Pacific Coast Salmon 5-Year Review of Essential Fish Habitat

Final Report to the Pacific Fishery Management Council

Revised May 25, 2011

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EEZ	exclusive economic zone
EFH	essential fish habitat
ESA	Endangered Species Act
ESU	evolutionarily significant unit
FERC	Federal Energy Regulatory Commission
FMC	Fishery Management Council
FMP	fisheries management plan
FMU	fishery management unit
GIS	geographic information system
HAPC	habitat area of particular concern
HU	hydrologic unit
IP	intrinsic potential
LNG	liquefied natural gas
LWD	large woody debris
MSA	Magnuson-Stevens Fishery Conservation and Management Act
NMFS	National Marine Fisheries Service
NOAA	National Oceanographic and Atmospheric Administration
NPFMC	North Pacific Fishery Management Council
PFMC	Pacific Fishery Management Council
PS	Puget Sound
SAV	submerged aquatic vegetation
USGS	United States Geological Survey

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1. INTRODUCTION

The Magnuson-Stevens Fishery Conservation and Management Act (MSA)(16 USC 1801 et seq) defines essential fish habitat (EFH) as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity," and requires Fishery Management Councils (FMCs) to describe and identify EFH in fishery management plans (FMPs). The FMPs should identify EFH based on current distribution, habitat components, historical presence, or other factors; and should also identify habitat requirements at each life stage and research needs. FMPs must evaluate potential adverse impacts from both fishing and non-fishing activities, as well as minimize adverse effects of fishing to the extent practicable. FMPs should identify Habitat Areas of Particular Concern (HAPC) within EFH based on the habitat's ecological function, sensitivity to human-induced disturbance, rarity, or whether development activities may stress a particular habitat. The National Marine Fisheries Service (NMFS) has approval authority for the designations provided by the FMCs.

The Pacific Fishery Management Council (Council) has, in Appendix A to Amendment 14 of the Pacific Coast Salmon FMP (Amendment 14)(PFMC 1999), identified EFH for Pacific Coast salmon as 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). Exceptions in freshwater include cases in which certain man-made or naturally occurring barriers represent the current upstream extent of Pacific salmon access. The Council designated Pacific salmon EFH in 1999, and made minor revisions during the EFH codification process in 2008 (2008 Final Rule)(78 FR 60987).

This report summarizes the results of a review conducted by an oversight panel (Panel) made up of staff from the Council and NMFS (Table 1), of the EFH for Pacific Coast salmon. The report includes a description of the general requirements and elements of EFH, including guidance for periodic reviews; a summary of existing designations of EFH for Pacific Coast salmon; the currently available information on the distribution of Pacific Coast salmon in both fresh and marine waters; potential changes to the existing EFH designations; potential changes to the list of impassible dams that currently form the upstream extent of EFH; an inquiry into whether appropriate models exist to predict salmon distribution where data on distribution are lacking; a discussion of potential HAPCs; a brief summary of new information on the life history and habitat requirements of salmon; updated information on threats to EFH both from fishing and non-fishing activities; and identification of research needs to further refine EFH.

Essential Fish Habitat Consultation

Federal agencies must consult with the NMFS on activities that may adversely affect EFH, regardless of whether or not those activities occur within designated EFH. In other words, an activity can adversely affect EFH without occurring within EFH. An adverse effect means any impact that reduces either the quantity or quality of EFH (50 CFR 600.810). For those activities that would adversely affect EFH, NMFS then provides EFH conservation recommendations to the Federal agency to avoid, minimize, or offset those adverse effects. Fishery Management Councils may also comment on proposed actions that may adversely affect EFH, and is obligated to provide comments on any activity that is likely to substantially affect the habitat, including EFH, of an anadromous fishery resource under its authority. Although state agencies are not required to consult with NMFS on activities that may adversely affect EFH, NMFS is obligated to provide conservation recommendations to state agencies if NMFS receives information that an activity will adversely affect EFH. Whenever possible, NMFS utilizes existing coordination procedures to transmit EFH conservation recommendations.

Table 1. Members of the Oversight Panel.

Name	Affiliation
Chuck Tracy	Pacific Fishery Management Council
Kerry Griffin	Pacific Fishery Management Council
John Coon	Pacific Fishery Management Council
John Stadler – Chair	NMFS Northwest Region, Habitat Conservation Division
Barbara Seekins	NMFS Northwest Region, Protected Resources Division
Phil Roni	NMFS Northwest Fisheries Science Center
Eric Chavez	NMFS Southwest Region, Habitat Conservation Division
Adam Obaza	NMFS Southwest Region, Habitat Conservation Division
Bryant Chesney	NMFS Southwest Region, Habitat Conservation Division
Charleen Gavette	NMFS Southwest Region, Habitat Conservation Division
Brian Spence	NMFS Southwest Fisheries Science Center
Nancy Munn	NMFS Northwest Region, Habitat Conservation Division
Steve Copps	NMFS Northwest Region, Sustainable Fisheries Division

The designations and detailed descriptions of EFH in the FMPs are used during the EFH consultation process to determine where and for what species EFH has been designated in the project area. The analysis of the adverse effects from the proposed action, and potential conservation measures that avoid, minimize, or offset those effects, are informed by the information contained in the FMP.

Essential Fish Habitat Periodic Reviews

The regulatory guidelines for implementing the EFH provisions of the MSA state that Regional FMCs and NMFS should periodically review the EFH provisions of FMPs and revise or amend EFH provisions as warranted, based on available information (50 CFR 600.815(a)(10)). This review included 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 Council may provide suggested changes to existing EFH to NMFS for their approval, if the information warrants changes. The regulatory guidance provides 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 Pacific Coast 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). The current review was initiated in 2009.

Since EFH for Pacific Coast salmon was first designated in 1999, NMFS has taken steps to clarify the process for designating and refining EFH. In 2002, NMFS published final rules to implement the EFH provisions of the MSA (50 CFR Part 600), and, in 2006, issued a memo providing additional guidance to refine the description and identification of EFH (NMFS 2006). The 5-year review presented was guided by these two clarifying documents.

Methods/Approach

The Panel convened via conference call, on an intermittent basis, from June, 2009 through March, 2011.

Available information on salmon distribution in freshwater and marine habitats, impassible barriers in freshwater, salmon life history, and threats to EFH from fishing and non-fishing activities was compared to the information in Amendment 14 to the Pacific Coast Salmon FMP. Using these comparisons, the Panel evaluated potential modifications to EFH and identified potential changes to EFH where warranted. The information used was gathered from publicly available sources.

Chronology

- Early 2009 NMFS and the Council received $100k from NMFS Headquarters to provide support for the review and the Oversight Panel was established
- September 2009 – The Council Staff provided an informational report at the September Council meeting
- September 2009 – The Council hired Cramer Fish Sciences to compile new references and develop an annotated bibliography on the list of barriers, the habitats used by salmon at all life stages, and threats to EFH, as well as review and synthesize potential actions to avoid, minimize, or offset adverse impacts to EFH associated with the identified threats.
- June 2010 – Contract with Cramer Fish Sciences concludes; Oversight Panel begins developing draft report for September 2010 Council meeting
- September 2010 – Draft report presented to the Council
- October 2010 – December 2010 - Comments on draft report solicited by the Panel
- April 2011 – Final report delivered to the Council

2. CURRENT EFH DESIGNATIONS FOR PACIFIC COAST SALMON

This section summarizes existing EFH for Pacific salmon contained in Amendment 14 and the 2008 Final Rule.

In Amendment 14 to the Pacific Coast Salmon FMP (PFMC 1999), the Council chose a comprehensive approach to designate EFH for several reasons: salmon distribution varies spatially and temporally; there is very limited information regarding ocean distribution and migration; and there is an immense diversity of freshwater habitats. The comprehensive approach is manifested in the text descriptions and the associated maps provided to assist the user. The text descriptions are the legal definition of EFH and for Pacific salmon are written broadly. This means that the species-specific maps of the U.S. Geological Survey (USGS) 4^{th} field hydrologic units (HUs) across a large geographic area oblige the user to make a more refined determination as to whether a particular activity is within, or may adversely affect, Pacific Coast salmon EFH, within that HU. EFH identification based on USGS 4^{th} field HUs recognizes the diversity of habitats essential to the species through all life stages, considers the variability of environmental conditions, and reinforces linkages between aquatic and adjacent upslope areas (PFMC 1999).

In describing Pacific Coast salmon EFH, the Council chose to include Alaskan marine waters designated by the North Pacific FMC (NPFMC) as EFH for salmon. This highlights the importance of habitats in the North Pacific Ocean and recognizes the fact that many of the salmon stocks spawned in the contiguous West Coast states migrate north past British Columbia and into the waters of Alaska.

Pacific salmon EFH underwent minor revisions in 2008 as a result of the Idaho County v. Department of Commerce lawsuit (Case No. CV02–C–EJL), which required NMFS to issue the Pacific salmon EFH descriptions as a Final Rule. The 2008 rulemaking exercise addressed some issues (fixed typographical and nomenclature errors; consolidated the marine and freshwater definitions of salmon EFH), but did not constitute an MSA-required review.

This section presents a summary of existing EFH descriptions for the three species of Pacific salmon managed by the Council. More detailed information can be found in Amendment 14 to the Pacific Coast Salmon Plan (PFMC 1999) and the Final Rule that codified Pacific Coast salmon EFH in 2008 (73 FR 60987). It is important to bear in mind that the text descriptions of EFH are the legal definition. Maps are provided to assist the user in interpreting the spatial extent of salmon EFH, but should not be considered to absolutely depict the extent of EFH. It follows that due to various factors (new information, changes to presence/absence of salmon, etc) the maps and descriptions will be amended over time.

The 2008 Final Rule merged the marine and freshwater designations of EFH to simplify the description. It identifies EFH for Pacific Coast salmon as "all streams, estuaries, marine waters, and other water bodies occupied or historically accessible to salmon in Washington, Oregon, Idaho, and California" and adds caveats for impassible barriers and for Puget Sound pink salmon (see following sections).

Chinook salmon

Chinook salmon (*Oncorhynchus tshawytscha*) EFH, as currently designated, includes all streams, estuaries, marine waters, and other water bodies occupied or historically accessible to Chinook salmon in Washington, Oregon, Idaho, and California. Exceptions include cases in which long-standing naturally occurring barriers (e.g., waterfalls) or specifically identified man-made barriers (e.g., dams) represent the current upstream extent of Pacific salmon access. Chinook salmon EFH includes the marine areas off Alaska designated as salmon EFH by the NPFMC. Including marine EFH designated by the NPFMC serves to recognize the migratory patterns of Chinook salmon, and the importance of habitat during all life stages. Current marine EFH for Chinook salmon includes the entire exclusive economic zone (EEZ) around Alaska. The southern extent of Chinook salmon marine EFH extends to Point Conception, CA, which represents the approximate southern extent of the Chinook range.

The designation of EFH is based on distribution data available at the time of Amendment 14, and all U.S. Geologic Survey (USGS) 4th field HUs with known or historical Chinook salmon presence at the time of Amendment 14, with the exception of those above certain man-made barriers, are currently designated as EFH for this species (Figures 1-3).

Amendment 14 includes descriptions of relevant habitat parameters, including the four major components of Chinook salmon freshwater EFH: (1) spawning and incubation; (2) juvenile rearing; (3) juvenile migration corridors; and (4) adult migration corridors and adult holding habitat. It also includes a detailed description of the life history and habitat requirements at each life stage.

Coho salmon

Coho salmon (*O. kisutch*) EFH, as designated in Amendment 14, includes all streams, estuaries, marine waters, and other water bodies occupied or historically accessible to coho salmon in Washington, Oregon, Idaho, and California. Exceptions include cases in which long-standing naturally occurring barriers (e.g., waterfalls) or specifically identified man-made barriers (e.g., dams) represent the current upstream extent of Pacific salmon access. Coho salmon EFH includes the marine areas off Alaska designated as salmon EFH by the NPFMC. Including marine EFH designated by the NPFMC serves to recognize the migratory patterns of coho salmon, and the importance of habitat during all life stages. Current marine EFH for coho salmon includes the entire EEZ around Alaska. The southern extent of

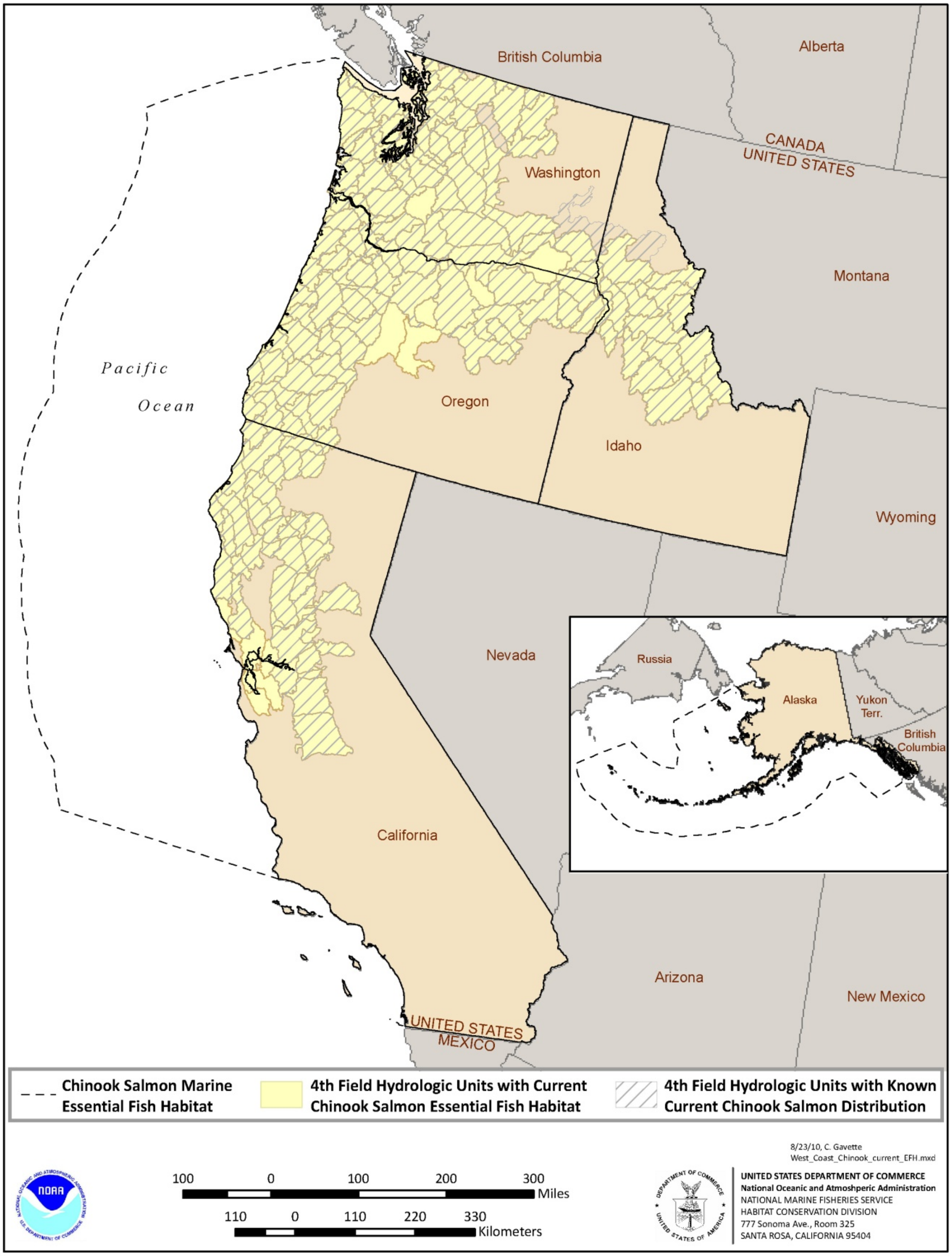

Figure 1. 4th field HUs and marine waters currently identified as EFH for Chinook salmon in relation to current Chinook salmon distribution for the U.S. West Coast and Alaska.

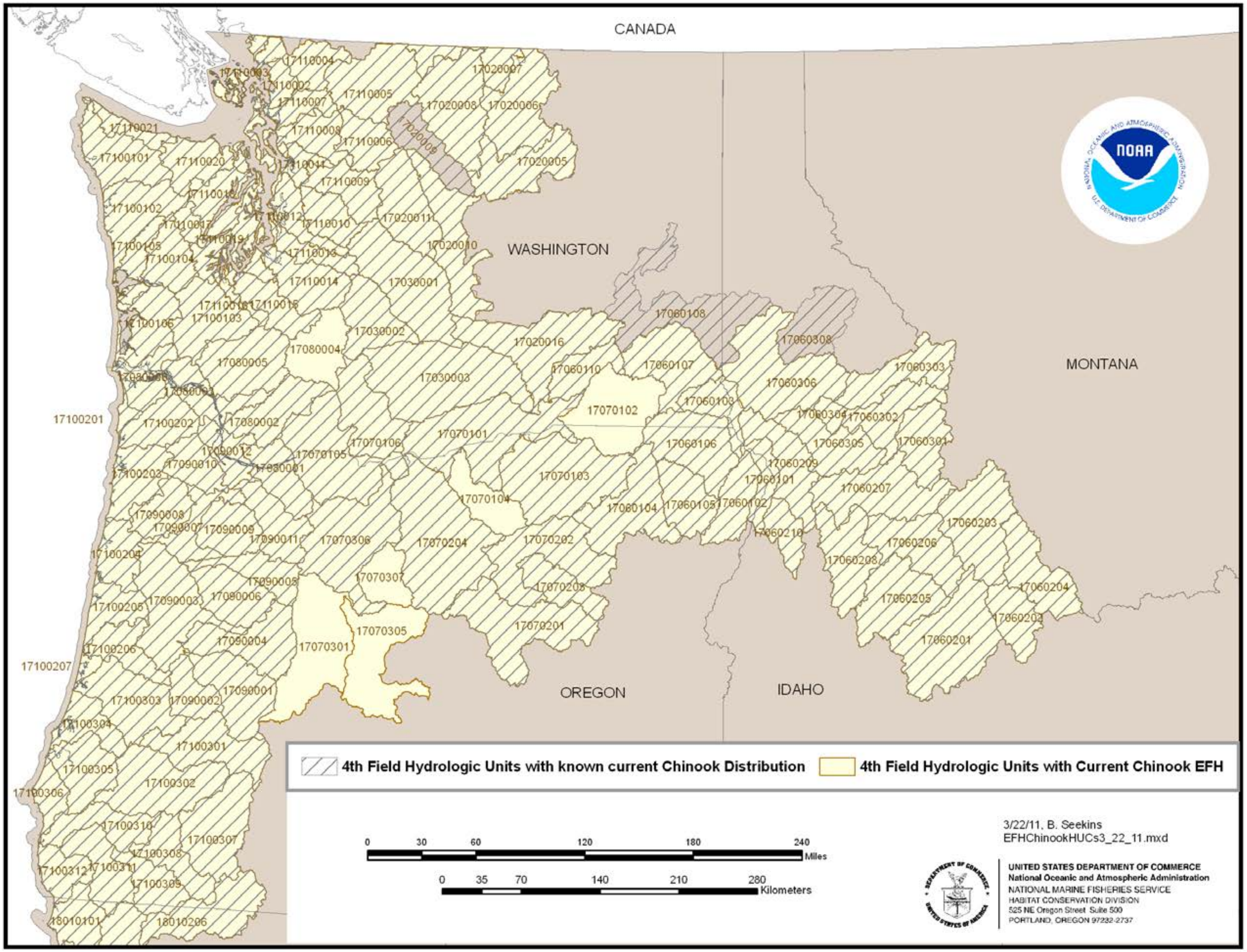

Figure 2. 4th field HUs currently identified as EFH for Chinook salmon in relation to current Chinook salmon distribution in Washington, Oregon, and Idaho.

