC, these habitats are recognized as being ecologically important to salmon and the EFH Conservation Recommendations would likely be only marginally different from what would occur without this designation. In addition, FMPs should give special consideration to fishing activities that occur in HAPCs, which could lead to management measures that reduce the impact of those activities on EFH, thereby positively affecting habitat. However, because Council-managed fisheries do not occur in these areas (they are all in State waters), the Council cannot implement management measures to benefit EFH. Therefore, while this alternative would produce some positive effects on habitat, including the habitat of non-salmon species, the magnitude of those effects is expected to be minimal.

Effects on Fish Resources

Each of these alternatives could have positive effects on productivity of fish resources because they could lead to EFH Conservation Recommendations that are more protective of the habitat and fish resources than would occur without this designation. However, even without designation as a HAPC, these habitats are recognized as being ecologically important to salmon and the EFH Conservation Recommendations would likely be only marginally different from what would occur without this designation. In addition, FMPs should give special consideration to fishing activities that occur in HAPCs, which could lead to management measures that reduce the impact of those activities on EFH, thereby positively affecting the habitat used by fish resources. However, because Council-managed fisheries do not occur in these areas (they are all in State waters), the Council cannot implement management measures to benefit EFH. Therefore, while this alternative would produce some positive effects on aquatic habitat and the fish resources, including non-salmon species, the magnitude of those effects is expected to be minimal.

Effects on Protected Resources

Each of these alternatives could have positive effects on protected resources because they could lead to EFH Conservation Recommendations that are more protective of the habitat and protected resources than would occur without this designation. However, even without designation as an HAPC, these habitats are recognized as being ecologically important to salmon and the EFH Conservation Recommendations would likely be only marginally different from what would occur without this designation. In addition, FMPs should give special consideration to fishing activities that occur in HAPCs, which could lead to management measures that reduce the impact of those activities on EFH, thereby positively affecting the habitat used by protected resources. However, because Council-managed fisheries do not occur in these areas (they are all in State waters), the Council cannot implement management measures to benefit EFH. Therefore, while this alternative would produce some positive effects on aquatic habitat and the protected resources that use those habitats, including non-salmon species (e.g., eulachon and green sturgeon), and species that prey on salmon (e.g., marine mammals and seabirds), the magnitude of those effects is expected to be minimal.

Effects on Socioeconomics

Each of these alternatives could have negative effects on socioeconomics because they could lead to EFH Conservation Recommendations that are more protective of the habitat than would occur without this designation. If implemented by the Federal action agency, these stricter measures could increase the cost and timelines for permitting the projects. However, because these habitats are recognized as being ecologically important to salmon, the EFH Conservation Recommendations would likely be only marginally different from what would occur without this designation. In addition, Federal agencies are under no obligation to implement these recommendations. As a result, the potential negative effects on socioeconomics are expected to be minimal and insignificant. Fishery-dependent communities could be positively affected by increased productivity of salmon under this alternative, although these effects are expected to be minimal.

4.10 Fishing Activities that may Adversely Affect EFH

The EFH regulatory guidelines require that FMPs contain an evaluation of the potential adverse effects of fishing on EFH designated under the FMP, including effects of each fishing activity regulated under the FMP or other Federal FMPs [50 CFR 600.815(2)]. Each FMP must also minimize, to the extent practicable, adverse effects from fishing on EFH. Councils must act to prevent, mitigate, or minimize any adverse effects from fishing, to the extent practicable, if there is evidence that a fishing activity adversely affects EFH in a manner that is more than minimal and not temporary in nature. The fishing activities that could potentially adversely affect EFH are managed by the Council under four FMPs: Coastal Pelagic Species, Highly Migratory Species, Pacific Coast Salmon, and Pacific Coast Groundfish.

In addition, FMPs must identify fishing activities that are not managed under the MSA that may adversely affect EFH. Such activities may include fishing managed by state agencies or other authorities. Along the West Coast of the U.S., the Council defers management of several fisheries to the states (e.g., Dungeness crab, shrimp, and California halibut). In addition, several fisheries have international management agreements (e.g., Pacific halibut, hake, and tuna fisheries).

This set of alternatives involves revising the descriptions of the MSA and non-MSA fishing activities that may adversely affect salmon EFH. The three alternatives are under consideration are: 10A: No-action Alternative, 10B (preferred): Revise the descriptions of MSA fishing activities, and 10C (preferred): Revise the description of the non-MSA fishing activities. Alternative 10A is mutually exclusive with the other two alternatives, but they are not mutually exclusive of each other.

The EFH review identified several types of fishing activities that may adversely affect EFH. Table 7 in the proposed Appendix A lists these activities and whether the potential effects for each fishing activity would occur on freshwater, estuarine, or marine habitat types. Identical gear types are often used in both MSA fisheries and those managed under other authorities. There is a separate alternative for each of those categories. However, because the gears used are often identical and because the effects determination is the same, they are addressed together here.

In the context of this amendment, it is important to recognize that it is not the effects of the fishing activities that must be analyzed. Rather this EA analyzes the effects of revising the evaluations and descriptions of these activities in Appendix A, along with any measures that the Council may adopt to minimize the effects of these activities on salmon EFH. The effects of the actual fishing activities are analyzed annually when the Council adopts management measures under the four FMPs.

While there would be no effects resulting from simply updating the descriptions of the fishing activities, there could potentially be effects resulting from the adoption of minimization measures. However, because the Council is not considering any new management measures to minimize the effects of MSA-managed fisheries on salmon EFH, and cannot impose any measures to minimize the effects from non-MSA fisheries, this set of alternatives would not have any effect on fish resources, protected resources, habitat, or socioeconomics, and would not contribute to any cumulative effects from the remaining suite of alternatives.

4.11 Non-Fishing Activities That May Adversely Affect EFH

The alternatives under consideration for the non-fishing activities that may adversely affect EFH are the No-action Alternative and two alternatives to update existing activities and to describe new activities. The No-action Alternative is mutually exclusive with the other two alternatives, but they are not mutually exclusive of each other.

Alternative 11A: No-action Alternative

This alternative would not update the descriptions and conservation measures for the 21 non-fishing activities that may adversely affect EFH for Pacific Coast salmon. It would also not describe, and provide conservation measures for, the 10 additional non-fishing activities that were identified during the 5-year review process as having the potential to adversely affect EFH for Pacific Coast salmon. The No-action Alternative would not meet the intent of EFH provisions of the regulatory guidelines, including the required contents of a fishery management plan and the guidelines for conducting a periodic review of those EFH provisions. As such, it would not meet the purpose and need for the proposed action.

Effects on Habitat

The No-action Alternative could have negative effects on habitat if using outdated descriptions of the activities that may adversely affect EFH leads to an erroneous effects analysis during the EFH consultation process and EFH Conservation Recommendations that are no longer appropriate. However, because EFH consultations are not based solely on the descriptions and

EFH Conservation Recommendations in Appendix A, the negative effects of this alternative on habitat, including the habitat of species not managed under the MSA, are not expected to be significant.

Effects on Fish Resources

The No-action Alternative could have negative effects on productivity of fish resources if using outdated descriptions of the activities that may adversely affect EFH leads to an erroneous effects analysis during the EFH consultation process and EFH Conservation Recommendations that are no longer appropriate. However, because EFH consultations are not based solely on the descriptions and EFH Conservation Recommendations in Appendix A , the negative effects of this alternative on fish resources, including non-salmon species, are not expected to be significant.

Effects on Protected Resources

The No-action Alternative could have negative effects on protected resources if using outdated descriptions of the activities that may adversely affect EFH leads to an erroneous effects analysis during the EFH consultation process and EFH Conservation Recommendations that are no longer appropriate. However, because EFH consultations are not based solely on the descriptions and EFH Conservation Recommendations in Appendix A , the negative effects of this alternative on protected resources, including non-salmon species (e.g., eulachon and green sturgeon), and species that prey on salmon (e.g., marine mammals and seabirds) are not expected to be significant.

Effects on Socioeconomics

The No-action Alternative could have positive or negative socioeconomic effects. Using the existing descriptions of the activities that may adversely affect EFH would not affect the need for consultation on projects that may adversely affect EFH. However, if the EFH consultation is based solely on outdated information, this alternative could affect the EFH effects analysis and result in inappropriate EFH Conservation Recommendations, the socioeconomic effects of which could be either positive or negative, in terms of costs and timelines for permitting. Under this alternative, fishery dependent communities could be adversely affected if salmon productivity is reduced. However, EFH consultations are not based solely on the descriptions and EFH Conservation Recommendations contained in Appendix A and, therefore, any positive or negative socioeconomic effects of this alternative are not expected to be significant.

Alternative 11B: Revise the Descriptions and Conservation Measures of the Non-Fishing Activities (Preferred)

This alternative would revise the description and conservation measures of the 21 non-fishing activities that may adversely affect EFH for Pacific Coast salmon.

Effects on Habitat

This alternative could have positive effects on habitat if using updated descriptions of the activities that may adversely affect EFH leads to a more accurate effects analysis during the EFH consultation process and EFH Conservation Recommendations that are more applicable than would occur under the No-action Alternative. However, EFH consultations are not based solely on the descriptions and EFH Conservation Recommendations contained in Appendix A, so the positive effects of this alternative on habitat, including the habitats of species not managed under the MSA, are expected to be minimal.

Effects on Fish Resources

This alternative could have positive effects on productivity of fish resources if using updated descriptions of the activities that may adversely affect EFH leads to a more accurate effects analysis during the EFH consultation process and EFH Conservation Recommendations that are more applicable than would occur under the No-action Alternative. However, EFH consultations are not based solely on the descriptions and EFH Conservation Recommendations contained in Appendix A, so the positive effects of this alternative on aquatic habitats and the fish resources, including non-salmon species that rely on them, are expected to be minimal.

Effects on Protected Resources

This alternative could have positive effects on protected resources if using updated descriptions of the activities that may adversely affect EFH leads to a more accurate effects analysis during the EFH consultation process and EFH Conservation Recommendations that are more applicable than would occur under the No-action Alternative. However, EFH consultations are not based solely on the descriptions and EFH Conservation Recommendations contained in Appendix A, so the positive effects of this alternative on aquatic habitats and the protected resources, including non-salmon species that rely on them (e.g., eulachon and green sturgeon), and species that prey on salmon (e.g., marine mammals and seabirds) are expected to be minimal.

