APPENDIX A

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

AMENDMENT 14 TO THE PACIFIC COAST SALMON PLAN

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August 1999

ACKNOWLEDGMENTS

The primary drafting of this document was accomplished by Ms. Nora Berwick, Dr. John Coon, Mr. Mark Helvey, Mr. Stephen Phillips, Ms. Fran Recht, Mr. Phil Roni, Mr. Joe Scordino, and Mr. Lawrence Six. Additional contributions were provided by Dr. Robert Kope and Dr. Gary Morishima. Final compilation and editing were done by Ms. Berwick and the Pacific Fishery Management Council staff: Dr. Coon, Ms. Renee Heyden, Ms. Sandra Krause, and Ms. Kerry Aden.

This document is published by the Pacific Fishery Management Council pursuant to National Oceanic and Atmospheric Administration Award Number NA07FC0026.

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LIST OF ACRONYMS AND ABBREVIATIONS

ADFG	Alaska Department of Fish and Game
BLM	U.S. Bureau of Land Management
BPA	Bonneville Power Administration
CARA	California Rivers Assessment
CCAP	Coastal Change Analysis Program
CDFFP	California Department of Forestry and Fire Protection
CDFG	California Deptartment of Fish and Game
CWT	coded-wire tag
DO	dissolved oxygen
EEZ	U.S. Exclusive Economic Zone (3-200 miles offshore)
EFH	essential fish habitat
ELMR	estuarine living marine resources
EPA	Environmental Protection Agency
ESA	Endangered Species Act
ESU	evolutionarly significant units
FERC	Federal Energy Regulatory Commission
FMP	fishery management plan
FRI	Fisheries Research Institute
FSOS	For the Sake of the Salmon
GIS	Geographic Information System
IDFG	Idaho Department of Fish and Game
KRBFTF	Klamath River Basin Fisheries Task Force
NED	Northwest Environmental Database
NEP	National Estuary Program
NMFS	National Marine Fisheries Service
NMFS NWR	National Marine Fisheries Service - Northwest Regional Office
NMFS NWFSC	National Marine Fisheries Service - Northwest Fisheries Science Center
NMFS SWR	National Marine Fisheries Service - Southwest Regional Office
NOAA	National Oceanic and Atmospheric Administration
NOAA CSC	National Oceanic and Atmospheric Administration - Coastal Services Center
NOAA NOS	National Oceanic and Atmospheric Administration - National Ocean Service
NOAA ORCA	National Oceanic and Atmospheric Administration - Ocean Resources Conservation and Assessment Division
NPFMC	North Pacific Fishery Management Council
NPPC	Northwest Power Planning Council
NRC	National Research Council
NWIFC	Northwest Indian Fisheries Commission
OCSRI	Oregon Coastal Salmon Restoration Initiative
ODFW	Oregon Deptartment of Fish and Wildlife
ORIS	Oregon River Information System
OTSMS	Oregon Territorial Sea Management Study
OWRRI	Oregon Water Resources Research Institute
PFMC	Pacific Fishery Management Council
PSMFC	Pacific States Marine Fisheries Commission
PSWQAT	Puget Sound Water Quality Action Team
RAC	The Resources Agency of California
RACE	Resource Assessment and Conservation Engineering - NOAA/NMFS
SASSI	Salmon and Steelhead Stock Inventory
SSHIAP	Salmon and Steelhead Habitat Inventory and Assessment
USACOE	U.S. Army Corps of Engineers
USDA	U.S. Department of Agriculture
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
UW	University of Washington

WARIS	Washington Rivers Information System
WDF	Washington Department of Fisheries
WDFW	Washington Department of Fish and Wildlife
WDOE	Washington Department of Ecology
WFWC	Washington Fish and Wildlife Commission
WWPI	Western Wood Preservers Institute
WWWSD	Western Washington Watershed Screening Database

INTRODUCTION

Public Law 104-297, the Sustainable Fisheries Act of 1996, amended the Magnuson-Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act) to establish new requirements for "Essential Fish Habitat" (EFH) descriptions in federal fishery management plans (FMPs) and to require federal agencies to consult with National Marine Fisheries Service (NMFS) on activities that may adversely affect EFH. The Magnuson-Stevens Act requires all fishery management councils to amend their FMPs to describe and identify EFH for each managed fishery.

The Magnuson-Stevens Act requires consultation for all federal agency actions that may adversely affect EFH, and it does not distinguish between actions in EFH and actions outside EFH. Any reasonable attempt to encourage the conservation of EFH must take into account actions that occur outside of EFH, such as upstream and upslope activities that may have an adverse effect on EFH. Therefore, EFH consultation with NMFS is required by federal agencies undertaking, permitting, or funding activities that may adversely affect EFH, regardless of its location.

Under section 305(b)(4) of the Magnuson-Stevens Act, NMFS is required to provide EFH conservation and enhancement recommendations to federal and state agencies for actions that adversely affect EFH. However, state agencies and private parties are not required to consult with NMFS unless state or private actions require a federal permit or receive federal funding.

While there is no formal requirement for state and private collaboration in the consultation process on adverse effects to salmon EFH, there is common interest in the reduction of threats to species listed under the Endangered Species Act, prevention of future listings, and productive and sustainable coastal fisheries in the context of the Magnuson-Stevens Act. Conservation of anadromous fish resources through voluntary coordination is a goal without geographical or jurisdictional boundaries.

This appendix has five chapters. Chapter 1 identifies EFH for the Pacific salmon fishery. U.S. Geological Survey (USGS) hydrologic units (Table A-1) are used as the descriptors for EFH and a coastwide map showing EFH also is included (Figure A-1). Chapter 2 describes the life history and habitat requirements for each of the three species managed under the FMP (chinook salmon, coho salmon, and Puget Sound pink salmon) and provides a general context for these Pacific salmon. Chapter 3 describes potential adverse effects to salmon EFH as well as conservation and enhancement measures to avoid or minimize these effects. Chapter 4 describes additional information and research needs for marine and estuarine distributions, life history, and cited in Appendix A.

1.0 IDENTIFICATION OF ESSENTIAL FISH HABITAT FOR THE PACIFIC SALMON FISHERY

> *"Essential fish habitat means those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity."*
>
> *Magnuson-Stevens Act § 3*

EFH for the Pacific coast salmon fishery means those waters and substrate necessary for salmon production needed to support a long-term sustainable salmon fishery and salmon contributions to a healthy ecosystem. To achieve that level of production, EFH must include 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 the estuarine and marine areas, salmon EFH extends from the nearshore and tidal submerged environments within state territorial waters out to the full extent of the exclusive economic zone (370.4 km) offshore of Washington, Oregon, and California north of Point Conception. Foreign waters off Canada, while still salmon habitat, are not included in salmon EFH, because they are outside United States jurisdiction. The Pacific coast salmon fishery EFH also includes the marine areas off Alaska designated as salmon EFH by the North Pacific Fishery Management Council (NPFMC). The geographic range of the salmon fishery EFH is shown in Figure A-1. This identification of EFH is based on the descriptions of habitat utilized by coho, chinook, and pink salmon provided in Chapter 2 of this appendix.

The geographic extent of freshwater EFH is specifically defined as all currently viable waters and most of the habitat historically accessible to salmon within the USGS hydrologic units identified in Table A-1. Salmon EFH excludes areas upstream of longstanding naturally impassible barriers (i.e., natural waterfalls in existence for several hundred years). Salmon EFH includes aquatic areas above all artificial barriers except the impassible barriers (dams) listed in Table A-2. However, activities occurring above impassable barriers that are likely to adversely affect EFH below impassable barriers are subject to the consultation provisions of the Magnuson-Stevens Act. In the future, should subsequent analyses determine the habitat above any of the dams listed in Table A-2 is necessary for salmon conservation, the Council will modify the identification of EFH.[1/]

1.1 COMPREHENSIVE APPROACH TO IDENTIFICATION

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

Adopting an inclusive, watershed-based description of EFH using USGS hydrologic units 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

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[1/] Table A-6 (Chapter 2) provides documentation for the current and historic distribution, including areas above dams. Table A-1 is a subset of Table A-6.

by environmental conditions (droughts, floods, etc.) that make precise mapping difficult; and (3) reinforces important linkages between aquatic and adjacent upslope areas. Habitat available and utilized by salmon changes frequently in response to floods, landslides, woody debris inputs, sediment delivery, and other natural events. To expect the distribution of salmon within a stream, watershed, province, or region to remain static over time is unrealistic. Furthermore, this watershed-based approach is consistent with other Pacific salmon habitat conservation and recovery efforts such as those implemented under the Endangered Species Act (ESA). Additional details on Pacific salmon freshwater essential habitat is provided in Chapter 2 of this appendix.

As new and better information becomes available, the Council will consider potential modifications to the identification and description of EFH during the process of scoping changes to the FMP.

1.2 CONSIDERATION OF ARTIFICIAL BARRIERS

In identifying EFH, the Council considered artificial barriers (dams) that affect salmon habitat. Numerous hydropower, water storage, and flood control projects have been built that either block access to areas used historically by salmonids or alter the hydrography of downstream river reaches. 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 currently inaccessible habitat should be made available to the species. The Council, therefore, considered whether more than 50 large dams in Washington, Idaho, Oregon, and California should be designated as the upstream extent of EFH. The four criteria used to evaluate EFH and the dams were:

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 impassable 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.

4. *Has NMFS determined 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.

Based on these considerations, the Council excluded certain dams from the list of those representing the upstream extent of EFH including Elwha Dam, Merwin Dam, Landsburg Dam, Howard Hanson Dam, Condit Dam, Cushman Dam, Mayfield Dam, Foster Dam, Pelton Dam, and Englebright Dam. Several large, impassable dams, (e.g., Grand Coulee and Shasta dams), were removed from the list, since they are above other impassible dams. Subsequent analyses may indicate other dams should be removed from Table A-2.

Throughout the range of Pacific salmon, numerous hydropower dams are undergoing or are scheduled for relicensing by FERC. Information developed during the process of relicensing requires evaluation to determine whether fish passage facilities will be required at such dams to restore access to historically accessible habitat. Even though habitat above such barriers may not currently be designated as EFH, this conclusion does not diminish the potential importance of restoring access to these areas. 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.

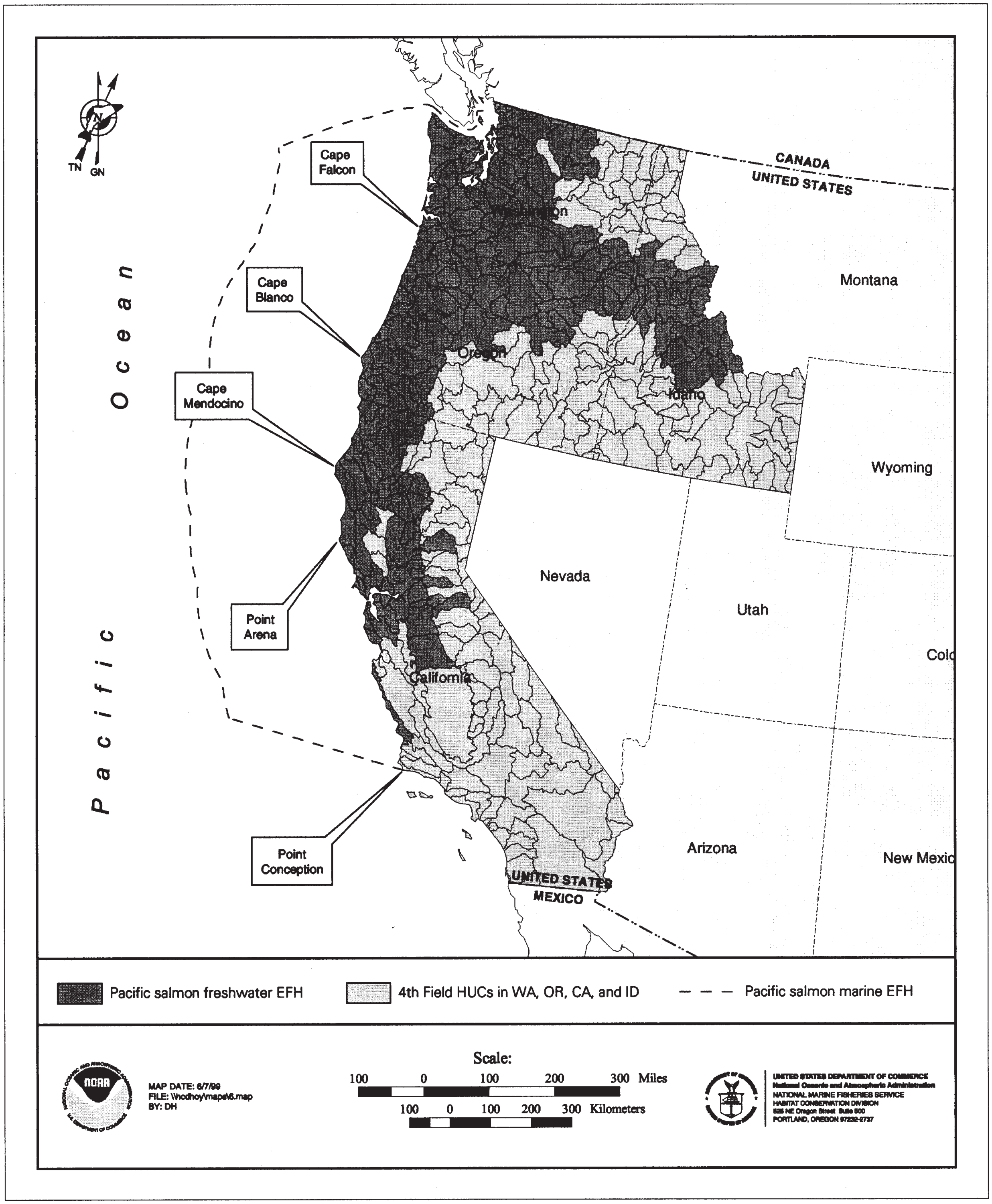

FIGURE A-1. Pacific salmon freshwater and marine EFH. Freshwater EFH includes currently viable aquatic habitat and most of the habitat historically accessible to Pacific salmon within the shaded hydrologic units (watersheds).

TABLE A-1. Pacific salmon freshwater EFH identified by USGS hydrologic unit number. (Page 1 of 5)

USGS Hydr. Unit	State(s)	Hydrologic Unit Name	Salmon Species
17110001	WA	Fraser (Whatcom)	coho salmon
17110002	WA	Strait of Georgia	chinook and coho salmon Puget Sound pink salmon
17110003	WA	San Juan Islands	chinook and coho salmon
17110004	WA	Nooksack River	chinook and coho salmon Puget Sound pink salmon
17110005	WA	Upper Skagit	chinook and coho salmon Puget Sound pink salmon Puget Sound sockeye salmon
17110006	WA	Sauk River	chinook and coho salmon Puget Sound pink salmon
17110007	WA	Lower Skagit River	chinook and coho salmon Puget Sound pink salmon Puget Sound sockeye salmon
17110008	WA	Stillaguamish River	chinook and coho salmon Puget Sound pink salmon
17110009	WA	Skykomish River	chinook and coho salmon Puget Sound pink salmon
17110010	WA	Snoqualmie River	chinook and coho salmon Puget Sound pink salmon
17110011	WA	Snohomish River	chinook and coho salmon Puget Sound pink salmon
17110012	WA	Lake Washington	chinook and coho salmon Puget Sound sockeye salmon
17110013	WA	Duwamish River	chinook and coho salmon
17110014	WA	Puyallup River	chinook and coho salmon Puget Sound pink salmon
17110015	WA	Nisqually River	chinook and coho salmon Puget Sound pink salmon
17110016	WA	Deschutes River	chinook and coho salmon
17110017	WA	Skokomish River	chinook and coho salmon
17110018	WA	Hood Canal	chinook and coho salmon Puget Sound pink salmon
17110019	WA	Puget Sound	chinook and coho salmon
17110020	WA	Dungeness - Elwha	chinook and coho salmon Puget Sound pink salmon
17110021	WA	Hoko - Crescent	chinook and coho salmon
17100101	WA	Hoh - Quillayute	chinook and coho salmon
17100102	WA	Queets - Quinault	chinook and coho salmon
17100103	WA	Upper Chehalis River	chinook and coho salmon
17100104	WA	Lower Chehalis River	chinook and coho salmon
17100105	WA	Grays Harbor	chinook and coho salmon
17100106	WA	Willapa Bay	chinook and coho salmon
17080001	OR/WA	Lower Columbia-Sandy River	chinook and coho salmon
17080002	WA	Lewis River	chinook and coho salmon
17080003	OR/WA	Lower Columbia - Clatskanie River	chinook and coho salmon
17080004	WA	Upper Cowlitz River	chinook and coho salmon
17080005	WA	Lower Cowlitz River	chinook and coho salmon

TABLE A-1. Pacific salmon freshwater EFH identified by USGS hydrologic unit number. (Page 2 of 5)

USGS Hydr. Unit	State(s)	Hydrologic Unit Name	Salmon Species
17080006	OR/WA	Lower Columbia	chinook and coho salmon
17090001	OR	Middle Fork Willamette River	chinook salmon
17090002	OR	Coast Fork Willamette River	chinook salmon
17090003	OR	Upper Willamette River	chinook and coho salmon
17090004	OR	McKenzie River	chinook and coho salmon
17090005	OR	N. Santiam River	chinook and coho salmon
17090006	OR	S. Santiam River	chinook and coho salmon
17090007	OR	Mid. Willamette River	chinook and coho salmon
17090008	OR	Yamhill River	chinook and coho salmon
17090009	OR	Molalla - Pudding River	chinook and coho salmon
17090010	OR	Tualatin River	chinook and coho salmon
17090011	OR	Clackamas River	chinook and coho salmon
17090012	OR	Lower Willamette River	chinook and coho salmon
17070101	OR/WA	Mid. Columbia - Lake Wallula	chinook salmon
17070102	OR/WA	Walla Walla River	chinook salmon
17070103	OR	Umatilla River	chinook salmon
17071004	OR	Willow	chinook salmon
17070105	OR/WA	Mid. Columbia - Hood	chinook and coho salmon
17070106	WA	Klickitat River	chinook salmon
17070301	OR	Upper Deschutes River	chinook salmon
17070305	OR	Lower Crooked River	chinook salmon
17070306	OR	Lower Deschutes River	chinook and coho salmon
17070307	OR	Trout Creek	chinook and coho salmon
17070201	OR	Upper John Day River	chinook salmon
17070202	OR	North Fork John Day River	chinook salmon
17070203	OR	Middle Fork John Day River	chinook salmon
17070204	OR	Lower John Day River	chinook salmon
17030001	WA	Upper Yakima River	chinook and coho salmon
17030002	WA	Naches River	chinook and coho salmon
17030003	WA	Lower Yakima River	chinook and coho salmon
17020005	WA	Chief Joseph River	chinook and coho salmon
17020006	WA/BC	Okanogan River	chinook salmon
17020007	WA/BC	Similkameen	chinook salmon
17020008	WA	Methow River	chinook and coho salmon
17020010	WA	Upper Columbia - Entiat River	chinook and coho salmon
17020011	WA	Wenatchee River	chinook and coho salmon
17020016	WA	Upper Columbia - Priest Rapids	chinook salmon
17060101	OR/ID	Hells Canyon	chinook salmon
17060102	OR	Imnaha River	chinook salmon
17060103	OR/WA/ID	Lower Snake - Asotin Creek	chinook and coho salmon
17060104	OR	Upper Grande Ronde	chinook and coho salmon

TABLE A-1. Pacific salmon freshwater EFH identified by USGS hydrologic unit number. (Page 3 of 5)

USGS Hydr. Unit	State(s)	Hydrologic Unit Name	Salmon Species
17060105	OR	Wallowa River	chinook and coho salmon
17060106	OR/WA	Lower Grande Ronde	chinook and coho salmon
17060107	WA	Lower Snake - Tucannon River	chinook and coho salmon
17060110	WA	Lower Snake River	chinook salmon
17060201	ID	Upper Salmon River	chinook salmon
17060202	ID	Pahsimeroi River	chinook salmon
17060203	ID	Mid. Salmon - Panther River	chinook salmon
17060204	ID	Lemhi River	chinook salmon
17060205	ID	Upper Middle Fork Salmon River	chinook salmon
17060206	ID	Lower Middle Fork Salmon River	chinook salmon
17060207	ID	Mid. Salmon - Chamberlain	chinook salmon
17060208	ID	S.F. Salmon River	chinook salmon
17060209	ID	Lower Salmon River	chinook salmon
17060210	ID	Little Salmon River	chinook salmon
17060301	ID	Upper Selway River	chinook salmon
17060302	ID	Lower Selway River	chinook salmon
17060303	ID	Lochsa River	chinook salmon
17060304	ID	M.F. Clearwater River	chinook salmon
17060305	ID	S.F. Clearwater River	chinook salmon
17060306	WA/ID	Clearwater River	chinook and coho salmon
17100201	OR	Necanicum River	chinook and coho salmon
17100202	OR	Nehalem River	chinook and coho salmon
17100203	OR	Wilson - Trask - Nestucca	chinook and coho salmon
17100204	OR	Siletz-Yaquina River	chinook and coho salmon
17100205	OR	Alsea River	chinook and coho salmon
17100206	OR	Siuslaw River	chinook and coho salmon
17100207	OR	Siltcoos River	chinook and coho salmon
17100301	OR	N. Umpqua River	chinook and coho salmon
17100302	OR	S. Umpqua River	chinook and coho salmon
17100303	OR	Umpqua River	chinook and coho salmon
17100304	OR	Coos River	chinook and coho salmon
17100305	OR	Coquille River	chinook and coho salmon
17100306	OR	Sixes River	chinook and coho salmon
17100307	OR	Upper Rogue River	chinook and coho salmon
17100308	OR	Middle Rogue River	chinook and coho salmon
17100309	CA/OR	Applegate River	chinook and coho salmon
17100310	OR	Lower Rogue River	chinook and coho salmon
17100311	CA/OR	Illinois River	chinook and coho salmon
17100312	CA/OR	Chetco River	chinook and coho salmon
18010101	CA/OR	Smith River	chinook and coho salmon
18010206	CA/OR	Upper Klamath River	chinook and coho salmon

TABLE A-1. Pacific salmon freshwater EFH identified by USGS hydrologic unit number. (Page 4 of 5)

USGS Hydr. Unit	State(s)	Hydrologic Unit Name	Salmon Species
18010207	CA	Shasta River	chinook and coho salmon
18010208	CA	Scott River	chinook and coho salmon
18010209	CA/OR	Lower Klamath River	chinook and coho salmon
18010210	CA	Salmon River	chinook and coho salmon
18010211	CA	Trinity River	chinook and coho salmon
18010212	CA	S.F. Trinity River	chinook and coho salmon
18010102	CA	Mad-Redwood	chinook and coho salmon
18010103	CA	Upper Eel River	chinook and coho salmon
18010104	CA	Middle Fork Eel River	chinook and coho salmon
18010105	CA	Lower Eel River	chinook and coho salmon
18010106	CA	South Fork Eel River	chinook and coho salmon
18010107	CA	Mattole River	chinook and coho salmon
18010108	CA	Big - Navarro - Garcia	chinook and coho salmon
18010109	CA	Gualala - Salmon Creek	chinook and coho salmon
18010110	CA	Russian River	chinook and coho salmon
18010111	CA	Bodega Bay	chinook and coho salmon
18060001	CA	San Lorenzo-Soquel	coho salmon
18060006	CA	Central Coastal	coho salmon
18050001	CA	Suisun Bay	chinook
18050002	CA	San Pablo Bay	chinook
18050003	CA	Coyote Creek	chinook
18050004	CA	San Francisco Bay	chinook and coho salmon
18050005	CA	Tomales-Drakes Bay	coho salmon
18050006	CA	San Francisco-Coastal South	coho salmon
18020101	CA	Sac.-Lower Cow-Lower Clear	chinook salmon
18020102	CA	Lower Cottonwood Creek	chinook salmon
18020103	CA	Sacramento - Lower Thomes	chinook salmon
18020104	CA	Sacramento - Stone Corral	chinook salmon
18020105	CA	Lower Butte Creek	chinook salmon
18020106	CA	Lower Feather River	chinook salmon
18020107	CA	Lower Yuba River	chinook salmon
18020108	CA	Lower Bear River	chinook salmon
18020109	CA	Lower Sacramento River	chinook salmon
18020110	CA	Lower Cache	chinook salmon
18020111	CA	Lower American River	chinook salmon
18020112	CA	Sacramento-Upper Clear	chinook salmon
18020113	CA	Cottonwood Headwaters	chinook salmon
18020114	CA	Elder Creek	chinook salmon
18020118	CA	Upper Cow - Battle Creek	chinook salmon
18020119	CA	Mill - Big Chico	chinook salmon
18020120	CA	Upper Butte Creek	chinook salmon