Figure 3. 4th field HUs currently identified as EFH for Chinook salmon in relation to current Chinook salmon distribution in California.

coho salmon marine EFH is Point Conception, CA, which represents the approximate southern extent of the range of coho salmon.

The designation of EFH is based on distribution data available at the time of Amendment 14, and all U.S. Geologic Survey (USGS) 4th field HUs with known or historical coho salmon presence at the time of Amendment 14, with the exception of those above the identified man-made barriers, are currently designated as EFH for this species (Figures 4-6).

Amendment 14 includes descriptions of relevant habitat parameters, including the four major components of coho salmon freshwater EFH: (1) spawning and incubation; (2) juvenile rearing; (3) juvenile migration corridors; and (4) adult migration corridors. The current EFH for coho salmon does not include adult holding habitat. Amendment 14 also includes detailed description of the life history and the habitat requirements for each life stage.

Puget Sound Pink Salmon

Puget Sound (PS) pink salmon (*O. gorbuscha*) life history and migratory patterns are distinctly different than Chinook and coho salmon, and are described in Amendment 14. Puget Sound pink salmon EFH, as currently designated, includes all streams, estuaries, marine waters, and other water bodies occupied or historically accessible to pink salmon within Washington State. Exceptions include cases in which long-standing naturally occurring barriers (e.g., waterfalls) or specifically identified man-made barriers (e.g., dams) represent the current upstream extent of Pacific salmon access. EFH for PS pink salmon also includes marine waters north and east of Cape Flattery, Washington, including Puget Sound, the Strait of Juan de Fuca and Strait of Georgia. It is difficult to determine a western limit for pink salmon essential marine habitat because of limited information on their ocean distribution, but most PS pink salmon are typically found in Canadian, Alaskan, and international waters both within and outside the EEZ north of Cape Flattery, Washington.

The designation of EFH is based on distribution data available at the time of Amendment 14, and USGS 4th field HUs with known or historical PS pink salmon presence at the time of Amendment 14, with the exception of those above the identified man-made barriers, are currently designated as EFH for this species (Figure 7).

The four major components of freshwater PS pink salmon EFH are: (1) spawning and incubation; (2) juvenile rearing; (3) juvenile migration corridors; and (4) adult migration corridors. The current EFH description for PS pink salmon does not include adult holding habitat. Amendment 14 also includes a detailed description of the life history and the habitat requirements per life stage.

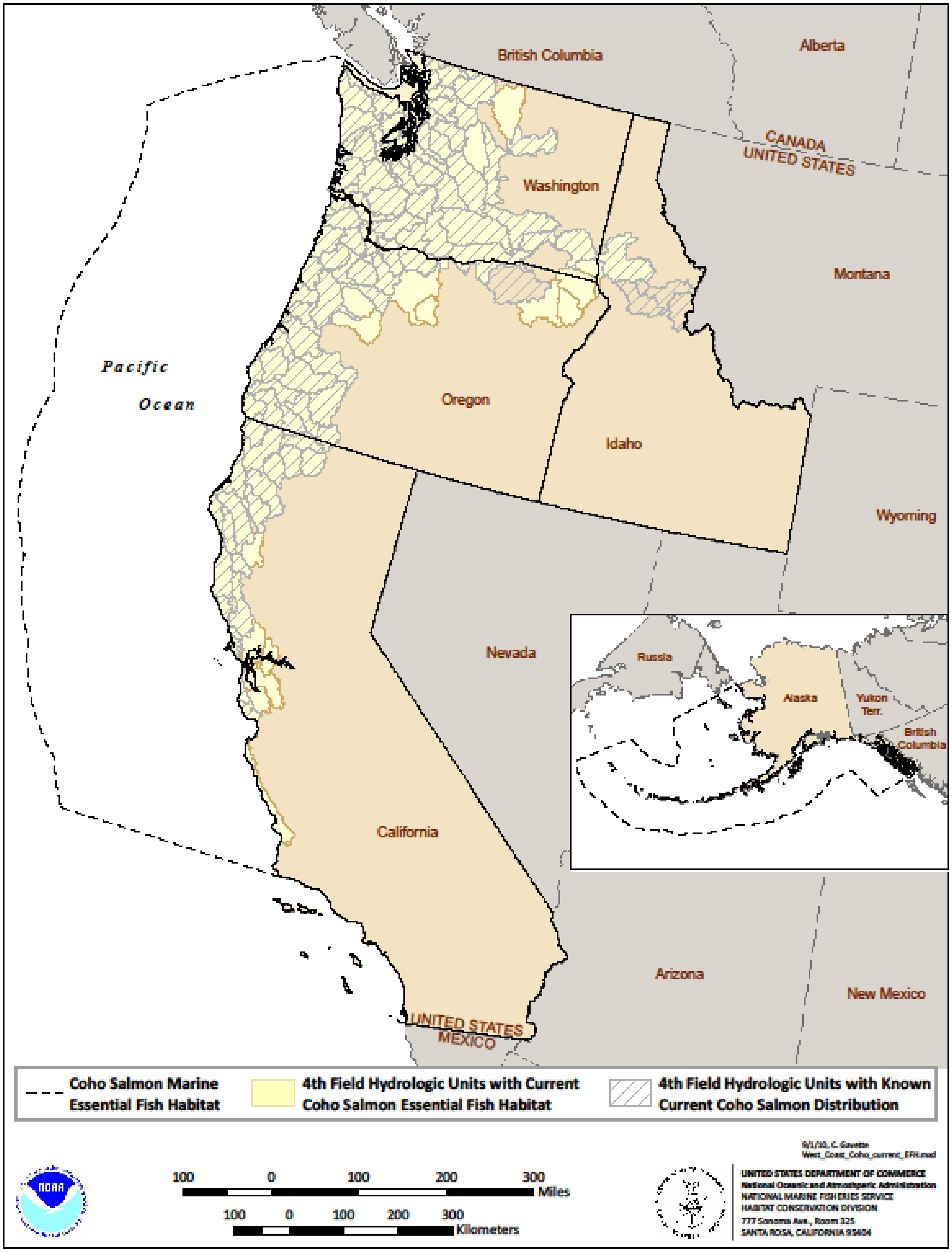

Figure 4. 4th field HUs and marine waters currently identified as EFH for coho salmon in relation to current coho salmon distribution in the U.S. West Coast and Alaska.

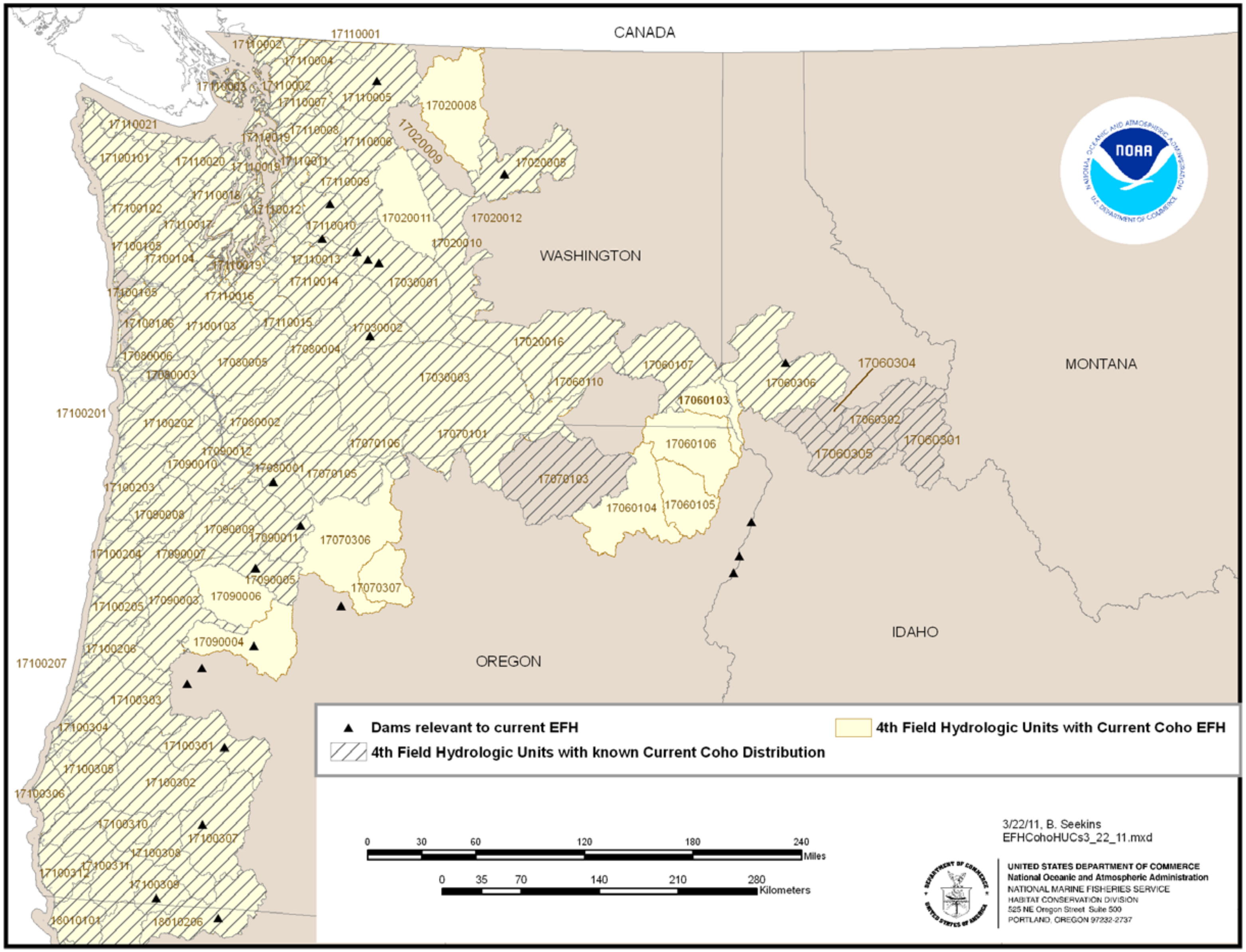

Figure 5. 4th field HUs currently identified as EFH for coho salmon in relation to current coho salmon distribution in Washington, Oregon, and Idaho.

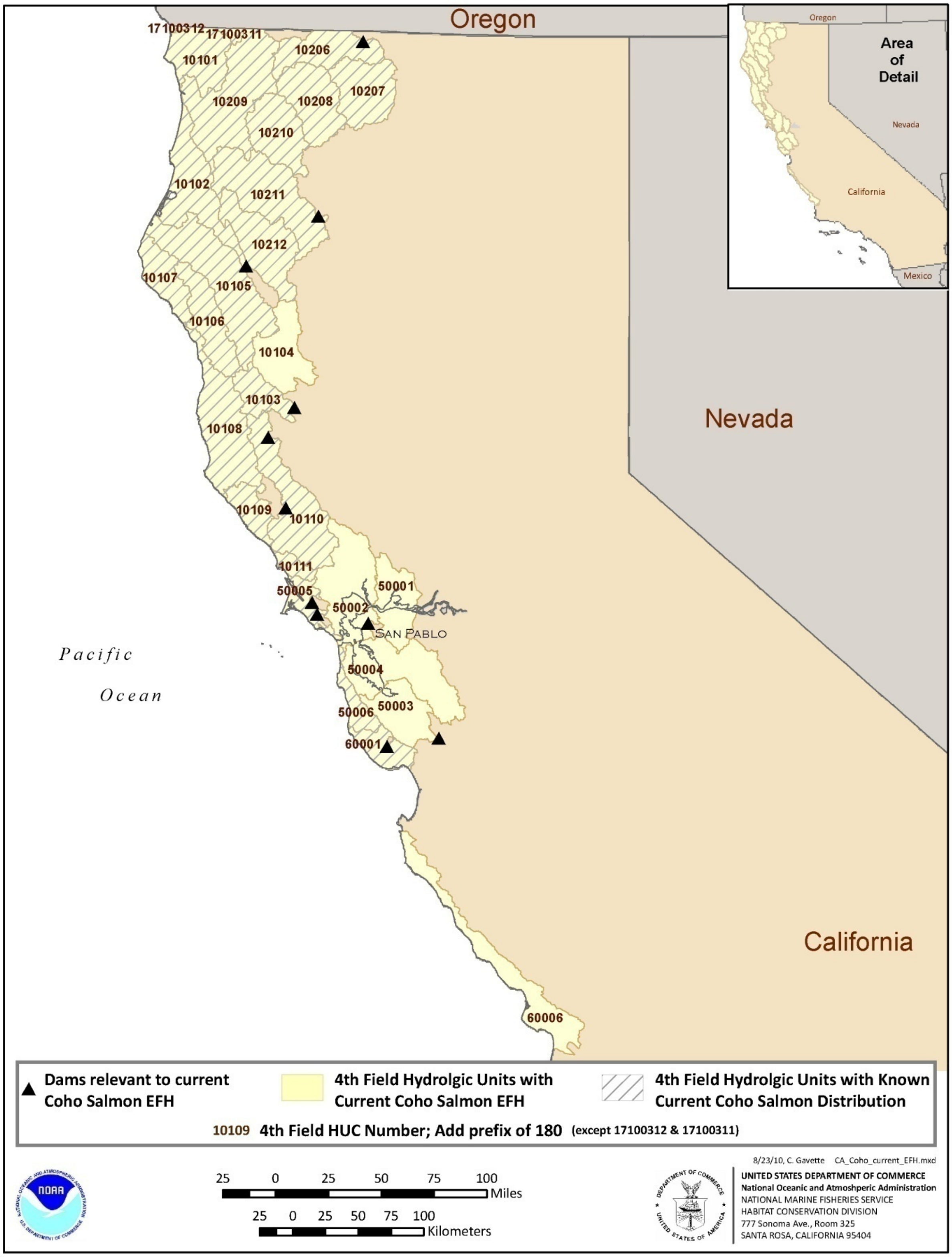

Figure 6. 4th field HUs currently identified as EFH for coho salmon in relation to coho salmon distribution in California.

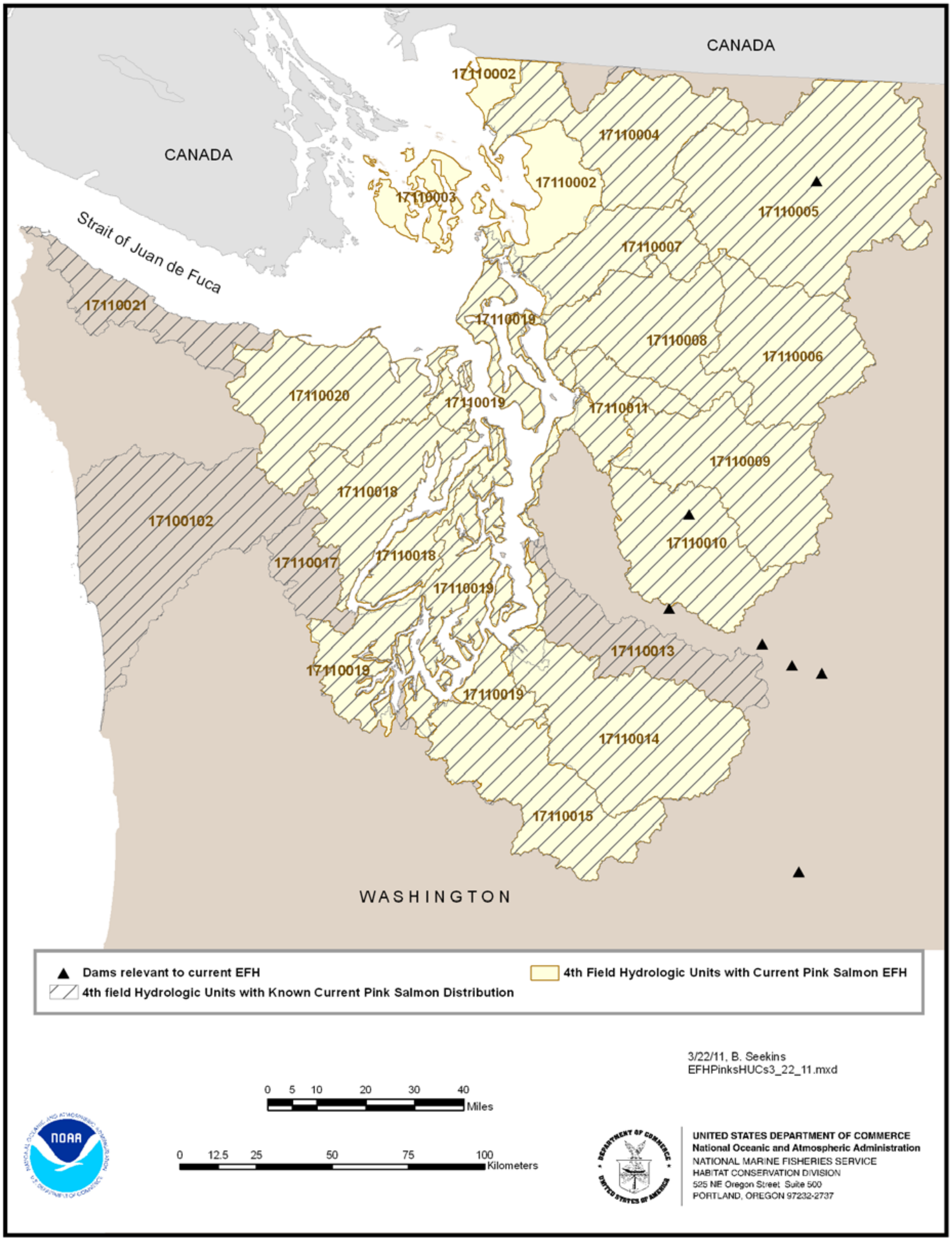

Figure 7. 4th field HUs currently identified as EFH for PS pink salmon in relation to current PS pink salmon distribution in western Washington.