Effects on Socioeconomics

This alternative could have minimal positive or negative socioeconomic effects. Using updated descriptions of the activities that may adversely affect EFH would not affect the need for consultation on projects that may adversely affect EFH. However, if the EFH consultation is based only on the existing 21 non-fishing activities (with updated information), this alternative could result in different EFH Conservation Recommendations than would occur under the No-action Alternative or under Alternative 11c, the socioeconomic effects of which could be either positive or negative, in terms of costs and timelines for permitting, and in terms of impacts to fishery-dependent communities. However, EFH consultations are not based solely on the descriptions and EFH Conservation Recommendations contained in Appendix A and, therefore, any positive or negative socioeconomic effects of this alternative are expected to be no more than minimal.

ALTERNATIVE 11C: ADD NEW NON-FISHING ACTIVITIES THAT MAY ADVERSELY AFFECT EFH (PREFERRED)

This alternative would add the following 10 new activities to the list of 21 non-fishing activities that may adversely affect EFH for Pacific Coast salmon:

11C1: Activities that generate underwater sound
11C2: Over-water structures
11C3: Alternative energy development
11C4: Liquefied natural gas projects
11C5: Desalination
11C6: Power plant intake
11C7: Pesticide use
11C8: Flood control and maintenance

11C9: Culvert construction
11C10: Coal export terminal facilities

These activities are proposed to be added to the list of non-fishing activities because they are recognized as having the potential to adversely affect EFH and occur throughout the geographic range of Pacific Coast salmon EFH. Although adding each activity to Appendix A is considered by the Council to be a separate alternative, the effects on the relevant resources and socioeconomics do not differ among them. Therefore, all 10 of these new activities are covered by the following analysis.

Effects on Habitat
Each of these alternatives would have positive effects on habitat if using a more comprehensive list and descriptions of the activities that may adversely affect EFH leads to a more accurate effects analysis during the EFH consultation process and EFH Conservation Recommendations that are more applicable than would occur under the No-action Alternative. However, EFH consultations are not based solely on the descriptions and EFH Conservation Recommendations contained in Appendix A, so the positive effects of this alternative on aquatic habitat, including the aquatic habitats of species not managed under the MSA, are expected to be minimal.

Effects on Fish Resources
Each of these alternatives would have positive effects on productivity of fish resources if using a more comprehensive list and descriptions of the activities that may adversely affect EFH leads to a more accurate effects analysis during the EFH consultation process and EFH Conservation Recommendations that are more appropriate than would occur under the No-action Alternative. However, EFH consultations are not based solely on the descriptions and EFH Conservation Recommendations contained in Appendix A, so the positive effects of this alternative on aquatic habitats and the fish resources, including non-salmon species that rely on them are expected to be minimal.

Effects on Protected Resources
Each of these alternatives would have positive effects on protected resources if using a more comprehensive list and descriptions of the activities that may adversely affect EFH leads to a more accurate effects analysis during the EFH consultation process and EFH Conservation Recommendations that are more appropriate than would occur under the No-action Alternative. However, EFH consultations are not based solely on the descriptions and EFH Conservation Recommendations contained in Appendix A, so the positive effects of this alternative on aquatic habitats and the protected resources, including non-salmon species that rely on them (e.g., eulachon and green sturgeon), and species that prey on salmon (e.g., marine mammals and seabirds) are expected to be minimal.

Effects on Socioeconomics
Each of these alternatives could have positive or negative socioeconomic effects, including fishery-dependent communities. The inclusion of these 10 activities in the list and descriptions of the activities that may adversely affect EFH would not create a new need for EFH consultation. This is because, for the purpose of EFH consultation, the determination that an activity may adversely affect EFH, and the need for consultation, is not contingent on it being described in Appendix A. However, the inclusion of these 10 activities is expected to inform the

EFH consultation and may result in different EFH Conservation Recommendations than would occur under the No-action Alternative or Alternative 11b, the socioeconomic effects of which could be either positive or negative, in terms of costs and timelines for permitting. Effects on fishery dependent communities could be positive under this alternative if salmon productivity is increased. However, EFH consultations are not based solely on the descriptions and EFH Conservation Recommendations in Appendix A and, therefore, any positive or negative socioeconomic effects of this alternative are not expected to be more than minimal.

4.12 Identify and Prioritize New Information and Research Needs

The EFH regulatory guidelines suggest that FMPs contain recommendations, preferably in priority order, for research efforts that the Councils and NMFS view as necessary to improve upon the description and identification of EFH, the identification of threats to EFH from fishing and other activities, and the development of conservation and enhancement measures for EFH. This set of alternatives considers updating the list of information and research needs. The two mutually exclusive alternatives under consideration are: 12A: No-action Alternative and 12B (preferred): Updating the list of information and research needs.

In the context of this amendment, it is important to recognize that it is not the effects of any activity carried out in order to conduct research or gather information that must be analyzed. Rather this amendment must analyze the effects of revising the list of these activities. The effects of any actions to fill these needs would be analyzed if, and when, the Council decides to pursue those activities. As such, the selection of either of these two alternatives would not have any effect on fish resources, protected resources, habitat, or socioeconomics, and would not contribute to any cumulative effects from the remaining suite of alternatives.

4.13 Process for Revising Salmon EFH Without FMP Amendment

This section considers a process that the Council can use to revise specific information on salmon EFH outside of the FMP amendment process. The two mutually exclusive alternatives under consideration are: 13A: No-action Alternative and 13B (preferred): Create a process to make specific changes to salmon EFH without amending the salmon FMP.

In the context of this amendment, it is important to recognize that it is not the effects of any revisions to the EFH Appendix that must be analyzed. Rather, it is the effects of establishing a process for making those revisions. Any revisions that are made through this process would be analyzed when the Council makes those changes. As such, the selection of either of these two alternatives would not have any effect on fish resources, protected resources, habitat, or socioeconomics, and would not contribute to any cumulative effects from the remaining suite of alternatives.

4.14 Cumulative Effects

A cumulative effects analysis is required by the Council on Environmental Quality (CEQ) (40 CFR 1508.7). The purpose of a cumulative effects analysis is to consider the combined effects of many actions on the human environment over time that would be missed if each action were evaluated separately. CEQ guidelines recognize that it is not practical to analyze the cumulative effects of an action from every conceivable perspective, but rather, the intent is to focus on those effects that are truly meaningful. A formal cumulative impact assessment is not necessarily required as part of an EA under NEPA as long as the significance of cumulative impacts has been considered (U.S. EPA 1999). The following addresses the significance of the expected cumulative impacts as they relate to the Federally-managed Pacific salmon fishery.

Consideration of the Affected Resources

In Chapter 3 (Affected Environment), the affected resources that exist within the Pacific salmon environment are identified. The significance of the cumulative effects will be discussed in relation to these affected resources:

- Habitat, biodiversity, and ecosystem functions
- Fish resources
- Protected resources
- Socioeconomic environment

Geographic Boundaries

The analysis of impacts focuses on actions related to the description and identification of Pacific salmon EFH, and any resulting management measures. The geographic scope for each of the affected resources listed above includes marine and inland waters. In marine waters, the core geographic scope is focused on the U.S. West Coast EEZ, north of Point Conception to the U.S./Canada border. For habitat, the core geographic scope is focused on EFH within the EEZ, although Pacific salmon exhibit wide migrations that traverse marine waters off Canada, Alaska, and parts of the Gulf of Alaska and Bering Sea. For inland waters, the core geographic scope includes estuaries and inland fresh waters that are designated as EFH for Pacific salmon and the surrounding terrestrial areas. This includes most of the HUs that currently or historically supported Pacific salmon populations. The same core geographic boundaries apply for habitat/ecosystem functions, protected resources, and the socioeconomic environment.

Temporal Boundaries

The temporal scope of past and present actions for the affected resources is primarily focused on actions that have occurred after approval of the 1999 Appendix A. The 2008 Final Rule (73 FR 60987) made only minor adjustments to EFH elements, and therefore would not change the temporal scope for analysis. For endangered species and other protected resources, the scope of past and present actions also extends to implementation of the Salmon FMP, except in the cases of Southern Resident killer whale, green sturgeon, and eulachon, which were listed under the ESA in 2005, 2006, and 2012, respectively and Steller sea lion, which was delisted under the ESA in 2013. The temporal scope of future actions for all affected resources extends about five years into the future. This period was chosen because the EFH regulations require Councils and NMFS to review EFH at least every five years, and revise as appropriate.

4.14.1 SUMMARY OF EFFECTS OF PROPOSED ACTION

The anticipated direct and indirect effects of this action are described in detail in this chapter, and compiled in Table 4-1. The purpose of presenting the direct and indirect effects is to determine the cumulative effects resulting from the incremental impact of this action, when added to other past, present, and reasonably foreseeable future actions. Table 4-1 groups actions into the general subject areas of salmon EFH: identification of EFH, consideration of 10(j) reintroduction efforts, impassable dams, marine/estuarine EFH, future revisions to EFH, Habitat Areas of Particular Concern, fishing activities, and non-fishing activities. The direct and indirect impacts to habitat, fish resources, and protected resources are all positive or neutral, while the socioeconomic impacts are either insignificantly positive, neutral, or insignificantly negative.

4.14.2 PAST AND PRESENT ACTIONS

Fishery-related Actions

Past and present actions include those fishery management actions outside the scope of this action. These include other actions under the Salmon FMP (e.g., setting annual ocean salmon fishery regulations) as well as actions under the other Pacific Council FMPs (Pacific Coast groundfish, HMS, and CPS). Each of these FMPs includes actions that could indirectly contribute to impacts involving this action. However, the EFH regulations require that each FMP and its related actions minimize any adverse effects to EFH, including that identified and described in other FMPs. The habitat protection measures inherent to each FMP would likely result in either neutral or slightly beneficial impacts to habitat and fisheries resources, when combined with the effects of this action. Further, the HMS and CPS fisheries are upper and mid-water column activities that do not interact with EFH described as important to salmon. Likewise, Council-area salmon fisheries do not employ bottom contact gear, and there is no evidence of direct gear effects on fish habitat from Council-managed salmon fisheries on EFH for salmon or other managed species. Groundfish fishery bottom contact gear has the potential to affect rocky reefs that are described as salmon EFH. However, many of these reefs are closed to bottom contact gear, and include the inherent habitat protections that would minimize or neutralize any cumulative impacts related to this action. The Council also adopted an ecosystem FMP that is non-regulatory and therefore would not contribute to any effects of this action.

