Appendix A Essential Fish Habitat (EFH) and Habitat Areas of Particular Concern (HAPC)

Contents

A.1 Overview

Section 303(a)(7) of the Magnuson-Stevens Act that FMPs describe and identify Essential Fish Habitat (EFH), minimize to the extent practicable the adverse effects of fishing on EFH, and identify other actions to conserve and enhance EFH. FMPs must describe EFH in text, map EFH distributions, and provide information on habitat and biological requirements for each life history stage of the species. This appendix contains all of the required EFH provisions of the FMP, including the requirement in EFH regulations (50 Code of Federal Regulations [CFR] 600.815(a)(2)(i)) that each FMP must contain an evaluation of the potential adverse effects of all regulated fishing activities on EFH.

In 2005 NMFS and the Council completed the Environmental Impact Statement for Essential Fish Habitat Identification and Conservation in Alaska (EFH EIS, NMFS 2005). The EFH EIS provided a thorough analysis of alternatives and environmental consequences for amending the Council's FMPs to include EFH information pursuant to Section 303(a)(7) of the Magnuson-Stevens Act and 50 CFR 600.815(a). Specifically, the EFH EIS examined three actions: (1) describing and identifying EFH for Council managed fisheries, (2) adopting an approach to identify HAPCs within EFH, and (3) minimizing to the extent practicable the adverse effects of fishing on EFH. The Council's preferred alternatives from the EFH EIS were implemented through Amendment 7 to the Salmon FMP and corresponding amendments to the Council's other FMPs.

The Council undertook the first five-year review of EFH in 2010 for the Council's managed species, which was documented in the Final EFH 5-year Review Summary Report (NPFMC and NMFS 2010). The review evaluated new information on EFH, including EFH descriptions and identification, and fishing and non-fishing activities that may adversely affect EFH. The review also assessed information gaps and research needs, and identified whether any revisions to EFH are needed or suggested. The Council identified various elements of the EFH descriptions meriting revision, and approved omnibus amendments 98/90/40/15/11 to the BSAI Groundfish FMP, the GOA Groundfish FMP, the BSAI King and Tanner Crab FMP, the Scallop FMP, and the Salmon FMP, respectively, in 2011. Amendment 11 to the Salmon FMP updated the description of EFH impacts from non-fishing activities, and EFH conservation recommendations for non-fishing activities; revised the timeline associated with the HAPC process to a 5-year timeline coinciding with the EFH 5-year review; and updated EFH research objectives in the FMP. While EFH identification and description for salmon species was considered as part of the 2010 EFH 5-year review, the implementation of changes was delayed because the methodology that has been proposed to revise EFH descriptions for salmon species was under peer review, and the Council determined to wait until the review process was complete before amendment this portion of the FMP.

From 2015 through 2017, the Council conducted most recent 5-year EFH review which is documented in the Final EFH 5-year Review Summary Report (Summary Report, Simpson et al. 2017). The report reviewed EFH descriptions in all six of the Council's FMPs. The salmon EFH review resulted in Amendment 13 to the Salmon FMP. Amendment 13 revised Appendix A to update the description of EFH for all five species of Pacific salmon, replaced the maps of marine EFH for all five species of Pacific salmon, and updates the analysis of fishing and non-fishing impacts to salmon habitat in areas that are considered salmon EFH.

A.2 Life History Features and Habitat Requirements of FMP Species

This section describes habitat requirements and life histories of the salmon species managed by this FMP. Information contained in this appendix details life history information for federally managed salmon species. Each species or species group is described individually; however, summary tables that denote habitat associations (Table 1), reproductive traits (Table 2), and predator and prey associations (Table 3) are also provided. In each section, a species-specific table summarizes habitat requirements.

Table 1 Summary of Habitat Associations for Salmon

Salmon Species	Life Stage	Nearshore				Shelf: Inner	Shelf: Middle	Shelf: Outer	Slope: Upper		Slope: Intermediate		Slope: Lower	Slope: Basin	Stratum Reference						
		Freshwater	Estuarine	Intertidal	Subtidal	1-50m	51-100m	101-200m	201-300m	301-500m	501-700m	701-1000m	1001-3000m	>3000m	Shallows	Island Pass	Bay/Fjord	Bank	Flat	Edge	Gully
Chinook	M	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x			
	LJ														x	x	x	x			
	EJ	x	x	x											x	x	x				
	L	x																			
	E	x																			
Chum	M	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x			
	LJ				x	x	x	x	x	x						x	x	x			
	EJ	x	x	x	x	x	x								x	x	x	x			
	L	x		x																	
	E	x		x																	
Coho	M	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x				
	LJ		x	x		x	x									x	x				
	EJ	x	x	x		x									x						
	E/L	x																			
Pink	M	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x				
	LJ		x		x		x	x	x						x	x	x				
	EJ		x	x	x	x	x	x	x						x	x	x				
	L	x																			
	E	x																			
Sockeye	M	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x				
	LJ		x	x	x	x	x	x	x							x	x				
	EJ	x				x															
	L	x																			
	E	x				x															

Salmon Species	Life Stage	Location				Location: Pelagic			Physical Oceanography					Substrate												
		Surface	Near surface	Semi-demersal	Demersal	1-200m (epi)	201-1000m (meso)	>1000m (bathy)	Upwelling areas	Gyres	Thermo/pycnocline	Fronts	Edges (ice, bath)	Organic Debris	Mud	Sand	Gravel	Mud & sand	Mud & gravel	Sand & mud	Gravel & mud	Gravel & sand	Gravel & sand & mud	Gravel & mud & sand	Cobble	Rock
Chinook	M	x	x	x	x	x			x	x	x	x	x													
	LJ	x	x	x	x	x			x	x	x	x	x													
	EJ	x	x	x	x									x		x						x			x	x
	L				x												x								x	
	E				x												x								x	
Chum	M	x	x	x	x	x	x		x	x	x	x	x	x			x					x			x	
	LJ	x	x	x	x	x	x		x	x	x	x	x													
	EJ	x	x	x		x			x	x		x		x	x	x	x					x		x	x	x
	L													x		x	x					x			x	x
	E													x		x	x					x			x	
Coho	M	x	x			x						x	x	x			x					x			x	
	LJ	x	x			x																				
	EJ	x		x											x	x	x					x			x	
	E/L													x			x									
Pink	M	x	x			x			x	x	x	x		x			x					x			x	
	LJ	x	x						x	x	x	x														
	EJ	x													x	x	x					x		x	x	
	L													x			x									
	E													x			x					x			x	
Sockeye	M	x	x			x											x					x			x	
	LJ	x	x			x																				
	EJ				x																					
	L																x					x			x	
	E																x					x			x	

Salmon Species	Life Stage	Structure										Community Associations												Oceanographic Properties			Life Stage
		Bars	Sinks	Slumps/Rockfalls/Debri	Channels	Ledges	Pinnacles	Seamounts	Reefs	Vertical Walls	Man-made	Algal Cover	Anemones	Enchinoderms	Soft Coral	Hard Coral	Mollusca	Drift Algae/Kelp	Kelp	Polychaetes	Sea Grasses	Sea Onions	Tunicates	Temperature (Celsius)	Salinity (ppt)	Oxygen Conc (ppm)	
Chinook	M	x		x	x	x	x		x	x	x								x					<15			M
	LJ	x		x	x	x	x		x	x	x							x	x					<15			LJ
	EJ																	x	x		x			<20			EJ
	L																							0-14			L
	E																							0-14	0		E
Chum	M	x		x	x	x	x		x	x	x							x	x		x			<15		8	M
	LJ	x			x	x	x	x	x	x	x							x	x					<15		8	LJ
	EJ	x		x	x	x	x		x	x	x	x						x	x		x			<15		8	EJ
	L																							>4		>4	L
	E																							>4		>4	E
Coho	M	x		x	x	x	x		x	x	x								x					<15		8	M
	LJ																	x	x		x			<15		8	LJ
	EJ	x		x	x	x	x		x	x	x							x	x		x			<15		>4	EJ
	E/L																							>4		>4	E/L
Pink	M	x		x	x	x	x		x	x	x								x					<15		8	M
	LJ							x																<15		8	LJ
	EJ	x		x	x	x	x		x	x	x	x						x	x		x			<15		8	EJ
	L																							>4		>4	L
	E																							>4		>4	E
Sockeye	M																							<15			M
	LJ							x																<15			LJ
	EJ																							<15			EJ
	L																										L
	E																										E

Table 2 Summary of Reproductive Traits for Salmon

Salmon Species	Life Stage	Age at Maturity				Fertilization/Egg Development					Spawning Behavior						Spawning Season											
		Female		Male																								
		50%	100%	50%	100%	External	Internal	Oviparous	Ovoviviparous	Viviparous	Batch Spawner	Broadcast Spawner	Egg Case Deposition	Nest Builder	Egg/Young Guarder	Egg/Young Bearer	January	February	March	April	May	June	July	August	September	October	November	December
Chinook	M	4	7	4	7	x		x						x			x						x	x	x	x	x	x
	LJ																											
	EJ																											
	L																											
	E																											
Chum	M	4	7	4	7	x		x						x			x	x					x	x	x	x	x	x
	LJ																											
	EJ																											
	L																											
	E																											
Coho	M		4		4	x		x						x									x	x	x	x	x	x
	LJ																											
	EJ																											
	L																											
	E																											
Pink	M		2		2	x		x						x									x	x	x	x		
	LJ																											
	EJ																											
	L																											
	E																											
Sockeye	M	5	6	5	6	x		x						x									x	x	x	x	x	x
	LJ																											
	EJ																											
	L																											
	E																											

Table 3 Summary of Predator and Prey Associations for Salmon

Predator to

Salmon Species	Life Stage	Algae	Plants	Plankton	Zooplankton	Diatoms	Sponges	Eusphausiid	Hydroids	Amphipoda	Copepods	Starfish	Polychaetes	Squid	Philodae (gunnels)	Bi-valves	Mollusks	Crustaceans	Ophiuroids (brittle stars)	Shrimps, mysidacae	Sand lance	Osmerid (eulachon)	Herring	Myctophid (lantern fishes)	Cottidae (sculpins)	Arrowtooth	Salmon	Cod	Pollock	Halibut
Chinook	M							X						X						X	X	X	X	X			X	X	X	
	LJ							X						X						X	X	X	X	X			X	X	X	
	EJ				X			X		X	X		X	X				X		X										
	L																													
	E																													
Chum	M			X	X			X		X	X			X						X	X	X	X	X	X			X	X	
	LJ			X	X			X		X	X			X				X		X	X	X	X	X	X			X	X	
	EJ			X	X			X		X	X		X					X		X	X	X	X		X			X	X	
	L			X	X																									
	E																													
Coho	M							X						X						X	X	X	X							
	LJ				X			X													X						X			
	EJ				X			X		X	X									X					X		X			
	L																													
	E																													
Pink	M				X			X		X	X									X	X	X	X	X						
	LJ				X			X		X	X									X	X	X	X							
	EJ				X			X		X	X									X	X	X	X							
	L				X																									
	E																													
Sockeye	M			X	X			X		X	X		X	X						X	X	X	X	X	X			X	X	
	LJ			X	X			X		X	X																			
	EJ			X	X																									
	L																													
	E																													

Prey of

Salmon Species	Life Stage	Jellyfish	Starfish	Chaetognaths (arrowworms)	Crab	Herring	Salmon	Pollock	Pac fic Cod	Rockfish	Rock Sole	Flathead Sole	Yellowfin sole	Arrowtooth flounder	Halibut	Salmon Shark	Northern Fur Seal	Harbor Seal	Steller sea lion	Dalls Porpoise	Beluga whale	Killer Whale	Minke whale	Eagles	Murres	Puffin	Kittiwake	Gull	Terrestrial Mammals
Chinook	M															X		X	X			X		X					X
	LJ															X			X			X							
	EJ						X	X	X																X		X	X	X
	L																												
	E																												
Chum	M															X	X	X	X			X		X				X	X
	LJ															X	X	X	X			X							
	EJ						X	X	X																X		X	X	X
	L																											X	
	E																											X	
Coho	M															X		X	X		X	X		X					X
	LJ																												
	EJ				X		X																		X	X	X	X	X
	L																												
	E																												
Pink	M															X	X	X	X	X			X	X				X	X
	LJ															X	X	X	X	X			X						
	EJ						X	X	X	X																			
	L																												
	E																												
Sockeye	M															X	X	X	X			X		X					X
	LJ						X	X	X																				
	EJ																												
	L																												
	E																												

A.2.1 Habitat Types in the Bering Sea, Aleutian Islands, and Gulf of Alaska

Bering Sea

The Bering Sea is a semi-enclosed, high-latitude sea. Of its total area of 2.3 million sq. km, 44 percent is continental shelf, 13 percent is continental slope, and 43 percent is deep-water basin. Its broad continental shelf is one of the most biologically productive areas of the world. The eastern Bering Sea (EBS) contains approximately 300 species of fish, 150 species of crustaceans and mollusks, 50 species of seabirds, and 26 species of marine mammals (Livingston and Tjelmeland 2000). However, commercial fish species diversity is lower in the EBS than in the GOA.

A special feature of the EBS is the pack ice that covers most of its eastern and northern continental shelf during winter and spring. The dominant circulation of the water begins with the passage of North Pacific water (the Alaska Stream) into the EBS through the major passes in the AI (Favorite et al. 1976). There is net water transport eastward along the north side of the Aleutian Islands (AI) and a turn northward at the continental shelf break and at the eastern perimeter of Bristol Bay. Eventually EBS water exits northward through the Bering Strait, or westward and south along the Russian coast, entering the western North Pacific via the Kamchatka Strait. Some resident water joins new North Pacific water entering Near Strait, which sustains a permanent cyclonic gyre around the deep basin in the central Bering Sea (BS).

The EBS sediments are a mixture of the major grades representing the full range of potential grain sizes of mud (subgrades clay and silt), sand, and gravel (Figure 1). The relative composition of such constituents determines the type of sediment at any one location (Smith and McConnaughey 1999). Sand and silt are the primary components over most of the seafloor, with sand predominating the sediment in waters with a depth less than 60 m. Overall, there is often a tendency of the fraction of finer-grade sediments to increase (and average grain size to decrease) with increasing depth and distance from shore. This grading is particularly noticeable on the southeastern BS continental shelf in Bristol Bay and immediately westward. The condition occurs because settling velocity of particles decreases with particle size (Stokes Law), as does the minimum energy necessary to resuspend or tumble them. Since the kinetic energy of sea waves reaching the bottom decreases with increasing depth, terrigenous grains entering coastal shallows drift with water movement until they are deposited, according to size, at the depth at which water speed can no longer transport them. However, there is considerable fine-scale deviation from the graded pattern, especially in shallower coastal waters and offshore of major rivers, due to local variations in the effects of waves, currents, and river input (Johnson 1983).

The distribution of benthic sediment types in the EBS shelf is related to depth (Figure 2). Considerable local variability is indicated in areas along the shore of Bristol Bay and the north coast of the Alaska Peninsula, as well as west and north of Bristol Bay, especially near the Pribilof Islands. Nonetheless, there is a general pattern whereby nearshore sediments in the east and southeast on the inner shelf (0 to 50 m depth) often are sandy gravel and gravelly sand. These give way to plain sand farther offshore and west. On the middle shelf (50 to 100 m), sand gives way to muddy sand and sandy mud, which continue over much of the outer shelf (100 to 200 m) to the start of the continental slope. Sediments on the central and northeastern shelf (including Norton Sound) have not been so extensively sampled, but Sharma (1979) reports that, while sand is dominant in places here, as it is in the southeast, there are concentrations of silt both in shallow nearshore waters and in deep areas near the shelf slope. In addition, there are areas of exposed relic gravel, possibly resulting from glacial deposits. These departures from a classic seaward decrease in grain size are attributed to the large input of fluvial silt from the Yukon River and to flushing and scouring of sediment through the Bering Strait by the net northerly current.

McConnaughey and Smith (2000) and Smith and McConnaughey (1999) describe the available sediment data for the EBS shelf. These data were used to describe four habitat types. The first, situated around the shallow eastern and southern perimeter and near the Pribilof Islands, has primarily sand substrates with a little gravel. The second, across the central shelf out to the 100 m contour, has mixtures of sand and mud. A third, west of a line between St. Matthew and St. Lawrence islands, has primarily mud (silt) substrates, with some mixing with sand (Figure 2). Finally, the areas north and east of St. Lawrence Island, including Norton Sound, have a complex mixture of substrates.

Important water column properties over the EBS include temperature, salinity, and density. These properties remain constant with depth in the near-surface mixed-layer, which varies from approximately 10 to 30 m in summer to approximately 30 to 60 m in winter (Reed 1984). The inner shelf (less than 50 m) is, therefore, one layer and is well mixed most of the time. On the middle shelf (50 to 100 m), a two-layer temperature and salinity structure exists because of downward mixing of wind and upward mixing due to relatively strong tidal currents (Kinder and Schumacher 1981). On the outer shelf (100 to 200 m), a three-layer temperature and salinity structure exists due to downward mixing by wind, horizontal mixing with oceanic water, and upward mixing from the bottom friction due to relatively strong tidal currents. Oceanic water structure is present year-round beyond the 200-m isobath.

Three fronts, the outer shelf, mid-shelf, and inner shelf, follow along the 200-, 100-, and 50-m bathymetric contours, respectively; thus, four separate oceanographic domains appear as bands along the broad EBS shelf. The oceanographic domains are the deep water (more than 200 m), the outer shelf (200 to 100 m), the mid-shelf (100 to 50 m), and the inner shelf (less than 50 m).

The vertical physical system also regulates the biological processes that lead to separate cycles of nutrient regeneration. The source of nutrients for the outer shelf is the deep oceanic water; for the mid-shelf, it is the shelf-bottom water. Starting in winter, surface waters across the shelf are high in nutrients. Spring surface heating stabilizes the water column, then the spring bloom begins and consumes the nutrients. Steep seasonal thermoclines over the deep EBS (30 to 50 m), the outer shelf (20 to 50 m), and the mid-shelf (10 to 50 m) restrict vertical mixing of water between the upper and lower layers. Below these seasonal thermoclines, nutrient concentrations in the outer shelf water invariably are higher than those in the deep EBS water with the same salinity. Winter values for nitrate-N/phosphate-P are similar to the summer ratios, which suggests that, even in winter, the mixing of water between the mid-shelf and the outer shelf domains is substantially restricted (Hattori and Goering 1986).

Effects of a global warming climate should be greater in the EBS than in the GOA. Located further north than the GOA, the seasonal ice cover of the EBS lowers albedo effects. Atmospheric changes that drive the speculated changes in the ocean include increases in air temperature, storm intensity, storm frequency, southerly wind, humidity, and precipitation. The increased precipitation, plus snow and ice melt, leads to an increase in freshwater runoff. The only decrease is in sea level pressure, which is associated with the northward shift in the storm track. Although the location of the maximum in the mean wind stress curl will probably shift poleward, how the curl is likely to change is unknown. The net effect of the storms is what largely determines the curl, and there is likely to be compensation between changes in storm frequency and intensity.

Ocean circulation decreases are likely to occur in the major current systems: the Alaska Stream, Near Strait Inflow, Bering Slope Current, and Kamchatka Current. Competing effects make changes in the Unimak Pass inflow, the shelf coastal current, and the Bering Strait outflow unknown. Changes in hydrography should include increases in sea level, sea surface temperature, shelf bottom temperature, and basin stratification. Decreases should occur in mixing energy and shelf break nutrient supply, while competing effects make changes in shelf stratification and eddy activity unknown. Ice extent, thickness, and brine rejection are all expected to decrease.

Temperature anomalies in the EBS illustrate a relatively warm period in the late 1950s, followed by cooling (especially in the early 1970s), and then by a rapid temperature increase in the latter part of that decade. For more information on the physical environment of the EBS, refer to the Alaska Groundfish Fisheries Programmatic Supplemental EIS (NMFS 2004).

Aleutian Islands

The Aleutian Islands lie in an arc that forms a partial geographic barrier to the exchange of northern Pacific marine waters with EBS waters. The AI continental shelf is narrow compared with the EBS shelf, ranging in width on the north and south sides of the islands from about 4 km or less to 42 to 46 km; the shelf broadens in the eastern portion of the AI arc. The AI comprises approximately 150 islands and extends about 2,260 km in length.

Bowers Ridge in the AI is a submerged geographic structure forming a ridge arc off the west-central AI. Bowers Ridge is about 550 km long and 75 to 110 km wide. The summit of the ridge lies in water approximately 150 to 200 m deep in the southern portion deepening northward to about 800 to 1,000 m at its northern edge.

The AI region has complicated mixes of substrates, including a significant proportion of hard substrates (pebbles, cobbles, boulders, and rock), but data are not available to describe the spatial distribution of these substrates.

The patterns of water density, salinity, and temperature are very similar to the GOA. Along the edge of the shelf in the Alaska Stream, a low salinity (less than 32.0 ppt) tongue-like feature protrudes westward. On the south side of the central AI, nearshore surface salinities can reach as high as 33.3 ppt, as the higher salinity EBS surface water occasionally mixes southward through the AI. Proceeding southward, a minimum of approximately 32.2 ppt is usually present over the slope in the Alaska Stream; values then rise to above 32.6 ppt in the oceanic water offshore. Whereas surface salinity increases toward the west as the source of fresh water from the land decreases, salinity values near 1,500 m decrease very slightly. Temperature values at all depths decrease toward the west.

Climate change effects on the AI area are similar to the effects described for climate change in the EBS. For more information on the physical environment of the AI, refer to the Alaska Groundfish Fisheries Programmatic Supplemental EIS (NMFS 2004).

Gulf of Alaska

The GOA has approximately 160,000 km^2 of continental shelf, which is less than 25 percent of the EBS shelf (Figure 1). The GOA is a relatively open marine system with land masses to the east and the north. Commercial species are more diverse in the GOA than in the EBS, but less diverse than in the Washington-California region. The most diverse set of species in the GOA is the rockfish group; 30 species have been identified in this area.

The dominant circulation in the GOA (Musgrave et al. 1992) is characterized by the cyclonic flow of the Alaska gyre. The circulation consists of the eastward-flowing Subarctic Current system at approximately 501 N and the Alaska Coastal Current (Alaska Stream) system along the northern GOA. Large seasonal variations in the wind-stress curl in the GOA affect the meanders of the Alaska Stream and nearshore eddies. The variations in these nearshore flows and eddies affect much of the region’s biological variability.

The GOA has a variety of seabed types such as gravely sand, silty mud, and muddy to sandy gravel, as well as areas of hardrock (Hampton et al. 1986) (Figure 1). Investigations of the northeast GOA shelf (less than 200 meters [m]) have been conducted between Cape Cleare (148° W) and Cape Fairweather (138° W) (Feder and Jewett 1987). The shelf in this portion of the GOA is relatively wide (up to 100 km). The dominant shelf sediment is clay silt that comes primarily from either the Copper River or the Bering and Malaspina glaciers. When the sediments enter the GOA, they are generally transported to the west. Sand predominates nearshore, especially near the Copper River and the Malaspina Glacier. Most of the western GOA shelf (west of Cape Igvak) consists of slopes characterized by marked dissection and steepness. The shelf consists of many banks and reefs with numerous coarse, clastic, or rocky bottoms, as well as patchy bottom sediments. In contrast, the shelf near Kodiak Island consists of flat relatively shallow banks cut by transverse troughs. The substrate in the area from Near Strait and close to Buldir Island, Amchitka, and Amukta Passes is mainly bedrock outcrops and coarsely fragmented sediment interspersed with sand bottoms.

Temperature anomalies in the GOA illustrate a relatively warm period in the late 1950s, followed by cooling (especially in the early 1970s), and then by a rapid temperature increase in the latter part of that decade. Subsurface temperature anomalies for the coastal GOA also show a change from the early 1970s into the 1980s, similar to that observed in the sea surface (U.S. GLOBEC 1996). In addition, high latitude temperature responses to El Niño southern oscillation events can be seen, especially at depth, in 1977, 1982, 1983, 1987, and the 1990s. Between these events, temperatures in the GOA return to cooler and more neutral temperatures. The 1997/98 El Niño southern oscillation event, one of the strongest recorded this century, has significantly changed the distribution of fish stocks off California, Oregon, Washington, and Alaska. The longer-term impacts of this event remain to be seen.

Piatt and Anderson (1996) provide evidence of possible changes in prey abundance due to decadal scale climate shifts. These authors examined relationships between significant declines in marine birds in the northern GOA during the past 20 years and found that significant declines in common murre populations occurred from the mid- to late-1970s to the early 1990s. Piatt and Anderson (1996) found marked changes in diet composition of five seabird species collected in the GOA from 1975 to 1978 and from 1988 to 1991. Their diet changed from capelin-dominated in the former period to one in which capelin was virtually absent in the latter period.

On a larger scale, evidence of biological responses to decadal-scale climate changes is also found in the coincidence of global fishery expansions or collapses of similar species complexes. For example, salmon stocks in the GOA and the California Current are out of phase. When salmon stocks do well in the GOA, they do poorly in the California Current and vice versa (Hare and Francis 1995, Mantua et al. 1997). For more information about the GOA physical environment, refer to the Alaska Groundfish Fisheries Programmatic Supplemental EIS (NMFS 2004).

Figure 1 Surficial sediment textural characteristics (Appendix B, NMFS 2005) for the continental shelf. Source: Naidu 1988.

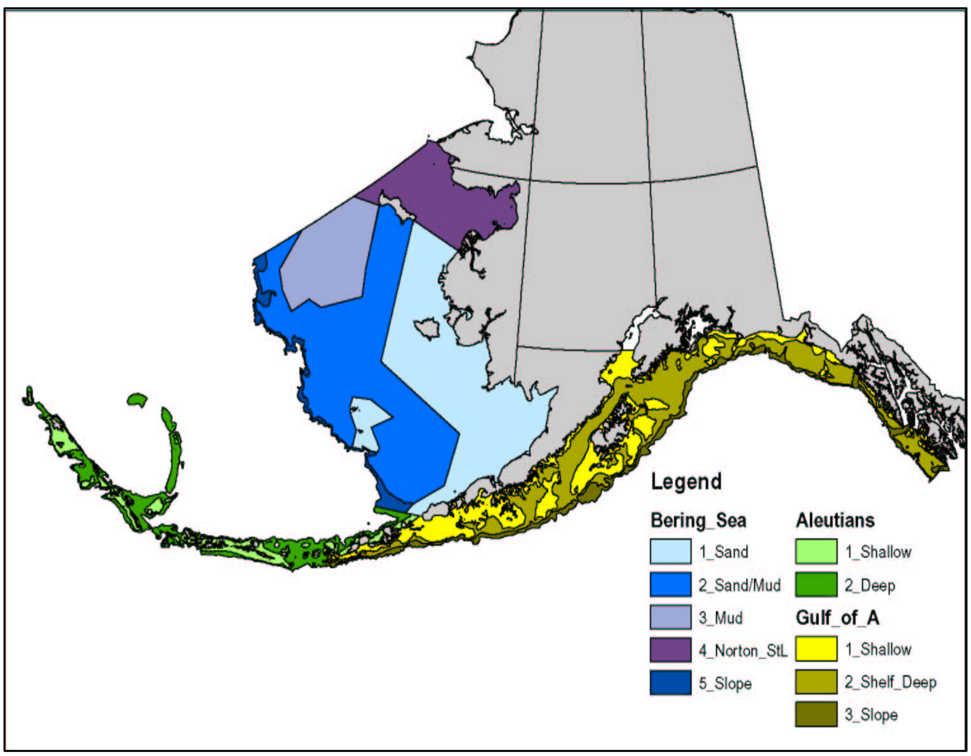
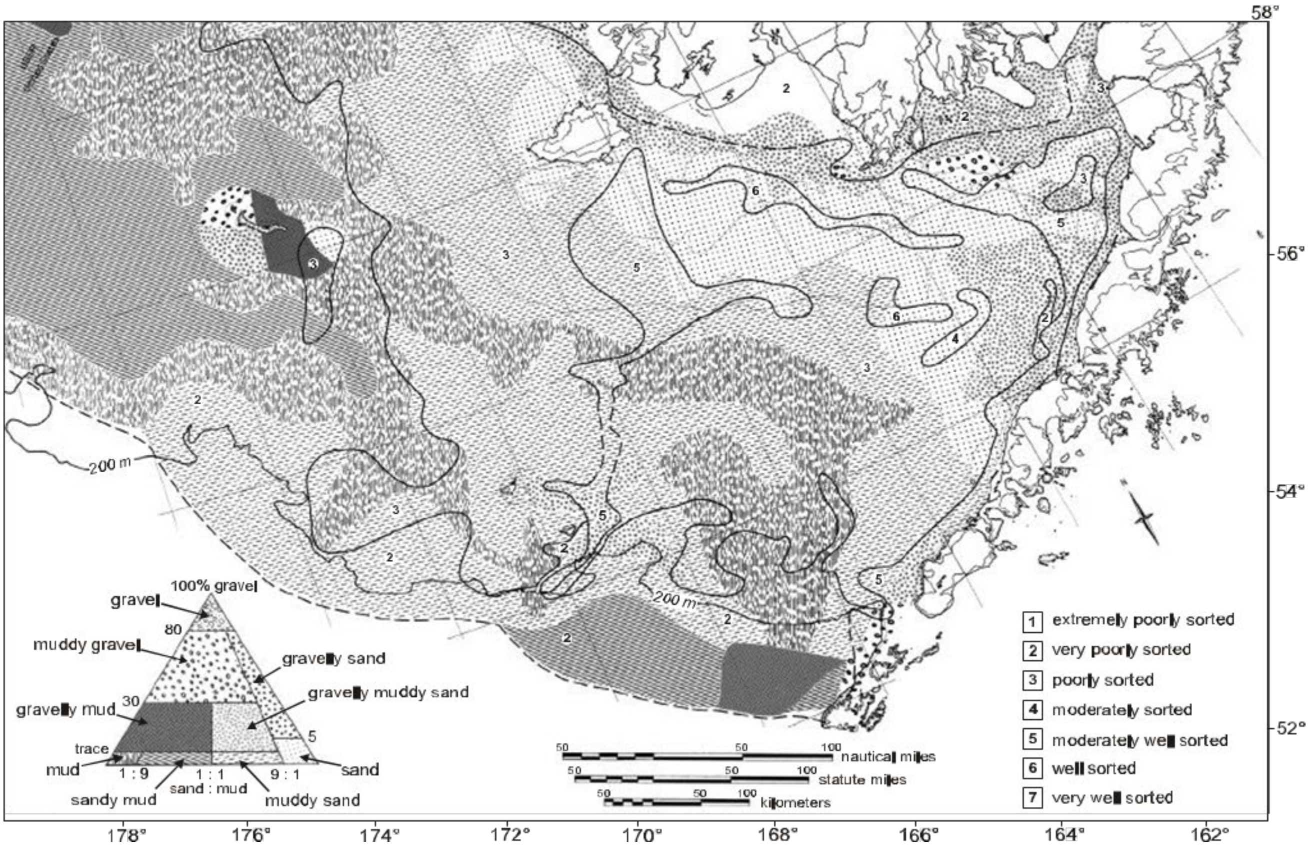


Figure 2 Distribution of Bering Sea Sediments. Source: Smith and McConnaughey 1999

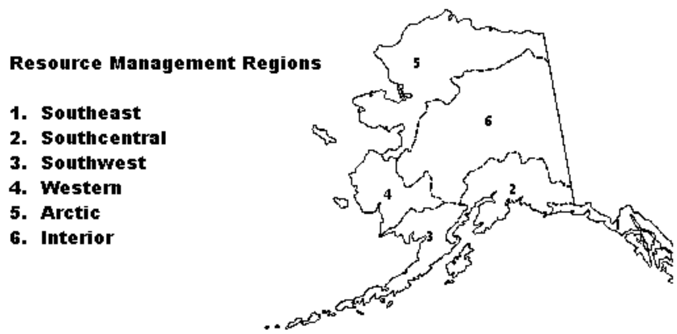


A.2.2 Information Specific to Salmon

Freshwater habitat for the salmon fisheries in Alaska includes all streams, lakes, ponds, wetlands, and other water bodies currently or historically accessible to salmon in the state. This represents a vast array of diverse aquatic habitats over an extremely large geographic area. Alaska contains over 3,000 rivers and has over 3 million lakes greater than 8 hectares. Over 14,000 water bodies containing anadromous salmonids identified in the state represent only part of the salmon EFH in Alaska because many likely habitats have not been surveyed. In addition to current and historically accessible waters used by Alaska salmon, other potential spawning and rearing habitats exist beyond the limits of upstream migration due to barrier falls or steep-gradient rapids. Salmon access to existing or potential habitats can change over time due to many factors, including glacial advance or recession, post-glacial rebound, and tectonic subsidence or uplifting of streams in earthquakes.

A significant body of information exists on the life histories and general distribution of salmon in Alaska. The location of many freshwater water bodies used by salmon are contained in documents organized and maintained by the Alaska Department of Fish and Game (ADF&G). Alaska Statute 16.05.870 requires ADF&G to specify the various streams that are important for spawning, rearing, or migration of anadromous fishes. This is accomplished through the *Catalog of Waters Important for Spawning, Rearing or Migration of Anadromous Fishes* and the *Atlas to the Catalog of Waters Important for Spawning, Returning or Migration of Anadromous Fishes*. The Catalog lists water bodies documented to be used by anadromous fish. The Atlas shows locations of these waters and the species and life stages that use them. The Catalog and Atlas are divided into six volumes for the six resource management regions established in 1982 by the Joint Boards of Fisheries and Game; see Figure 3.

Figure 3 Regional boundaries of the Resource Management Regions established by the Joint Boards of Fisheries and Game.



The Catalog and Atlas, however, have significant limitations. The location information and maps are derived from U.S. Geological Survey quadrangles which may be out of date because of changes in channel and coastline configurations. In southeast Alaska, for example, new streams are colonized by salmon in Glacier Bay as glaciers rapidly recede. Polygons are sometimes used to specify areas with a number of salmon streams that could not be depicted legibly on the maps. Waters within these polygons are often productive for juvenile salmon.

Data for the Catalog come from personal, in-field surveys by aircraft, boat, and foot for purposes of managing fish habitat and fisheries, and the upper limit of salmon is not always observed. Upper points specified in the Catalog usually reflect the extent of surveys or known fish usage rather than actual limits of anadromous fish. Upper areas used by salmon are further limited due to the remoteness and vastness of the Alaska regions. Comparably, the Alaska region has identified salmon for freshwater reaches in an area that would span between the states of Washington and Ohio and between the northern and southern borders of the United States.

In addition, only a limited number of water bodies have actually been surveyed. Virtually all coastal waters in the State provide important habitat for anadromous fish, as do many unsurveyed small- and medium-sized tributaries to known anadromous fish-bearing water bodies in remote parts of the State. Small tributaries, flood channels, intermittent streams, and beaver ponds are often used for juvenile rearing. Because of their remote location, small size, or ephemeral nature, most of these systems have not been surveyed and are not included in the Catalog or Atlas.

Prior to Amendment 13, marine EFH for the salmon fisheries in Alaska included all estuarine and marine areas used by Pacific salmon of Alaska origin, extending from the influence of tidewater and tidally submerged habitats to the limits of the U.S. EEZ. Salmon habitat ranges waters of the Continental Shelf, which extends to about 30 to 100 km offshore from Dixon Entrance to Kodiak Island, then becomes more narrow along the Pacific Ocean side of the Alaska Peninsula and AI chain. In BS areas of southwest and western Alaska and in Chukchi and Beaufort Seas areas of northwest and northern Alaska, the Continental Shelf becomes much wider. In oceanic waters beyond the Continental Shelf, the documented range of Alaska salmon extends from lat. 42° N north to the Arctic Ocean and to long. 160° E. In the deeper waters of the Continental Slope and ocean basin, salmon occupy the upper water column, generally from the surface to a depth of about 50 m. Chinook and chum salmon, however, use deeper layers, generally to about 300 m, but on occasion to 500 m. Identifying EFH so broadly greatly reduces the potential utility of EFH designations for management purposes, and also reduces the credibility of the EFH program nationwide.

