Amendments 16 and 12 to the Fishery Management Plan for
Bering Sea/Aleutian Islands King and Tanner Crabs

1. Amendment 16 supersedes Amendment 8. In the Executive Summary box of FMP amendments, revise the text for Amendment 8 and add text for Amendment 16 and 12 as follows:

8. Defined essential fish habitat (superceded by Amendment 16)
12. Identify Habitat Areas of Particular Concern and protection measures (proposed)
16. Defined essential fish habitat and protection measures (proposed)

2. In the Executive Summary, under FMP Management Measures, add the following text to the table, under Category 1 (Fixed in the FMP):

Essential Fish Habitat
Habitat Areas of Particular Concern

3. In the Executive Summary, under <u>Category 1 Management Measures</u>, the following text is added to read as follows:

Essential Fish Habitat (EFH) - The FMP describes and identifies EFH for BSAI crab and identifies fishing and non-fishing threats to BSAI crab EFH, research needs, and EFH conservation and enhancement recommendations.

Habitat Areas of Particular Concern (HAPC) - The FMP identifies specific HAPCs for the BSAI crab fisheries and establishes management measures to reduce potential adverse effects of fishing on HAPCs.

4. In Section 4.0 Definitions of Terms, the following text is added to read as follows:

Habitat Conservation Areas: Areas where fishing restrictions are implemented for purposes of habitat conservation.
Habitat Conservation Zone: A subset of a habitat conservation area in which additional restrictions are imposed on fishing beyond those restrictions established for the habitat conservation area to protect specific habitat features.
Habitat Protection Areas: Areas of special, rare habitat features where fishing activities that may adversely affect the habitat are restricted.

5. In Section 7.2.4, the habitat objective is revised to read as follows:

<u>Habitat Objective</u>: To protect, conserve, and enhance adequate quantities of essential fish habitat (EFH) to support king and Tanner crab populations and maintain a healthy ecosystem

Habitat is defined as the physical, chemical, geological, and biological surroundings the support healthy, self-sustaining populations of living marine resources. Habitat includes both the physical component of the environment which attracts living marine resources (e.g. salt marshes, sea grass beds, coral reefs, intertidal lagoons, and near shore characteristics) and the chemical (e.g. salinity, benthic community) and biological characteristics (e.g. scallop life stage histories, oceanography) that are necessary to support living marine resources. The quality and availability of habitat supporting the king and Tanner crab populations are important. Fishery managers should strive to ensure that those waters and substrate necessary to king and Tanner crabs for spawning, breeding, feeding, or growth to maturity are available. It is also important to consider the potential impact of king and Tanner crab fisheries on other fish and shellfish populations. King and Tanner crab EFH is described in Appendix F of this FMP.

Those involved in both management and exploitation of king and Tanner crab resources will actively review actions by other human users of the management area to ensure that their actions do not cause deterioration of habitat. Any action by a State or Federal agency potentially affecting king and Tanner crab habitat in an adverse manner may be reviewed by the Council for possible action under the Magnuson-Stevens Act. The Council will also consider the effect on king and Tanner crab habitat of its own management decisions in other fisheries.

6. In section 8.0, add the following text to table 8.1, under Category 1,

Essential Fish Habitat
Habitat Areas of Particular Concern

7. Section 8.1.6 Essential Fish Habitat and HAPC is added to read as follows:

8.1.6 Essential Fish Habitat and Habitat Areas of Particular Concern

8.1.6.1 Description of Essential Fish Habitat

Section 303(a)(7) of the Magnuson-Stevens Act requires FMPs to describe and identify Essential Fish Habitat (EFH), minimize to the extent practicable adverse effects of fishing on EFH, and identify other actions to conserve and enhance EFH. This FMP describes king and tanner crab EFH in text, maps EFH distributions, and includes information on habitat and biological requirements for each life history stage of the species. Appendix F contains this required information, as well as identifying an EFH research approach.