3. REVIEW ESSENTIAL FISH HABITAT FOR PACIFIC COAST SALMON

A primary purpose of an EFH review is to examine new or newly-available information, especially as it relates to the information that was used as the basis for the original EFH designations. The regulatory guidance provides guidelines for organizing information. They recommend organizing the habitat information into one of four levels, and then suggest describing EFH based on the highest level of data (50 CFR 600.815(a)(1)(B)). These levels are:

Level 1: Distribution data are available for some or all portions of the geographic range of the species. At this level, only distribution data are available to describe the geographic range of a species (or life stage).

Level 2: Habitat-related densities of the species are available. At this level, quantitative data (i.e., density or relative abundance) are available for the habitats occupied by a species or life stage.

Level 3: Growth, reproduction, or survival rates within habitats are available. At this level, data are available on habitat-related growth, reproduction, and/or survival by life stage.

Level 4: Production rates by habitat are available. At this level, data are available that directly relate the production rates of a species or life stage to habitat type, quantity, quality, and location.

The available data on the habitat of Pacific Coast salmon includes some from all four levels. Pacific Coast salmon are distributed over a wide geographic range, with populations adapted to local habitat conditions that can vary widely across this range. Current distribution data (Level 1) is generally available across the entire geographic range. However, historical distribution data are lacking in certain parts of the range, and particularly in areas in which salmon populations have been extirpated. Information from the other levels, on the other hand, is generally not available across the entire range, and where available is usually limited to a smaller geographic area (i.e., a watershed or basin). Habitat-specific information from one location does not necessarily apply across the entire range. Therefore, it is appropriate to determine the geographic distribution of EFH for Pacific Coast salmon using Level 1 information, and incorporate information from the other levels, when possible, in the species- and life-stage-specific descriptions of EFH.

The Panel included two geographic information system (GIS) specialists who provided spatial information and maps to assist in identifying existing EFH and distribution information and determining whether new information warranted changes to the existing EFH maps. Updates, refinements, and revisions have occurred to both the hydrologic units and the salmon distribution data sets since the 1999 designation of EFH. The data used to create the 1999 designation was compared to recent data and NMFS GIS specialists provided potential updates to EFH where appropriate.

Historical and Current Distribution

The Panel recognizes that, as currently designated, EFH for Pacific Coast salmon is very broad, and includes virtually all freshwater habitats in those river systems that are currently or were historically occupied by salmon. However, the MSA defines EFH as “those waters and substrate necessary to fish for spawning, breeding, feeding or growth to maturity.” The anadromous life history strategies of Pacific salmon rely on the connectedness of their habitats, from the rivers and streams downstream to the estuary and out to marine waters. Every habitat along this continuum serves a vital function in salmon life history, whether it is spawning, rearing, foraging, migrating, or a combination of these functions. Excluding any of these habitats from EFH would ignore the dependency that salmon have on this continuum and would conflict with the statutory definition of EFH. The Panel also recognized that within any river system, there is a limit on the upstream extent of habitats utilized by salmon, and that the three species will utilize the various habitats differently (e.g., coho salmon will spawn in smaller streams than either Chinook salmon or PS pink salmon). However, the data to allow for identification of EFH on a stream-by-stream basis are not available.

The Panel compared the current data on distribution of Pacific Coast salmon in freshwater and marine habitats with the current EFH designations. The freshwater and marine habitats are discussed separately because freshwater systems are classified by spatially-explicit HUs and marine waters are not. In addition, the physical nature of the habitats is different (e.g., freshwater systems have both natural and man-made barriers to salmon).

Freshwater Distribution

This section describes the various strategies that the Panel considered for determining the freshwater distribution of Pacific Coast salmon. The strategies included using current subbasin-scale distribution data and information on man-made impassible barriers (dams) to determine the current and historical distribution of salmon at the subbasin scale (4th field HU) and modeling the freshwater habitat to estimate salmon distribution at a finer resolution (e.g., stream reach). The resulting salmon distribution data were then compared to the data used to designate EFH in Amendment 14. Finally, the Panel makes recommendations to the Council on where and at what spatial resolution EFH for Pacific Coast salmon should be designated.

Amendment 14 provided the following rationale for adopting a subbasin-based designation of EFH:

> *"Adopting an inclusive, watershed-based description of EFH using USGS HUCs 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) 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 Panel agrees with this rationale, and used it for this review of EFH for Pacific Coast salmon.

Spatial Resolution of Salmon Distribution

Distribution data were obtained from the publicly available GIS data sets Streamnet (http://www.streamnet.org/) and Calfish (http://www.calfish.org/). These data were examined to determine whether it would be possible or practical to delineate EFH at finer spatial resolution.

Using USGS Hydrologic Units for EFH Designations

The current designations of freshwater EFH designations for the three species of Pacific Coast salmon are based on USGS 4th field HUs. Defining EFH at a 4th field HU level results in relatively coarse geographic descriptors. Geospatial mapping has improved significantly since the original Amendment

14, and USGS 5th or 6th field HUs are commonly used in many geospatial applications. One way to provide a more refined and precise interpretation of the text descriptions for Pacific Coast salmon EFH is to present historical and current distribution in smaller HUs. The resulting descriptions would provide a more precise spatial representation of EFH and would remove areas that are neither current nor historical salmon habitat from EFH.

However, several obstacles make this task difficult. First, and most significant, is the paucity of salmon distribution data for the 5th and 6th field HUs, where many of the HUs have no distribution data. Within the 174 4th field HUs that are currently designated as EFH, there are approximately 1052 5th field HUs and 5492 6th field HUs. Approximately 808 (77%) of the 5th field and 2990 (54%) 6th field HUs have known presence data. Figures 8 and 9 illustrate the extent of the 5th and 6th field HUs that lack distribution data. It is important to note that because neither Streamnet nor Calfish contain data on salmon absence, it is not reasonable to assume that all units without distribution data are unoccupied. Nor is current distribution information necessarily a good indicator of historical occupancy. The Panel concluded that the uncertainty associated with these smaller hydrologic units that lack distribution data, and the need to maintain a consistent approach across the geographic range of Pacific Coast salmon, precluded refining EFH down to the 5th or 6th field HU.

The second and less problematic issue is the magnitude of staff resources required to analyze all 5492 6th field HUs or 1052 5th field HUs. To ensure areas were not being erroneously omitted from, or included in, EFH designations, biologists with detailed knowledge of salmon distribution in a particular geographic region would need to evaluate these individual 5th or 6th field HUs. This task could not be completed during this review process. Therefore, the Panel concluded that designating EFH at the 4th field HU was both reasonable and appropriate at this time.

Mapping EFH at the 4th field HU may be seen as overly broad because it appears to incorporate not only the streams, but the upland areas as well. However, EFH can be designated only in aquatic habitats, so it is the streams in each HU that are designated as EFH, and not the uplands. Figure 10 illustrates how the extent of EFH is actually far less than the entire 4th field HU.

Designating at the 4th field level also may be seen as overly broad because it designates all streams, in their entirety, within that HU as EFH. However, the Panel recognizes that there will be portions of the streams in each 4th field HU that are not currently or historically utilized by salmon, especially in the upper reaches. Similar to the difficulty in designating EFH at the 6th field HU level, salmon distribution for each stream reach is not available across the entire geographic range of salmon. This apparent broadness can be reduced if the designations are modified in practice according to location and species-specific information. If, for example, a stream reach is upstream of the upper-most reach occupied, either currently or historically, by a particular species, then it should not be considered EFH for that species. Consulting biologists with a better understanding of salmon distribution in a particular region should be able to make this type of determination.

The 4th field HUs used to designate EFH in Amendment 14 were based on data created by the USGS in 1987. However, in 1999 the U.S. Department of Agriculture's Natural Resource Conservation Service published an updated GIS dataset that differs slightly from the 1987 data in the spatial extent, names, and codes of some of the HUs. These inconsistencies appear to be confined to the California Central Valley and the Puget Sound Region, where in some areas the subbasins have been more accurately

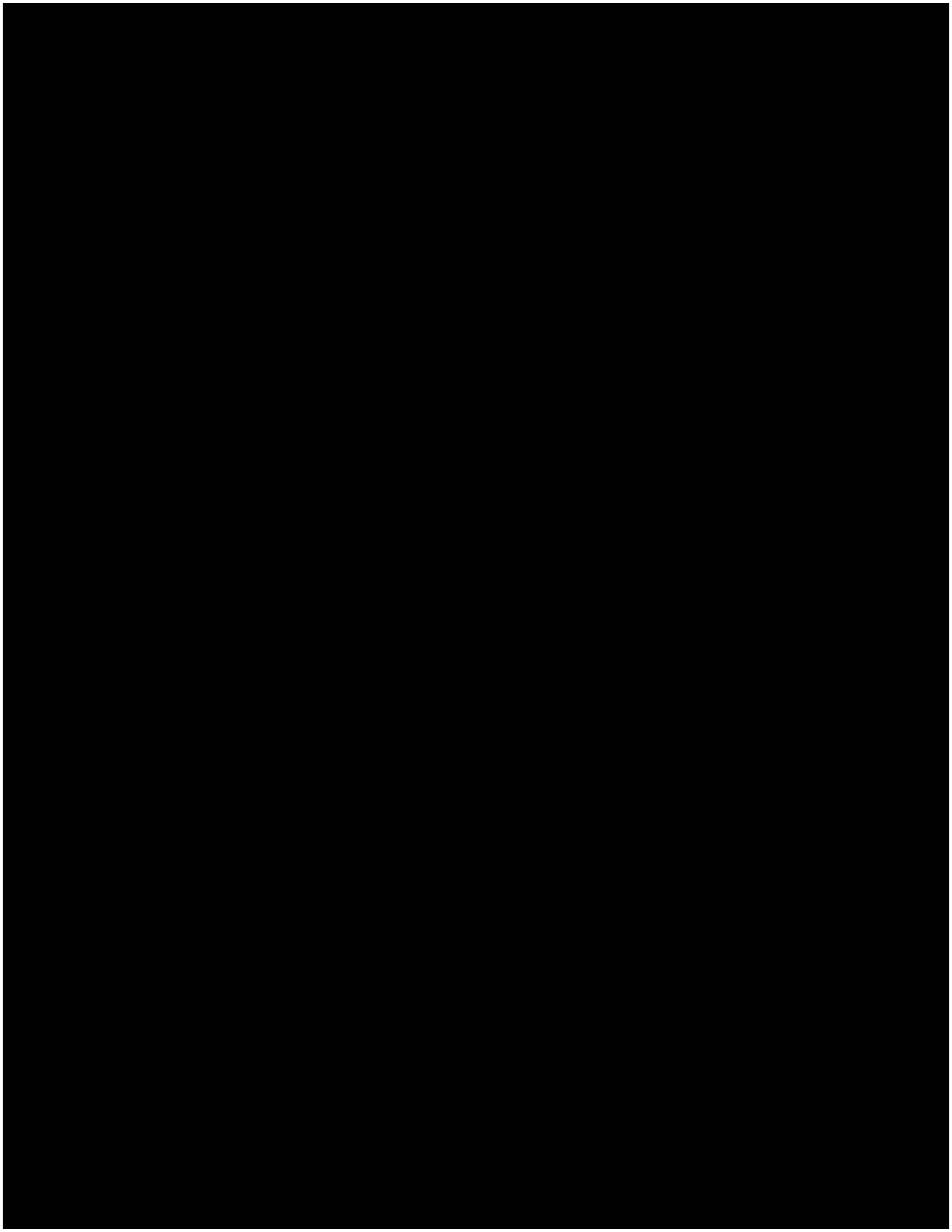

Figure 8. Example comparison of 6th field HUs with current or historical distribution data for coho salmon with those lacking distribution data.

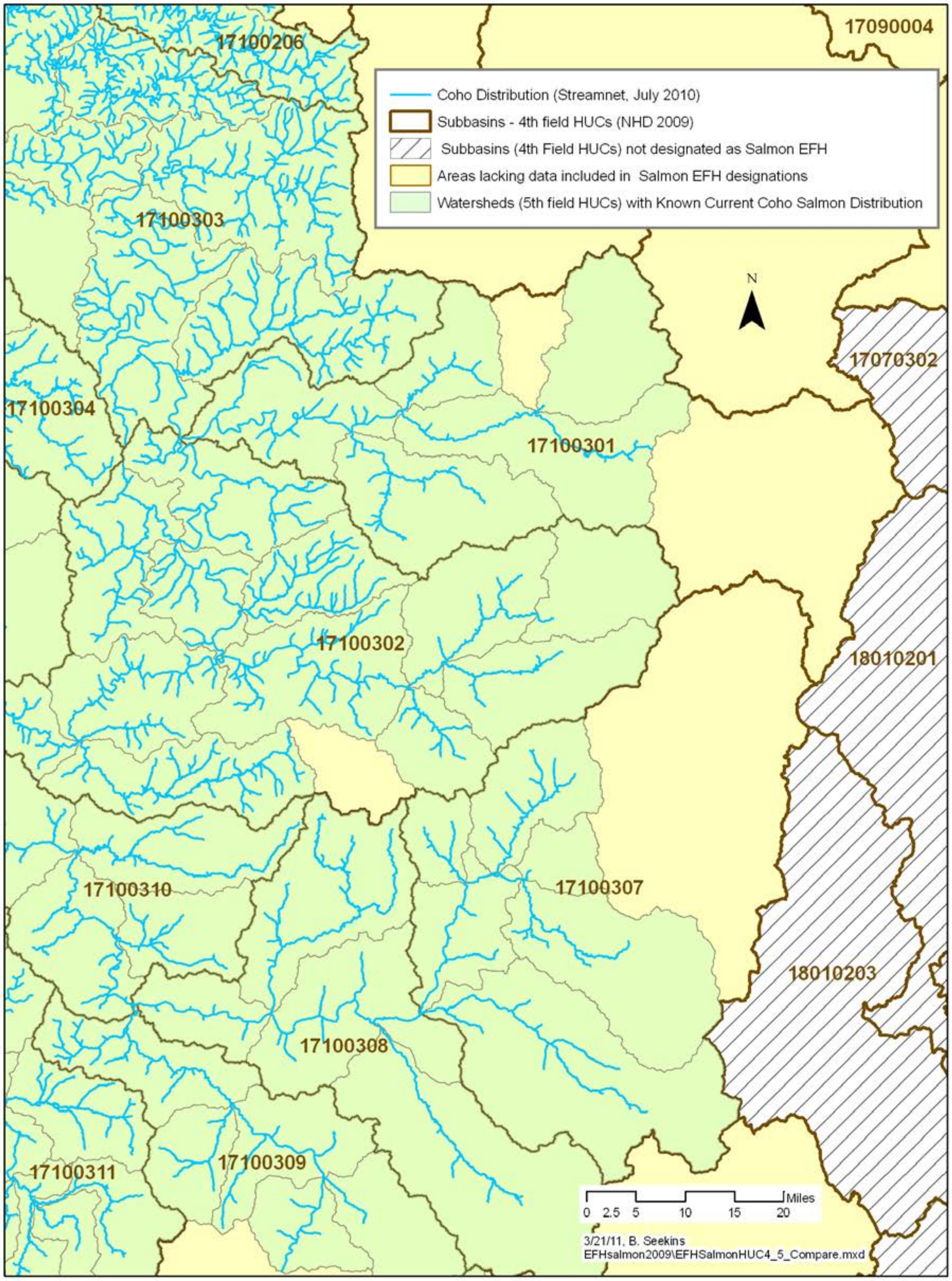

Figure 9. Example comparison of 5th field HUs with current or historical distribution data for coho salmon with those lacking distribution data.