TABLE A-1. Pacific salmon freshwater EFH identified by USGS hydrologic unit number. (Page 5 of 5)

USGS Hydr. Unit	State(s)	Hydrologic Unit Name	Salmon Species
18020125	CA	Upper Yuba	chinook salmon
18040001	CA	Mid. San Joaquin- L. Cowchilla	chinook salmon
18040002	CA	Mid. San Joaquin- L. Merced- L. Stanislaus	chinook salmon
18040003	CA	San Joaquin Delta	chinook salmon
18040004	CA	L. Calaveras - Mormon Slough	chinook salmon
18040005	CA	L. Consumnes- L. Mokelumne	chinook salmon
18040010	CA	Upper Stanislaus	chinook salmon
18040011	CA	Upper Calveras	chinook salmon
18040013	CA	Upper Cosumnes	chinook salmon

TABLE A-2. List of man-made barriers (dams) that represent the upstream extent of Pacific salmon EFH. (Page 1 of 2)

Name of Barrier	State	USGS Hydrologic Unit	Tributary/Basin
Gorge Lake Dam	WA	17110005	Skagit River
Cedar Falls Dam	WA	17110012	Cedar River
Tolt Dam	WA	17110010	Snoqualmie River
Keechelus Dam	WA	17030001	Yakima River
Kachess Dam	WA	17030001	Yakima River
Cle Elum Dam	WA	17030001	Yakima River, Cle Elum River
Rimrock Dam	WA	17030002	Naches River
Chief Joseph Dam	WA	17020005	Upper Columbia River
Dworshak Dam	ID	17060308	Clearwater River
Hells Canyon Complex (Hells Canyon, Oxbow, and Brownlee Dams)	ID	17050201	Snake River
Opel Springs Dam	OR	17070306	Deschutes River
Big Cliff Dam	OR	17090005	N. Santiam River
Cougar Dam	OR	17090004	McKenzie River
Dexter Dam	OR	17090001	Middle Fork Willamette River
Dorena Dam	OR	17090002	Coast Fork Willamette River
Soda Springs Dam	OR	17100301	N. Umpqua River
Lost Creek Dam	OR	17100307	Rogue River
Applegate Dam	OR	17100309	Applegate River
Bull Run Dam	OR	17080001	Bull Run River/Sandy River
Oak Grove Dam	OR	17090011	Clackamas River
Iron Gate Dam	CA	18010206	Klamath River
Lewiston Dam	CA	18010211	Trinity River
Dwinnell Dam or Shasta River Dam	CA	18010207	Shasta
Robert W. Matthews Dam	CA	18010102	Mad River
Coyote Valley Dam	CA	18010110	E. Fork Russian River
Warm Springs Dam	CA	18010110	Dry Creek
Scott Dam	CA	18010103	Eel River
Keswick Dam	CA	18020112	Sacramento River
Oroville Dam	CA	18020121 & 18020123	Feather River
Black Butte Dam	CA	18020115	Stoney Creek
Whiskeytown Dam	CA	18020112	Clear Creek
Camp Far West Dam	CA	18020126	Bear River
Nimbus Dam	CA	18020111	American River
Friant Dam	CA	18040006	San Joaquin River
Camanche Dam	CA	18040005	Mokelumne River

TABLE A-2. List of man-made barriers (dams) that represent the upstream extent of Pacific salmon EFH. (Page 2 of 2)

Name of Barrier	State	USGS Hydrologic Unit	Tributary/Basin
New Hogan Dam	CA	18040011	Calaveras River
Crocker Diversion Dam	CA	18040008	Merced River
Goodwin Dam	CA	18040010	Stanislaus River
La Grange Dam	CA	18040002	Tuolumne River
Nicasio Dam	CA	18050005	Nicasio Creek
Peters Dam	CA	18050005	Lagunitas Creek
San Pablo Dam	CA	18050002	San Pablo Bay
LeRoy Anderson Dam	CA	18050003	Coyote Creek
Newell Dam	CA	18060001	Newell Creek

2.0 ESSENTIAL FISH HABITAT DESCRIPTIONS

The following essential habitat and life history descriptions were developed for the three Pacific salmon species actively managed under the *Pacific Coast Salmon Plan*. This includes chinook and coho salmon stocks from Washington, Oregon, Idaho, and California as well as pink salmon stocks originating from watersheds within Puget Sound (PFMC 1997b). Descriptions for pink or sockeye salmon originating from outside of Puget Sound, and for chum salmon (*Oncorhynchus keta*), steelhead (*Oncorhynchus mykiss*), and cutthroat trout (*Oncorhynchus mykiss*) are not included, because incidental catches of these species in Council-managed ocean fisheries are rare.

2.1 ESSENTIAL HABITAT DESCRIPTION FOR CHINOOK SALMON (*Oncorhynchus tshawytscha*)

2.1.1 General Distribution and Life History

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

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

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

The natural freshwater range of the species includes large portions of the Pacific rim of North America and Asia. In North America, chinook salmon historically ranged from the Ventura River in California (~34° N latitude) to Kotzebue Sound in Alaska (~66° N latitude); in addition, the species has been identified in North America in the Mackenzie River, which drains into the Arctic Ocean (McPhail and Lindsey 1970, Major *et al.* 1978). At present, the southern-most populations occur in the San Joaquin River, although chinook salmon are occasionally observed in Rivers south of San Francisco Bay, such as the San Luis Obispo and Carmel rivers. In Asia, natural populations of chinook salmon have been documented from Hokkaido Island, Japan (~42° N latitude), to the Andyr River in Russia (~64° N latitude). In marine environments, chinook salmon from Washington, Oregon, and California range widely throughout the north Pacific Ocean and the Bering Sea, as far south as the U.S./Mexico border.

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

Declines in the abundance of chinook salmon have been well documented throughout the southern portion of the range. Concern over coast-wide declines from southeastern Alaska to California was a major factor leading to the signing of the Pacific Salmon Treaty between the United States and Canada in 1985. Wild chinook salmon populations have been extirpated from large portions of their historic range in a number of watersheds in California, Oregon, Washington, Idaho, and southern British Columbia (Nehlsen *et al.* 1991), and a number of Evolutionarily Significant Units (ESUs) have been listed or proposed for listing by NMFS as at risk of extinction under the ESA (NMFS 1998, 1999). For example, the Columbia River formerly supported the world's largest chinook salmon run, but currently five Columbia Basin ESUs are listed as "threatened" under the ESA - Snake River spring/summer, Snake River fall, upper Columbia River spring, lower Columbia River and upper Willamette River chinook salmons (NMFS 1992, 1999).

Habitat degradation is the major cause for extinction of populations; many extinctions are related to dam construction and operation (NMFS 1996, Myers *et al.* 1998). Urbanization, agricultural land use, water diversion, and logging are also factors contributing to habitat degradation and the decline of chinook salmon (Nehlson *et al.* 1991, Spence *et al.* 1996). The development of large-scale hatchery programs have, to some degree, mitigated the decline in abundance of chinook in some areas. However, genetic and ecological interactions of hatchery and wild fish have also been identified as risk factors for wild populations, and the high harvest rates directed at hatchery fish may cause over-exploitation of co-mingled wild populations (Reisenbichler 1997, Mundy 1997). Recent increases in pinniped populations also raise concerns over the impacts of pinniped predation on the recovery of salmonids in certain situations (NMFS 1997c).

2.1.2 Fisheries

Chinook salmon are highly prized by commercial, sport, and subsistence fishers, because of their large size and excellent palatability. Because of their migrations through coastal waters, however, chinook salmon returning to Washington, Oregon, and California waters are harvested in fisheries over a wide geographic area. Considerable management and regulatory efforts focus on chinook salmon fisheries primarily due to the value of the fish, the numerous states and agencies involved in regulating these fisheries, and concerns about declining abundance.

Ocean fisheries targeting chinook salmon use hook-and-line gear, but gill nets are used in commercial and tribal freshwater fisheries in the Columbia and Klamath Rivers, and other rivers. Chinook salmon fisheries have some bycatch associated with them, most often other salmonids and undersized chinook salmon. While the majority of these fish survive the hooking encounter, substantial (> 25%) mortality may occur (Wertheimer 1988, Wertheimer *et al.* 1989, Gjernes *et al.* 1993). A complete and current description of ocean fisheries, harvest levels, and management framework can be found in the most recent versions of the annual PFMC documents *Review of Ocean Salmon Fisheries* and *Preseason Report I* (PFMC 1999a, 1999b).

2.1.3 Relevant Trophic Information

Chinook salmon eggs, alevins, and juveniles in freshwater streams provide an important nutrient input and food source for aquatic invertebrates, other fishes, birds, and small mammals. The carcasses of chinook adults can also be an important nutrient input in their natal watersheds, as well as providing food sources for terrestrial mammals such as bears, otters, minks, and birds such as gulls, eagles, and ravens (Cederholm *et al.* 1989, Bilby *et al.* 1996, Ben-David *et al.* 1997). Because of their relatively low abundance in coastal and oceanic waters, chinook salmon in the marine environment are typically only an incidental food item in the diet of other fishes, marine mammals, and coastal sea birds (Botkin *et al.* 1995). However, pinniped predation on migrating salmonids, both adult spawners and downstream migrating smolts, can be substantial especially at sites of restricted passage and small salmonid populations (NMFS 1997c).

2.1.4 Habitat and Biological Associations

Table A-3 summarizes chinook salmon habitat use by life history stage.

2.1.4.1 Eggs and Spawning

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

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

Chinook salmon spawn in a broad range of habitats. They have been known to spawn in water depths ranging from a few centimeters to several meters deep, and in small tributaries 2-3 m wide to large rivers such as the Columbia and the Sacramento (Chapman 1943, Burner 1951, Vronskiy 1972, Healey 1991). Chinook salmon redds (nests) range in size from 2 to 40 m^2, occur at depths of 10-700 cm and at water velocities of 10-150 cm/s (Healey 1991). Typically, chinook salmon redds are 5-15 m^2 and located in areas with water velocities of 40-60 cm/s. The depth of the redd is inversely related to water velocity, and the female buries her eggs in clean gravel or cobble 10-80 cm in depth (Healey 1991). Because of their large size, chinook salmon are able to spawn in higher water velocities and utilize coarser substrates than other salmon species. Female chinook salmon select areas of the spawning stream with high subgravel flow such as pool tailouts, runs, and riffles (Vronskiy 1972, Burger *et al.* 1985, Healey 1991). Because their eggs are the largest of the Pacific salmon, ranging from 6 to 9 mm in diameter (Rounsefell 1957, Nicholas and Hankin 1988), with a correspondingly small surface-to-volume ratio, they may be more sensitive to reduced oxygen levels and require a higher rate of irrigation than other salmonids. Fertilization of the eggs occurs simultaneous with deposition. Males compete for the right to breed with spawning females. Chinook salmon females have been reported to remain on their redds from six to 25 days after spawning (Neilson and Geen 1981, Neilson and Banford 1983), defending the area from superimposition of eggs from another female. This period of redd protection roughly coincides with the period the eggs are most sensitive to physical shock.

2.1.4.2 Larvae/Alevins

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

TABLE A-3. Chinook salmon habitat use by life history stage. (See key to abbreviations and EFH data levels on the next page.)

Stage - EFH Data Level	Duration or Age	Diet/Prey	Season/Time	Location	Water Column	Bottom Type	Oceanographic Features	Other
Eggs EFH Data Level 0-4; not all habitats have been sampled	50-130 d	Non-feeding stage; eggs consumed by birds, fish, and mammals.	Late summer, fall, and winter	Intragravel in stream beds	20-80 cm gravel depth; 15-700 cm water depth	Medium to course gravel	NA	**DO** < 2 mg/l lethal, optimum > 8 mg/l; **Temperature** 0-17°C, optimum 5-14°C; **Water velocity** 15-190 cm/s
Larvae (alevins) EFH Data Level 0-4; not all habitats have been sampled	50-125 d until fry emerge from gravel	Non-feeding stage; Alevins consumed by birds, fish and mammals	Fall, winter, and early spring	Intragravel until fry emergence	20-80 cm gravel depth; 15-700 cm water depth	Medium to course gravel	NA	**DO** < 2 mg/l lethal, optimum > 8 mg/l; **Temperature** 0-17°C, optimum 5-14°C; **Water velocity** 15-190 cm/s
Juveniles (freshwater) EFH Data level 0-4; not all habitats have been sampled	days-yrs	Insect larvae, adults, plankton	Year-round, depending on race	Streams, lakes, sloughs, rivers	0-120 cm	Varied	NA	**DO** lethal at <2 mg/l, optimum at saturation; **Temperature** 0-26°C, optimum 12-14°C; **Salinity** < 29 ppt
Juveniles (Estuary and oceanic) EFH Data Level 0-3; not all habitats have been sampled	6-months to 2 yrs	Estuary: copepods, euphausiids, amphipods. Ocean: fish, squid, euphausiids	Estuary: spring, summer, fall. Ocean: year-round	BCH BAY, IP, ICS, OCS	P, N, SD/SP 30-80 m preferred depth	All bottom types	Estuarine, littoral then more open water, UP, F, CL, G	**DO** lethal at <2 mg/l, optimum at saturation; **Temperature** 0-26°C, optimum 12-14°C; **Salinity** sea water
Adults EFH Data Level 0-2; not all habitats have been sampled	2-8 yrs of age from egg to mature adult	Fish, squid, euphausiids, amphipods, and copepods	Spawning: July-Feb. Non-spawning: Year round	Oceanic to nearshore migrations, spawn in freshwater	P, N, SD/SP	NA	Different stock groups have specific oceanic migratory patterns	**DO** Preferred >5 mg/l, optimum at saturation; **Temperature** 0-26°C; optimum <14°C

Major sources: Healey 1991, Bjorn and Reiser 1991, Myers *et al.* 1998, NOAA 1990, Fisher and Pearcy 1995, Spence *et al.* 1996.

KEY FOR TABLES A-3, A-4, AND A-5.

EFH Data Level

0 No systematic sampling has been conducted for this species and life stage; may have been caught opportunistically in small numbers during other surveys.

1 Presence/absence distribution data are available for some or all portions of the geographic range.

2 Habitat-related densities are available. Density data should reflect habitat utilization, and the degree that a habitat is utilized is assumed to be indicative of habitat value.

3 Habitat-related growth, reproduction, or survival rates are available. The habitats contributing the most to productivity should be those that support the highest growth, reproduction, and survival of the species (or life history stage).

4 Habitat-related production rates are available. Essential habitats are those necessary to maintain fish production consistent with a sustainable fishery and a healthy ecosystem.

Location where found (in waters of these depths)

BAY - nearshore bays, give depth if appropriate (e.g., fjords)
BCH - beach (intertidal)
BSN - basin (>3,000 m)
IP - island passes (areas of high current), give depth if appropriate
ICS - inner continental shelf (1-50 m)
LSP - lower slope (1,000-3,000 m)
MCS - middle continental shelf (50-100 m)
OCS - outer continental shelf (100-200 m)
USP - upper slope (200-1,000 m)

Where found in water column

D - demersal (found on bottom)
N - neustonic (found near surface)
P - pelagic (found off bottom, not necessarily associated with a particular bottom type)
SD/SP - semi-demersal or semi-pelagic if slightly greater or less than 50% on or off bottom

Bottom Types

M - mud
SM - sandy mud
MS - muddy sand
S - sand
CB - cobble
G - gravel
R - rock
C - coral
K - kelp
SAV - subaquatic vegetation other than kelp (e.g., eelgrass).

Oceanographic Features

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

Other

U=Unknown
NA=not applicable

2.1.4.3 Juveniles (Freshwater)

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

In contrast, stream-type fish generally spend at least one year in freshwater before emigrating to sea. Alaskan fish are predominantly stream-type, while chinook salmon from northern British Columbia are approximately half stream-type and half ocean-type (Taylor 1990a, Healey 1991). Ocean-type life histories are most common in central and southern British Columbia, Washington, Oregon, and California, with the exception of populations inhabiting the upper reaches of large river basins such as the Fraser, Columbia, Snake, and to a lesser extent the Klamath and Sacramento.

Water and habitat quality and quantity determine the productivity of a watershed for chinook salmon. Both stream and ocean-type fish utilize a wide variety of habitats during their freshwater residency, and are dependent on the quality of the entire watershed, from headwater to the estuary. Juvenile chinook inhabit primarily pools and stream margins, particularly undercut banks, behind woody debris accumulations, and other areas cover and reduced water velocity (Lister and Genoe 1970, Bjornn and Reiser 1991). While chinook salmon habitat preferences are similar to coho salmon, chinook salmon inhabit slightly deeper (15-120 cm) and higher velocity (0-38 cm/s) areas than coho salmon (Bjornn and Reiser 1991, Healey 1991). The stream or river must provide adequate summer and winter rearing habitat, and migration corridors from spawning and rearing areas to the sea. Stream-type juveniles are more dependent on freshwater ecosystems, because of their extended residence in these areas. The length of freshwater residence and growth is determined partially by water temperature and food resources. The principal foods in freshwater are larval and adult insects, while those in estuarine areas include epibenthic organisms, insects, and zooplankton.

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

2.1.4.4 Juvenile (Estuarine)

Although both stream and ocean-type chinook salmon may reside in estuaries, stream-type chinook salmon generally spend a very brief period in the lower estuary before moving into coastal waters and the open ocean (Healey 1980, 1982, 1983; Levy and Northcote 1981). In contrast, ocean-type chinook salmon typically reside in estuaries for several months before entering coastal waters of higher salinity (Healey 1980, 1982; Congleton *et al.* 1981, Levy and Northcote 1981, Kjelson *et al.* 1982).

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

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

The chinook salmon diet during estuarine residence is highly variable and is dependent upon the particular estuary, year, season, and prey abundance. In general, chinook are opportunistic feeders, consuming larval and adult insects and amphipods when they first enter estuaries, with increasing dependance on larval and juvenile fish (including other salmonids) as they grow larger. Preferred diet items for chinook salmon include aquatic and terrestrial insects such as chironomid larvae, dipterans, cladoceans such as *Daphnia*, amphipods including *Eogammarus* and *Corophium*, and other crustacea such as *Neomysis*, crab larvae, and cumaceans (Sasaki 1966, Dunford 1975, Birtwell 1978, Levy *et al.* 1979, Northcote *et al.* 1979, Healey 1980, 1982; Kjelson *et al.* 1982, Levy and Northcote 1981, Levings 1982, Gordon and Levings 1984, Myers 1980; Reimers 1973). Larger juvenile chinook consume juvenile fishes such as anchovy *(Engraulidae)*, smelt *(Osmeridae)*, herring *(Clupeidae)*, and stickleback *(Gasterosteidae)*.

Growth in estuaries is quite rapid and chinook may enter the upper reaches of estuarine environments as 35-40 mm fry, and leave as 70-110 mm smolts (Rich 1920, Levy and Northcote 1981, 1982; Reimers 1973, Healey 1980). Growth rates during this period are difficult to estimate because small individuals are continually entering the estuary from upstream, while larger individuals depart for marine waters. Reported growth for populations range from .22 mm/d to .86 mm/d, and is as high as 1.32 mm/d for groups of marked fish (Rich 1920; Levy and Northcote 1981, 1982; Reimers 1973; Healey 1980; Kjelson *et al.* 1982; Healey 1991; Levings *et al.* 1986).

2.1.4.5 Juveniles (Marine)

After leaving the freshwater and estuarine environment, juvenile chinook disperse to marine feeding areas. Ocean-type fish which have a longer estuarine residence, tend to be coastal oriented, preferring protected waters and waters along the continental shelf (Healey 1983). In contrast, stream-type fish pass quickly through estuaries, are highly migratory, and may migrate great distances into the open ocean.

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

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

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

The coastal distribution of chinook salmon is similar to coho salmon (Hartt and Dell 1986), with high concentrations in areas of pronounced coastal upwelling. Juvenile chinook are generally found within 55 km of the Washington, Oregon, and California coast, with the vast majority of fish found less than 28 km offshore (Pearcy and Fisher 1990, Fisher and Pearcy 1995). Historically, juvenile chinook salmon have been reported in coastal streams as far south as San Luis Obispo (Jordan 1895) and the Ventura River (Jordan and Gilbert 1881), so it can be presumed that their historical ocean distribution occasionally included coastal upwelling areas off southern California. Point Conception (34°30' N latitude), California, is considered the faunal break for marine fishes, with salmon and other temperate water fishes found north and subtropical fishes found south of this point (Allen and Smith 1988). Therefore, the historic southern edge of the marine distribution appears to be near Point Conception, California, and expands and contracts seasonally and between years depending on ocean temperature patterns and upwelling.

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

While the marine distribution of chinook salmon can be highly variable within and among populations, migration and ocean distribution patterns show similarities among some geographic areas. For example, chinook salmon that spawn in rivers south of the Rogue River in Oregon disperse and rear in marine waters off the Oregon and California coast, while those spawning north of the Rogue River migrate north and west along the Pacific coast (Godfrey 1968, Major *et al.* 1978, Cleaver 1969, Wahle and Vreeland 1977, Wahle *et al.* 1981, Healey and Groot 1987). These migration patterns result in the harvest of fish from Oregon, Washington, and British Columbia within the EEZ off the Alaskan coast.

Chinook salmon are the most piscivorous of the Pacific salmon. Accordingly, fishes make up the largest component of their diet at sea, although squids, pelagic amphipods, copepods, and euphausiids are also important at times (Merkel 1957, Prakash 1962, Ito 1964, Hart 1973, Healey 1991).

2.1.4.6 Adults

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

Chinook salmon become sexually mature at a wide range of ages from two to eight years, with "jacks" or precocious males maturing after one to two years. Overall, the most common age of ocean- and stream-type maturing adults is three to five years, with males tending to be slightly younger than females. In general, stream-type fish have a longer generation time than do ocean-type fish, presumably owning to their longer freshwater residence, and chinook salmon from Alaska and more northern latitudes typically mature a year or more later than their southern counterparts (Roni and Quinn 1995, Myers *et al.* 1998). This phenomenon may also be an artifact of fishing pressure.

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

Prior to sexual maturation and spawning, adult chinook salmon often hold in large, deep, low velocity pools, with abundant large woody debris or other cover features. These areas may serve as a refuge from high river temperatures, predators, or a refuge to reduce metabolic demands and reserve energy until spawning commences (Berman and Quinn 1991). The spawning densities of chinook and coho salmon have been correlated with a number of factors including large woody debris and pool frequency (Montgomery *et al.* In prep.).

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

2.1.4.7 Databases on Chinook Salmon Distribution

To determine the geographic extent of chinook salmon freshwater and estuarine distribution, we examined the available information and selected databases on chinook salmon distribution and habitat use (see tables in Sections 2.4 and 2.5). The databases fell into three general categories, (1) regional, small scale (1:100,000 or 1:250,000) regional Geographic Information System (GIS) databases on salmon distribution (StreamNet, Washington Rivers Information System [WARIS], Oregon River Information System [ORIS], etc.), (2) local, large scale GIS database of limited coverage (county, tribal datasets, etc.), and (3) databases on habitat quality (U.S. Forest Service [USFS] stream survey data, state agency stream survey data, etc.). Unfortunately, databases in category 2 and 3 are of limited utility in specifically determining chinook salmon freshwater distribution, because they are composed of numerous, incompatible, small databases with incomplete geographic coverage. These datasets may, however, be useful during the EFH consultation process.

Small scale, regional databases such as StreamNet (1998) are suitable for portraying the overall distribution of chinook salmon and have utility for determining presence on the majority of specific stream reaches. Various life stages (migration, spawning and rearing, and rearing only) are delimited in the database distribution data as well. The hydrography used by StreamNet to spatially reference fish distribution is predominantly composed of 1:100,000 scale data, but both 1:63,500 and 1:24,000 linework has been added where appropriate to reference all the distribution data available to the project.