8.1.6.2 Description of Habitat Areas of Particular Concern

The EFH regulations at 50 CFR 600.815(a)(8) provide the Councils with guidance to identify habitat areas of particular concern (HAPCs). HAPCs are meant to provide greater focus to conservation and management efforts and may require additional protection from adverse effects. FMPs should identify specific types or areas of habitat within EFH as HAPCs based on one or more of the following considerations:

1. the importance of the ecological function provided by the habitat;
2. the extent to which the habitat is sensitive to human-induced environmental degradation;
3. whether, and to what extent, development activities are, or will be, stressing the habitat

type; or

4. the rarity of the habitat type.

In 2005, the Council identified the following areas as HAPCs within EFH:

- Alaska Seamount Habitat Protection Areas
- Bowers Ridge Habitat Conservation Zone

Maps of these HAPCs, as well as their coordinates, are contained in Appendix F.

8.1.6.3 Conservation and Enhancement Recommendations for EFH and HAPC

Appendix F identifies fishing and non-fishing threats to EFH. Conservation and enhancement recommendations for non-fishing threats to EFH and HAPCs are described therein.

In order to protect EFH from fishing threats, the Council established the following areas:

- Aleutian Islands Habitat Conservation Area
- Aleutian Islands Coral Habitat Protection Areas

Maps of these areas, as well as their coordinates, are contained in Appendix F. In addition, the Council established restrictions for these areas as described below.

Aleutian Islands Habitat Conservation Area
The use of nonpelagic trawl gear is prohibited year-round in the Aleutian Islands Habitat Conservation Area, except in designated areas; however, the use of trawl gear is prohibited in the king and tanner crab fisheries (see Section 8.1.1).

Aleutian Islands Coral Habitat Protection Areas
The use of bottom contact gear, as described in 50 CFR part 679, and anchoring by federally permitted fishing vessels is prohibited in the Aleutian Islands Coral Habitat Protection Areas.

In order to minimize adverse effects of fishing, the Council also established restrictions for HAPCs. These restrictions are described below.

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 in the Alaska Seamount Habitat Protection Area.

Bowers Ridge Habitat Conservation Zone
The use of mobile bottom contact gear, as described in 50 CFR part 679, is prohibited in the Bowers Ridge Habitat Conservation Zone.

8.1.6.4 Review of EFH and HAPC

An annual review of existing and new EFH information will be conducted by NMFS or the Council and this information will be provided to the Crab Plan Team for their review during the annual SAFE

process. To address regulatory guidelines for review and revision of EFH FMP components, the Council will conduct a complete review of all the EFH components of the FMP once every 5 years and will amend the FMP as appropriate to include new information.

Additionally, the Council may use the FMP amendment cycle every three years to solicit proposals for HAPCs and/or conservation and enhancement measures to minimize the potential adverse effects of fishing. Any proposal endorsed by the Council would be implemented by FMP amendment.

8. Section 8.1.7 Habitat Areas of Particular Concern is added to read as follows:

8.1.7 Habitat Areas of Particular Concern

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.

50 CFR 600.815(a)(8) provides the Councils with guidance to identify habitat areas of particular concern. 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.

8.1.7.1 HAPC Designation

In 2005, the Council identified the Alaska Seamount Habitat Protection Areas and the Bowers Ridge Habitat Conservation Zone within crab EFH as HAPCs in the BSAI to minimize adverse effects from fishing on EFH. Maps of these HAPCs, as well at the coordinates, are contained in Appendix F.

Alaska Seamount Habitat Protection Area
The use of bottom contact gear, including pot gear, by a federally permitted fishing vessel, as described in 50 CFR part 679, is prohibited in the Alaska Seamount Habitat Protection Area. Anchoring by a federally permitted fishing vessel, as described in 50 CFR part 679, is also prohibited.

Bowers Ridge Habitat Conservation Zone
The use of mobile bottom contact gear, as described in 50 CFR part 679, is prohibited in the Bowers Ridge Habitat Conservation Zone.

9. Replace Appendix F with the file **Appendix F EFH**.

10. Revise Appendix I by adding the following references in alphabetical order:

NMFS. 2005. Environmental Impact Statement for Essential Fish Habitat Identification and Conservation in Alaska. April 2005. NMFS P. O. Box 21668, Juneau, AK 99801.