With Amendment 13, the Council modified marine EFH for salmon using a new methodology to refine the geographic scope of EFH for Pacific salmon in marine waters off Alaska developed by the NMFS Alaska Fisheries Science Center. In order to better define EFH within the U.S. EEZ for Pacific salmon found in Alaska, Echave et al. (2012) acquired catch, maturity, salinity, temperature, and station depth data for the Bering Sea and Gulf of Alaska from seven datasets. The objectives of this study were to 1) refine existing Level 1 EFH information by describing the presence/absence and geographic distribution of each species and life history of salmon, and 2) assess their Level 2 EFH habitat-specific densities. The influence of sea surface salinity, sea surface temperature, and bottom depth on the distribution of Pacific salmon was analyzed. By calculating and mapping the coincidence of the 95% range of each environmental variable for each of the five species at each maturity stage, the updated EFH descriptions reduce the area of designated EFH for Pacific salmon by 71.3% on average (Echave et al. 2012). Juvenile salmon EFH generally consist of the water over the continental shelf within the Bering Sea extending north to the Chukchi Sea, and over the continental shelf throughout the Gulf of Alaska and within the inside waters of the Alexander Archipelago. Immature and mature Pacific salmon EFH includes nearshore and oceanic waters, often extending well beyond the shelf break, with fewer areas within the inside waters of the Alexander Archipelago and Prince William Sound.

This was the first time that salmon data sets from multiple surveys, agencies, and years were accumulated and formatted for Pacific salmon distribution and habitat analysis. Distribution was plotted for each salmon species and life history within the Alaska EEZ. To better describe salmon EFH, additional detailed habitat preference analysis was performed with available biophysical data from approximately 84% of the events.

Foreign waters (i.e., off British Columbia in the GOA and off Russia in the BS) and international waters are not included in salmon EFH because they are outside United States jurisdiction.

A.2.3 Habitat Description for Pink Salmon *(Oncorhynchus gorbuscha)*

Life History and General Distribution

The natural freshwater range of pink salmon includes the Pacific rim of Asia and North America north of about 40°N. Within this vast area, spawning pink salmon are widely distributed in coastal streams of both continents up to the Bering Strait. North, east, and west of the Bering Strait, spawning populations become more irregular and occasional. Centers of large spawning populations occur at roughly parallel positions along the two continents from about lat. 44°N to 65°N in Asia and about 48°N to 64°N in North America. In marine environments along both the Asian and North American coastlines pink salmon occupy ocean waters south of the limits of spawning streams.

Pink salmon are distinguished from other Pacific salmon by having a fixed 2-year life span, being the smallest of the Pacific salmon as adults (averaging 1.0 to 2.5 kg), the fact that the young migrate to sea soon after emerging from the gravel, and developing a marked hump in large maturing males. This last characteristic is responsible for the vernacular name humpback salmon used in some areas. Because of the fixed 2-year life cycle, pink salmon spawning in a particular river system in old and even years are reproductively isolated from each other and have developed into genetically different lines. In some river systems, like the Fraser River in British Columbia, only the odd-year line exists; returns in even years are negligible. In Bristol Bay, Alaska, the major runs occur in even years, whereas the coastal area between these two river systems is characterized by runs in both even and odd years. In different parts of the range populations are sometimes characterized by the phenomena of dominance where one brood line is much stronger than the other brood line. 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 their river of origin to spawn and die.

Pink salmon are considered to be have either the simplest or most specialized life cycle within the genus, depending on whether Pacific salmon originated from marine or freshwater ancestors. One view holds that *Oncorhynchus* evolved from an ancestral freshwater form of Pacific *Salmo* during the Pleistocene, probably in the vicinity of the present-day Sea of Japan. Under this scenario, pink salmon that rely least on the freshwater environment are the most specialized. Pink salmon have 52 chromosomes, fewer than other Pacific salmon, which also may suggest specialization. Another view considers Salmonidae as relatively primitive teleosts, of probable marine pelagic origin, and about five million years old. This alternative view to freshwater origin of Pacific salmon is supported, in part, by Pliocene fossils from California and Oregon. The marine origin view holds that during evolution salmonids tended towards greater dependence on fresh water and away from dependence on the sea. Under this scenario, pink salmon, with the least dependence on the freshwater environment, is considered the least advanced extant *Oncorhynchus* species.

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, birds and small mammals. In the marine environment, pink salmon fry and juveniles are food for a host of other fishes and coastal sea birds.

Subadult and adult pink salmon are known to be eaten by 15 different marine mammals, sharks, other fishes such as Pacific halibut and humpback whales. 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.

Millions of pink salmon adults returning to spawn in thousands of streams throughout Alaska provide significant nutrient input into the trophic level of these 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.

Approximate Upper Size Limit of Juvenile Fish: Roughly 25 cm.

Habitat and Biological Associations

Eggs and Spawning: Pink salmon choose a fairly uniform spawning bed in small and large streams in both 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. In large rivers, they may spawn in discrete sections of main channels or in tributary channels. Pink salmon avoid spawning in quiet deep water, in pools, in areas with a slow current, or over heavily silted or mud-covered streambeds. Places selected for egg deposition is determined by the optimal combination of two main interconnecting variables: depth of water and velocity of current.

On both the Asian and North American sides of the Pacific Ocean, pink salmon generally spawn at depths of 30 to 100 cm. Well populated spawning grounds of pink salmon are mainly at depths of 20 to 25 cm, less often reaching depths of 100 to 150 cm. In dry years, when spawning grounds are crowded, nests can be found at shallower depths of 10 to 15 cm. Current velocities in pink salmon spawning grounds varied from 30 to 100 cm/s, sometimes reaching 140 cm/s. Directly over the redds, about 5 to 7 cm from the surface, the velocity can range from 30 to 140 cm/s but usually averages from 60 to 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. Chum salmon, by contrast, tended to select spawning sites in areas with upwelling spring water and a relatively constant water temperature, without much regard to surface stream water. Pink salmon spawning beds consist primarily of coarse gravel with a few large cobbles, a large mixture of sand, and a small amount of silt. High quality spawning grounds of pink salmon can best be summarized as clean, coarse gravel.

Larvae/Alevins: Fertilized eggs begin their 5- to 8-month period of embryonic development and growth in intragravel interstices. 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. Collectively, these requirements are, on average, only partially met even under the most favorable natural conditions. Overall freshwater survival of pink salmon from egg to advanced alevin and emerged fry, even in highly productive streams, commonly reaches only 10 to 20 percent and at times is as low as about 1 percent.

Rates of egg development, survival, size of hatched alevins and percentage of deformed fry are related to temperature and oxygen levels during incubation. Temporary low stream temperatures or dissolved oxygen concentrations, however, may be relatively unimportant at some developmental stages, but lethal at others. Generally, low oxygen levels are non-lethal early, but lethal late in development. Eggs subjected to low dissolved oxygen levels hatched prematurely at a rate dependent on the degree of hypoxia. Spinal deformities occurred in eggs incubated at 3.0° and 4.5°C before gastrulation. In one study, over 50 percent of developing pink salmon eggs died at dissolved oxygen levels of 3 to 4 mg/l, and among those that hatched many alevins were deformed.

Juveniles: Newly emerged pink salmon fry show a preference for saline water over fresh water, which may, in some situations, facilitate migration from the natal stream area. 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.

Early marine schools of pink salmon fry, often in tens or hundreds of thousands of fish, tend to follow shorelines and, during the first weeks at sea, spend much of their time in shallow water of only a few centimeters deep. It has been suggested that this onshore period involves a distinct ecological life history stage in both pink and chum salmon. 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. Juvenile pink salmon in the BS off the northeastern Kamchatka coast are found in one of three hydrological zones during their first three to four months of marine life: (1) the littoral zone, up to 150 m from shore; (2) open parts of inlets and bays from 150 m to 3.2 km from shore; and (3) the open parts of the large Karaginskiy Gulf, 3.2 to 96.5 km from shore. Distribution within these regions is seasonally related to the size of pinks, with an offshore movement of larger fish in August and September.

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. Collectively, diet studies show that pink salmon are both opportunistic and generalized feeders and on occasion they specialize in specific prey items. Diel sampling of stomachs showed fewer and more digested food items at night than during the day indicating that juvenile pinks are primarily diurnal feeders.

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. Entering the estuary as fry at around 3 cm in length, maturing adults return to the same area 14 to 16 months later ranging in length from 45 to 55 cm.

The population biology of pink salmon revolves around the 2-year life cycle. A phenomenon of cycle dominance between odd- and even-year brood lines within specific regions is common. Dominance can be weak or strong, complete, or non-existent. It can also shift between brood lines. With complete dominance, the off-year line is absent while non-dominance is characterized by similar population strength between odd- and even-year runs. Although many causes for dominance and its various characteristics in pink salmon populations have been proposed, none satisfactorily explains the event. Genetically, pink salmon are more similar within odd- or even-year brood lines across broad geographic regions than across brood lines within the same stream. It has been suggested for some geographic areas that present odd- and even-year pink salmon populations arose from separate glacial refuges during late Pleistocene times.

Scientists have recognized six distinct ocean migration patterns for regional stock groups of pink salmon throughout the North Pacific. Only two of these stock groups, those originating in

Washington state and British Columbia and those originating in southeast, central, and southwest 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 two broad stock groups co-mingle in the GOA during their second summer at sea while migrating towards natal areas.

Table 4 Habitat and biological associations of pink salmon, *Onchorynchus gorbusch*a

Stage - EFH Level	Duration or Age	Diet/Prey	Season/ Time	Location	Water Column	Bottom Type	Oceanographic Features	Other
Eggs and larvae	90 to 125 days	Eggs predated by birds, fish, and mammals	Late summer, fall, winter, and early spring	Intragravel; in stream beds; water courses, rivers streams, sloughs; lakes, ponds; beach (intertidal)	15 to 50 cm in gravel depth	Medium to coarse gravel, cobble, gravel	NA	Develop at 1-10°C, eggs hatch at about 100 d, larvae emerge from gravel about 125 d post hatch
Juveniles, freshwater	1 to 15 days; short streams = 1 day, longer rivers = 15 day	Fry are predated by birds, fish, and mammals	Spring	Rivers and streams; water courses, rivers streams, sloughs; lakes, ponds; beach (intertidal)	Generally migrating in upper portion of water column	Varied	NA	Downstream migration is mostly in darkness
Juveniles, estuarine	2 to 3 months	Copepods, euphausiids, decapod larva, amphipods	Summer	Estuarine, initially nearshore, then offshore in bays and inlets, along kelp beds	Generally occupying the upper portion of water column	Varied: kelp, subaquatic vegetation	NA	Preference for increasing salinities, school with other salmon and Pacific sandfish
Juveniles, marine	3 to 6 months	Copepods, euphausiids, decapod larva, amphipods	Summer, fall, and early, pre anulus winter	Coastal; inner, middle, and outer continental shelf; moving further offshore with growth	Generally migrating in upper portion of water column	Varied: kelp, subaquatic vegetation	Upwelling, fronts, thermo- or pycnocline, edges	Coastal and shelf migrations move into oceanic waters in later stages
Immature and maturing adults marine	6 to 10 months	Fish, squid, euphausiids, amphipods, and copepods	Spring, summer, and early fall	Oceanic to nearshore in final migration	Pelagic, neustonic	NA	Upwelling, fronts, thermo- or pycnocline, edges; Regional stocks have specific oceanic migratory patterns	Rapid marine growth; onset of maturation timing varies among stocks; earlier north, later south
Adults, freshwater	2 years of age from egg to mature adult, final stage 1 to 2 months	Active feeding ceases, digestive organs atrophy	Spawning (Aug-Oct)	Water courses, rivers streams, sloughs; lakes, ponds; beach (intertidal)	Varied, holding in pools, spawning on shallow riffles	Medium to coarse gravel, cobble, gravel	NA	Sexual dimorphism in spawning males, called humpback salmon

A.2.4 Habitat Description for Chum Salmon (*Oncorhynchus keta)*

Life History and General Distribution

Chum salmon spawn in streams emptying into the North Pacific Ocean north of about 40EN in both Asia and North America. In Asia, chum salmon spawn in streams on the east side of the Korean peninsula in both South and North Korea northward, including Japan, China (tributaries to the Amur River), Russia and westward into the Arctic Ocean as far west as the Lena River. In North America, chum salmon spawn in streams entering the North Pacific Ocean as far south as northern California and northward in streams along the coasts of Oregon, Washington, British Columbia, and Alaska on into the BS, Arctic Ocean, and Beaufort Sea as far east as the Mackenzie River in Northwest Territory. Chum salmon spawn in Yukon Territory, Canada, in tributaries of the Yukon River. Only populations small in numbers spawn north and east of the Noatak River, which enters the ocean at Kotzebue, Alaska, and south of Tillamook Bay, Oregon.

In general, chum salmon spawn in the lower reaches of coastal streams less than 100 miles upstream from the ocean. Two notable exceptions are the Yukon River in North America and the Amur River in Russia and China where chum salmon migrate upstream more than 1,500 miles to spawning areas. In Prince William Sound, and to a lesser extent southeast Alaska, chum salmon will spawn in the intertidal portions of streams in areas where ground water upwells into the streams. Chum salmon throughout their range tend to build their redds in areas of streams where ground water (about 4° to 7°C) upwells.

In North America, chum salmon return from the ocean to spawn, for the most part, between June and January. In general, spawning starts earlier in the north and ends later in the southern part of their range. Of course, major exceptions in this pattern occur. The latest spawning in southeast Alaska occurs in the Chilkat River, near Haines, Alaska, from September through January. Most chum salmon spawning in Alaska is usually finished by early November. Most spawning in Washington/Oregon takes place from August through November; however, August spawners have been declining in recent years. Chum salmon return to the Quilcene National Fish Hatchery in December, and the Nisqually River near Olympia, Washington, has spawners during January and February and sometimes into March.

So called summer and fall races of chum salmon occur in Asia and North America. Summer and fall races both enter the Yukon River. The summer chum salmon start entering the river in May and the fall chum enter the river in June and July. The fall stocks tend to spawn farthest up river in September through November. Summer chum are more abundant than fall chum in the Yukon River; however, the fall chum are larger. In southern southeast Alaska and northern British Columbia summer chum enter mostly mainland rivers in mid-June and spawning may extend into late October and early November. Fall chum in southern southeast Alaska and northern British Columbia spawn mostly in streams on the Islands and spawning typically occurs during September and October. Unlike the Yukon River, summer chum salmon in southern Southeast Alaska and northern British Columbia are larger than the fall stocks for the same age, even though the summer stocks may spawn more than 3 months earlier.

Chum salmon return to spawn as 2- to 7-year-olds. Two-year-old chum are rare in North America and occur primarily in the southern part of their range, e.g., Oregon. Seven-year-old chum are also rare and occur mostly in the northern areas. In general, chum salmon get older from south to north. Three- and four-year-olds tend to dominate in the southern areas and 4-, 5-, and 6-year-olds tend to dominate in the more northern areas. For the most part older chum salmon are larger than younger fish but much overlap occurs between the age groups. The largest chum salmon in North America (and probably the world) occur in the Portland Canal area, which forms the border between Alaska and British Columbia.

Chum salmon fry, like pink salmon, do not overwinter in the streams but migrate (mostly at night) out of the streams directly to the sea shortly after emergence. The range of this outmigration occurs between February and June but most fry leave the streams during April and May. Chum salmon do tend to linger and forage in the intertidal areas at the head of bays. Estuaries are very important for chum salmon rearing during the spring and summer.

Juvenile chum salmon are present in the coastal waters mostly during July through October, and generally move to the north and west along the coasts of Oregon, Washington, British Columbia, and Alaska. Most juvenile chum salmon are thought to leave the coastal waters and move south into the North Pacific Ocean between Kodiak and False Pass during late fall. After chum salmon form an annulus on their scales (January to March) they are considered immature. They may remain immature for several years until they start maturing and begin their migration to their spawning streams.

Both Asian and North American chum salmon winter in the North Pacific but Asian chum salmon migrate much further east than North American chum salmon migrate to the west. North American chum salmon are seldom found west of 175EE; however, Asian salmon are found eastward to at least 140EW. However, Asian and North American stocks of chum salmon are intermingled on the high seas.

After the 1976 to 1977 Regime Shift in the North Pacific Ocean, most chum salmon stocks increased in abundance through the mid-1990s. The Regime Shift apparently created very favorable ocean conditions for all species of salmon from northern British Columbia to northern Alaska. However, as the abundance increased, age at maturity increased, and size at age decreased drastically. Chum salmon of the same age in the early 1990s weighed up to 46 percent less than they weighed in the early 1970s. During this same time, Asian chum salmon also matured older and their size at age declined. These changes in size and age at maturity as population numbers increased suggests that the North Pacific Ocean may have carrying capacity limits for chum salmon under certain conditions.

Relevant Trophic Information

Chum salmon eggs, alevins, and juveniles in freshwater streams provide an important food source for many birds (e.g., gulls, crows, magpies, ouzels, kingfishers), small mammals, other fishes, and many invertebrates. Chum salmon carcasses provide nutrients for the freshwater watersheds and estuaries. Carcasses are also highly important for food for many birds (e.g., eagles, ravens, crows, gulls, magpies). The late chum salmon return to the Chilkat River system near Haines, Alaska, is the reason that large numbers of bald eagles congregate on the spawning grounds every year in September through December. Adult chum salmon and spawned carcasses provide a major food source for brown and black bears, wolverines, wolves, and many other small mammals. Many species of invertebrates utilize carcasses for food.

Approximate Upper Size Limit of Juvenile Fish: If the term juvenile chum salmon refers to the fry stage up to the time of the first annulus formation in the ocean, which occurs in January-March, the approximate upper size limit is about 30 cm. Juvenile chum salmon in the outside waters of Southeast Alaska in mid to late August range in size up to about 25 cm.

Habitat and Biological Associations

Eggs/Spawning: Chum salmon spawn in gravel in streams, side-channel sloughs, and intertidal portions of streams when the tide is below the spawning area. In all of these areas upwelling ground water is often the common denominator. Many side-channel sloughs have very little current on the surface and can be very silty; however, the upwelling ground water keeps the silt in suspension in the intragravel water. The upwelling water also keeps these spawning areas with slow moving surface water from freezing in the winter. The depth that eggs are deposited in the streams varies according to the gravel size, current, and size of the female, but the range is about 8 to 50 cm. Eggs and sperm are deposited in the redd simultaneously and each female spawns with up to six males at the same time. Several redds are constructed by each female and different males may be involved in the spawning act in subsequent redds. Stream life of both sexes varies and is longer in the early stages of the run (about 14 days) and shorter near the end of the run (as few as 6 days) in coastal streams.

Larvae/Alevins: Fertilized eggs incubate in the streambed gravel for about 5 to 8 months. Eggs, alevins, and pre-emergent fry can be killed by desiccation, freezing, mechanical injuries due to streambed shifting, e.g., during floods, and predators. The intragravel water during incubation and rearing must be of suitable temperatures and be free of toxins with adequate oxygen and flow to remove waste products. Survival from deposited eggs to emergent fry is highly variable, ranging from about 1 to 20 percent. The health of the eggs and emerging fry is also dependent on gravel composition, spawning time, spawning density, and genetic characteristics. In general, chum salmon eggs have to be fertilized in water above 4°C and in salinity less than 2 parts per thousand. Dissolved oxygen levels during incubation need to be above 3 to 4 mg/l.

Juveniles: After emerging from the streambed (as early as February and as late as June) schooling chum salmon fry migrate downstream, mostly at night, to the estuaries where they tend to feed in the intertidal grass flats and along the shore. Chums can utilize these intertidal wetlands for several months before actively migrating out of bays and into channels on the way to the outside waters. Pink salmon on the other hand tend to move more directly to more open water areas. Chum salmon utilize a wide variety of food items, including mostly invertebrates (including insects), and gelatinous species. Offshore movement of larger juveniles occurs mostly in July to September.

Adults: Chum salmon reside in the ocean for about 1 to 6 years. Adults mature at ages 2 through 7 years; however, 2- and 7-year-old chum salmon are rare. Throughout their range 3-, 4-, and 5-year olds are common but 3- and 4-year-old salmon dominate the southern stocks and 4-, 5-, and 6-year-old chum salmon dominate the northern stocks. Slow or rapid growth in the ocean can modify age at maturity. Slower growth during the second year at sea causes some chum salmon to mature 1 or 2 years later. Chum salmon eat a variety of foods during their ocean life, e.g., amphipods, euphausiids, pteropods, copepods, fish, and squid larvae. Chum salmon also utilize gelatinous zooplankton for food more often than any of the other species of salmon. Chum salmon have a much larger stomach than the other species of salmon and this large capacity may allow them to utilize the nutrients from the gelatinous zooplankton more efficiently.

Asian and North American chum salmon are intermingled on the high seas as immature and during their last year at sea. Recently, immature and maturing chum salmon from Washington, British Columbia, and southeast Alaska have been identified in the BS in August. Chum salmon spawn mostly in November in Washington and southern British Columbia so these fish are capable of long distant migrations in their last year in the sea.

Special Habitat Concerns: Chum salmon are subject to the same habitat concerns as the other species of salmon, e.g., habitat destruction or silting due to logging and road building activities, blockages due to dams, and pollution. In addition, chum salmon have two habitat requirements that are essential in their life history that make them very vulnerable: (1) reliance on upwelling ground water for spawning and incubation, and (2) reliance on estuaries/tidal wetlands for juvenile rearing after migrating out of the streams. The hydrology of upwelling ground water into stream gravel is highly complex and poorly understood. Whatever activities change the amount and quality of groundwater that upwells would very likely affect chum salmon survival in a negative manner. Drilling activities and uplift of land masses due to earthquakes are two phenomena known to affect groundwater. Wetlands and estuaries near communities are very vulnerable to pollution and filling activities that would negatively affect essential chum salmon rearing areas.

Chum salmon will spawn in intertidal portions of streams, most notably in Prince William Sound. The intertidal portion of streams is very vulnerable to disturbance, such as earthquakes and coastal pollution from oil spills, etc. In Prince William Sound, chum salmon spawners are active in the intertidal zone of streams from late June through September. Eggs, alevins, and fry are in the intertidal gravel from late June through May. That leaves a very narrow window in June when the intertidal zone may be free of adults, eggs, alevins, or fry.

Table 5 Habitat and biological associations of chum salmon, *Onchorhynchus keta*

Stage - EFH Level	Duration or Age	Diet/ Prey	Season/ Time	Location	Water Column	Bottom Type	Oceanographic Features	Other
Eggs and larvae	90 to 125 days	Eggs predated by birds, fish, and mammals	Early summer, fall, winter, and early spring	Intragravel in stream beds; water courses, rivers streams, sloughs; lakes, ponds; beach (intertidal)	7.5 to 50 cm in gravel depth	Small to coarse gravel; cobble; gravel	NA	Develop at 1-10°C, eggs hatch at 52-173 d, larvae emerge from gravel 146-325 d
Juveniles (freshwater)	1 to 15 days; short streams = 1 day, longer rivers=30 days	Fry are predated by birds, fish, and mammals	Spring	Rivers and streams; water courses, rivers streams, sloughs; lakes, ponds; beach (intertidal)	Generally migrating in upper portion of water column	Varied	NA	Downstream migration is mostly in darkness
Juveniles (estuarine)	2 to 3 months	Copepods, euphausiids, decapod larva, amphipods, gelatinous zooplankton	Summer	Estuarine, initially nearshore, then offshore in bays and inlets, along kelp beds	Generally occupying the upper portion of water column	Varied: kelp, subquatic vegetation	NA	Preference for increasing salinities, school with other salmon and Pacific sandfish
Juveniles, (marine)	3 to 6 months	Copepods, euphausiids, decapod larva, amphipods, gelatinous zooplankton	Summer, fall, and winter, prior to annulus formation in Jan.-Mar.	Coastal; inner, middle, and outer continental shelf; moving further offshore with growth	Generally migrating in upper portion of water column	Varied: kelp, subquatic vegetation	Upwelling, front, thermo- or pycnocline, edges	Coastal and shelf migrations move into oceanic waters in later stages
Immature and maturing adults (marine)	6 to 10 months	Fish, squid, euphausiids, amphipods, copepods, and gelatinous zooplankton	Spring, summer, and early fall	Oceanic to nearshore in final migration	Pelagic, neustonic	NA	Upwelling, front, thermo- or pycnocline, edges; Regional stocks have specific oceanic migratory patterns	Rapid marine growth; onset of maturation timing varies widely among stocks; generally earlier north, later south
Adults (freshwater)	2 to 7 years of age from egg to mature adult, final stage 1-2 months	Active feeding ceases, digestive organs atrophy	Spawning (June-January)	Water courses, rivers streams, sloughs; lakes, ponds; beach (intertidal)	Varied, holding in pools, spawning on shallow riffles, pools or side-channel sloughs	Small to coarse gravel; cobble; gravel	NA	Sexual dimorphism in spawners, males develop large teeth, called dog salmon

A.2.5 Habitat Description for Sockeye Salmon (*Oncorhynchus nerka)*

Life History and General Distribution

The natural freshwater range of sockeye salmon includes the Pacific rim of Asia and North America north of about 40°N. Within this area, the primary spawning grounds of sockeye salmon in North America extend from tributaries of the Columbia River to the Kuskokwim River in western Alaska, and on the Asian side, the spawning areas are found mainly on the Kamchatka Peninsula. Spawning populations become more irregular and occasional north of the Bering Strait, on the north coast of the Sea of Okhotsk, and in the Kuril Islands. Centers of the two largest spawning complexes in the North Pacific rim occur in the Bristol Bay watershed of southwestern Alaska and the Fraser River drainage of British Columbia. In marine environments along both the

Asian and North American coastlines, sockeye salmon occupy ocean waters south of the limits of spawning systems.

Sockeye salmon exhibit a greater variety of life history patterns than other members of the genus *Oncorhynchus,* and characteristically make more use of lake rearing habitat in juvenile stages. Although sockeye salmon are primarily anadromous, there are distinct populations called kokanee, which mature, spawn, and die in fresh water without a period of sea life. Typically, but not universally, juvenile anadromous sockeye utilize lake rearing areas for 1 to 3 years after emergence from the gravel; however, some populations utilize stream areas for rearing and migrate to sea soon after emergence. Anadromous sockeye may spend from 1 to 4 years in the ocean before returning to fresh water to spawn and die in late summer and fall.

The adaptations of sockeye salmon to lake environments appear to require more precise homing to spawning areas, both as to time and location than is found in the other species of Pacific salmon. Although available spawning localities are more restricted because of the usual requirement of a lake rearing environment for the juveniles, this adaptation is successful for sockeye salmon. Juvenile sockeye salmon in fresh water do not need the territorial stream behavior displayed by juvenile Chinook and coho salmon, but do exhibit schooling tendencies more characteristic of pelagic feeding fishes.

Other distinctions of sockeye salmon include growth rate and size at maturity. Sockeye do not exhibit the rapid marine growth of coho or pink salmon (*O. gorbuscha*), which mature and return to fresh water after a single winter in the ocean, or of Chinook salmon or chum salmon (*O. keta*), which attain a much larger average size at maturity. The flesh of sockeye is a darker red than that of the other salmon species, a color long considered to be a marketing attribute of the canned and, more recently, the fresh or fresh-frozen product.

Relevant Trophic Information

Sockeye salmon eggs, alevins, and juveniles in freshwater streams and lake systems provide an important nutrient and food source for aquatic invertebrates, other fishes, birds, and small mammals. In the marine environment sockeye salmon juveniles are food for many other fishes and coastal sea birds. Adult sockeye salmon are known to be eaten by marine mammals and sharks.

Millions of sockeye salmon adults returning to spawn in thousands of streams throughout Alaska provide significant nutrient input into the trophic level of these coastal watersheds. Adult sockeye salmon in streams are major food sources for gulls, eagles, and other birds, along with bear, otter, mink, and other mammals.

Approximate Upper Size Limit of Juvenile Fish: Roughly 25 cm.

Habitat and Biological Associations

Eggs/Spawning: Sockeye salmon generally spawn in late summer and autumn. Within this period, time of spawning for different stocks can vary greatly, apparently because of adaptations to the most favorable survival conditions for spawning, egg and alevin incubation, emergence, and subsequent juvenile feeding. Although timing of spawning varies little from year to year within a specific spawning area, there are great differences in timing among spawning areas. The timing of spawning appears to be dependent to some degree on the temperature regimen in the gravel where the eggs are incubated. This varies distinctly among spawning area types. In the Bristol Bay region of Alaska, spawning begins in late July in the smaller streams, in early to mid-August in the tributaries of some lakes, and in late August to mid-September in most lake beach areas. In Lake Kuril and its tributaries, spawning continues from the end of June until early February with the main spawning occurring from September to November.

Among the species of Pacific salmon, the sockeye salmon exhibits the greatest diversity in adaptation to a wide variety of spawning habitats. The selection of habitats and timing of spawning by a sockeye stock are linked to success of survival, not only during spawning and incubation of the eggs and alevins, but also in the chain of freshwater and marine environments to which the progeny are subsequently exposed. In most instances, but not all, the subsequent environment of the juveniles is a lake or lake chain, and the behavior of the juveniles after emergence depends on the location of the spawning area in relation to the lake rearing area to be utilized. Lake-beach spawning has been recorded in most sockeye lake systems, and is apparently important habitat. Sockeye are also known to spawn in areas that lack lake rearing habitat. These river spawning or sea type sockeye lay their eggs in river systems with no lake, and emergent fry apparently feed in the stream or low-salinity estuaries for several months before migrating to offshore ocean areas. The circumstances surrounding the initial establishment of a spawning colony and the subsequent adaptive behavior of the progeny can only be surmised. However, the continued use of a specific spawning environment by a sockeye stock depends on the precise homing ability of the species, in which straying to other potential spawning locations is minimal.

The composition of spawning substrate utilized by sockeye salmon varies widely. Some lake-beach spawning occurs to a depth of nearly 30 m in areas of strong upwelling groundwater. In some lakes, mass spawning takes place over large angular gravel too large to be moved by salmon in the normal digging process. The eggs settle in the crevices between the rocks. Generally, however, spawning along lake beaches and in streams takes place in gravel small enough to be readily dislodged by digging, and the digging process tends to remove the silt and clean the gravel where the eggs are deposited. Water depth does not seem to be a critical factor to sockeye in selecting a spawning site. In the small streams and spring ponds, it is common to observe pairs of salmon in the spawning process with their dorsal surfaces protruding from the water. In larger rivers, spawning depths are generally not great because riffle areas are preferred. Spawning on lake beaches can extend to considerable depths. It is clear that sockeye can detect upwelling groundwater areas along lake beaches and in spring ponds areas in which to spawn. Generally, the spawning beds are situated in areas with clean gravel, or along the borders between pools and riffles in shallow water with moderate to fast currents. In large rivers, they may spawn in discrete sections of main channels or in tributary channels.

Superimposition is minimized by the territorial defense of the redd by the female following egg deposition, which protects the redd for a few days. Female territory is partly a function of spawner density. Estimates of the capacity of streams to support spawning sockeye were based on density of one female/2 m^2. In spawning channels, maximum fry production was achieved at the spawner density of one female/m^2.

Larvae/Alevins: Fertilized eggs begin their 5- to 8-month period of embryonic development and growth in intragravel interstices. 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. Collectively, these requirements are, on average, only partially met even under the most favorable natural conditions. Overall freshwater survival of sockeye salmon from egg to advanced alevin and emerged fry, even in highly productive streams, commonly reaches only 10 to 20 percent, and at times is as low as 1 percent.

Rates of egg development, survival, size of hatched alevins, and percentage of deformed fry are related to temperature and oxygen levels during incubation. Temporary low stream temperatures or dissolved oxygen concentrations, however, may be relatively unimportant at some developmental stages, but lethal at others. Generally, low oxygen levels are non-lethal early, but lethal late in development.

Juveniles: Fry emergence apparently begins in early to mid-April in most instances, peaks in early to mid-May, and ends in late May to early June. Newly emerged sockeye salmon fry show a marked negative rheotaxis and actively swim downstream to lakes. In some lake outlet spawning areas, the emerging fry swim laterally in an attempt to reach the river banks and avoid being swept downstream. The emergence behavior of fry in lakeshore spawning areas has not been reported. It has been suggested that the seasonal timing of sockeye fry emergence optimizes the timing of dispersal into their feeding habitat, particularly to take advantage of the seasonal peak abundance of zooplankton of appropriate size. It is postulated that fry emerging earlier or later than the optimum may suffer greater mortality, and thus that timing is a response to this selective pressure. The survival value in entering the lake early is to take advantage of feeding in the lake as long as possible during the summer, thus achieving larger size in preparation for spring smoltification. Annual timing of fry migration and its seasonal pattern is a function of the seasonal timing of the adult spawning period, ecological factors within the incubation habitat that affects development rate and alevin behavior, and transit time needed by the fry to reach their feeding habitat.

Upon entering nursery lakes, sockeye fry disperse quickly into their lake feeding areas. Movement of fry into the nursery areas may be direct and immediate, or sequential, the latter involving occupation of intermediate feeding areas for a period of time. The plasticity of response suggests definite racial adaptations to a variety of different environmental conditions. Intermediate feeding and growth can occur along outlet river banks before migration into the nursery lake. In-lake dispersions of fry is probably a mechanism whereby the lake zooplankton is effectively utilized as food for the juvenile fish.

Sockeye salmon juveniles typically spend one or more growing seasons in the limnetic zone of a nursery lake before smoltification. The transition in feeding behavior and diet from the time of emergence of the fry from stream or lakeshore to the time of smoltification takes many forms. In general, it is a shift from dependence on dipteran insects to pelagic zooplankton. The annual growth attained by juvenile sockeye and length of residence in fresh water varies greatly among populations in different lake systems, as well as between years within individual lakes. Factors affecting growth are highly complex and include (1) size and species composition of the food supply; (2) water temperature and thermal stratification of the lake; (3) photoperiod and length of growing season; (4) relative turbidity of the lake and available light intensity in the water column; (5) intra- and interspecific competition; (6) parasitism and disease; (7) feeding behavior of juvenile sockeye to minimize predation; and (8) migratory movements to seek favorable feeding environments. Growth influences durations of stay in fresh water before smoltification, and within many lake populations the larger members of a year class tend to migrate to sea earlier the spring or migrate a year earlier than smaller members. In the more southern systems, smoltification after 1 year is nearly universal. Size is not strictly the determinant for duration of stay in fresh water, because some populations with very poor freshwater growth in their first year migrate as yearlings, whereas other populations exhibiting good first-year growth migrate predominantly after a second year of growth. Emergent fry of Ariver spawning or sea type sockeye, which spawn in systems lacking lake rearing habitat, feed in the stream or low-salinity estuaries for several months before migrating to offshore ocean areas.

Sockeye fry at the beginning of lake life are between 25 and 31 mm and weigh between 0.1 and 0.2 g. Yearling smolts vary greatly in size; average range 60 to 125 mm and 2.0 to 30.0 g. After a second year of growth in a lake, 2-year-old smolts often overlap the size range of yearlings, and have been reported at an average of 200 mm and 84.0 g at Hidden Lake in central Alaska. Sea type sockeye smolts are typically the same size as yearling smolts when they migrate to offshore ocean areas.