The formation and modification of stream channels and habitats is a dynamic process. Habitat available and utilized by chinook salmon changes frequently in response to floods, landslides, woody debris inputs, sediment delivery, and other natural events (Sullivan *et al.* 1987, Naiman *et al.* 1992, Reeves *et al.* 1995). To expect the distribution of chinook salmon within a stream, watershed, province, or region to remain static over time is unrealistic. Therefore, current information on chinook salmon distribution is useful for determining which watersheds chinook salmon inhabit, but not necessarily for identifying specific stream reaches and habitats utilized by the species.

2.1.4.8 Habitat Areas of Particular Concern

Information exists on the type of stream reaches preferred by chinook salmon for spawning and rearing. It is generally accepted that salmon spawn and rear primarily in stream reaches with a slope less than 4-5% (Lunetta *et al.* 1997), while they migrate through much steeper stream reaches. Furthermore, recent research has indicated that chinook and other fall-spawning anadromous salmonids are found primarily in plane-bed, pool-riffle, and forced-pool riffle stream channels[1/], which are channel types less than 4% slope (Montgomery and Buffington 1997, Montgomery *et al.* In prep.). Stream reaches greater than 4% slope are not frequently utilized by chinook salmon for spawning and rearing, because of their high bed load transport rate, deep scour, and coarse substrate (Montgomery *et al.* In prep.). Stream reaches less than 4-5% slope that potentially display plane-bed, pool-riffle, forced-pool-riffle morphology can be determined using GIS technology. Gradient and channel type as identified by GIS technology can differ from those actually present in the field (Lunetta *et al.* 1997, Montgomery and Buffington 1997). Therefore, it is important that a 1:24,000

1/ See Montgomery and Buffington (1997) for a description of this channel classification system.

or larger (finer) scale maps are used to determine potential channel type and a fine scale (10 m or less) digital elevation model is used to calculate slopes and channel types. Furthermore, slope and channel type should be confirmed in a representative number of reaches by site visits or existing habitat surveys. While the technology exists to develop this information, data at this scale and resolution have only been developed for specific provinces, not for the entire region; and, therefore, could not be used in the current EFH identification process. However, the existing information should be useful in the consultation process.

The delineation of channel types allows identification of potentially important and vulnerable habitats in the absence of accurate salmon distribution or habitat data. Moreover, degraded stream reaches, those lacking key roughness elements (e.g., large woody debris), and stream reaches with a high potential for restoration will still be identified as potential habitat. Therefore, the protection and restoration of chinook salmon habitat should focus on pool-riffle, plane bed, and forced-pool-riffle channels. Furthermore, any activity adjacent to or upstream of activity that could influence the quality of these important reaches or channels should be evaluated. Other vulnerable habitats that are in need of protection and restoration are off-channel rearing areas (e.g., wetlands, oxbows, side channels, sloughs) and estuarine and other near-shore marine areas. Submarine canyons and other regions of pronounced upwelling are also thought to be particularly important during El Niño events (N. Bingham, Pacific Coast Federation of Fishermen's Associations, P.O. Box 783, Mendocino, CA 95460, pers. comm.) and may need additional consideration for protection.

2.1.4.9 Freshwater Essential Fish Habitat

Freshwater EFH for chinook salmon consists of four major components, (1) spawning and incubation; (2) juvenile rearing; (3) juvenile migration corridors; and (4) adult migration corridors and adult holding habitat. Important features of essential habitat for spawning, rearing, and migration include adequate (1) substrate composition; (2) water quality (e.g., dissolved oxygen, nutrients, temperature, etc.); (3) water quantity, depth, and velocity; (4) channel gradient and stability; (5) food; (6) cover and habitat complexity (e.g., large woody debris, pools, channel complexity, aquatic vegetation, etc.); (7) space; (8) access and passage; and (9) flood plain and habitat connectivity. This incorporates, but is not limited to, life-stage specific habitat criteria summarized in Table 2-1.

Chinook salmon essential freshwater habitat includes all those streams, lakes, ponds, wetlands, tributaries, and other water bodies currently viable and most of the habitat historically accessible to chinook salmon within Washington, Oregon, Idaho, and California. Figure A-2 illustrates the watersheds currently utilized by chinook salmon from Washington, Oregon, Idaho and California within the hydologic units identified at the end of the chapter for all Council-managed salmon (Table A-6). Current chinook EFH does not include the aquatic habitat in watersheds above Dworshak Dam and the Hells Canyon Dam complex (Table A-2). Figure A-3 depicts the approximate historical freshwater distribution and the currently identified range of common marine occurrence of chinook salmon from Washington, Oregon, Idaho, and California. The geographic extent of the historic freshwater distribution of chinook salmon is based on data from Table A-5. Data on the marine range of chinook salmon are from National Oceanic and Atmospheric Administration (NOAA) (1990).

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

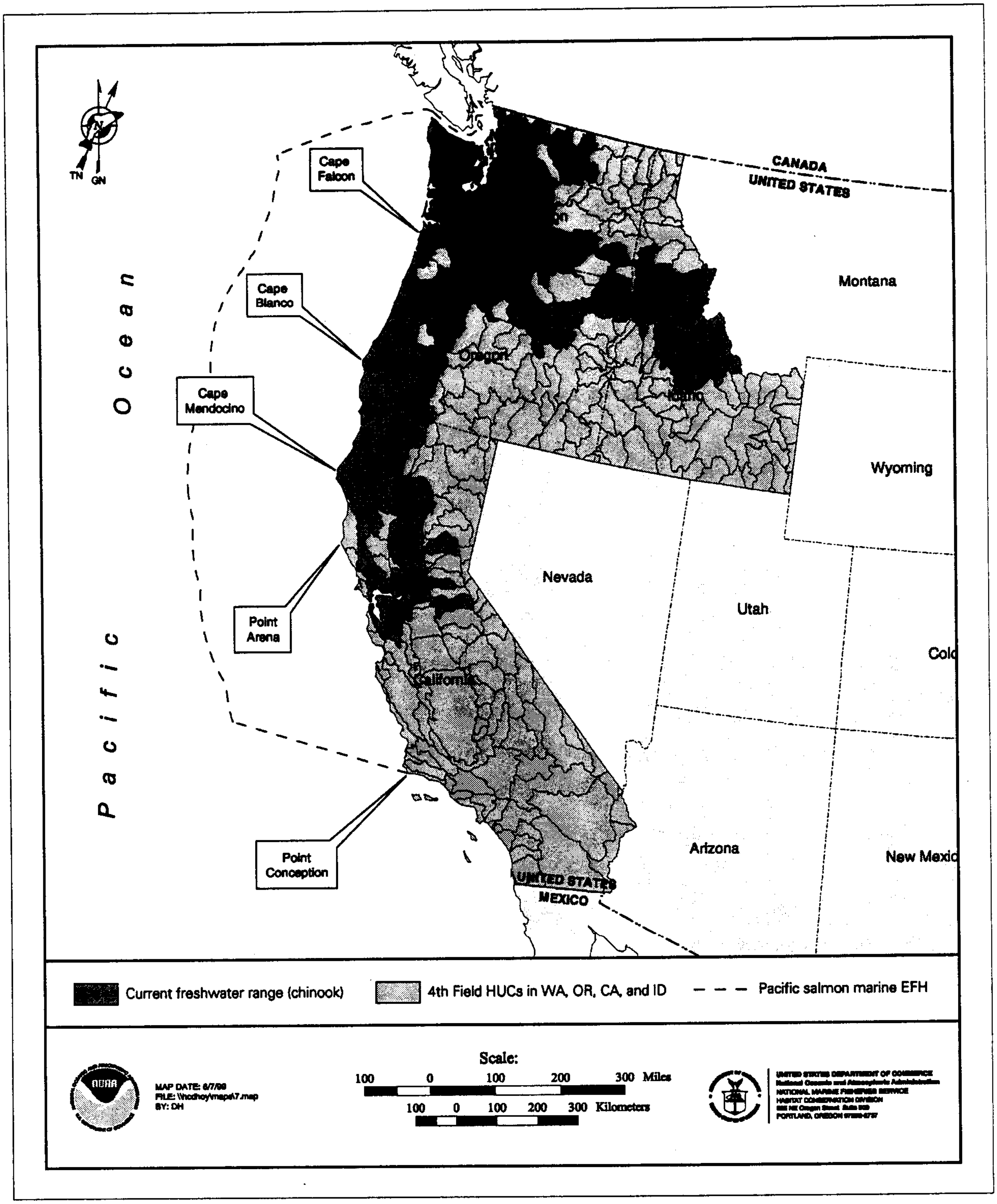

FIGURE A-2. Watersheds currently utilized by chinook salmon from Washington, Oregon, Idaho, and California.

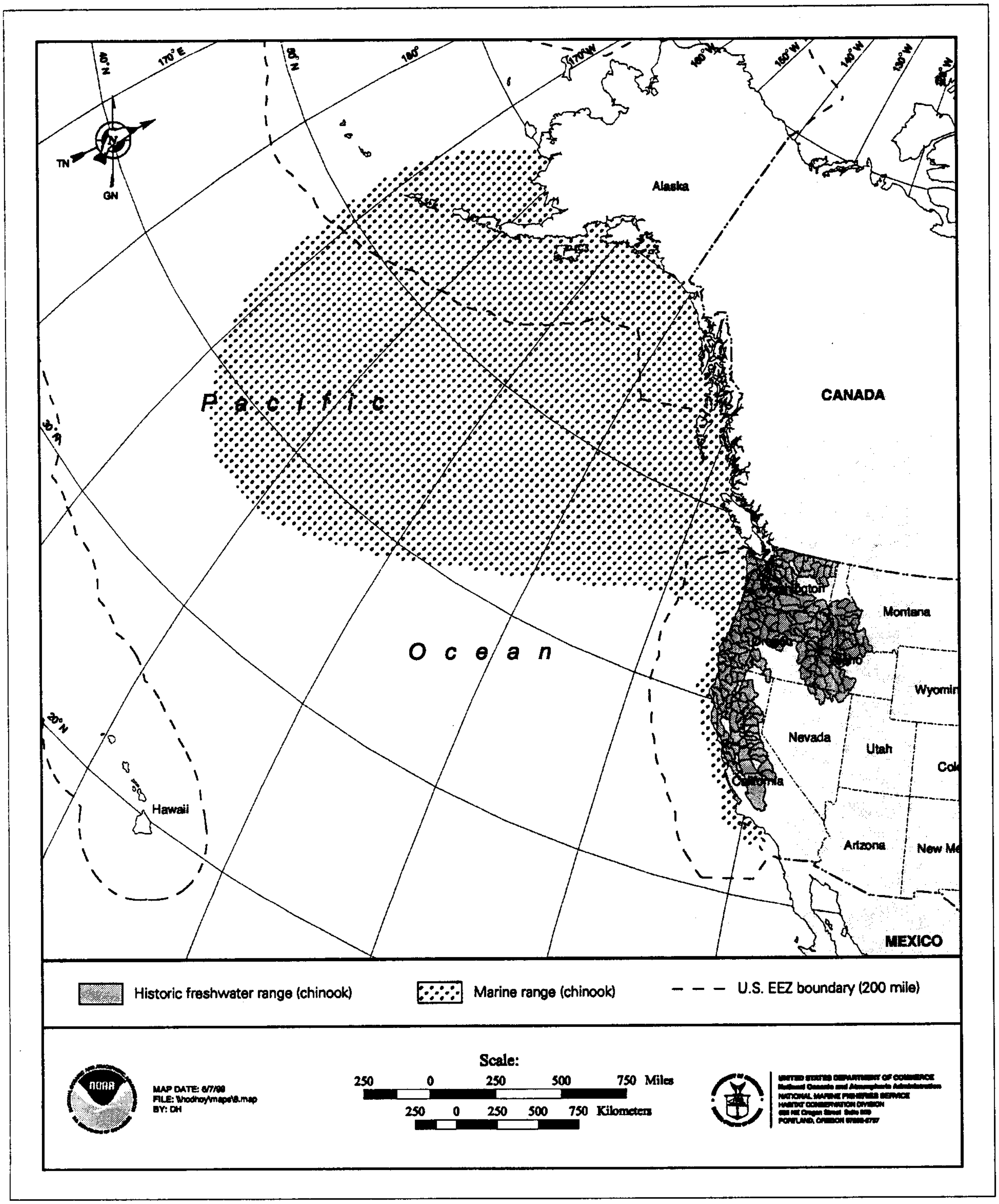

FIGURE A-3. Approximate historically accessible freshwater distribution and currently identified range of common marine occurrence of chinook salmon originating from Washington, Oregon, Idaho, and California.

2.1.4.10 Marine Essential Fish Habitat

The important elements of chinook salmon marine EFH are (1) estuarine rearing; (2) ocean rearing; and (3) juvenile and adult migration. Important features of this estuarine and marine habitat are (1) adequate water quality; (2) adequate temperature; (3) adequate prey species and forage base (food); and (4) adequate depth, cover, marine vegetation, and algae in estuarine and near-shore habitats. The available information for each life-history stage is summarized in Table A-3. Overall chinook salmon marine distribution is extensive, varies seasonally, interannually, and can only be defined generally (Figure A-3).

Limited information exists on chinook salmon habitat use in marine waters. Chinook are found throughout the North Pacific and have been encountered in waters far offshore. Available research (Pearcy and Fisher 1990, Fisher and Pearcy 1995), suggests that ocean-type juvenile chinook salmon are found in highest concentrations over the continental shelf. However, Fisher *et al.* (1983, 1984) found no clear evidence that young chinook were more abundant close to the coast. Ocean-type juvenile chinook appear to utilize different marine areas for rearing than stream-type juvenile chinook that are believed to migrate to ocean waters further offshore early in their ocean residence (Healey 1991). Coded-wire-tag recoveries of chinook salmon from high-seas fisheries and tagging programs (Myers *et al.* 1996; Healey 1991, Fig.18) provide evidence that chinook salmon utilize areas outside the continental shelf. Catch data and interviews with commercial fishermen indicate that maturing chinook salmon are found in highest concentrations along the continental shelf within 60 km of the Washington, Oregon, and California coast lines. Many stream-type chinook populations do not appear to be as heavily exploited as ocean-type chinook, indicating that stream-type fish may be vulnerable to coastal fisheries for only a short time during their spawning migrations (Healey 1991). Determination of a specific or uniform westward boundary within the EEZ which covers the distribution of essential marine habitat is difficult and would contain considerable uncertainty. Therefore, the geographic extent of essential marine habitat for chinook salmon includes all marine waters within the EEZ north of Point Conception, California (Figure A-3) and the marine areas off Alaska designated as salmon EFH by the North Pacific Fishery Management Council (NPFMC).

2.2 ESSENTIAL HABITAT DESCRIPTION FOR COHO SALMON *(Oncorhynchus kisutch)*

2.2.1 General Distribution and Life History

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

Coho or "silver" salmon are a commercially and recreationally important species found in small streams and rivers throughout much of the Pacific Rim, from central California to Korea and northern Hokkaido, Japan (Godfrey 1965, Scott and Crossman 1973). They are distinguished from other Pacific salmon by the presence of irregular black spots confined to the back and the upper lobe of the caudal fin, and bright red sides and a bright green back and head when sexually mature (Godfrey 1965, Scott and Crossman 1973). Coho salmon spawn in freshwater streams, juveniles rear for at least one year in fresh water and spend about 18 months at sea before reaching maturity as adults. Precocious male coho salmon or "jacks" become sexually mature after only 6 months at sea, one year earlier than typical adult fish. Because coho salmon have relatively fixed residence times in both fresh and salt water, the species exhibits fewer age classes than all other Pacific salmon, with the exception of pink salmon. Most coho salmon populations south of central British Columbia consist of two-year-old jacks and three-year-old adults, while populations north of central British Columbia have two or three-year-old jacks and three or four-year-old adults (Gilbert 1912, Pritchard 1940, Shapovalov and Taft 1954, Wright 1970, Godfrey *et al.* 1975, Crone and Bond 1976). The older age at maturity of more northern populations is a product of the juveniles spending two years in freshwater as opposed to one year residence of more southern populations.

Unlike other Pacific salmon species, where the majority of production comes from large spawning populations in a few river basins, coho salmon production results from spawners using numerous small streams (Sandercock 1991). North American coho salmon populations are widely distributed along the

Pacific coast and spawn in tributaries to most major river basins from the San Lorenzo River in Monterey Bay, California, to Point Hope, Alaska, and through the Aleutian Islands (Godfrey 1965, Sandercock 1991). The species is most abundant in coastal areas from central Oregon through southeast Alaska and widely distributed throughout the North Pacific (Manzer *et al.* 1965, French *et al.* 1975, Godfrey *et al.* 1975).

In Alaska, coho salmon catches are at historically high levels, and trends in abundance of most stocks are stable (Baker *et al.* 1996, Slaney *et al.* 1996, Northcote and Atagi 1997, Wertheimer 1997). However, many coho salmon populations in southern British Columbia, Washington, Oregon, and California are depressed from historical levels with stocks at the southern-most end of the range generally at greatest risk of extinction (Nehlsen *et al.* 1991; Nelson 1993, 1994; Brown *et al.* 1994; Bryant 1994). Some stocks, particularly those in the Columbia River Basin above Bonneville Dam (*e.g.*, Idaho coho stocks), are thought to be extinct (Nehlsen *et al.* 1991). Coastal stocks of coho salmon from the Columbia River to the southern extent of their range in Monterey Bay were recently listed as a "threatened" species under the ESA, while coho salmon in the Columbia River Basin, southwest Washington, Puget Sound, and the Strait of Georgia are candidates for listing (NMFS 1995, 1997a, 1997b, 1999a).

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

2.2.2 Fisheries

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

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

Bycatch in coho salmon fisheries is usually limited to other salmon species, primarily chinook and chum salmon, and occasionally pink salmon. Species such as steelhead, Dolly Varden, pollock, pacific cod, halibut, salmon sharks, and coastal rockfish make up a small part of the catch. Coho salmon are also taken incidentally in other salmon fisheries. When regulations prohibit the retention of coho, the majority of released fish survive the hooking encounter, however, large numbers can be hooked and substantial mortality incurred. Substantial coho salmon bycatch can lead to restrictions on these fisheries (Pacific Fishery Management Council [PFMC] 1998). A complete and current description of ocean fisheries, harvest levels, and management framework can be found in the most recent versions of the annual PFMC *Review of Ocean Salmon Fisheries* and *Preseason Report I* (PFMC 1999a, 1999b).

2.2.3 Relevant Trophic Information

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

2.2.4 Habitat and Biological Associations

Table A-4 summarizes coho salmon habitat use by life history stage.

Coho salmon are highly migratory at each stage of their life and are dependent on high-quality spawning, rearing, and migration habitat. Water depth, water velocity, water quality, cover, and lack of physical obstruction are important elements in all migration habitats. Soon after emergence in spring, fry move from spawning areas to rearing areas. In fall, juveniles may migrate from summer rearing areas to areas with winter habitat (Sumner 1953, Skeesick 1970, Swales *et al.* 1988). Such juvenile migrations may be extensive within the natal stream basin, or, less frequently, fish may migrate between basins through salt water or connecting estuaries (Greg Bryant, NMFS, 1330 Bayshore Way, Eureka, California 98501, pers. comm.). Seaward migration of coho smolts in Washington, Oregon, and California occurs predominantly after one year in fresh water, but may not occur until two or more years in more northern or less productive environments. This migration is primarily triggered by photoperiod and usually coincides with spring freshet (Shapovalov and Taft 1954, Chapman 1962, Crone and Bond 1976). During this transition, coho undergo major physiological changes to enable them to osmoregulate in salt water and are especially sensitive to environmental stress at that time. While migration patterns at sea differ considerably by province and stock, juvenile coho generally migrate north or south in coastal waters and may move north and offshore into the North Pacific Ocean (Loeffel and Forster 1970, Hartt 1980, Miller *et al.* 1983, Pearcy and Fisher 1988). After 12 to 14 months at sea they migrate along the coast to their natal streams.

2.2.4.1 Eggs and spawning

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

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

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

TABLE A-4. Coho salmon habitat use by life history stage. (See key to abbreviations and EFH data levels on page A-16.)

Stage - EFH Data Level	Duration or Age	Diet/Prey	Season/Time	Location	Water Column	Oceanographic Features	Other
Eggs EFH Data Level 0-4; not all habitats have been sampled	50 days at optimum temperatures	Non-feeding stage; eggs consumed by birds, fish and mammals	Fall/winter	Streambeds	Intragravel; water depth 4-35 cm	NA	**DO** < 2 mg/l lethal, optimum > 8 mg/l; **Temperature** 0-17°C; optimum 4.4-13.3°C; **Substrate** 2-10 cm with < 12% fines (<3.3 mm), optimum <5% fines; **Water velocity** 25-90 cm/s
Larvae (alevins). EFH Data Level 0-4; not all habitats have been sampled	100 days at optimum temperatures	Non-feeding stage; Alevins consumed by birds, fish and mammals	Winter/spring	Streambeds	Intragravel; water depth 4-35 cm	NA	**DO** < 3 mg/l lethal, optimum > 8 mg/l; **Temperature** 0-17°C; optimum 4.4-13.3°C; **Substrate** 2-10 cm with < 12% fines (<3.3 mm), optimum <5% fines; **Water velocity** 25-90 cm/s
Juveniles (freshwater) EFH Data Level 0-4; not all habitats have been sampled	1-2 yrs, most (>90%) 1 yrs	Aquatic, terrestrial, and estuarine invertebrates, fish; predators include birds, fish, mammals	Rearing - all year Migration - spring and fall	Streams, lakes, BAY (estuaries)	Water depth 0-122 cm in streams	NA	**DO** lethal at <2 mg/l, optimum at saturation; **Temperature** 0-26°C; optimum 12-14°C; **Salinity** < 29 ppt; **Water velocity** 5-30 cm/s
Juveniles (marine) EFH Data Level 0-3; not all habitats have been sampled	16 months (except precocious males)	Epipelagic fish (herring, sand lance) and marine invertebrates (copepods, euphausiids, amphipods, crab larvae)	Rearing - all year Migration - all year	BCH, ICS, MCS, OCS, USP, BAY, IP	Pelagic	UP, CL, F; migration influenced by currents, salinity, and temperature	**Temperature** <15°C; **Depth** <10 m
Adults (freshwater) EFH Data Level 1-2; not all habitats have been sampled	up to 2 months	Little or none	Migration - fall Spawning - fall, winter	Rivers, streams, lakes			

Primary Sources: Shapovalov and Taft 1954, Sandercock 1991, Bjorrn and Reiser 1991, Weitkamp *et al.* 1995, Spence *et al.* 1996.

2.2.4.2 Larvae/Alevins

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

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

2.2.4.3 Juveniles (Freshwater)

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

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

Coastal streams, wetlands, lakes, sloughs, tributaries, estuaries, and tributaries to large rivers can all provide coho rearing habitat. The most productive habitats exist in smaller streams less than fourth order having low-gradient alluvial channels with abundant pools formed by large woody debris (Foerster and Ricker 1953, Chapman 1965). Beaver ponds and large slackwater areas can provide some of the best rearing areas for juvenile coho (Bustard and Narver 1975, Nickelson *et al.* 1992). Coho juveniles may also use brackish-water estuarine areas in summer and migrate upstream to fresh water to overwinter (Crone and Bond 1976).

During summer rearing, the highest juvenile coho densities tend to occur in areas with abundant prey (e.g., drifting aquatic invertebrates and terrestrial insects that fall into the water) and structural habitat elements (e.g., large woody debris and associated pools). Preferred habitats include a mixture of different types of pools, glides, and riffles with large woody debris, undercut banks, and overhanging vegetation which provide advantageous positions for feeding (Foerster and Ricker 1953, Chapman 1965, Reeves *et al.* 1989, Bjornn and Reiser 1991). Coho grow best where water temperature is between 10 and 15°C, and dissolved oxygen (DO) is near saturation. Juvenile coho can tolerate temperatures between 0° and 26°C if changes are not abrupt (Brett 1952, Konecki *et al.* 1995). Their growth and stamina decline significantly when DO levels drop below 4 mg/l, and a sustained concentration less that 2 mg/l is lethal (Reeves *et al.* 1989). Summer populations are usually constrained by density-dependant effects mediated through territorial behavior. In flowing water, juvenile coho usually establish individual feeding territories, whereas in lakes, large pools, and estuaries they are less likely to establish territories and may aggregate where food is abundant (Chapman 1962, McMahon 1983). Because growth in summer is often density-dependent, the size of juveniles in late summer is often inversely related to population density.