Non Fishery-Related Actions

Non-fishing activities that introduce chemical pollutants, sewage, changes in water temperature, salinity, dissolved oxygen, and suspended sediment into the aquatic environment pose a risk to all of the identified affected resources. Human-induced non-fishing activities tend to be localized in project areas where they occur.

Development and maintenance activities related to residential and commercial construction, roads, and bridges are frequent activities occurring in the action area. Activities that affect salmon habitat include mobilization of sediment into streams, sound energy related to heavy equipment and pile driving, fuel leaks or spills, and stream bed modification. These actions can potentially adversely affect EFH. However, most of these activities have a Federal nexus in that a Federal permit is required to undertake all or part of the activity. As such, the Federal action agency must consult with NMFS, which will issue EFH Conservation Recommendations and in most cases, ESA Terms and Conditions. Given the best practices that are typically applied to such activities, it is unlikely that the activities would present more than minimal effects.

Agricultural practices occur adjacent to many streams occupied by Pacific salmon that are also subject to best practices to minimize fertilizer and pesticide risk, sedimentation, and other agriculture-related activities that could potentially adversely affect aquatic environments, including salmon habitat. For example, Oregon Senate Bill 1010 provides guidance on best practices to avoid or mitigate adverse effects (ODA 1999). Agricultural activities are also identified as a non-fishing impact that could adversely affect salmon EFH, and therefore have been subject to EFH Conservation Recommendations since 2000, when there is a Federal nexus. Although it is possible that agricultural practices could present adverse effects, it is likely that those effects would be minimal due to best practices.

Forestry practices can also affect habitat, including salmon EFH. Tree felling, road construction, and site preparation can alter stream hydrology and increase sediment delivery. The 1999 Appendix A offers a suite of Conservation Recommendations that are designed to minimize, avoid, or mitigate adverse effects (PFMC 1999). Although it is possible that forestry practices could present adverse effects, it is likely that those effects would be minimal due to best practices.

4.14.3 Reasonably Foreseeable Future Actions

Fishery-related Actions

This proposed action does not directly affect fishery management measures such as allowable harvest, time/area restrictions, or gear use. However, there is potential in the future that restriction on fishing activities could be implemented based on EFH considerations. Therefore, we describe fishery-related actions here, despite the fact that there are no proposed changes to fishing activities for Pacific salmon.

The management practices of PFMC relative to fishery and harvest management actions are precautionary in nature, with minimum escapement targets that restrict both commercial and recreational harvest when returns of adults are predicted to be below certain thresholds. This conservative approach is designed to result in positive impacts on the health of the Pacific salmon stocks. The PFMC and NMFS regularly assess the status of the fisheries and make necessary adjustments to ensure that there is a reasonable expectation of meeting the objectives of the FMP and the requirements of National Standard 1 of the MSA.

If the Council and NMFS determine in the future that fishing activities should be restricted to minimize impacts to EFH, it is reasonable to conclude that the impacts would be positive to habitat, and positive or neutral to fish resources and protected resources, and likely not significant. Habitat impacts would be positive because by definition, minimization measures are implemented expressly to protect EFH. Such minimization measures can be applied to the salmon fishery or to other Council-managed fisheries to protect salmon EFH. Impacts to fish resources would likely be neutral or positive because actions that benefit habitat will also benefit the fish resources that rely on that habitat. Impacts to protected resources would be neutral or positive also, because actions that benefit habitat will also benefit the protected resources that rely on that habitat, and although some fishing effort may be displaced, protected resources would retain harvest-related protections. Impacts to socioeconomic resources would likely be neutral to negative in the short-term but would be neutral to positive in the long-term.

In June 2013, the PFMC adopted an advisory Fishery Ecosystem Plan (FEP) which would address species and issues not currently addressed in existing FMPs, including the Pacific salmon plan. Because the FEP is purely advisory, it does not have the inherent regulatory mechanism that would apply to fisheries management activities. Nonetheless, it is worthy of consideration, given that the FEP is intended to provide baseline fisheries and environmental information that could be used in the development of future management activities.

Implementation of an FEP could have positive environmental and biological impacts associated with forage fish and unmanaged fish protection. Such protections could accrue benefits to managed species such as Pacific salmon which depend on forage fish and some unmanaged fish for their survival and reproduction. While adverse impacts on forage fish and unmanaged fish under any of the alternatives are expected to be minimal, actions taken under the FEP are expected to further benefit these resources, helping to offset any negative impacts. It could potentially have negative short-term socioeconomic impacts if actions taken to protect forage species and unmanaged species resulted in reduced harvest opportunity for managed species. In the context of regulations that may impose further restrictions on harvest, alternatives which alleviate production costs may be more beneficial to stability in the industry than would be the case if harvest conditions were expected to remain stable.

Another potential fishery-related action is the potential to add or remove stocks from FMP. As with the action of Amendment 16, the removal of stocks from Federal management means that EFH will no longer be identified and described for those stocks. By the same token, EFH is not designated for sockeye salmon, chum salmon, or pink salmon stocks from outside Puget Sound, even though they are targeted in areas concurrent with Council-managed stocks. If a salmon stock is removed from the FMP, the stock would lose its EFH protections. However, most Pacific salmon stocks have redundant habitat protections, via the Critical Habitat designations under the ESA, or via EFH protections for other stocks that would remain under Council management. The only exception would be in the case where there are no redundant protections in place, although this is unlikely, given the broad extent of ESA and EFH designations. Based on this, it is reasonable to conclude that the effects of this future action would be neutral. The socioeconomic impacts are difficult to anticipate, but because removal of a stock from Federal management would not include any inherent change in harvest regulations, the effects are likely to be neutral as well.

Several Pacific Coast fisheries are managed by states, tribes, or under international agreement. These include Pacific whiting, some highly migratory species, Dungeness crab, pink shrimp, California halibut, and others. Some of the activities were included in the EFH review, for consideration of potential adverse effects.

Non Fishery-Related Actions

Non-fishing activities that introduce chemical pollutants, sewage, changes in water temperature, salinity, dissolved oxygen, and suspended sediment into the aquatic environment pose a risk to all of the identified affected resources. Human-induced non-fishing activities tend to be localized in project areas where they occur.

Long-term climate change effects such as ocean acidification and rainfall patterns could affect trophic interactions and geographic distribution of salmon. These changes would in turn affect viability and structure of fisheries, and distribution and abundance of salmon stocks. Although the net effect of these changes is likely to be negative, some stocks or fisheries may benefit from the changing conditions and resulting shifts in distribution. However, while these potential effects are foreseeable, they are not likely to be significant in the near term, defined here as approximately the subsequent five years. Cyclical changes, like those associated with El Niño events and the Pacific Decadal Oscillation would affect similar components of the environment as long-term climate change (PFMC 2011b). Cyclical changes, while expected to be both positive and negative, are more likely to be noticeable in the short-term; however, because these events are part of the historical baseline, they are unlikely to be significant, and positive and negative impacts should average out over the long-term.

4.14.4 Summary of Cumulative Effects

The activities described in all the action alternatives generally result in positive impacts to habitat, fish resources, and protected resources. Socioeconomic effects are generally neutral or insignificantly negative. EFH is by design protective of habitat, and it is widely agreed that habitat protections generally have positive effects on fish and protected resources. The cumulative effects of past, present, and reasonably foreseeable future fishery-related and non-fishery-related activities are largely unknown. However, existing practices are in place to minimize, avoid, or mitigate potential adverse effects. Finally, the effects related to this action are generally positive, as it is inherently a habitat protection action. Therefore, it is reasonable to conclude that the cumulative effects of implementing EFH requirements likely result in overall neutral or positive impacts to habitat, fish, and protected resources. The cumulative effects of this action in conjunction with others describe here, are overall neutral with regard to socioeconomic resources.

Table 4-1. Summary of effects

Action	Effects			
	Habitat	Fish Resources	Protected Resources	Socioeconomics
Identification of salmon EFH	+	+	+	Neutral
Consideration of 10(j) efforts	Neutral			
Impassable Dams	+	+	+	Neutral
Marine/Estuarine EFH	Neutral			
Future Revisions	+	+	+	Neutral
HAPCs	+	+	+	Negative/insignificant
Fishing Activities	Neutral			
Non-Fishing Activities	+/neutral	+/neutral	+/neutral	Negative/insignificant
Past and Present Actions				
Fishing Activities	Neutral			
Non-Fishing Activities	+/neutral	+/neutral	+/neutral	Negative/insignificant
Groundfish FMP	Neutral			Negative/insignificant
HMS FMP	Neutral			Negative/insignificant
CPS FMP	Neutral			Negative/insignificant
Agriculture	Unknown			Negative/insignificant
Development	Unknown			+
Forestry	Unknown			+/neutral
Reasonably Foreseeable Future Actions				
Fishing Activities	Neutral			

Non-Fishing Activities	+/neutral	+/neutral	+/neutral	Negative/insignificant
Management Measures		Negative/insignificant		Neutral
Ecosystem Plan		+		Negative/Insignificant
Add/remove FMP stocks		Neutral		Neutral
Climate Change		Negative/insignificant		Neutral
Cumulative Effects	Neutral/ Positive	Neutral/ Positive	Neutral/ Positive	Neutral

5.0 CONSISTENCY WITH OTHER APPLICABLE LAW

5.1 MAGNUSON-STEVENS FISHERY CONSERVATION AND MANAGEMENT ACT (MSA)

5.1.1 NATIONAL STANDARDS

The MSA provides parameters and guidance for Federal fisheries management, requiring the Councils and NMFS adhere to a broad array of policy ideals. Overarching principles for fisheries management are found in the MFCMA National Standards. In crafting fisheries management regimes, the Councils and NMFS must balance their recommendations to meet these different national standards. However, the action alternatives in this EA will have no effect on the management of fisheries, and are, therefore, compatible with the MSA National Standards.

5.1.2 FMP PROVISIONS

The MSA lists a number of required provisions for FMPs and amendments. Among those provisions, one is particularly applicable to this amendment. Section 303(a)(7) requires that FMPs describe and identify EFH for the fishery based on the guidelines established by the Secretary under section 305(b)(1)(A) of the MSA, 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. The action alternatives in this EA are consistent with this provision in that they, in combination with each other, update the EFH provisions already in the salmon FMP and the 1999 Appendix A, based on new information.