After smoltification and exodus from natal river systems in spring or early summer, juvenile sockeye enter the marine environment where they reside for 1 to 4 years, usually 2 or 3 years, before returning to spawn. Depending on the stock, they may reside in the estuarine or nearshore environment before moving into oceanic waters. They are typically distributed in offshore waters by autumn following outmigration. During the initial marine period, yearling sockeye forage actively on a variety of organisms, apparently preferring copepods and insects, but also eating amphipods, euphausiids, and fish larvae when available. Their growth rate is about 0.6 mm/d.

After entering the open sea during their first summer, juvenile sockeye salmon remain in a band relatively close to the coast. Off the outer coast of British Columbia and southeast Alaska, the juveniles are often recorded on the open sea in late June. By July, the fish are found moving northwestward into the GOA. Sampling in the North Pacific has shown that by October juvenile sockeye are still somewhat distributed primarily nearshore. Evidence indicates the northwestward movement up the eastern Pacific rim is followed by a southwestward movement along the Alaska Peninsula. An offshore movement into the GOA in late autumn or winter is conjectured for the location of age 1 sockeye in early spring.

Adults: Sockeye salmon from different regions differ in growth rate and age and size at maturity. Growth in length is greatest during the first year at sea, and increase in weight is greatest during the second year. Most sockeye spend 2 to 3 years feeding in the ocean before their final summer of return. There is substantial variation in size among populations within an age class. In Alaska, the average size of females that had spent 2 years in the ocean ranged from 45 to 54 cm, and of those that had spent 3 years the average ranged from 51 to 60 cm.

Table 6 Habitat and biological associations of sockeye salmon, *Onchorynchus nerka*

Stage	Duration or Age	Diet/ Prey	Season/ Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs and larvae (alevins)	Eggs: 90 to 100 days larvae: 100 to 125 days	NA	Late summer, fall and winter	Water courses, rivers streams, sloughs; lakes, ponds	Intragravel	Cobble, gravel	NA	Develop at 1-10°C, eggs hatch about 100 d, alevins emerge from gravel about 125 d post hatch
Juveniles, Freshwater	1 to 3 years, fry emerge and move quickly to lakes, or, rarely, 3 to 4 months in estuaries	Copepods, bosminids, Daphnia chironomids dipterans, stoneflies	For yearling and older smolt, early to late summer for sea type run	water courses, rivers streams, sloughs; lakes, ponds; estuarine	Pelagic, neustonic	NA	NA	Preference pelagic feeding in lakes, usually not with other fishes, except when predators present
Juveniles, estuarine	1 to 4 months	Copepods, amphipods,	Spring, summer, fall	Beach (intertidal); estuarine, to 30 m	Pelagic, neustonic	NA	Upwelling, thermo- and pycnocline	Larger fish progressively farther from shore
Juveniles, marine	6 to 8 months	Copepods, amphipods, small fishes, squid mysids, euphausiids	Early summer to late winter	Beach (intertidal); inner and middle continental shelf; island passes; nearshore bays	Pelagic, neustonic	NA	Upwelling, thermo- and pycnocline	Movements from near-shore to offshore areas
Adult, immature and maturing, marine	1 to 4 years from smolt to mature adult	Copepods, amphipods, insects, small fishes, squid	Immature: year round 1 to 3 years	Beach (intertidal), inner/ middle/ outer continental shelf, upper and lower slope; basin; island passes; nearshore bays	Pelagic, neustonic	NA	Upwelling	Migration timing for different regional stock groups varies; earlier in the north, later in the south
Adults, freshwater	2 to 4 months	No active feeding in freshwater	Spawning migration (May-August)	Water courses, rivers streams, sloughs; lakes, ponds	Depth in streams <10 cm, depth in lakes to 20 m	Cobble, gravel	NA	Migration timing for different regional stock groups varies; earlier in the north, later in the south

A.2.6 Habitat Description for Chinook Salmon (*Oncorhynchus tshawytscha)*

Life History and General Distribution

Chinook salmon, also called king, spring, or tyee salmon, are the least abundant and largest of the Pacific salmon. 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. 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 (lat. ~34°) to Kotzebue Sound in Alaska (~66° N); in addition, the species has been identified in North America in the Mackenzie River, which drains into the Arctic Ocean. In Asia, natural populations of Chinook salmon have been documented from Hokkaido Island, Japan (~42° N) to the Andyr River in Russia (~64° N). Within this range, the largest rivers tend to support the largest aggregate runs of Chinook salmon and have the largest individual spawning populations. 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 River and the Fraser River, which are near the center of the species range along this Pacific coast.

In marine environments, Chinook salmon range widely throughout the North Pacific Ocean and the BS, from lat. 38° to 65°. The southern edge of the marine distribution expands and contracts seasonally and between years depending on ocean temperature patterns. While the marine distribution of Chinook salmon can be highly variable even within a population, there are general migration and ocean distribution patterns characteristic of populations in specific geographic areas. For example, Chinook salmon that spawn in rivers from the Rogue River in Oregon south to California disperse and rear in oceanic waters off the Oregon and California Coast, whereas those that spawn north of the Rogue River to southeast Alaska migrate north and westward along the Pacific coast. Some exceptions to these generalized migratory pattern exist, most notably Chinook salmon originating in Puget Sound which have a more localized migratory pattern. These migration patterns are of particular interest for the management of Chinook salmon in the EEZ off Alaska, as they result in the harvest of fish from Oregon, Washington, British Columbia, and Alaska within the management zone. For this reason, directed fisheries are managed under the purview of the U.S.-Canada Pacific Salmon Treaty.

Pacific salmon have a generalized life history that includes the incubation and hatching of embryos and 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, 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. At least 16 age categories of mature Chinook salmon have been documented, involving three possible freshwater ages and total ages of 2 to 8 years, reflecting the high variability within and among populations in length of freshwater, estuarine, and oceanic residency. Chinook salmon also demonstrate variable ocean migration patterns and timing of spawning migrations.

This variation in life history strategy has been explained by separating Chinook salmon into two races: stream- and ocean-type fish. Stream-type fish have long freshwater residence as juveniles (1 to 2 years), migrate rapidly to oceanic habitats, enter freshwater as immature or “bright” fish, and spawn far upriver in late summer or early fall. Ocean-type fish have short, highly variable freshwater residency (lasting up to a year), extensive estuarine residency, a more coastal-oriented ocean distribution, and spawn within a few weeks of freshwater entry in the lower portions of the watershed. Within these two types, there is also substantial variability. For example, adult run-timing is strongly influenced by in-river flow volumes and temperature levels.

Chinook salmon have distinctly different feeding habits and distribution and in ocean habitats than do other species of Pacific salmon. Chinook salmon are highly piscivorous, and are also distributed deeper in the water column than other species of Pacific salmon. While other species of salmon generally are surface oriented, utilizing primarily the upper 20 m, Chinook salmon tend to be at greater depths and are often associated with bottom topography. 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, and Chinook salmon are commonly encountered as bycatch in mid-water and bottom trawl fisheries.

Declines in the abundance of Chinook salmon have been well documented throughout the southern portion of the range. 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, and a number of evolutionarily significant units (ESUs) have been listed by National Marine Fisheries Service as at risk of extinction under the Endangered Species Act (ESA). Habitat degradation is the major cause for decline and extirpation of populations; most are related to dam construction. Urbanization, agricultural land use and water diversion, and logging are also factors contributing to habitat degradation and the decline of Chinook salmon. 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. Additionally, concern over coast-wide declines from southeast Alaska to the Pacific Northwest was a major factor leading to the signing of the Pacific Salmon Treaty between the United States and Canada in 1985 to share the burden of conservation and available harvest.

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, and minks, and birds such as gulls, eagles, and ravens. 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.

Approximate Upper Size Limit of Juvenile Fish: 71 cm total length. This is the regulatory minimum harvest size used in the Alaska hook-and-line fisheries in order to minimize catches of immature fish. However, because Chinook salmon can mature at ages of 2 to 8 total years, the term "juvenile" is better defined by physiological progress of maturation rather than a threshold size.

Habitat and Biological Associations

Chinook salmon occur over abroad geographic range, encompassing different ecotypes and very diverse habitats. Across the geographic range that the species has colonized, populations of Chinook salmon have developed localized adaptations to site specific characteristics. These local adaptations result in different and diverse characteristics of biological importance, including timing of spawning, adult and juvenile migration timing, age and size at maturity, duration of freshwater residency, and ocean distribution. Chinook salmon have been studied and managed intensively for decades. There is a large body of literature describing their biology and ecology. For freshwater habitats, however, habitat-specific information for Chinook salmon in particular watersheds is sparse, especially in the northern portion of the range, and for estuarine and marine habitats, there is little data beyond presence/absence or density information. The range in the amount of habitat specific information by life-history stage is reflected in the information levels assigned the different life-history stages.

Eggs/Spawning: Chinook salmon spawn in a broad range of habitats. They have been known to spawn in water ranging from a few centimeters deep to several meters deep, and in channel widths ranging from small tributaries 2 to 3 m wide to the main stems of large rivers such as the Columbia and Sacramento. Typically, redd (nest) size is 5 to 15 m^2, and water velocities are 40 to 60 cm/sec. The depth of the redd is inversely related to water velocity; generally the female buries her eggs in clean gravel, 20 to 36 cm deep. Because of their large size, Chinook salmon are able to spawn in higher water velocities and utilize coarser substrates than other salmon species. In general, female Chinook salmon select sections of the spawning stream with high subgravel flow. Because their eggs are the largest of the Pacific salmon, with a correspondingly small surface-volume ratio, they may be more sensitive to reduced oxygen levels and require a higher rate of irrigation. Fertilization of the eggs occurs simultaneous with deposition. Males compete for the right to breed with a spawning females. Chinook females remain on their redds 6 to 25 days after spawning, defending the area from superimposition of eggs from another female.

Larvae/Alevins: Fertilized eggs begin their 5- to 8-month period of embryonic development and growth in intragravel interstices. 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. Rates of egg development, survival, size of hatched alevins and percentage of deformed fry are related to temperature and oxygen levels during incubation. Generally, low oxygen levels are non-lethal early, but lethal late in development. Under natural conditions, 30 percent or less of the eggs survive to emerge from the gravel as fry.

Juveniles: Chinook salmon are typically 33 to 36 mm in length when they emerge from the incubation gravel. Residency in freshwater and size and timing of seawater migration are highly variable. Ocean-type fish can migrate seaward immediately after yolk absorption. The majority of ocean-type fish migrate at 30 to 90 days after emergence, but some fish move seaward as fingerlings in the late summer of their first year, while others overwinter and migrate as yearling fish. Stream-type fish, in contrast, generally spend at least 1 year in freshwater, migrating as 1- or 2-year-old fish. In Alaska, the stream-type life history predominates although ocean-type life histories have been documented in a few Alaska watersheds. 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 salt water. The stream/river ecosystem must provide adequate 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 principal foods in freshwater are larval and adult insects. The seaward migration of smolts is timed so that the smolts arrive in the estuary when food is plentiful. Migration and rearing habitats overlap. Stream flows during the migratory period tend to be high, which facilitates seaward movement and provides some sheltering from predation.

After entering saltwater, Chinook juveniles disperse to oceanic feeding areas. Ocean-type fish have more extended estuarine residency, tend to be more coastal oriented, and do not generally migrate as far as stream-type fish. Food in estuarine areas include epibenthic organisms, insects, and zooplankton.

Adults: Chinook salmon typically remain at sea for 1 to 6 years. They have been found in oceanic waters at temperatures ranging from 1 to 15°C. They do not concentrate at the surface as do other Pacific salmon, but are most abundant at depths of 30 to 70 m. Fish make up the largest component of their diet at sea, although squid, pelagic amphipods, copepods, and euphausiids are also important at times.

Ocean distribution patterns have been shown to be influenced by both genetics and environmental factors. 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 GOA, while those originating south of Cape Blanco migrate south and west into waters off Oregon and California. As a result, Chinook salmon that occur in the EEZ fishery in Alaska originate from the Oregon coast to southeast Alaska. Not all stocks within this large geographic area are distributed into the southeast Alaska fishery, however. For example, Puget Sound stocks do not normally migrate that far north.

Habitat Concerns

While habitat loss and alteration have reduced, and in some cases, extirpated Chinook salmon over a large portion of their southern range, both freshwater and marine habitat in Alaska remains largely intact. Losses of Chinook habitat have occurred as a result of development, such as mining, petroleum development, and logging. The oceanic environment of Chinook salmon is considered largely unchanged by anthropogenic activities, although offshore petroleum production and local, transitory pollution events such as oil spills do pose some degree of risk.

Offshore petroleum production and large-scale transport of petroleum occurs in the Alaska EEZ, although at this time there is no offshore production of petroleum in the commercial troll area of the EEZ. Offshore oil and gas development and transport will inevitably result in some oil entering the environment at levels exceeding background amounts. The Exxon Valdez oil spill was shown to have direct effects on the survival and habitats of pink salmon. Chinook salmon were not directly affected, because of their different habitat utilization in the spill area. In general, the early life history stages of fish are more susceptible to oil pollution than juveniles or adults.

By far, the most serious habitat concern for Chinook salmon is the degradation of the freshwater watersheds that support those stages of their life history. Dams and impoundments for hydroelectric power and water diversion have caused large-scale extirpation of Chinook salmon in the Pacific Northwest by eliminating access to anadromous fish, and have altered the spawning, rearing, and migration corridors of Chinook salmon in many watersheds. There are presently no dams in place or in planning that would block rivers used by Chinook salmon in Alaska. However, because many Chinook salmon harvested under the FMP for Alaska originate in the Pacific Northwest, these types of habitat impacts in other regions directly affect the Alaska fishery. Logging and associated road construction has resulted in degraded habitat by causing increased erosion and sedimentation, changes in temperature regimes, and changes in seasonal flow patterns. Timber harvest has been a major resource use in southeast Alaska, and it is increasing in southcentral Alaska. Timber harvest in the Pacific Northwest and British Columbia also impacts the Alaska fishery because of the presence of stocks from these regions in the Alaska EEZ.

Placer mining has caused serious degradation of Chinook habitats in some river systems, especially in Yukon River drainages. While these impacts are of concern, most of the stocks directly affected do not migrate into the Chinook fishery managed under the FMP.

Urbanization and coastal development can have pronounced effects on coastal ecosystems, particularly estuaries, through modification of the hydrography, biology, and chemistry in the developed area. Increased nutrient input, filling of productive wetlands, and influx of contaminants commonly occur with coastal development. These impacts can reduce or eliminate rearing potential for juvenile Chinook salmon. Increased levels of coastal development in Alaska as well as in the Pacific Northwest and British Columbia can be expected.

There is a definite south-north cline to the degree of habitat degradation and the status of Chinook populations in the eastern Pacific. Habitat degradation in Alaska is certainly a management concern, but to date has not had the degree of impacts on Chinook populations as in the Pacific Northwest. In southeast Alaska, logging is considered the largest potential threat to anadromous fish habitat. Relatively little logging has occurred, however, in watersheds supporting Chinook salmon in the region.

Table 7 Habitat and biological associations of Chinook salmon, *Oncorhynchus tshawytscha*

Stage - EFH Level	Duration or Age	Diet/Prey	Season/ Time	Location	Water Column	Bottom Type	Oceano-graphic/ Riverine Features	Other
Eggs and larvae (alevins)	50 to 250 days	NA	Late summer, fall, winter, early spring	Streambeds	Intragravel 20 to 80 cm deep	Gravel	Riverbed	**DO**< 3 mg/l lethal, optimum >7 **Temp** 0-17 C, Optimum 4-12 C
Juveniles (freshwater)	Days to years	Insect larvae and adults, zooplankton	Year-round, depending on race	Streams, sloughs, rivers	Surface to several meters	Varied	Pools, stream and river margins, woody debris	Extremely varied freshwater life history. **DO**< 2 mg/l lethal, optimum >7 **Temp** 0-22 C, Optimum 8-12 C
Juveniles (Estuary)	Days to 6 months	Copepods, euphausiids, amphipods, juvenile fish	Spring, summer, fall	Beach (intertidal); nearshore bays	Neustonic, pelagic	All bottom types	Estuarine, littoral	Sea-type can be estuarine dependent **Temp** 2-22 C, Optimum 8-12 C **Salinity** 0-33 ppt
Juvenile (marine)	6 to 9 months: Up to first marine annulus	Epipelagic fish, euphasiids, large copepods, pelagic amphipods	Spring-winter	Island passes; inner/ middle/ outer continental shelf; upper slope; basin	Pelagic	All bottom types	Upwelling, front, gyre, thermo- or pycnocline, edges	Initially surface oriented; some stocks move rapidly offshore, some remain nearshore. **Temp:** 1-15 C, Optimum 5-12 C
Immature and Maturing Adults (marine)	2 to 8 years of age	Epipelagic fish (herring, sand lance, smelt, anchovy), shrimp, squid	Year Round	Nearshore bays, island passés; inner/ middle/ outer continental shelf; upper slope; basin	Neustonic, pelagic	All bottom types	Upwelling, front, gyre, thermo- or pycnocline, edges	Not surface oriented until maturing. Use salinity gradients, olfaction for terminal homing. **Temp:** 5-22 C
Adults (freshwater)	2 weeks to 4 months	Little or none	Spawning: (July-Feb) Freshwater Migration: Year round, varies greatly among populations	Rivers, large streams and tributaries	0.5-10 m	Alluvial bottom types; gravel for spawning	Deep pools for resting, Riffles, pool-riffle transition for spawning	Entry timing to freshwater highly variable. **Temp:** 1-26 C, Optimum 4-15 C

A.2.7 Habitat Description for Coho Salmon (*Oncorhynchus kisutch*)

General Distribution and Life History

Coho salmon are widely distributed in cool areas of the North Pacific Ocean and most adjoining fresh and estuarine waters. Coho use more diverse habitats than other anadromous salmonids. They spawn in most accessible freshwater streams throughout their range, rear for at least 1 year in fresh or estuarine waters, and spend about 18 months at sea before reaching maturity. In North America, coho range along the Pacific coast from Monterey Bay, California, to Point Hope, Alaska, through the Aleutians. The species is most abundant in coastal areas from central Oregon north through southeast Alaska. In the southern part of their range, coho stocks are generally depressed from historical levels, and hatcheries are often used to supplement wild runs. Coho are cultured for market in several countries; attempts to establish self-sustaining coho runs in other areas of the world have had limited success.

In Alaska, most coho are wild fish with a distribution north to Point Hope on the eastern Chukchi Sea, west and south to the limits of United States territorial waters, and east to the Canadian border as far north as the Yukon River drainage. Compared to southern stocks, coho abundance in the Alaska Region for most stocks is considered stable.

Relevant Trophic Information

Adult coho provide important food for bald eagles, terrestrial mammals (e.g., brown bear, black bear, and river otter), marine mammals (e.g., Steller sea lion, harbor seal, beluga, and orca), and salmon sharks. Adults also transfer essential nutrients from marine to freshwater environments. Juveniles are eaten by a variety of birds (e.g., gulls, terns, kingfishers, cormorants, mergansers, herons), fish (e.g., Dolly Varden, steelhead, cutthroat trout, and arctic char), and mammals (e.g., mink and water shrew). Juvenile coho are also significant predators of pink salmon fry during their seaward migration.

Approximate Upper Size Limit of Juvenile Fish: 35 cm.

Habitat and Biological Associations

Juvenile and adult coho are highly migratory and depend on suitable habitat in their migration routes. Unobstructed passage and suitable water depth, water velocity, water quality, and cover are important elements in all migration habitat. Soon after emergence in spring, fry may move around considerably seeking optimal, unoccupied habitat for rearing. In fall, juveniles may migrate from summer rearing areas to areas with winter habitat. Such juvenile migrations may be extensive within the natal stream basin or between basins through salt water or connecting estuaries. Seaward migration of coho smolts occurs usually after 1-2 years in fresh water. The migration is timed primarily by photoperiod and occurs in spring, usually coincident with a spring freshet. During this transition, coho undergo major physiological changes to enable them to osmoregulate in salt water and are at that time, especially sensitive to environmental stress. At sea, juvenile Alaska coho generally migrate north and offshore into the North Pacific Ocean and Bering Sea. After 12 to 14 months at sea, they migrate to coastal areas and then along the coast to their natal streams.

Egg/Larvae: Fertilized eggs and larvae require incubation in porous substrate that allows constant circulation of cool, high-quality water that provides oxygen and removes waste. Interstitial space in the substrate must be great enough to allow growth and movement through the gravel to accommodate emergence. Sand or silt in the substrate can limit intragravel flow and trap emerging fry. As the yolk sac is absorbed, the larvae become photopositive and move through the substrate into the water column. Fry emerge between March and July, depending on when the eggs were fertilized and water temperature during development.

Juveniles (Fresh Water): In Alaska, juvenile coho usually spend 1-2 years in fresh or estuarine waters before migrating to sea, although they may spend up to 5 years where growth is slow. Coho need to attain a length of about 85 mm to become smolts. Coho smolt production is most often limited by the productivity of freshwater and estuarine habitats used for juvenile rearing. Survival from eggs to smolts is usually less than 2 percent. If spawning escapement is adequate, sufficient fry are usually produced to exceed the carrying capacity of rearing habitat. In this case, carrying capacity of summer habitat sets a density-dependent limit on the juvenile population. This summer population is then reduced by density-independent mortality over winter depending on the severity of winter conditions, fish size, and quality of winter habitat.

Coastal streams, lakes, estuaries, and tributaries to large rivers can all provide coho rearing habitat. The most productive habitats are in smaller streams less than fourth order having low-gradient alluvial channels with abundant pools often formed by large woody debris or fluvial processes. Beaver ponds can provide some of the best summer rearing areas for juvenile coho. Coho juveniles also may use brackish-water estuarine areas in summer and migrate upstream to fresh water to overwinter.

During the summer rearing stage, fish density tends to be highest in areas with abundant food (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. Coho grow best where water temperature is between 10 and 15EC, and dissolved oxygen (DO) is near saturation. Juvenile coho can tolerate temperatures between 0E and 26EC if changes are not abrupt. 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. Summer populations are usually constrained by density-dependent 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. Growth in summer is often density-dependent, and the size of juveniles in late summer is often inversely related to population density.

In winter, food is less important and territorial behavior fades. Juveniles aggregate in freshwater habitats that provide cover with relatively stable temperature, depth, velocity, and water quality. Winter mortality factors include hazardous conditions during winter peak stream flow, stranding of fish by ice damming, physiological stress from low temperature, and progressive starvation. In winter, juveniles prefer a narrower range of habitats than in summer, especially large mainstream pools, backwaters, and secondary channel pools with abundant large woody debris, and undercut banks and debris along riffle margins. Survival in winter, in contrast to summer, is generally not density-dependent, and varies directly with fish size and amount of cover and ponded water, and inversely with the magnitude of the peak stream flow.

The seaward migration of smolts in native stocks is typically in May and June, and is presumably timed so that the smolts arrive in the estuary when food is plentiful. Habitat requirements during seaward migration are similar to those of rearing juveniles, except that smolts tend to be more fragile and more susceptible to predation. High streamflow aids their migration by assisting them downstream and reducing their vulnerability to predators. Turbidity from melting glaciers may also provide cover from predators. Migration cover is also provided by woody debris and submerged riparian vegetation. Migrating smolts are particularly vulnerable to predation because they are concentrated and moving through areas of reduced cover where predators congregate. Mortality during seaward migration can exceed 50 percent.

Juveniles (Estuarine): Juvenile coho primarily use estuarine habitat during their first summer and also as they are leaving fresh water during their seaward migration. Intertidal sections of freshwater streams (i.e., stream-estuary ecotones) can be important rearing habitat for age 0 coho from May to October. These areas may account for one-quarter of the juvenile production in small streams. Growth in these areas is particularly rapid because of abundant invertebrate food. Habitats used include glides and pools during low tide, and coho occupy the freshwater lens during high tide. In fall, juvenile coho move upstream to fresh water to overwinter.

During seaward migration, coho smolts may be present in the estuary from May to August. Rapid growth during the early period in the estuary is critical to survival because of high size-dependent mortality from predation.

Juveniles (Marine): After leaving fresh water, coho in Alaska spend up to 4 months in coastal waters before migrating offshore and dispersing throughout the North Pacific Ocean and Bering Sea. Southeast Alaska juvenile coho are ubiquitous in inside waters from June to August at depths up to 50 m, and move offshore by September. Offshore, juvenile salmon are concentrated over the continental shelf within 37 km of shore where the shelf is narrow, but may extend to at least 74 km from shore in some areas. Stock-specific aggregations have not been noted at this stage. Marine invertebrates are the primary food when coho first enter salt water, and fish prey increase in importance as the coho grow.

Immature and Maturing Adults (Marine): Most coho occupy epipelagic areas in the central GOA and BS during the 12 to 14 months after leaving coastal areas. Some coho also use coastal and inshore waters at this life stage, but those are likely to be smaller at maturity. The spatial distribution of suitable habitat conditions is affected by annual and seasonal changes in oceanographic conditions; however, coho generally use offshore areas of the North Pacific Ocean and the Bering Sea from lat. 40° to 60° N. The distribution of ocean harvest is generally more northerly than that for stocks from other regions.

Growth is the objective at this stage of the coho life cycle, and bioenergetics are controlled mainly by food quantity, food quality, and temperature. Food for salmon is most abundant above the halocline, which may range from 100 to 200 m in depth in the North Pacific. The bioenergetics of growth is best in epipelagic offshore habitat where forage is abundant and sea surface temperature is between 12 and 15°C. Coho rarely use areas where sea surface temperature exceeds 15°C.

Most coho remain at sea for about 16 months before returning to coastal areas and entering fresh water to spawn, although some precocious males will return to spawn after about 6 months at sea. Before entering fresh water to spawn, most coho slow their feeding and begin to lose weight as they develop secondary sex characteristics. Survival from smolt to adult averages about 10 percent.

Adults (Freshwater): Adult coho enter fresh water from early July through December and spawn from September through January. Fidelity to natal streams is high and straying rates are generally less than 5 percent. The fish feed little and migrate upstream using olfactory cues that were imprinted in early development.

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. Upstream migrations are blocked where fall heights exceed 3.3 m or falls more than 1.2 m high have jumping pools less than 1.25 times the falls height. Blockages also occur where stream gradient exceeds 12 percent for more than 70 m, or 16 percent for more than 30 m, or 20 percent for more than 15 m, or 24 percent for more than 8 m.

Spawning sites selected for use have relatively silt-free gravels ranging from 2 mm to 10 cm in diameter, well-oxygenated intra-gravel flow, and nearby cover. In Alaska streams, between 2,500 and 4,000 eggs are deposited among several nests by each female coho. Several males may attend each female, but larger males usually dominate by driving off smaller males. Soon after spawning, adult coho die in or near the spawning areas.

Table 8 Habitat and biological associations of coho salmon (*Oncorhynchus kisutch*)

Stage -EFH Level	Duration or Age	Diet/Prey	Season/ Time	Location	Water Column	Bottom Type	Oceanographic/ Riverine Features	Other
Eggs/ Larvae	150 days at optimum temperature	NA	Fall/ winter	Water courses, rivers, streams, sloughs; lakes, ponds	Intra-gravel	Gravel	Streambed	DO < 2 mg/l lethal, optimum >8 mg/l; Temperature 0-17°C; optimum 4.4-13.3°C; substrate 2-10 cm with <15 percent fines (<3.3 mm), optimum <5 percent fines
Juveniles, Freshwater (fry to smolt)	1 to 5 years, most (>90 percent) 1 to 2 years	Invertebrates and fish	Entire year	Water courses, rivers, streams, sloughs; lakes, ponds	Entire column	N/A	Pools, woody debris, currents for migration	DO lethal at <3 mg/l, optimum at saturation; Temperature 0-26°C; optimum 12-14°C.
Juveniles, Estuarine	1 to 6 months	Invertebrates and fish	Rearing - summer, Migration - spring	Estuarine	Mid-water and surface, pelagic; neustonic	N/A	Pools, glides, etc.	
Juveniles, Marine	Up to 4 months	fish and invertebrates	June - September	Beach (intertidal), inner/ middle continental shelf; nearshore bays; island passes	Pelagic; neustonic	N/A	Upwelling, thermo- or pycnocline	Temperature <15°C; Depth <10 m
Immature/ Maturing Adults, Marine	12 to 14 months	Fish (e.g., herring, sand lance)		Beach (intertidal), inner/ middle continental shelf; upper and lower slope; basin; nearshore bays; island passes	Pelagic; neustonic	N/A	Upwelling	Temperature range 1-26°C; optimum 12-14°C
Adults, Freshwater	Up to 2 months	Little or none	migration - fall; spawning - fall, winter	Water courses, rivers, streams, sloughs; lakes, ponds	Deep parts of streams and lakes	Alluvial bottom types	Deep pools, Pool-riffle transition	Temperature range 1-26°C; optimum 12-14°C

A.3 Essential Fish Habitat

Essential Fish Habitat (EFH) is defined in the Magnuson-Stevens Act as “those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity”. For the purpose of interpreting the definition of essential fish habitat: “waters” includes aquatic areas and their associated physical, chemical, and biological properties that are used by fish, and may include areas historically used by fish where appropriate; "substrate" includes sediment, hard bottom, structures underlying the waters, and associated biological communities; "necessary" means the habitat required to support a sustainable fishery and a healthy ecosystem; and "spawning, breeding, feeding, or growth to maturity" covers a species' full life cycle.

EFH is determined to be the general distribution of a species described by life stage. General distribution is a subset of a species' total population distribution, and is identified as the distribution of 95 percent of the species population, for a particular life stage, if life history data are available for the species. Where information is insufficient and a suitable proxy cannot be inferred, EFH is not described. General distribution is used to describe EFH for all stock conditions whether or not higher levels of information exist, because the available higher level data are not sufficiently comprehensive to account for changes in stock distribution (and thus habitat use) over time.

EFH is described for FMP-managed species by life stage as general distribution using guidance from the EFH Final Rule (67 FR 2343), including the EFH Level of Information definitions. Analytical tools are used and recent scientific information is incorporated for each life history stage from scientific habitat assessment reports. EFH descriptions include both text (see section 3.1) and a map (see section 3.2), if information is available for a species particular life stage.

EFH descriptions are interpretations of the best scientific information. In support of this information, a thorough review of FMP species is contained in the Environmental Impact Statement for Essential Fish Habitat Identification and Conservation (NMFS 2005) (EFH EIS) in Section 3.2.1, Biology, Habitat Usage, and Status of Magnuson-Stevens Act Managed Species and detailed by life history stage in Appendix F: EFH Habitat Assessment Reports. This EIS was supplemented by two 5-year reviews, which re-evaluated EFH descriptions, maps, and fishing and non-fishing impacts on EFH in light of new information (Simpson et al. 2017). The EFH descriptions are risk averse, supported by scientific rationale, and account for changing oceanographic conditions, regime shifts, and the seasonality of migrating salmon stocks.

A.3.1 Descriptions and Maps of Essential Fish Habitat

EFH descriptions and maps are based on the best available scientific information. The EFH maps show freshwater and marine salmon EFH. The freshwater EFH is based on the ADF&G's *Catalogue of Waters Important for the Spawning, Rearing, or Migration of Anadromous Fishes* (ADF&G 1998a). Marine EFH maps are based on Echave et al. (2012). As a disclaimer, the salmon distributions in the marine EFH maps are based on intermittent survey data and documented occurrences, and known habitat associations, and therefore should not be used to infer EEZ wide species distribution and density.

A summary of the habitat information levels for each species, as described in the EFH regulations at 50 CFR 600.815(a)(1)(iii), is listed in Table 9. A "1" indicates that general distribution data are available for some or all portions of the geographic range of the species.

Table 9 EFH Information Levels for Alaska Stocks of Pacific Salmon

Salmon Species	Freshwater Eggs	Freshwater Larvae and Juveniles	Estuarine Juveniles	Marine Juveniles	Marine Immature and Maturing Adults	Freshwater Adults
Pink	1	1	1	1	1	1
Chum	1	1	1	1	1	1
Sockeye	1	1	1	1	1	1
Chinook	1	1	1	1	1	1
Coho	1	1	1	1	1	1

A.3.1.1 Pink Salmon

Freshwater Eggs

EFH for pink salmon eggs is the general distribution area for this life stage, located in gravel substrates in those waters identified in ADF&G's *Catalogue of Waters Important for the Spawning, Rearing, or Migration of Anadromous Fishes* (ADF&G 1998a).

Freshwater Larvae and Juveniles

EFH for larval and juvenile pink salmon is the general distribution area for this life stage, located in those waters identified in ADF&G's *Catalogue of Waters Important for the Spawning, Rearing, or Migration of Anadromous Fishes* (ADF&G 1998a) and contiguous rearing areas within the boundaries of ordinary high water during the spring, generally migrate in darkness in the upper water column. Fry leave streams in within 15 days and the duration of migration from a stream towards sea may last 2 months.

Estuarine Juveniles

Estuarine EFH for juvenile pink salmon is the general distribution area for this life stage, located in estuarine areas, as identified by the salinity transition zone (ecotone) and the mean higher tide line, within nearshore waters and generally present from late April through June.

Marine Juveniles

Marine EFH for juvenile pink salmon is the general distribution area for this life stage, located in marine waters off the coast of Alaska from the mean higher tide line to the 200-nautical mile (nm) limit of the U.S. EEZ, including the GOA, EBS, Chukchi Sea, and Arctic Ocean. Juvenile pink salmon distribute within coastal waters along the entire shelf (0 to 200m) from mid-summer until December; then migrate to pelagic waters (upper 50m) of the slope (200 to 3,000m).

Marine Immature and Maturing Adults

Marine EFH for immature and maturing adult pink salmon is the general distribution area for this life stage, located in marine waters off the coast of Alaska to depths of 200 m and range from the mean higher tide line to the 200-nm limit of the U.S. EEZ, including the GOA, EBS, Chukchi Sea, and Arctic Ocean. Mature adult pink salmon are present from fall through the mid-summer in pelagic waters (upper 50m) of the slope (0-200m) before returning to spawn in intertidal areas and coastal streams.

Freshwater Adults

EFH for pink salmon is the general distribution area for this life stage, located in freshwaters identified in ADF&G's *Catalogue of Waters Important for the Spawning, Rearing, or Migration of Anadromous Fishes* (ADF&G 1998a) and wherever there are spawning substrates consisting of medium to course gravel containing less than 15 percent fine sediment (less than 2-mm diameter), 15 to 50 cm in depth from June through September.