NPFMC. 2005. Environmental Assessment/Regulatory Impact Review/Regulatory Flexibility Analysis for Amendments 65/65/12/7/8 to the BSAI Groundfish FMP (#65), GOA Groundfish FMP (#65), BSAI Crab FMP (#12), Scallop FMP (#7) and the Salmon FMP (# 8) and regulatory amendments to provide Habitat Areas of Particular Concern. March 2005. NPFMC 605 West 4th St. Ste. 306, Anchorage, AK 99501-2252. 248pp.

G:\FMGROUP\Amendment 78-73 EFH-HAPC\CouncilFiles\crab FMP text\KTC fmp amend text without appendix.wpd
mnbrown:10/13/05 based on Council review
gharrington:8/05

FMP for BSAI King and Tanner Crabs
Appendix F: Essential Fish Habitat and Habitat Areas of Particular Concern

Contents

1.0 Overview

Section 303(a)(7) of the Magnuson-Stevens Act requires 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 16 to the BSAI King and Tanner Crab FMP and corresponding amendments to the Council's other FMPs.

2.0 Life History Features and Habitat Requirements of FMP Species

This section describes habitat requirements and life histories of the crab species managed by this FMP. Information contained in this appendix details life history information for federally managed crab species. Each species or species group is described individually; however, summary tables that denote habitat associations (Table 2), reproductive traits (Table 3), and predator and prey associations (Table 4) are also provided. In each section, a species-specific table summarizes habitat requirements.

2.1 Habitat Types

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 Gulf of Alaska (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 Aleutian Islands (AI) (Favorite et al. 1976). There is net water transport eastward along the north side of the 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. 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 Priblof 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.

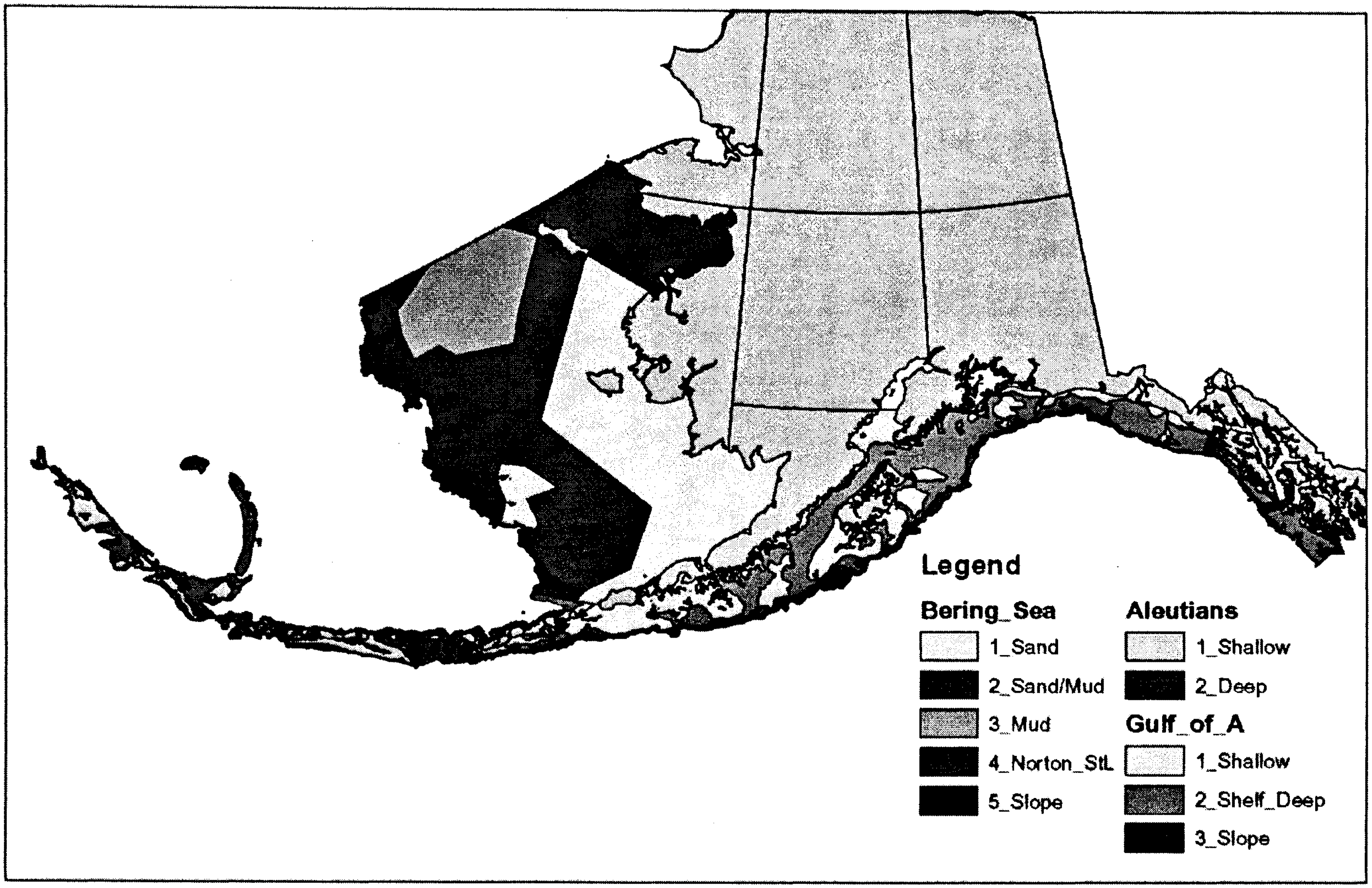
Bowers Ridge in the AI is a submerged geographic structure forming a ridge arc off the west-central AI. Bowers Ridge is about 550 km long and 75 to 110 km wide. The summit of the ridge lies in water approximately 150 to 200 m deep in the southern portion deepening northward to about 800 to 1,000 m at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