5.1.3 CONSISTENCY WITH THE MANAGEMENT STRATEGIES IN THE SALMON FMP

Similar to the MSA National Standards Guidelines, the goals and objectives of the Salmon FMP are intended to provide a framework to guide the Council's decisions. Because the action alternatives considered in this EA do not affect the management of the salmon fishery, they are consistent with the Salmon FMP management strategies.

5.2 COASTAL ZONE MANAGEMENT ACT

Section 307(c)(1) of the Federal Coastal Zone Management Act (CZMA) requires all Federal activities that directly affect the coastal zone be consistent with approved state coastal zone management programs to the maximum extent practicable. The alternatives would be implemented in a manner that is consistent to the maximum extent practicable with the enforceable policies of the approved coastal zone management programs of Washington, Oregon and California. This determination has been submitted to the responsible state agencies for review under section 307(c)(1) of the CZMA, and reviewed for consistency with the Washington/Oregon/California coastal zone management programs.

Under the CZMA, each state develops its own coastal zone management program, which is then submitted for Federal approval. This has resulted in programs which vary widely from one state to the next. None of the alternatives are expected to affect any state's coastal management program.

5.3 Endangered Species Act

Section 7(a)(2) of the ESA requires that Federal agencies ensure that any action authorized, funded, or carried out by such agency is not likely to jeopardize the continued existence of any endangered species or threatened species or result in the destruction or adverse modification of critical habitat. In addition, Section 7(a)(3) of the ESA requires that Federal agencies consult with NMFS and the U.S. Fish and Wildlife Service on any action authorized, funded, or carried out by such agency that may affect a species listed under the ESA or their designated critical habitat.

This action is not expected to have adverse effects on any listed species or critical habitat. As described in this document, this action may have minimal effects on listed species in freshwater areas where EFH designations would change slightly under the preferred alternative. NMFS has consulted with itself under ESA section 7 and prepared a memo concluding that implementation of the preferred alternative is not likely to adversely affect any listed species or critical habitat.

5.4 Marine Mammal Protection Act

The Marine Mammal Protection Act (MMPA) of 1972 is the principal federal legislation that guides marine mammal species protection and conservation policy in the United States. Under the MMPA, NMFS is responsible for the management and conservation of 153 stocks of whales, dolphins, porpoise, as well as seals, sea lions, and fur seals, while the USFWS is responsible for walrus, sea otters, and the West Indian manatee. None of the alternatives will result in the take of any marine mammals. Therefore, NMFS does not need to seek authorization or a permit under the MMPA for this action.

5.5 Migratory Bird Treaty Act

The Migratory Bird Treaty Act of 1918 was designed to end the commercial trade of migratory birds and their feathers that, by the early years of the 20th century, had diminished populations of many native bird species. The Act states that it is unlawful to take, kill, or possess migratory birds and their parts (including eggs, nests, and feathers), and is an agreement between the United States, Canada, Japan, Mexico, and Russia to protect a common migratory bird resource. The Migratory Bird Treaty Act prohibits the take of seabirds, but the incidental take of seabirds does occur. None of the alternatives are likely to affect the incidental take of seabirds protected by the Migratory Bird Treaty Act.

5.7 Paperwork Reduction Act

The proposed action does not require the collection of any information for the Federal Government and is therefore not subject to the Paperwork Reduction Act.

5.8 EO 12898 (Environmental Justice)

EO 12898 obligates federal agencies to identify and address "disproportionately high adverse human health or environmental effects of their programs, policies, and activities on minority and low-income populations in the United States" as part of any overall environmental impact analysis associated with an action. NOAA guidance, NAO 216-6, at §7.02, states that "consideration of EO 12898 should be specifically included in the NEPA documentation for decision-making purposes." Agencies should also encourage public participation especially by affected communities during scoping, as part of a broader strategy to address environmental justice issues.

The proposed action is not expected adversely affect human health or environmental conditions, so it will not disproportionately affect minority or low-income populations.

5.9 EO 13132 (Federalism)

Executive Order 13132 enumerates eight fundamental federalism principles. The first of these principles states "Federalism is rooted in the belief that issues that are not national in scope or significance are most appropriately addressed by the level of government closest to the people." In this spirit, the Executive Order directs agencies to consider the implications of policies that may limit the scope of or preempt state's legal authority. Preemptive action having such federalism implications is subject to a consultation process with the states; such actions should not create unfunded mandates for the states; and any final rule published must be accompanied by a federalism summary impact statement.

The proposed actions would not have federalism implications subject to Executive Order 13132.

5.10 EO 13175 (Consultation and Coordination with Indian Tribal Government)

EO 13175 is intended to ensure regular and meaningful consultation and collaboration with tribal officials in the development of federal policies that have tribal implications, to strengthen the United States government-to-government relationships with Indian tribes, and to reduce the imposition of unfunded mandates upon Indian tribes.

The Secretary recognizes the sovereign status and co-manager role of Indian tribes over shared federal and tribal fishery resources. At Section 302(b)(5), the Magnuson-Stevens Act reserves a seat on the Council for a representative of an Indian tribe with federally-recognized fishing rights from California, Oregon, Washington, or Idaho. Through the tribal representative on the Council, the Tribes have the opportunity to exercise this role. Therefore, the proposed action is consistent with EO 13175.

5.11 EO 13186 (Responsibilities of Federal Agencies to Protect Migratory Birds)

EO 13186 supplements the MBTA (above) by requiring federal agencies to work with the U.S. Fish and Wildlife Service to develop memoranda of agreement to conserve migratory birds. A memorandum of understanding between NMFS and the USFWS was finalized on July 14, 2012. The protocols developed by this memorandum will guide agency regulatory actions and policy decisions in order to address this conservation goal. The EO also directs agencies to evaluate the effects of their actions on migratory birds in environmental documents prepared pursuant to the NEPA.

The proposed action is not expected to have any adverse effects on migratory birds and is, therefore, consistent with EO 13186.

5.12 Regulatory Flexibility Act

The purpose of the Regulatory Flexibility Act (RFA) is to relieve small businesses, small organizations, and small governmental entities of burdensome regulations and record-keeping requirements. Major goals of the RFA are: (1) to increase agency awareness and understanding of the impact of their regulations on small business, (2) to require agencies communicate and explain their findings to the public, and (3) to encourage agencies to use flexibility and to provide regulatory relief to small entities. The RFA emphasizes predicting impacts on small entities as a group distinct from other entities and the consideration of alternatives that may minimize the impacts while still achieving the stated objective of the action. An initial regulatory flexibility analysis (IRFA) is conducted unless it is determined that an action will not have a "significant economic impact on a substantial number of small entities."

The objective of this rule is to revise and update the EFH provisions of the Salmon FMP that were previously approved by the Secretary of Commerce in 2000. EFH provisions are required under the Magnuson Fisheries Conservation and Management Act (16 U.S.C. 1802(b)(7). All vessels harvesting salmon from the ocean troll fishery are considered small under the Small Business Administration approved definition of a small fish harvester (average gross receipts not in excess of $20.5 million) (79 FR 33467, June 12, 2014). Therefore, there can be no disproportionate impacts between small and large vessels. Furthermore, there are no disproportionate impacts based on homeport, gear type, or vessel size from the promulgation of this proposed rule.

The following fishery information is found in the 2013 Stock Assessment and Fisheries Evaluation report (PFMC 2014). In 2013, there were 2,270 permits issued for this fishery, with a total exvessel value of $34.1 million. Of the 2,270 permits, only 1,177 actually landed salmon. In California, 670 vessels landed salmon for an exvessel value of $23.6 million; in Oregon, 399 vessels landed salmon for an exvessel value of $7.6 million; and in Washington, 108 vessels landed salmon for an exvessel value of $2.8 million. Treaty Indian ocean fisheries landed salmon with an exvessel value of $6.4 million.

This rule would not result in any immediate impacts on revenues or costs for the small entities participating in the Pacific salmon fishery because it does not contain any new management measures that would have specific economic impact on the fishery. However, future rulemakings that are promulgated by NMFS on behalf of the Secretary may be based in part on the identification and description of the EFH and such actions would likely have specific measurable impacts on the small entities participating in the fishery.

As a result, a NMFS economist will either prepare an initial regulatory flexibility analysis (IRFA) or certify that IRFA is not required. NMFS will conduct the appropriate analyses for any subsequent rulemakings stemming from this proposed rule.

5.13 EO 12866 (Regulatory Planning and Review)

EO 12866, Regulatory Planning and Review, was signed on September 30, 1993, and established guidelines for promulgating new regulations and reviewing existing regulations. The EO covers a variety of regulatory policy considerations and establishes procedural requirements for analysis of the benefits and costs of regulatory actions. Section 1 of the EO deals with the regulatory philosophy and principles that were to guide agency development of regulations. It stresses that in deciding whether and how to regulate, agencies should assess all of the costs and benefits across all regulatory alternatives. Based on this analysis, NMFS should choose those approaches that maximize net benefits to society, unless a statute requires another regulatory approach.

The Regulatory Impact Review is designed to determine whether the proposed action could be considered a “significant regulatory action” according to EO 12866. EO 12866 defines a “significant regulatory action”, and requires agencies to provide analysis of the costs and benefits of such action and reasonable feasible alternatives. An action may be considered “significant” if it is expected to: 1) have an annual effect on the economy of $100 million or more or adversely affect in a material way the economy, a sector of the economy, productivity, competition, jobs, the environment, public health or safety, or state, local, or tribal governments or communities; 2) create a serious inconsistency or otherwise interfere with action taken or planned by another agency; 3) materially alter the budgetary impact of entitlement, grants, user fees, or loan programs or the rights and obligations of recipients thereof; or 4) raise novel legal or policy issues arising out of legal mandates, the President's priorities, or the principles set forth in the EO.

A regulatory program is "economically significant" if it is likely to result in the effects described in Item 1 above. The RIR is designed to provide information to determine whether the proposed regulation is likely to be "economically significant." The exvessel value of the West Coast commercial salmon fisheries and total income impacts associated with the recreational salmon fisheries, at $79.3 million in 2013, was well below $100 million. Therefore it is unlikely that the options considered by the Pacific Fishery Management Council (Council) would have been projected to have effects in excess of $100 million and; therefore, would not be economically significant. The actions do not create serious inconsistencies or interfere with the actions of other agencies, do not alter entitlements, grants, etc., and do not raise novel legal or policy issues. Therefore, the action is not likely to be found significant under EO 12866.