In winter, territorial behavior is diminished, and juveniles aggregate in freshwater habitats that provide cover with relatively stable depth, velocity, and water quality. Winter mortality factors include hazardous conditions during winter peak stream flow (e.g., scour, high velocities), stranding of fish during floods or by ice damming, physiological stress from low temperature, and progressive starvation (Hartman *et al.* 1984). In winter, juveniles prefer a narrower range of habitats than in summer, especially large mainstream pools, backwaters, beaver ponds, off-channel ponds, sloughs, and secondary channel pools with abundant large woody debris, and undercut banks and debris along riffle margins (Skeesick 1970, Nickelson *et al.* 1992). Survival in winter, in contrast to summer, is generally density-independent, and varies directly with fish size and amount of cover and ponded water, and inversely with the magnitude of the peak stream flow. Survival from eggs to smolts is usually less than 2% (Neave and Wickett 1953).

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

2.2.4.4 Juveniles (Estuarine)

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

2.2.4.5 Juveniles (Marine)

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

Juvenile coho salmon generally stay in nearshore coastal and inland waters well into October (Hartt and Dell 1986). Juvenile coho from Oregon and presumably other areas will initially be found south of their natal streams, moved by strong southerly currents (Pearcy 1992). When these currents weaken in the winter months, juvenile coho migrate northward. In strong upwelling years, where the band of favorable temperatures and available prey is more extensive, coho salmon appear to be more dispersed off shore. In weak upwelling years, coho salmon concentrate in upwelling zones closer to the shore (Pearcy 1992), and often near submarine canyons and other areas of consistent upwelling (N. Bingham, Pacific Coast Federation of Fishermen's Associations, P.O. Box 783, Mendocino, California, 95460, pers. comm., February 1998). Generally, juvenile coho are found in highest concentrations within 60 km of the California, Oregon, and Washington coast, with the majority found within 37 km of the coast (Pearcy and Fisher 1990, Pearcy 1992). Puget Sound origin coho salmon are typically found in the Strait of Juan de Fuca and coastal waters of Vancouver Island throughout summer months (Hartt and Dell 1986).

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

While juvenile and maturing coho are found in the open north Pacific, the highest concentrations appear to be found in more productive waters of the continental shelf within 60 km of the coast. Coho salmon have been occasionally reported off the coast of southern California near the Mexican border (Bryant 1994). However, Point Conception (34°30' N latitude), California, is considered the faunal break for marine fishes, with salmon and other temperate water fishes primarily found north and subtropical fishes to the south (Allen and Smith 1988), although the southern limit expands and contracts seasonally and between years depending on ocean temperature patterns and upwelling.

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

Marine invertebrates, such as copepods, euphausiids, amphipods, and crab larvae, are the primary food when coho first enter salt water. Fish represent an increasing proportion of the diet as coho salmon grow and mature (Shapovalov and Taft 1954, Healey 1978, Myers and Horton 1982, Pearcy 1992). Growth is controlled mainly by food quantity, food quality, and temperature. Growth is best in pelagic habitats where forage is abundant and sea surface temperature is between 12 and 15°C (Godfrey *et al.* 1975, Hartt 1980, Healey 1980). Coho salmon rarely use areas where sea surface temperature exceeds 15°C and are generally found in the uppermost 10 m of the water column. Coho salmon do not aggregate in offshore oceanic waters and prefer slightly warmer ocean temperatures than do other Pacific salmon (Godfrey 1965, Manzer *et al.* 1965, Welch 1995). Before entering fresh water, most coho slow their feeding and begin to lose weight as they develop secondary sexual characteristics and large gonads. Precocious males return to spawn after approximately six months at sea, but most coho remain at sea for about 16 months before returning to coastal areas and entering fresh water to spawn (Godfrey 1965; Wright 1968, 1970; Sandercock 1991).

2.2.4.6 Adults

Adult coho enter fresh water from early July through December, often after the onset of fall freshets, with peak river entry occurring as early as September in Alaska, in October and November in British Columbia, Washington, and Oregon, and in December and even January in California (Briggs 1953, Godfrey 1965, Ricker 1972, Fraser *et al.* 1983, Bryant 1994). Some populations, often referred to as the "summer-run" coho salmon, are exceptionally early, entering rivers in late spring and early summer (Aro and Shepard 1967, Houston 1983, Washington Department of Fisheries [WDF] *et al.* 1993). In general, larger river basins have a wider range of river entry times than do smaller systems, and river entry occurs later the farther south a river is situated (Godfrey 1965, Sandercock 1991). The fish feed little and migrate upstream to their natal stream using olfactory cues imprinted in early development (Harden Jones 1968, Quinn and Tolson 1986, Sandercock 1991). Fidelity of mature fish to natal streams is high, and straying rates are generally less than 5% (Shapovalov and Taft 1954, Lister *et al.* 1981, Labelle 1992). Adult coho may travel for a short time and distance upstream to spawn in small streams or may enter large river systems and travel for weeks to reach spawning areas more than 2,000 km upstream (Godfrey 1965, Aro and Shepard 1967, McPhail and Lindsay 1970, Sandercock 1991, WDF *et al.* 1993).

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

The survival of coho salmon is generally affected by numerous factors in both salt and fresh water, including ocean conditions, location of natal stream, freshwater migration length, stream flow, and other environmental factors. Hatchery coho salmon have smolt-to-adult survival rates that average between 3-5%, but can be much higher in areas such as Puget Sound, or lower during unfavorable years (Coronado-Hernandez 1995). Wild stocks typically show marine survival rates two to three times greater than hatchery fish (Seiler 1989, Pearcy 1992, Coronado-Hernandez 1995).

2.2.4.7 Databases on Distribution

To determine the geographic extent of coho salmon freshwater and estuarine distribution, we examined the available information and databases on coho salmon distribution and habitat use (see tables in Sections 2.4 and 2.5). The databases fell into three general categories, (1) regional, small-scale (e.g., 1:100,000 or 1:250,000) regional GIS databases on coho salmon distribution (e.g., StreamNet, WARIS, ORIS, etc.); (2) local, large scale GIS database of limited scope (e.g., county, tribal datasets, etc.); and (3) databases on habitat surveys and habitat quality (e.g., USFS stream survey data, state, and tribal stream survey data, etc.). Unfortunately, databases in categories 2 and 3 are of limited utility in determining coho salmon freshwater distribution, because they are comprised of many small, disparate, incompatible databases with incomplete geographic coverage. These datasets may, however, be useful during EFH consultations.

Small-scale, regional databases such as StreamNet (1998) are suitable for portraying the overall distribution of chinook salmon and have utility for determining presence on the majority of specific stream reaches. Various life stages (migration, spawning and rearing, and rearing only) are delimited in the database distribution data as well. The hydrography used by StreamNet to spatially reference fish distribution is predominantly composed of 1:100,000 scale data, but both 1:63,500 and 1:24,000 linework has been added where appropriate to reference all the distribution data available to the project.

The formation and modification of stream channels and habitats is a dynamic process. Habitat available and utilized by coho and other salmonids also changes frequently in response to floods, landslides, woody debris inputs, sediment delivery, and other natural events (Sullivan *et al.* 1987, Naiman *et al.*1992, Reeves *et al.* 1995). It is unrealistic to expect coho salmon distribution within a stream, watershed, province, or region to remain static over time. Therefore, coarse scale regional GIS databases are useful only for determining which watersheds coho salmon inhabit, but not for identifying specific stream reaches and habitats utilized by the species.

2.2.4.8 Habitat Areas of Particular Concern

Information exists on the type of stream reaches preferred by coho salmon for spawning and rearing. It is generally accepted that they spawn and rear in stream reaches and channels less than 4-5% gradient (Lunetta *et al.* 1997). Furthermore, coho and other fall spawning anadromous salmonids are found primarily in plane-bed, pool-riffle, and forced-pool-riffle stream channels[2/], which are channel types less than 4% (Montgomery and Buffington 1997, Montgomery *et al.* In press). Stream reaches greater than 4% slope (gradient) are generally not utilized by coho salmon for spawning, because of their high bed load transport rate, deep scour, and coarse substrate (Montgomery *et al.* In press). Stream reaches less than 4% that potentially display plane-bed, pool-riffle, and forced-pool-riffle morphology can be identified using GIS technology. However, channel types identified with GIS technology can differ from those actually present in the field (Lunetta *et al.* 1997, Montgomery and Buffington 1997). Therefore, it is important that 1:24,000 or larger scale maps be used to determine potential channel type and a fine scale (10 m or less) digital elevation model to calculate slopes. Furthermore, slope and channel type should be confirmed in a representative number of reaches by site visits or existing habitat surveys. While the technology exists to develop this information, data at this scale and resolution have only been developed for provinces, not the entire region; and, therefore, could not be used in the current EFH identification process. However, the existing information will be useful in the consultation process.

The delineation of channel types allows identification of potentially important and vulnerable habitats in the absence of accurate salmon distribution or habitat data. Moreover, degraded stream reaches, those lacking key roughness elements (e.g., large woody debris), and stream reaches with a high potential for restoration will still be identified as potential habitat. Therefore, the protection and restoration of coho salmon habitat should focus on pool-riffle, plane bed, and forced-pool-riffle channels. Furthermore, any activity adjacent to or upstream of activity that could influence the quality of these important habitats should be evaluated. Other vulnerable habitats that are in need of protection and restoration are off-channel rearing areas (e.g., wetlands, oxbows, side channels, sloughs), estuaries, and other near-shore marine areas. Submarine canyons and other regions of pronounced upwelling are also thought to be particularly important during El Niño events (N. Bingham, Pacific Coast Federation of Fishermen's Associations, P.O. Box 783, Mendocino, California 95460, pers. comm.) and may need additional consideration for protection. Finally, off-channel areas are particularly important winter habitats for juvenile coho salmon (Cederholm and Scarlett 1981), and one of the primary factors limiting coho salmon smolt production in many areas (Nicholson *et al.* 1992).

2.2.4.9 Freshwater Essential Fish Habitat

Freshwater EFH for coho salmon consists of four major components, (1) spawning and incubation; (2) juvenile rearing; (3) juvenile migration corridors; and (4) adult migration corridors. Important features of essential habitat for spawning, rearing, and migration include adequate (1) substrate composition; (2) water quality (e.g., dissolved oxygen, nutrients, temperature, etc.); (3) water quantity, depth and velocity; (4) channel gradient and stability; (5) food; (6) cover and habitat complexity (e.g., large woody debris, channel complexity, aquatic vegetation, etc.); (7) space; (8) access and passage; and (9) habitat and flood plain connectivity. This incorporates, but is not limited to, life-stage specific habitat criteria summarized in Table A-4.

Coho salmon essential freshwater habitat includes all those streams, lakes, ponds, wetlands, and other water bodies currently viable and most of the habitat historically accessible to coho within Washington, Oregon, and California. Figure A-4 illustrates the watersheds currently utilized by coho from Washington, Oregon, and California within the USGS hydrologic units identified at the end of the chapter for all Council-managed salmon (Table A-6). Figure A-5 depicts the approximate historical freshwater distribution and the currently identified range of common marine occurrence of coho salmon. The geographic extent of the historic freshwater distribution of coho salmon is based on data from Table A-6. Data on the marine range of coho salmon are from NOAA (1990).

2/ See Montgomery and Buffington (1997) for a description of this channel classification system.

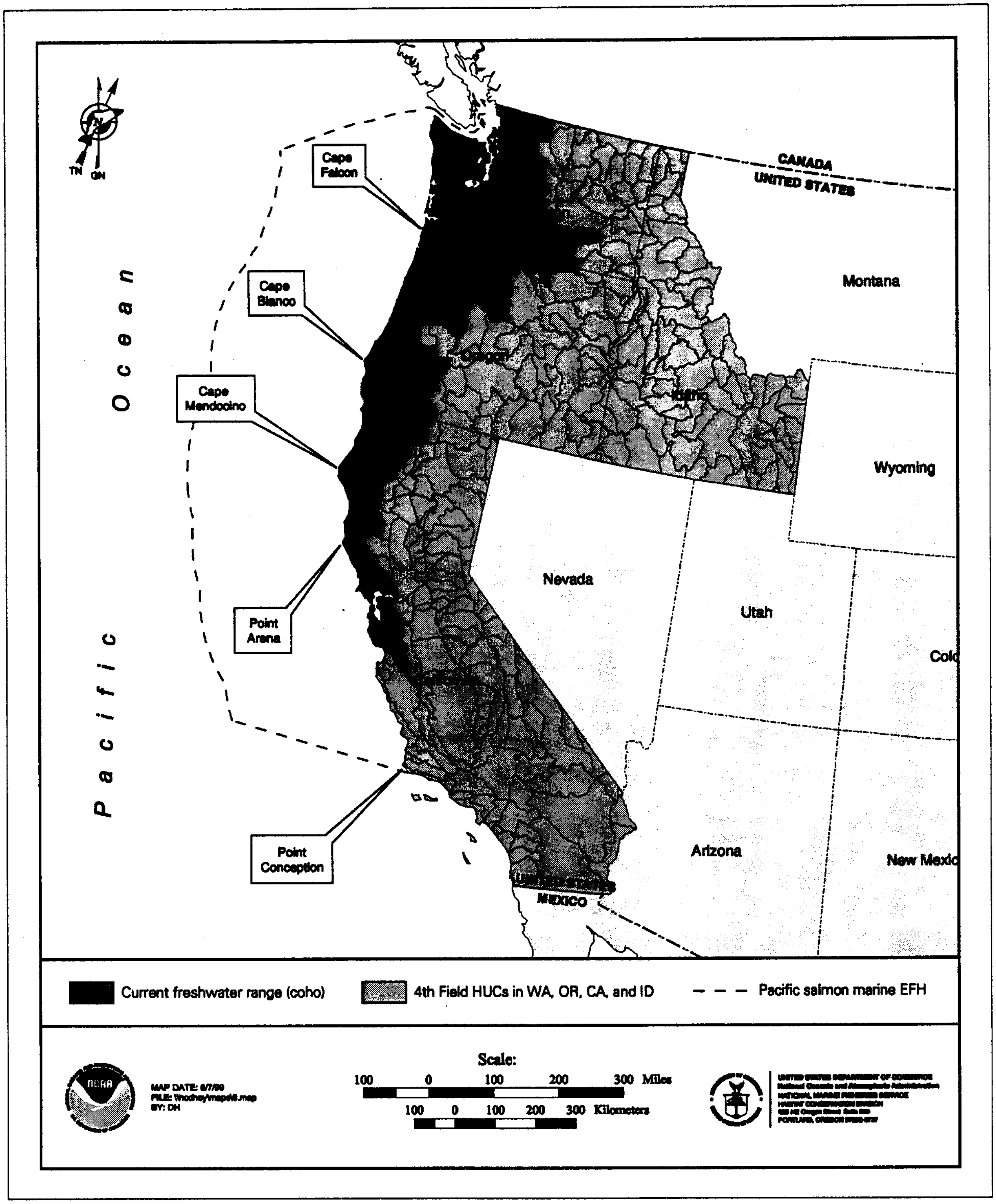

FIGURE A-4. Watersheds currently utilized by coho salmon from Washington, Oregon, and California.

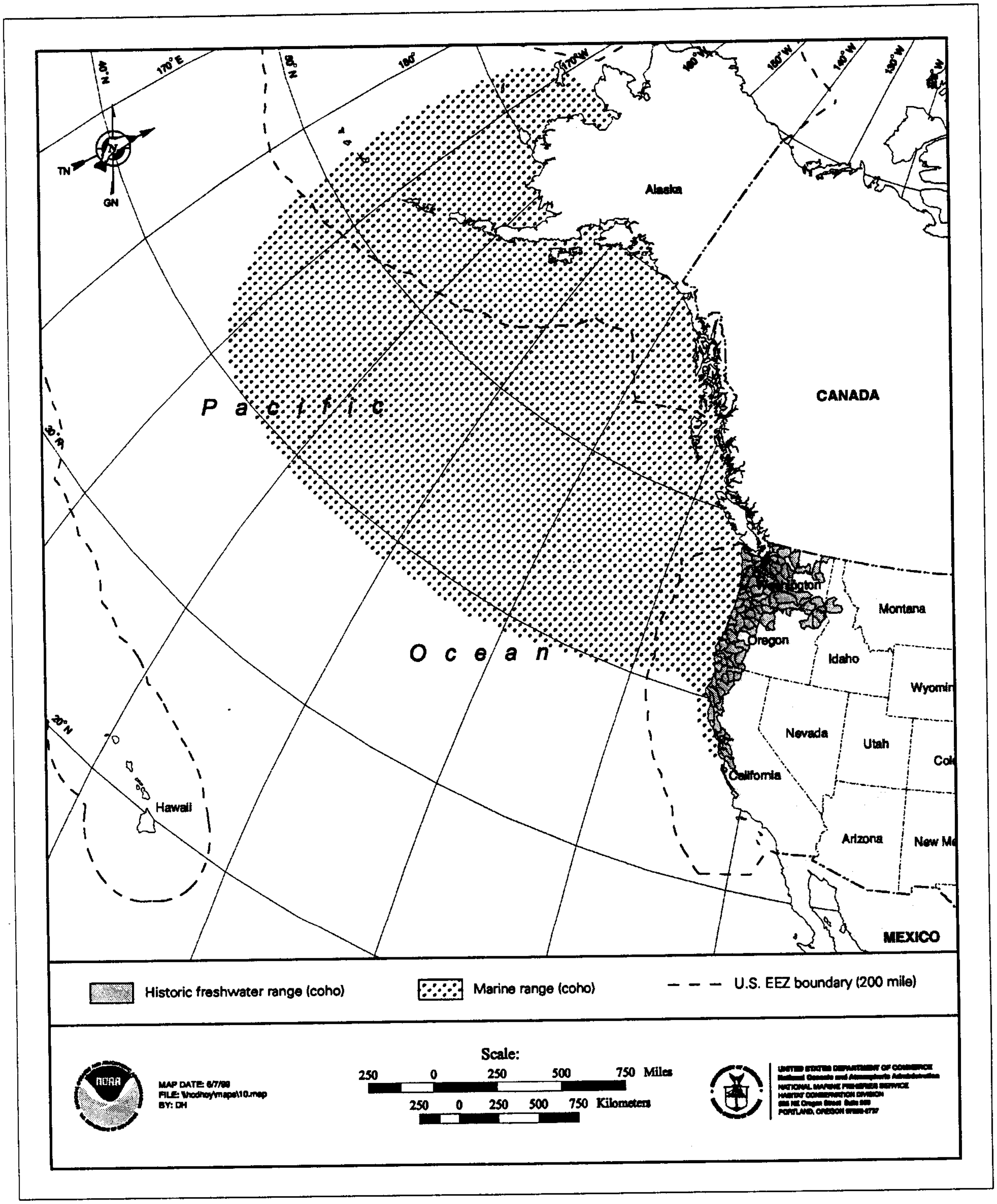

FIGURE A-5. Approximate historically accessible freshwater distribution and currently identified range of common marine occurrence of coho salmon from Washington, Oregon, and California.

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

2.2.4.10 Marine Essential Fish Habitat

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

Limited information exists on coho salmon habitat use in marine waters. While juvenile and maturing coho are found in the open north Pacific, the highest concentrations appear to be found in more productive waters of the continental shelf, coho have also been encountered in an extensive offshore area as far west as 44° N latitude, 175° W longitude (Sandercock 1991). CWT recoveries of coho salmon from high seas fisheries and tagging programs (Myers *et al.*, 1996; Healey 1991, fig.18) provide evidence that coho salmon utilize offshore areas. Shapalov and Taft (1954) reported coho within 150 km offshore in their study of Waddell Creek coho. Catch data and interviews with commercial fishermen indicate that maturing coho salmon are found in highest concentrations along the continental shelf within 60 km of the Washington, Oregon, and California coast lines. However, determination of a specific or uniform westward boundary within the EEZ which covers the distribution of essential marine habitat is difficult and would contain considerable uncertainty. Therefore, the geographic extent of essential marine habitat for coho salmon includes all marine waters within the EEZ north of Point Conception, California (Figure A-5) and the marine areas off Alaska designated as salmon EFH by the NPFMC.

2.3 ESSENTIAL HABITAT DESCRIPTION FOR PUGET SOUND PINK SALMON (*Oncorhynchus gorbuscha*)

2.3.1 General Distribution and Life History

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

Pink (or "humpback") salmon are the smallest of the Pacific salmon, averaging just 1.0-2.5 kg at maturity (Scott and Crossman 1973). Adult pink salmon are distinguished from other Pacific salmon by the presence of large dark oval spots on the back and entire caudal fin, and their general coloration and morphology (Scott and Crossman 1973). Maturing males develop a marked hump on their back, which is responsible for their vernacular name "humpback" salmon. Pink salmon are unique among Pacific salmon by exhibiting a nearly invariant two-year life span within their natural range (Gilbert 1912, Davidson 1934, Pritchard 1939, Bilton and Ricker 1965, Turner and Bilton 1968). Upon emergence, pink salmon fry migrate quickly to sea and grow rapidly as they make extensive feeding migrations. After 18 months in the ocean the maturing fish return to freshwater to spawn and die. Pink salmon spawn closer to tidewater than most other Pacific salmon species, generally within 50 km of a river mouth, although some populations may migrate up to 500 km upstream to spawn, and a substantial fraction of other populations may spawn intertidally (Hanavan and Skud 1954, Hunter 1959, Atkinson *et al.* 1967, Aro and Shepard 1967, Helle 1970, WDF *et al.* 1993). Pink salmon often have extremely large spawning populations throughout much of their range, exceeding hundreds of thousands of adult fish in many populations (Takagi *et al.* 1981, Heard 1991, WDF *et al.* 1993).

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

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

Pink salmon populations in Alaska are abundant, with historic record catches over the past decade, exceeding 100 million fish statewide in several years (Wertheimer 1997). Farther south, pink salmon populations may not be at record levels, but are generally healthy. For example, recent reviews of the status of pink salmon from Washington and southern British Columbia indicated that, with a few exceptions, odd-year populations in those areas were generally healthy and near historic levels, while even-year populations were small, but stable or increasing (Ricker 1989, Nehlsen *et al.* 1991, Lichatowich 1993, Hard *et al.* 1996). For example, the 1995 run-size estimate of Fraser River odd-year pink salmon was approximately 12 million fish, and that of Puget Sound was 3.4 million fish (PFMC 1998).

2.3.2 Fisheries

Pink salmon are the most abundant Pacific salmon, contributing about 40% by weight and 60% in numbers of all salmon caught commercially in the north Pacific Ocean and adjacent waters (Neave *et al.* 1967). Coastal fisheries for pink salmon presently occur in Asia (Japan and Russia) and North America (Canada and the United States), with major fisheries in Russia, Canada, and the U.S. Historically, some pink salmon were caught in high seas fisheries by Japan and Russia. Most pink salmon in the U.S. are caught in Alaska where major fisheries occur in the Southeast, Prince William Sound, and Kodiak regions; with lesser fisheries in the Cook Inlet, Alaska Peninsula, and Bristol Bay regions (Heard 1991). Catches of pink salmon decrease south of Alaska, with about 10 million fish caught annually in British Columbia, 2-3 million in Washington, and a negligible number in Oregon and California (Heard 1991, PFMC 1999a). Most pink salmon are harvested in the marine environment by purse seines with smaller commercial catches made by set and drift gill net and troll fisheries. Marine recreational fisheries primarily use troll gear. Washington marine pink salmon harvests are predominantly composed of Fraser River-origin fish (Hard *et al.*1996, PFMC 1984). The Pacific Salmon Commission (PSC) manages fisheries for pink salmon in U.S. Convention waters north of 48° N latitude to meet Fraser River natural spawning escapement and U.S./Canada allocation requirements. Fisheries for pink salmon have some bycatch associated with them, primarily other

Pacific salmon species. A complete and current description of ocean fisheries, harvest levels, and management framework can be found in the most recent versions of the annual PFMC *Review of Ocean Salmon Fisheries* and *Preseason Report I* (PFMC 1999a, 1999b).