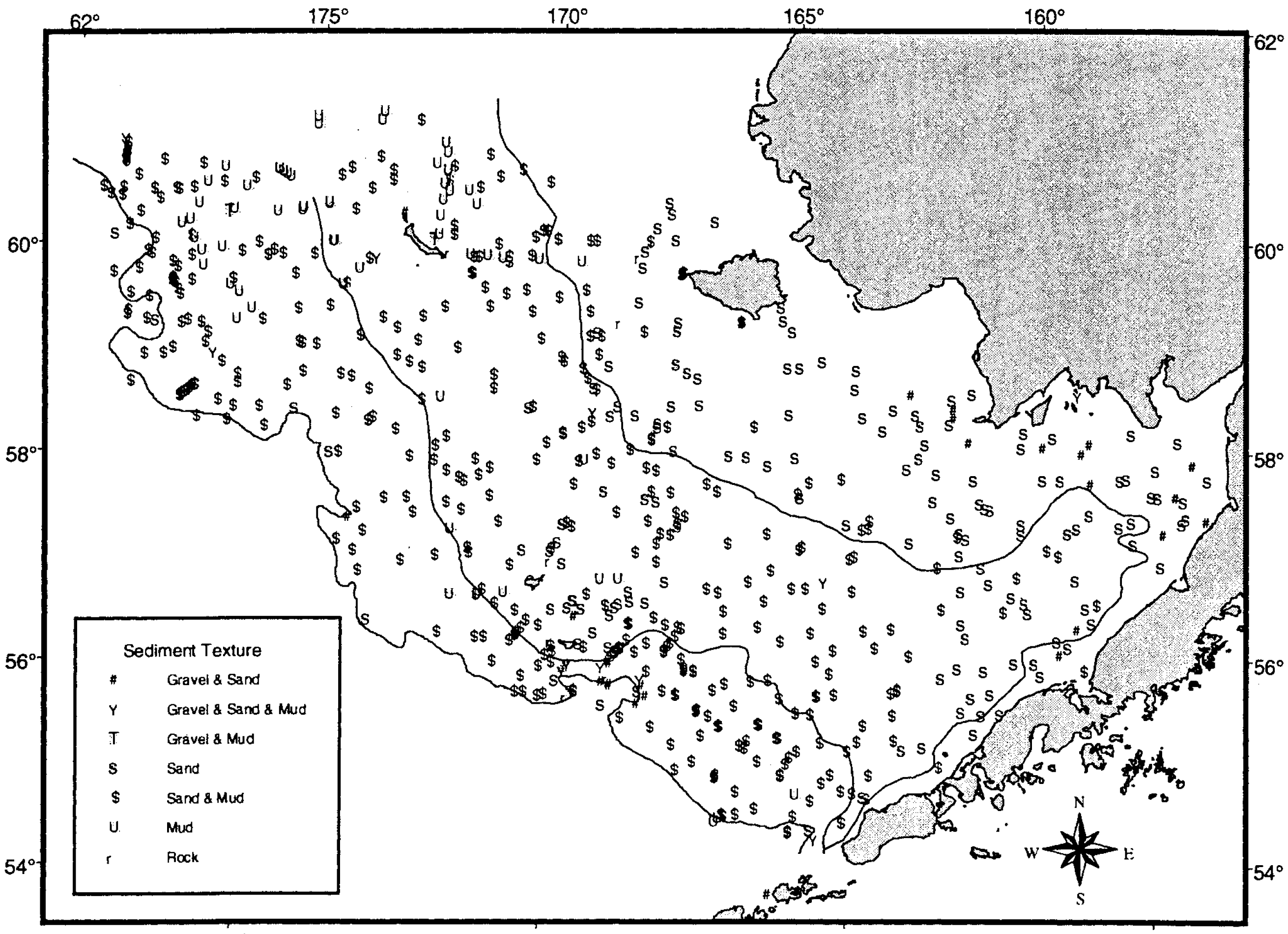
Climate change effects on the AI area are similar to the effects described for climate change in the EBS. For more information on the physical environment of the AI, refer to the Alaska Groundfish Fisheries Programmatic Supplemental EIS (NMFS 2004).