5.14 NATIONAL ENVIRONMENTAL POLICY ACT

Finding of No Significant Impact (FONSI)
National Oceanic and Atmospheric Administration Administrative Order 216-6 (NAO 216-6) (May 20, 1999) contains criteria for determining the significance of the impacts of a proposed action. In addition, the Council on Environmental Quality regulations at 40 C.F.R. 1508.27 state that the significance of an action should be analyzed both in terms of “context” and “intensity”. Each criterion listed below is relevant in making a finding of no significant impact and has been considered individually, as well as in combination with the others. The significance of this action is analyzed based on the NAO 216-6 criteria and CEQ’s context and intensity criteria.

These include:
(1) Can the proposed action be reasonably expected to jeopardize the sustainability of any target species that may be affected by the action?
Response: The proposed action will not jeopardize the sustainability of any target species because it will not directly degrade their habitat or affect them individually, or result in any activity that would do so. The proposed action is intended to be beneficial to Pacific Coast salmon managed under the Pacific Coast Salmon FMP by revising the description and identification of essential fish habitat (EFH) for these species.

(2) Can the proposed action be reasonably expected to jeopardize the sustainability of any non-target species?
Response: The proposed action will not jeopardize the sustainability of any non-target species because it will not directly degrade their habitat or affect them individually, or result in any activity that would do so. The proposed action will revise the description and identification of EFH for Pacific Coast salmon and may indirectly benefit non-target species as a result.

(3) Can the proposed action be reasonably expected to allow substantial damage to the ocean and coastal habitats and/or EFH as defined under the Magnuson-Stevens Fishery Conservation and Management Act and identified in FMPs?
Response: The proposed action will not cause any damage to the ocean and coastal habitats and/or EFH because it will not result in any activities that could cause such harm. It is expected to lead, through the required EFH consultation process, to reduced levels of damage from anthropogenic activities relative to what would have occurred without the proposed action because the EFH Conservation Recommendations should provide measures to reduce harm from those activities.

(4) Can the proposed action be reasonably expected to have a substantial adverse impact on public health or safety?
Response: The proposed action is not expected to adversely affect public health or safety, either directly or indirectly, because it will not result in any activities that would have such effects.

(5) Can the proposed action be reasonably expected to adversely affect endangered or threatened species, marine mammals, or critical habitat of these species?
Response: The proposed action is not expected to adversely affect any endangered or threatened species, marine mammals, or critical habitat of these species because it will not result in any activities that would either degrade their habitat or affect them individually. It may, however, provide some benefits to these species if, through the required EFH consultation process, conservation measures implemented to protect salmon EFH also protect the habitat of these species.

(6) Can the proposed action be expected to have a substantial impact on biodiversity and ecosystem function within the affected area (e.g., benthic productivity, predator-prey relationships)?
Response: The proposed action is not expected to adversely impact biodiversity or ecosystem function within the affected area because it will not result in any activity that would have such effects. It may, however, provide some benefits if, through the required EFH consultation process, conservation measures are implemented to protect salmon EFH that also protect biodiversity and ecosystem function.

(7) Are significant social or economic impacts interrelated with significant natural or physical environmental effects?
Response: Since there are no significant natural or physical environmental effects expected, the proposed action is not expected to have any social or economic impacts interrelated with significant natural or physical environmental effects. The proposed action will not result in any activity that would have significant effects.

(8) Are the effects on the quality of human environment expected to be highly controversial?
Response: The effects of the proposed action are not expected to be controversial, as the data and information being used to inform any revisions to salmon EFH are publicly available, widely used, not controversial, and the basis is an updated version of the data that formed the basis for the original description of EFH for Pacific Coast salmon in 1999. The proposed action was developed through the Council process, including multiple Council meetings (April 2011, March 2012, September 2012, April 2013, and September 2013), comments provided by the public at these meetings were considered in adopting the proposed action.

(9) Can the proposed action reasonably be expected to result in substantial impacts to unique areas, such as historic or cultural resources, park land, prime farmlands, wetlands, wild and scenic rivers or ecologically critical areas?
Response: The proposed action is not expected to adversely affect any unique characteristics of the geographic area because it will not result in any activity that would have such effects. It may, however, provide some indirect benefits if, through the required EFH consultation process, conservation measures are implemented to protect salmon EFH that also protect these unique characteristics.

(10) Are the effects on the human environment likely to be highly uncertain or involve unique or unknown risks?
Response: The proposed action is not likely to result in effects on the human environment that are highly uncertain or involve unique or unknown risks. The effects on the human environment of designating EFH are well understood, and will be no different from the effects that occurred when EFH for Pacific Coast salmon was first designated in 1999.

(11) Is the proposed action related to other actions with individually insignificant, but cumulatively significant impacts?
Response: As a result of the cumulative effects analysis, section 4.14 of this EA, the proposed action is not expected to be related to other actions with individually insignificant but cumulatively significant impacts.

(12) Is the proposed action likely to adversely affect districts, sites, highways, structures, or objects listed or eligible for listing in the National Register of Historic Places or may cause loss or destruction of significant scientific, cultural or historical resources?
Response: The proposed action does not involve, and is not expected to affect, anything listed, or eligible for listing in the NRHP or cause the loss or destruction of significant cultural, scientific, or historical resources.

(13) Can the proposed action reasonably be expected to result in the introduction or spread of a non-indigenous species?
Response: The proposed action does not involve any activities that would result in the introduction or spread of a non-indigenous species.

(14) Is the proposed action likely to establish a precedent for future actions with significant effects or represents a decision in principle about a future consideration?
Response: The proposed action is not expected to establish a precedent for future actions with significant effects because it will not directly affect any future actions. One potential issue is how designating EFH above an impassible dam will affect FERC relicensing. Although such a designation would provide support for providing passage during the relicensing process, it is not likely that the designation of EFH would, by itself, be a deciding factor.

(15) Can the proposed action reasonably be expected to threaten a violation of Federal, State, or local law or requirements imposed for the protection of the environment?
Response: The proposed action will not result in any activity that would violate any laws or requirements imposed for the protection of the environment.

(16) Can the proposed action reasonably be expected to result in cumulative adverse effects that could have a substantial effect on the target species or non-target species?
Response: The proposed action is not expected to result in cumulative adverse effects that have a substantial effect on the target or non-target species because it is limited to revising the EFH provisions of the Pacific Coast Salmon FMP. The intent of the proposed action is to improve the protection of the habitats that support the target species (Council-managed salmon) and non-target species (both managed and unmanaged species). It does not affect the management of any fishery, and has no adverse effect on the environment. Therefore, cumulative adverse effects are not expected to occur.

DETERMINATION
In view of the information presented in the EA, it is hereby determined that the approval by NMFS of this the action will not significantly impact the quality of the human environment as described above and in the supporting EA. In addition, all beneficial and adverse impacts of the proposed action have been addressed to reach the conclusion of no significant impacts. Accordingly, preparation of an Environmental Impact Statement for this action is not necessary.

Barry A. Thom   9/09/2014

Date

Barry A. Thom
Deputy Regional Administrator
West Coast Region, NMFS

List of Persons and Agencies Consulted
This action is a Council-recommended action that includes all interested and potential cooperating agencies, such as US Fish and Wildlife Service, tribal government representatives, and state representatives for WA, OR, ID, and CA.

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Proposed

APPENDIX A TO THE PACIFIC COAST SALMON FISHERY MANAGEMENT PLAN

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

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List of abbreviations, acronyms, and initialisms

°C	degrees Celsius
µPa	micropascal
ACZA	ammoniacal copper zinc arsenate
ATTF	Alaska Timber Task Force
BMP	best management practice
BTA	best technology available
CCA	chromated copper arsenate
CDFW	California Department of Fish and Wildlife
CFR	Code of Federal Regulations
cm	centimeter
Cm/s	centimeters per second
Council	Pacific Fishery Management Council
CWT	coded wire tags
dB	decibels
DDT	dichlorodiphenyltrichloroethane
EEZ	exclusive economic zone
EFH	essential fish habitat
EMF	electromagenetic field
EPA	Environmental Protection Agency
ESA	Endangered Species Act
FAD	fish attraction device
FEERC	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
HDD	horizontal directional drilling
HU	hydrologic unit
Hz	hertz
IAS	invasive alien species
IMO	International Marine Organization
IUCN	International Union for Conservation of Nature
JNCC	Joint Nature Conservation Committee
kg	kilogram
km	kilometer
kPa	kilopascal
LID	low impact development
LNG	liquified natural gas
LTF	log transfer facility
LWD	large woody debris
m	meter
MHHW	mean higher high water
MSA	Magnuson-Stevens Fishery Conservation and Management Act
MSF	multi-stage flash
NEPA	National Environmental Policy Act
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 Fisheries 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
OTSMS	Oregon Territorial Sea Management Study
Pa	pascal
PFMC	Pacific Fisheries 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) 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 essential fish habitat 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 (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 exclusive economic zone (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 USGS 4th field hydrologic units (HUs). Such an approach is appropriate, because it (1) recognizes the species' use of diverse habitats and underscores the need to account for all of

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

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 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 (SAV) 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 Fishery Management Plan: 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 4^{th} field HUs that were historically, but are not currently, occupied by salmon (Table 2) and are not above the dams listed in Table 3.

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 4^{th} 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 exclusive economic zone (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 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 4. Table 5 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 large woody debris (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., hyphoreic) 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 5.

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 5. 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). Coded-wire-tag 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 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 4. Table 6 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 that 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, P.O. Box 783; Mendocino, California, 95460, 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., hyphoreic) 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 6.

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 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 PS pink salmon is in Table 4. Table 7 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 7. 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 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. Amendment 14 to the Pacific Salmon FMP states that 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 Derelict Gear section).

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 Derelict gear section).

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.

Amendment 14 notes that 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 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

Fishery Management Plans 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

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

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.

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 (NEPA), Endangered

Species 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 Alien Invasive Species

- 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 (SEL_{cum}). The interim criteria established by the FHWG includes a threshold for peak pressure[3] (206 dB re: 1µPa) and SEL_{cum}[4] (187 dB re: 1µPa^2·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.

While many activities introduce noise into the aquatic environment, it is not realistic to describe them all

3 dB peak pressure is referenced to 1 µPa throughout the rest of this document.
4 dB SEL and SEL_{cum} are references to 1 µPa^2·sec throughout this document

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.