2.3.3 Relevant Trophic Information

Pink salmon eggs, alevins, and fry in freshwater streams provide an important nutrient input and food source for aquatic invertebrates, other fishes, especially sculpins, birds, and small mammals (Pritchard 1934, Hoar 1958, Hunter 1959, Tagmazyan 1971, Khorevin *et al.* 1981). In the marine environment, pink salmon fry and juveniles are food for a host of other fishes, including other Pacific salmon, and coastal sea birds (Thorsteinson 1962, Parker 1971, Bakshtansky 1980, Karpenko 1982).

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

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

2.3.4 Habitat and Biological Associations

Table A-5 summarizes pink salmon habitat use by life history stage.

2.3.4.1 Eggs and Spawning

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

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

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

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

TABLE A-5. Pink salmon habitat use by life stage. (See key to abbreviations and EFH data levels on page A-16.)

Stage - EFH Data Level	Duration or Age	Diet/Prey	Season/Time	Location	Water Column	Bottom Type	Oceanographic Features	Other
Eggs EFH Data Level 0-4; not all habitats have been sampled	90-100 d	Non-feeding stage; eggs consumed by birds, fish and mammals	Late summer, fall, and winter	Intragravel in stream beds	15-50 cm depth in gravel; water depth 10-15 cm	Medium to course gravel	NA	**DO** < 2 mg/l lethal, optimum > 8 mg/l; **Temperature** 0-17°C, optimum 4.4-13.3°C; **Water velocity** 20-140 cm/s
Larvae (alevins) EFH Data Level 0-4; not all habitats have been sampled	100-125 d, fry emerge and migrate quickly from stream	Non-feeding stage; alevins consumed by birds, fish, and mammals	Fall, winter, and early spring	Intragravel until fry emergence	15-50 cm depth in gravel; water depth 10-15 cm	Medium to course gravel	NA	**DO** < 3 mg/l lethal, optimum > 8 mg/l; **Temperature** 0-17°C, optimum 4.4-13.3°C; **Water velocity** 20-140 cm/s
Juveniles EFH Data Level 0-3; not all habitats have been sampled	2 yrs	Copepods, euphausiids, decapod larvae, amphipods, fish squid	Estuary: spring Ocean: year-round	BCH BAY, IP	P, N; migration influenced by currents, salinity, and temperature	All bottom types	Estuarine, littoral then open water; UP, F, CL, E; migration may be influenced by surface currents, salinities and temperatures	**DO** lethal at <2 mg/l, optimum at saturation; **Temperature** 0-26°C, optimum 12-14°C; **Salinity** sea water; School with other salmon and Pacific sandfish
Adults EFH Data Level 0-2; not all habitats have been sampled	2 yrs of age from egg to mature adult	Fish, squid, euphausiids, amphipods, and copepods	Spawning: Aug-Dec	Oceanic to nearshore migrations	P, N	NA	Different regional stock groups have specific oceanic migratory patterns	**DO** lethal at <3 mg/l, optimum at saturation; **Temperature** 0-26°C, optimum <14°C; Migration timing for different regional stock groups varies; earlier in the north, later in the south

Primary sources: NOAA 1990, Bjornn and Rieser 1991, Heard 1991, Spence *et al.* 1996.

2.3.4.2 Larvae/Alevins

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

2.3.4.3 Juveniles (Freshwater)

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

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

2.3.4.4 Juveniles (Estuarine and Marine)

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

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

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

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

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

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

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

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

2.3.4.5 Adults

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

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

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

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

2.3.4.6 Databases on Distribution/Habitat Areas of Particular Concern

Annual spawner survey data are available for most streams in the Puget Sound basin utilized by pink salmon. Furthermore, WDF *et al.* (1993) and Williams *et al.* (1975) provide information on streams and stream reaches most utilized for pink salmon spawning. Because pink salmon enter freshwater primarily to spawn and juveniles spend little to no time in freshwater, adequate spawning habitat is critical to sustaining productive pink salmon populations. Therefore, it is important that pink salmon spawning areas and estuarine rearing areas receive adequate protection.

2.3.4.7 Freshwater Essential Fish Habitat

Freshwater EFH for Puget Sound pink salmon consists of four major components, (1) spawning and incubation; (2) juvenile rearing; (3) juvenile migration corridors; and (4) adult migration corridors. Important features of essential habitat for spawning, rearing, and migration include adequate, (1) substrate composition; (2) water quality (e.g., dissolved oxygen, nutrients, temperature, etc.); (3) water quantity, depth, and velocity; (4) channel gradient and stability; (5) food; (6) cover and habitat complexity (e.g., large woody debris, channel complexity, etc.); (7) space; (8) access and passage; and (9) habitat and flood plain connectivity. This incorporates, but is not limited to, life-stage specific habitat criteria summarized in Table A-5. Pink salmon essential freshwater habitat includes all those streams, lakes, ponds, wetlands, and other water bodies currently viable and most of the habitat historically accessible to pink salmon within Washington. Figure A-6 illustrates the watersheds currently utilized by Puget Sound pink salmon within the USGS hydrologic units identified in Table A-6. Figure A-7 depicts the approximate historical freshwater distribution and currently identified range of common marine occurrence of Puget Sound pink salmon. The geographic extent of these pink salmon is based on data from Table A-6. Data on the marine range of Puget Sound pink salmon is from NOAA (1990).

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

2.3.4.8 Marine Essential Habitat

The important elements of pink salmon marine EFH are (1) estuarine rearing; (2) early ocean rearing; and (3) juvenile and adult migration. Important features of this estuarine and marine habitat are (1) adequate water quality; (2) adequate temperature; (3) adequate prey species and forage base (food); and (4) adequate depth, cover, and marine vegetation in estuarine and nearshore habitats. Overall pink salmon marine distribution is extensive, varies seasonally, interannually, and can only be defined generally (Figure A-7). Estuarine and nearshore areas such as Puget Sound and other inland marine waters of Washington State and British Columbia are critical to the early marine survival of pink salmon. Therefore, essential marine habitat for Puget Sound pink salmon includes all nearshore marine waters north and east of Cape Flattery, Washington, including Puget Sound, the Strait of Juan de Fuca and Strait of Georgia. 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 (Figure A-7).

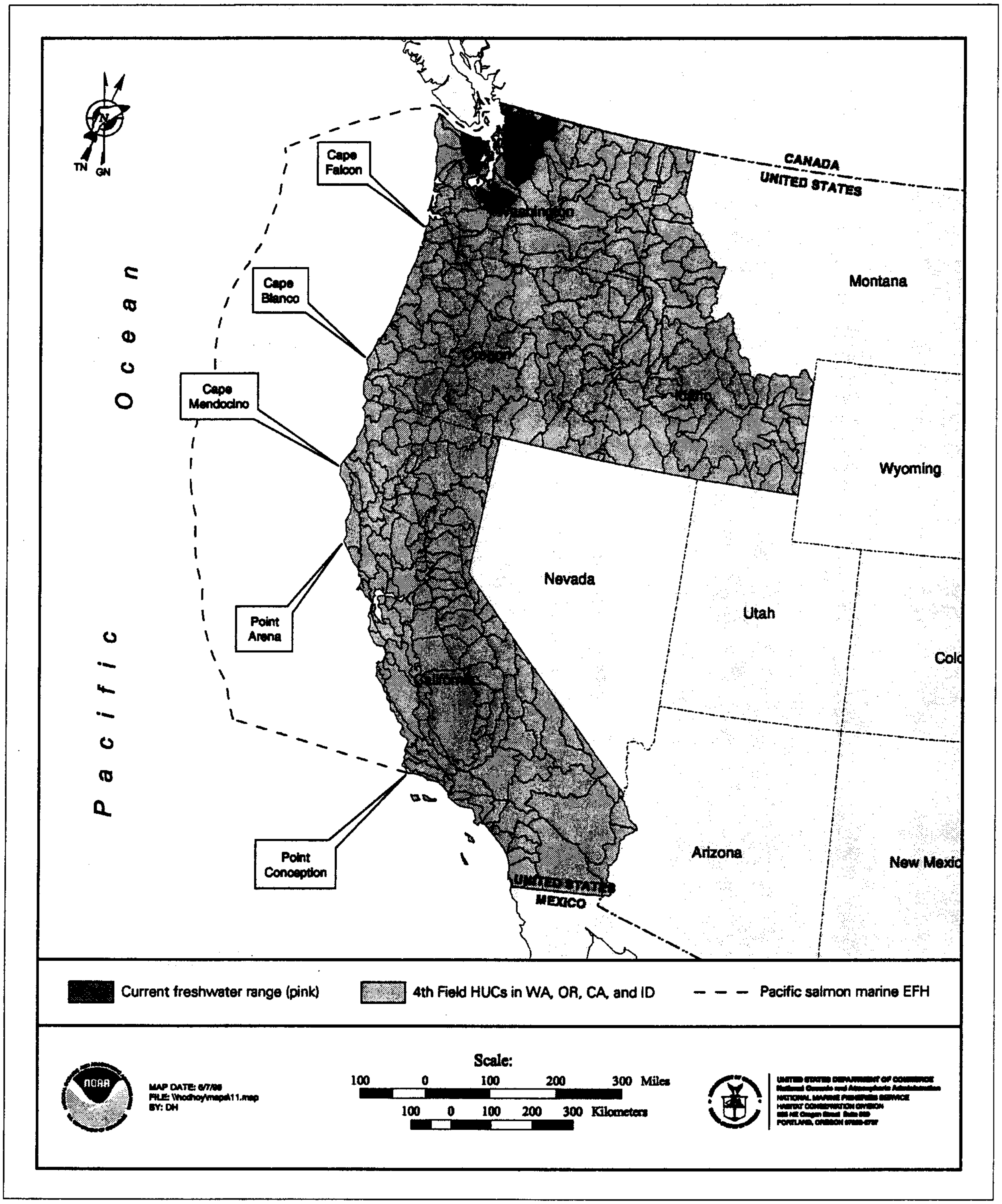

FIGURE A-6. Watersheds currently utilized by pink salmon from Washington.

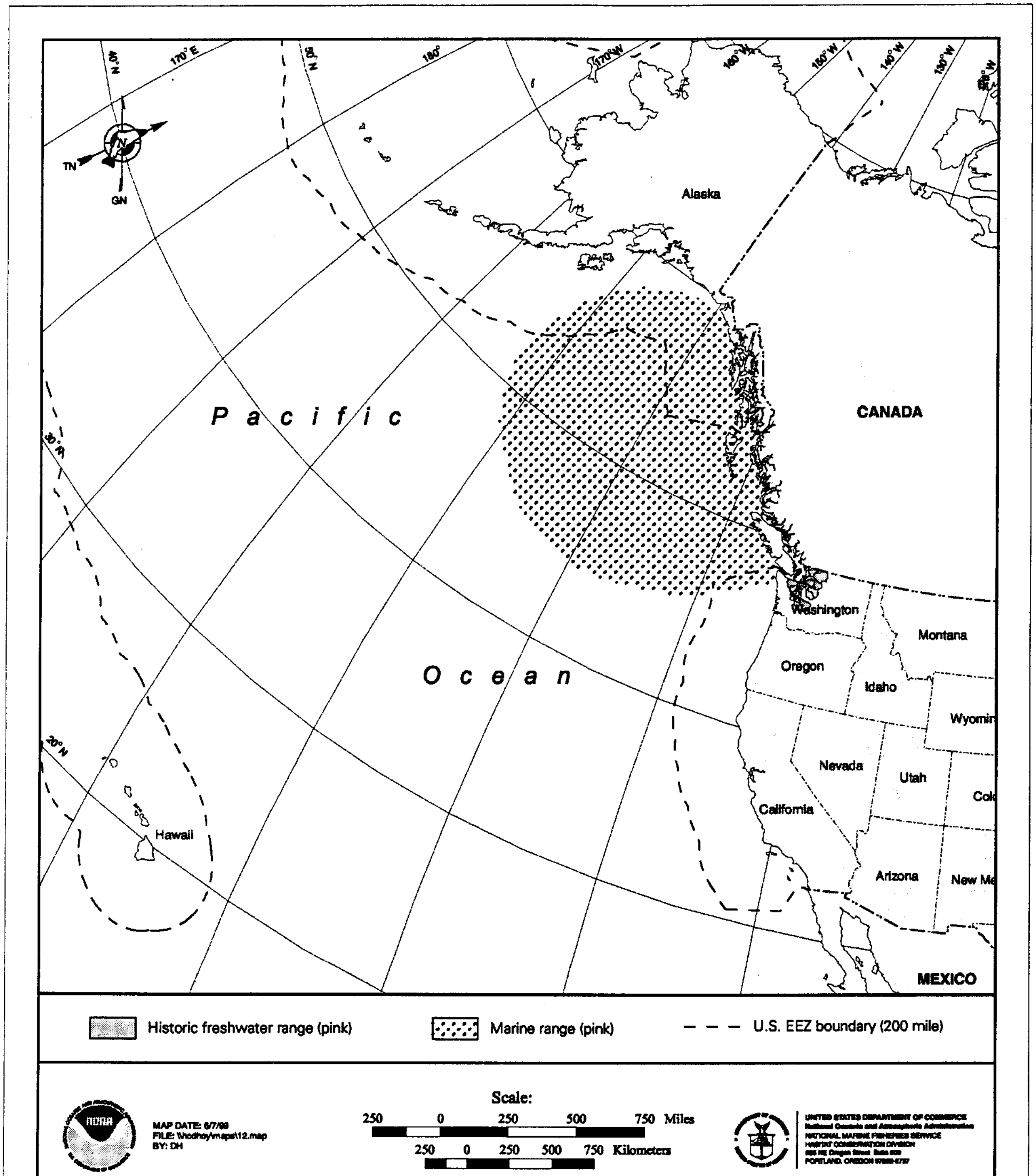

FIGURE A-7. Approximate historically accessible freshwater distribution, and currently identified range of common marine occurrence of Puget Sound pink salmon.

2.4 USGS HYDROLOGIC UNITS UTILIZED BY PACIFIC SALMON AND ADDITIONAL SOURCES OF SALMON DISTRIBUTION INFORMATION

A listing of the USGS hydrologic units utilized by salmon is provided in Table A-6. This information was used as a basis for the current and historic geographic distribution of salmon in freshwater habitat. Table A-7 provides a summary of additional sources of salmon distribution information utilized for this appendix.

TABLE A-6. Current and historic salmon distribution as defined by USGS hydrologic units. Superscripted numbers indicate salmon species present: 1=Chinook, 2=Coho, and 3=Puget Sound Pink. Unit # designates USGS Hydrological Unit Code. C/H indicates whether salmon distribution is current habitat (C), inaccessible historic (H), or currently accessible, but unutilized historic habitat (H*). (Page 1 of 7)

Unit #	State(s)	Hydrologic Unit Name	C/H	Documentation
17110001	WA/BC	Fraser/Whatcom	C^{2}	WDF *et al.* 1993
17110002	WA	Strait of Georgia	$C^{1,2,3}$	WDF *et al.* 1993
17110003	WA	San Juan Islands	C^{2}	WDF *et al.* 1993
17110004	WA	Nooksack R.	$C^{1,2,3}$	WDF *et al.* 1993
17110005	WA	Upper Skagit	$C^{1,2,3}$	WDF *et al.* 1993
17110006	WA	Sauk R.	$C^{1,2,3}$	WDF *et al.* 1993
17110007	WA	Lower Skagit R.	$C^{1,2,3}$	WDF *et al.* 1993
17110008	WA	Stillaguamish R.	$C^{1,2,3}$	WDF *et al.* 1993
17110009	WA	Skykomish R.	$C^{1,2,3}$	WDF *et al.* 1993
17110010	WA	Snoqualmie R.	$C^{1,2,3}$	WDF *et al.* 1993
17110011	WA	Snohomish R.	$C^{1,2,3}$	WDF *et al.* 1993
17110012	WA	Lake Washington	$C^{1,2}$	WDF *et al.* 1993
17110013	WA	Duwamish R.	$C^{1,2}$	WDF *et al.* 1993
17110014	WA	Puyallup R.	$C^{1,2,3}$	WDF *et al.* 1993
17110015	WA	Nisqually R.	$C^{1,2,3}$	WDF *et al.* 1993
17110016	WA	Deschutes R.	$C^{1,2}$	WDF *et al.* 1993
17110017	WA	Skokomish R.	$C^{1,2}$	WDF *et al.* 1993
17110018	WA	Hood Canal	$C^{1,2,3}$	WDF *et al.* 1993
17110019	WA	Puget Sound	$C^{1,2}$	WDF *et al.* 1993
17110020	WA	Dungeness - Elwha	$C^{1,2,3}$	WDF *et al.* 1993
17110021	WA	Crescent - Hoko	$C^{1,2}$	WDF *et al.* 1993
17100101	WA	Hoh - Quillayute	$C^{1,2}$	WDF *et al.* 1993
17100102	WA	Queets - Quinault	$C^{1,2}$	WDF *et al.* 1993
17100103	WA	U. Chehalis R.	$C^{1,2}$	WDF *et al.* 1993
17100104	WA	L. Chehalis R.	$C^{1,2}$	WDF *et al.* 1993
17100105	WA	Grays Harbor	$C^{1,2}$	WDF *et al.* 1993
17100106	WA	Willapa Bay	$C^{1,2}$	WDF *et al.* 1993
17080001	OR/WA	L. Columbia - Sandy	$C^{1,2}$	Fulton 1968^{1}, 1970^{2}; WDF *et al.* 1993^{1,2}; Oregon Department of Fish and Wildlife (ODFW) 1996^{2}
17080002	WA	Lewis R.	$C^{1,2}$	Fulton 1968^{1}, 1970^{2}; WDF *et al.* 1993^{1,2}
17080003	OR/WA	L. Columbia-Clatskanie	$C^{1,2}$	Fulton 1968^{1}, 19702; WDF *et al.* 1993^{1,2}; ODFW 1996^{2}
17080004	WA	Upper Cowlitz R.	$C^{1,2}$	Fulton 1968^{1}, 1970^{2}; WDF *et al.* 1993^{1,2}
17080005	WA	Lower Cowlitz R.	$C^{1,2}$	Fulton 1968^{1}, 1970^{2}; WDF *et al.* 1993^{1,2}

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Unit #	State(s)	Hydrologic Unit Name	C/H	Documentation
17080006	OR/WA	L. Columbia	C^{1,2}	Fulton 1968^{1}, WDF *et al.* 1993^{1,2}, ODFW 1996^{2}
17090001	OR	M.F. Willamette R.	C^{1}	Fulton 1968
17090002	OR	Coast F. Willamette R.	H^{1}	Fulton 1968, ODFW 1996
17090003	OR	U. Willamette R.	C^{1,2}	Fulton 19681, BPA 1994^{2}, ODFW 1996^{1}
17090004	OR	McKenzie R.	C^{1,2}	Fulton 1968^{1}, BPA 1994^{2}
17090005	OR	North Santiam R.	C^{1,2}	Fulton 1968^{1},BPA 1994^{2}, ODFW 1996^{1},
17090006	OR	South Santiam R.	C^{1,2}	Fulton 1968^{1}, BPA 1994^{2}
17090007	OR	Mid. Willamette R.	C^{1,2}	Fulton 1968^{1}, BPA 1994^{2}, ODFW 1996^{1}
17090008	OR	Yamhill R.	C^{2}, H^{*1}	Parkhurst *et al.* 1950^{1,2}, BPA 1994^{2}
17090009	OR	Mollala-Pudding	C^{1,2}	Fulton 1968^{1}, Parkhurst *et al.* 1950^{2}, BPA 1994^{2}, ODFW 1996^{1}
17090010	OR	Tualatin R.	C^{2}, H^{*1}	Parkhurst *et al.* 1950^{1}, BPA 1994^{2}
17090011	OR	Clackamas R.	C^{1,2}	Fulton 1968^{1}, BPA 1994^{2}, ODFW 1996^{1}
17090012	OR	L. Willamette R.	C^{1,2}	Fulton 1968^{1},BPA 1994^{2}, ODFW 1996^{1}
17070101	OR/WA	M. Columbia-L. Wallula	C^{1,2}	Fulton 1968 ^{1}, Fulton 1970^{2}
17070102	OR/WA	Walla Walla R.	H^{*1,2}	Fulton 1968 ^{1}, Fulton 1970^{2}
17070103	OR	Umatilla R.	H^{*1}	Fulton 1968
17070104	OR	Willow	H^{1}	NMFS 1998
17070105	OR/WA	Mid. Columbia-Hood	C^{1,2}	Fulton 1968^{1}, 1970^{2}; WDF *et al.* 1993^{2}, ODFW 1996^{2}
17070106	WA	Klickitat R.	C^{1,2}	Fulton 1968^{1}, 1970^{2}
17070301	OR	Upper Deschutes R.	H^{1}	Nielson 1950, Fulton 1968, Nehlson 1995
17070303	OR	Beaver - South Fork	H^{1}	Fulton 1968, Nehlson 1995, ODFW 1996
17070304	OR	Upper Crooked R.	H^{1}	Nielson 1950, Fulton 1968, Nehlson 1995
17070305	OR	Lower Crooked R.	H^{1}	Nielson 1950, Fulton 1968, Nehlson 1995
17070306	OR	Lower Deschutes R.	C^{1,2}	Nielson 1950^{1}, Fulton 1968^{1}, 1970^{2}; BPA 1994^{2}
17070307	OR	Trout Creek	C^{2}, H^{*1}	Nielson 1950^{1}, BPA 1994^{2}
17070201	OR	Upper John Day R.	C^{1}	Nielson 1950, Fulton 1968
17070202	OR	N.F. John Day R.	C^{1}	Nielson 1950, Fulton 1968
17070203	OR	Middle F. John Day R.	C^{1}	Nielson 1950, Fulton 1968
17070204	OR	Lower John Day R.	C^{1}	Nielson 1950, Fulton 1968
17030001	WA	Upper Yakima R.	C^{1,2}	Fulton 1968, WDF *et al.* 19932
17030002	WA	Naches R.	C^{1,2}	Fulton 1968, WDF *et al.* 19932
17030003	WA	Lower Yakima R.	C^{1,2}	Fulton 1968, WDF *et al.* 19932
17020005	WA	Chief Joseph	C^{1}, H^{*2}	Fulton 1968^{1}, Bryant and Parkhurst 1950^{2}, WDF *et al.* 1993^{1}
17020006	WA/BC	Okanogan R.	C^{1}	Fulton 1968, WDF *et al.* 1993
17020007	WA/BC	Similkameen	H^{1}	Fulton 1968, WDF *et al.* 1993
17020008	WA	Methow R.	C^{1}, H^{*2}	Fulton 1968^{1}, Bryant and Parkhurst 1950^{2}WDF *et al.* 1993^{1}