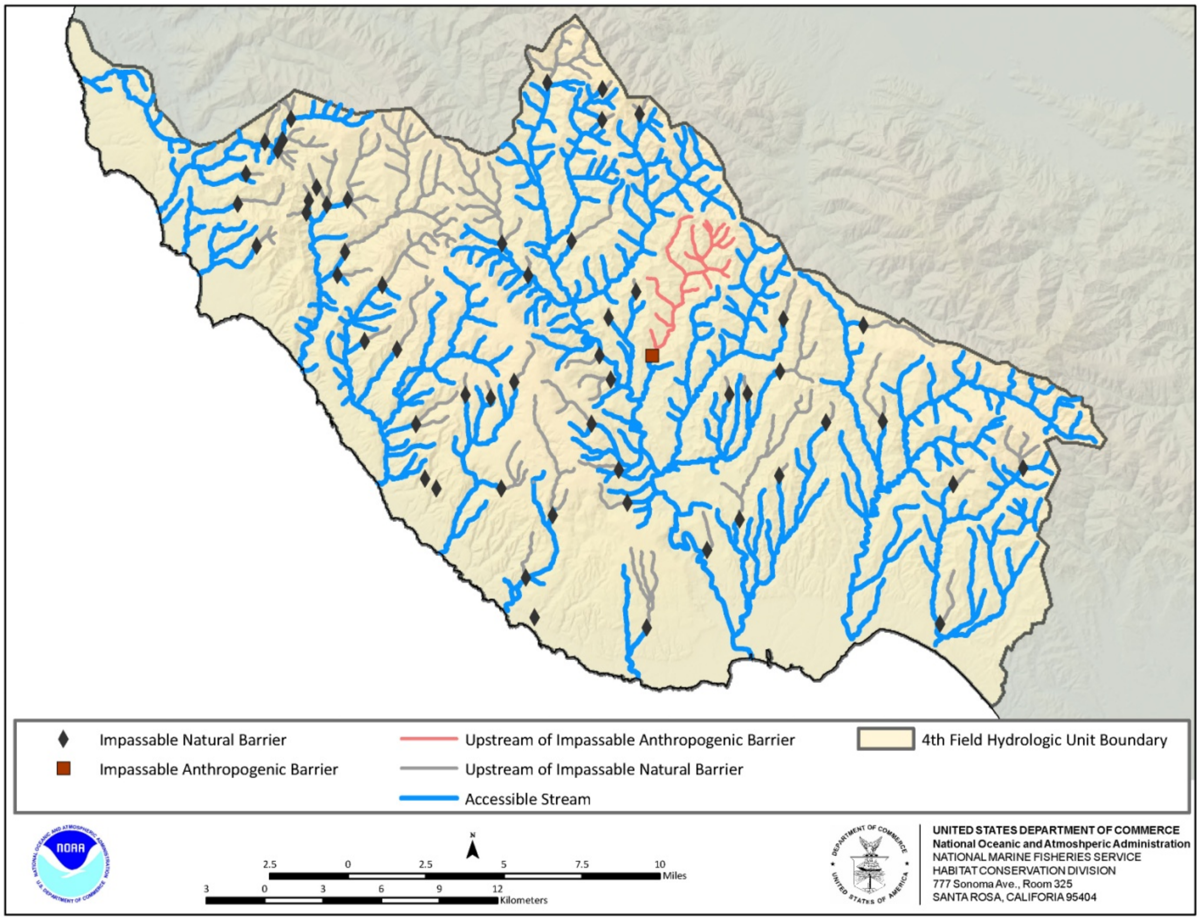

Figure 10. Example 4th field HU showing stream segments that are designated as EFH. Accessible stream reaches below anthropogenic and natural barriers that represent the upstream extent of EFH are shown.

delineated. The Panel determined that the updated GIS data is the most appropriate information to use for this review. Differences between these datasets, and the potential changes are noted in the tables where they affect the designation of EFH.

4th Field Distribution Data by Species

The Panel determined the current distribution, at the 4th field HU, of all three species of Pacific Coast salmon in Oregon, Washington, and Idaho using data on the presence of these species obtained from Streamnet (http://www.streamnet.org/), and in California from Calfish (http://www.calfish.org/). These data sets include data from stream surveys. However, because not all stream reaches are surveyed, Streamnet includes streams where, based on the best professional judgment of the state fisheries biologists, salmon are expected to occur. Additionally, Calfish represents only the known distribution based on where the species has been recently observed and reported. The majority of observations only indicate where the species was sampled for or otherwise observed. Because of this, the data likely underestimates the absolute geographic distribution of the species. And, as the species may not be found on an annual basis in all indicated reaches due to natural variations, the data does not verify that the species are currently present in a given stream. Conversely, the absence of distribution for a given stream does not necessarily indicate that the species does not occur in that stream. In addition, the Panel is aware of some current distribution data that are not reflected in the Calfish database (e.g., Leidy et al. 2007; Ettlinger et al. 2010).

Chinook Salmon

The current distribution data for Chinook salmon is depicted in Figures 1-3, which also compares these data with Amendment 14. There are 10 4th field HUs that are currently designated as EFH, but have no current distribution data for Chinook salmon (Table 2). In three cases, Amendment 14 indicates that these were either inaccessible historical habitat, or currently accessible but underutilized habitat. Therefore, they meet the general description of EFH and should retain their designation. These HUs are either currently accessible or were historically occupied by Chinook salmon, and therefore meet the designation criteria as described in Amendment 14. Of the remaining seven HUs, five were indicated in Amendment 14 as having data on presence in 1999, but that data was either not incorporated into the GIS databases used in this review or was found in the intervening years to be erroneous. The remaining two HUs are the San Juan Islands and Strait of Georgia, where Chinook salmon are known to occur in the marine waters, but not in the streams. Therefore, it is only the marine waters of these HUs that qualify as EFH for this species.

Four 4th field HUs have current Chinook salmon distribution data, but were not designated as EFH in Amendment 14 (Table 3). The presence of Chinook salmon in Lake Chelan (17020009) appears to be limited to the lower reaches, below a naturally impassible stream reach. Although Chinook salmon are present in the lake, these are non-anadromous fish, and are not likely to part of the FMU and therefore not managed by the Council. Another HU, Palouse (17060108) has current Chinook salmon distribution data but was not designated as EFH. The third, the lower north fork of the Clearwater River (17060308) had no data on presence in 1999, but now does. These data are from the relatively short portion of river that is below Dworshak Dam. The fourth HU is Tomales-Drakes Bay (18050005). Ettlinger et al (2010) reported that Chinook salmon have been observed in this subbasin (Lagunitas Creek) in 12 out of the last 15 years.

Although Calfish lacks Chinook salmon distribution data for Coyote Creek (18050003), an HU that is currently designated as EFH for this species, Leidy et al. (2007) report that Chinook salmon are present in this subbasin.

Using the most recent 4thfield HU GIS data produces potential alterations to the Chinook salmon EFH designation. Comparing the 1999 HUCs designated as EFH to the most recent data reveal several differences in HU numbers, names, and spatial extent, primarily in the California Central Valley. Figure 11 illustrates those differences. While some new areas may be designated as EFH, other areas that were previously designated as EFH may now be excluded. For example, the Fresno River is now defined as a separate subbasin where it was previously incorporated into the larger San Joaquin HU. The lack of historical or current Chinook salmon presence in the Fresno River precludes its inclusion in EFH. In the same way the area covered by the southwest corner of the current designation would no longer be included. This is due to the newer data more accurately defining the subbasin boundaries. Table 4 shows the 4th field HUs from Amendment 14 that should be removed from EFH for Chinook salmon because they no longer exist.

Recommendation

The Panel recommends consideration of updating EFH designations for Chinook salmon, based on the distribution information provided above and the potential changes indicated in Tables 4 and 5.

Table 2. 4th field HUs lacking current distribution data but designated as EFH in Amendment 14, and the reason they are included in Amendment 14. Species: CK = Chinook salmon, CO = coho salmon, PK = PS pink salmon. Basis for inclusion in Amendment 14: C = occupied in 1999; H = inaccessible historical habitat; H*= accessible as of 1999 but unutilized, NA = not indicated.

4^{th} Field Hydrologic Unit	Tributary/Basin	State	Species	Basis for Inclusion in Amendment 14
17020008	Methow River	WA	CO	H*
17020011	Wenatchee River	WA	CO	C
17060103	Lower Snake – Asotin Creek	ID/WA	CO	H*
17060104	Upper Grande Ronde	OR	CO	H*
17060105	Wallowa River	OR	CO	H*
17060106	Lower Grande Ronde	OR/WA	CO	H*
17070102	Walla Walla River	OR/WA	CK	H*
17070301	Upper Deschutes River	OR	CK	H
17070305	Lower Crooked River	OR	CK	H
17070306	Lower Deschutes River	OR	CO	C
17070307	Willow Creek	OR	CK	H*
17070307	Trout Creek	OR	CK and CO	H*
17080004	Upper Cowlitz	WA	CK	C
17090004	McKenzie River	OR	CO	C
17090006	South Santiam	OR	CO	C
17110002	Strait of Georgia*	WA	CH and PK	NA
17110003	San Juan Islands*	WA	CK and PK	NA
18010104	Middle Fork Eel River	CA	CO	C
18010109	Gualala-Salmon River	CA	CK	C
18010111	Bodega Bay	CA	CK	C
18050001	Suisun Bay	CA	CK and CO	C
18050002	San Pablo Bay	CA	CK and CO	C
18050004	San Francisco Bay	CA	CK and CO	C
18060006	Central Coastal	CA	CO	H*

* These hydrologic units include marine waters, but no Chinook salmon or PS pink salmon distribution data in freshwater.

Table 3. 4th field HUs having current or historical distribution data but are not designated as EFH in Amendment 14. Ck=Chinook salmon; CO = coho salmon, PK = PS pink salmon.

4^{th} Field hydrologic unit	Tributary/Basin	State	Species	Basis for Exclusion From Amendment 14
17020009	Lake Chelan	WA	CK	No data reported.
17060108	Palouse	ID/ WA	CH	No data reported
17060301	Upper Selway River	ID	CO	No data reported
17060302	Lower Selway River	ID	CO	No data reported
17060304	MF Clearwater River	ID	CO	No data reported
17060305	SF Middle Clearwater River	ID	CO	No data reported
17060308	Lower NF Clearwater River	ID	CH	No data reported
17070103	Umatilla River	OR	CO	No data reported
17110013	Duwamish River	WA	PK	No data reported, but recent large returns
17110017	Skokomish River	WA	PK	No data reported. Outside of FMU?
17110021	Hoko-Crescent	WA	PK	No data reported. Outside of FMU?
17100102	Queets-Quinault	WA	PK	No data reported. Outside of FMU?
18050005	Tomales-Drakes Bay	CA	CK	No data reported

Table 4. 4th field HUs in California that are currently designated as EFH for Chinook salmon in Amendment 14, but due to revisions in the HU codes and names, no longer exist.

USGS 4th Field Hydrologic Unit	Hydrologic Unit Name
18010111	Bodega Bay
18020101	Sac.–Lower Cow–Lower Clear
18020102	Lower Cottonwood Creek
18020103	Sacramento – Lower Thomes
18020105	Lower Butte Creek
18020106	Lower Feather River
18020107	Lower Yuba River
18020108	Lower Bear River
18020109	Lower Sacramento River
18020110	Lower Cache
18020112	Sacramento–Upper Clear
18020113	Cottonwood Headwaters
18020114	Upper Elder – Upper Thomas
18020118	Upper Cow – Battle Creek
18020119	Mill – Big Chico
18020120	Upper Butte Creek
18040004	L. Calaveras – Mormon Slough
18040005	L. Consumnes– L. Mokelumne

Figure 11. Comparison of the California Central Valley 4th field HUs designated as EFH in Amendment 14 with the newly defined HUs having current or historical Chinook salmon distribution data. Note that the spatial extent of EFH for Chinook salmon has expanded in some areas.

Coho Salmon

The current distribution data for coho salmon is depicted in Figures 4-6, which also compares these data with Amendment 14. There are 16 4th field HUs that are currently designated as EFH, but have no current distribution data for coho salmon (Table 2). Of these, Amendment 14 indicates that six were currently accessible but not occupied The remaining 10 were indicated in Amendment 14 as having data on presence in 1999, but that data was either not incorporated into the GIS databases used in this review or was found in the intervening years to be erroneous. These HUs are either currently accessible or were historically occupied by coho salmon, and therefore meet the designation criteria as described in Amendment 14.

Although Calfish lacks coho salmon distribution data for Coyote Creek (18050003) and San Pablo Bay (18050002), HUs that are currently designated as EFH for this species, Leidy et al. (2005, cited in Leidy et al. 2007)) found evidence for probable occurrence in these subbasins.

Seven 4th field HUs have current data on presence of coho salmon, but were not designated as EFH in Amendment 14 (Table 3).

Recommendation

The Panel recommends further consideration of the designation of EFH for coho salmon based on the distribution information provided above and the potential changes indicated in Table 5.

Puget Sound Pink Salmon

The current distribution of PS pink salmon is depicted in Figure 7, which also compares these data with Amendment 14. There are two 4th field HUs that are currently designated as EFH, but for which Streamnet has no distribution data (Table 2), and no distribution data are noted in Amendment 14. Although PS pink salmon utilize the adjacent marine waters, they are not known to occur in the streams of these hydrologic HUs. However, these two HUs also include marine waters that are assumed to support emigrating juveniles and returning adults. Therefore, despite the lack of PS pink salmon in the stream systems of these HUs, they do qualify as EFH, but only the marine waters. There are four 4th field HUs that have current data on the presence of pink salmon, but are not currently designated as EFH (Table 3). Of these, the Duwamish (17110013) has experienced dramatic returns of pink salmon in recent years. The Washington State Department of Fish and Wildlife estimates that up to 2.1 million pink salmon will return to the Duwamish system in 2011. Despite the lack of data on presence in the Duwamish in 1999, there is no question that pink salmon occupy this system.

The three remaining HUs, the Skokomish River (17110017), the Hoko-Crescent (17110021) and the Queets-Quinault (17110102) are shown in SteamNet as being occupied by pink salmon. However, their distribution in these systems is limited and they may have simply been missed by Amendment 14.

Another possible explanation for the exclusion of the Hoko-Crescent and Queets-Quinault pink salmon is that they are not part of the PS pink salmon fishery management unit (FMU). The PS pink salmon FMU is not clearly defined in the FMP and the western boundary is uncertain. The Elwha River is the westernmost subbasin that was designated as EFH for this species. This coincides with the westernmost populations of the pink salmon Evolutionarily Significant Unit (ESU) identified by NMFS in the 1996 status review (NMFS 1996). In this Status Review, two pink salmon ESUs (even-year and odd-year) were found to be distributed in the Elwha River and eastward. Whether or not the status review erroneously excluded the Hoko-Crescent and Queets-Quinault HUs is unknown, but it appears that the 1999 designation of EFH for PS pink salmon is based on the ESUs.

Recommendation

The Panel recommends further consideration of the designation of EFH for PS pink salmon based on the distribution information provided above and the potential changes indicated in Table 5.

Distribution Modeling

The Panel considered using new modeling applications that could be useful for assessing salmon habitat suitability. The desired outcome was to use a modeling approach to infer salmon distribution in areas that lack such information and to increase the precision of spatial distribution maps. To have utility, a model must be applicable across the entire geographic range of Pacific Coast salmon, yet be sufficiently precise to provide information on a relatively small spatial scale. Although many models to assess salmonid habitat are in use, most are applicable to a relatively limited geographic scope. Only Intrinsic Potential (IP) was considered to potentially be of use and was the only model explored past the discussion stage.

Intrinsic Potential

Intrinsic Potential models are intended to predict the historical (i.e., pre-anthropogenic disturbance) potential for a given stream reach to develop habitat characteristics suitable for a particular salmonid species and life stage based on a limited set of geomorphic and hydrologic characteristics. Most IP models convert values for stream gradient, valley width index, and mean annual discharge (landform, geomorphic, and hydrologic functions that interact to govern movement and deposition of sediment, large wood, and other structural elements along a river network) into separate suitability ratings scaled between 0 and 1. These individual suitability values are combined (typically as the geometric mean of these three suitability values) into the IP value for a particular reach. Additionally, some models may incorporate other environmental factors thought to limit the distribution or abundance of a particular species. For example, models of coho salmon intrinsic potential in California streams incorporate a mean August air temperature threshold as a method of masking out regions where water temperatures are too warm for coho salmon.

Intrinsic Potential models have potential application both in identifying EFH and in designating HAPCs. Specifically, the Panel explored using IP in areas that lack robust empirical information regarding salmonid presence/absence, either because they have not been surveyed or because populations have been extirpated. If a given hydrologic unit has never been surveyed and the paucity of valid information precludes definitively concluding current or historical presence, IP can be used to infer answers to those questions. IP models also typically include biophysical factors such as gradient that could be used to evaluate the relative suitability of different stream reaches, though such potential uses are confounded by the fact that IP models may be poor predictors of current habitat conditions, as none of the variables reflect habitat changes caused by anthropogenic activities. Figure 12 shows an example of how IP can be used to infer habitat suitability. In this example, stream reaches with suitable IP are highlighted and then colored to indicate stream reaches above currently impassible barriers. One barrier (Nicasio Dam) is being considered for fish passage while the other (Peters Dam) is not. Both dams, however, show IP above the barrier.

IP models have also been used extensively by salmon technical recovery teams to provide rough estimates of the relative habitat potential among different watersheds and subwatersheds. In these applications, the sum of all stream segment distances weighted by their IP values is calculated, a value termed IP-km. These estimates were used as proxies for relative habitat capacity in different hydrologic units.

Table 5. All 4th field HUs with current or historical distribution data for each species of Pacific Coast salmon and potential changes to the current EFH designations. C = currently designated as EFH; D = current or historical distribution data but not currently designated as EFH. The new HUs are from the updated dataset that overlap with the out-of-date HUs that are designated as EFH in Amendment 14.