<u>Potential adverse effects from pile driving</u>

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 Fisheries Hydroacoustic Working Group (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 sound exposure level (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 (SEL_{cum}). Injury is expected to any fish that is exposed to either a peak pressure that exceeds 206 dB (dB) or a size-dependent SEL_{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 Endangered Species Act (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 Irrigation Water Withdrawal, Storage and Management section).

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, large woody debris 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, large woody debris 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 to assure that application and timing measures fostering high nutrient utilization are employed.
- Apply conservation measures for water intake (See Irrigation Water Withdrawal, Storage and Management section 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 aggregation/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 mollusc 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 estuarine section).

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, 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 (MHHW) 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.

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 large woody debris) 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). Beaver 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 alien invasive species, 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 best management practices for control of runoff from developing areas, construction sites, roads, highways and bridges affecting salmon EFH. In addition to the previous guidelines, the options following represent a short menu of general types of conservation actions that can contribute to the restoration and maintenance of properly functioning salmon habitat. The following suggested measures are adapted from Metro (1997), ODFW (1989), and EPA (1993).

- Protect existing, and wherever practicable, establish new riparian buffer zones of appropriate width on all permanent and ephemeral streams that include or influence EFH. Establish buffers wide enough to support shading, large woody debris input, leaf litter inputs, sediment and nutrient control, and bank stabilization functions.

- Plan development sites to minimize clearing and grading and cut-and-fill activities.

- During construction, temporarily fence setback areas to avoid disturbance of natural riparian vegetation and maintain riparian functions for EFH.

- Use best management practices in building as well as road construction and maintenance operations such as avoiding ground disturbing activities during the wet season, minimizing the time disturbed lands are left exposed, using erosion prevention and sediment control methods, minimizing vegetation disturbance, maintaining buffers of vegetation around wetlands, streams and drainage ways, and avoiding building activities in areas of steep slopes with highly erodible soils. Use methods such as sediment ponds, sediment traps, or other facilities designed to slow water run-off and trap sediment and nutrients.

- Where feasible, remove impervious surfaces such as abandoned parking lots and buildings from riparian areas, and re-establish wetlands.

- Implement Low Impact Development (LID) 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.

<u>Potential Conservation Recommendations for Culvert Construction</u>

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, large woody debris, and sediment transport which affect river, wetland, riparian, and estuarine systems, increased competition with nonnative species, and increased predation and disease.

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

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

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

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

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

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

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

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 nonavoidable 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 large woody debris 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. Reverse osmosis 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 (ppt) 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 (HDD) 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 submerged aquatic vegetation 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.

Potential adverse effects from dredging and dredged spoil disposal

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 estuary alteration section, below). Dredging not only removes plants and reduces water clarity, but can change the entire physical, biological, and chemical structure of the ecosystem (Phillips 1984). Dredging also can reverse the normal oxidation/reduction potential of the sediments of an eelgrass system, which can reverse the entire nutrient-flow mechanics of the ecosystem (Phillips 1984).

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

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 predator s (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, large woody debris 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 h eat; *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 consequence s 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 DDT 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 m ill effluents. Estuarine food chains are extremely complex and sensitive to alterations in the physical and chemical range of stresses. Loss or disruption of one element can have a cascading effect on species presence and productivity.

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

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), Lock wood (1990), and Meyer, (1997 pers. co mm.).

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 nonavoidable adverse effects (See EPA 1993; Metro 199 7; SCS Enginners 1989).
- Utilize best management practices for controlling pollution from marina operations, boatyards, and fueling facilities.
- (Note that broad guidance to “determine cumulative effects” is too general and does not connect with the aim of minimizing potential adverse effects.)
- 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 large woody debris 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 large woody debris) 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 National Pollutant Discharge Elimination System (NPDES) permits and other state and Federal programs (EPA 1996). Adherence to guidelines such as the ATTF operational and siting guidelines and best management practices 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 best management practices (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 beaver (both commercial and recreational) in areas important to fish.
- Avoid silvicultural activities harmful to beaver (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]

Potential adverse effects from grazing

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

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).

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 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, large woody debris, 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, large woody debris, 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 large woody debris. 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 submerged aquatic vegetation; 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 Game (CDFG) 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 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 Endangered Species Act (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, haybales, 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.
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4.2.2.19 Introduction/Spread of Invasive Alien Species

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 Endangered Species Act (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 IMO 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 large woody debris 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: 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 dam section) to water management activities and facilities, where applicable.
- Establish adequate instream flow conditions for salmon by using, for example, the Instream Flow Incremental Methodology.
- Undertake efforts to purchase or lease, from willing sellers and lessors, water rights necessary to maintain instream flows in accordance with appropriate state and Federal laws.
- Identify and use appropriate water conservation measures in accordance with state law.
- In accordance with state law, install totalizing flow meters at major diversion points 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.

<u>*Potential adverse effects from liquefied natural gas projects*</u>

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 either this document or Amendment 14.

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, reverse osmosis, electrochemical, or biological treatments) and recycle on site to minimize discharge to streams. Test wastewater before discharge for compliance with the Federal and state clean water standards.
- Minimize mine-generated sediments from entering or affecting EFH. Minimize the aerial extent of ground disturbance (e.g., through phasing of operations), and stabilize disturbed lands to reduce erosion. Employ methods such as contouring, mulching, and construction of settling ponds to control sediment transport.
- Reclaim, rather than bury, mine waste that contains heavy metals, acid materials, or other toxic compounds if leachate can enter EFH through groundwater.
- Restore natural contours and plant native vegetation on site after use to restore habitat function to the extent practicable.

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 Pile Driving) and dredging of navigation channels (see Dredging and Dredged Spoil Disposal in Amendment 14). 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 (see Section 4.1). 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 (ACZA) and chromated copper arsenate (CCA) (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 derived 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 submerged aquatic vegetation 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 submerged aquatic vegetation, 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 once-through cooling 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 Construction/Urbanization section). This increased scour of gravel and cobble in areas where salmon eggs, alevins, or fry reside can kill salmon directly or indirectly increase mortality by carrying them downstream and away from stream cover. Urban roads can be a major source of sediment input during construction as can the installation of bridges, culverts, and diversions with coffer dams. However, these project impacts seem to be more temporary and less pervasive on sediment input than forest roads (Waters 1995).

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

Conservation Measures for Road Building and Maintenance

Following are the types of measures that can be undertaken by the action agency on a site-specific basis to conserve salmon EFH habitat in areas that have the potential to be affected by road building and maintenance activities. Not all of these suggested measures are necessarily applicable to any one project or activity that may adversely affect salmon EFH. More specific or different measures based on the best and most current scientific information may be developed prior to, or during, the EFH consultation process and communicated to the appropriate agency. The options represent a short menu of general types of conservation actions that can contribute to the protection and restoration of properly functioning salmon habitat. The following suggested measures are adapted from Murphy (1995), 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:
        - Head of bar buffer. The operators will protect the upstream third of the bar from any excavation activities.
        - Lateral buffer. 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.
        - Excavated backwater length. Not greater than two-thirds of the bar feature, and will include the head slope and side slope of the backwater.
        - Excavated backwater depth. 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.
        - Excavated backwater head slope. No steeper than 10 to 1 (horizontal to vertical).
        - Excavated backwater side slopes. 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).

Potential adverse effects from vessel operations/transportation/navigation

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 (IUCN) 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 4.2.2.17Introduction/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 best management practices 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 on Dredging, Grazing, Mineral Mining, Agriculture, Construction/Urbanization, and Forestry).

The introduction of pollutants into EFH can create both lethal and sublethal habitat conditions to salmon and their prey. For example, fish kills may result from a pesticide run-off event, high water temperatures, or when algae blooms caused by excess nutrients deplete the water of oxygen.
Pollutant and water quality impacts to EFH can also have more chronic effects detrimental to fish survival. Contaminants can be assimilated into fish tissues by absorption across the gills or through bio-accumulation as a result of consuming contaminated prey. Pollutants either suspended in the water column (e.g., nitrogen, contaminants, fine sediments) or settled on the bottom (through food chain effects) can affect salmon. Many heavy metals and persistent organic compounds such as pesticides and polychlorinated biphenyls tend to adhere to solid particles. As the particles are deposited these compounds or their degradation products (which may be equally or more toxic than the parent compounds) can bioaccumulate in benthic organisms at much higher concentrations than in the surrounding waters (Oregon Territorial Sea Management Study [OTSMS] 1987; Stein et al. 1995).

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 best management practices and monitoring programs. It is, therefore, critical that actions aimed at improving EFH water quality, especially in streams and rivers, are taken in concert with state agencies (e.g., Oregon Department of Environmental Quality, WDOE California Water Resources Control Board; Idaho Department of Health and Welfare) responsible for water quality management.

Some pollutant discharges are regulated through discharge permits which set effluent discharge limitations and/or specify operation procedures, performance standards, or best management practices. Additional effort to improve water quality is also being fostered by states under the guidance of the Coastal Zone Management Reauthorization Act. These efforts rely on the implementation of best management practices to control polluted run-off (EPA 1993). Although not yet a consistently applied mechanism to improve water quality, vegetated buffers along streams have been shown to be effective in providing such functions as sediment trapping, removal of nutrients and metals, moderation of water temperatures, increasing stream and channel stability and allowing recruitment of woody debris.

Following are the types of measures that can be undertaken by the action agency on a site-specific basis to conserve salmon EFH in areas that have the potential to be affected by both point and nonpoint sources of pollution. Not all of these suggested measures are necessarily applicable to any one project or activity that may adversely affect salmon EFH. More specific or different measures based on the best and most current scientific information may be developed prior to, or during, the EFH consultation process, and communicated to the appropriate agency. The options represent a short menu of general types of conservation actions that can contribute to the protection and restoration of properly functioning salmon habitat. The following suggested measures are adapted from Gauvin (1997), Washington Fish and Wildlife Commission (WFWC) (1997), 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 and develop appropriate management plans to attain management goals.
- Allocate more resources to complete existing and future TMDL's 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 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		

[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.) 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.), 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), Bear Dam (Bear Creek), Owens Dam (Owens Creek) Mariposa Dam

[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.) Peters Dam (Lagunitas Cr.)
18050006	San Francisco Coastal South	CA		X		
18060015	Monterey Bay[6]	CA		X		Newell Dam (Newell Cr.)