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Unit #	State(s)	Hydrologic Unit Name	C/H	Documentation
17020010	WA	Upper Columbia-Entiat	C^1,H^2	Fulton 1968^1, Fulton 1970^2, WDF *et al.* 1993^1, Bryant and Parkhurst 1950^2, BPA 1994^2
17020011	WA	Wenatchee R.	$C^{1,2}$	Fulton 1968^1, Bryant and Parkhurst 1950^2, WDF *et al.* 1993^1, BPA 1994^2
17020016	WA	U. Colum.-Priest Rapids	$C^{1,2}$	Fulton 1968^1, 1970^2; WDF *et al.* 1993^1
17020001	WA/BC	F. D. Roosevelt Lake	$H^{1,2}$	Bryant and Parkhusrt 1950^{1,2}, Fulton 1968^1
17020002	WA/BC	Kettle R.	H^1	Bryant and Parkhusrt 1950, Fulton 1968
17020003	WA	Colville R.	H^1	Bryant and Parkhusrt 1950, Fulton 1968
17020004	WA	Sanpoil R.	H^1	Bryant and Parkhusrt 1950, Fulton 1968
17010307	WA	Lower Spokane R.	$H^{1,2}$	Bryant and Parkhusrt 1950^{1,2}, Fulton 1968^1, Fulton 1970^2
17010216	WA/BC	Pend Oreille R.	H^1	Bryant and Parkhurst 1950, Fulton 1968
17060101	OR/ID	Hells Canyon	C^1	Fulton 1968, Mathews and Waples 1991
17060102	OR	Imnaha R.	C^1	Fulton 1968, Mathews and Waples 1991, ODFW 1996
17060103	OR/WA/ID	Lower Snake - Asotin	$H^{*1,2}$	Parkhurst 1950^2, Mathews and Waples 1991^1
17060104	OR	Upper Grande Ronde	C^1, H^{*2}	Parkhurst 1950^2, Fulton *et al.* 1969^1, Mathews and Waples 1991^1
17060105	OR	Wallowa R.	C^1, H^{*2}	Parkhurst 1950^2, Fulton 1968^1, Mathews and Waples 1991^1
17060106	OR/WA	Lower Grande Ronde	C^1, H^{*2}	Parkhurst 1950^2, Mathews and Waples 1991^1, ODFW 1996^1
17060107	WA	L. Snake/Tucannon R.	C^1, H^{*2}	Parkhurst 1950^2, WDF *et al.* 1993^1
17060110	WA	Lower Snake R.	C^1, H^{*2}	Parkhurst 1950^2, Mathews and Waples 1991, ODFW 1996^1
17060201	ID	U. Salmon R.	C^1	Fulton 1968, Mathews and Waples 1991
17060202	ID	Pahsimeroi R.	C^1	Fulton 1968, Mathews and Waples 1991
17060203	ID	M. Salmon - Panther	C^1	Fulton 1968, Mathews and Waples 1991
17060204	ID	Lemhi R.	C^1	Fulton 1968, Mathews and Waples 1991
17060205	ID	Upper M.F. Salmon	C^1	Fulton 1968, Mathews and Waples 1991
17060206	ID	Lower M.F. Salmon	C^1	Fulton 1968, Mathews and Waples 1991
17060207	ID	M. Salmon-Chamberlain	C^1	Fulton 1968, Mathews and Waples 1991
17060208	ID	S.F. Salmon R.	C^1	Fulton 1968, Mathews and Waples 1991
17060209	ID	Lower Salmon R.	C^1	Fulton 1968, Mathews and Waples 1991
17060210	ID	Little Salmon R.	C^1	Fulton 1968, Waples *et al.* 1991
17060301	ID	Upper Selway R.	C^1	Fulton 1968, Mathews and Waples 1991
17060302	ID	Lower Selway R.	C^1	Fulton 1968, Mathews and Waples 1991
17060303	ID	Lochsa R.	C^1	Fulton 1968, Mathews and Waples 1991
17060304	ID	M.F. Clearwater R.	C^1	Fulton 1968
17060305	ID	S.F. Clearwater R.	C^1	Fulton 1968
17060306	WA/ID	Clearwater	C^1, H^{*2}	Parkhurst 1950^2, Fulton 1968^1

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Unit #	State(s)	Hydrologic Unit Name	C/H	Documentation
17060307	ID	Upper N.F. Clearwater	H^{1}	Fulton 1968, Mathews and Waples 1991
17060308	ID	Lower N.F. Clearwater	H^{1}	Fulton 1968, Mathews and Waples 1991
17050201	OR/ID	Brownlee Reservoir	H^{1}	Fulton 1968, Mathews and Waples 1991
17050202	OR	Burnt R.	H^{1}	Fulton 1968
17050203	OR	Powder R.	H^{1}	Fulton 1968
17050101	ID	C.J. Strike Resevoir	H^{1}	Fulton 1968, Mathews and Waples 1991
17050102	ID/NV	Bruneau R.	H^{1}	Fulton 1968
17050103	ID	Middle Snake - Succor	H^{1}	Fulton 1968, Mathews and Waples 1991
17050104	ID	Upper Owyhee	H^{1}	Fulton 1968
17050105	ID/NV/OR	S.F. Owyhee R.	H^{1}	Fulton 1968
17050106	ID/NV/OR	E. Little Owyhee R.	H^{1}	Fulton 1968
17050107	ID/OR	Middle Owyhee R.	H^{1}	Fulton 1968
17050108	ID/OR	Jordan Cr.	H^{1}	Fulton 1968
17050109	OR	Crooked - Rattlesnake	H^{1}	Fulton 1968
17050110	OR	Lower Owyhee R.	H^{1}	Fulton 1968
17050111	ID	North and M.F Boise R.	H^{1}	Fulton 1968
17050112	ID	Boise - Mores	H^{1}	Fulton 1968
17050113	ID	S.F. Boise R.	H^{1}	Fulton 1968
17050114	ID	Lower Boise R.	H^{1}	Fulton 1968
17050115	ID/OR	Middle Snake - Payette	H^{1}	Fulton 1968, Mathews and Waples 1991
17050116	OR	Upper Malheur R.	H^{1}	Fulton 1968
17050117	OR	Lower Malheur R.	H^{1}	Fulton 1968
17050118	OR	Bully Cr.	H^{1}	Fulton 1968
17050119	OR	Willow Cr.	H^{1}	Fulton 1968
17050120	ID	S.F Payette R.	H^{1}	Fulton 1968
17050121	ID	M.F. Payette R.	H^{1}	Fulton 1968
17050122	ID	Payette R.	H^{1}	Fulton 1968
17050123	ID	N.F. Payette R.	H^{1}	Fulton 1968
17050124	ID	Weiser R.	H^{1}	Fulton 1968
17040212	ID	U. Snake - Rock	H^{1}	Fulton 1968, Mathews and Waples 1991
17040213	ID/NV	Salmon Falls	H^{1}	Fulton 1968, Mathews and Waples 1991
17100201	OR	Necanicum R.	C^{1,2}	ORIS 1994^{1,2}, ODFW 1996^{2}
17100202	OR	Nehalem R.	C^{1,2}	ORIS 1994^{1,2}, ODFW 1996^{1,2}
17100203	OR	Wilson-Trask-Nestuccu	C^{1,2}	ORIS 1994^{1,2}, ODFW 1996^{1,2}
17100204	OR	Siletz-Yaquina R.	C^{1,2}	ORIS 1994^{1,2}, ODFW 1996^{1,2}
17100205	OR	Alsea R.	C^{1,2}	ORIS 1994^{1,2}, ODFW 1996^{1,2}
17100206	OR	Siuslaw R.	C^{1,2}	ORIS 1994^{1,2}, ODFW 1996^{1,2}
17100207	OR	Siltcoos R.	C^{1,2}	ORIS 1994^{1,2}, ODFW 1996^{1,2}
17100301	OR	N. Umpqua R.	C^{1,2}	ORIS 1994^{1,2}, ODFW 1996^{1,2}

TABLE A-6. Current and historic salmon distribution as defined by USGS hydrologic units. Superscripted numbers indicate salmon species present: 1=Chinook, 2=Coho, and 3=Puget Sound Pink. Unit # designates USGS Hydrological Unit Code. C/H indicates whether salmon distribution is current habitat (C), inaccessible historic (H), or currently accessible, but unutilized historic habitat (H*). (Page 5 of 7)

Unit #	State(s)	Hydrologic Unit Name	C/H	Documentation
17100302	OR	S. Umpqua R.	$C^{1,2}$	ORIS 1994^{1,2}, ODFW 1996^{1,2}
17100303	OR	Umpqua R.	$C^{1,2}$	ORIS 1994^{1,2}, ODFW 1996^{1,2}
17100304	OR	Coos R.	$C^{1,2}$	ORIS 1994^{1,2}, ODFW 1996^{1,2}
17100305	OR	Coquille R.	$C^{1,2}$	ORIS 1994^{1,2}, ODFW 1996^{1,2}
17100306	OR	Sixes R.	$C^{1,2}$	ORIS 1994^{1,2}, ODFW 1996^{1,2}
17100307	OR	Upper Rogue R.	$C^{1,2}$	ORIS 1994^{1,2}, ODFW 1996^{1,2}
17100308	OR	Middle Rogue R.	$C^{1,2}$	ORIS 1994^{1,2}, ODFW 1996^{1,2}
17100309	CA/OR	Applegate R.	$C^{1,2}$	ORIS 1994^{1,2}, ODFW 1996^{1,2}
17100310	OR	Lower Rogue R.	$C^{1,2}$	ORIS 1994^{1,2}, ODFW 1996^{1,2}
17100311	CA/OR	Illinois R.	$C^{1,2}$	ORIS 1994^{1,2}, ODFW 1996^{1,2}
17100312	CA/OR	Chetco R.	$C^{1,2}$	ORIS 1994^{1,2}, ODFW 1996^{1,2}
18010101	CA/OR	Smith R.	$C^{1,2}$	Nehlsen *et al.*1991^{1}, Klamath River Basin Fisheries Task Force (KRBFTF) 1991^{1}, Brown and Moyle 1991^{2}
18010201	OR	Williamson R.	H^{1}	KRBFT 1991, Nehlson *et al.* 1991
18010202	OR	Sprague R.	H^{1}	KRBFT 1991, Nehlson *et al.* 1991
18010203	OR	Upper Klamath Lake	H^{1}	KRBFT 1991, Nehlson *et al.* 1991
18010206	CA/OR	Upper Klamath R.	$C^{1,2}$	KRBFT 1991^{1}, Brown and Moyle 1991^{2}
18010207	CA	Shasta R.	$C^{1,2}$	Nehlsen *et al.* 1991^{1}, KRBFT 1991, Brown and Moyle 1991^{2}
18010208	CA	Scott R.	$C^{1,2}$	KRBFT 1991^{1}, Brown and Moyle 1991^{2}
18010209	CA/OR	Lower Klamath R.	$C^{1,2}$	KRBFT 1991^{1}, Brown and Moyle 1991^{2}
18010210	CA	Salmon R.	$C^{1,2}$	KRBFT 1991^{1}, Brown and Moyle 1991^{2}
18010211	CA	Trinity R.	$C^{1,2}$	KRBFT 1991^{1}, Brown and Moyle 1991^{2}
18010212	CA	S.F. Trinity R.	$C^{1,2}$	KRBFT 1991^{1}, California Department of Fish and Game (CDFG) 1998^{2}
18010102	CA	Mad-Redwood	$C^{1,2}$	Higgins *et al.* 1992^{1,2}
18010103	CA	Upper Eel R.	$C^{1,2}$	Brown and Moyle 1991^{2}, Higgins *et al.* 1992^{1}
18010104	CA	Middle Fork Eel R.	$C^{1,2}$	Brown and Moyle 1991^{2}, Higgins *et al.* 1992^{1}
18010105	CA	Lower Eel R. R.	$C^{1,2}$	Brown and Moyle 1991^{2}, Nehlsen *et al.* 1991^{1}, Higgins *et al.* 1992^{1,2}
18010106	CA	South Fork Eel R.	$C^{1,2}$	Brown and Moyle 1991^{2}, Nehlsen *et al.* 1991^{1}, Higgins *et al.* 1992^{1,2}
18010107	CA	Mattole R.	$C^{1,2}$	Nehlsen *et al.* 1991^{1}, Brown and Moyle 1991^{2}, Higgins *et al.* 1992^{2}
18010108	CA	Big - Navarro - Garcia	C^{2}, H^{*1}	Brown and Moyle 1991^{2}, Higgins *et al.* 1992^{2}, Maahs and Gilleard 1994^{1}
18010109	CA	Gualala - Salmon R.	C^{2}, H^{*1}	Brown and Moyle 1991^{2}, Nehlsen *et al.* 1991^{1}, Higgins *et al.* 1992^{2}
18010110	CA	Russian R.	$C^{1,2}$	Nehlsen *et al.* 1991^{1}, Brown and Moyle 1991^{2}
18010111	CA	Bodega Bay	C^{2}, H^{*1}	Nehlsen *et al.* 1991^{1}, Brown and Moyle 1991^{2}
18050001	CA	Suisun Bay	$C^{1,2}$	Clark 1929^{1}, Evermann and Clark 1931^{1}, Brown and Moyle 1991^{2}

TABLE A-6. Current and historic salmon distribution as defined by USGS hydrologic units. Superscripted numbers indicate salmon species present: 1=Chinook, 2=Coho, and 3=Puget Sound Pink. Unit # designates USGS Hydrological Unit Code. C/H indicates whether salmon distribution is current habitat (C), inaccessible historic (H), or currently accessible, but unutilized historic habitat (H*). (Page 6 of 7)

Unit #	State(s)	Hydrologic Unit Name	C/H	Documentation
18050002	CA	San Pablo Bay	$C^{1,2}$	Clark 1929[1], Evermann and Clark 1931[1], Brown and Moyle 1991[2]
18050003	CA	Coyote	$C^{1,2}$	Clark 1929[1], Evermann and Clark 1931[1], Brown and Moyle 1991[2], NMFS 1998[1]
18050004	CA	San Francisco Bay	$C^{1,2}$	Clark 1929[1], Evermann and Clark 1931[1], Brown and Moyle 1991[2], NMFS 1998[1]
18020001	CA, OR	Goose Lake	H^{1}	Clark 1929, Evermann and Clark 1931
18020003	CA	Lower Pit R.	H^{1}	Clark 1929, Yoshiyama *et al.* 1996
18020004	CA	McCloud R.	H^{1}	Clark 1929, Yoshiyama *et al.* 1996
1802005	CA	Sacramento Headwaters	H^{1}	Clark 1929, Yoshiyama *et al.* 1996
18020101	CA	Sac. L. - Cow L. Clear	C^{1}	Clark 1929, Evermann and Clark 1931
18020102	CA	Lower Cottonwood Cr.	C^{1}	Clark 1929, Hanson *et al.* 1940
18020103	CA	Sac.-Lower Thomes	C^{1}	Clark 1929, Evermann and Clark 1931
18020104	CA	Sac.-Stone Corral	C^{1}	Clark 1929, Evermann and Clark 1931
18020105	CA	Lower Butte	C^{1}	Clark 1929, Yoshiyama *et al.* 1996
18020106	CA	Lower Feather R.	C^{1}	Clark 1929, Yoshiyama *et al.* 1996
18020107	CA	Lower Yuba R.	C^{1}	Clark 1929, Nehlsen *et al.* 1991
18020108	CA	Lower Bear R.	C^{1}	Clark 1929, Hanson *et al.* 1940
18020109	CA	Lower Sacramento R.	C^{1}	Clark 1929
18020110	CA	L. Cache Creek	H^{1}	Yoshiyama *et al.* 1996
18020111	CA	Lower American R.	C^{1}	Clark 1929, Yoshiyama *et al.* 1996
18020112	CA	Sac.-Upper Clear	C^{1}	Clark 1929, Yoshiyama *et al.* 1996
18020113	CA	Cottonwood Headwaters	C^{1}	Clark 1929, Hanson *et al.* 1940, Yoshiyama *et al.* 1996
18020114	CA	U. Elder- U. Thomes	H^{1}	Yoshiyama *et al.* 1996
18020115	CA	Upper Stony Creek	H^{1}	Yoshiyama *et al.* 1996
18020118	CA	Upper Cow-Battle	C^{1}	Clark 1929, Yoshiyama *et al.* 1996
18020119	CA	Mill-Big Chico	C^{1}	Clark 1929, Yoshiyama *et al.* 1996
18020120	CA	Upper Butte Cr.	C^{1}	Clark 1929, Yoshiyama *et al.* 1996
18020121	CA	N.F. Feather R.	H^{1}	Clark 1929, Hanson *et al.* 1940
18020122	CA	E. Branch N.F. Feather	H^{1}	Clark 1929, Hanson *et al.* 1940
18020123	CA	M.F. Feather R.	H^{1}	Clark 1929, Hanson *et al.* 1940
18020125	CA	Upper Yuba R.	$C^{1}H^{1}$	Clark 1929, Yoshiyama *et al.* 1996
18020128	CA	N.F. American R.	H^{1}	Clark 1929, Yoshiyama *et al.* 1996
18020129	CA	S.F. American R.	H^{1}	Clark 1929, Yoshiyama *et al.* 1996
18030010	CA	Upper King	H^{1}	Yoshiyama *et al.* 1996
18030012	CA	Tulare-Buena Vista Lakes	H^{1}	Yoshiyama *et al.* 1996
18040001	CA	U. Mid. San Joaquin - Lower Chowchilla	H^{*1}	Clark 1929, Yoshiyama *et al.* 1996

TABLE A-6. Current and historic salmon distribution as defined by USGS hydrologic units. Superscripted numbers indicate salmon species present: 1=Chinook, 2=Coho, and 3=Puget Sound Pink. Unit # designates USGS Hydrological Unit Code. C/H indicates whether salmon distribution is current habitat (C), inaccessible historic (H), or currently accessible, but unutilized historic habitat (H*). (Page 7 of 7)

Unit #	State(s)	Hydrologic Unit Name	C/H	Documentation
18040002	CA	Mid. San Joaquin - L. Merced - L. Stanislaus	H^{*1}	Clark 1929, Yoshiyama *et al.* 1996
18040003	CA	San Joaquin Delta	C^1	Clark 1929, Yoshiyama *et al.* 1996
18040004	CA	L. Calaveras-Mormon Slough	H^{*1}	Clark 1929, Yoshiyama *et al.* 1996
18040005	CA	L. Consumnes-L. Mokelumne	C^1	Clark 1929, Yoshiyama *et al.* 1996
18040006	CA	Upper San Joaquin	H^1	Clark 1929, Yoshiyama *et al.* 1996
18040008	CA	Upper Merced	H^1	Clark 1929, Yoshiyama *et al.* 1996
18040009	CA	Upper Tuolumne	C^1H^1	Clark 1929, Campbell and Moyle 1990
18040010	CA	Upper Stanislaus	H^1	Clark 1929, Campbell and Moyle 1990
18040011	CA	Upper Calaveras	C^1	Clark 1929
18040012	CA	Upper Mokelumne	H^1	Clark 1929
18040013	CA	Upper Cosumnes	C^1H^1	Clark 1929
18060001	CA	San Lorenzo - Soquel	C^2, H^{*1}	Snyder 1914^1, Brown and Moyle 1991^2, Bryant 1994^2
18060002	CA	Pajaro R.	C^2, H^{*1}	Snyder 1914^1, Bryant 1994^2
18060006	CA	Central Coastal	$H^{*1,2}$	Jordan 1895^1, Brown and Moyle 1991^2, Bryant 1994^2
18050005	CA	Tomales-Drake Bays	C^2	Brown and Moyle 1991
18050006	CA	San Fran.-Coastal South	C^2	Brown and Moyle 1991
18060012	CA	Carmel R.	H^{*2}	Brown and Moyle 1991

Note: Juvenile chinook salmon were also reported in the Ventura River (USGS No. 18010101) by Jordan and Gilbert (1881), but no other reports of adults or a self sustaining population were located.

TABLE A-7. Selected databases on salmon distribution and habitat evaluated for EFH mapping and identification. (Page 1 of 6)

Data – Source	Format	Type – Scale	Extent	EFH Utility	Quality	Species	Life Stage	Contact
EFH DATA LEVEL 1 - PRESENCE/ABSENCE:								
StreamNet/ Northwest Environmental Database (NED)- Pacific States Marine Fisheries Commission (PSMFC)	River Reach Number (RRN) linked dBase files - online database	Dynamically segmented reach file - 1:100,000	CRB, coastal OR, WA, limited CA data	Mapping, consultation	Species distribution information, escapement, hatcheries, (wetlands, wildlife and other data in NED)	Chinook, Coho, Sockeye, Pink	Adult spawning Egg-smolt rearing	Matt Freid PSMFC Gladstone, OR (503) 650-5400 www.psmfc.org
USFS/Bureau of Land Management (BLM) habitat surveys and distribution data, aquatic inventory and stream identification	Hardcopy and some digital files	Individual habitat units - some data linked to 1:100,000 reaches	Federal forest/range lands, private lands in matrix	Consultation	Species distribution and habitat quality data not collected using consistent criteria, needs evaluation	Chinook, Coho, Sockeye, Pink	Adult spawning Egg-smolt rearing	Shaun McKinney USFS Siuslaw, NF (541) 750-7188
National Wetlands Inventory (NWI) - U.S. Fish and Wildlife Service (USFWS)	ArcInfo digital line graph (DLG) coverages - online dBase.	DLG files - 1:24,000 scale	Nationwide	Mapping, consultation	Wetland and estuarine habitats nationwide	General	Egg to smolt Juvenile marine	www.nwi.fws.gov
Estuarine Living Marine Resources (ELMR) – NOAA National Ocean Service (NOS)	Hardcopy, digital development proposed	Relative estuarine abundance/ 1:500,000	All major West Coast estuaries	Mapping	Relative species abundance in West Coast estuaries, validates species presence, digital data of limited utility for EFH mapping	Chinook, Coho, Sockeye, Pink	Juvenile marine Adult marine	Steve Brown NOAA - Ocean Resources Conservation and Assessment Division (ORCA) Sephen.K.Brown@noaa.gov (301) 713-3000
Pacific Salmon Tagging database - Fisheries Research Institute (FRI), University of Washington	Hardcopy and digital database	Tag release/ recovery data - scale N/A	CA, OR, WA, ID	Mapping	Tag release recovery data showing ocean distribution of West Coast stocks	Chinook, Coho, Sockeye, Pink	Adult Marine	Katherine Myers Box 35790 University of Washington Seattle, WA 98195
Minerals Management Service, National Marine Sanctuaries databases	Hardcopy reports/ maps, digital availability unknown.	Substrates, key habitat areas - Variable data formats, completeness	Various sites on CA, OR, WA coasts	Needs further evaluation	Data sources being reviewed by PFMC Groundfish Management Team for nearshore distribution, possible relevance to anadromous EFH effort	General	Adult marine	National Marine Sanctuary Program
Pacific Fisheries Information Network (PACFIN) - PSMFC	Online database	Commercial catch data - scale variable	Coastal CA, OR, WA	Needs further evaluation	Some salmonid presence information inferred from catch data	Chinook, Coho, Sockeye, Pink	Adult marine	PSMFC Gladstone, OR www.psmfc.org

TABLE A-7. Selected databases on salmon distribution and habitat evaluated for EFH mapping and identification. (Page 2 of 6)

Data – Source	Format	Type – Scale	Extent	EFH Utility	Quality	Species	Life Stage	Contact
EFH DATA LEVEL 1 - PRESENCE/ABSENCE (continued):								
California Rivers Assessment (CARA) – Public Service Research Program, UC Davis	PC database, some online data	Presence data by reach/ 1:250,000	CA	Mapping	Presence/absence for a subsample of rivers, some historic use data	Chinook, Coho	Adult spawning Egg-smolt rearing	David Hudson (916)752-0532 http://endeavor.des.ucdavis.edu
Environmental Protection Agency (EPA)/USGS Hydrography – USGS Water Information Clearinghouse	GIS polylines	1:100,000 scale reach file	CA, OR, WA, ID	Template for general EFH mapping	Hydrography template for mapping species distribution data	General	Adult spawning Egg-smolt rearing	Tom Haltom USGS (916)278-3061 tchaltom@usgs. gov
Brown and Moyle Report - NMFS Southwest Regional Office (SWR)	Hardcopy	Current and historical coho freshwater distribution	Northern/ central CA coast	Mapping, integrated with SW region coho data	Historic extent of coho salmon habitat in CA from available documentation by stream name	Coho	Adult spawning Egg-smolt rearing	NMFS Northwest Regional Office (NWR) 525 NE Oregon St. Portland, OR 97323
CA Dept. of Forestry and Fire Protection (CDFFP)/Private timberland surveys	Hardcopy reports, various GIS, and other databases	Land use, cover, own., hab. surveys, etc. variable scales	Private forest lands, CA	EFH consultation	Variable scale/structure data collected on private forest lands, much of these data are proprietary	Coho, Chinook, General	Adult spawning Egg-smolt rearing	Robin Marose CDFFP (916)227-2656 Various sources for private data
CDFG - Eel River surveys	PC database	Presence data attached to reach file - 1:100,000	Eel River, CA	EFH mapping	Coho distribution limited to the Eel River basin in CA, integrated with NMFS SW region coho data	Coho	Adult spawning Egg-smolt rearing	Paul Veisze (916)323-1667 pveisze@dfg.ca. gov
CDFG Hazardous Materials Spill Response database	Various hardcopy reports, GIS, and other databases	Shoreline and substrates data - various scales and formats	Local to state level	EFH consultation	Habitat type, substrate, and other data useful to long term EFH management	General	Juvenile marine Adult marine	Kim McKlegneghan (916)322-9210
NMFS San Francisco Bay and Gulf of Farralones surveys	Hardcopy reports, digital not available	Beach seine/trawl data for pathology studies	San Francisco Bay Delta and Gulf of Farallones chinook dist.	EFH consultation	Chinook salmon parr, smolts, and juveniles collected for pathology studies, useful for presence/absence.	Chinook, General	Juvenile marine Adult marine	Bruce Macfarlane (415)435-3149 Bruce.Macfarlane@noaa.gov
San Francisoco Bay National Estuary Program	Hardcopy reports, digital data availability unknown	Habitat and pollutant sites - variable scales	San Francisco Bay and Delta	EFH consultation	Possible source for data on key habitat areas (e.g., submerged aquatic vegetation)	General	Juvenile marine Adult marine	www.abag. ca.gov/bayarea/sfep/sfep.html