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

2.2 General Life History Information for Crab

Shallow inshore areas (less than 50 m depth) are very important to king crab reproduction as they move onshore to molt and mate. Tanner crabs also occupy shallower depths during molting and mating. All BSAI crab are highly vulnerable to predation and damage during molting when they shed their exoskeleton. Female king crab molt annually to mate while Tanner and snow crab exhibit terminal molt and carry sperm for future clutch fertilization. The habitat occupied by molting and mating crab differs from that occupied by mature crabs during the remainder of the year. The EFH EIS crab technical team noted protection of crab in molting mating habitat during this sensitive life history stage is important.

Larval stages are distributed according to vertical swimming abilities, and the currents, mixing, or

stratification of the water column. Generally, the larval stages occupy the upper 30 m, often in the mixed layer near the sea surface. As the larvae molt and grow into more actively swimming stages they are able to seek a preferred depth. After molting through multiple larval stages, crabs settle on the bottom. Settlement on habitat with adequate shelter, food, and temperature is imperative to survival of first settling crabs. Young of the year red and blue king crabs require nearshore shallow habitat with significant cover that offers protection (e.g., sea stars, anemones, macroalgae, shell hash, cobble, shale) to this frequently molting life stage. Early juvenile stage Tanner and snow crab also occupy shallow waters and are found on mud habitat. Late juvenile stage crab are most active at night when they feed and molt. The EFH EIS crab technical team emphasized the importance of shallow areas to all early juvenile stage crabs and in particular the importance to red and blue king crabs of high relief habitat nearshore with extensive biogenic assemblages. The area north and adjacent to the Alaska peninsula (Unimak Island to Port Moller), the eastern portion of Bristol Bay, and nearshore areas of the Pribilof and Saint Matthew Islands are locations known to be particularly important for king crab spawning and juvenile rearing.

Egg Stage

Female king and Tanner crabs extrude eggs, carry and nurture them outside the maternal body. The number of eggs developed by the female increases with body size and is linked to nutrition at favorable temperatures. Information on egg bearing females is used to define habitat for the egg stage of crabs.

Larval Stage

Successful hatch of king and Tanner crab larvae is a function of temperature and concentration of diatoms, so presence of larvae in the water column can vary accordingly. Larvae are planktonic. Their sustained horizontal swimming is inconsequential compared to horizontal advection by oceanographic conditions. Larvae vertically migrate within the water column to feed. Diel vertical migration may be a retention mechanism to transport larvae inshore.