USGS 4th Field Hydrologic Unit	State(s)	Hydrologic Unit Name	Species Distribution Data			Potential change
			Chinook	Coho	PS Pink	
17020005	WA	Columbia River	C	C		None
17020006	WA	Okanogan River	C			None
17020009	WA	Lake Chelan	D			Designate as EFH for Chinook salmon
17020007	WA	Similkameen	C			None
17020008	WA	Methow River	C	C		None
17020010	WA	Upper Columbia – Entiat River	C	C		None
17020011	WA	Wenatchee River	C	C		None
17020016	WA	Upper Columbia – Priest Rapids	C	C		None
17030001	WA	Upper Yakima River	C	C		None
17030002	WA	Naches River	C	C		None
17030003	WA	Lower Yakima River	C	C		None
17060101	OR/ID	Hells Canyon	C			None
17060102	OR	Imnaha River	C			None
17060103	OR/WA/ID	Lower Snake – Asotin Creek	C	C		None
17060104	OR	Upper Grande Ronde	C	C		None
17060105	OR	Wallowa River	C	C		None
17060106	OR/WA	Lower Grande Ronde	C	C		None
17060107	WA	Lower Snake – Tucannon River	C	C		None
17060110	WA	Lower Snake River	C	C		None
17060201	ID	Upper Salmon River	C			None
17060202	ID	Pahsimeroi River	C			None
17060203	ID	Mid. Salmon – Panther River	C			None
17060204	ID	Lemhi River	C			None
17060205	ID	Upper Middle Fork Salmon River	C			None
17060206	ID	Lower Middle Fork Salmon River	C			None
17060207	ID	Mid. Salmon – Chamberlain	C			None
17060208	ID	S.F. Salmon River	C			None
17060209	ID	Lower Salmon River	C			None

USGS 4th Field Hydrologic Unit	State(s)	Hydrologic Unit Name	Species Distribution Data			Potential change
			Chinook	Coho	PS Pink	
17060210	ID	Little Salmon River	C			None
17060301	ID	Upper Selway River	C	D		Designate as EFH for coho salmon
17060302	ID	Lower Selway River	C	D		Designate as EFH for coho salmon
17060304	ID	M.F. Clearwater River	C	D		Designate as EFH for coho salmon
17060305	ID	S.F. Clearwater River	C	D		Designate as EFH for coho salmon
17060306	WA/ID	Clearwater River	C	C		None
17060308	ID	Lower NF Clearwater River	D	D		Designate as EFH for Chinook salmon and coho salmon
17070101	OR/WA	Mid. Columbia – Lake Wallula	C	C		None
17070102	OR/WA	Walla Walla River	C			None
17070103	OR	Umatilla River	C	D		Designate as EFH for coho salmon
17070104	OR	Willow	C			None
17070105	OR/WA	Mid. Columbia – Hood	C	C		None
17070106	WA	Klickitat River	C	C		None
17070201	OR	Upper John Day River	C			None
17070202	OR	North Fork John Day River	C			None
17070203	OR	Middle Fork John Day River	C			None
17070204	OR	Lower John Day River	C			None
17070301	OR	Upper Deschutes River	C			None
17070305	OR	Lower Crooked River	C			None
17070306	OR	Lower Deschutes River	C	C		None
17070307	OR	Trout Creek	C	C		None
17080001	OR/WA	Lower Columbia–Sandy River	C	C		None
17080002	WA	Lewis River	C	C		None
17080003	OR/WA	Lower Columbia – Clatskanie River	C	C		None
17080004	WA	Upper Cowlitz River	C	C		None
17080005	WA	Cowlitz River	C	C		None
17080006	OR/WA	Lower Columbia	C	C		None
17090001	OR	Middle Fork Willamette River	C			None
17090002	OR	Coast Fork Willamette River	C			None
17090003	OR	Upper Willamette River	C	C		None
17090004	OR	McKenzie River	C	C		None

USGS 4th Field Hydrologic Unit	State(s)	Hydrologic Unit Name	Species Distribution Data			Potential change
			Chinook	Coho	PS Pink	
17090005	OR	N. Santiam River	C	C		None
17090006	OR	S. Santiam River	C	C		None
17090007	OR	Mid. Willamette River	C	C		None
17090008	OR	Yamhill River	C	C		None
17090009	OR	Molalla – Pudding River	C	C		None
17090010	OR	Tualatin River	C	C		None
17090011	OR	Clackamas River	C	C		None
17090012	OR	Lower Willamette River	C	C		None
17100101	WA	Hoh – Quillayute	C	C		None
17100102	WA	Queets – Quinault	C	C	D	Designate as EFH for PS pink salmon
17100103	WA	Upper Chehalis River	C	C		None
17100104	WA	Lower Chehalis River	C	C		None
17100105	WA	Grays Harbor	C	C		None
17100106	WA	Willapa Bay	C	C		None
17100201	OR	Necanicum River	C	C		None
17100202	OR	Nehalem River	C	C		None
17100203	OR	Wilson – Trask – Nestucca	C	C		None
17100204	OR	Siletz–Yaquina River	C	C		None
17100205	OR	Alsea River	C	C		None
17100206	OR	Siuslaw River	C	C		None
17100207	OR	Siltcoos River	C	C		None
17100301	OR	N. Umpqua River	C	C		None
17100302	OR	S. Umpqua River	C	C		None
17100303	OR	Umpqua River	C	C		None
17100304	OR	Coos River	C	C		None
17100305	OR	Coquille River	C	C		None
17100306	OR	Sixes River	C	C		None
17100307	OR	Upper Rogue River	C	C		None
17100308	OR	Middle Rogue River	C	C		None
17100309	CA/OR	Applegate River	C	C		None
17100310	OR	Lower Rogue River	C	C		None

USGS 4th Field Hydrologic Unit	State(s)	Hydrologic Unit Name	Species Distribution Data			Potential change
			Chinook	Coho	PS Pink	
17100311	CA/OR	Illinois River	C	C		None
17100312	CA/OR	Chetco River	C	C		None
17110001	WA	Fraser (Whatcom)		C		None
17110002	WA	Strait of Georgia†	C	C	C	None
17110003	WA	San Juan Islands†	C	C	C	None
17110004	WA	Nooksack River	C	C	C	None
17110005	WA	Upper Skagit	C	C	C	None
17110006	WA	Sauk River	C	C	C	None
17110007	WA	Lower Skagit River	C	C	C	None
17110008	WA	Stillaguamish River	C	C	C	None
17110009	WA	Skykomish River	C	C	C	None
17110010	WA	Snoqualmie River	C	C	C	None
17110011	WA	Snohomish River	C	C	C	None
17110012	WA	Lake Washington	C	C		None
17110013	WA	Duwamish River	C	C	D	Designate as EFH for PS pink salmon
17110014	WA	Puyallup River	C	C	C	None
17110015	WA	Nisqually River	C	C	C	None
17110016	WA	Deschutes River	C	C		None
17110017	WA	Skokomish River	C	C	D	Designate as EFH for PS pink salmon
17110018	WA	Hood Canal†	C	C	C	None
17110019	WA	Puget Sound†	C	C	C	None
17110020	WA	Dungeness – Elwha†	C	C	C	None
17110021	WA	Hoko – Crescent	C	C	D	Designate as EFH for PS pink salmon
18010101	CA/OR	Smith River	C	C		None
18010102	CA	Mad–Redwood	C	C		None
18010103	CA	Upper Eel River	C	C		None
18010104	CA	Middle Fork Eel River	C	C		None
18010105	CA	Lower Eel River	C	C		None
18010106	CA	South Fork Eel River	C	C		None
18010107	CA	Mattole River	C	C		None
18010108	CA	Big – Navarro – Garcia	C	C		None

USGS 4th Field Hydrologic Unit	State(s)	Hydrologic Unit Name	Species Distribution Data			Potential change
			Chinook	Coho	PS Pink	
18010109	CA	Gualala – Salmon Creek	C	C		None
18010110	CA	Russian River	C	C		None
18010206	CA/OR	Upper Klamath River	C	C		None
18010207	CA	Shasta River	C	C		None
18010208	CA	Scott River	C	C		None
18010209	CA/OR	Lower Klamath River	C	C		None
18010210	CA	Salmon River	C	C		None
18010211	CA	Trinity River	C	C		None
18010212	CA	S.F. Trinity River	C	C		None
18020104	CA	Sacramento – Stone Corral	C			None
18020111	CA	Lower American River	C			None
18020115	CA	Upper Stony	C			Designate as EFH due to the new HU dataset
18020116	CA	Upper Cache	C			Designate as EFH due to the new HU dataset
18020125	CA	Upper Yuba	C			None
18020126	CA	Upper Bear	C			Designate as EFH due to the new HU dataset
18020151	CA	Cow Creek	C			Designate as EFH due to the new HU dataset
18020152	CA	Cottonwood Creek	C			Designate as EFH due to the new HU dataset
18020153	CA	Battle Creek	C			Designate as EFH due to the new HU dataset
18020154	CA	Clear Creek-Sacramento River	C			Designate as EFH due to the new HU dataset
18020155	CA	Paynes Creek-Sacramento River	C			Designate as EFH due to the new HU dataset
18020156	CA	Thomes Creek-Sacramento River	C			Designate as EFH due to the new HU dataset
18020157	CA	Big Chico Creek-Sacramento River	C			Designate as EFH due to the new HU dataset
18020158	CA	Butte Creek	C			Designate as EFH due to the new HU dataset
18020159	CA	Honcut Headwaters-Lower Feather	C			Designate as EFH due to the new HU dataset
18020161	CA	Upper Coon-Upper Auburn	C			Designate as EFH due to the new HU dataset
18020162	CA	Upper Putah	C			Designate as EFH due to the new HU dataset
18020163	CA	Lower Sacramento	C			Designate as EFH due to the new HU dataset
18040001	CA	Middle San Joaquin– LowerChowchilla	C			None
18040002	CA	LowerSan Joaquin	C			None
18040003	CA	San Joaquin Delta	C			None
18040008	CA	Upper Merced	C			Designate as EFH due to the new HU dataset

USGS 4th Field Hydrologic Unit	State(s)	Hydrologic Unit Name	Species Distribution Data			Potential change
			Chinook	Coho	PS Pink	
18040009	CA	Upper Tuolumne	C			Designate as EFH due to the new HU dataset
18040010	CA	Upper Stanislaus	C			None
18040011	CA	Upper Calveras	C			None
18040012	CA	Upper Mokelumne	C			Designate as EFH due to the new HU dataset
18040013	CA	Upper Cosumnes	C			None
18040051	CA	Rock Creek-French Camp Slough	C			Designate as EFH due to the new HU dataset
18050001	CA	Suisun Bay	C	C		None
18050002	CA	San Pablo Bay	C	C		None
18050003	CA	Coyote Creek	C	C		None
18050004	CA	San Francisco Bay	C	C		None
18050005	CA	Tomales–Drakes Bay	D	C		Designate as EFH for Chinook salmon
18050006	CA	San Francisco–Coastal South		C		None
18060001	CA	San Lorenzo–Soquel		C		None
18060006	CA	Central Coastal		C		None

A workshop on Salmon Intrinsic Potential was held in Portland, OR on Nov. 19-20, 2008. A resultant product of that workshop is a paper titled "Development & Management of Fish Intrinsic Potential Data and Methodologies: State of the IP 2008 Summary Report" (Sheer et al. 2009). An excerpt from the report reads "IP models have been developed for some salmon and steelhead ESUs listed under the ESA, and model results have been incorporated into recovery planning activities. However, currently, there is no standard methodology for developing geospatial datasets needed for IP models nor are there peer-reviewed species preference curves for many resident and anadromous species in the Pacific Northwest."

Figure 12. Example of how Intrinsic Potential can help identify potentially suitable habitats for Pacific Coast salmon.

To date, IP models have been limited to several ESUs of Pacific salmon that are listed under the ESA. Although ESUs are not directly relevant to the MSA and EFH, the Panel assumed that IP models for ESA-listed salmon are applicable to all managed salmon of the same species in that area. These ESUs include:

Lower Columbia coho salmon
Lower Columbia Chinook salmon
Oregon Coast coho salmon
Willamette Chinook salmon
Puget Sound Chinook salmon
Snake River spring/ summer Chinook salmon
Upper Columbia River spring-run Chinook salmon
Southern Oregon/Northern California Coast coho salmon
Central California Coast coho salmon
California Coastal Chinook salmon

No GIS data for Snake River fall Chinook salmon are available, and the Panel is not aware of any IP models that have been developed for pink salmon. The NMFS Southwest Region GIS staff currently have resultant GIS data for the IP model work done in that region. However, individual data files do not exist for each hydrologic unit making any desired analysis fairly time-consuming. The NMFS Northwest Region GIS staff do not currently have GIS data for the IP models and would need to obtain it to use IP to infer EFH for particular hydrologic units.

Before IP modeling can be utilized to refine EFH for any of the species of Pacific Coast salmon managed under the FMP there must be regionally based models that that lead to similar spatial resolution of salmon habitat. Those models must, when taken together, cover the entire geographic range of that species. It is clear that IP modeling is inconsistent, at best, covering only a relatively small portion of the geographic range of any species. These gaps preclude the use of IP models in EFH designations, and will require significant time and effort to fill. However, the Panel also recognizes that in some cases of sparse information, existing IP can be used as a tool to investigate the likelihood of suitable salmonid habitat on a site- by-site basis for the purposes of EFH consultation.

Impassible Dams Designated as the Upstream Extent of EFH

Numerous dams block access to historical salmon habitat and/or alter the hydrography of downstream river reaches. In identifying EFH in Amendment 14, the Council considered dams that completely blocked fish passage, and used four criteria to determine whether a particular dam should represent the upstream extent of EFH:

1. *Is the dam federally owned or operated, licensed by the Federal Energy Regulatory Commission (FERC), state licensed, or subject to state dam safety supervision?* This criterion assures the dam is of sufficient size, permanence, impassibility, and legal identity to warrant consideration for inclusion in this list;

2. *Is the dam upstream of any other impassible dam?* This criterion provides for a continuous boundary of designated habitat;

3. *Is fish passage to upstream areas under consideration, or are fish passage facilities in the design or construction phase?* There is no currently, or soon to be, accessible freshwater salmon habitat that is expendable. All such habitat is key to the conservation of these species and needs the special considerations for protection and restoration incumbent with designation; and

4. *Has NMFS determined that the dam does not block access to habitat that is key for the conservation of the species?* This criterion provides for designation of habitat upstream of, and exclusion of, otherwise listed dams when NMFS is able to determine restoration of passage and conservation of such habitat is necessary for long-term survival of the species and sustainability of the fishery.

As a result, EFH was designated above a number of impassible dams that met one or more of these criteria, including Elwha Dam, Merwin Dam, Landsburg Dam, Howard Hanson Dam, Condit Dam, Cushman Dam, Mayfield Dam, Foster Dam, Pelton Dam, and Englebright Dam. Justification for designating EFH above impassable barriers has been provided in both the EFH regulations and Amendment 14 to the FMP. The regulatory text at 50 CFR §600.815(a)(1)(iv)(F) states:

> *"If degraded or inaccessible aquatic habitat has contributed to reduced yields of a species or assemblage and if, in the judgment of the Secretary and the appropriate Council(s), the degraded conditions can be reversed through such actions as improved fish passage techniques (for stream or river blockages), improved water quality measures (removal of contaminants or*

increasing flows), 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."

Amendment 14 included the following language regarding habitat needed to support a sustainable fishery and the identification of such habitat through other processes and analyses:

"While available information is not sufficient to conclude that currently accessible habitat is sufficient for supporting sustainable salmon fisheries and a healthy ecosystem, subsequent analyses (e.g., in recovery planning, ESA consultations, or hydropower proceedings) may conclude that inaccessible habitat should be made available to the species."

Amendment 14 then focused specifically on the importance of considering the need to restore fish passage to historically accessible areas through the FERC relicensing process noting:

"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. Therefore, a determination on a case-by-case basis during FERC relicensing proceedings whether fish passage facilities will be required to provide access to habitat above currently impassible barriers will be necessary. Should salmon access or reintroduction above any of the dams listed in Table A-2 become feasible, the Council will remove them from the list, and the areas above the barriers would be designated as salmon EFH."

The EFH provisions of the MSA are intended to ensure conservation and protection of EFH to promote a sustainable fishery, which requires a more robust population than necessary to ensure persistence of the population or ESU. Therefore, the Panel determined that if the habitat may be necessary for the persistence of the population or ESU, it is clearly necessary to promote a sustainable fishery. As demonstrated in both the EFH regulations and Amendment 14 to the FMP, designating EFH above impassable dams is appropriate under certain conditions and has been done in the past. The Panel agreed that the four criteria identified in Amendment 14 were still applicable and further elaborated on the interpretation of criterion 4. Specifically, habitats that may be necessary to contribute to the conservation or recovery of a species, as identified in a document such as a biological opinion, recovery plan, critical habitat designation, or FERC/Federal Power Act fish passage prescriptions, are clearly necessary to support a sustainable fishery. When available, economic analyses regarding the cost of providing fish passage should also be taken into consideration. Recovery plans must identify priority actions necessary for population recovery. In some cases, recovery plans specifically identify habitat upstream of existing dams that are on the list of impassible dams marking the upstream extent of EFH, thereby providing support for designating EFH above those dams. Consultation under the ESA typically includes issuance of a biological opinion (Opinion), which includes mandatory actions to protect the species and/or its designated critical habitat. These actions may include fish passage above dams on the list of impassable dams marking the upstream extent of EFH, again providing support for designating EFH above those dams. Another example is that of fish passage "prescriptions" issued under Section 18 of the Federal Power Act, in which NMFS may require fish passage installation and/or upgrades to existing facilities to address the impacts of a hydropower project and expand access to historical and currently suitable habitat above dams to contribute to the conservation of the species. In such cases, habitat above the dam should be designated as EFH and a new upstream extent of EFH should be identified.

The Panel applied the selection criteria to the dams that were previously determined to be the upstream extent of EFH, as published in the 2008 Final Rule that codified the EFH descriptions for Pacific Coast salmon, along with two others that were recommended to NMFS by the Bureau of Reclamation in 2007. Table 5 lists all the dams that were considered, the potential changes to the dams that are designated as the upstream extent of EFH, and the rationale behind those changes. Designation of the habitat above any of these dams as EFH would mean that consultation would be required for any Federal action that may adversely affect EFH in those areas. Designating EFH above a dam would also require that the upstream habitats be examined to see what, if any, impassible dams there are further upstream and any additional 4th field HUs that would become accessible. In areas where EFH may be designated above impassable dams, the Panel did not investigate the dams located further upstream to determine the new extent of EFH.