TABLE A-7. Selected databases on salmon distribution and habitat evaluated for EFH mapping and identification. (Page 3 of 6)

Data – Source	Format	Type – Scale	Extent	EFH Utility	Quality	Species	Life Stage	Contact
EFH DATA LEVEL 1 - PRESENCE/ABSENCE (continued):								
CDFG San Francisco Bay Delta surveys	Hardcopy reports, digital data availability unknown	Trawl/seine data for relative abundance	All species, San Francisco Bay/Delta CA	EFH consultation	CDFG surveys of fish community composition at several stations throughout S.F. Bay Estuary	Chinook, General	Juvenile marine Adult marine	Judd Muscat CDFG (916)324-3411
Oregon River Information Coverages - ODFW	GIS polyline coverages and attribute data	Dynamically segmented reach file - 1:100,000	OR	EFH mapping, consultation and management	ORIS data updated to larger scale, preferred scale for province maps, species distribution segregated by use type, useful for general mapping	Chinook, Coho	Adult spawning Egg-smolt rearing	http://rainbow.dfw.state.or.us/ftp
Oregon Rivers Information System - ODFW	GIS and reach linked attribute database	Dynamically segmented reach file - 1:250,000	OR	EFH mapping	Useful for coarse maps of large areas, under-represents spawning habitat. Migration corridor and spawning areas not clearly distinguished	Chinook, Coho	Adult spawning Egg-smolt rearing	Brent Forsberg ODFW P.O. Box 59 Portland, OR 97297
ODFW Core Area Maps	GIS and attribute database	Dynamically segmented 1:100,000 reach files	OR	Mapping, consultation	Preferred spawning and rearing habitats in key river basins information is good for coastal streams, less detailed in Columbia River Basin	Chinook, Coho	Adult spawning Egg-smolt rearing	http://rainbow.dfw.state.or.us/ftp
ODFW Habitat Surveys	Hardcopy data, linkage to GIS in progress	Habitat units, will be linked to 1:24,000 scale reaches	OR coast state and private lands	Consultation	Habitat suitability surveys for salmonids at management relevant scales, identifies current and potential anadromous habitats	General	Adult spawning Egg-smolt rearing	Kim Jones ODFW (541)737-7619 jonesk@fsl.orst. edu
OR Dept. of Land Conservation & Development estuarine inventories	Various hardcopy reports and digital databases	Estuarine extent, habitat types	OR Coast	Consultation	Statewide criteria for estuarine inventories implemented at the county level	General	Adult spawning Juvenile marine	Various county level data sources

TABLE A-7. Selected databases on salmon distribution and habitat evaluated for EFH mapping and identification. (Page 4 of 6)

Data – Source	Format	Type – Scale	Extent	EFH Utility	Quality	Species	Life Stage	Contact
EFH DATA LEVEL 1 - PRESENCE/ABSENCE (continued):								
Coastal Change Analysis Program (CCAP) - NOAA Coastal Services Center (CSC)/ Columbia R. National Estuary Prog. - EPA	GIS and attribute database - CD format	Habitat/land cover data - variable scales	Columbia River Estuary, OR coast to Tillamook Bay	Consultation	Time series remote sensing images of uplands habitat change, useful for identifying long term EFH trends	General	Adult spawning Egg-smolt rearing Juvenile marine	NOAA - CSC www.csc.noaa.gov
Tillamook Bay National Estuary Project - Oregon State University	Hardcopy reports, GIS coverages	Reach/land cover data/ 1:24,000 - 1:100,000 scale	Tillamook Bay basin, OR HUC# 17100203	Mapping, consultation	Species distribution data for coho, chinook and chum, segregated by use type for Tillamook Bay tributaries	Chinook, Coho, General	Adult spawning Egg-smolt rearing Juvenile marine	www.orst.edu/ dept/tbaynep/ active.html
State/Private watershed analysis data, watershed organization databases	Various hardcopy and digital databases	Numerous data categories, variable scales	State and private lands OR/WA/CA/ ID	Consultation	Locally specific data useful for EFH consultation	Chinook, Coho, Sockeye, Pink, General	Adult spawning Egg-smolt rearing	Various sources
WARIS - Washington Department of Fish and Wildlife (WDFW)	GIS and attribute database	Dynamically segmented reach file - 1:100,000	WA	Mapping, consultation	Species distribution segregated by use type, useful for general mapping.	Chinook, Coho, Sockeye, Pink	Adult spawning Egg-smolt rearing	Martin Hudson WDFW (360) 902-2487 hudsomgh@dfw.wa.gov
Western Washington Watershed Screening Database (WWWSD) - WDFW	GIS ArcInfo coverages, database	Reach, land cover data, road density - 1:24,000	Western WA	Mapping, consultation	Habitat screening tool potentially useful for identifying key stream reaches, demonstrates extent of river miles at 1:24,000	Chinook, Coho, Sockeye, Pink	Adult spawning Egg-smolt rearing	Brad Johnson EPA Region 10 (206)553-4150 bjohnson@r0dj05.r10.epa.gov
Washington State Department Natural Resources Stream Typing Database	Digital	1:24,000	WA	EFH consultation and mapping	Fish presence and absence, template for Salmon and Steelhead Habitat Inventory and Assessment (SSHIAP)	general (salmonid presence and absence)	Adult spawning Egg-smolt rearing	Wash. DNR 1111Wash. St. SE Olympia, WA 98504 (360) 902-1000
Salmon and Steelhead Stock Inventory (SASSI) - WDFW	Hardcopy (integrated with WARIS)	Dynamically segmented 1:100,000 reach files	WA	Mapping, consultation	Preferred spawning and rearing habitats by species for river basins with critical spawning habitat	Chinook, Coho, Sockeye, Pink	Adult spawning Egg-smolt rearing	WDFW P.O. Box 43138 Olympia, WA 98504-3150 (360)902-2700

TABLE A-7. Selected databases on salmon distribution and habitat evaluated for EFH mapping and identification. (Page 5 of 6)

Data – Source	Format	Type – Scale	Extent	EFH Utility	Quality	Species	Life Stage	Contact
EFH DATA LEVEL 1 - PRESENCE/ABSENCE (continued):								
SSHIAP - WDFW and Northwest Indian Fisheries Commission (NWIFC)	Hardcopy, GIS database in development	Channel morphology, stream flows, seral stage - 1:24,000	Western WA (partially complete)	Mapping, consultation	Habitat suitability surveys at management relevant scales useful for identifying currently and potentially suitable anadromous habitats	Chinook, Coho, Sockeye, Pink	Adult spawning Egg-smolt rearing	Randy McIntosh NWIFC (360)438-1180
Willapa Watershed Information System - Interrain Pacific	GIS and attribute database - CD format	GIS reach and land cover - variable scales	Willapa Bay basin, WA	Consultation	Time series remote sensing images of uplands habitat change, useful for identifying long term trends	Chinook, Coho	Adult spawning Egg-smolt rearing Juvenile marine Adult marine	Interrain Pacific (503)226-8108 www.interrain.org
Idaho Rivers Information System - Idaho Department of Fish and Game (IDFG)	GIS and attribute database	Dyna. seg. reach file - 1:250,000 (in conversion to 1:100,000)	ID	Mapping	Data scale limits utility to general mapping for information purposes only	Chinook	Adult spawning Egg-smolt rearing	Jerome Hansen IDFG 600 S. Walnut Boise, ID 83707 (208)334-3098
Puget Sound Intertidal Habitat Inventory - Washington Department of Natural Resources	GIS and attribute database - CD format	Substrates and vegetation - 1:24,000 scale	Puget Sound, WA	Consultation	Puget Sound shoreline habitat inventories, partially complete coverage of Bellingham Bay to Canadian border	General	Juvenile marine Adult marine	WA Nat. Heritage Program Mail Stop 47027 Olympia, WA 98504
Puget Sound National Estuary Program (NEP) - EPA	Hardcopy, digital avail. unknown	unknown	Puget Sound, WA	Consultation	Sediment contamination, point source pollution location data, etc.	General	Juvenile marine Adult marine	Nancy McKay Puget Sound NEP (360)407-7300
Tribal/local government habitat, land cover, zoning maps, etc.	Various hardcopy and digital formats	Various data types and scales	Local: CA, OR, WA, ID	Consultation	Numerous tribal/local government data sources may have consultation and management utility	Chinook, Coho, Sockeye, Pink	Adult spawning Egg-smolt rearing	Various sources
Commercial fishing logbooks	Hardcopy	Location of key marine habitat areas - scale N/A	Coastal CA, OR, WA	Needs further evaluation	Experience based knowledge of key salmonid marine habitat areas and characteristics	Chinook, Coho, Sockeye, Pink	Adult marine	Various sources

TABLE A-7. Selected databases on salmon distribution and habitat evaluated for EFH mapping and identification. (Page 6 of 6)

Data – Source	Format	Type – Scale	Extent	EFH Utility	Quality	Species	Life Stage	Contact
EFH DATA LEVEL 2 - HABITAT-RELATED DENSITIES:								
NMFS Salmonid Escapement Database (prepared by Big Eagle Associates and LGL), Incorporated into StreamNet	Restricted database	Salmonid escapement in selected West Coast rivers - 1:100,000 reaches	Selected river basins CA, OR, WA, ID	See StreamNet (incorporated into StreamNet)	Escapement data acquired from state, federal, tribal and intergovernmental agencies for Washington, Oregon, and California	Chinook, Coho, Sockeye, Pink	Adult spawning	NMFS - Northwest Fisheries Science Center (NWFSC) 2725 Montlake Blvd. E Seattle, WA 98112
Klamath Resources Information System – USFWS	GIS and interactive database - CD format	Multiple data coverages, bibliographic data - variable scales	Klamath River basin below Iron Gate dam	consultation	Escapement data for all species in selected area sub-basins, model system for consultation and management	Chinook, Coho	Adult spawning Egg-smolt rearing	USFWS Klamath River Fishery Resource Office, P.O. Box 1006, Yreka, CA 96097
Desktop GIS System for Salmonid Resources in the Columbia River	GIS database	1:250,000	Columbia River Basin (WA, OR, ID)	mapping and consultation	Spawning escapement and hatchery release data, similar to StreamNet	Coho, Chinook, Sockeye	Adult spawning, juvenile (hatchery smolts)	Bob Emmett NMFS 2030 S. Marine Sciences Dr. Newport, OR 87365

EFH DATA LEVEL 3 - REPRODUCTION, GROWTH, SURVIVAL RATES BY HABITAT:

NA

EFH DATA LEVEL 4 - PRODUCTION RATES BY HABITAT:

NA

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

3.1 FISHING ACTIVITIES AFFECTING SALMON ESSENTIAL FISH HABITAT

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

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

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

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

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

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

3.1.1.1 Gear Effects

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

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

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

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

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

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

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

3.1.1.2 Harvest of Prey Species

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

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

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

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

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

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

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

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

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

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

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

3.1.2.1 Gear Effects on Essential Fish Habitat

See previous section entitled Gear Effects on Essential Fish Habitat.

3.1.2.2 Harvest of Prey Species

See previous section entitled Harvest of Prey Species.

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

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

3.1.2.4 Redd or Juvenile Fish Disturbance

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

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

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

3.1.2.5 Effects of Fishing Vessel Operation on Habitat

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

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

3.2 NONFISHING ACTIVITIES AFFECTING SALMON ESSENTIAL FISH HABITAT

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

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

3.2.1 The Consultation Process

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

Established habitat conservation policies and approaches of PFMC and NMFS provide the framework for implementing the Magnuson-Stevens Act. The Magnuson-Stevens Act requires federal agencies undertaking, permitting or funding activities that may adversely affect EFH to consult with NMFS. Under Section 305(b)(4) of the Magnuson-Stevens Act, NMFS is required to provide EFH conservation and enhancement recommendations to federal and state agencies for actions that adversely affect EFH; however, state agencies and private parties are not required to consult with NMFS. EFH consultations will be combined with existing interagency consultations and environmental review procedures that may be required under other statutes such as the ESA, Clean Water Act, the National Environmental Policy Act, the Fish and Wildlife Coordination Act, the Federal Power Act, or the Rivers and Harbors Act. To the extent that EFH and ESA consultations are integrated, NMFS will apply the provisions of the 1997 Secretarial Order 3206. NMFS NWR and NMFS SWR will provide additional information on the consultation process upon request.

3.2.1.1 A Programmatic Approach to the Consultation Process

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

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

3.2.1.2 Consultation Scenarios

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

HABITAT ELEMENT	INDICATORS	PROPERLY FUNCTIONING	AT RISK	NOT PROPERLY FUNCTIONING
Channel Condition & Dynamics:	Width/Depth Ratio	<10[b/e/]	>10	>10
	Streambank Condition	>90% stable; i.e., on average, less than 10% of banks are actively eroding[b/]	80-90% not eroding	<80% not eroding
	Floodplain Connectivity	off-channel areas are frequently hydrologically linked to main channel; overbank flows occur and maintain wetland functions, riparian vegetation and succession	reduced linkage of wetland, floodplains and riparian areas to main channel; overbank flows are reduced relative to historic frequency, as evidenced by moderate degradation of wetland function, riparian vegetation/succession	severe reduction in hydrologic connectivity between off-channel, wetland, floodplain and riparian areas; wetland extent drastically reduced, riparian vegetation/succession altered significantly, and channel degradation apparent
Flow/Hydrology:	Change in Peak/ Base Flows	watershed hydrograph indicates peak flow, base flow and flow timing characteristics comparable to an undisturbed watershed of similar size, geology and geography	some evidence of altered peak flow, baseflow and/or flow timing relative to an undisturbed watershed of similar size, geology and geography.	pronounced changes in peak flow, baseflow and/or flow timing relative to an undisturbed watershed of similar size, geology and geography
	Increase in Drainage Network	zero or minimum increases in drainage network density from roads[h/l/]	moderate increases in drainage network density from roads (e.g., about 5%)[h/l/]	significant increases in drainage network density from roads (e.g., 20-25%)[h/l/]
Watershed Conditions:	Road Density & Location	<2 mi/mi², [j/] no valley bottom roads	2-3 mi/mi², some valley bottom roads	>3 mi/mi², many valley bottom roads
	Disturbance History	<15% ECA **(entire watershed) with no concentration of disturbance in unstable or potentially unstable areas, and/or refugia, and/or riparian area; and for NWFP area (except AMAs**), ≥15% retention of LSOG in watershed[k/]	<15% ECA** (entire watershed), but disturbance concentrated in unstable or potentially unstable areas, and/or refugia, and/or riparian area; and for NWFP area (except AMAs), ≥15% retention of LSOG in watershed[k/]	>15% ECA** (entire watershed) and disturbance concentrated in unstable or potentially unstable areas, and/or refugia, and/or riparian area; does not meet NWFP standard for LSOG retention
	Riparian Reserves	the riparian reserve system provides adequate shade, large woody debris recruitment, and habitat protection and connectivity in all subwatersheds, and includes known refugia for sensitive aquatic species (>80% intact), and/or for grazing effects: percent similarity of riparian vegetation to the potential natural community/ composition >50%[l/]	moderate loss of connectivity or function (shade, LWD recruitment, etc.) of riparian reserve system, or incomplete protection of habitats and refugia for sensitive aquatic species (≈70-80% intact), and/or for grazing effects: percent similarity of riparian vegetation to the potential natural community/composition 25-50% or better[l/]	riparian reserve system is fragmented, poorly connected, or provides inadequate protection of habitats and refugia for sensitive aquatic species (<70% intact), and/or for grazing effects: percent similarity of riparian vegetation to the potential natural community/composition <25%[l/]
Estuarine Conditions:	Habitat Quantity/ Quality	the estuarine system provides for adequate, prey production, cover, and habitat complexity, for both smolts and returning adults	moderate loss of prey production, cover, and habitat complexity	gross loss of prey production, cover, and habitat complexity
	Aerial Extent	estuary provides for most (i.e., greater than 80% intact) of its historical areal extent and diversity of shallow water habitat types including vegetated wetlands and marshes, tidal channels, submerged aquatic vegetation, tidal flats, and large woody debris	50-80% of pre-modification area or volume and diversity of habitats	<50% of pre-modification area or volume; low diversity of habitats
	Hydrologic Conditions/ Sediment/ Nutrient Input	fresh water inflow and other hydrologic circulation patterns and sediment and nutrient inputs are similar to historic conditions	Moderate interrruption of estuarine circulation and nutrient and sediment delivery	Gross interrruption of estuarine circulation and nutrient and sediment delivery

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

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

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

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

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

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

1. **Federal actions involving ESA-listed species:** In the situation where federal agency actions are subject to Section 7 consultations under the ESA, such consultations will be combined with EFH consultations to accommodate the substantive requirements of both ESA and the Magnuson-Stevens Act as appropriate.

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

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

3. **Nonfederal actions involving ESA-listed species:** For nonfederal actors, EFH consultation is voluntary. In situations where nonfederal actions occur in areas under a NMFS-approved conservation plan, NMFS participation in, and approval of the plan would be combined with the EFH consultation and would constitute the NMFS requirements of the Magnuson-Stevens Act for providing conservation recommendations to state agencies. Included in this scenario would be coordination with Section 4(d) rulemaking, Section 4(f) recovery planning, and Section 10 permitting under the ESA.

4. **Nonfederal actions that do not involve ESA-listed species:** States and tribes are not required to consult with NMFS under the Magnuson-Stevens Act provisions for EFH unless there is a federal nexus. However, NMFS will provide conservation recommendations to state agencies on actions identified by PFMC as having a substantial adverse effect on salmon habitat or upon state agency request.

3.2.1.3 NMFS/PFMC Cooperation on EFH

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

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

3.2.2 Salmonid Habitat Requirements

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

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

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

- Tables A-3 through A-5 summarize, by species, the life history stage, diet, season/time, location in substrate and in water column, ocean features, and oxygen/temperature/salinity requirements for the stage.

- Table A-11 reviews salmon movements and habitat use (e.g., for adult migration pathways, spawning and incubation, stream rearing, smolt migration, estuarine and marine residence), the characteristic features required in each habitat (e.g., gravel and cobble with sufficient water and oxygen during spawning and rearing), and the commonest expression of habitat degradation found (e.g., elevated temperatures, reduced pool frequency, etc.).

- Table A-10, by describing indicators of the functioning of specified habitat elements or "pathways", as well as criteria for proper functioning/risk/malfunction of the listed habitat elements, sets the broad habitat conditions to be targeted by conservation and enhancement activities.

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

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

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

3.2.3 Adverse Effects on Essential Fish Habitat

The intent of EFH guidance is to enable regional development activities to avoid or minimize adverse effects by forward, informed planning. This is the essence of sustainable development. A measure of its success is the maintenance of properly functioning salmonid habitat conditions (Table A-10). A corollary is the restoration of diminished salmonid resources and their roles in regional economies, culture, and ecosystems through restoration of degraded or lost habitat. Maintenance and recovery of properly functioning conditions can be used to assess effects of proposed federal agency actions on EFH. Useful tools in the assessment of project effects are the NMFS' 1996 "Matrix of Pathways and Indicators" and associated decision tree for making effective determinations for individual or grouped actions at the watershed scale. The highest benefit to cost ratios of mitigations are achieved with timely informed plans which detail likely resources to be affected and actions which can avoid or minimize adverse effects to properly functioning habitat.

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

3.2.4 Conservation and Enhancement Measures

3.2.4.1 Background

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

3.2.4.2 Measures

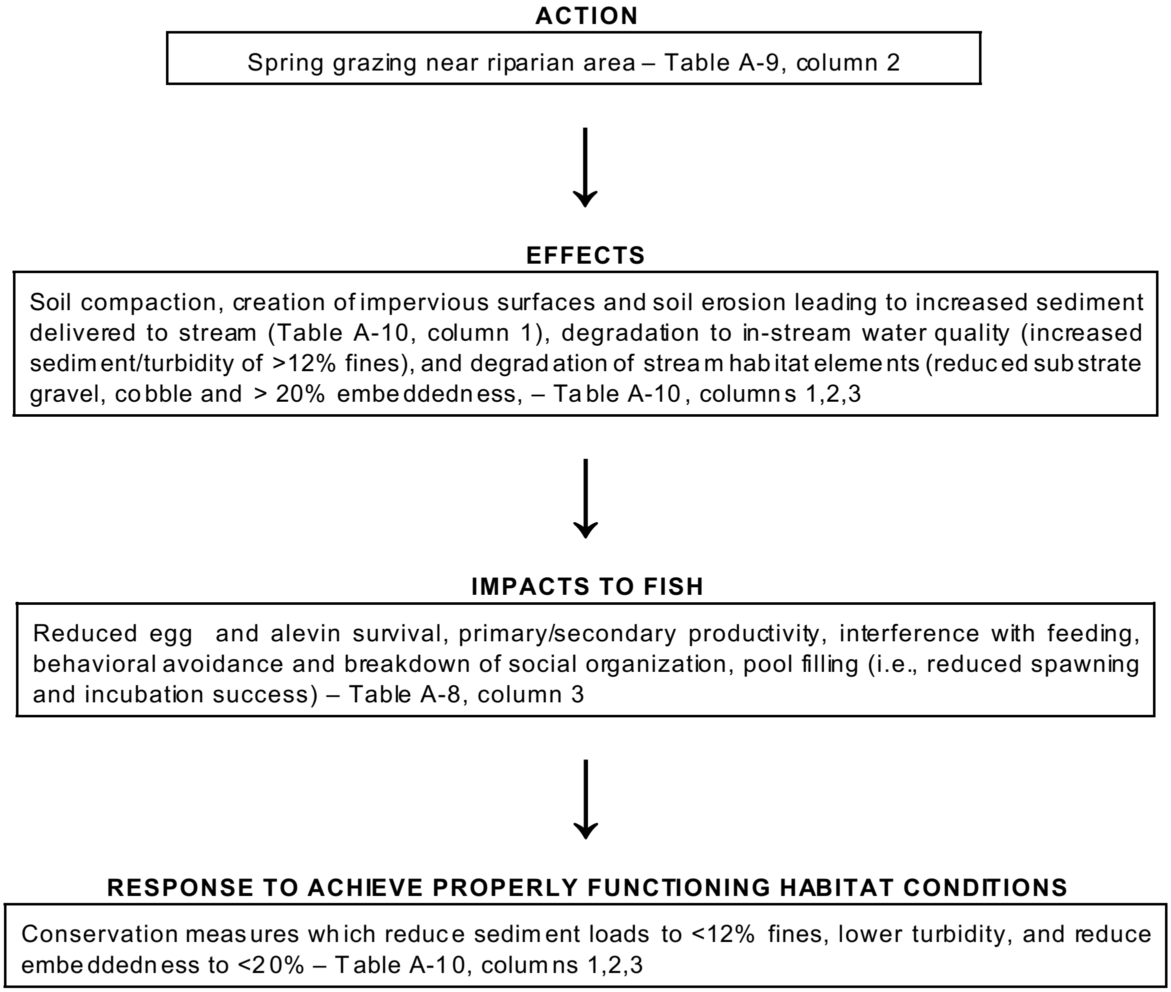
Established policies and procedures of PFMC and NMFS provide the framework for conserving and enhancing EFH. Components of this framework include adverse impact avoidance and minimization, compensatory mitigation, and enhancement. New and expanded responsibilities contained in the Magnuson-Stevens Act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

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

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

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

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



ACTION

Spring grazing near riparian area – Table A-9, column 2

EFFECTS

Soil compaction, creation of impervious surfaces and soil erosion leading to increased sediment delivered to stream (Table A-10, column 1), degradation to in-stream water quality (increased sediment/turbidity of >12% fines), and degradation of stream habitat elements (reduced substrate gravel, cobble and > 20% embeddedness, – Table A-10, columns 1,2,3

IMPACTS TO FISH

Reduced egg and alevin survival, primary/secondary productivity, interference with feeding, behavioral avoidance and breakdown of social organization, pool filling (i.e., reduced spawning and incubation success) – Table A-8, column 3

RESPONSE TO ACHIEVE PROPERLY FUNCTIONING HABITAT CONDITIONS

Conservation measures which reduce sediment loads to <12% fines, lower turbidity, and reduce embeddedness to <20% – Table A-10, columns 1,2,3

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

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

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

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

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

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

3.2.5.1 Agriculture

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

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

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

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

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

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

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

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

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

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

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

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

- Reduce erosion and run-off by using such practices as contour plowing and terracing, nontill agriculture, conservation tillage, crop sequencing, cover and green manure cropping and crop residue, and, by maximizing the use of filter strips, field borders, grassed waterways, terraces with safe outlet structures, contour strip cropping, diversion channels, sediment retention basins, and other mechanisms including re-establish vegetation

- Participate in, and benefit from existing programs to encourage wetland conservation and conservation reserves, avoid planting in areas of steep slopes and erodible soils, and avoid disturbance or draining of wetlands and marshes.