Early Juvenile Stage

The early juvenile stage includes crabs first settling on the bottom (glacothoe and megalops), young of the year crabs, and crabs up to a size approximating age 2. Habitat relief is obligatory for red and blue King crabs of this life stage. Individuals are typically less than 20 mm CL distributed in nearshore waters among niches provided by sea star arms, anemones, shell hash, rocks and other bottom relief. Early juvenile Tanner crab settle on mud, are known to occur there during summer but are not easily found in this habitat in winter.

Late Juvenile Stage

The late juvenile stage for crab is defined as the size at about age 2 to the first size of functional maturity. Late juvenile crabs are typically found further offshore in cooler water than early juvenile crabs. Smaller red king crabs of this life stage form pods during the day that break apart during the night when the crabs forage and molt. As these crabs increase in size, podding behavior declines and the animals are found to forage throughout the day.

Mature Stage

Mature crabs are defined as those crabs of a size that is functionally mature. Functional maturity is based on size observed in mating pairs of crabs. This maturity definition differs from morphometric maturity based on chela height and physiological maturity when sperm or eggs can be produced. The mature stage includes crabs from the first size of functional maturity to senescence.

The following abbreviations are used in the habitat tables to specify location, position in the water column, bottom type, and other oceanographic features.

Table 1 Abbreviations used in the EFH report tables to specify location, depth, bottom type, and other oceanographic features.

Location

ICS = inner continental shelf (1-50 m)
MCS = middle continental shelf (50-100 m)
OCS = outer continental shelf (100-200 m)
USP = upper slope (200-1000 m)
LSP = lower slope (1000-3000 m)
BSN= basin (>3000 m)

BCH = beach (intertidal)
BAY = nearshore bays, give depth if appropriate (e.g., fjords)
IP = island passes (areas of high current), give depth if appropriate

Water column

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

Bottom Type

M = mud | S = sand | R = rock
SM = sandy mud | CB = cobble | C = coral
MS = muddy sand | G = gravel | K = kelp
SAV = subaquatic vegetation (e.g., eelgrass, not kelp)

Oceanographic Features

UP = upwelling | G = gyres | F = fronts | E = edges
CL = thermocline or pycnocline

General

U = Unknown | N/A = not applicable

Table 2. Summary of Habitat Associations for BSAI Crab

BSAI Crab		Nearshore				Shelf			Slope					
						Inner	Middle	Outer	Upper		Inter-mediate		Lower	Basin
Species	Life Stage	Freshwater	Estuarine	Intertidal	Subtidal	1-50m	51-100m	101-200m	201-300m	301-500m	501-700m	701-1000m	1001-3000m	>3000m
Blue King Crab	M					x	x	x						
	LJ					x	x	x						
	EJ					x	x							
	L					x	x							
	E					x	x	x						
Golden King Crab	M							x	x	x	x	x		
	LJ												x	x
	EJ												x	x
	L													
	E							x	x	x	x			
Red King Crab	M					x	x	x						
	LJ					x	x	x						
	EJ					x	x							
	L					x	x							
	E					x	x	x						
Snow Crab	M					x	x	x						
	LJ					x	x	x						
	EJ					x	x							
	L					x	x							
	E					x	x	x						
Tanner	M					x	x	x	x	x	x			
	LJ			x	x	x	x	x	x	x				
	EJ				x	x	x	x	x	x				
	L		x	x	x	x	x							
	E				x	x	x	x	x	x	x	x		

BSAI Crab		Stratum Reference							Location							Physical Oceanography				
													Pelagic							
Species	Life Stage	Shallows	Island Pass	Bay/Fjord	Bank	Flat	Edge	Gully	Surafce	Near surface	Semi-demersal	Demersal	1-200m (epi)	201-1000m (meso)	>1000m (bathy)	Upwelling areas	Gyres	Thermo/pycnocline	Fronts	Edges (ice, bath)
Blue King Crab	M											x								
	LJ											x								
	EJ											x								
	L												x							
	E											x								
Golden King Crab	M		x		x							x								
	LJ				x							x								
	EJ											x								
	L												x							
	E				x							x								
Red King Crab	M											x								
	LJ											x								
	EJ											x								
	L												x							
	E											x								
Snow Crab	M											x								
	LJ											x								
	EJ											x								
	L												x							
	E											x								
Tanner	M			x	x							x							x	
	LJ				x							x						x	x	
	EJ				x							x								
	L												x						x	
	E											x							x	