The potential changes to the dams that are designated as the upstream extent of EFH fall into 4 broad categories and several subcategories, as follows:

1 Corrections to the 2008 Final Rule, where a dam was designated as the upstream extent of EFH in Amendment 14, but was inadvertently omitted from 2008 Final Rule;
2 Update HU name and code to match those published by the USDA in 1999;
3 Delete a dam from the list and designate the habitat upstream as EFH because:
   - a Fish passage is now occurring or passage facilities are under construction;
   - b Fish passage at the dam is in the planning stage;
   - c Fish passage at the dam is being considered;
   - d Critical habitat has been designated above this dam;
   - e Habitat above this dam has been identified in a document as habitat that may be necessary to contribute to the conservation or recovery of a species; or
   - f The dam is upstream of another impassible barrier, either natural or man-made;
4 Designate a dam as the upstream extent of EFH because it was investigated due to a comment by a Federal agency and found to meet the criteria.

Not all of these changes are as strongly supported as others. Some, such as corrections to the final rule, updating HU names and codes, and designating the habitat above a dam as EFH because fish are now being passed, are not seen by the Panel as being controversial and can be easily implemented. However, designating habitat above a dam as EFH because passage is being considered or that it “may be essential to” or “is necessary for” the conservation of the species has broader implications, with the potential for significantly expanding EFH. Such changes will require careful consideration by the Council. In doing so, the Council should consider several factors, including, but not limited to, the strength of the information that supports the changes, the likelihood that passage will be possible in the foreseeable future, and the extent of EFH that will be designated above the dam. For these reasons, the Panel is not making specific recommendations for revising this list.

The results from this evaluation process, including potential changes to the list of dams that form the upstream extent of EFH and the rationale behind those potential changes, are shown in Table 5. The Panel notes that recovery plans for a number of ESA-listed salmon ESUs are in draft form and have not been finalized. Consequently, there are uncertainties regarding which populations will be targeted in recovery scenarios and which of these populations may require passage above currently impassable dams in order to achieve recovery goals. Assessments regarding both the necessity of above-dam habitats for recovery and the feasibility of providing passage are currently underway. In some cases, it is clearly evident in draft recovery plans that passage will be required above specified dams to achieve recovery criteria for a particular ESU. In others, passage will almost certainly be required above one or more dams in order for recovery criteria to be met; however, the specific dams to be targeted for passage have not yet been explicitly identified. In the former case, we believe there is strong justification for designating the habit above identified dams as EFH. In the latter cases, we have noted the dams under consideration for passage in Table 5, but acknowledge that the justification for designating EFH upstream of these dams is not as straightforward. These specific cases will need to be revisited in a future EFH review.

Because of the changes to the 4th field HUs in the California Central Valley, areas that were not previously designated as EFH may become EFH. This may mean that additional dams may need to be designated as the upstream extent of EFH. One example is the Monticello Dam on Putah Creek.

Recommendations

The Panel recommends that the Council consider updating the list of impassible dams that mark the upstream extent of EFH based on the information provided in Table 5. The habitat above dams that are deleted from the list would then be designated as EFH for the appropriate species. The next natural or manmade barrier(s) upstream would then represent the new upstream extent of EFH

Marine Distribution

As currently designated, the geographic extent of marine EFH for Chinook salmon and coho salmon includes all marine waters within the EEZ north of Point Conception, California to the U.S. - Canada border and the marine areas off Alaska designated as salmon EFH by the NPFMC. For PS pink salmon, marine EFH is currently designated to include 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. 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. The current designation of marine EFH for PS pink salmon is based on the Elwha River being the western most extent of the FMU. However, if pink salmon from the Hoko-Crescent and Queets-Quinault systems were included in the FMU, some portion of the marine waters off the coast of Washington, from Cape Flattery, south to the Queets-Quinault should be considered EFH.

The current marine EFH designations are necessarily broad due to insufficient data in 1999 to more narrowly define EFH. In recent years, additional data have been collected on the marine distribution of Pacific Coast salmon (e.g., Bi et al. 2008; Peterson et al. 2010; Pool et al. *in prep*.). However, the Panel concluded that it would be better to wait to refine marine EFH until an effort to model marine distribution of salmon in Alaskan waters is complete. Similar to the PFMC, when the NPFMC designated EFH for salmon, the lack of data and resources resulted in designations that included the entire EEZ off the coast of Alaska. To address this issue, the NPFMC and the Alaska Region of NMFS are developing a model to predict marine distribution for each life-stage of five species of Pacific Coast salmon (Chinook salmon, coho salmon, pink salmon, sockeye salmon and chum salmon) in Alaskan waters. The model uses fish catch and hydrographical data compiled from multiple research efforts conducted within the Alaskan EEZ using systematic surface and midwater trawls at designated survey stations. Data sets include those obtained from NMFS and its Alaskan Fisheries Science Center, U.S. Global Ocean Ecosystem Dynamics program, the University of Alaska Fairbanks, the Department of Fisheries and Oceans Canada, and the International North Pacific Fisheries Commission. This model is expected to significantly reduce the extent of salmon EFH in Alaskan waters and can provide a basis for future refinement of marine EFH for the three species of Pacific Coast salmon managed by the Council.

The effort by the NPFMC to refine marine EFH for salmon would also have direct implications on the EFH designations for salmon managed by the Council. As described above, the EFH designations in Amendment 14 included Alaskan marine waters designated by the NPFMC as EFH for salmon. This was intended to highlight the importance of habitats around the North Pacific Ocean, as well as the far-ranging migrations that many stocks exhibit. Because the salmon managed by the Council rely heavily

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Table 6. Potential changes to the impassible dams representing the upstream extent of EFH. Note that an impassible barrier limits EFH extent only above that particular barrier. The remainder of the HU would still be considered EFH.

4th field Hydrologic Unit	State(s)	Hydrologic Unit Name	Impassible Man-made Barrier (from 2008 F.R.)	Supporting information	Potential Change
17020005	WA	Columbia River	Chief Joseph Dam	N/A	N/A
17030001	WA	Upper Yakima River	Keechelus Dam Kachess Dam (Kachess R.)	Bureau of Reclamation has conducted preliminary assessment of passage at Keechelus and Kachess Dams (BOR 2008; 2010), but is not moving forward with additional study until after passage is provided at Cle Elum and Bumping Dams.	Designate habitat above Keechelus and Kachess Dams as EFH
17030001	WA	Upper Yakima River	Cle Elum Dam (Cle Elum R.)	Bureau of Reclamation is in the process of planning passage for salmonids at Cle Elum Dam (BOR 2010).	Designate habitat above Cle Elum Dam as EFH.
17030002	WA	Naches River	Rimrock Dam (Tieton R.)	Bureau of Reclamation has conducted preliminary assessment of passage at Rimrock (Tieton) Dam (BOR 2008; 2010), but is not moving forward with additional study until after passage is provided at Cle Elum and Bumping Dams.	Designate habitat above Rimrock Dam as EFH.
17060101	OR/ID	Hells Canyon	Hells Canyon Complex (Hells Canyon, Oxbow, and Brownlee Dams)	Oxbow and Brownlee Dams are upstream of Hells Canyon Dam.	Change to Hells Canyon Dam, and delete Oxbow and Brownlee Dams
17060306	WA/ID	Clearwater River	Dworshak Dam (at border of HUCs 17060306 and 17060308)	N/A	N/A
17070103	OR	Umatilla	McKay Dam (McKay Creek)	Bureau of Reclamation (BOR 2007) proposed that McKay Dam be designated as upstream extent of EFH. NMFS staff subsequently verified that this dam meets the selection criteria for upstream extent of EFH.	Designate McKay Dam as the upstream extent of EFH (on McKay Creek only)
17070305	OR	Lower Crooked River	Opal Springs Dam	According to Scot Carlon, Hydro Division, NWR, a settlement agreement is possible to provide passage for Willamette River spring-run Chinook salmon at Opal Springs Dam.	Designate habitat above Opal Springs Dam as EFH for Chinook salmon
17080001	OR/WA	Lower Columbia-Sandy River	Impassable man-made barrier	The name of the impassible dam on the Bull Run River was inadvertently omitted from the 2008 Final Rule. It is Bull Run Dam #2. The CHART final report (NMFS 2005a) noted that habitat above the Bull Run Dam complex "may be essential" to the conservation of LCR Chinook salmon.	Two possible recommendations: (1) Designate habitat above as EFH for Chinook only; or (2) Keep the dam and properly identify as Bull Run Dam #2.

4th field Hydrologic Unit	State(s)	Hydrologic Unit Name	Impassible Man-made Barrier (from 2008 F.R.)	Supporting information	Potential Change
17090001	OR	Middle Fork Willamette River	Dexter Dam	Critical Habitat has been designated above Dexter Dam (70 FR 52630, September 2, 2005). In addition, spring-run Chinook salmon are currently being trapped and hauled above Dexter Dam. EFH above Dexter should be for Chinook only.	Designate habitat above Dexter Dam as EFH for Chinook
17090002	OR	Coast Fork Willamette River	Dorena Dam	N/A	N/A
17090004	OR	McKenzie River	Cougar Dam	N/A	N/A
17090005	OR	N. Santiam River	Big Cliff Dam	The CHART final report (NMFS 2005a) maintained that areas above the North Santiam dams "may be essential" for the conservation of Upper Willamette Chinook salmon and agreed that the Technical Recovery Team's viability assessment (McElhany et al., 2003) strongly suggests that these areas may warrant designation. In addition, the reintroduction of Upper Willamette Chinook salmon is underway, via trucking around the dams.	Designate habitat above Big Cliff Dam as EFH for Chinook salmon (coho salmon are not trucked around the dams)
17090011	OR	Clackamas River	Oak Grove Dam	According to the CH designations (70 FR 52630, September 2, 2005) and Google Earth, CH stops about 1 mile downstream of Oak Grove Dam. There may be a naturally-impassible waterfalls below this dam.	Delete Oak Grove Dam from list if a falls that is downstream of the dam is a natural barrier.
17100301	OR	N. Umpqua River	Soda Springs Dam	PacifiCorp is in process of constructing fish passage facility, with construction scheduled for completion in 2012 (http://www.pacificorp.com/about/newsroom/ 2010nrl/ptbwossfpp.html)	Designate habitat above Soda Springs Dam as EFH
17100307	OR	Upper Rogue River	Lost Creek Dam	N/A	N/A
17100308	OR	Middle Rogue	Emigrant Dam	Bureau of Reclamation (BOR 2007) proposed that Emigrant Dam be designated as upstream extent of EFH. NMFS staff subsequently verified that this dam meets the four selection criteria for upstream extent of EFH.	Designate Emigrant Dam as the upstream extent of EFH
17100309	CA/OR	Applegate	Applegate Dam	N/A	N/A
17110005	WA	Upper Skagit	Gorge Lake Dam	N/A	N/A
17110010	WA	Snoqualmie	Tolt Dam (S. Fork Tolt R.)	N/A	N/A
17110012	WA	Lake Washington	Cedar Falls (Masonry) Dam (Cedar R.)	N/A	N/A
18010102	CA	Mad-Redwood	Robert W. Matthews dam	N/A	N/A

4th field Hydrologic Unit	State(s)	Hydrologic Unit Name	Impassible Man-made Barrier (from 2008 F.R.)	Supporting information	Potential Change
18010103	CA	Upper Eel	Scott Dam	N/A	N/A
18010110	CA	Russian	Coyote Valley Dam (E. Fork Russian R.)\Warm Springs Dam (Dry Cr.)	N/A	N/A
18010206	CA/OR	Upper Klamath	Iron Gate Dam	NMFS/USFWS jointly filed final FPA prescriptions for fishways for the Klamath Hydroelectric Project (NMFS 2007b) , which withstood the trial-type hearing challenging the scientific basis. This led to the Klamath Hydropower Settlement Agreement process, which is ongoing and would provide for the removal of four dams on the mainstem Klamath River. NMFS Klamath Opinion on Operation of the Klamath Project between 2010 and 2018 (2010B) notes that the loss of historical habitat above Iron Gate Dam, combined with other factors (e.g., hatchery practices, land management activities, water withdrawals), "have contributed to the high risk of extinction of this population".	Designate habitat above Iron Gate Dam as EFH for coho and Chinook
18010207	CA	Shasta	None	This dam was mistakenly deleted from the 2008 F.R.	Re-designate Dwinnell Dam as the upstream extent of EFH
18010211	CA	Trinity	Lewiston Dam	N/A	N/A
18020111	CA	Lower American	Nimbus Dam	Public Draft CV Recovery Plan (NMFS 2009c) notes areas upstream of Nimbus and Folsom dams (NF, MF, and SF American River) are being considered for re-introduction of spring-run Chinook salmon	The designation of EFH above Nimbus and Folsom Dams warrants special consideration in a future EFH review and/or as new information becomes available. EFH designation above Nimbus and Folsom Dams warrant special consideration in a future EFH review and/or as new information becomes available.
18020115	CA	Upper Stony		This dam was mistakenly deleted from the 2008 F.R.	Designate Black Butte Dam as the upstream extent of EFH
18020126	CA	Upper Bear		This dam was mistakenly deleted from the 2008 F.R.	Add Camp Far West Dam

4th field Hydrologic Unit	State(s)	Hydrologic Unit Name	Impassible Man-made Barrier (from 2008 F.R.)	Supporting information	Potential Change
18020154	CA	Clear Creek-Sacramento River	Keswick Dam (Sacramento R.) Whiskeytown Dam (Clear Cr.)	Keswick Dam should have remained on the list of impassible dams in 2008 Final Rule. However, as noted below, based on newly available information, there is strong support for designating EFH above Keswick Dam and Shasta Dam NMFS Opinion on the Long-term Operations of the Central Valley Project and State Water Project (NMFS 2009a) includes long-term passage prescriptions at Shasta Dam and re-introduction of winter-run into its native habitat above the dam Public Draft CV Recovery Plan (NMFS 2009c) identifies the re-establishment of viable winter-run Chinook populations in both the Little Sacramento and McCloud rivers as critical to recovery of the Central Valley winter-run Chinook ESU. Public Draft CV Recovery Plan (NMFS 2009c) identifies the re-establishment of viable spring-run populations in the Little Sacramento and McCloud rivers as critical to recovery of the Basalt and Porous Lava Diversity Group within the Central Valley spring-run Chinook ESU.	Leave Whiskeytown Dam as the upstream extent of EFH Designate habitat above Keswick Dam and Shasta Dam as EFH for Chinook. Correct 4th field HUC. Listed in Amendment 14 as 18020112
18020159	CA	Honcut Headwaters-Lower Feather	None	Oroville Dam was listed in Amendment 14 as the upstream extent of EFH, but mistakenly was deleted from the 2008 F.R. NMFS staff recommended at that time to add the Feather River Fish Barrier Dam because that dam (approx 1.5 miles downstream of Oroville Dam) more logically defines the upstream extent for EFH on the Feather River. No fish pass this dam, and there is yet another impassible dam between Oroville and the Fish Barrier Dams. Public Draft CV Recovery Plan (NMFS 2009c) notes the area upstream of Oroville Dam (NF Feather River) is being considered for re-introduction of spring-run Chinook salmon	Designate Feather River Fish Barrier Dam as the upstream extent of EFH The designation of EFH above Feather River Fish Barrier Dam and Oroville Dam warrants special consideration in a future EFH review and/or as new information becomes available Correct 4th field HUC. Listed in Amendment 14 as 18020121 &18020123
18040006	CA	Upper San Joaquin		This dam was mistakenly deleted from the 2008 F.R.	Designate Friant Dam as the upstream extent of EFH

4th field Hydrologic Unit	State(s)	Hydrologic Unit Name	Impassible Man-made Barrier (from 2008 F.R.)	Supporting information	Potential Change
18040008	CA	Upper Merced	Crocker Diversion Dam	This dam was mistakenly deleted from the 2008 F.R. Public Draft CV Recovery Plan (NMFS 2009c) identifies areas upstream of Crocker Diversion and New Exchequer dams (Merced River) among three above-dam alternatives to be considered for re-introduction of spring-run Chinook salmon in the Southern Sierra Diversity Group; the establishment of a viable spring-run population in one of these three alternatives (i.e., upper Stanislaus, upper Tuolumne, or upper Merced) is identified as critical to recovery of the Central Valley spring-run Chinook ESU	Designate Crocker Diversion Dam as the upstream extent of EFH The designation of EFH above Crocker Diversion and New Exchequer Dams warrants special consideration in a future EFH review and/or as new information becomes available
18040009	CA	Upper Tuolumne	La Grange Dam (Tuolumne R.)	Public Draft CV Recovery Plan (NMFS 2009c) identifies areas upstream of LaGrange and Don Pedro dams (Tuolumne River) among three above-dam alternatives to be considered for re-introduction of spring-run Chinook salmon in the Southern Sierra Diversity Group; the establishment of a viable spring-run population in one of these three alternatives (i.e., upper Stanislaus, upper Tuolumne, or upper Merced) is identified as critical to recovery of the Central Valley spring-run Chinook ESU	The designation of EFH above La Grange and Don Pedro Dams warrants special consideration in a future EFH review and/or as new information becomes available Correct 4th field HUC. Listed in Amendment 14 as 18040002
18040010	CA	Upper Stanislaus	Goodwin Dam	Public Draft CV Recovery Plan (NMFS 2009c) identifies areas upstream of Goodwin, Tulloch, and New Melones dams (NF Stanislaus River) among three above-dam alternatives to be considered for re-introduction of spring-run Chinook salmon in the Southern Sierra Diversity Group; the establishment of a viable spring-run population in one of these three alternatives (i.e., upper Stanislaus, upper Tuolumne, or upper Merced) is identified as critical to recovery of the Central Valley spring-run Chinook ESU	The designation of EFH above Goodwin, Tullock and New Melones Dams warrants special consideration in a future EFH review and/or as new information becomes available
18040011	CA	Upper Calaveras California	New Hogan Dam	N/A	N/A

4th field Hydrologic Unit	State(s)	Hydrologic Unit Name	Impassible Man-made Barrier (from 2008 F.R.)	Supporting information	Potential Change
18040012	CA	Upper. Mokelumne	Camanche Dam	Public Draft CV Recovery Plan (NMFS 2009c) identifies areas upstream of Camanche and Pardee dams (Upper Mokelumne River) to be considered for re-introduction of spring-run Chinook salmon	The designation of EFH above Camanche and Pardee Dams warrants special consideration in a future EFH review and/or as new information becomes available Correct 4th field HUC. Listed in Amendment 14 as 18040005
18050002	CA	San Pablo Bay	San Pablo Dam (San Pablo Cr.)	N/A	N/A
18050003	CA	Coyote	LeRoy Anderson Dam	N/A	N/A
18050005	CA	Tomales-Drake Bays	Nicasio Dam (Nicasio Cr.)/Peters Dam (Lagunitas Cr.)	N/A	N/A
18060001	CA	San Lorenzo-Soquel	Newell Dam (Newell Cr.)	N/A	NA

on habitats in Alaskan waters, maintaining these waters as EFH is justifiable. However, it is unclear to the Panel whether changes to EFH in Alaskan waters made by the NPFMC would automatically result in changes to EFH for Council-managed stocks, or whether the Council would need to take action to adopt these changes.