Figure 4 EFH Distribution for Freshwater Pink Salmon – Southeastern Region

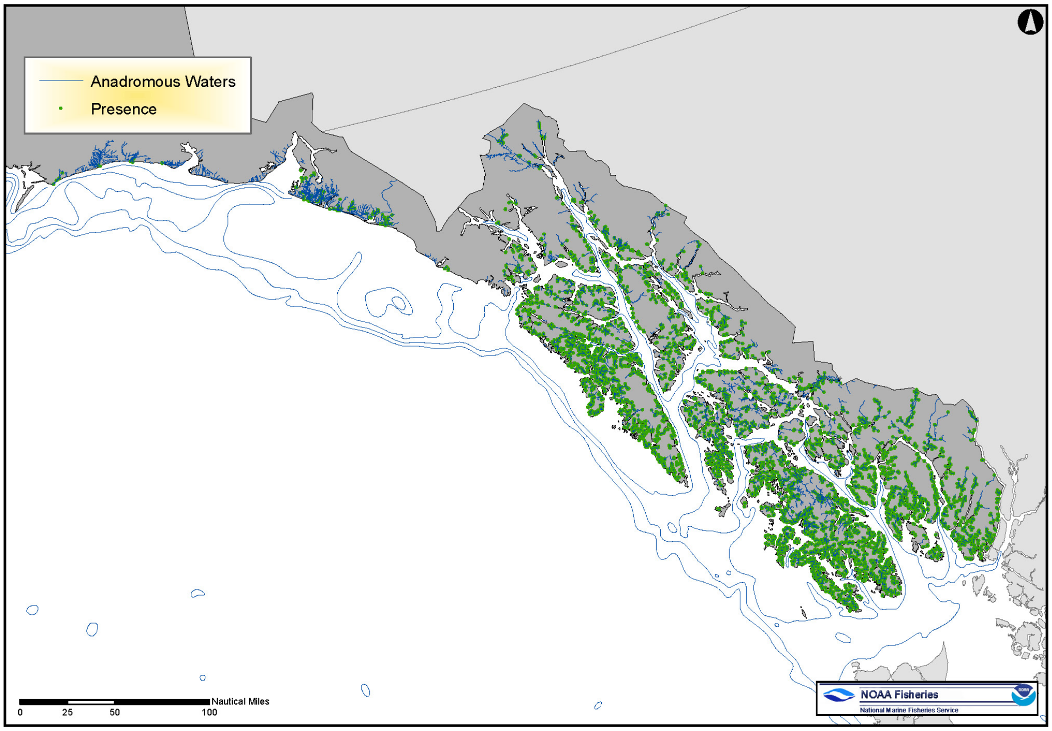


Figure 5 EFH Distribution for Freshwater Pink Salmon - South-Central Region

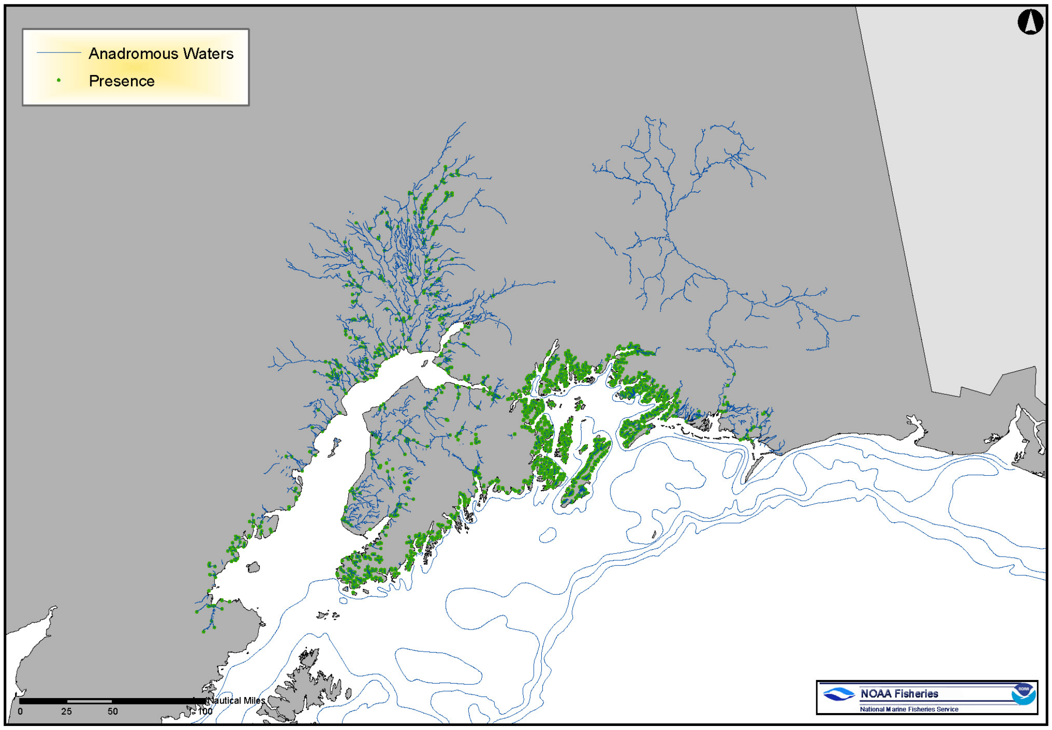


Figure 6 EFH Distribution for Freshwater Pink Salmon – Southwestern Region

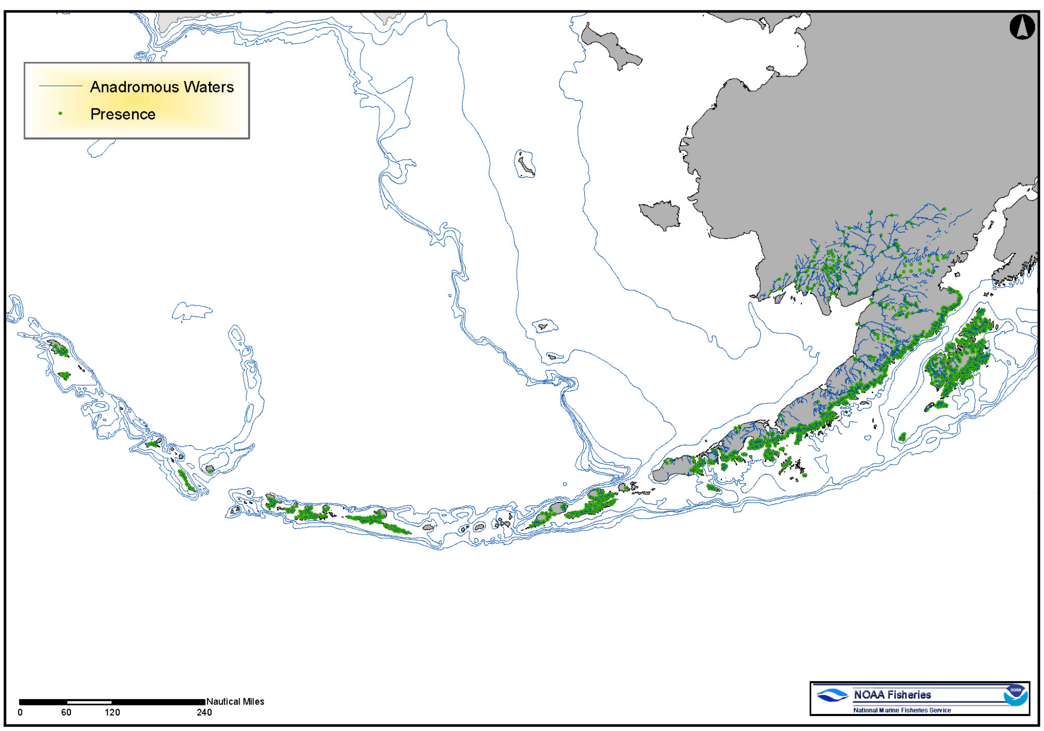


Figure 7 EFH Distribution for Freshwater Pink Salmon – Western Region

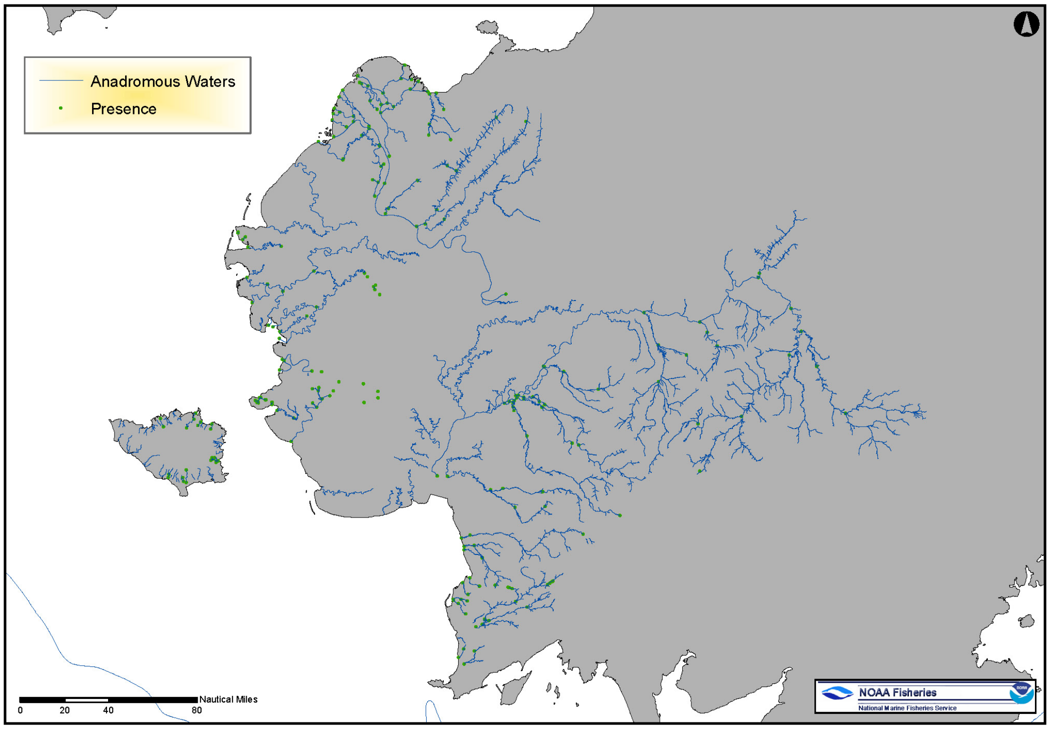


Figure 8 EFH Distribution for Freshwater Pink Salmon – Arctic Region

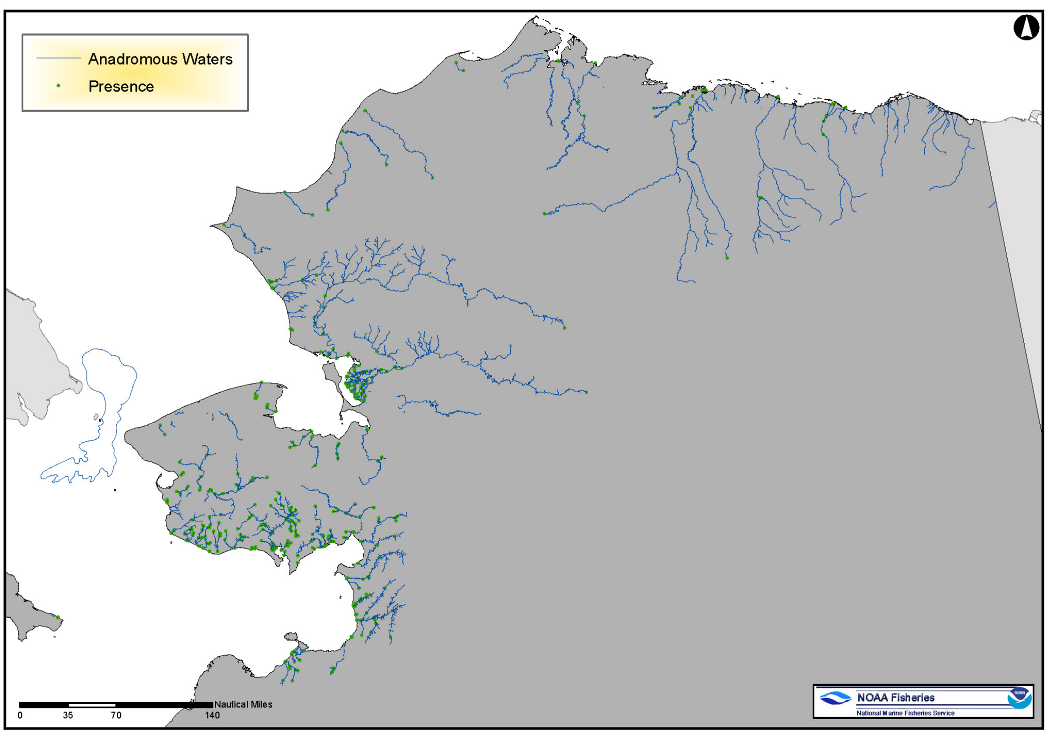


Figure 9 EFH Distribution for Freshwater Pink Salmon – Interior Region

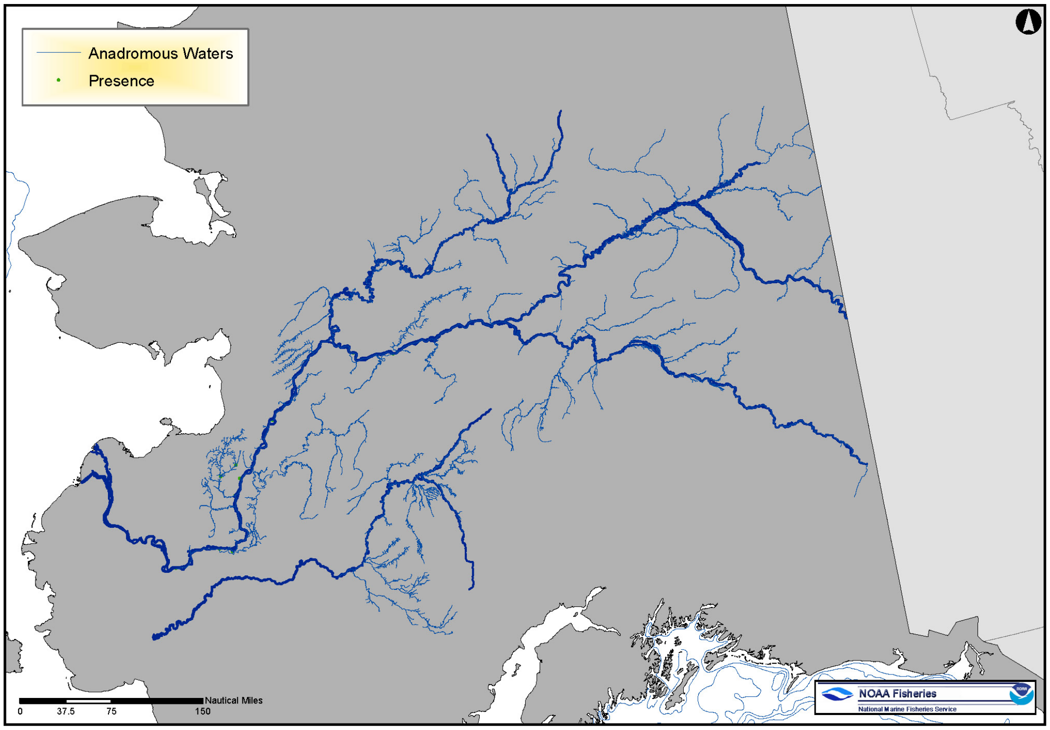


Figure 10 Pink salmon juvenile marine life history stage EFH map

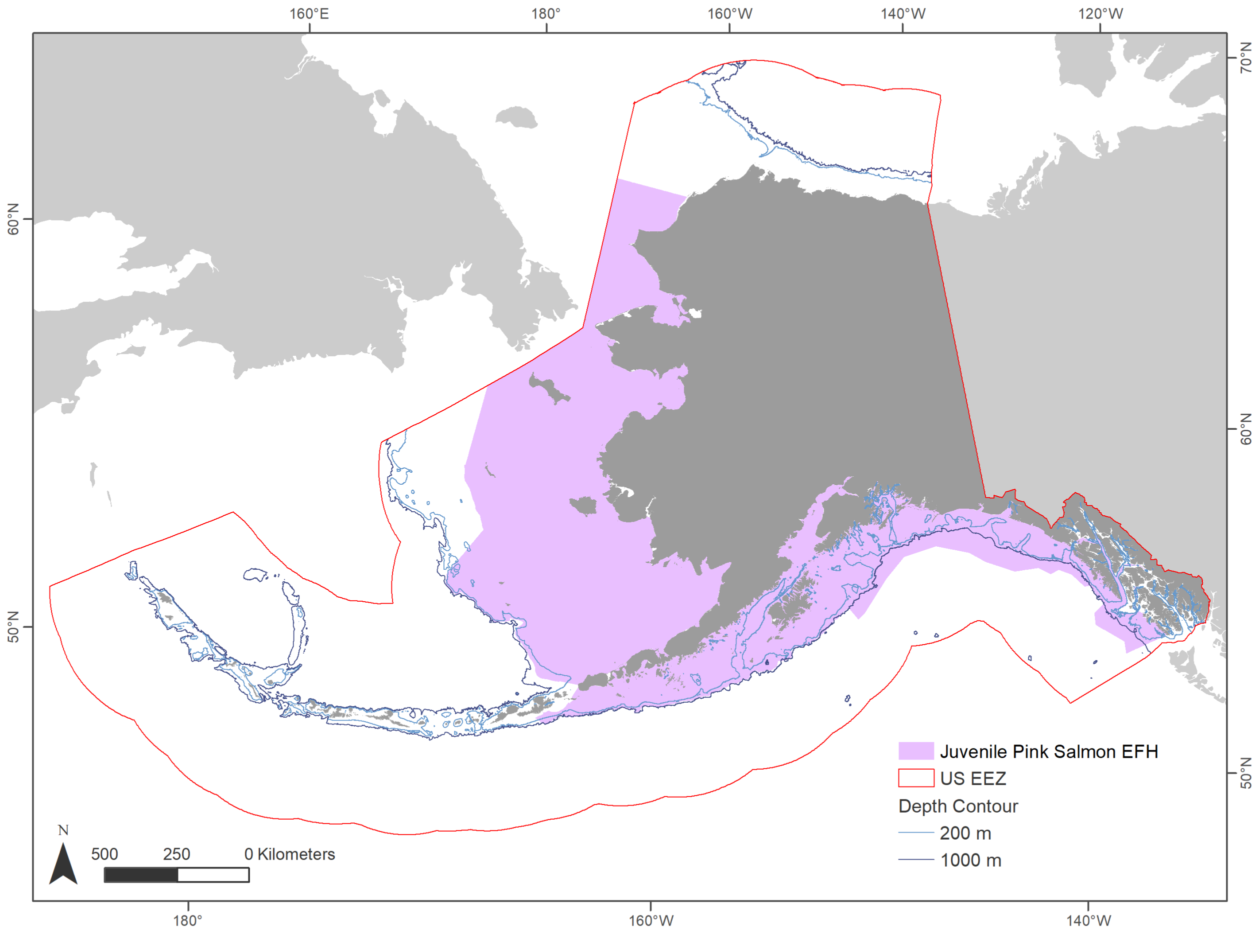
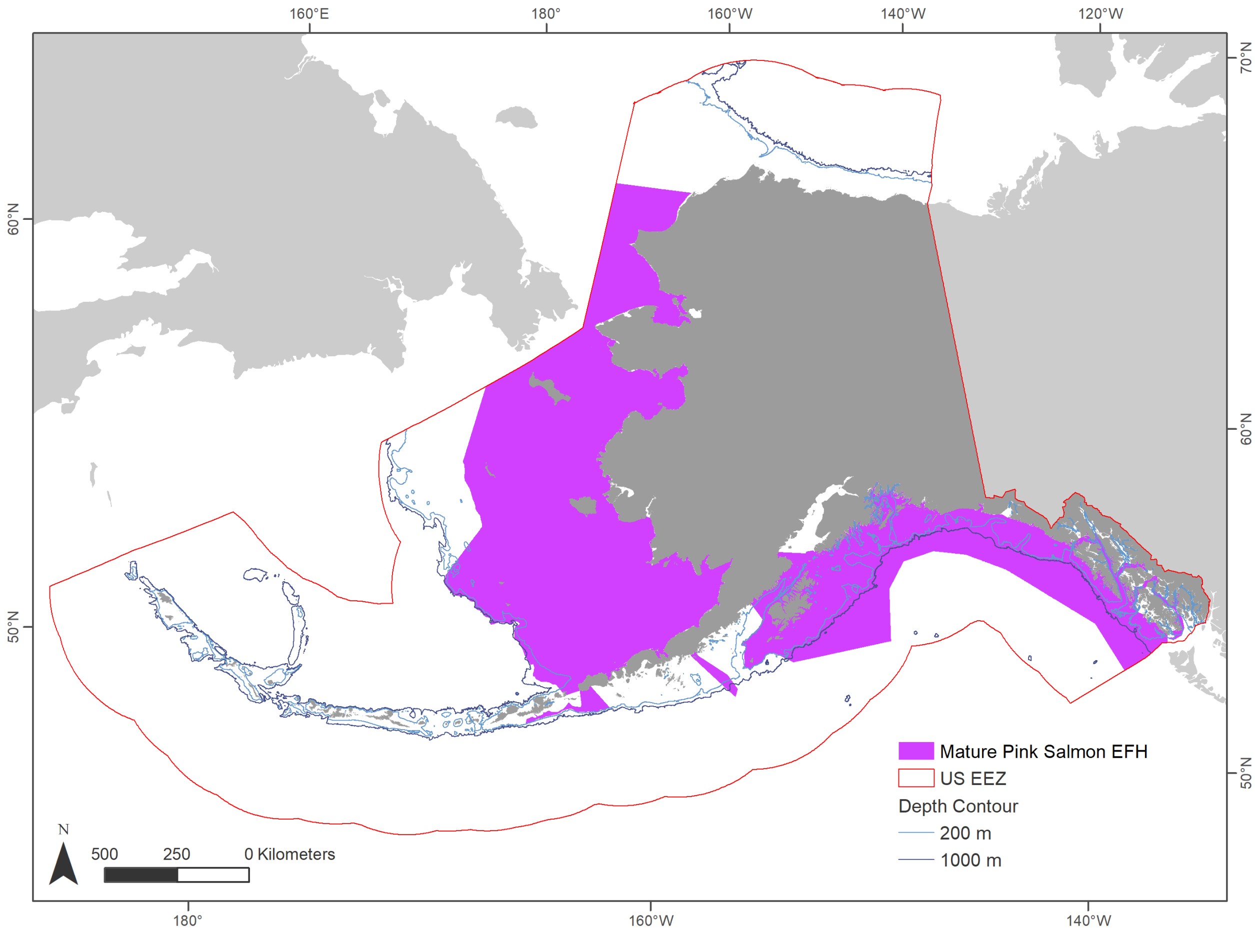


Figure 11 Pink salmon mature marine life history stage EFH map



A.3.1.2 Chum Salmon

Freshwater Eggs

EFH for chum salmon eggs is the general distribution area for this life stage, located in gravel substrates in those waters identified in ADF&G's *Catalogue of Waters Important for the Spawning, Rearing, or Migration of Anadromous Fishes* (ADF&G 1998a).

Freshwater Larvae and Juveniles

EFH for larval and juvenile chum salmon is the general distribution area for this life stage, located in those waters identified in ADF&G's *Catalogue of Waters Important for the Spawning, Rearing, or Migration of Anadromous Fishes* (ADF&G 1998a) and contiguous rearing areas within the boundaries of ordinary high water and contiguous rearing areas within the boundaries of ordinary high water during the spring, generally migrate in darkness in the upper water column. Fry leave streams in within 15 days and the duration of migration from a stream towards sea may last 2 months.

Estuarine Juveniles

Estuarine EFH for juvenile chum salmon is the general distribution area for this life stage, located in estuarine areas, as identified by the salinity transition zone (ecotone) and the mean higher tide line, within nearshore waters from late April through June.

Marine Juveniles

Marine EFH for juvenile chum salmon is the general distribution area for this life stage, located in marine waters off the coast of Alaska to approximately 50 m in depth from the mean higher tide line to the 200-nm limit of the EEZ, including the GOA, EBS, Chukchi Sea, and Arctic Ocean.

Marine Immature and Maturing Adults

EFH for immature and maturing adult chum salmon is the general distribution area for this life stage, located in marine waters off the coast of Alaska to depths of 200 m and ranging from the mean higher tide line to the 200-nm limit of the EEZ, including the GOA, EBS, Chukchi Sea, and Arctic Ocean.

Freshwater Adults

EFH for chum salmon is the general distribution area for this life stage, located in freshwaters identified in ADF&G's *Catalogue of Waters Important for the Spawning, Rearing, or Migration of Anadromous Fishes* (ADF&G 1998a) and wherever there are spawning substrates consisting of medium to course gravel containing less than 15 percent fine sediment (less than 2-mm diameter) and finer substrates can be used in upwelling areas of streams and sloughs from June through January.