BSAI Crab		Substrate													Structure									
Species	Life Stage	Organic Debris	Mud	Sand	Gravel	Mud & sand	Mud & gravel	Sand & mud	Gravel & mud	Gravel & sand	Gravel & sand & mud	Gravel & mud & sand	Cobble	Rock	Bars	Sinks	Slumps\Rockfalls\Debris	Channels	Ledges	Pinnacles	Seamounts	Reefs	Vertical Walls	Man-made
Blue King Crab	M			x	x								x	x			x	x	x	x		x	x	
	LJ			x	x								x	x			x	x	x	x		x	x	
	EJ																							
	L																							
	E			x	x								x	x			x	x	x	x		x	x	
Golden King Crab	M			x	x								x	x			x	x	x	x	x	x	x	
	LJ			x	x								x	x			x	x	x	x		x	x	
	EJ																							
	L																							
	E			x	x								x	x			x	x	x	x		x	x	
Red King Crab	M	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										
	L																							
	E	x	x	x	x	x	x	x	x	x	x	x												
Snow Crab	M	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												
	L																							
	E	x	x	x	x	x	x	x	x	x	x	x												
Tanner	M	x	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	x	x	x		x	x	x	x						x
	EJ	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x	x						x
	L																							
	E	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x	x						x

Table 3. Summary of Reproductive Traits of BSAI Crab

BSAI Crab		Age at Maturity: Female		Age at Maturity: Male		Fertilization/Egg Development					Spawning Behavior						Spawning Season											
Species	Life Stage	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
Blue King Crab	M	6+			6+	X		X								X	X	X	X	X	X	X	X					
	LJ																											
	EJ																											
	L																											
	E																											
Golden King Crab	M	6+			6+	X		X								X	X	X	X	X	X	X	X	X	X	X	X	X
	LJ																											
	EJ																											
	L																											
	E																											
Red King Crab	M	7 to 8		7 to 10		X		X								X	X	X	X	X	X	X	X					
	LJ																											
	EJ																											
	L																											
	E																											
Snow Crab	M	5 to 6		6 to 8		X	X	X								X	X	X	X	X	X	X						
	LJ																											
	EJ																											
	L																											
	E																											
Tanner Crab	M	5 to 6		6 to 8		X	X	X								X	X	X	X	X	X	X						
	LJ																											
	EJ																											
	L																											
	E																											

Table 4. Summary of Predator and Prey Relationships for BSAI Crab

BSAI Crab — Predator to

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
Blue King Crab	M	X				X			X			X	X			X	X	X												
	LJ	X				X			X			X	X			X	X	X												
	EJ																													
	L																													
	E																													
Golden King Crab	M	X				X			X			X	X			X	X	X	X											
	LJ	X				X			X			X	X			X	X	X												
	EJ																													
	L																													
	E																													
Red King Crab	M	X				X			X			X	X			X	X	X												
	LJ	X				X			X			X	X			X	X	X												
	EJ																													
	L																													
	E																													
Snow Crab	M	X				X			X			X	X			X	X	X												
	J	X				X			X			X	X			X	X	X												
	L																													
Tanner Crab	M	X				X			X			X	X			X	X	X												
	LJ	X				X			X			X	X			X	X	X												
	EJ																													
	L	X			X	X																								
	E																													

BSAI Crab — Prey of

Species	Life Stage	Jellyfish	Starfish	Chaetognaths (arrowworms)	Crab	Herring	Salmon	Pollock	Pac fic Cod	Rockfish	Rock Sole	Flathead Sole	Yellowfin sole	Arrowtooth flounder	Skate	Hailbut	Salmon Shark	Northern Fur Seal	Harbor Seal	Steller sea lion	Dalls Porpoise	Beluga whale
Blue King Crab	M								X							X						
	LJ								X							X						
	EJ								X							X						
	L																					
	E																					
Golden King Crab	M								X							X						
	LJ								X							X						
	EJ								X							X						
	L																					
	E																					
Red King Crab	M								X							X						
	LJ								X							X						
	EJ								X							X						
	L																					
	E																					
Snow Crab	M								X													
	J								X			X	X		X	X						
	L																					
Tanner Crab	M								X													
	LJ								X		X	X	X		X	X						
	EJ								X		X	X	X		X	X						
	L	X		X		X	X	X														
	E																					