Recommendation

The Panel recommends further consideration of the designation of marine EFH and better definition of the FMU for coho salmon and PS pink salmon, based on the available information provided on marine distribution of Pacific Coast Salmon.

Essential Fish Habitat Descriptions

Pursuant to the EFH guidelines (50 CFR 600), FMPs should summarize the life history information necessary to understand each species' relationship to or dependence on its various habitats, using text, tables, and figures, as appropriate. A major part of the periodic EFH review process is aimed at updating the descriptions of EFH, which provide detailed information on the habitats used by Council-managed species.

Existing EFH Descriptions

Amendment 14 provides descriptions of EFH for each species and life stage that were developed through an extensive review and synthesis of the literature available in 1999. They provide a review of life history for each species, text descriptions, and tables that summarize, for each species, the habitats used by each life history stage and the important features of those habitats.

New Information

The Council enlisted Cramer Fish Sciences to develop an annotated bibliography (Bergman 2010) of relevant information that could inform and update the library of information relative to the habitat requirements of Pacific Coast salmon (Appendix A). The literature on salmon is very rich, and the Panel recognized that it did not have the necessary resources to compile an annotated bibliography of all recent and relevant information. Instead, the bibliography was intended to present a representative sample of the recent literature. Bergman (2010) includes about 100 references in the annotated bibliography, which presents literature for Chinook salmon, coho salmon, and PS pink salmon. The bibliography divides the literature into five distinct life stages: eggs and spawning, freshwater juveniles, estuarine juveniles, marine juveniles, and adults. For each life stage, the annotated bibliography presents several key or representative references. Because Pacific Coast salmon have been extensively studied for more than 100 years, especially in the freshwater environment, the Panel expects that the new information would help to refine the EFH descriptions.

This section highlights some of the literature that can be used to supplement the habitat descriptions in Amendment 14. The literature cited here provides information, such as use of a specific type of habitat not discussed in Amendment 14, and demonstrates that the descriptions should be revised to be more comprehensive.

Chinook Salmon

Eggs and Spawning
Chinook salmon have been shown to spawn in stream reaches characterized as low-gradient pool-riffle reaches (Montgomery et al. 1999). Chinook salmon redds were associated with large woody debris (LWD) in the Lower Mokelumne River (Merz 2001), where substrate was smaller and the mean depth of

the redds was greater. The study concluded that the presence of LWD improves otherwise lower-quality habitat, making it more suitable for spawning, and may allow greater concentration of redds on suitable sites.

Juveniles -Freshwater

In low-gradient alluvial valleys of the upper Columbia River basin, juvenile Chinook salmon are most often associated with streams that contain LWD and pools (UCSRB 2007). In higher-gradient fluvial valleys, large boulders provide habitat complexity.

Recent studies provide new insight into the importance of floodplain habitat to juvenile Chinook salmon. Floodplain and other seasonally inundated habitats provide better rearing habitat, with higher growth rates, for juvenile Chinook salmon than the adjacent river (Sommer et al. 2001; Jeffres 2006). Sommer et al. (2001) attributed the higher growth rates in inundated floodplains to significantly greater abundance of drift invertebrates. Inundated floodplains also appear to be better migration habitat than the adjacent river.

Effects of river flows on juvenile migration were investigated by Brandes and McLain (2001) and Sykes et al. (2009). Brandes and McLain (2001) found that more juveniles enter the Sacramento-San Joaquin Delta as fry during wet years and overall juvenile production leaving the delta is higher in wet years. Fry survival appears lower in delta than upriver in higher-flow years. This speaks to the diversity of the habitats used by salmonids, and this diversity maintains production under changing environmental conditions. Sykes et al. (2009) found that flow manipulations that change the timing, duration, and magnitude of temperature and flow in the spring could affect the migration of juvenile Chinook salmon.

Juveniles - Estuaries

Estuaries are important rearing, foraging, and migration habitat for juvenile Chinook salmon. Bottom et al. (2005) found that fry and fingerlings make extensive use of marsh habitats in the Salmon River estuary. A study by Semmens (2008) found that juvenile Chinook salmon have a strong preference for native eelgrass. No such preference was found for other structured benthic habitats such as oyster beds, non-native eelgrass, or non-native cordgrass. Ehinger et al. (2007) found that certain types of delta habitat, distributary channels and wetlands in particular, may have a major role in juvenile Chinook salmon productivity.

Juveniles – marine

Juvenile Chinook salmon migrate from the estuary to the surf zone, where they feed for up to two summer months before migrating offshore (Jarrin et al. 2009). When in the surf zone, they had growth rates of 0.6 mm per day. Smaller fish fed on amphipods but switched to a piscivorous diet as they grew.

Several studies have investigated the growth and survival of juvenile Chinook salmon in the marine environment. Analyzing the growth rings on scales of adults returning to the Yukon and Kuskokwim Rivers, Ruggerone et al. (2009) found a positive correlation between growth during the first year of marine residence and growth during the freshwater phases, and that growth during each year of marine residence was positively correlated with growth during the previous year. The authors related this correlation to the piscivorous diet and foraging benefits of larger size.

Coastal upwelling is a strong determinant of year class strength (Scheuerell and Williams 2005). Upwelling increases near-shore ocean productivity, and leads to increased growth and survival of juveniles, while reduced upwelling leads to reduced growth and survival of juvenile salmon.

Adults

Elevated water temperature has been shown to affect the upstream migration of adults. Spring run Chinook salmon in Sacramento river basin hold in pools that have moderate water velocities and cover and preferred temperatures between 3 and 13°C (CDFG 1998). Lindley et al. (2004) found that upstream migration of Central Valley Chinook salmon was blocked at 21°C, with fish becoming stressed as temperatures approached 20°C. Similarly, Goniea et al. (2006) reported that migration rates for upriver bright Chinook salmon in the lower Columbia River slowed when water temperature exceeds 20°C. This slowed migration was associated with temporary use of tributaries that averaged 2-7°C cooler than the mainstem.

Central Valley spring-run Chinook salmon utilize mid- to high-elevation streams that provide appropriate temperatures and sufficient flow, cover, and pool depth as over-summering habitat (Yoshiyama et al. 1998). Thermal patchiness in streams provides habitat for Chinook salmon at the margin of their temperature tolerance (Torgensen et al. 1999).

Coho Salmon

Juveniles – freshwater

Flooded riparian vegetation and oxbow channels associated with beaver ponds are critical to winter and summer survival of juvenile coho salmon in Klamath River (CDFG 2004). Juvenile coho salmon make substantial use of off-channel habitat within non-natal tributaries of Klamath estuary (NMFS 2007a). Displaced fish display high fidelity with regard to this non-natal habitat, as well as greater fitness at the smolt stage compared to fish that overwintered in natal tributary. Coho salmon juveniles have been found to move into non-natal tributaries in fall and winter and exhibit higher winter growth and survival than fish that stay in mainstem areas (Ebersole et al. 2006; Ebersole et al. 2009).

Although tributary rearing habitat is widely recognized as important to young-of-the-year coho salmon, the mainstem habitats may also play a critical role in their survival in rivers such as Klamath where tributary conditions are particularly hostile (NRC 2002).

Koski (2009), describe several studies and observations that have recently provided new insights into the fate of "nomads", juvenile coho salmon that move downstream between the time of emergence and October, and the role of the stream-estuary ecotone and estuary in developing this life history strategy that promotes coho salmon resilience. Nomad coho salmon can acclimate to brackish water, survive, and grow well in the stream-estuary ecotone and estuary, and then return upstream into freshwater to overwinter before migrating to the ocean as smolts. Nomads may enter the estuarine environment from natal or non-natal streams, rear there throughout the summer, and then immigrate to a non-natal stream for overwintering and smolting in the spring. These estuarine and overwintering habitats have enabled coho salmon to develop this unique nomad life history strategy that may help to ensure their resilience.

Juveniles - Estuaries

Pink salmon

Juveniles – marine

Moss et al. (2007) found that juvenile pink salmon were concentrated in nearshore habitats, but had lower growth rates relative to other habitats. This lower survival was attributed to density-dependent factors.

Salmon – General

Juveniles – estuarine

River plumes are important foraging habitat for juvenile salmon. Juvenile salmon tend to be abundant in the frontal and plume regions compared to more marine shelf waters (Robertis et al. 2005), but stomach fullness is higher in marine waters than the front or plume areas. The Columbia River plume is important juvenile salmon habitat, particularly during first month or two of ocean residence (NMFS 2008c).

Juveniles - Marine
Ocean conditions play a critical role in the growth and survival of juvenile Pacific salmon. The first few months of ocean residency is the period of critical climatic influences on survival, suggesting that coastal and estuarine environments are key areas of biological interactions (Francis and Mantua 2003). Wind-driven upwelling in the ocean replenishes nutrients in surface waters and promotes productivity at the base of the food chain (NWF 2007). Warm water conditions negatively impact salmon in California Current and also affect migration patterns of salmon predators for a top-down effect (Peterson et al. 2006). Pacific Decadal Oscillation (PDO) and El Nino Southern Oscillation events appear to have significant influence on survival and migratory patterns (Shared Strategy 2007) with Pacific salmon size being negatively correlated with El Nino events (Wells et al. 2006). Predatory and forage fish distributions respond to ocean temperatures, predator/prey interactions and possibly turbidity (Emmett et al. 2006).

Wells et al. (2008) found that salmon rely heavily on krill and rockfish during early and later life stages.

The literature cited above identifies relevant information pertaining to specific habitats and habitat features, for each species, that were not discussed in Amendment 14. These habitats include tributaries, floodplains, oxbows and other offchannel areas, thermal refugia, river plumes, estuaries, eelgrass, surf-zone and general marine habitats. The literature identifies a number of important habitat features that contribute to the growth, survival, and productivity of Pacific Coast salmon, such as large woody debris, water temperature, stream flow, prey availability, and ocean upwelling. This information should be used to revise and refine the descriptions of EFH for each species and life stage.

<u>Recommendation</u>

The Panel recommends further consideration by the Council of the descriptions of EFH contained in the Pacific Coast salmon FMP, based on the information described above.

The Panel also recommends that the Council consider incorporating the additional information cited in this report into the annotated bibliography.

Habitat Areas of Particular Concern

The implementing regulations for the EFH provisions of the MSA (50 CFR part 600) recommend that the FMPs include specific types or areas of habitat within EFH as “habitat areas of particular concern” (HAPC) based on one or more of the following considerations: (1) the importance of the ecological function provided by the habitat; (2) the extent to which the habitat is sensitive to human-induced environmental degradation; (3) whether, and to what extent, development activities are, or will be, stressing the habitat type; and (4) the rarity of the habitat type. The intended goal of identifying such habitats as HAPCs is to provide additional focus for conservation efforts. While the HAPC designation does not add any specific regulatory process, it highlights certain habitat types that are of high ecological importance. This designation is manifested in EFH consultations, in which NMFS can call attention to a HAPC and recommend that the Federal action agency make an extra effort to protect these important habitats.

The Council designated HAPCs in Amendment 19 to the Pacific Coast Groundfish FMP (seagrasses, canopy kelp, estuaries, rocky reefs, and a number of clearly defined areas of interest), but not in its three other FMPs. Amendment 14 discusses HAPCs for each species but stops short of establishing HAPCs, citing lack of sufficient data on which to base HAPCs.

Several FMCs have designated discrete habitat areas as HAPCs, while others broadly designated all areas of a specific habitat type as HAPCs. The “areas of interest” and estuaries designated by the Council in the Pacific Coast Groundfish FMP are examples of discrete HAPCs, while the seagrass, canopy kelp, and rocky reef HAPCs are examples of the broadly defined HAPCs that are not mapped, but are based on a description of the habitat. Some FMCs designated HAPCs for all of the managed species in their jurisdictions, and others only designated HAPCs for particular species or life stages. HAPCs, like EFH generally, are subject to periodic reviews and are therefore subject to being modified over time.

As part of this 5-year review, the Panel developed five potential HAPCs. Habitat types were initially identified using the best available information and the collective professional knowledge and experience gained by the Panel 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.

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 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 large woody debris 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).

Complex channels and floodplain habitat and the HAPC considerations.

1. *The importance of the ecological function provided by the habitat.* Complex floodplains habitats, including wetlands, oxbows, side channels, sloughs, and beaver ponds, have been shown to be important habitats for salmonids. 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).

2. *The extent to which the habitat is sensitive to human-induced environmental degradation.* 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 reached 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).

3. *Whether, and to what extent, development activities are, or will be, stressing the habitat type*. 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.

4. *The rarity of the habitat type*. Historically, neither complex floodplain habitats nor mid-gradient channels with large quantities of inchannel 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% loss of side-channel sloughs habitats, and roughly 90% 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 maps or spatial descriptions may not be reliable from year to year. As such, this HAPC should rely on detailed text that describes the general attributes of these habitats, rather than spatially explicit descriptions or maps.

Thermal Refugia. Areas to escape high 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.

Thermal refugia and the HAPC considerations.

1. *The importance of the ecological function provided by the habitat.* 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.

2. *The extent to which the habitat is sensitive to human-induced environmental degradation.* 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). In addition, human-induced climate change is anticipated to lead to increased freshwater

temperatures, thereby degrading or eliminating thermal refugia that currently exist (Battin et al. 2007).

3. *Whether, and to what extent, development activities are, or will be, stressing the habitat type.* As noted previously, artificial barriers can block access to thermal refugia, especially those located higher up in the watershed, and cause increased temperatures downstream (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).

4. *The rarity of the habitat type.* 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).

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.

1. *The importance of the ecological function provided by the habitat. S*pawning is a particularly important element of the life history of any species of fish. Adverse effects to 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.

2. *The extent to which the habitat is sensitive to human-induced environmental degradation.* 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.

3. *Whether, and to what extent, development activities are, or will be, stressing the habitat type.* 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% 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.

4. *The rarity of the habitat type.* 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 a variety of niche habitats including 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 maps or spatial descriptions may not be reliable from year to year. As such, this HAPC should rely on detailed text that describes the general attributes of these habitats, rather than spatially explicit descriptions or maps.

Estuaries. Estuaries can be defined as "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 defined as the mean higher high water tidal level, 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 were designated as a HAPC in Amendment 19 to the Pacific Coast Groundfish FMP (PFMC 2005).

Estuaries and HAPC considerations.

1. *The importance of the ecological function provided by the habitat.* 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).

2. *The extent to which the habitat is sensitive to human-induced environmental degradation.* 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.

3. *Whether, and to what extent, development activities are, or will be, stressing the habitat type.* 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% 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% of its aquatic habitat area (Collins et al. 2003).

4. *The rarity of the habitat type.* 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.

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).

Eelgrasses (Zostera *marina*) form 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).

Both kelps (canopy-forming) and eelgrass (seagrasses) were designated as HAPCs in Amendment 19 to the Pacific Coast Groundfish FMP (PFMC 2005)

Marine and estuarine SAV and HAPC considerations

1. *The importance of the ecological function provided by the habitat.* 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).

2. *The extent to which the habitat is sensitive to human-induced environmental degradation.* 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.

3. *Whether, and to what extent, development activities are, or will be, stressing the habitat type.* 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.

4. *The rarity of the habitat type.* 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 % of the shoreline has kelp, while up to 34% of the shoreline has eelgrass (Mumford, 2007).

The location and size of both kelp and seagrass beds vary over space and time, and maps or spatial descriptions may not be reliable from year to year. As such, this HAPC should rely on detailed text that describes the general attributes of these habitats, rather than spatially explicit descriptions or maps.

In addition to the five HAPCs discussed above, the Panel considered the potential for designating migratory corridors as a HAPC. Given the life history strategies of salmon, migratory corridors have extremely high ecological value and are often at risk of degradation due to human activities (e.g., impassible culverts). However, the migratory corridors of salmon extend from the spawning habitats, downstream to the estuary, and through marine waters. While HAPCs are intended to be a subset of EFH, a HAPC based on the migratory corridors would include all habitats used by salmon, and, therefore, all of EFH. As such, migratory corridors do not meet the intent of the HAPC provisions in the implementing regulations, and the Panel did not pursue it further.

Recommendation

The Panel recommends further consideration of designation of HAPCs based on the information provided on the value to salmon of channels and floodplains; thermal refugia; spawning habitat; estuaries; and marine and estuarine submerged aquatic vegetation.

4. THREATS TO EFH

Fishing Activities That May Affect EFH

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 6. These include fishing activities not managed under the MSA that may adversely affect salmon EFH.

Fishing activities, derelict gear, harvest of prey species, 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 Panel identified marine debris (and derelict fishing gear, separately) as a potential adverse affect. 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 any changes to overall fishing activities have remained level or have decreased since 1999.

Table 7. Summary of fishing activities that potentially affect to 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

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 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.

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 EFH by smothering 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 areas of EFH 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). 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).

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).

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).

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% of historical levels (Scheuerell et al. 2005). Gresh et al (2000) estimated that just 6-7% 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.

Vessel impacts

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.

Vessels can adversely affect EFH by affecting physical or chemical mechanisms. Physical effects can include physical contact with spawning gravel and redds (freshwater streams) and propeller wash in eelgrass beds (estuaries). Derelict, sunk, or abandoned vessels can cause physical damage to essentially any bottom habitat the vessel comes into contact with. This could potentially cause harm to corals, sponges, rocky reefs, sandy ocean floor, eelgrass beds, and other habitats.