Figure 12 EFH Distribution for Freshwater Chum Salmon – Southeastern Region

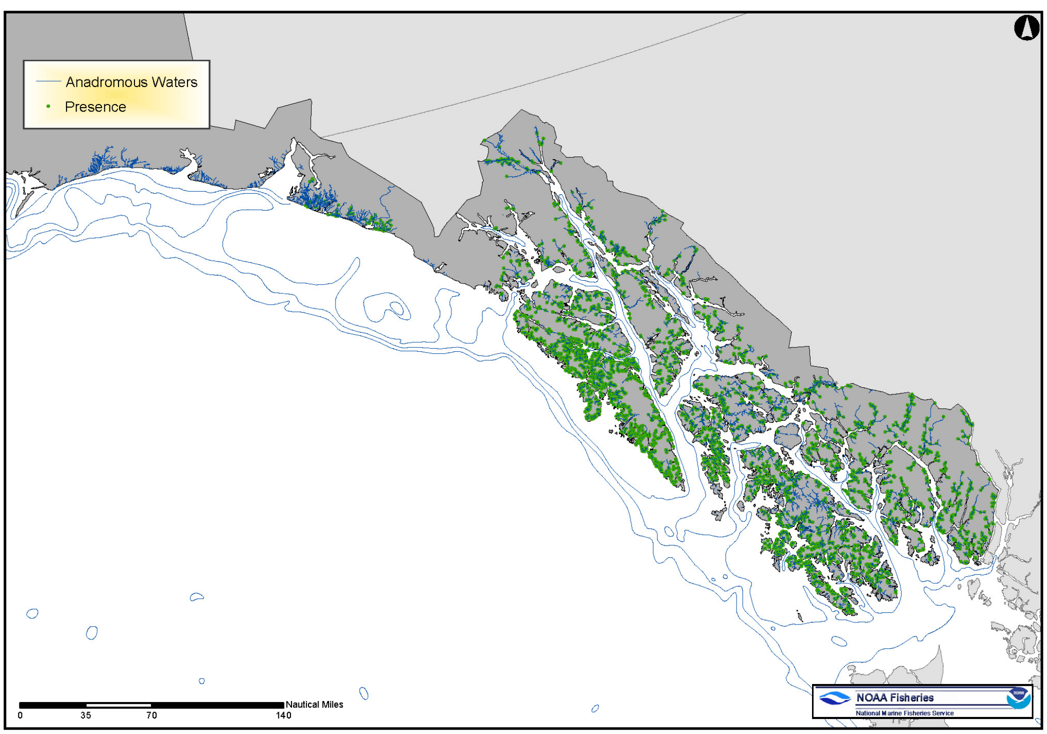


Figure 13 EFH Distribution for Freshwater Chum Salmon – South-Central Region

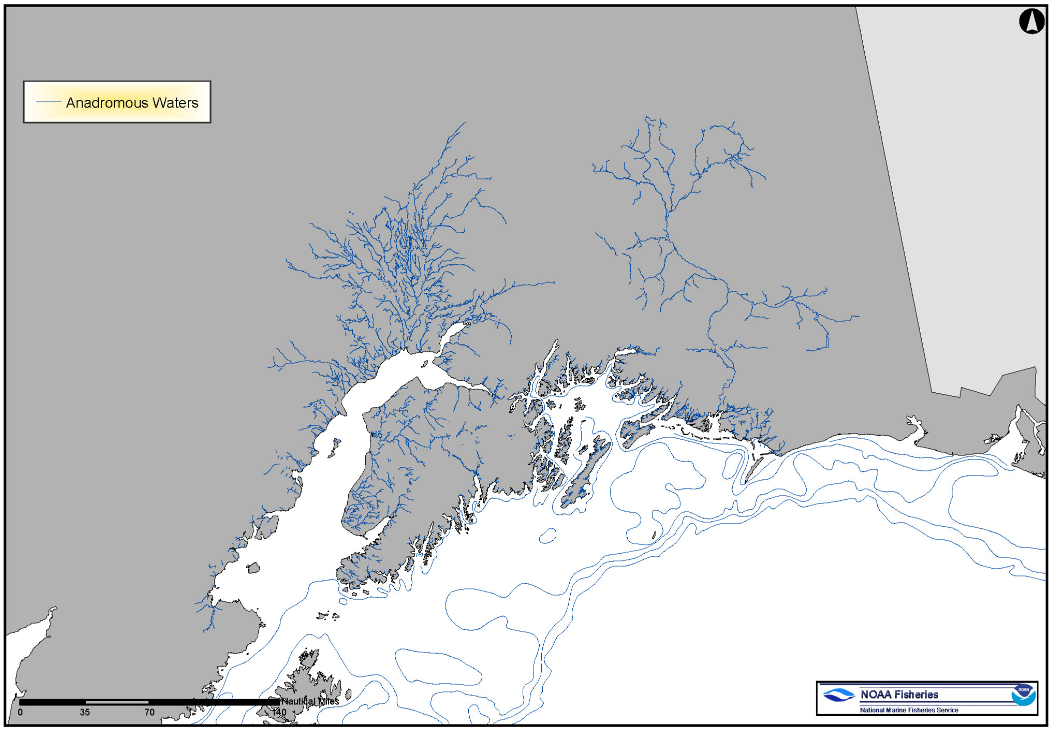


Figure 14 EFH Distribution for Freshwater Chum Salmon – Southwestern Region

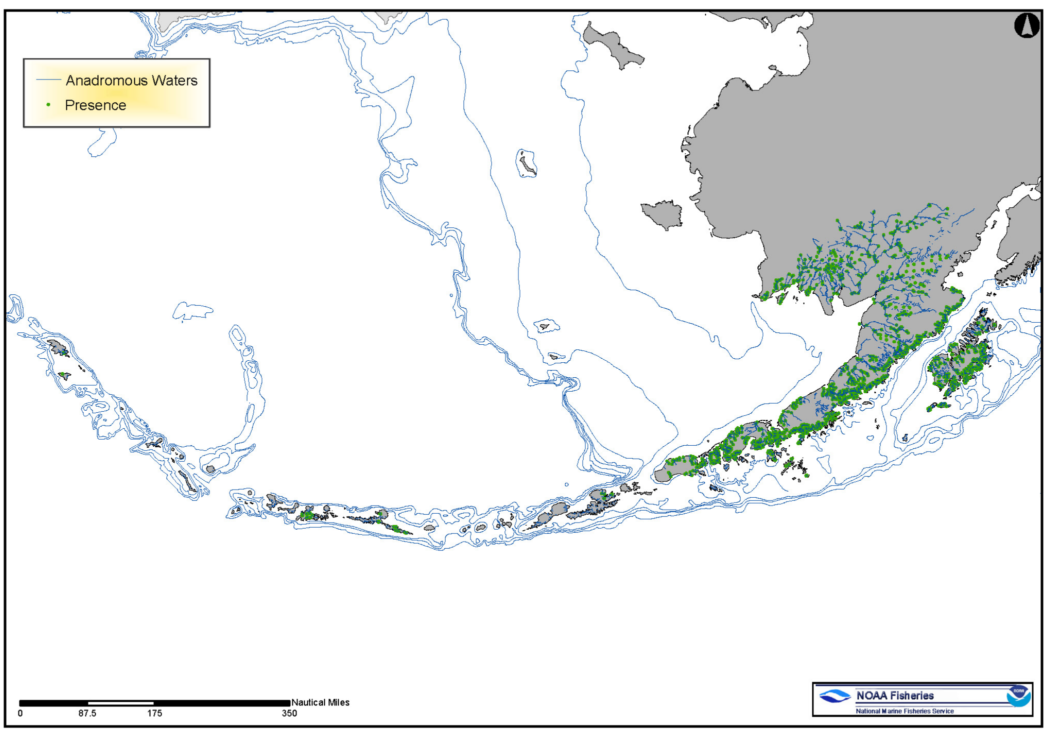


Figure 15 EFH Distribution for Freshwater Chum Salmon – Western Region

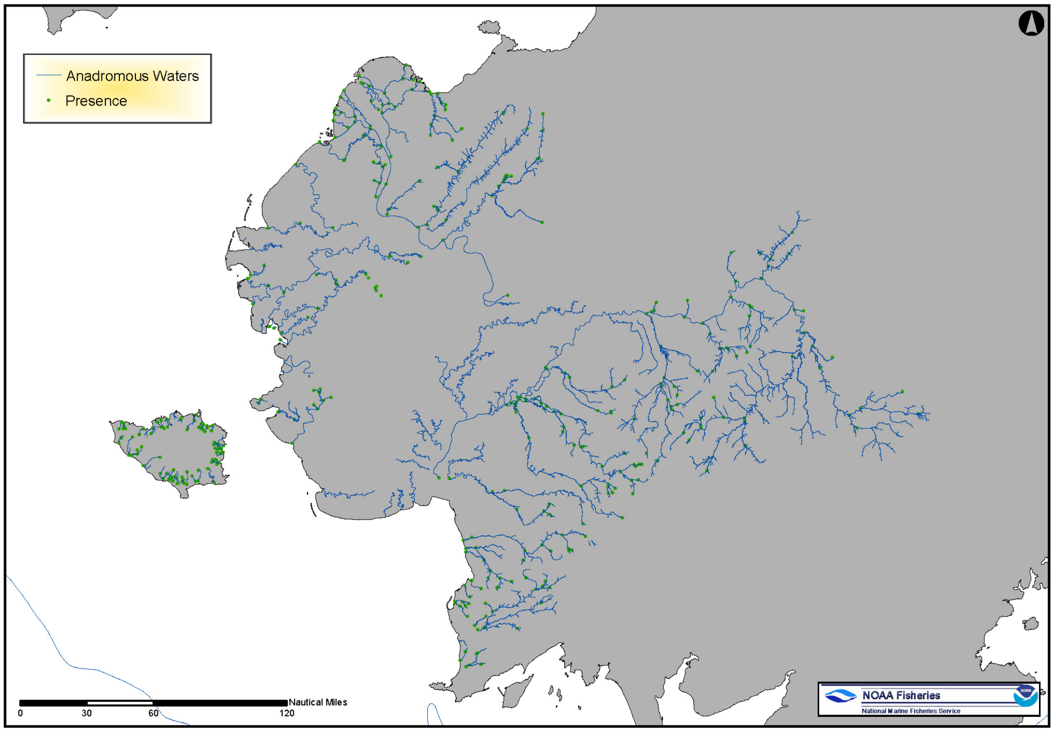


Figure 16 EFH Distribution for Freshwater Chum Salmon – Arctic Region

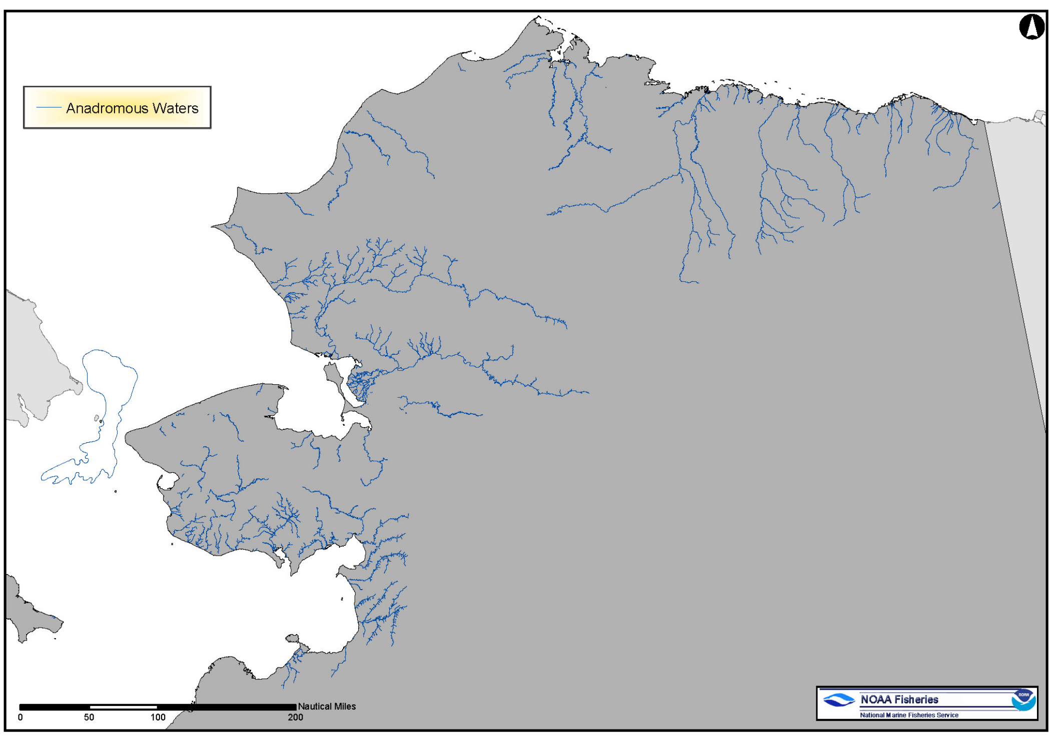


Figure 17 EFH Distribution for Freshwater Chum Salmon – Interior Region

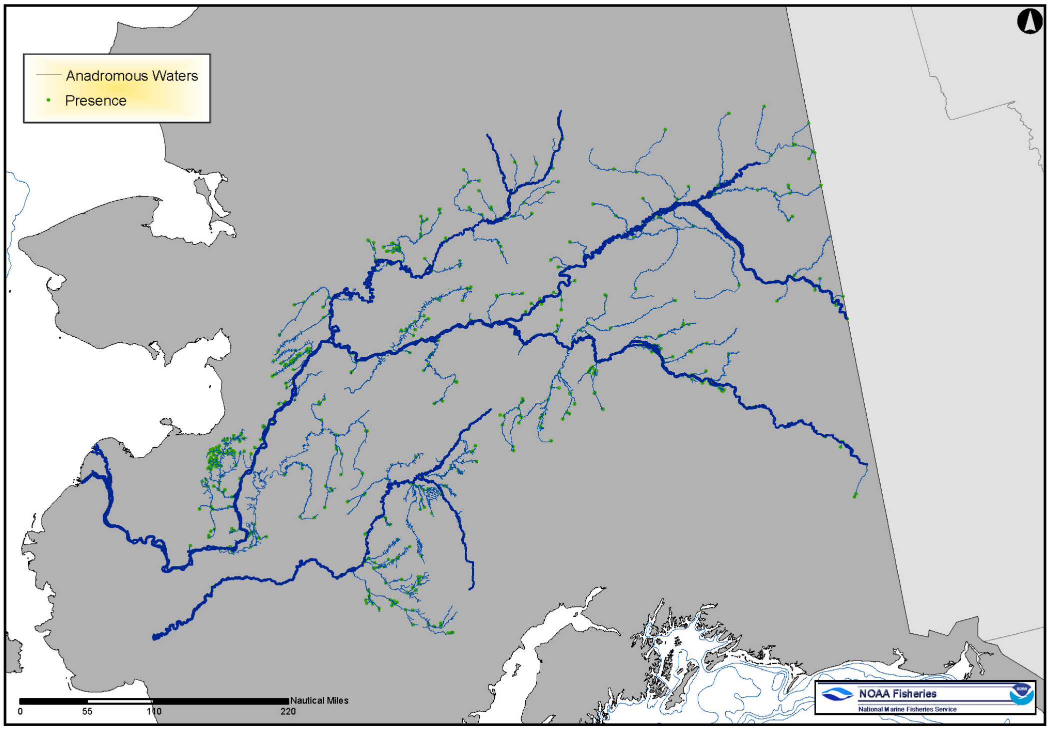


Figure 18 Chum salmon juvenile marine life history stage EFH map

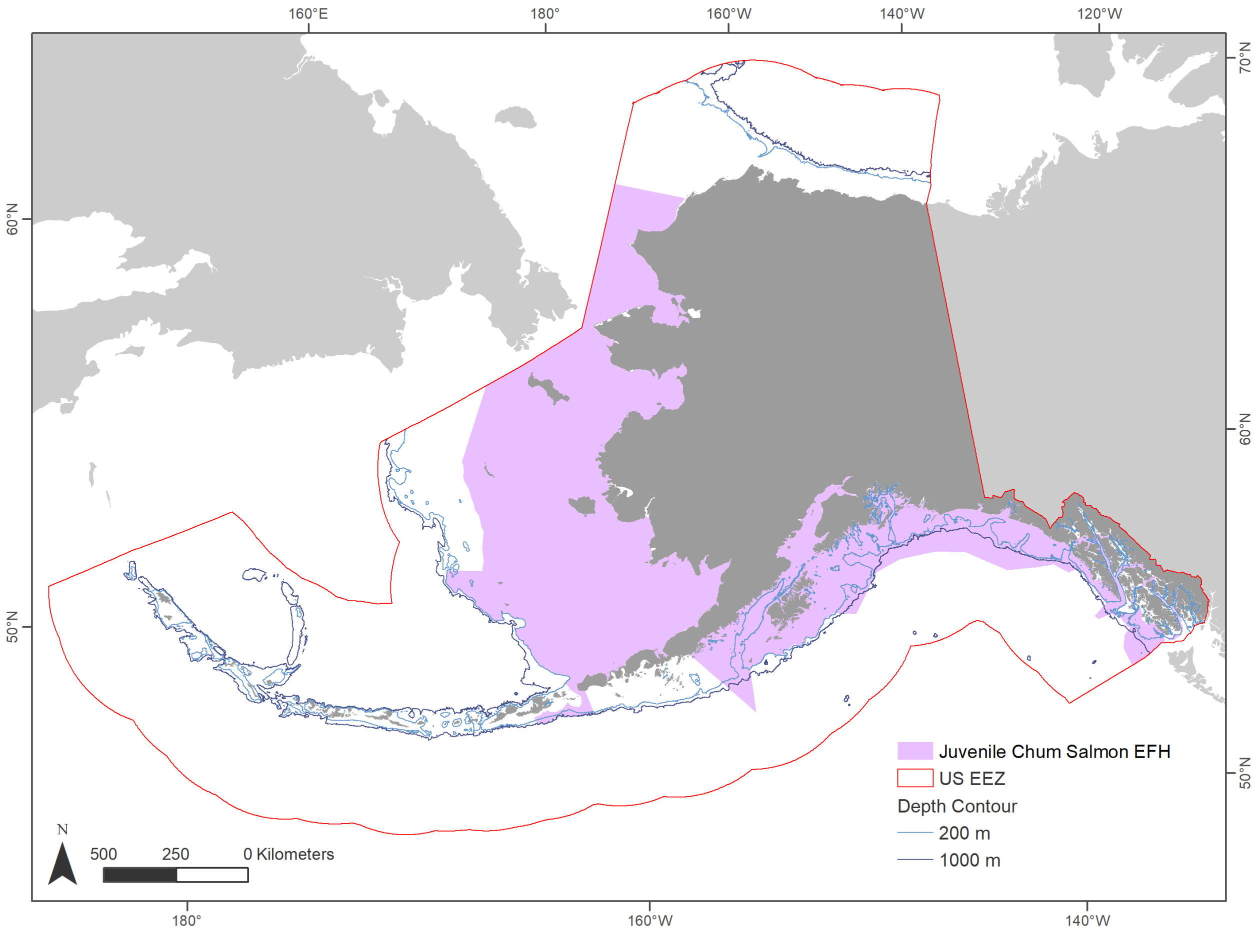


Figure 19 Chum salmon immature marine life history stage EFH map

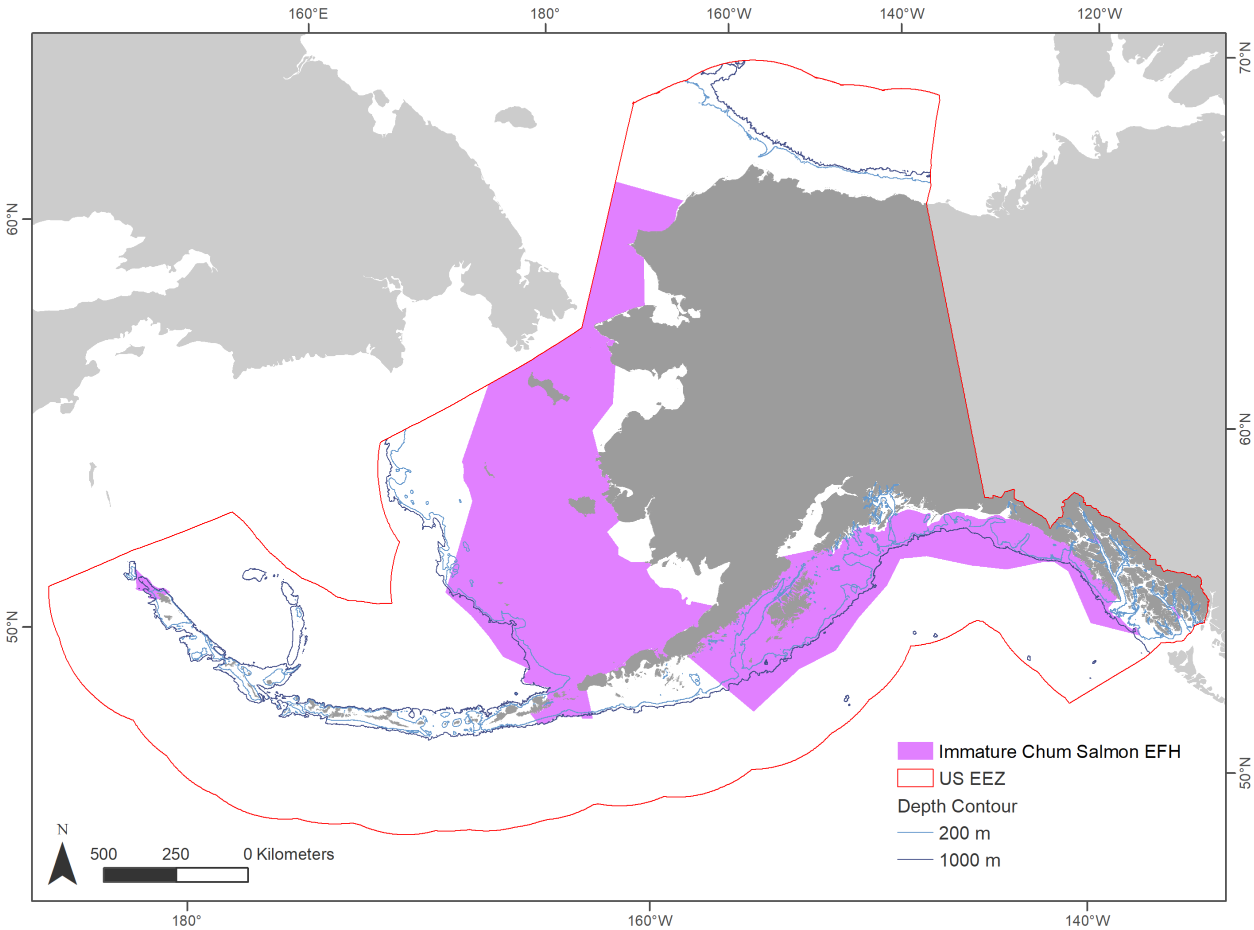
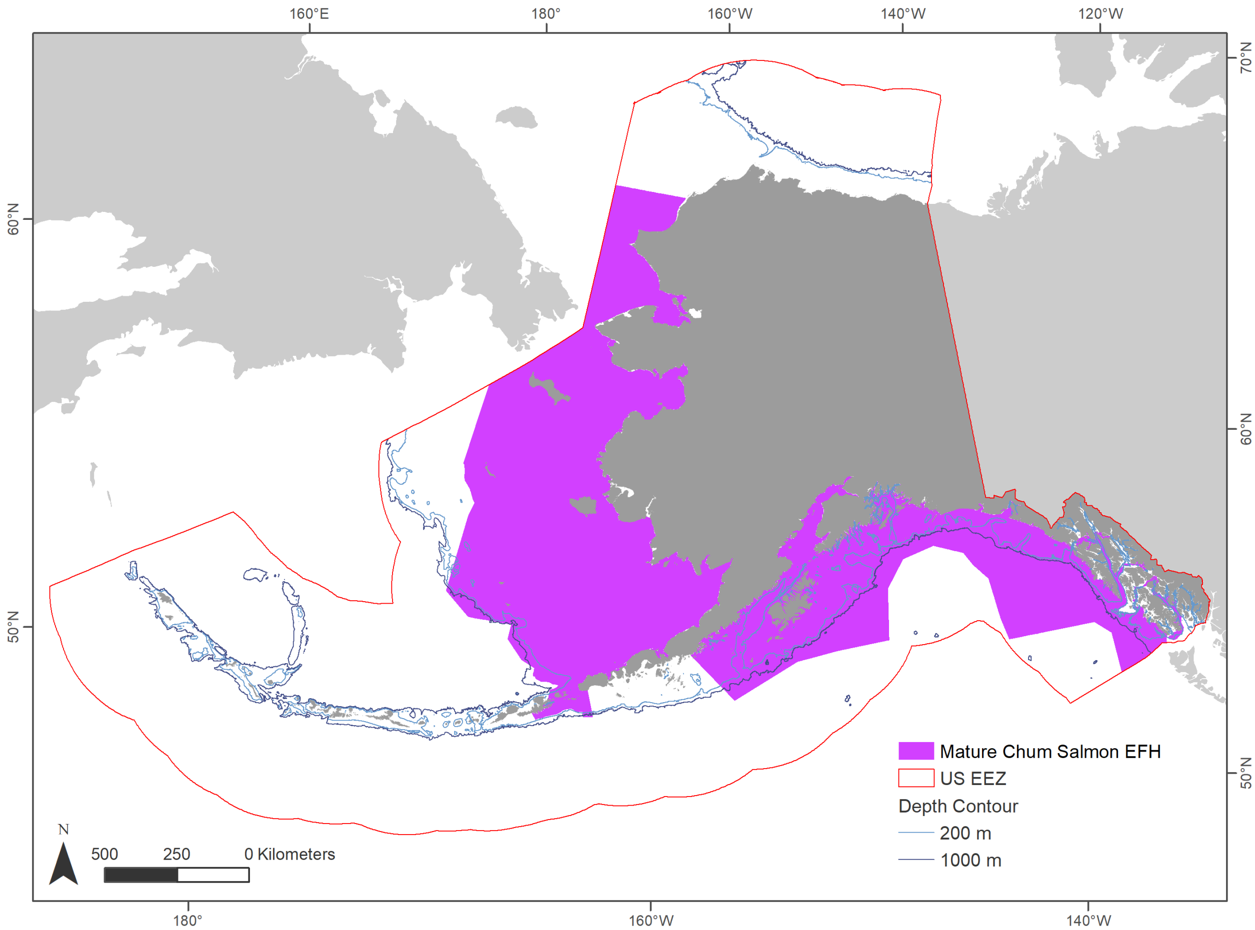


Figure 20 Chum salmon mature marine life history stage EFH map



A.3.1.3 Sockeye Salmon

Freshwater Eggs

EFH for sockeye salmon eggs is the general distribution area for this life stage, located in gravel substrates in those waters identified in ADF&G's *Catalogue of Waters Important for the Spawning, Rearing, or Migration of Anadromous Fishes* (ADF&G 1998a).

Freshwater Larvae and Juveniles

EFH for larval and juvenile sockeye salmon is the general distribution area for this life stage, located in those waters identified in ADF&G's *Catalogue of Waters Important for the Spawning, Rearing, or Migration of Anadromous Fishes* (ADF&G 1998a) and contiguous rearing areas within the boundaries of ordinary high water. Juvenile sockeye salmon require year-round rearing habitat. Fry generally migrate downstream to a lake or, in systems lacking a freshwater lake, to estuarine and riverine rearing areas for up to 2 years. Fry out migration occurs from approximately April to November and smolts generally migrate during the spring and summer.

Estuarine Juveniles

Estuarine EFH for juvenile sockeye salmon is the general distribution area for this life stage, located in estuarine areas, as identified by the salinity transition zone (ecotone) and the mean higher tide line, within nearshore waters. Under-yearling, yearling, and older smolts occupy estuaries from March through early August.

Marine Juveniles

Marine EFH for juvenile sockeye salmon is the general distribution area for this life stage, located in marine waters off the coast of Alaska to depths of 50 m and range from the mean higher tide line to the 200-nm limit of the U.S. EEZ, including the GOA, EBS, Chukchi Sea, and Arctic Ocean from mid-summer until December of their first year at sea.

Marine Immature and Maturing Adults

EFH for immature and maturing adult sockeye salmon is the general distribution area for this life stage, located in marine waters off the coast of Alaska to depths of 200 m and range from the mean higher tide line to the 200-nm limit of the U.S. EEZ, including the GOA, EBS, Chukchi Sea, and Arctic Ocean.

Freshwater Adults

EFH for sockeye salmon is the general distribution area for this life stage, located in freshwaters identified in ADF&G's *Catalogue of Waters Important for the Spawning, Rearing, or Migration of Anadromous Fishes* (ADF&G 1998a) and wherever there are spawning substrates consisting of medium to course gravel containing less than 15 percent fine sediment (less than 2-mm diam.) and finer substrates can be used in upwelling areas of streams and sloughs from June through September. Sockeye often spawn in lake substrates, as well as in streams.