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; Childs 2003
17060105	Wallowa River	N/A	Fulton 1970; Childs 2003
17070306	Lower Deschutes	N/A	Seals and French 2012
17090004	McKenzie	N/A	Fulton 1970: Williams 1981
17090006	South Santiam	N/A	Fulton 1970; Williams 1981
18010104	Middle Fork Eel	Williams et al. 2006	Brown and Moyle 1991; 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; Spence et al. 2005
18050004	San Francisco Bay	NMFS 1998; Leidy et al. 2007	Brown and Moyle 1991; Leidy et al. 2005; Spence et al. 2005
18050005	Tomales-Drake Bays	Ettlinger et al. 2012	N/A
18060001	San Lorenzo-Soquel	N/A	Brown and Moyle 1991; Spence et al. 2011; 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 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) 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) 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) 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 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. 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.

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	S - sand	R - rock
SM - sandy mud	CB - cobble	C - coral
MS - muddy sand	G - gravel	K - kelp

SAV - subaquatic vegetation other than kelp (e.g., eelgrass).

Oceanographic Features

UP - upwelling	G - gyres	F - fronts
CL - thermo-or pycnocline	E – edges	

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 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; Temperature 0-17 °C; optimum 4.4-13.3 °C; Substrate 2-10 cm with < 12% fines (<3.3 mm), optimum <5% fines; Water velocity 25-90 cm/s
Larvae (alevins). 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; Temperature 0-17 °C; optimum 4.4-13.3 °C; Substrate 2-10 cm with < 12% fines (<3.3 mm), optimum <5% fines; Water velocity 25-90 cm/s
Juveniles (freshwater) EFH Data Level 0-4	1-2 yrs, most (>90%) 1 yrs	Aquatic, terrestrial, and estuarine invertebrates, eggs, fish	Rearing - all year 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; Temperature 0-25 °C; optimum 12-14 °C; Salinity < 29 ppt; Water velocity 5-30 cm/s
Juveniles (estuarine) EFH Data Level 0-3	0-2 yrs	Insects, copepods, euphausiids, amphipods, crab larvae, fish	Rearing – winter, spring, summer, Migration - all year	BCH, BAY	Pelagic	NA	Temperature <15 °C
Juveniles and adults (marine) 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 Migration - all year	BCH, ICS, MCS, OCS, USP, BAY, IP	Pelagic	UP, CL, F; migration influenced by currents, salinity, and temperature	Temperature <15 °C

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) EFH Data Level 1-2	up to 2 months	Little or none	Migration - fall 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 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) 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 EFH Data Level 0-3	2 yrs	Pteropods, amphipods, crab larvae,, euphausiids, copepods, , amphipods, fish squid	Estuary: spring, summer 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 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.

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

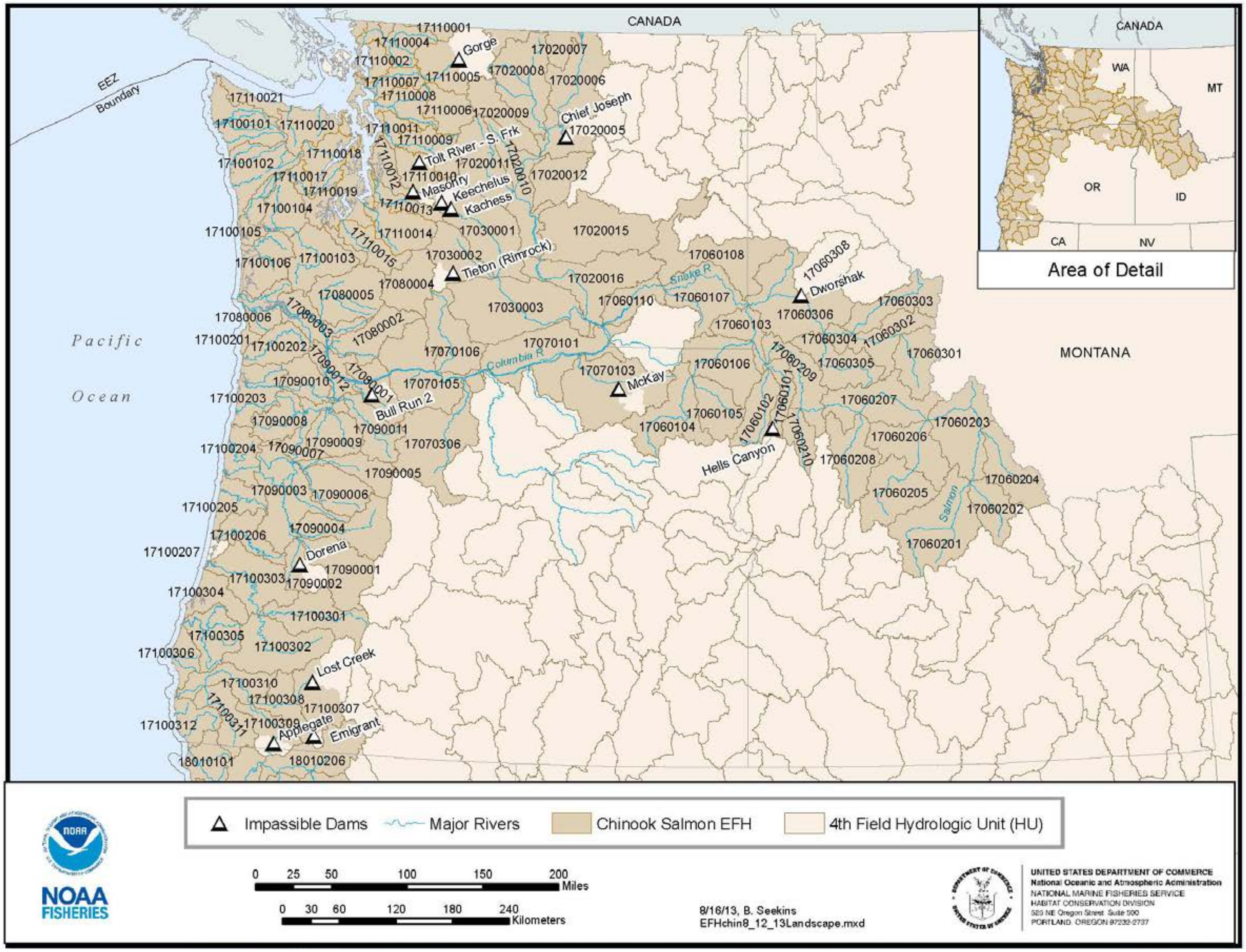

Figure 2. Chinook salmon EFH in Washington, Oregon, and Idaho. EFH designations are based on the USGS 4th field hydrologic units.

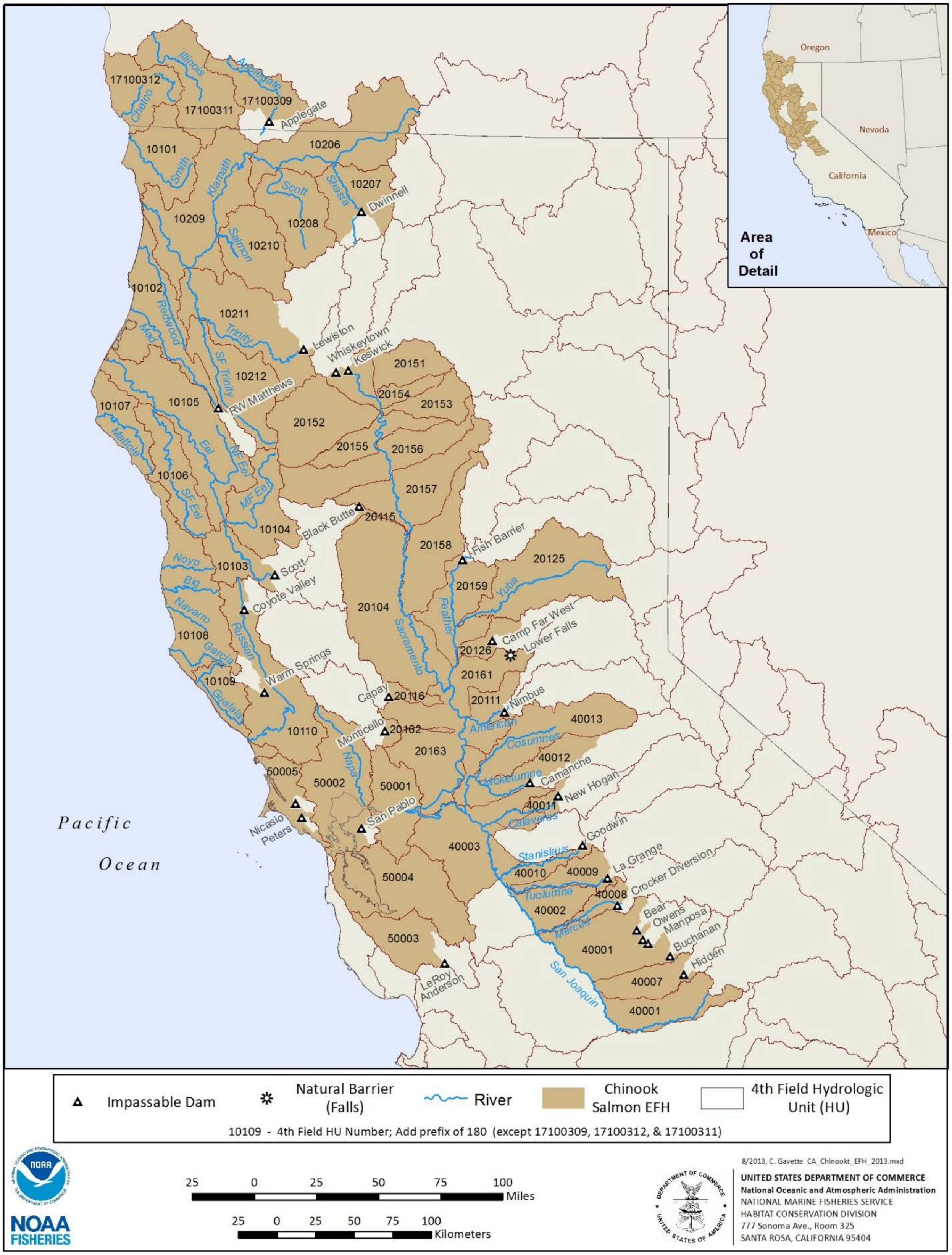

Figure 3. Chinook salmon EFH in California. EFH designations are based on the USGS 4th field hydrologic units.