Chemical effects could come in the form of anti-fouling paint, oil/gas spills, bilge waste, or other potential contaminants associated with commercial or recreational vessels, and could occur in freshwater, estuaries, or the marine environment.

Studies in Alaska and New Zealand (Horton 1994; Sutherland and Ogle 1975) have found that in shallow water where boat use is high and especially where channels are constricted, developing salmon eggs and alevins in the gravel can suffer high mortalities as a result of pressure changes caused by boat operations, which can result in removal of gravel or mechanical shock generated in the area under the midline of the boat. Studies done on the effects of jet sleds, drift boat, or kayak operation on the behavior and survival of free swimming juvenile salmon on the Rogue River have shown minimal effects, although behavioral responses are observed when vessels pass directly overhead (especially nonmotorized kayaks or driftboats) (Satterwaithe 1995). Studies along the Columbia River indicated that the wake of large ships caused significant numbers of Chinook salmon juveniles to be killed from being washed up and stranded on sand bars and mud flats. Stranding was not observed on the Skagit River from jet sled use (K. Bauersfel 1998) or on the Rogue River from private motorboat and commercial tour boat use (Satterwaithe 1995).

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 set aside a portion of the biomass as forage reserves for predator species. For example, the harvest guideline formula for Pacific sardine incorporates a 150,000 metric ton (mt) cutoff, meaning that the annual harvest guideline is based on the estimated biomass minus 150,000 mt. Other prey species such as krill, copepods, and amphipods, are salmon prey species that are not directly fished, but that can be adversely affected by fishing activities.

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.

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).

Minimizing Effects

Fishery Management Plans are required to minimize adverse affects 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.

Gear Effects

Amendment 14 does not identify any studies that indicate direct gear effects on Pacific Coast salmon EFH from Council-managed fisheries, although some studies indicate that there may be impacts to benthic organisms and their habitats due to bottom trawling and dredging activities. Outmigrating Pacific salmon juveniles feed on various epibenthic invertebrates and zooplankton, including benthic copepods, implying that there could be impacts to prey species. However, Amendment 14 notes that salmon are not known to be dependent on soft ocean bottom habitats. Therefore, it does not conclude that fishing gear effects in the ocean directly affect benthic prey species. Table 6 lists gear types used in

Council-area fisheries that could impact Pacific Coast salmon EFH. Amendment 14 notes that "detailed management measures have not been developed because of the lack of information demonstrating an adverse effect on EFH from salmon 'gear.'" Amendment 14 recommends research to study gear effects on salmon EFH and their prey, especially disturbance to eelgrass beds and rocky habitat. Amendment 14 also offers minimization measures for prey harvest, carcass removal, redd disturbance, and vessel impacts. However, several fishing impacts are presented here that were not considered in Amendment 14.

Conservation measures for gear effects were not presented in Amendment 14, which instead noted the need for research to study the effects of gear on salmon EFH and prey, especially related to disturbance of eelgrass beds and rocky habitat. The 2008 Final Rule did not address fishing effects to Pacific salmon EFH.

Recommendation

The Panel recommends consideration of newly identified fishing activities that may adversely affect EFH and the consideration of measures to minimize impacts to Pacific salmon EFH, in accordance with the 2002 EFH regulatory guidance.

Non-Fishing Activities That May Affect EFH

The MSA requires FMCs and NMFS to identify non-fishing activities that may adversely affect EFH, as well as actions to encourage the conservation and enhancement of EFH, including recommended options to avoid, minimize, or mitigate for the adverse effects identified in the FMP. Amendment 14 includes 21 such activities and conservation measures, and the Panel identified 10 additional non-fishing threats (Table 7). This section provides a description of 10 non-fishing threats to EFH that have gained attention since Amendment 14 was published. Some threats are more developed than others, and some include preliminary conservation measures while others do not. However, each threat description contains the information necessary to, at a minimum, inform the Council on the potential severity of the adverse effects from these activities. See Amendment 14 for a description of the 21 threats to EFH of Pacific Coast salmon identified in 1999. It is important to note that many projects consist of more than one of these 31 threats, and the cumulative effects of those threats should be considered when making EFH conservation recommendations.

The Panel anticipates that, should the Council amend the Pacific Coast Salmon FMP, the descriptions of all 31 threats will be expanded upon and refined, and that conservation measures will be developed for each threat. In addition, the Council may determine that threats in addition to those discussed here and in Amendment 14 merit inclusion in the amendment.

Table 8. Non-fishing threats to Pacific Coast salmon EFH. Newly identified threats appear in the right column. Detailed information on the threats identified in the first column can be found in Amendment 14.

Threats Identified in Amendment 14 (1999)	New Threats Identified During EFH Review
Agriculture	Pile driving
Artificial Propagation of Fish and Shellfish	Over-water structures
Bank Stabilization	Alternative energy development
Beaver removal and Habitat Alteration	Liquefied natural gas projects
Construction/Urbanization	Desalination
Dam Construction/Operation	Power plant intakes
Dredging and Dredged Spoil Disposal	Pesticide use

Estuarine Alteration	Flood control maintenance
Forestry	Culvert construction
Grazing	Climate change
Habitat Restoration Projects	
Irrigation/Water Management	
Mineral Mining	
Introduction/Spread of Nonnative Species	
Offshore Oil and Gas Drilling	
Road Building and Maintenance	
Sand and Gravel Mining	
Vessel Operation	
Wastewater/Pollutant Discharge	
Wetland and Floodplain Alteration	
Woody Debris/Structure Removal	

Pile driving

Pile driving can generate intense underwater sound pressure waves that can adversely affect the ecological functioning of EFH. These pressure waves have been shown to injure and kill fishes, including salmon (e.g., Caltrans 2001; Longmuir and Lively 2001; Stotz and Colby 2001; Abbott and Bing-Sawyer 2002; Stadler, pers. com. 2002). 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.

Potential Adverse Impacts

Injuries associated directly with pile driving are poorly studied but include rupture of the swimbladder and internal 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, the firmness of the substrate into which the pile is being driven, the depth of water, and the type and size of the pile-driving hammer. Injury or death associated with pile driving appears to be positively correlated with the size of the pile because the greater energy required to drive larger piles produces higher sound levels. Fish-kills have been associated with 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. Firmer substrates require more energy to drive piles, and produce more intense sound pressures. Sound attenuates more rapidly with distance from the source in shallow than in deep water (Rogers and Cox 1988).

Two main types of hammers are used to drive piles – impact and vibratory. Impact hammers use a large weight or piston to strike the top of the pile and drive it into the substrate and appear to pose the greater risk to fishes. All reported instances of fishes killed or injured during pile driving have occurred when impact hammers were used. Vibratory hammers, on the other hand, vibrate the pile vertically to emulsify the surrounding sediment and cause the pile to sink. While injury and death have not been observed from vibratory hammers, there are no data to show they are harmless. One reason for these observed differences is the different types of sounds that each hammer produces. Impact hammers produce intermittent but intense spikes of sound while vibratory hammers produce continuous sounds of lower intensity. The magnitude of the effect on salmon that are exposed to the sounds from pile driving will depend on the size and physical condition of the fish, the depth of the fish in the water column, and the characteristics of the received sound including the shape and energy content of the sound pressure wave.

To aid in the assessment of the risks posed by impact pile driving, the Fisheries Hydroacoustic Working Group (FHWG), a group of Federal and state agencies with a stake in this issue, 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. Using these criteria, injury is expected to any fish that is exposed to either a peak pressure that exceeds 206 decibel (dB) (re: 1 µPa) or a size-dependent cumulative SEL that exceeds 187 dB (re: 1 μPa^2-sec) for fishes larger than 2 grams, and 183 dB (re: 1 μPa^2-sec) for fishes smaller than 2 grams.

Sounds have been shown to alter the behavior of fishes; including salmon (see review by Hastings and Popper 2005). The observed behavioral changes include startle responses and increases in stress hormones. Other potential changes include reduced predator awareness and reduced feeding. Feist et al (1991) 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. Directed studies on the effects of pile driving sound on the behavior of salmonids are limited, although Ruggerone et al (2008) found no observable changes in the behavior of caged coho salmon in the vicinity of pile driving. Faced with the paucity of data, NMFS is currently using a conservative criteria 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 estuary and are more prone to predation than for a subadult or adult in marine waters.

Potential Conservation Measures

- Avoid driving piles when salmon are present, if possible, especially the younger life stages.
- Avoid driving hollow steel piles with an impact hammer. Drive the piles with a vibratory hammer or select piles that are made of alternate materials produce less-harmful sounds.
- Drive piles during low tide periods when located in intertidal and shallow subtidal areas.
- Under those conditions where impact hammers are required, the piles should be driven as deep as possible with a vibratory hammer prior to the use of the impact hammer.
- 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.
- Drive piles when the current is reduced (i.e., centered on slack current) in areas of strong current to minimize the number of fish exposed to adverse levels of underwater sound.

Overwater Structures

Overwater structures include commercial and residential piers and docks, floating breakwaters, barges, rafts, booms, and mooring buoys. 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). 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, 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.

Potential Adverse Effects

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 through 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. These piscivorous birds congregate near hydroelectric dams throughout the Columbia River Estuary and forage on salmonids (Roby et al. 2007; Collis et al. 2002).

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.

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). In the San Francisco Estuary, the Smithsonian Institute conducts Rapid Assessment Surveys to determine nonnative species distribution on overwater structures. Of the294 distinct nonnative taxa observed, 60% were found on floating docks, 20% on intertidal benthos, and 13% 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).

Construction and maintenance of overwater structures often involves driving of pilings (see Pile Driving) and dredging of navigation channels (see Dredging and Dredged Spoil Disposal in Amendment 14). Both activities may also adversely affect EFH.

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 outmigration in Washington (Haas et al. 2002).

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 outmigration 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

- 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 deep water to avoid light limitation and grounding impacts to the intertidal zone, and maintain at least one foot of water between the substrate and the bottom of the float.
- 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.

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)" (US 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 to 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

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 to 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 to 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 imped 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 to 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 to 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.

Recommended Conservation Measures

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 derelect 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.

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 -162^{o} C. This reduces the volume of natural gas to approximately 1/600th of its gaseous state volume, making it possible for economical transportation with tankers. Upon arrival at the destination the LNG is either vaporized onshore or offshore and sent out into an existing pipeline infrastructure or transported onshore for storage and future vaporization. The process of vaporization occurs when LNG is heated and converted back to its gaseous state. LNG facilities can utilize open loop, closed loop, combined loop, or ambient air systems for vaporization. Open loop systems utilize warm water for vaporization, and closed loop systems generally utilize a recirculating mixture of ethylene glycol for vaporization. Another type of closed-loop system is submerged combustion vaporization (SCV) which provides a water bath with submerged pipe coils. Combined loop systems utilize a combination of these systems.

Onshore LNG facilities generally include a deepwater access channel, land-based facilities for vaporization and distribution, storage facilities, and a pipeline to move the natural gas. Offshore facilities generally include some type of a deepwater port with a vaporization facility and pipelines to transport natural gas into existing gas distribution pipelines or onshore storage facilities. Deepwater ports and onshore terminals require specific water depths and include an exclusion zone for LNG vessel and/or port facility security.

Potential adverse effects to EFH

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 to 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^{o} C 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

- 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.

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 indicating 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 through 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.

Potential Adverse Effects

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 at desalination plants are expected to be similar to those described under 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, as well as phytoplankton, invertebrate and fish communities. The effects to 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 for Pacific Coast salmon are not clear, but 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 plumes that are near ambient temperature. Because RO plants are becoming more common, relative to the MSF plants, this is a lesser problem than in the past. MSF plants can produce brines that are 10-15° C warmer than the receiving waters. However, most studies have found that the thermal impacts dissipate quickly, typically diminishing 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.

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

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; Langord et al. 1978; 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 2004a; 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

- 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.

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 to salmon or their prey. Beginning in 2008, NMFS has issued three Opinions (NMFS 2008b; 2009b; 2010a) to the Environmental Protection Agency (EPA) on the registration of 18 pesticides, and is scheduled to complete consultation on 19 others by 2012. These Opinions determined that when applied according to the label instructions, many of these pesticides can have severe effects to individual and populations of threatened and endangered Pacific salmonids under NMFS’ jurisdiction. The 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 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 to 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 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.

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

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 2009z). 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

- 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.

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.

Amendment 14 includes culvert construction and maintenance under the Road Building and Maintenance section. However, the effects and conservation recommendations are cursory. Any revisions to Pacific Coast salmon EFH would benefit from an updated stand-alone section on culvert effects and conservation recommendations.

Potential Adverse Effects

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 to 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 to benthic invertebrates and aquatic vegetation (. 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</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.

Climate change

Human activities that emit greenhouse gases (GHG) such as carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and fluorinated gases contribute to a changing climate. Global climate change is correlated to the residence time of these compounds in the atmosphere and their ability to warm the planet. Examples of human activities that contribute to GHG emissions include burning fossil fuels, deforestation, and land development. While climate change remains controversial and future conditions rely on mathematical models, strong evidence suggests the direction climate change will take and the effects it can have on Pacific salmon species (Zabel et al. 2006; ISAB 2007).

Pacific Northwest temperatures have increased by about 0.8° C, and models project warming of 2.0° C by the 2040s and 3.3° C by the 2080s (Mote and Salathé 2009). Precipitation is also projected to increase with a more intense seasonal cycle - autumns and winters may become wetter and summers may become drier. Regional climate models indicate that overall extreme precipitation in western Washington will increase and the snowpack in the Cascades will decrease (Mote and Salathé 2009).

These climate changes will likely have widespread impacts on Pacific salmon throughout their native range (Battin et al. 2007; ISAB 2007). Decreased summer precipitation could reduce spawning habitat for salmon populations that have already experienced habitat loss from impassable barriers. Winter precipitation increases causing a higher frequency of flooding that would scour eggs and larvae from the riverbed. Adult salmon that prefer slow moving pools would also see a decrease in this type of habitat. High winter flows may also degrade valuable estuarine zones through pollution, variable freshwater influx and physical disturbance. As the climate warms and regional snowpacks would reduced, snow fed streams would become more reliant on rainfall, and cold water flows that support salmonid growth and survival, freshwater ecosystems and human water supplies would be affected (Mote et al. 2003; Climate Impacts Group 2004). Warmer temperatures will likely also melt snow packs earlier and would change the timing of juvenile emigration from freshwater habitats (ISAB 2007). Changes in snowpack would further alter flow patterns leading to intensified summer droughts and reduced habitat for rearing and migrating juvenile salmon (Battin et al. 2007; Luce and Holden 2009).

Regional models also predict increase water temperatures throughout salmon habitats (ISAB 2007). Warmer water may cause salmon to experience direct mortality, become more susceptible to disease and contaminants or encounter decreased populations of freshwater prey items. Existing impassable barriers prevent salmon from reaching cool water spawning areas found at higher elevations. This problem would be exacerbated if the limited number of currently accessible cold-water spawning habitat areas were eliminated due to increased temperatures. Additionally, water temperature increases would also affect water chemistry by reducing dissolved oxygen levels. In the marine environment, increased water temperatures would promote stratification between warmer surface waters and cooler, nutrient rich deep waters. The resulting thermocline could prevent nutrient cycling between regions diminishing growth of phytoplankton that form the base of marine food webs (Climate Impacts Group 2004; Scheuerell and Williams 2005). Without this food source, fewer juvenile salmon would be able to reach maturity.

The ocean is a major sink for atmospheric CO_2, and changes in atmospheric concentrations will affect oceanic conditions. Specifically, as the level of CO_2 in the atmosphere increases, it will dissolve more readily in the ocean, increasing the concentration of carbonic acid and lowering the pH of seawater. This change may not directly harm salmon, as they are able to survive lower pH in freshwater habitat, but their ecosystem may be far less productive. Planktonic organisms that form the base of many marine food webs secrete $CaCO_3$ shells necessary for survival. Lower pH will dissolve or prevent the formation of these shells causing mortality (Orr et al. 2005). Juvenile salmon rely on plankton as a food source and decreased plankton abundance could affect salmon growth and survival. Changing ocean temperatures may later salmon behavior, distribution and migrations (ISAB 2007).

Future climate scenarios predict increased fire frequency and intensity in western North America (ISAB 2007). Drought, and hot, dry weather will result in an increase in outbreaks of insects, which will affect forest and watershed health. Finally, climate change is expected to increase the demand placed on already-limited sources of water, increasing the conflict between meeting the needs of humans and those of salmon (Miles et al. 2000). Streams may be diverted more frequently for drinking, irrigation, frost protection or other purposes as human populations continue to increase along the Pacific Coast (Vicuna et al. 2007).

Recommendation

The Panel recommends that the Council give further consideration to updating the non-fishing threats to EFH contained in Amendment 14, adding the newly identified threats described above, and developing conservation recommendations for each threat.

5. INFORMATION AND RESEARCH NEEDS

This report and Amendment 14 identified the following information and research needs:

1. Improve fine scale mapping of salmon distribution to inform future reviews of EFH for Pacific Coast salmon and aid in more precise and accurate designation of EFH and the consultation process. Potential approaches include, but are not limited to:
    a. Develop distribution data at the 5th or 6th HUs, across the geographic range of these species.
    b. Develop habitat models that can be used to predict suitable habitat, both current and historical, across the geographic range of these species.
    c. Develop seasonal distribution data at a 1:24,000 or finer scale.
2. Improve data on habitat conditions across the geographic range of Pacific Coast salmon to help refine EFH in future reviews.
3. Improve data on marine distribution of Pacific Coast salmon, and develop models to predict marine distribution to inform revisions to EFH in future reviews.
4. Improve data on the potential 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.

Recommendation

The Panel recommends further consideration of the information and research needs for refining EFH during the next review, based on the data gaps identified in this review and Amendment 14.

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APPENDIX A: ANNOTATED BIBLIOGRAPHY FOR 2010 ESSENTIAL FISH HABITAT REVIEW