Figure 21 EFH Distribution for Freshwater Sockeye Salmon – Southeastern Region

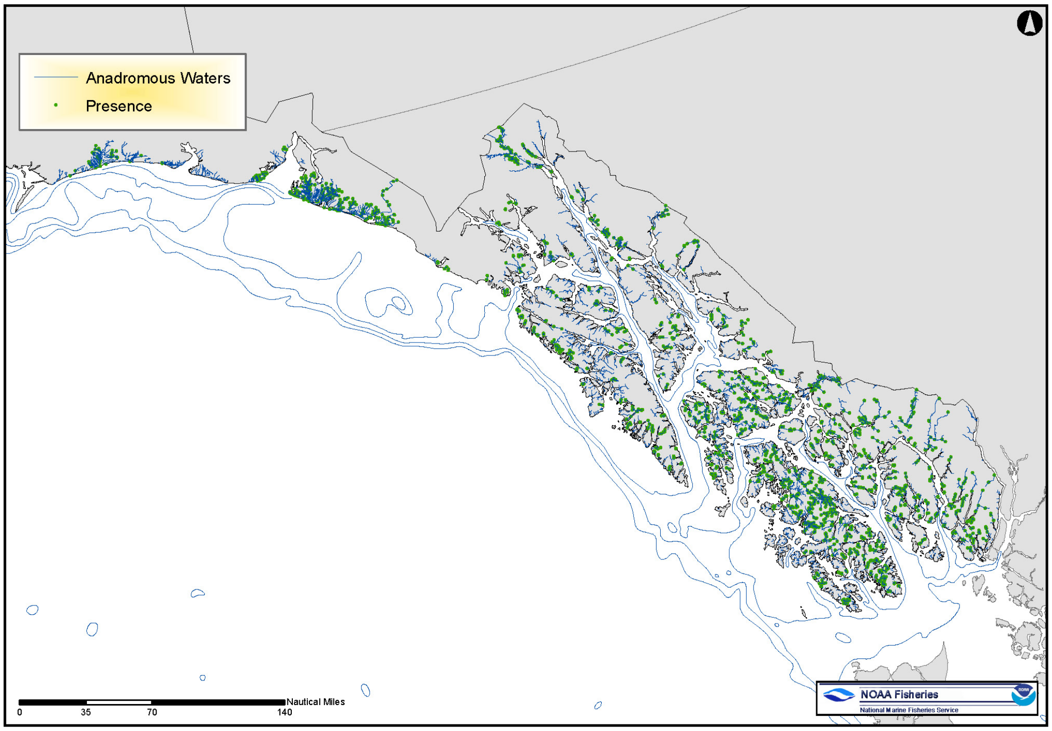


Figure 22 EFH Distribution for Freshwater Sockeye Salmon – South-Central Region

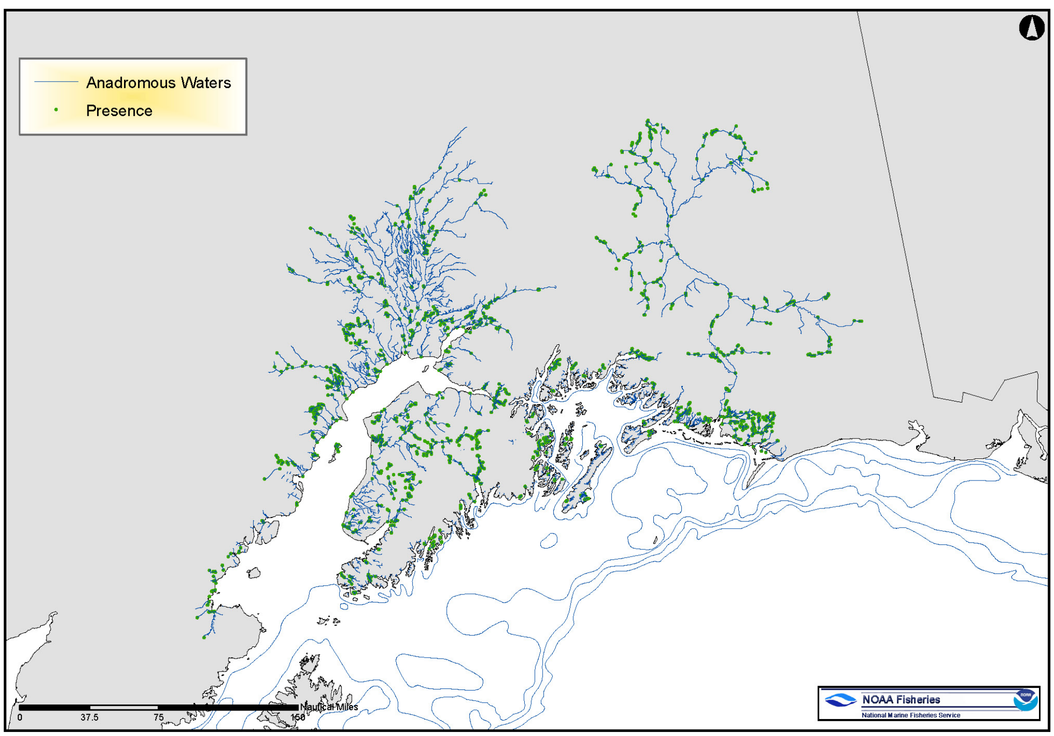


Figure 23 EFH Distribution for Freshwater Sockeye Salmon – Southwestern Region

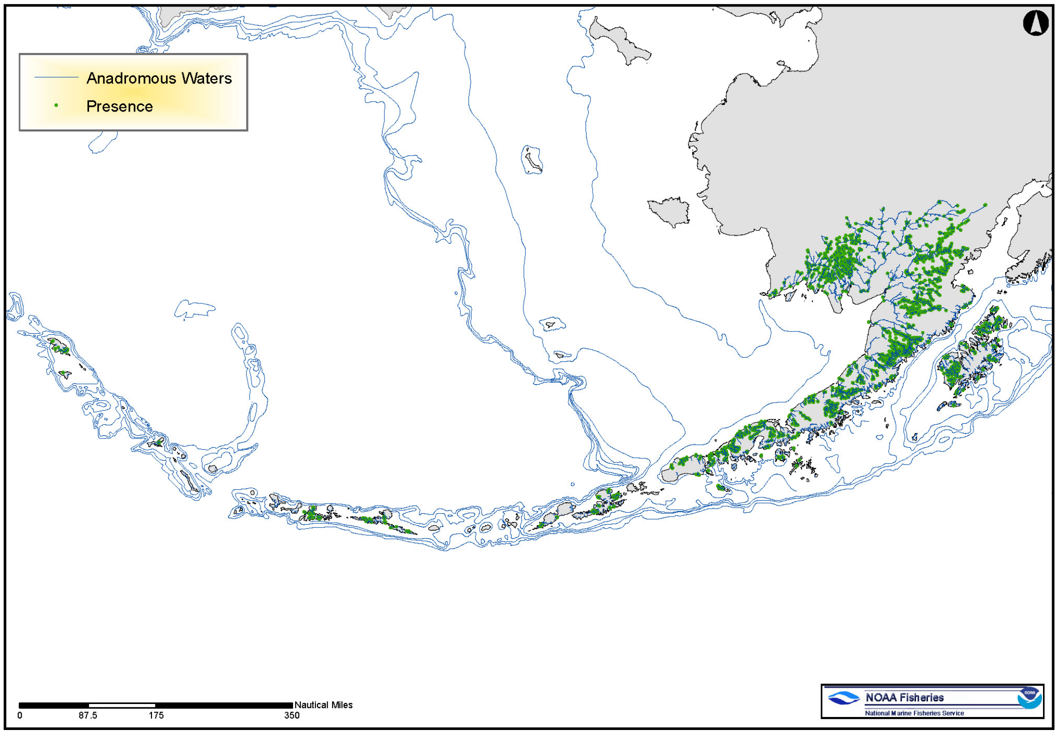


Figure 24 EFH Distribution for Freshwater Sockeye Salmon – Western Region

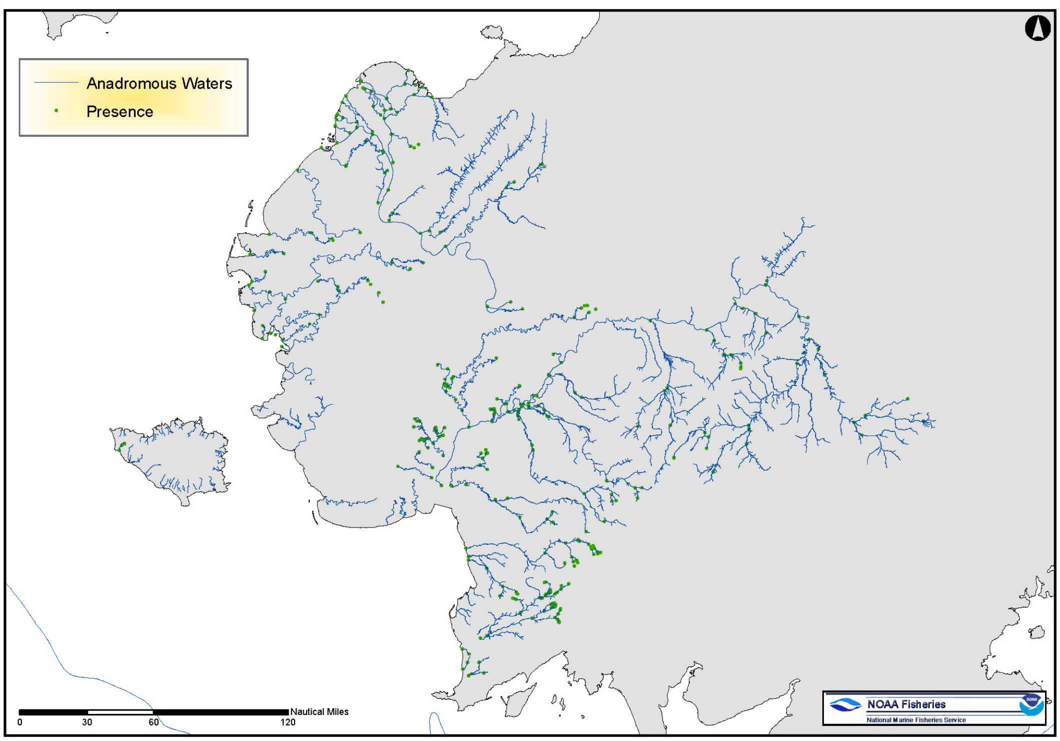


Figure 25 EFH Distribution for Freshwater Sockeye Salmon – Arctic Region

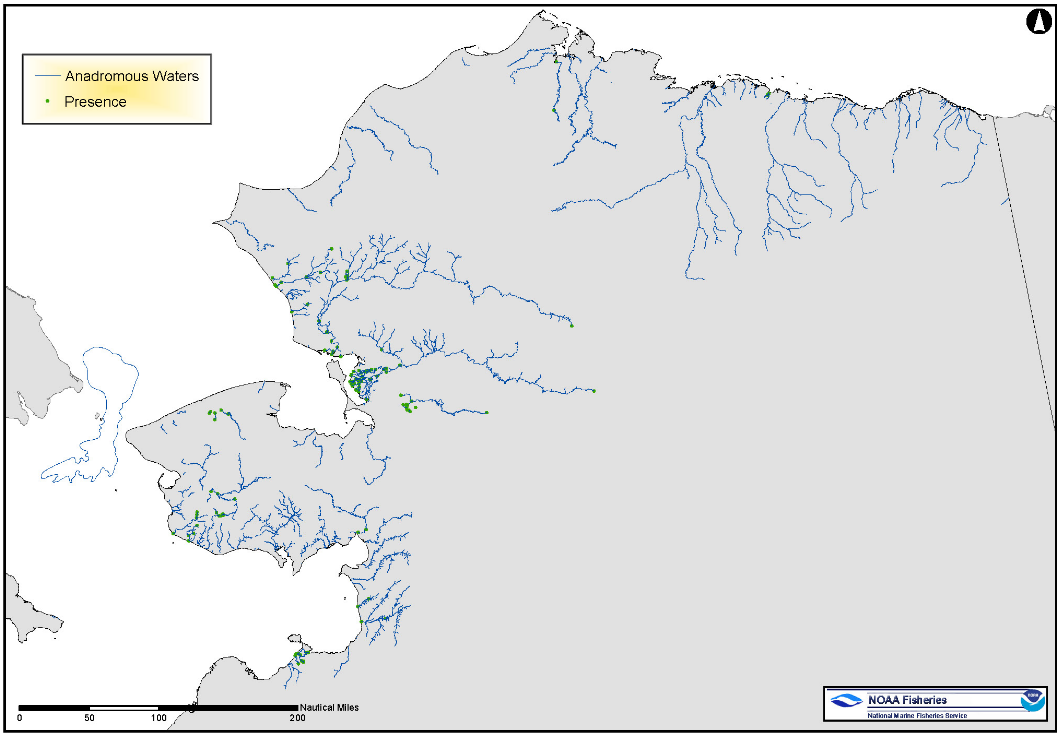


Figure 26 EFH Distribution for Freshwater Sockeye Salmon – Interior Region

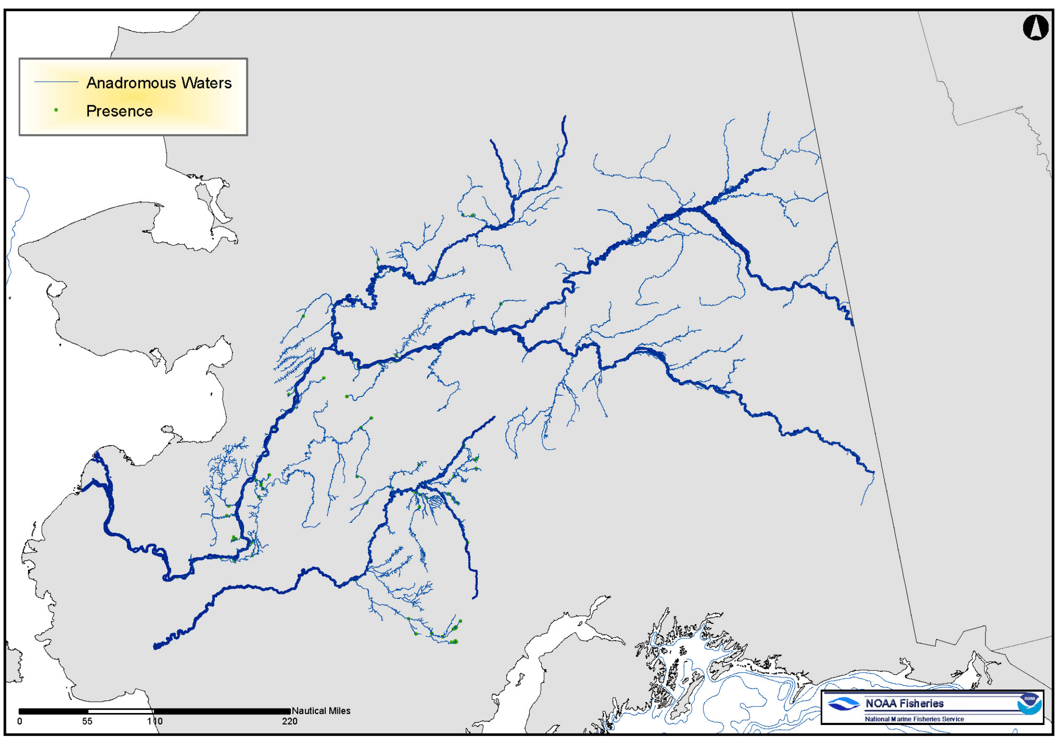


Figure 27 Sockeye salmon juvenile marine life history stage EFH map

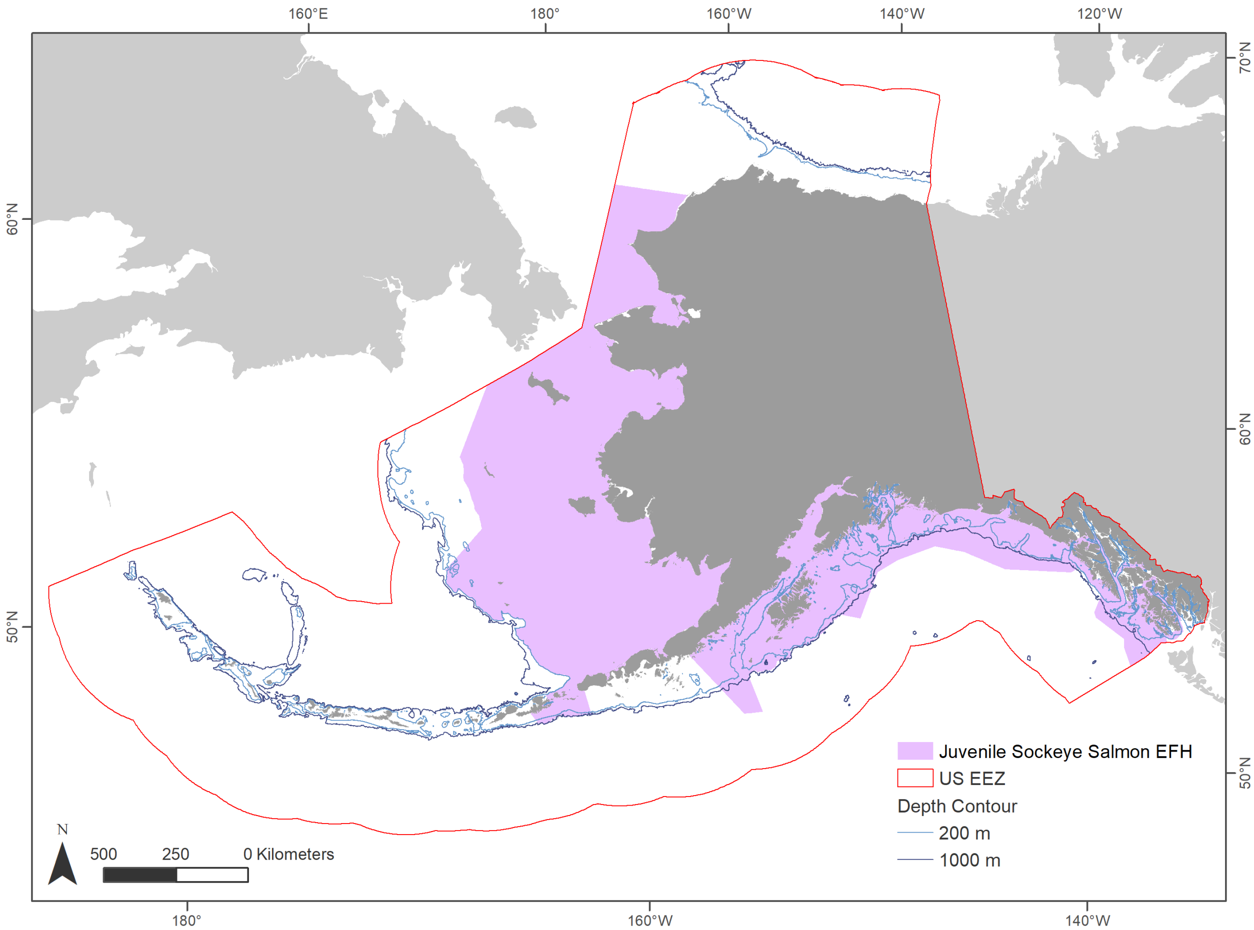


Figure 28 Sockeye salmon immature marine life history stage EFH map

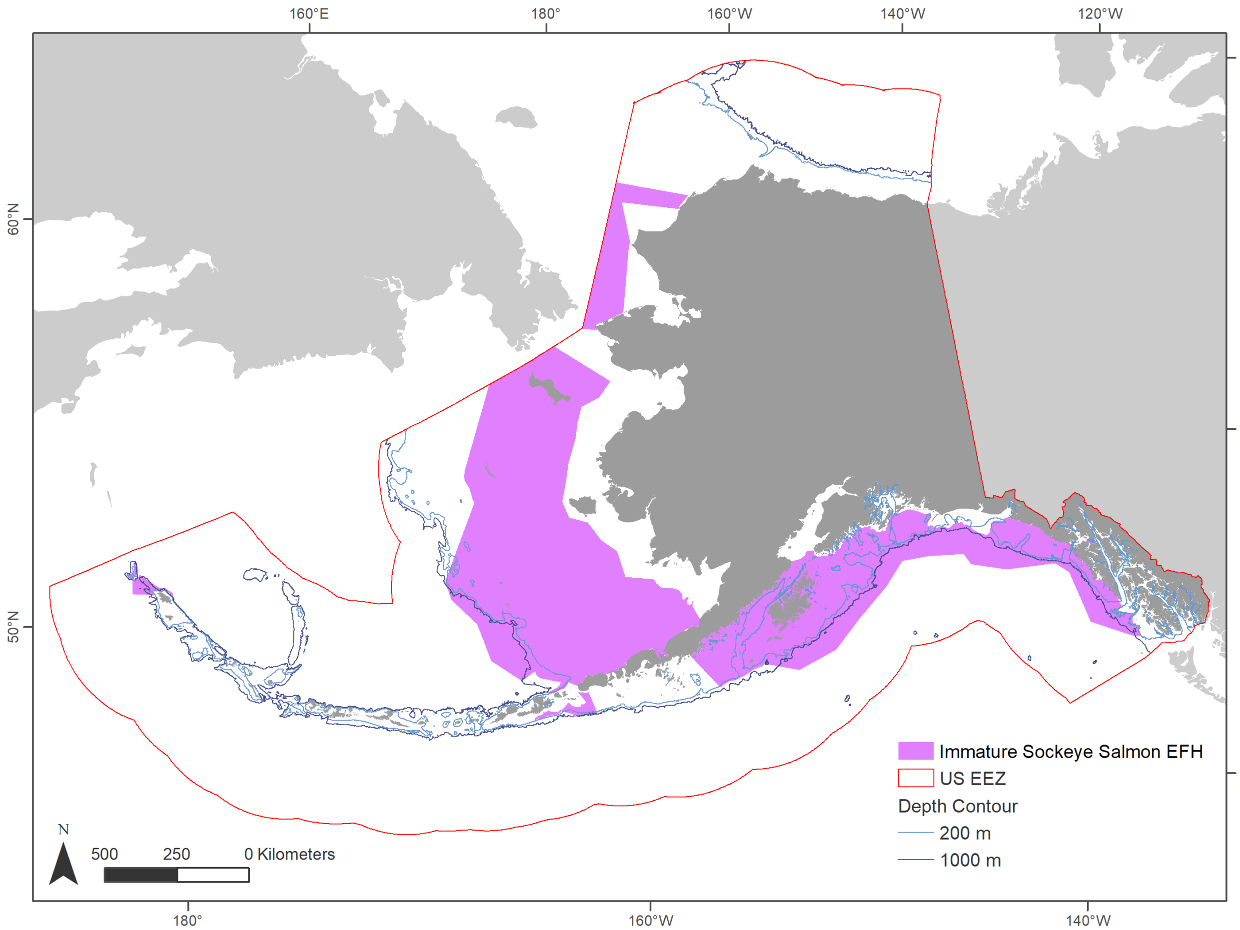
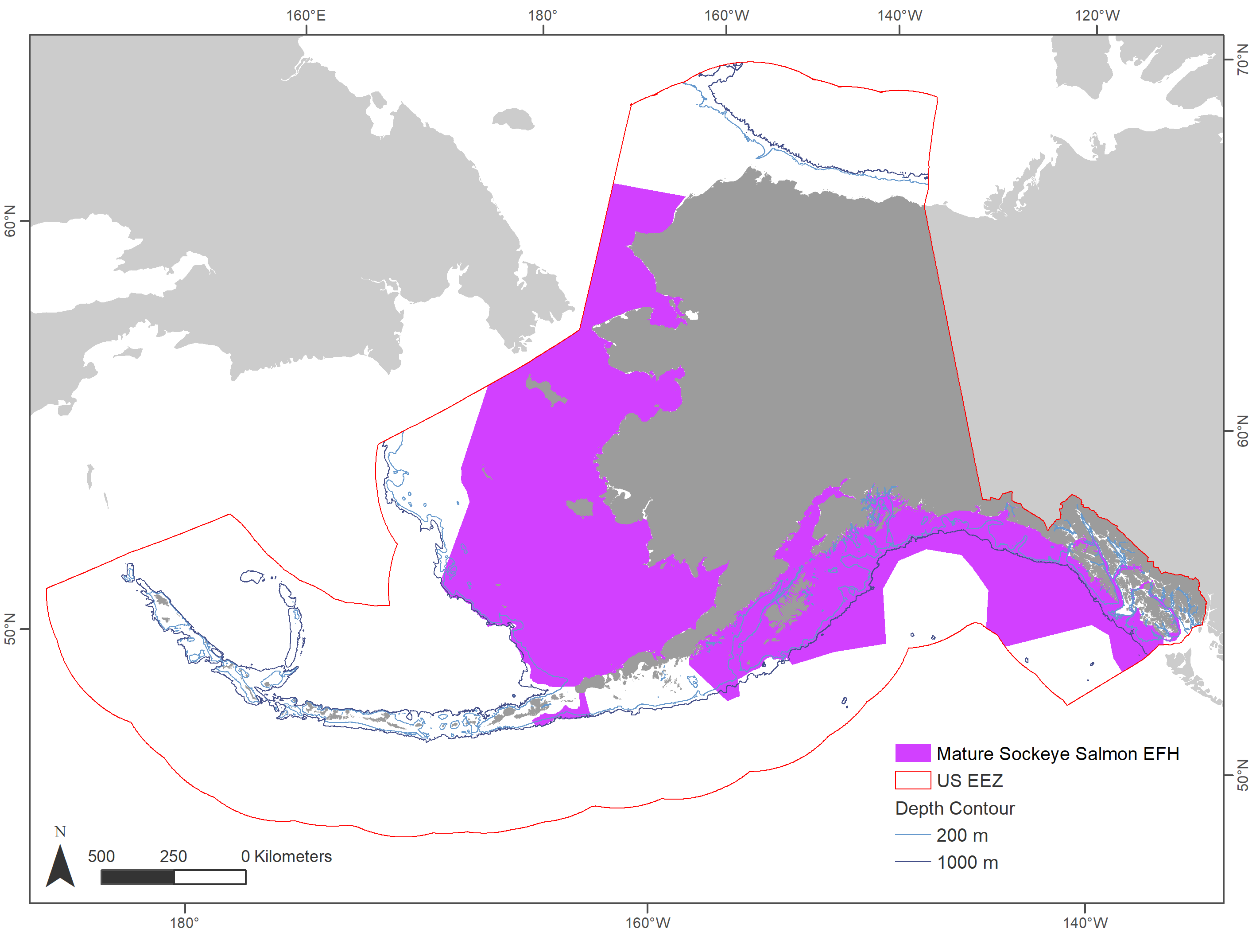


Figure 29 Sockeye salmon mature marine life history stage EFH map



A.3.1.4 Chinook Salmon

Freshwater Eggs

EFH for Chinook salmon eggs is the general distribution for this life stage, located in gravel substrates in those waters identified in ADF&G's *Catalogue of Waters Important for the Spawning, Rearing, or Migration of Anadromous Fishes* (ADF&G 1998a).

Freshwater Larvae and Juveniles

EFH for larval and juvenile Chinook salmon is the general distribution area for this life stage, located in those waters identified in ADF&G's *Catalogue of Waters Important for the Spawning, Rearing, or Migration of Anadromous Fishes* (ADF&G 1998a) and contiguous rearing areas within the boundaries of ordinary high water. Juvenile Chinook salmon out-migrate from freshwater areas in April toward the sea and may spend up to a year in a major tributaries or rivers, such as the Kenai, Yukon, Taku, and Copper Rivers.

Estuarine Juveniles

Estuarine EFH for juvenile Chinook salmon is the general distribution area for this life stage, located in estuarine areas, as identified by the salinity transition zone (ecotone) and the mean higher tide line, within nearshore waters. Chinook salmon smolts and post-smolt juveniles may be present in these estuarine habitats from April through September.

Marine Juveniles

Marine EFH for juvenile Chinook salmon is the general distribution area for this life stage, located in marine waters off the coast of Alaska from the mean higher tide line to the 200-nm limit of the EEZ, including the GOA, EBS, Chukchi Sea, and Arctic Ocean. Juvenile marine Chinook salmon are at this life stage from April until annulus formation in January or February during their first winter at sea.

Marine Immature and Maturing Adults

EFH for immature and maturing adult Chinook salmon is the general distribution area for this life stage, located in marine waters off the coast of Alaska and ranging from the mean higher tide line to the 200-nm limit of the U.S. EEZ, including the GOA, EBS, Chukchi Sea, and Arctic Ocean. Marine mature Chinook salmon inhabit pelagic marine waters from January to September, by which time the mature fish migrate out of marine waters.

Freshwater Adults

EFH for adult Chinook salmon is the general distribution area for this life stage, located in fresh waters identified in ADF&G's *Catalogue of Waters Important for the Spawning, Rearing, or Migration of Anadromous Fishes* (ADF&G 1998a) wherever there are spawning substrates consisting of gravels from April through September.

Figure 30 EFH Distribution for Freshwater Chinook Salmon – Southeastern Region

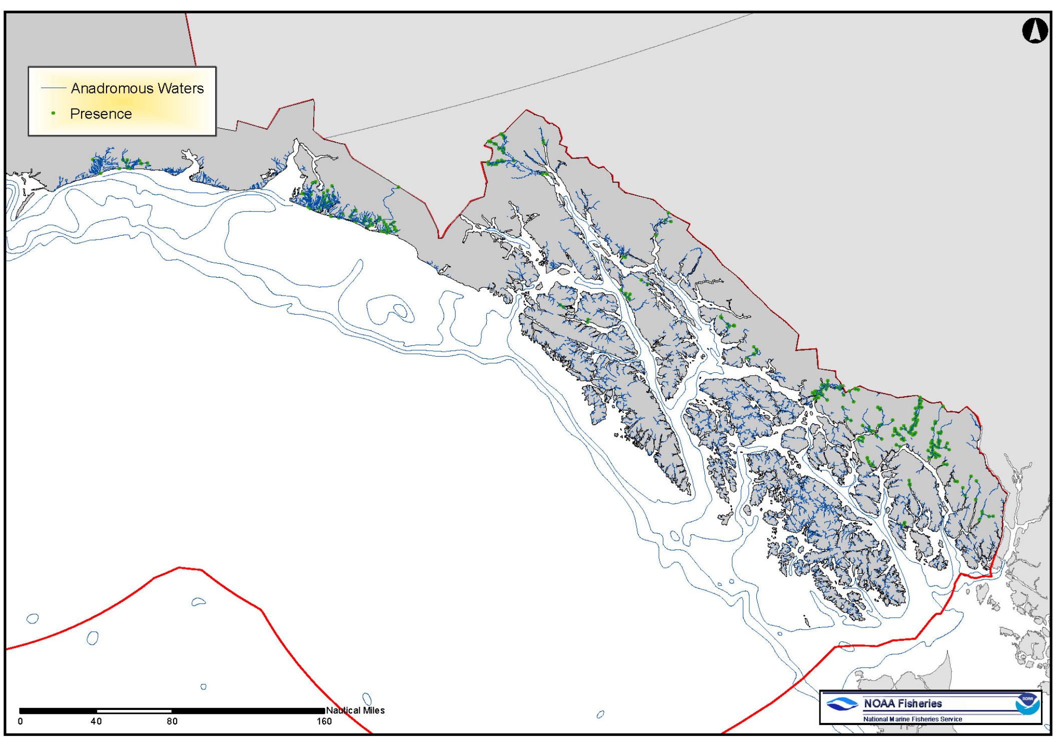


Figure 31 EFH Distribution for Freshwater Chinook Salmon – South-Central Region

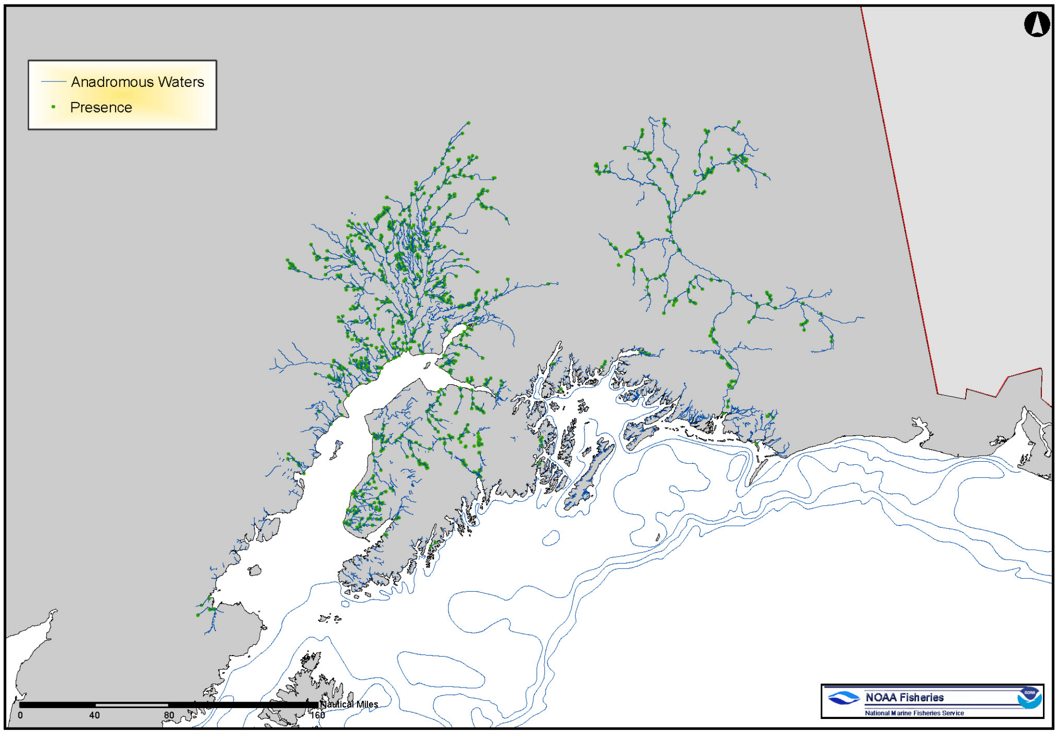


Figure 32 EFH Distribution for Freshwater Chinook Salmon – Southwestern Region

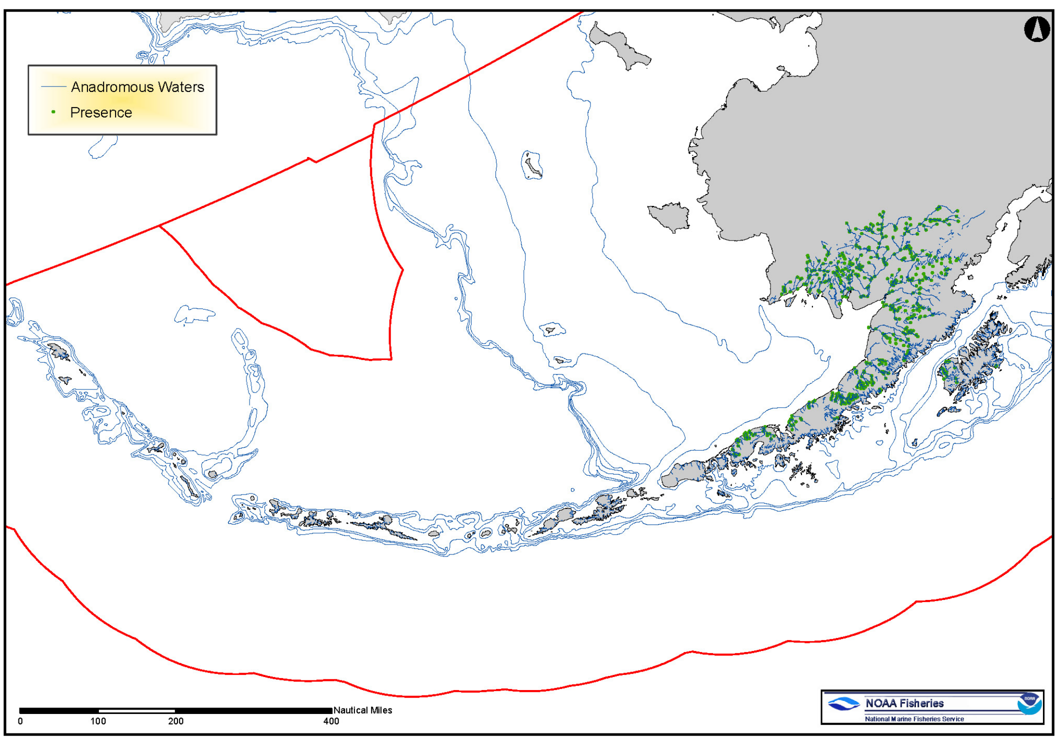


Figure 33 EFH Distribution for Freshwater Chinook Salmon – Western Region

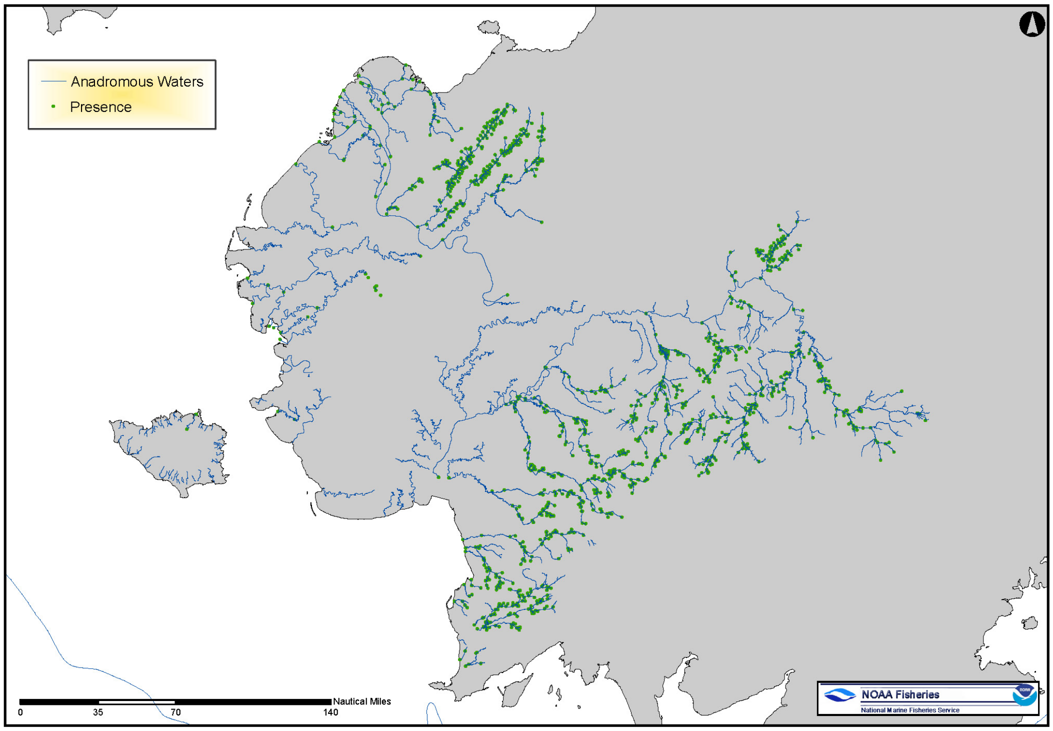


Figure 34 EFH Distribution for Freshwater Chinook Salmon – Arctic Region

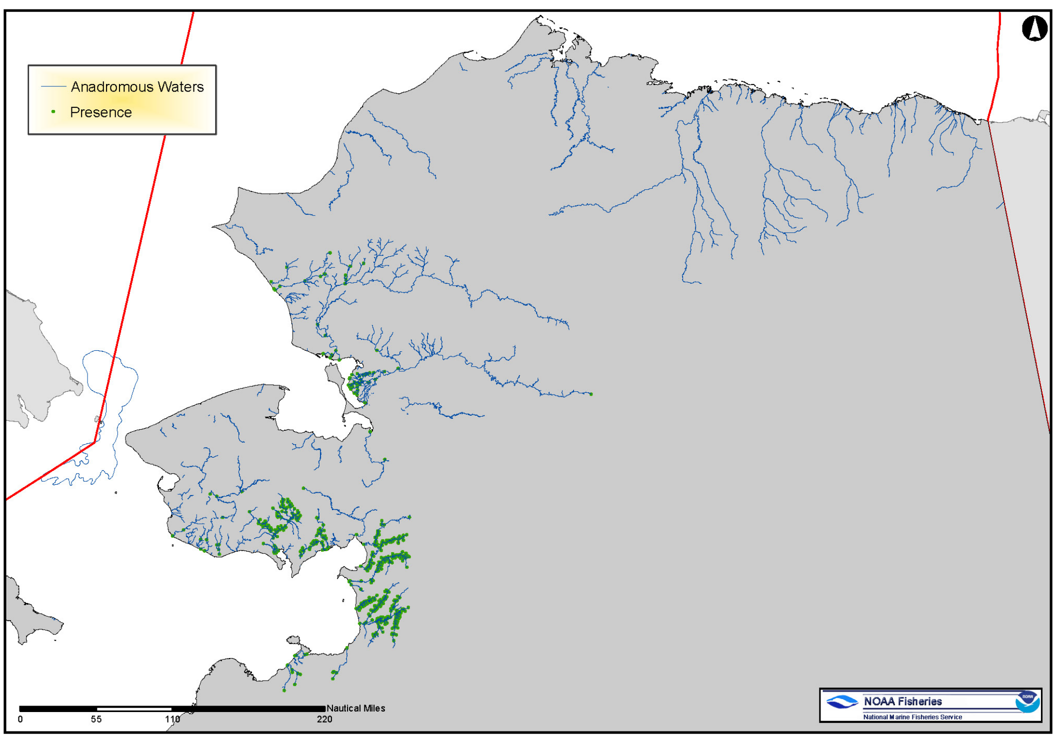


Figure 35 EFH Distribution for Freshwater Chinook Salmon – Interior Region

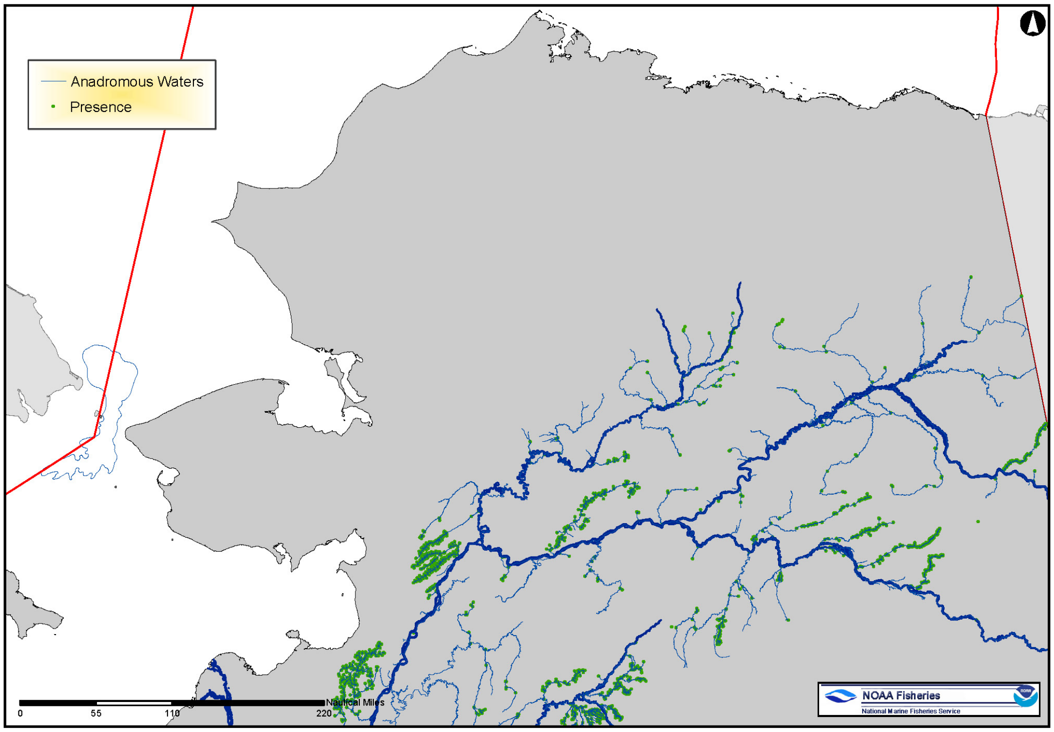


Figure 36 Chinook salmon juvenile marine life history stage EFH map

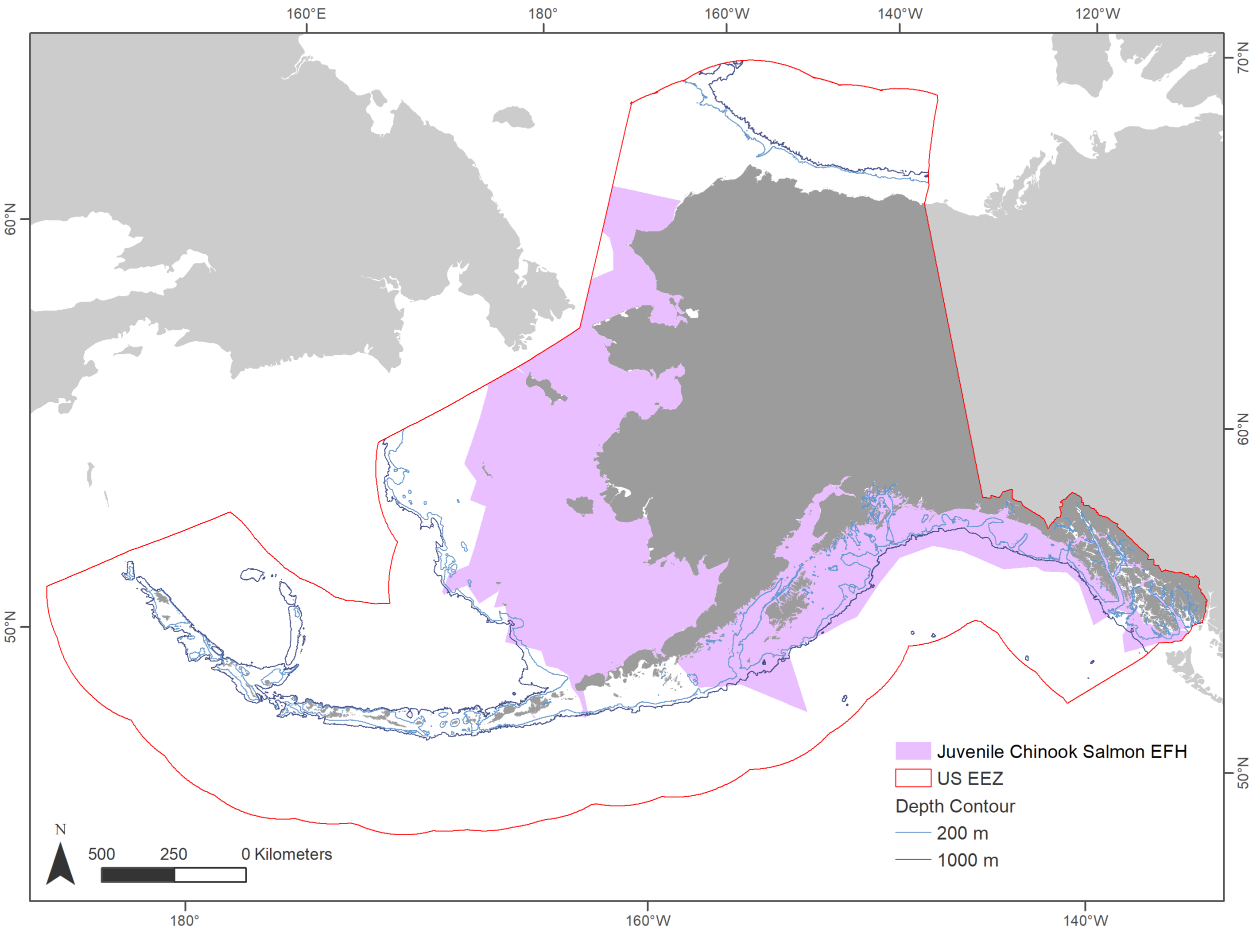


Figure 37 Chinook salmon immature marine life history stage EFH map

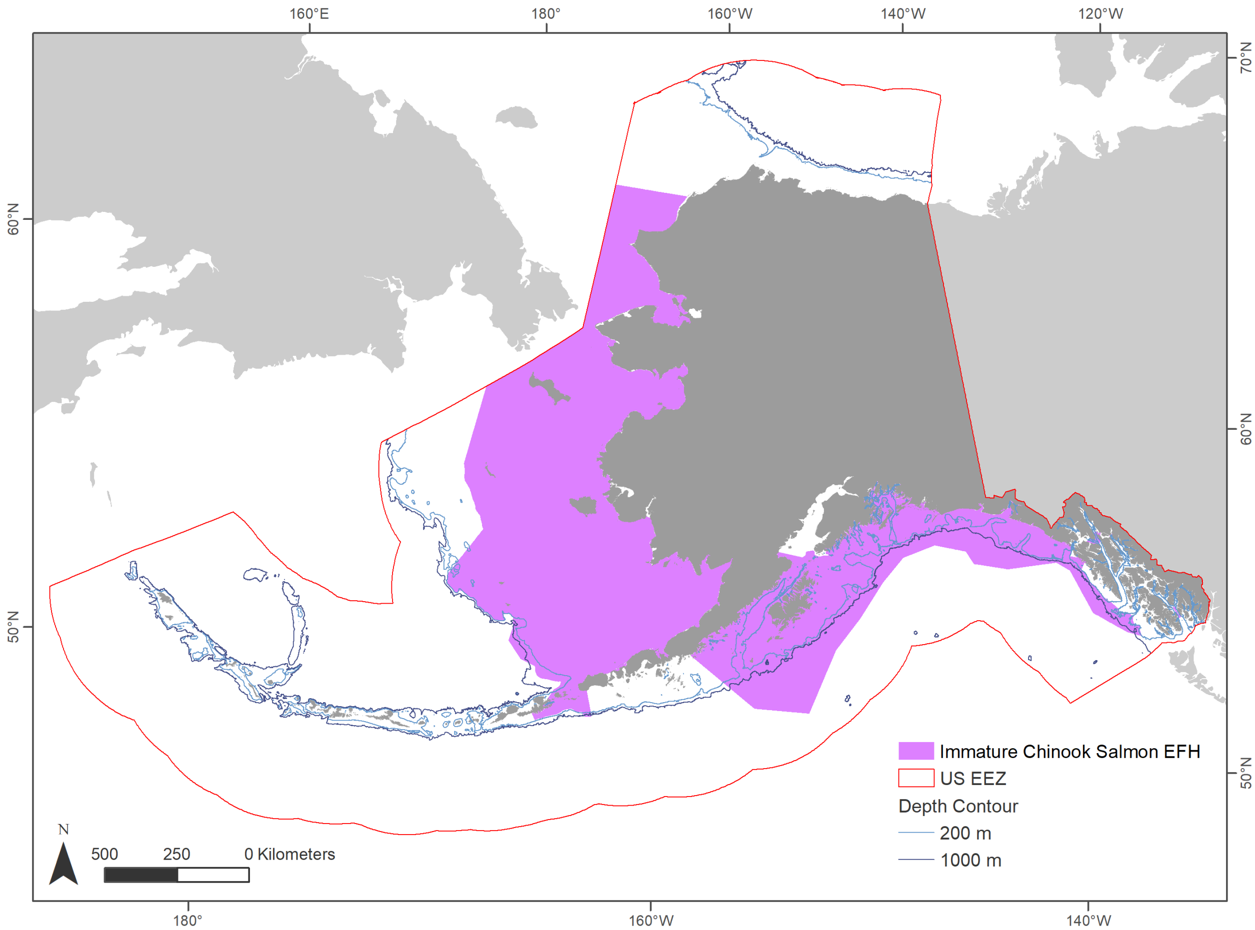
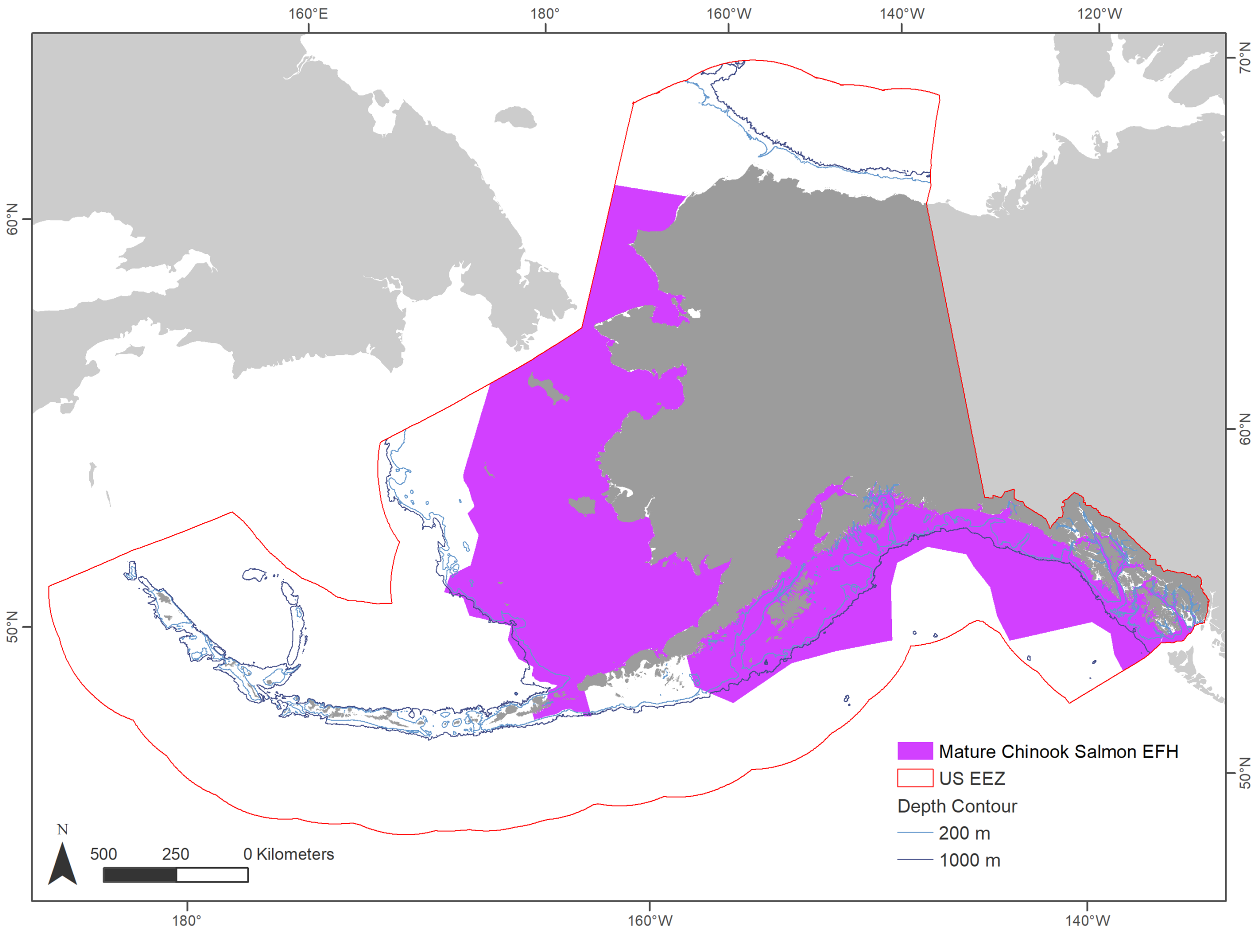


Figure 38 Chinook salmon mature marine life history stage EFH map



A.3.1.5 Coho Salmon

Freshwater Eggs

EFH for coho salmon eggs is the general distribution area for this life stage, located in gravel substrates in those waters identified in ADF&G's *Catalogue of Waters Important for the Spawning, Rearing, or Migration of Anadromous Fishes* (ADF&G 1998a).