- Incorporate water quality monitoring as an element of land owner assistance programs for water quality. Evaluate monitoring results and adjust practices accordingly.

- Minimize the use of chemical treatments within the riparian management zone. Review pesticide use strategies to minimize impact to EFH. Reduce pesticide application by evaluating pest problems, past pest control measures, and following integrated pest management strategies. Select pesticides considering their persistence, toxicity, runoff potential, and leaching potential.

- Optimize the siting of new confined animal facilities or the expansion of existing facilities to avoid areas adjacent to surface waters containing EFH or in areas with high leaching potential to surface or groundwater. Use appropriate methods to minimize discharges from confined animal facilities (for both wastewater and process water).

- Where water quality is limited from nutrients or where leaching potential is high, avoid land application of manure or other fertilizer unless appropriate management measures are in place to assure that sediment and nutrient input to surface water is controlled. Observe best management practices to assure that application and timing measures fostering high nutrient utilization are employed.

- Apply conservation measures for water intake (see irrigation water withdrawal, storage and management section below) to agricultural activities where applicable.

3.2.5.2 Artificial Propagation of Fish and Shellfish

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

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

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

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

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

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

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

3.2.5.3 Bank Stabilization

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

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

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

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

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

- Use vegetative methods of bank erosion control whenever feasible. Where vegetative mechanisms are not sufficient alone, explore these methods in conjunction with ground contouring. Hard bank protection should be a last resort and the following options should be explored, in order of priority: tree revetments, stream barbs/flow deflectors, toe-rock, and vegetation riprap.

- Determine the cumulative effects of existing and proposed bio-engineered or bank hardening projects on salmon EFH, including salmon prey species before planning new bank stabilization projects.

- Contour slopes according to the preferred ratio of 3-5:1 and avoid slopes of less than 2:1.

- Develop plans that minimize alteration or disturbance of the bank and existing riparian vegetation. Use temporary fencing to minimize disturbance from intrusion.

- Revegetate sites to resemble the appropriate natural community associations, utilizing vegetation management to limit livestock grazing and maintain an appropriate buffer zone.

- Minimize the use of creosote or treated wood in lakes and in estuarine or other areas with low circulation or flow. Where treated wood is used, it should be certified as produced in accordance with the most current version of “Best Management Practices for Treated Wood in Western Aquatic Environments” (WWPI 1996). Treated materials containing copper compounds should not be installed when migrating salmon are present.

3.2.5.4 Beaver Removal and Habitat Alteration

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

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

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

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

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

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

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

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

3.2.5.5 Construction/Urbanization

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

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

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

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

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

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

Following are the types of measures that can be undertaken by the action agency on a site-specific basis to conserve salmon EFH in areas that have the potential to be affected by construction and urbanization activities. Not all of these suggested measures are necessarily applicable to any one project or activity that may adversely affect salmon EFH. More specific or different measures based on the best and most current scientific information may be developed prior to, or during, the EFH consultation process, and communicated to the appropriate agency. The EPA (1993) publication "Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters" extensively describes best management practices for control of runoff from developing areas, construction sites, roads, highways and bridges affecting salmon EFH. In addition to the previous guidelines, the options following represent a short menu of general types of conservation actions that can contribute to the restoration and maintenance of properly functioning salmon habitat. The following suggested measures are adapted from Metro (1997), ODFW (1989), and EPA (1993).

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

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

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

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

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

3.2.5.6 Dam Construction/Operation

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

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

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

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

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

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

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

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

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

- Operate facilities to create flow conditions adequate to provide for passage, water quality, proper timing of life history stages, avoid juvenile stranding and redd dewatering, and maintain and restore properly functioning channel, floodplain, riparian, and estuarine conditions. Specific flow objectives have been developed for the Columbia and Snake river and Sacramento bay/delta river systems and other systems with federally operated facilities where there are species listed under the ESA, through FERC orders, through specific legislative acts (e.g., the Central Valley Water Improvement Act, the Bay-Delta Accord), water quality orders, and through legal settlement agreements. Federal projects are operated within the context of the projects' authorized purposes, applicable state water laws, and contractual commitments.

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

3.2.5.7 Dredging and Dredged Spoil Disposal

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

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

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

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

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

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

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

- Explore collaborative approaches between material management planners, pollution control agencies, and others involved in watershed planning to identify point and nonpoint sources of sediment and sediment pollution; to promote the establishment of riparian area buffers to help reduce sediment input, and to promote use of best management measures to control sediment input.

- Avoid dredging in or near spawning redds, eelgrass beds, and other EFH areas of particular concern; especially where the areal extent of the dredging could affect the prey base for outmigrating juvenile salmon.

- Monitor dredging activities especially contaminate sediments and regularly report effects on EFH. Re-evaluate activities based on the results of monitoring.

- Employ best engineering and management practices for all dredging projects to minimize water-column discharges. Avoid dredging during juvenile outmigration through estuaries. Where avoidance is not fully possible, area and timing guidelines should be established in consultation with local, state, tribal, and federal fish biologists.

- When reviewing open-water disposal permits for dredged material, identify direct and indirect effects of such projects on EFH. Consider upland disposal options as an alternative. Mitigate all nonavoidable adverse effects and monitor mitigation effectiveness.

- Determine cumulative effects of existing and proposed dredging operations on EFH.

- Explore the use of clean dredged material for beneficial use opportunities.

3.2.5.8 Estuarine Alteration

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

- Unique hydrological features by which fresh water slows and flows over a wedge of heavier intruding tidal salt water resulting in suspended terrestrial and autochthonous products settling into the inflowing salt water or into bottom sediments.

- Shallow nutrient-rich environments resulting in an enormously productive vegetative habitat and detrital food chain for many organisms, such as crustaceans and juvenile fish.

- Critical nursery habitats for many aquatic organisms, particularly anadromous fish and ecotones for shorebirds and waterfowl.

- Contributing to the “trapping” and recycling of nutrients: an area where an accumulation of nutrients such as potassium and nitrogen are concentrated and recycled – a repeating interactive process by which the incoming tidal water re-suspends nutrients at the fresh-salt water interface while moving them back up the estuary, and the land-based sources of nutrients move towards the sea.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

- Minimize alteration of estuarine habitat in areas of salmon EFH, including eelgrass beds, tidal channels, and estuarine and tidally-influenced marshes. Minimize effects through appropriate site design, engineering, best management practices, and mitigate all nonavoidable adverse effects (See EPA 1993, Metro 1997, SCS Enginners 1989).

- Utilize best management practices for controlling pollution from marina operations, boatyards, and fueling facilities.

- Determine cumulative effects of a past and current estuarine alterations on salmon EFH before additional estuarine alteration occurs.

- Design appropriate restoration and mitigation performance objectives for properly functioning conditions and values of EFH and monitor achievement of these objectives.

- Utilize the placement of woody debris as a part of marsh and estuary enhancement and mitigation work; avoid scavenging logs from estuarine areas; re-position, rather than remove, logs that are hazardous to navigation within river or estuary; and maximize removal of dikes where possible.

- Promote awareness and use of the U.S. Department of Agriculture's (USDA's) Wetland Reserve Program to encourage restoration of estuarine habitat.

- Maximize maintenance of freshwater inflow to estuaries.

- Design culvert replacements and repairs in EFH to increase fish passage for both adult and juvenile fish.

3.2.5.9 Forestry

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

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

The removal of riparian canopy reduces shading and increases the amount of solar radiation reaching the streams. The result is higher maximum stream temperatures and increased daily stream temperature fluctuations (Beschta *et al.* 1987; Beschta *et al.* 1995). Even small increases in temperature (1-2° C) can result in shifts in the timing of life history events such as spawning and incubation. The cumulative effects of stream temperature changes downstream of logged areas are not well documented.

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

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

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

- Establish riparian management zones and avoid forestry activities in zones of old growth and late successional forests. Use limited harvest, thinning, planting, or other management in second-growth forests in order to facilitate recovery and protection of the key functions identified through watershed analyses.

- Utilize appropriate buffer strips (e.g., riparian trees and shrubs, grass filter strips, etc.) as a management option to protect and enhance salmon freshwater EFH.

- As part of forestry planning, analyze the cumulative effects of past and current forestry management activities on EFH as indicated in watershed analyses.

- Determine harvest suitability methods based on risk assessment for site-specific conditions (e.g., unstable slopes, erodible soils). Avoid harvest and road building activities on sites that have a high potential for landslides and on sites that can contribute large woody debris to streams directly or through landslides and debris flows. Plan timber harvest, road construction, and site preparation activities for the dry season or on snow to minimize erosion. Design ground-based logging operations to minimize total area subject to compaction by skid trails.

- Apply chemicals by following forestry best management practices (EPA 1993) for ensuring federal and state water quality, including practices designed to avoid drift of chemical sprays, pollution from the cleaning of equipment used in spraying or fueling activities, and erosion.

- Avoid reliance on in-channel manipulation until problems in riparian and upland habitats that caused the habitat to be degraded have been addressed by to controlling erosion, stabilizing or obliterating roads, upgrading culverts for fish passage, and restoring native vegetative communities. Use silvicultural treatments which minimize stream disturbance.

3.2.5.10 Grazing

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

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

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

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

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

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

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

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

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

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

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

- Minimize livestock access to stream reaches containing salmon redds during spawning and incubation periods (McCullough and Espinosa 1996) by utilizing grazing and vegetation management schemes that promote grazing in other areas and by locating water facilities away from the stream channel and riparian zone wherever feasible.

- Utilize special monitoring, management, and grazing regimes or mitigation activities that allow recovery of degraded areas and maintain streams, wetlands, and riparian areas in properly functioning condition.

- Utilize upland grazing management that minimizes surface erosion and disruption of hydrologic processes. Where range is not in properly functioning condition, forage species composition is altered, productivity reduced, and trends are down, select demonstrably restorative grazing regimes or minimize grazing activity until vegetation has recovered. Once conditions have improved, adjust the grazing strategies to account for all herbivory (e.g., including wildlife) at proper use levels to minimize deterioration of range conditions in the future (Spence *et al*. 1996).

- Determine cumulative effects of past and current grazing operations on EFH when designing grazing management strategies.

- Minimize application of chemical treatments within the riparian management zone.

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

3.2.5.11 Habitat Restoration Projects

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

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

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

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

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

- Protect a watershed’s habitat-forming processes (e.g., riparian community succession, bedload transport, runoff pattern) that maintain the biophysical structure and function of aquatic ecosystems.

- Develop and conduct habitat restoration activities based on a watershed-scale analysis and conservation plan, and where practicable, a sub-basin or basin-scale analysis and plan with restoration of habitat-forming processes as the primary goal.

- Monitor and evaluate all habitat restoration activities for sustained biophysical process and function.

3.2.5.12 Irrigation Water Withdrawal, Storage, and Management

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

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

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

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

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

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

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

The physical means of withdrawing water may adversely affect salmon. For major irrigation withdrawals, water is either stored in impoundments or diverted directly from the river channel at pumping facilities. Individual irrigators commonly construct smaller “push-up” dams from soil and rock within the stream channel, to divert water into irrigation ditches or to create small storage ponds from which water is pumped. In addition, pumps may be submerged directly into rivers and streams to withdraw water. Effects of these irrigation withdrawals and impoundments on aquatic systems include creating impediments or blockages to migration (for both adults and juveniles), diverting juveniles into irrigation ditches or damage to juveniles as a result of impingement on poorly designed fish exclusion screens (Spence *et al.* 1996).

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

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

California	The state's most potent instream flow protection is a result of administrative activities of the State Water Resources Control Board, which is required to consider the comments of CDFG when making decisions about appropriation and transfer permits. Since 1991, individuals have been authorized to change the purpose of existing rights to instream purposes. Private individuals and organizations have also taken advantage of the opportunity to initiate public trust proceedings.
Idaho	Only the Idaho Water Resources Board is allowed to apply to the Department of Water Resources for an instream water right. State statutes allow "the public" to petition the Board to apply for instream flow rights, but the Board has interpreted this language to mean that it may accept petitions only from state agencies. Applications approved by the Department of Water Resources must be submitted to the Idaho State Legislature for approval.
Oregon	Only the Oregon Water Resources Department may hold instream water rights. The Water Resource Department considers requests from ODFW, Environmental Quality, and Parks and Recreation agencies. Individuals may acquire existing rights and take responsibility for changing the use to instream purposes in an administrative hearing, but then must turn the right over to the Water Resources Department to be held in trust.
Washington	WDOE establishes minimum flows either at its own initiative or after request from the Department of Fisheries and Wildlife. Because minimum flows are established through administrative rule-making procedures, public notice and hearings are involved. Individuals may donate rights to the state and specify that they are to be used for instream purposes under the state's trust water rights program, which is administered by WDOE.

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

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

- Apply conservation and enhancement measures for dams (see dam section) to water management activities and facilities, where applicable.

- Establish adequate instream flow conditions for salmon by using, for example, the Instream Flow Incremental Methodology.

- Undertake efforts to purchase or lease, from willing sellers and lessors, water rights necessary to maintain instream flows in accordance with appropriate state and federal laws.

- Identify and use appropriate water conservation measures in accordance with state law.

- In accordance with state law, install totalizing flow meters at major diversion points. For water withdrawn from reservoirs, install gauges that identify the water surface elevation range from full reservoir elevation to dead pool storage elevation. Additionally, if the reservoir is located in-channel, install gauges upstream and downstream of the reservoir.

- Screen water diversions on all fish-bearing streams.

- Incorporate juvenile and adult salmon passage facilities on all water diversions.

3.2.5.13 Mineral Mining

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

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

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

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

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

Commercial operations may also involve road building, tailings disposal, and the leaching of extraction chemicals, all of which may create serious impacts to salmon EFH. Cyanide, sulfuric acid, arsenic, mercury, heavy metals, and reagents associated with such development are a threat to salmonid habitat. Improper or in-water disposal of tailings may cause toxicity to salmon or their prey downstream. On land placement of tailings in unstable or landslide prone areas can cause large quantities of toxic compounds to be released into streams or to contaminate groundwater (NPFMC 1997). Indirectly, the sodium cyanide solution used in heap leach mining is contained in settling ponds from where they might contaminate groundwater and surface waters (Nelson *et al.* 1991).

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

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

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

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

- Avoid mineral mining in waters, riparian areas, or flood plains of streams containing or influencing the salmon spawning and rearing habitats.

- Assess the cumulative effects of past and proposed mineral extraction activities and take these into account in planning for mining operations.

- Utilize an integrated environmental assessment, management, and monitoring package in accordance with state and federal law.

- Minimize spillage of dirt, fuel, oil, toxic materials, and other contaminants into the water and riparian areas. Monitor turbidity during operations. Prepare a spill prevention plan and maintain spill containment and water repellent/oil absorbent clean-up materials on hand.

- Treat wastewater (acid neutralization, sulfide precipitation, reverse osmosis, electrochemical, or biological treatments) and recycle on site to minimize discharge to streams. Test wastewater before discharge for compliance with the federal and state clean water standards.

- Minimize mine-generated sediments from entering or affecting EFH. Minimize the aerial extent of ground disturbance (e.g., through phasing of operations), and stabilize disturbed lands to reduce erosion. Employ methods such as contouring, mulching, and construction of settling ponds to control sediment transport.

- Reclaim, rather than bury, mine waste that contains heavy metals, acid materials, or other toxic compounds if leachate can enter EFH through groundwater.

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

3.2.5.14 Introduction/Spread of Nonnative Species

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

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

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

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

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

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

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

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

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

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

- Provide public awareness materials on the potential impacts resulting from the release of nonnative organisms into the natural environment.

- For the commercial import of plants and animals for aquarium and ornamental plant trades, import those organisms that have been evaluated and determined to be safe for importing.

- Avoid ballast water exchange in nearshore coastal waters. Use shore-based ballast water treatment systems and ship-board ballast treatment systems as alternatives.

- Use native organisms for aquaculture and mariculture operations whenever possible.

- Develop appropriate eradication methods for nonnative plant species and nonnative predatory species.

3.2.5.15 Offshore Oil and Gas Exploration, Drilling, and Transportation

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

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

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

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

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

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

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

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

- Monitor and enforce double hull standards for all oil tankers doing business in U.S. waters, as well as other pollution prevention measures of the Oil Pollution Act of 1990.

- Utilize adequate spill prevention measures such as tug escorts, speed limits, the use of marine pilots, vessel traffic systems, designated areas to be avoided, traffic separation schemes, rescue/salvage tugs, and compliance with international, national, and state spill prevention standards.

- Utilize the agreement between the ten major oil company members of the Western States Petroleum Association as a catalyst to involve other oil carriers and maximize routing of tankers carrying Alaskan North Slope crude to California ports at least 50 miles seaward of the Pacific coast while transiting the coastline after leaving Prince William Sound.

- Route dry cargo vessels and other vessels carrying significant quantities of oil or hazardous cargo at least 50 miles seaward of the Pacific coast while transiting the coast.

- Avoid national marine sanctuaries and areas designated as areas to be avoided and support efforts to re-evaluate and strengthen precautionary and readiness measures in national marine sanctuaries.

- Apply vessel maintenance, inspection programs, and crew training programs, required for oil tank vessels to dry cargo and other vessels carrying significant quantities of oil.

- Monitor and report water and sediment quality around all oil extraction, bunkering, or transfer facilities, and gather other baseline information to assure better natural resource damage assessments after spill events.

3.2.5.16 Road Building and Maintenance

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

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

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

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

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

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

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

- Revegetate cut banks, road fills, bare shoulders, disturbed streambanks, etc. after construction to prevent erosion. Check and maintain sediment control and retention structures throughout the rainy season.

- Minimize riparian corridor damage during construction of roads (and bridges, culverts, and other crossings) and avoid locating roads in floodplains.

- Rehabilitate roads by upgrading problem culverts or replacing with bridges, outsloping road surfaces to drain properly without maintenance, revegetating bare surfaces, and other measures as necessary for stability.

- Utilize state or federal culvert design guidelines (e.g., NMFS 1996b) for design and installations of culverts.

3.2.5.17 Sand and Gravel Mining

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

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

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

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

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

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

3.2.5.18 Vessel Operations

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

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

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

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

3.2.5.19 Wastewater/Pollutant Discharge

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

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

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

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

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

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

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

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

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

- Monitor water quality discharges following National Pollutant Discharge Elimination System requirements from all discharge points (including municipal storm water systems, and desalinization plants).

- Apply the management measures developed for controlling pollution from run-off in coastal areas to all watersheds affecting salmon EFH.

- For those water bodies that are defined as water quality limited in salmon EFH (303(d) list), establish total maximum daily loads and develop appropriate management plans to attain management goals.

- Where in-stream flows are insufficient for water quality maintenance, establish conservation guidelines for water use permits, encourage the purchase or lease of water rights and the use of water to conserve or augment instream flows in accordance with state and federal water law.

- Establish and update, as necessary, pollution prevention plans, spill control practices, and spill control equipment for the handling or transporting toxic substances in salmon EFH. Consider bonds or other damage compensation mechanisms to cover clean-up, restoration, and mitigation costs.

3.2.5.20 Wetland and Floodplain Alteration

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

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

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

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

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

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

3.2.5.21 Woody Debris/Structure Removal From Rivers and Estuaries

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

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

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

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

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

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

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

- Avoid removing woody debris and large rocks and boulders in salmon EFH.

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

4.0 ADDITIONAL INFORMATION AND RESEARCH NEEDS

While far more research has been conducted on Pacific salmon life history and habitat requirements than most other marine fishes, significant research gaps exist on distribution and marine life history and habitat requirements. The lack of specific and comprehensive information on distribution prevented detailed delineation and fine-scale mappings of EFH. The process of identifying Pacific salmon EFH emphasized the need for accurate, fine-scale GIS data on freshwater and marine distribution, habitat conditions, and the need for compilation of uniform and compatible datasets. Future efforts should focus on developing accurate, seasonal salmon distribution data at a 1:24,000 or finer scale (particularly in freshwater) to aid in more accurate and precise delineation of EFH and in the EFH consultation process. It should be noted, however, that more detailed and precise freshwater distribution data will not eliminate the need for a watershed-based approach for recovery and protection of Pacific salmon EFH.

Defining salmon EFH using USGS fourth-field hydrologic units resulted in entire watersheds being defined as EFH even when large portions of the watershed were not historically used by Pacific salmon. For example, a large impassible waterfall historically and currently precludes salmon from approximately 50% of Snoqualmie hydrologic unit (USGS No. 17110010). The waters above this natural barrier are not considered EFH, though activities that may impact the quality and quantity of downstream EFH could be subject to the provisions of EFH. Classification by subwatersheds, defined by the USGS as fifth-field hydrologic units would allow more restrictive and precise delineation of EFH. These subwatershed boundaries and codes are in development for some areas, but were not available for initial EFH delineation. Detailed, fine-scale information on seasonal salmon distribution would allow accurate delineation of freshwater EFH using fifth- or even sixth-field hydrologic units. Furthermore, it would help provide the basis for more accurate descriptions of EFH and habitats areas of particular concern. Additional physical variables such as water quality, riparian vegetation, land-use, and other physical features could be incorporated into this watershed framework to determine the most productive watersheds, those in need of restoration, and to develop priorities for restoration. Ultimately, a detailed analysis of salmon production and watershed condition throughout the Pacific Northwest is needed to determine the characteristics of productive watersheds and stream reaches for Pacific salmon.

Few studies exist on Pacific salmon oceanic and coastal distributions and EFH descriptions for Pacific salmon relied heavily upon a few key studies on juvenile salmon (e.g. Pearcy 1992, Hartt and Dell 1986, etc.) and anecdotal information from commercial fishermen. Fine (large) scale seasonal information on salmon marine distribution is needed to more accurately depict the distribution of juvenile, maturing, and adult Pacific salmon, which is thought to be dynamic, changing with ocean conditions. Moreover, early ocean residence is believed to be a critical period for salmon survival (Pearcy 1992) and little information exists on habitat utilization, feeding, and survival during this period. Similarly, there is a paucity of data on estuarine habitat utilization and survival and marine and oceanic distribution during winter months.

In contrast to the marine environment, considerable information exists on the freshwater life history requirements of Pacific salmon. However, little habitat- and season-specific survival information exists for most life stages. Furthermore, models are needed to predict juvenile and adult production in relation to habitat quality, ocean conditions, and the effects of anthropogenic activities such as forest practices, agriculture, grazing, and urbanization. Finally, the development of models and research on habitat impacts and salmon production will prove critical for effective consultation and for refining Pacific salmon EFH descriptions.

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