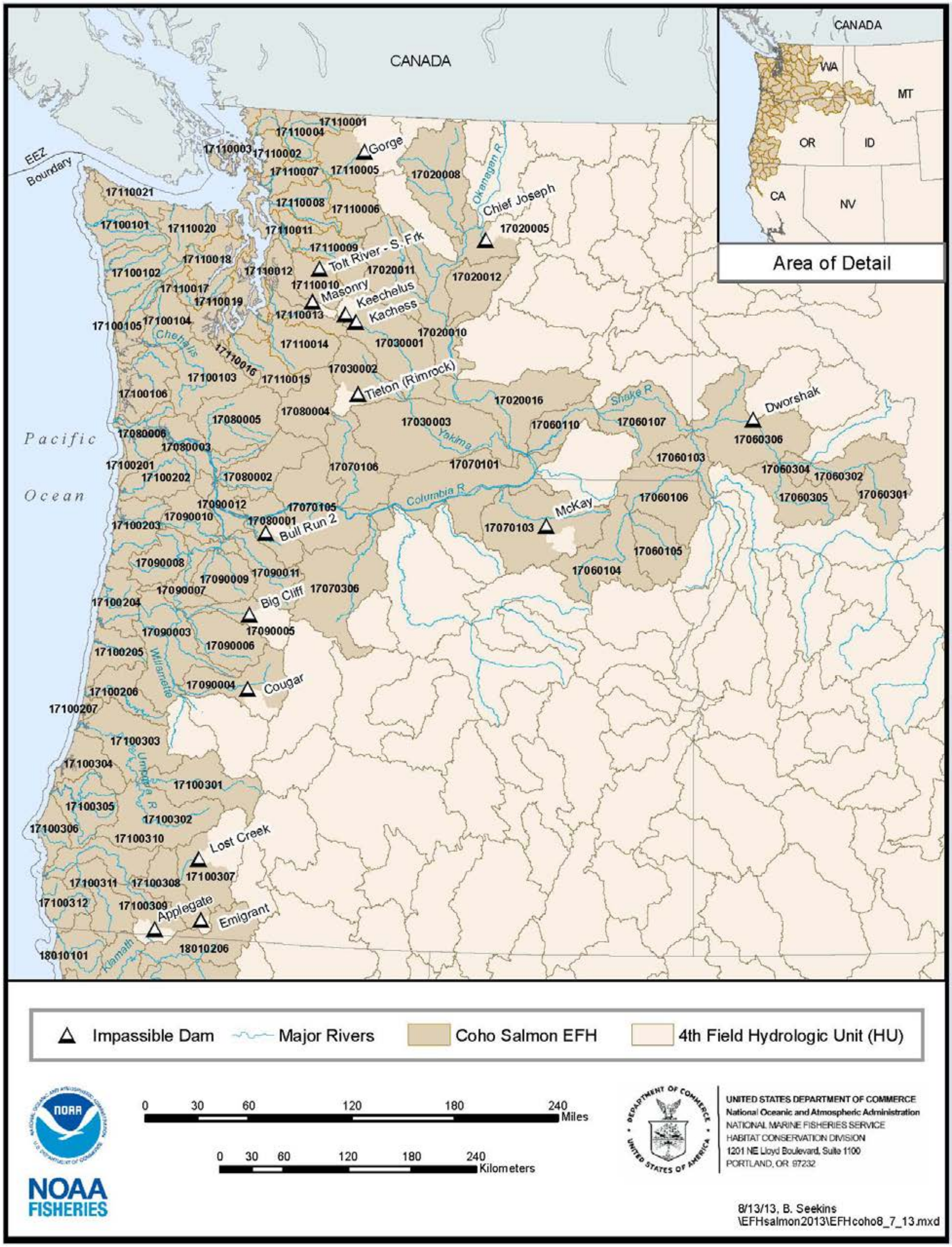

Figure 4. Coho salmon EFH in Washington, Oregon, and Idaho. EFH designations are based on the USGS 4th field hydrologic units.

Figure 5. Coho salmon EFH in California. EFH designations are based on the USGS 4th field hydrologic units.

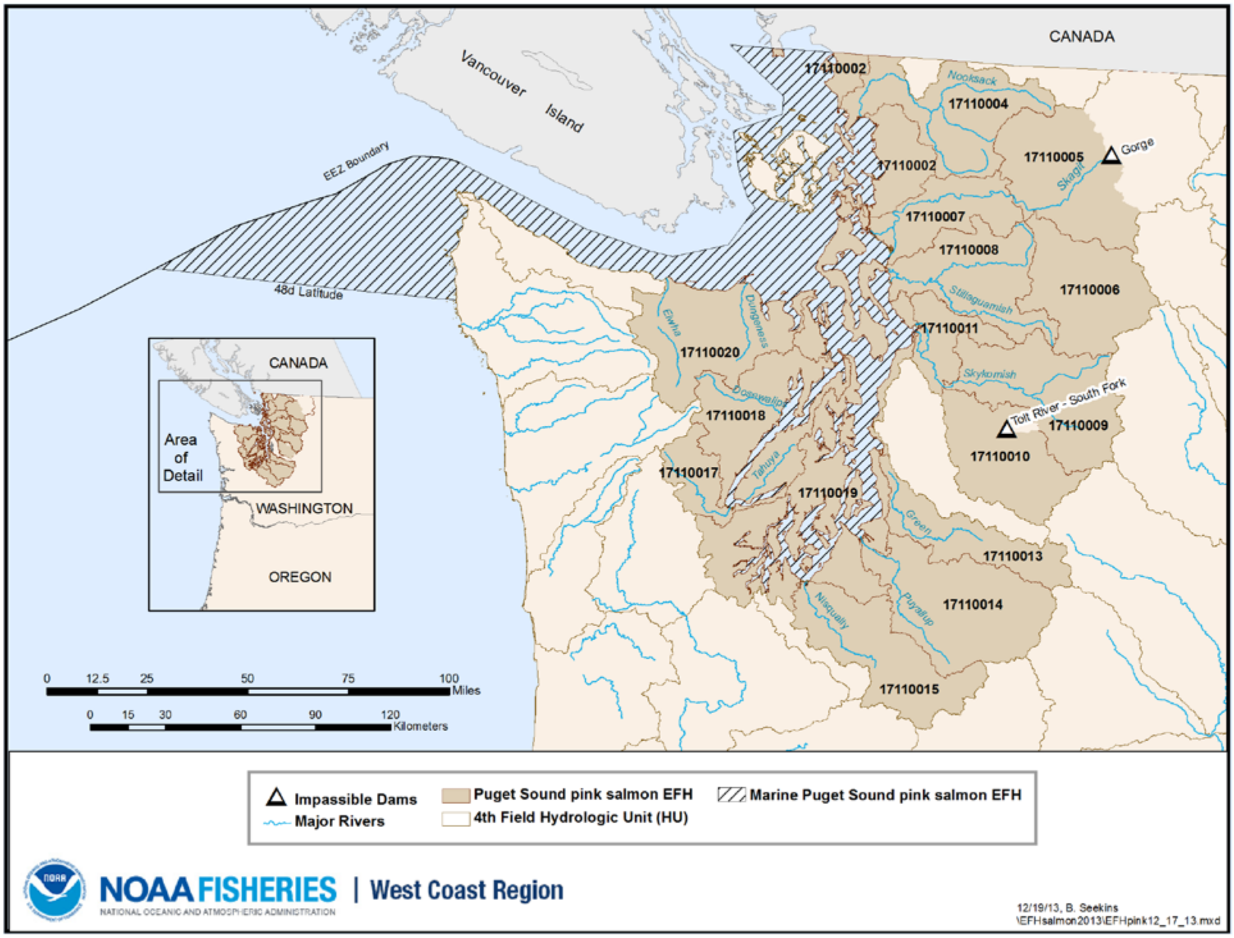

Figure 6. Puget Sound pink salmon EFH. EFH designations are based on the USGS 4th field hydrologic units.

Proposed Changes to the

PACIFIC COAST
SALMON FISHERY MANAGEMENT PLAN

FOR COMMERCIAL AND RECREATIONAL SALMON FISHERIES

OFF THE COASTS OF WASHINGTON, OREGON, AND CALIFORNIA

Reflecting Changes Included in Amendment 18

Proposed changes to page vi

SUPPLEMENTARY FMP DOCUMENTS

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

APPENDIX A ~~- FROM AMENDMENT 14~~ 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)

Proposed changes to page 1

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, ~~and~~ 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).

Proposed changes to Table 1, page 3

TABLE I. Record of salmon FMP documents.

DOCUMENT	CONTENT SUMMARY
Amendment 13 (64 FR 26328, May 14, 1999) 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 (66 FR 29238, May 30, 2001; Effective June 29, 2001)	1) Update of the EIS and editorial improvements in the plan 2) New requirements of the SFA, including essential fish habitat, optimum yield, overfishing, and bycatch 3) Clarification of the stocks managed and management objectives 4) Minor revision of allocation north of Cape Falcon to allow more harvest in selective fisheries
Amendment 15 (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 (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 2) Stock classification 3) Establishment of ACLs and AMs 4) Acceptable biological catch and incorporating scientific uncertainty 5) Revision of status determination criteria 6) Characterization of stock conservation objectives related to reference points 7) Development and modification of *de minimis* fishing provisions.
Amendment 17 (Effective January 1, 2013)	1) Minor corrections from Amendment 16 and updating language to reflect current practices. 2) Approval of maximum fishing mortality threshold for Quillayute fall coho.
Amendment 18 (Effective date TBD)	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.

Proposed changes to Section 4.1, starting on page 42

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 ~~fresh water, salmon EFH includes all those streams, lakes, ponds, wetlands, and other currently viable water bodies and most of the habitat historically accessible to salmon (except above certain impassable natural barriers~~ Washington, Oregon, Idaho, and California as identified in Table 1~~Table 1-1~~ of Appendix A. Salmon EFH includes aquatic areas above all artificial barriers except the impassable barriers (dams) listed in Table 1 ~~Table A-2~~ 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 ~~effects of~~ fishing activities and the use of fishing gear; prey removal by other fisheries; and ~~the effect of~~ salmon fishing ~~on the reduction of~~ 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 ~~Section 3.1~~ of Appendix A provides descriptions of the potential impacts on EFH from fishing activities. ~~and measures to assess or reduce those impacts~~. The descriptions ~~and measures~~ 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 4^{th} 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.