Freshwater Larvae and Juveniles

EFH for larval and juvenile coho salmon is the general distribution area for this life stage, located in those waters identified in ADF&G's *Catalogue of Waters Important for the Spawning, Rearing, or Migration of Anadromous Fishes* (ADF&G 1998a) and contiguous rearing areas within the boundaries of ordinary high water. Fry generally migrate to a lake, slough, or estuary and rear in these areas for up to 2 years.

Estuarine Juveniles

Estuarine EFH for juvenile coho salmon is the general distribution area for this life stage, located in estuarine areas, as identified by the salinity transition zone (ecotone) and the mean higher tide line, within nearshore waters. Juvenile coho salmon require year-round rearing habitat and also migration habitat from April to November to provide access to and from the estuary.

Marine Juveniles

Marine EFH for juvenile coho salmon is the general distribution area for this life stage, located in marine waters off the coast of Alaska from the mean higher tide line to the 200-nm limit of the U.S. EEZ, including the GOA, EBS, Chukchi Sea, and Arctic Ocean. Marine juvenile coho salmon inhabit these marine waters from June to September.

Marine Immature and Maturing Adults

EFH for immature and maturing adult coho salmon is the general distribution area for this life stage, located in marine waters off the coast of Alaska to 200 m in depth and range from the mean higher tide line to the 200-nm limit of the U.S. EEZ, including the GOA, EBS, Chukchi Sea, and Arctic Ocean.   Marine mature coho salmon inhabit pelagic marine waters in the late summer, by which time the mature fish migrate out of marine waters.

Freshwater Adults

EFH for coho salmon is the general distribution area for this life stage, located in freshwaters as identified in ADF&G's *Catalogue of Waters Important for the Spawning, Rearing, or Migration of Anadromous Fishes* (ADF&G 1998a) and wherever there are spawning substrates consisting mainly of gravel containing less than 15 percent fine sediment (less than 2-mm diameter) from July to December.

Figure 39 EFH Distribution for Freshwater Coho Salmon – Southeastern Region

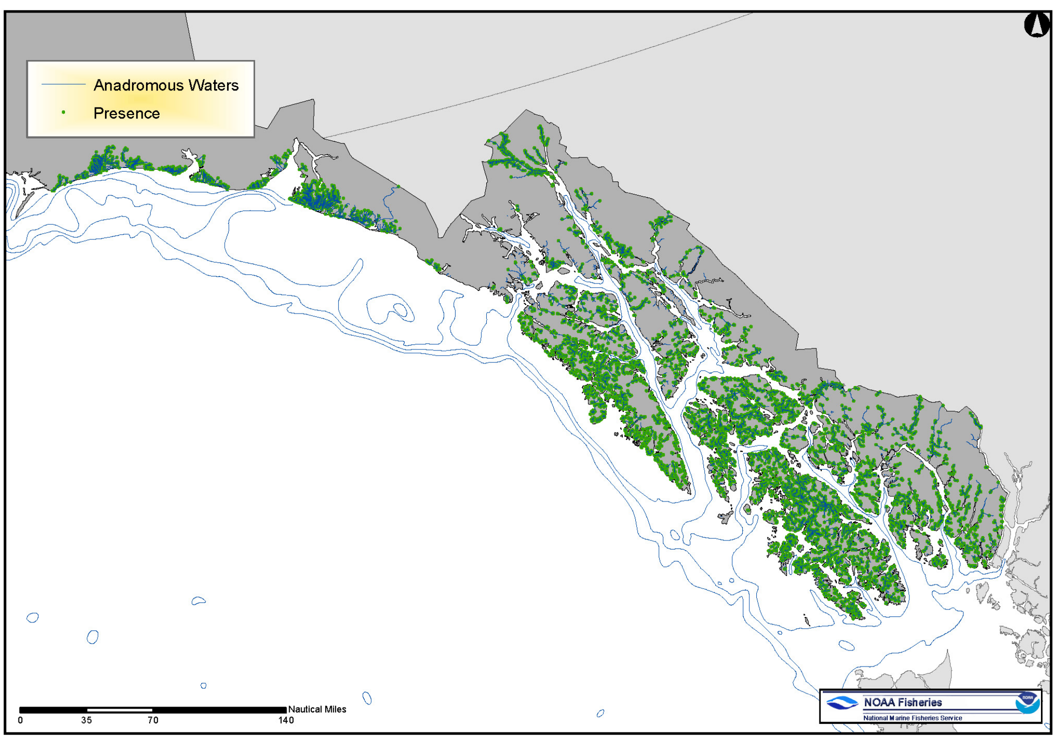


Figure 40 EFH Distribution for Freshwater Coho Salmon – South-Central Region

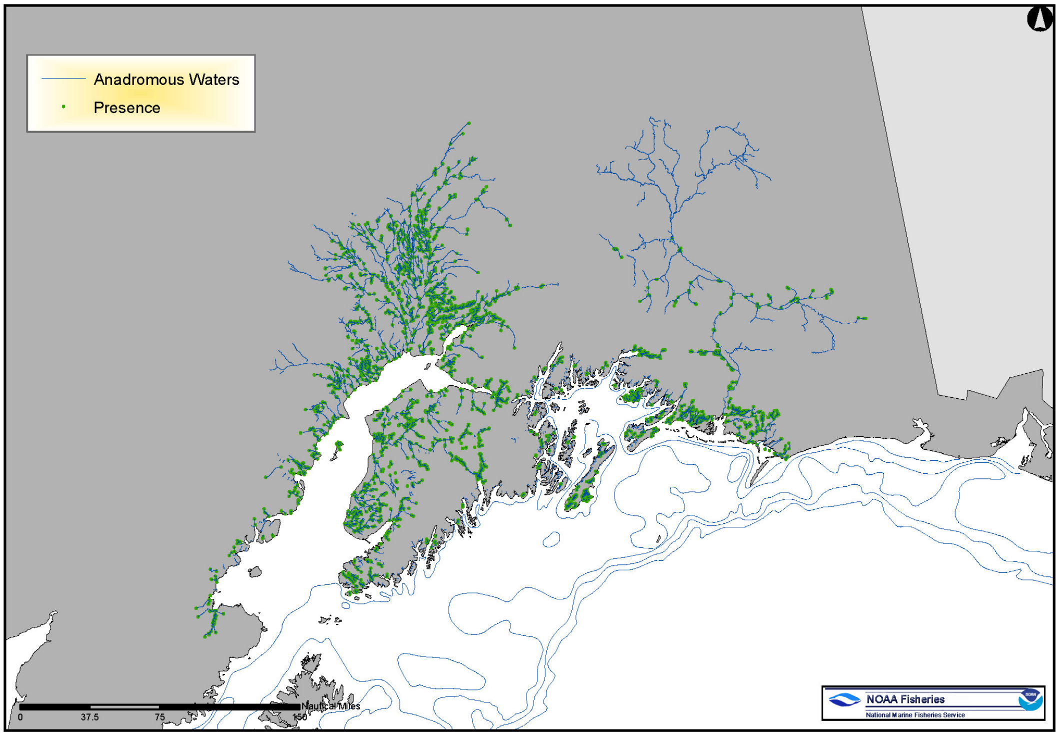


Figure 41 EFH Distribution for Freshwater Coho Salmon – Southwestern Region

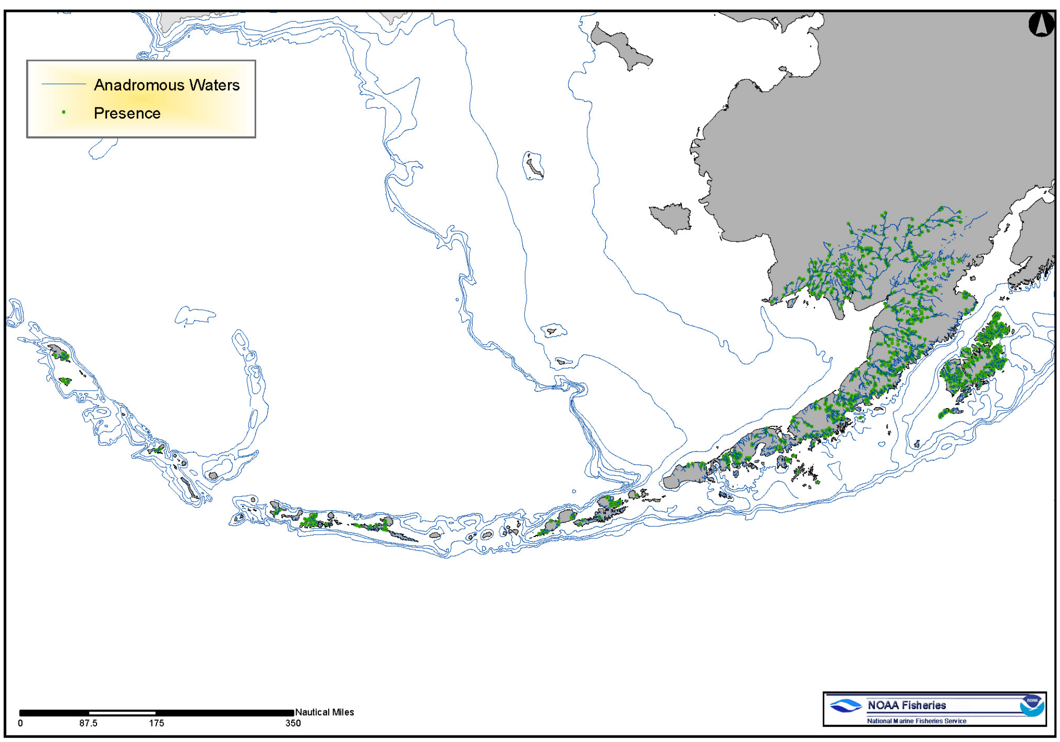


Figure 42 EFH Distribution for Freshwater Coho Salmon – Western Region

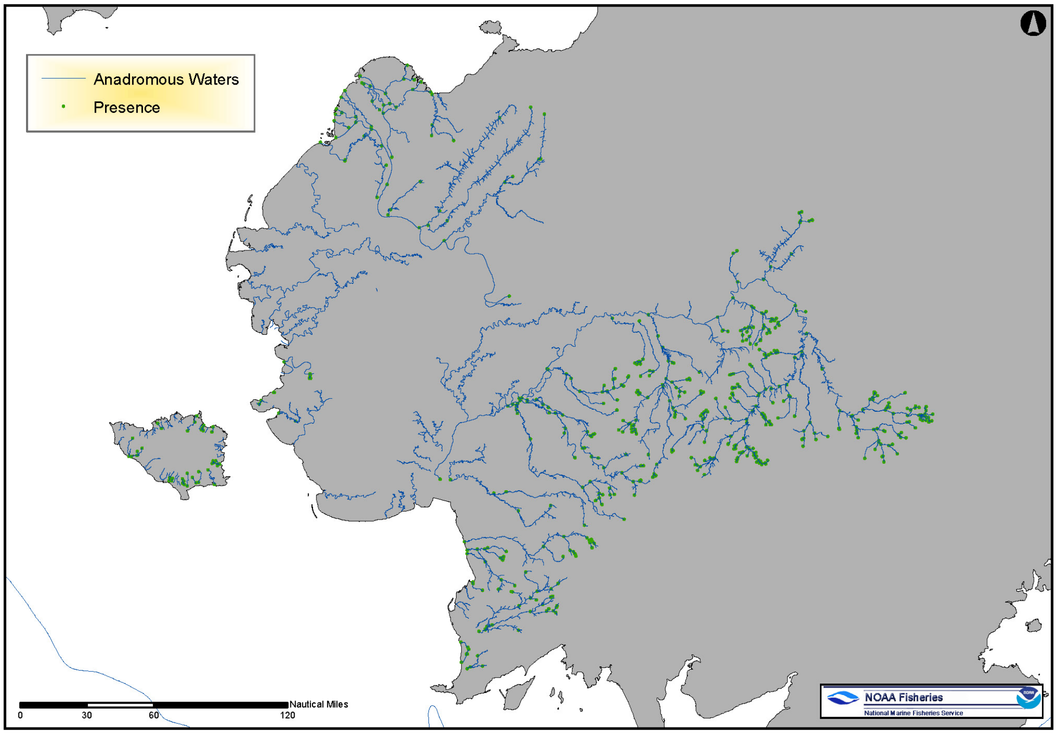


Figure 43 EFH Distribution for Freshwater Coho Salmon – Arctic Region

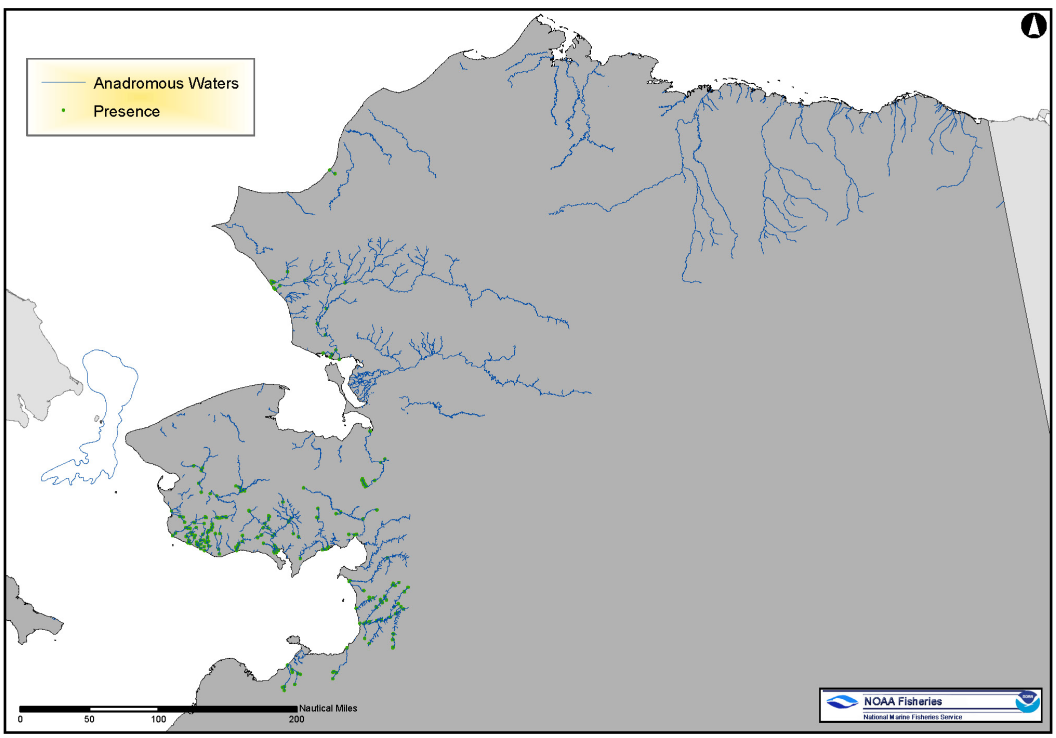


Figure 44 EFH Distribution for Freshwater Coho Salmon – Interior Region

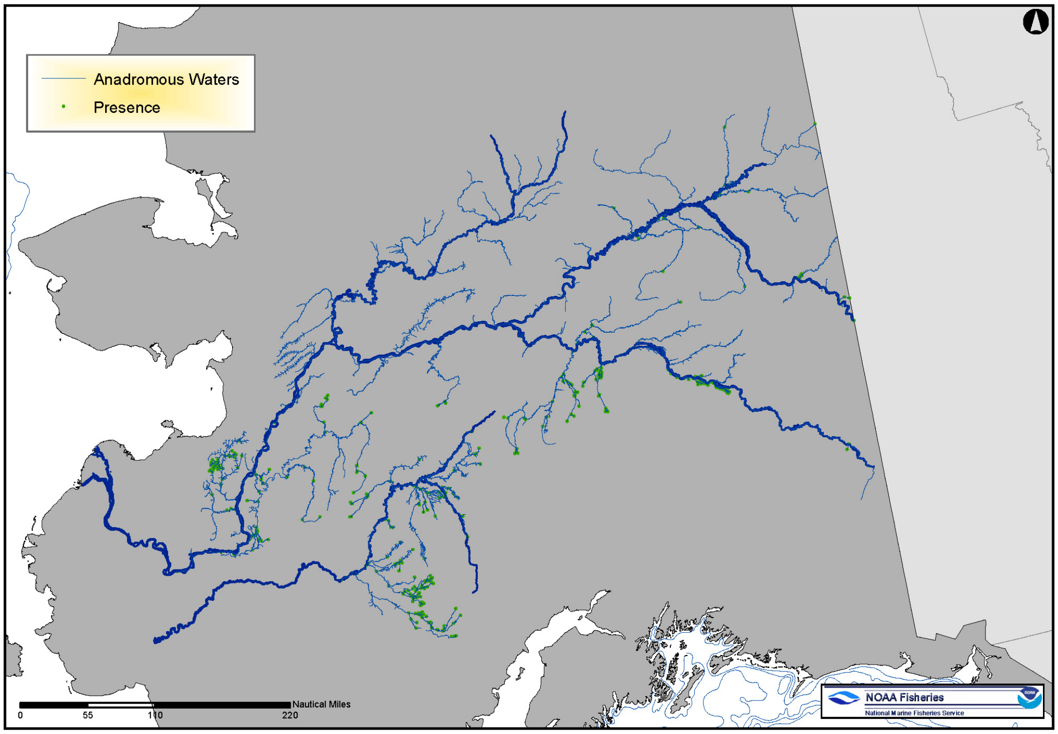


Figure 45 Coho salmon juvenile marine life history stage EFH map

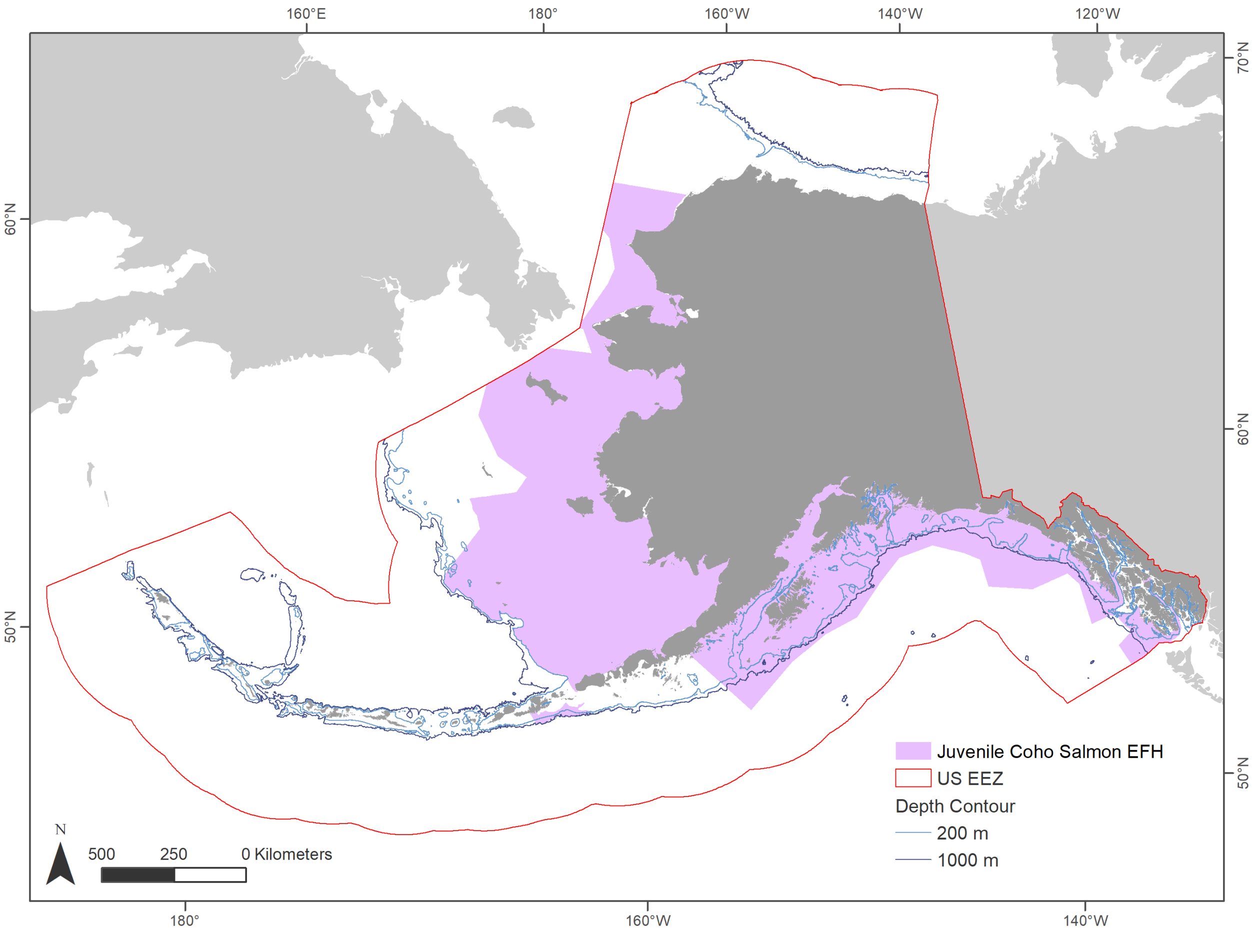
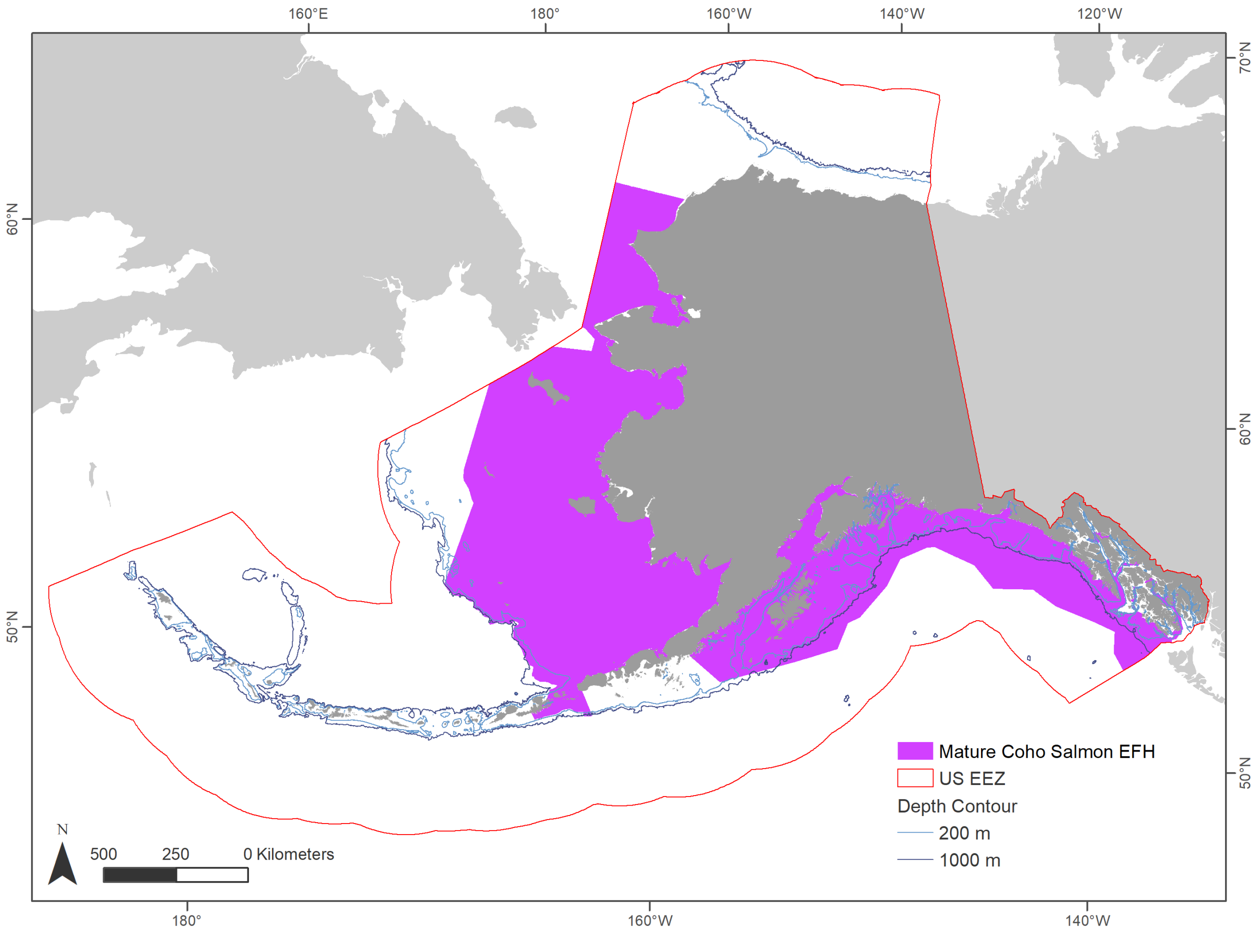


Figure 46 Coho salmon mature marine life history stage EFH map



A.3.2 Essential Fish Habitat Conservation and Habitat Areas of Particular Concern

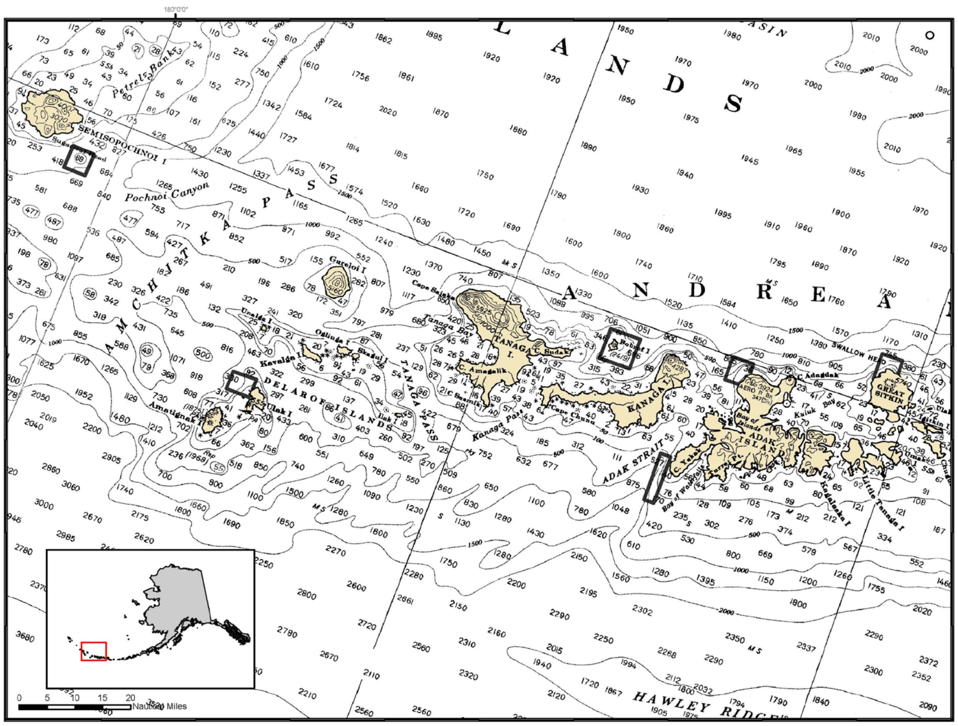
The Council established the Aleutian Islands Habitat Conservation Area, the Aleutian Islands Coral Habitat Protection Areas, and the GOA Slope Habitat Conservation Areas to protect EFH from fishing threats. The Council also established Habitat Areas of Particular Concern (HAPCs) within EFH to protect those areas from fishing threats: the Alaska Seamount Habitat Protection Areas, the Bowers Ridge Habitat Conservation Zone, and the GOA Coral Habitat Protection Areas (NPFMC 2005). Maps of these areas are provided below.

HAPCs are specific sites within EFH that are of particular ecological importance to the long-term sustainability of managed species, are of a rare type, or are especially susceptible to degradation or development. HAPCs are meant to provide greater focus to conservation and management efforts and may require additional protection from adverse effects.

A.3.2.1 Aleutian Islands Coral Habitat Protection Areas

The use of bottom contact gear, as described in 50 CFR part 679, is prohibited year-round in the Aleutian Islands Coral Habitat Protection Areas, see Figure 47. Anchoring by a federally permitted fishing vessel is also prohibited. The coordinates for these areas are provided in Federal regulations at §679.22(a).

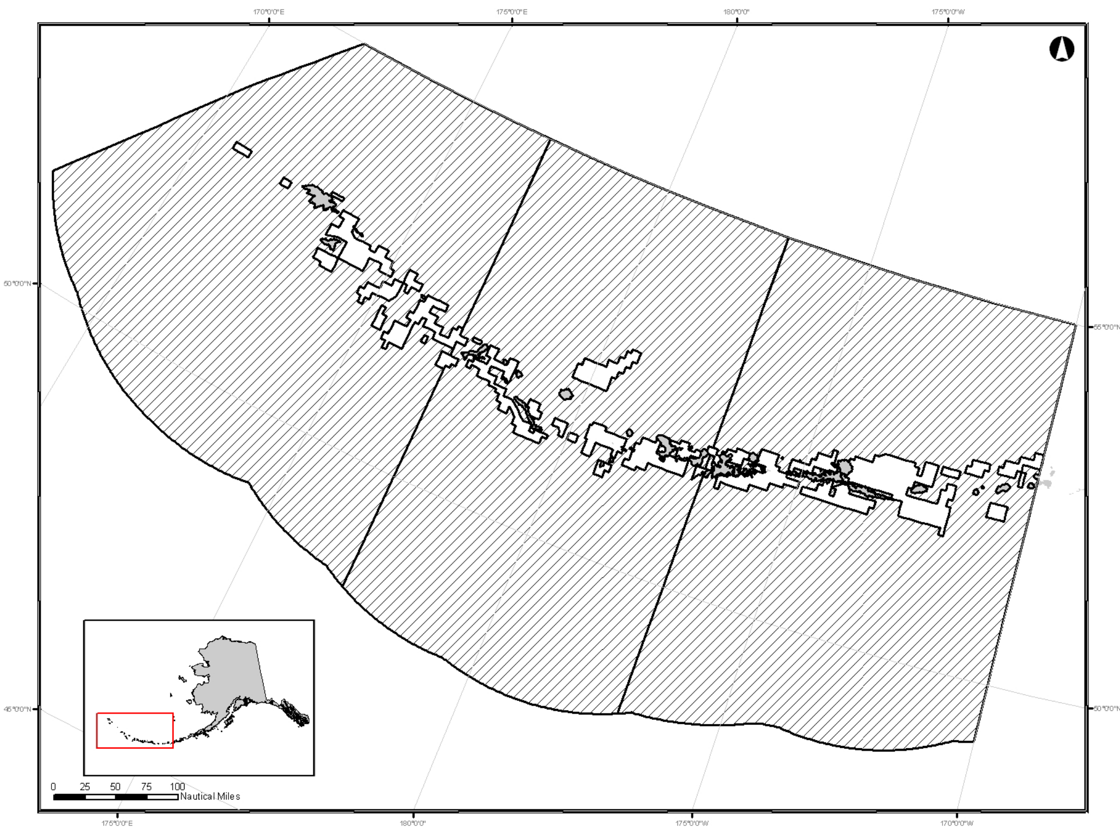
Figure 47 Aleutian Islands Coral Habitat Protection Areas



A.3.2.2 Aleutian Islands Habitat Conservation Area

Nonpelagic trawl gear fishing is prohibited year-round in the Aleutian Islands Habitat Conservation Area, except for designated areas open to nonpelagic trawl gear. The Aleutian Islands Habitat Conservation Area is defined as the entire Aleutian Islands groundfish management subarea, as defined in 50 CFR 679. Areas open to nonpelagic trawl gear fishing in the Aleutian Islands shown in Figure 48. The coordinates for this area is provided in Federal regulations at §679.22(a).

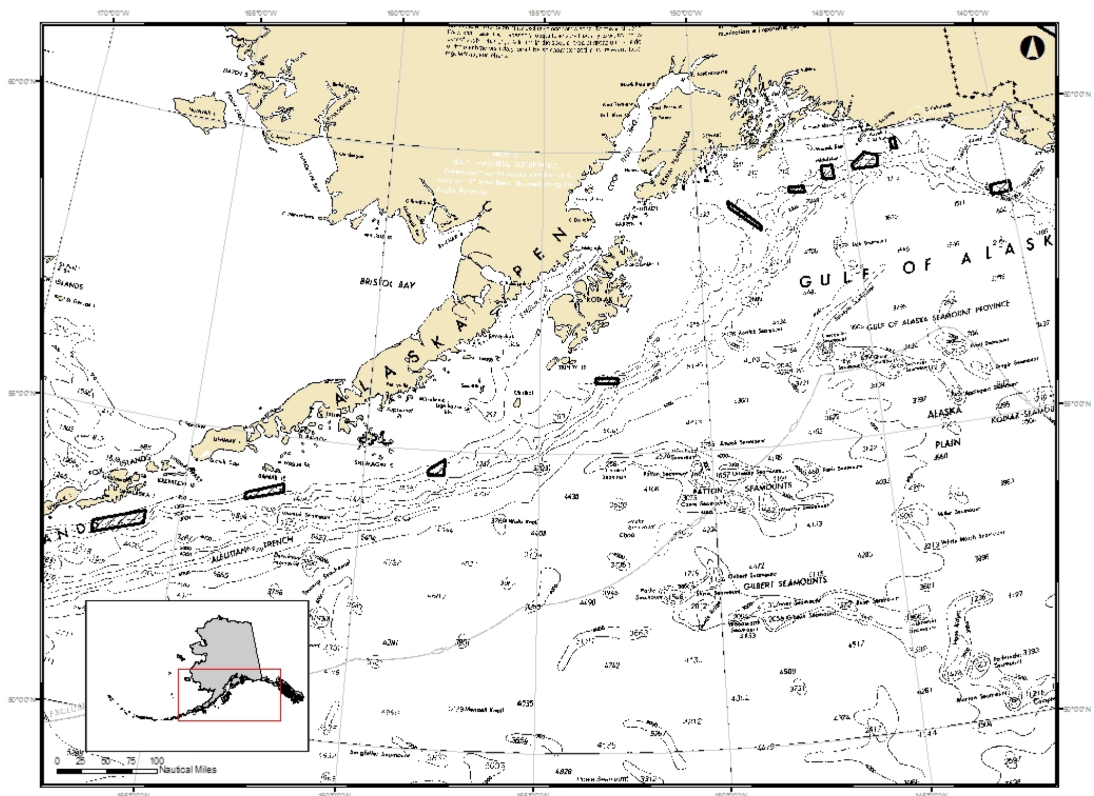
Figure 48 Aleutian Islands Habitat Conservation Area. Polygons are areas open to nonpelagic trawl gear.



A.3.2.3 GOA Slope Habitat Conservation Areas

Nonpelagic trawl gear fishing is prohibited in the GOA Slope Habitat Conservation Areas, as shown in Figure 49. The coordinates for these areas are provided in Federal regulations at §679.22(b).

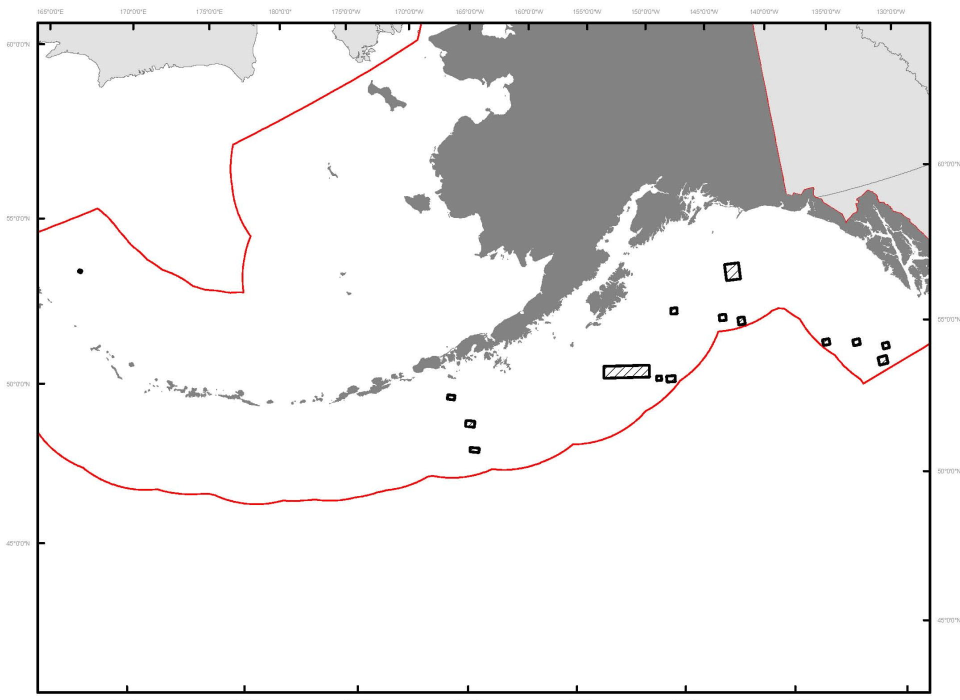
Figure 49 GOA Slope Habitat Conservation Areas are located within the thick line boxes.



A.3.2.4 Alaska Seamount Habitat Protection Areas

The use of bottom contact gear and anchoring by a federally permitted fishing vessel, as described in 50 CFR part 679, is prohibited year-round in the Alaska Seamount Habitat Protection Areas, as shown in Figure 50. The coordinates for these areas are provided in Federal regulations at §679.22(b).

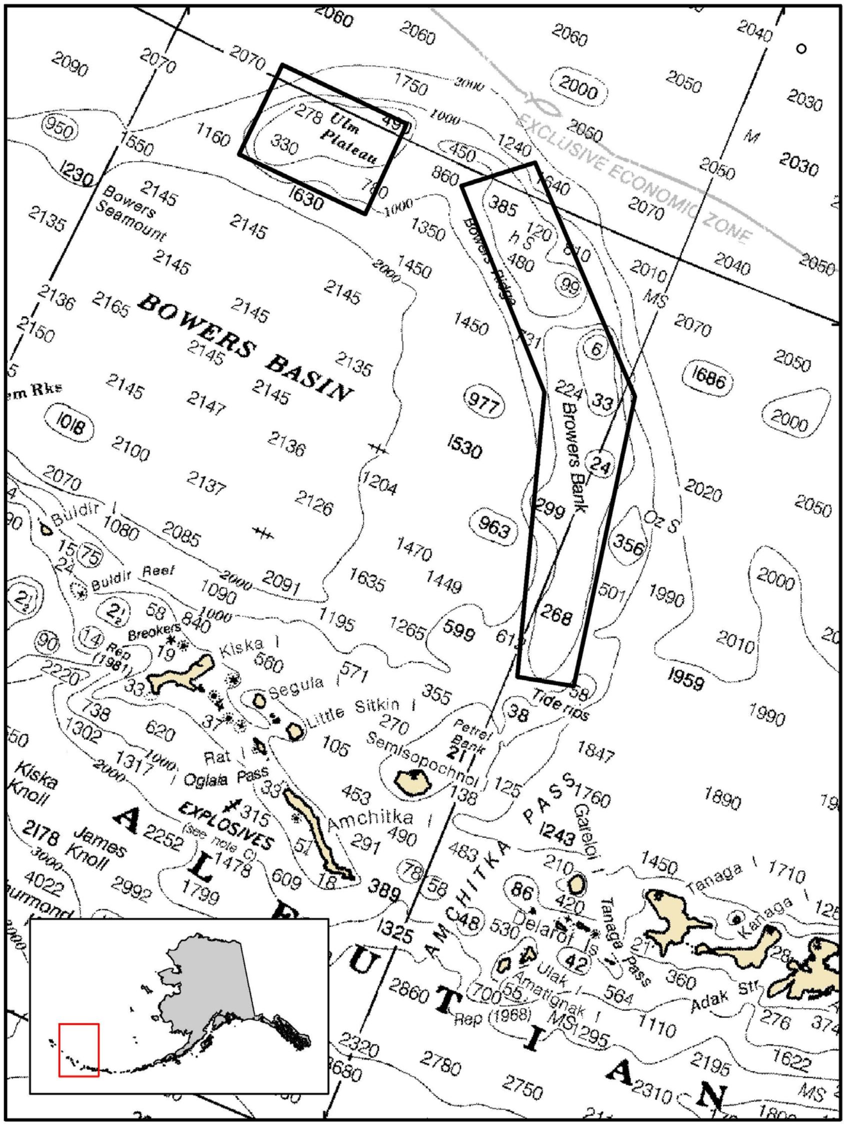
Figure 50 Alaska Seamount Habitat Protection Areas are located within the thick line boxes.



A.3.2.5 Bowers Ridge Habitat Conservation Zone

The use of mobile bottom contact gear, as described in 50 CFR part 679, is prohibited year-round in the Bowers Ridge Habitat Conservation Zone, see Figure 51. The coordinates for these areas are provided in Federal regulations at §679.22(a).

Figure 51 Bowers Ridge Habitat Conservation Zone



A.3.2.6 GOA Coral Habitat Protection Areas

Within the GOA Coral HAPC are GOA Coral Habitat Protection Areas. Bottom contact gear fishing and anchoring are prohibited in the GOA Coral Habitat Protection Area, as shown in Figure 52 and Figure 53. The coordinates for these areas are provided in Federal regulations at §679.22(b).

Figure 52 GPA Coral HAPC and GOA Coral Protection Areas in the Fairweather Grounds

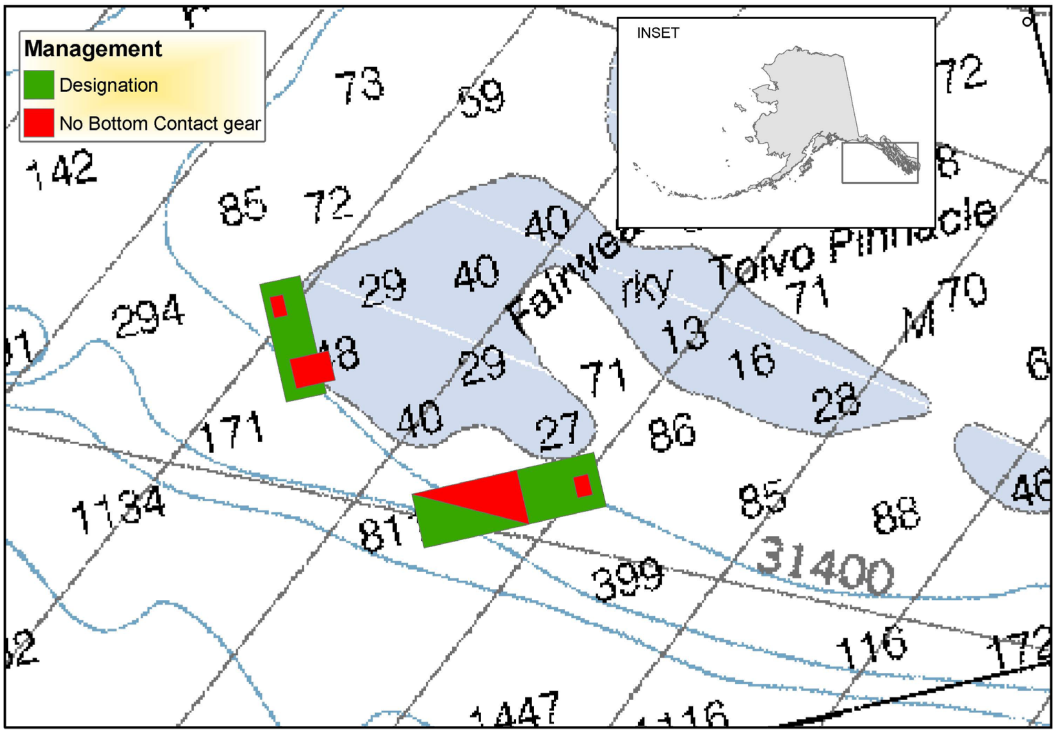
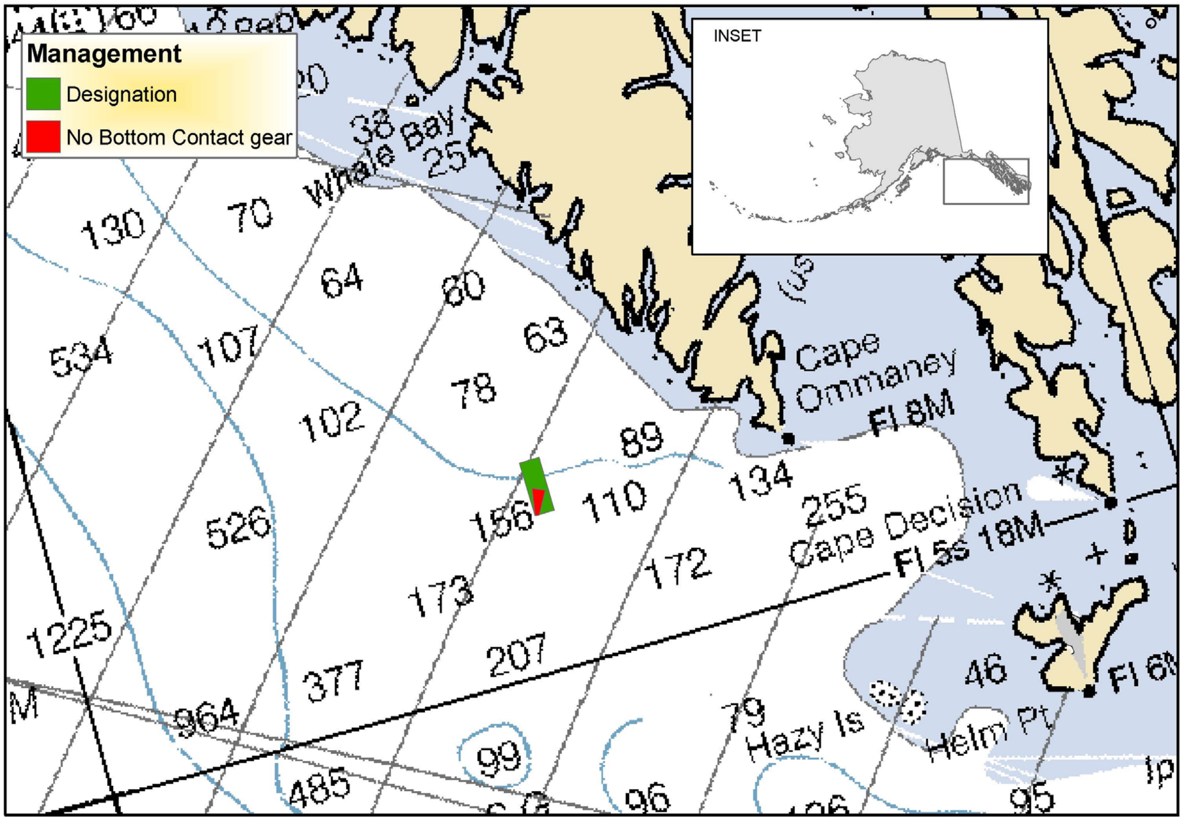


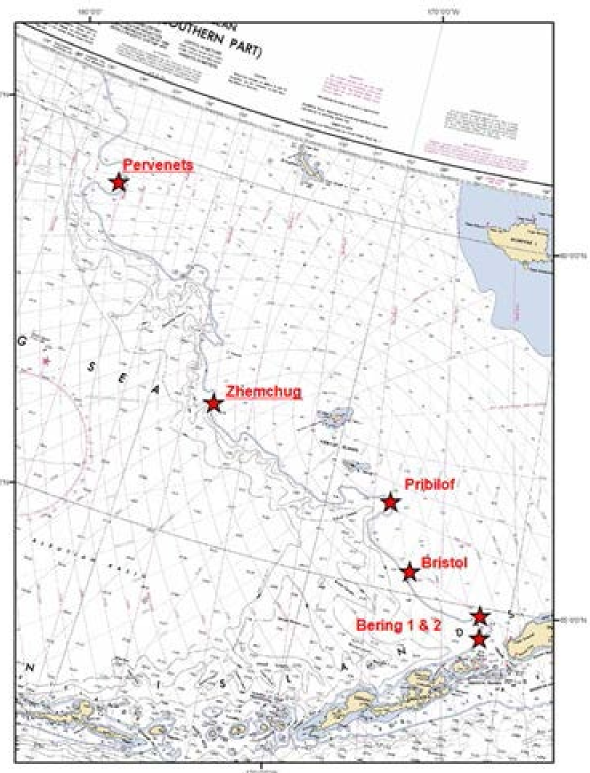
Figure 53 GOA Coral HAPC and GOA Coral Protection Areas near Cape Ommaney



A.3.2.7 Skate Egg Concentration Sites

The Council designated six areas of skate egg concentration as HAPC without any additional associated regulatory measures. The Council did not recommend regulations to limit fishing in the proposed HAPC because there is no evidence of adverse effects from fishing on skate populations within these HAPC that would need to be addressed through regulation.

Figure 54 Map of Skate Egg Concentration Sites.



A.3.2.8 HAPC Process

The Council may designate specific sites as HAPCs and may develop management measures to protect habitat features within HAPCs.

50 CFR 600.815(a)(8) provides guidance to the Councils in identifying HAPCs. FMPs should identify specific types or areas of habitat within EFH as habitat areas of particular concern based on one or more of the following considerations:

(i) The importance of the ecological function provided by the habitat.
(ii) The extent to which the habitat is sensitive to human-induced environmental degradation.
(iii) Whether, and to what extent, development activities are, or will be, stressing the habitat type.
(iv) The rarity of the habitat type.

Proposed HAPCs, identified on a map, must meet at least two of the four considerations established in 50 CFR 600.815(a)(8), and rarity of the habitat is a mandatory criterion. HAPCs may be

developed to address identified problems for FMP species, and they must meet clear, specific, adaptive management objectives.
The Council will initiate the HAPC process by setting priorities and issuing a request for HAPC proposals. Any member of the public may submit a HAPC proposal. HAPC proposals may be solicited every 5 years, to coincide with the EFH 5-year review, or may be initiated at any time by the Council. The Council may periodically review existing HAPCs for efficacy and considerations based on new scientific research.

A.4 Effects of Fishing on Essential Fish Habitat

This section addresses the requirement in EFH regulations (50 CFR 600.815(a)(2)(i)) that each FMP must contain an evaluation of the potential adverse effects of all regulated fishing activities on EFH. This evaluation must 1) describe each fishing activity, 2) review and discuss all available relevant information, and 3) provide conclusions regarding whether and how each fishing activity adversely affects EFH. Relevant information includes the intensity, extent, and frequency of any adverse effect on EFH; the type of habitat within EFH that may be affected adversely; and the habitat functions that may be disturbed.

In addition, the evaluation should 1) consider the cumulative effects of multiple fishing activities on EFH, 2) list and describe the benefits of any past management actions that minimize potential adverse effects on EFH, 3) give special attention to adverse effects on HAPCs and identify any EFH that is particularly vulnerable to fishing activities for possible designation as HAPCs, 4) consider the establishment of research closure areas or other measures to evaluate the impacts of fishing activities on EFH, 5) and use the best scientific information available, as well as other appropriate information sources.

This evaluation assesses whether fishing adversely affects EFH in a manner that is more than minimal and not temporary in nature (50 CFR 600.815(a)(2)(ii)). This standard determines whether Councils are required to act to prevent, mitigate, or minimize any adverse effects from fishing, to the extent practicable. Although methods used to understand the effects of the groundfish fishing activities in the EFH Environmental Impact Statement of 2005 are different from those described in this FMP, Appendix B of the EFH EIS (2005) also contains a comprehensive, peer-reviewed analysis of fishing effects on EFH and detailed results for managed species.

Fishing operations change the abundance or availability of certain habitat features (e.g., prey availability or the presence of living or non-living habitat structure) used by managed fish species to accomplish spawning, breeding, feeding, and growth to maturity. These changes can reduce or alter the abundance, distribution, or productivity of that species, which in turn can affect the species' ability to "support a sustainable fishery and the managed species' contribution to a healthy ecosystem" (50 CFR 600.10). The outcome of this chain of effects depends on characteristics of the fishing activities, the habitat, fish use of the habitat, and fish population dynamics. The duration and degree of fishing's effects on habitat features depend on the intensity of fishing, the distribution of fishing with different gears across habitats, and the sensitivity and recovery rates of habitat features.

For the salmon fisheries, the analysis found that the effects of EFH are almost non-existent because troll and purse seine gear, which are predominant in the fisheries, generally never touches benthic habitat. Thus, the effects on EFH of the Alaska salmon fisheries are considered minimal and temporary in nature, and the salmon fisheries were not analyzed in detail in Appendix B of the EFH EIS (NMFS 2005).

Habitat Connections

Five species of Pacific salmon (chinook, chum, pink, coho, and sockeye) are managed under the Salmon FMP. Because all of these species use similar types of habitat, including habitats where fishing activities may occur, fishing effects on EFH were evaluated for all species together.

Spawning/Breeding—Salmon spawn and deposit their eggs in gravel areas of freshwater rivers and streams. Successful spawning depends upon the numbers of spawners, available habitat for spawning and nursery areas, and environmental conditions. Impacts to spawning and breeding of salmon occur when these habitat areas are disturbed, spawning biomass is reduced, or spawners are unable to reach suitable spawning areas.

Feeding—Once salmon smolts begin to enter the ocean, they feed on copepods. As they get larger, they add squid, juvenile herring, smelt, and other forage fish and invertebrate species to their diets. Salmon smolts use the nearshore area after entering the ocean, moving offshore as they get older, using pelagic habitats when at sea.

Growth to Maturity—Salmon feed throughout the open ocean of the North Pacific for up to 6 years (depending upon species) before maturing and returning to their natal rivers to spawn. Growth and mortality of juveniles depend on food availability, predation, bycatch in fisheries, and environmental conditions.

Salmon Fishing

No evidence suggests salmon troll, drift gillnet, or purse seine gear impacts habitat. The activity targets only adult salmon in the water column, successfully avoiding any significant disturbance of the benthos, substrate, or intertidal habitat. The EEZ salmon fisheries do not occur in any areas designated as Habitat Areas of Particular Concern.

Groundfish Fishing

The 2005 EFH FEIS, 2010 EFH Review, and 2015 EFH Review concluded that fisheries do have long term effects on habitat, and these impacts were determined to be minimal and not detrimental to fish populations or their habitats. For the 2015 EFH Review, a new Fishing Effects (FE) model was developed (Harris et al. 2017, Simpson et al. 2017). The Council used a three-tiered method to evaluate whether there are adverse effects of fishing on EFH. This analysis considered impacts of commercial fishing first at the population level, then used objective criteria to determine whether additional analysis is warranted to evaluate if habitat impacts caused by fishing are adverse and more than minimal or not temporary. With the FE model, the ability to analyze fishing effects on habitat has grown exponentially. Vessel Monitoring System data provided a much more detailed treatment of fishing intensity, allowing better assessments of the effects of overlapping effort and distribution of effort between and within grid cells. The development of literature-derived fishing effects database has increased our ability to estimate gear-specific susceptibility and recovery parameters. The distribution of habitat types, derived from increased sediment data availability, has improved. The combination of these parameters has greatly enhanced our ability to estimate fishing impacts. Based on the analysis with the FE model, the Council found that the effects of fishing on EFH in a holistic manner do not currently meet the threshold of more than minimal and not temporary.

Evaluation of Effects on Salmon EFH

Issue	Evaluation
Spawning/breeding	MT (Minimal, temporary, or no effect)
Feeding	MT (Minimal, temporary, or no effect)
Growth to maturity	MT (Minimal, temporary, or no effect)

Summary of Effects—No commercial fisheries in Alaska are thought to adversely affect salmon spawning habitat given almost no effort (except recreational and subsistence fisheries) in freshwater spawning and rearing areas. Thus, the effects of the fisheries on spawning of salmon are considered minimal and temporary in nature.

Fisheries are considered not to have any impact on freshwater or pelagic habitats used by juvenile salmon. However, fisheries do catch some species eaten by piscivorus species of salmon in the ocean, including squid, capelin, and juvenile herring. Currently, the catch of these prey species is very small relative to overall population size of these species, so fishing activities are considered to have minimal and temporary effects on feeding of all salmon species.

As stated above, fisheries are considered to have minimal effects on prey availability of salmon, including juveniles. Fisheries impacts on juvenile salmon at sea are due to incidental catches in groundfish fisheries. Bycatch in groundfish fisheries is almost nonexistent for pink salmon, coho salmon, and sockeye salmon, but does occur in measurable numbers for chum salmon and Chinook salmon taken in trawl fisheries, particularly the pollock trawl fisheries in the Bering Sea and Gulf of Alaska. The Council has recommended, and NMFS has implemented, a number of measures to minimize chum salmon and Chinook salmon bycatch in the groundfish fisheries in the Bering Sea and Gulf of Alaska. Thus, fishing activities are considered to have minimal and temporary effects on growth to maturity of salmon.

Fishing activities are considered to have overall minimal and temporary effects on the EFH for all salmon species. Fishing activities only interact with salmon habitat to any degree in the ocean habitats, and the concerns about these interactions center on effects on prey availability and bycatch. Prey of salmon (from copepods up to squid and forage fish) are not subject to directed fisheries removals, and bycatch is not a significant factor in total mortality. Professional judgement led to the conclusion that fisheries do not adversely affect the EFH of salmon species.

A.5 Non-fishing Activities that may Adversely Affect Essential Fish Habitat

The waters, substrates and ecosystem processes that provide EFH and support sustainable fisheries are susceptible to a wide array of human activities and climate related influences completely unrelated to the act of fishing. These activities range from easily identified point source anthropogenic discharges in watersheds or nearshore coastal zones to less visible influences of changing ocean conditions or increased variability in regional temperature or weather patterns. Broad categories of such activities include, but are not limited to, mining, dredging, fill, impoundment, discharge, water diversions, thermal additions, actions that contribute to nonpoint source pollution and sedimentation, introduction of potentially hazardous materials, introduction of exotic species, and the conversion of aquatic habitat that may eliminate, diminish, or disrupt the functions of EFH. For Alaska, these categories of non-fishing impacts are presented and discussed in the non-fishing impacts report, which NMFS updates every five years with the 5-year EFH review.

The most recent report is *Impacts to EFH from Non-Fishing Activities in Alaska* (Limpinsel et al. 2017). This report addresses non-fishing activities requiring EFH consultations and that may adversely affect EFH. The report offers general conservation measures for a wide variety of non-fishing activities grouped into four broad categories of ecotones: (1) wetlands and woodlands; (2) headwaters, streams, rivers, and lakes; (3) marine estuaries and nearshore zones; and (4) open water marine and offshore zones. The report emphasizes the recognition that water quality and quantity are the most important EFH attributes for sustainable fisheries. It also recognizes that in Alaska, water contributes to ecosystems processes supporting EFH under the influence of three climate zones, through eight terrestrial ecoregions, and water eventually influences the character of seventeen coastal zones and four Large Marine Ecosystems (LMEs). The report also provides: (1) descriptions of ecosystem processes and functions that support EFH through freshwater and marine systems; (2) the current observations and influence of climate change and ocean acidification to our federally managed fisheries in Alaska; and (3) discussions oil spill response technologies and increasing vessel traffic in the Bering Sea and Arctic Ocean.

The purpose of this report is to assist in the identification of activities that may adversely impact EFH and provide general EFH conservation recommendations to avoid or minimize adverse impacts. Section 305(b) of the MSA requires each Federal agency to consult with NMFS on any action that agency authorizes, funds, or undertakes, or proposes to authorize, fund, or undertake, that may adversely affect EFH. Each Council shall comment on and make recommendations to the Secretary and any Federal or State agency concerning any such activity that, in the view of the Council, is likely to substantially affect the habitat, including essential fish habitat, of an anadromous fishery resource under its authority. If NMFS or the Council determines that an action authorized, funded, or undertaken, or proposed to be authorized, funded, or undertaken, by any State or Federal agency would adversely affect any EFH, NMFS shall recommend to the agency measures that can be taken to conserve EFH. Within 30 days after receiving EFH conservation recommendations from NMFS, a Federal agency shall provide a detailed response in writing to NMFS regarding the matter. If the response is inconsistent with NMFS's recommendations, the Federal agency shall explain its reasons for not following the recommendations.

EFH conservation recommendations are non-binding to Federal and state agencies. EFH consultations do not supersede regulations or jurisdictions of Federal or state agencies. NMFS has no authority to issue permits for projects or require measures to minimize impacts of non-fishing activities. Most non-fishing activities identified in this report are already subject to numerous Federal, state, and local environmental laws and regulations designed to minimize and mitigate impacts. Listing all applicable laws and management practices is beyond the scope of this FMP or the non-fishing impacts report. Environmentally sound engineering and management practices are strongly encouraged to mitigate impacts from all actions to conserve and protect EFH.

Table 10 identifies activities other than fishing that may adversely affect EFH and identifies known and potential adverse effects to EFH. More information on these activities and the potential adverse effects is provided in the non-fishing impacts report (Limpinsel et al. 2017).

Table 10 Summary on Non-Fishing Effects on Habitat

Threats	HABITAT ALTERATION	Alternation of original or normal habitat	Loss of offshore habitat	Loss of pelagic habitat	Loss of nearshore habitat	Loss of benthic habitat	Loss of aquatic vegetaion	Loss of wetland value	Loss of original sediment type	Detrital matter introduction	TOPOGRAPHIC ALTERATION	Change in original feature or structure	Accretion \ Overburden of original feature	Erosion \ Dispersal of feature	ORGANISM ALTERATION	Physical damage to organism	Mortality	Spatial alteration	Gene pool deterioration	Introduction of exotic species	Introduction of pathogens\disease	Change in photosynthetic regime	OCEANOGRAPHIC ALTERATION	Change in temperture regime	Change in salinity	Change in circulation pattern	WATER QUALITY ALTERATION	Change in dissolved oxygen content	Eutrophication, nutrient loading	Water contamination	Suspended sediments, turbidity	Atmospheric deposition
Excavation																																
Dredging		X			X	X	X	X	X			X	X	X		X	X					X		*	*	*		*	X	X	X	
Dredge Material Disposal		X	X		X	X	X	X	X	X		X	X			X	X	X			X	X		*	*	*		*	X	X	X	
Marine Mining		X	X			X			X	X		X	X	X		X	X				X	X		X	X	X		*	X	X	X	
Nearshore Mining		X			X	X	X		X	X		X	X	X		X	X				X	X		*	*	*		*	X	X	X	
Recreational Uses																																
Boating				X	X	X	X			X						X	X			X	X			*	*	*		*	*	X	X	X
Stream Bank Over-usage		X						X	X	X		X	X	X		X	X				X	X							X	X	X	
Fish Waste Processing																																
Shoreside Discharge		X			X	X	X		X	X		X	X								X	X		X	X			*	X	X	X	
Vessel Discharge				X		X				X											X	X						*	X		X	
Aquaculture					X		X			X								X	X	X	X	X		X	X	X		*	X	X	X	
Petroleum Production																																
Production Facility		X	X		X	X	X	X	X	X		X	X	X			X	X			X	X		X	X	X				X	X	X
Exploration		X	X		X	X	X	X				X	X	X		X	X				X	X				X				X	X	X
Oil Spill		X	X		X	X	X	X	X	X						X	X		X		X	X			*			X		X	X	X
Hydrological																																
Hydroelectric Dams									X								X				X	X						X			X	
Impoundments		X					X	X	X			X	X	X		X	X				X	X						X	X		X	
Flood Erosion/Control		X			X		X	X	X			X	X	X		X	X					X						X	X			
Agricultural																																
Agriclutural/Farming		X			X		X	X	X	X		X	X	X				X			X			*	*			X	X	X	X	
Insect Control					X		X	X								X	X				X	X								X		X
Forestry		X			X		X	X	X	X		X	X	X		X		X				X		X	*					X	X	
Water Diversion/Withdraw l		X			X		X	X				X	X	X								X		*		X		X	X	X	X	
Harbors/Ports/Marinas																																
Port Construction		X			X	X	X	X	X	X		X	X	X		X	X	X				X		*	*	X		*		X	X	
Port Development		X			X	X	X	X	X	X		X	X	X		X	X	X			X	X				*		*		X	X	
Artifical Reefs		X			X	X						X	X	X				X				X		X	X	X						
Municipal and Industrial																																
Non-point Source				X	X	X	X	X	X	X			X			X	X	X	X		X	X		X	X			X		X		X
Coastal Urbanization		X			X	X	X	X	X	X		X	X	X		X	X	X	X	X	X	X		X	X	X		X	X	X	X	X
Sew age Treatment		X			X	X				X			X			X	X		X	X	X	X		X	X			X	X	X		
Storm Water Runoff					X					X						X	X		X	X	X	X		X	X			X	X	X	X	
Environmental																																
Climatic Changes/Shifts				X	X		X						X	X								X		X	X	X						X
Toxic Algal Bloom																X	X		X		X	X			*			X				
Introduction of Exotic Species																X	X	X	X	X	X								X			
Marine Transportation																																
Vessel Groundings		X			X	X	X		X	X		X		X		X	X			X	X									X		
Ballast Water				X		X										X	X		X	X	X	X		X	X					X		
Marine Debris		X		X	X	X	X		X	X			X			X	X	X			X	X								X		

* - short term impact

A.6 Cumulative Effects of Fishing and Non-fishing Activities on EFH

This section summarizes the cumulative effects of fishing and non-fishing activities on EFH. The cumulative effects of fishing and non-fishing activities on EFH were considered in the 2005 EFH EIS, but insufficient information existed to accurately assess how the cumulative effects of fishing and non-fishing activities influence ecosystem processes and EFH. The 2015 5-year review has reevaluated potential impacts of fishing and non-fishing activities on EFH using recent technologies and literature, and the current understanding of marine and freshwater fisheries science, ecosystem processes, and population dynamics (Simpson et al. 2017).

As previously identified in Section 4.4 EFH-EIS (NMFS 2005), historical fishing practices may have had effects on EFH that have led to declining trends in some of the criteria examined (Table 4.4-1). For fishing impacts to EFH, the FE model calculates habitat reductions at a monthly time step since 2003 and incorporates susceptibility and recovery dynamics, allowing for an assessment of cumulative effects from fishing activities for the first time. As identified in Section A.4, the effects of current fishing activities on EFH are considered as minimal and temporary or unknown using the new methods.

The cumulative effects from multiple non-fishing anthropogenic sources are increasingly recognized as having synergistic effects that may degrade EFH and associated ecosystem processes that support sustainable fisheries. Non-fishing activities may have potential long term cumulative impacts due to the long term additive and chronic nature of the activities combined with climate change (Limpinsel et al. 2017). However, the magnitude of the effects of non-fishing activities cannot currently be quantified with available information. NMFS does not have regulatory authority over non-fishing activities, but frequently provides recommendations to other agencies to avoid, minimize, or otherwise mitigate the effects of these activities.

Fishing and each activity identified in the analysis of non-fishing activities may not significantly affect the function of EFH. However, the synergistic effect of the combination of all of these activities may be a cause for concern. Unfortunately, available information is not sufficient to assess how the cumulative effects of fishing and non-fishing activities influence the function of EFH on an ecosystem or watershed scale. The magnitude of the combined effect of all of these activities cannot be quantified, so the cumulative level of concern is not known at this point.

A.7 Research Approach for EFH

The Council identified the following research approach for EFH regarding minimizing fishing impacts.

Objectives

Establish a scientific research and monitoring program to understand the degree to which impacts have been reduced within habitat closure areas, and to understand how benthic habitat recovery of key species is occurring.

Research Questions

Reduce impacts. Does the closure effectively restrict higher-impact trawl fisheries from a portion of the GOA slope? Is there increased use of alternative gears in the GOA closed areas? Does total bottom trawl effort in adjacent open areas increase as a result of effort displaced from closed areas? Do bottom trawls affect these benthic habitats more than the alternative gear types? What are the research priorities? Are fragile habitats in the AI affected by any fisheries that are not covered by the new EFH closures? Are sponge and coral essential components of the habitat supporting FMP species?

Benthic habitat recovery. Did the habitat within closed areas recover or remain unfished because of these closures? Do recovered habitats support more abundant and healthier FMP species? If FMP species are more abundant in the EFH protection areas, is there any benefit in yield for areas that are still fished without EFH protection?

Research Activities

- Fishing effort data from observers and remote sensing would be used to study changes in bottom trawl and other fishing gear activity in the closed (and open) areas. Effects of displaced fishing effort would have to be considered. The basis of comparison would be changes in the structure and function of benthic communities and populations, as well as important physical features of the seabed, after comparable harvests of target species are taken with each gear type.
- Monitor the structure and function of benthic communities and populations in the newly closed areas, as well as important physical features of the seabed, for changes that may indicate recovery of benthic habitat. Whether these changes constitute recovery from fishing or just natural variability/shifts requires comparison with an area that is undisturbed by fishing and otherwise comparable.
- Validate the LEI model and improve estimates of recovery rates, particularly for the more sensitive habitats, including coral and sponge habitats in the Aleutian Islands region, possibly addressed through comparisons of benthic communities in trawled and untrawled areas.
- Obtain high resolution mapping of benthic habitats, particularly in the on-shelf regions of the Aleutian Islands.
- Time series of maturity at age should be collected to facilitate the assessment of whether habitat conditions are suitable for growth to maturity.
- In the case of red king crab spawning habitat in southern Bristol Bay, research the current impacts of trawling on habitat in spawning areas and the relationship of female crab distribution with respect to bottom temperature.

Research Time Frame

Changes in fishing effort and gear types should be readily detectable. Biological recovery monitoring may require an extended period if undisturbed habitats of this type typically include large or long-lived organisms and/or high species diversity. Recovery of smaller, shorter-lived components should be apparent much sooner.

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