2.3 Habitat Description for Red King Crab (*Paralithodes camtschaticus*)

Life History and General Distribution

Red king crab (*Paralithodes camtshaticus*) is widely distributed throughout the BS and AI, GOA, Sea of Okhotsk, and along the Kamchatka shelf. Red king crab are typically at depths <100 fathoms (fm). King crab molt multiple times per year through age 3 after which molting is annual. At larger sizes, king crab may skip molt as growth slows. Females grow slower and do not get as large as males. In Bristol Bay, 50 percent maturity is attained by males at 12 cm CL and 9 cm CL by females (about 7 years). Female red king crab in the Norton Sound area reach 50 percent maturity at 6.8 cm and do not attain maximum sizes found in other areas. Size at 50 percent maturity for females in the western Aleutians is 8.9 cm CL. Natural mortality of adult red king crab is assumed to be about 18 percent per year (M=0.2), due to old age, disease, and predation.

Fishery

The red king crab fisheries are prosecuted using mesh covered pots (generally 7 or 8 feet square) set on single lines. Mean age at recruitment is about 8 to 9 years. Two discrete populations of red king crab are actively fished in the BSAI region: Bristol Bay and Norton Sound. A third population surrounding the AI was managed separately as Adak and Dutch Harbor stocks until 1996 when the management areas were combined. The fishery on the Adak stock was closed in 1996, and the fishery on the Dutch Harbor stock has closed since the 1983 to 1984 season. These fisheries historically occurred in the winter and spring. Red king crab are allowed as bycatch during golden king crab fisheries in those areas. Other populations of red king crab are fished in the Pribilof Islands area, St. Matthew, and St. Lawrence Island area, but are managed in conjunction with the predominant blue king crab fisheries. Red king crab stocks are managed separately to accommodate different life histories and fishery characteristics. Male only red king crab >16.5 cm CL are allowed to be taken from Bristol Bay and the Pribilof and AI. The minimum size limit for harvest of male only crab from the Norton Sound and the St. Matthew and St. Lawrence Island population is 12 cm. The season in Bristol Bay begins on November 1 and generally has lasted less than 10 days in recent years. Bycatch in red king crab fisheries consists primarily of Tanner crab and nonlegal red king crab. The commercial fishery for red king crab in Norton Sound occurs in the summer, opening July 1, and a winter through-the-ice fishery opens November 15 and closes May 15.

Bottom trawls and dredges could disrupt nursery and adult feeding areas.

Relevant Trophic Information

Pacific cod is the main predator on red king crabs. Walleye pollock, yellowfin sole, and Pacific halibut are minor consumers of pelagic larvae, settling larvae, and larger crabs, respectively. Juvenile crab may be cannibalistic during molting.

Approximate Upper Size Limit of Juvenile Crab (in cm): The size at 50 percent maturity is 7 and 9 cm CL for female and male red king crabs, respectively, from Norton Sound and St. Matthew and St. Lawrence Islands; it is 9 and 12 cm, respectively, for Bristol Bay and the Pribilof and Aleutian Islands.

Habitat and Biological Associations

Egg: Egg hatch of larvae is synchronized with the spring phytoplankton bloom in southeast Alaska suggesting temporal sensitivity in the transition from benthic to planktonic habitat. Also see mature phase description; eggs are carried by adult female crab.

Larvae: Red king crab larvae spend 2 to 3 months in pelagic larval stages before settling to the benthic life stage. Reverse diel migration and feeding patterns of larvae coincide with the distribution of food sources.

Early Juvenile: Early juvenile stage red king crabs are solitary and need high relief habitat or coarse substrate such as boulders, cobble, shell hash, and living substrates such as bryozoans and stalked ascidians. Young-of-the-year crabs occur at depths of 50 m or less.

Late Juvenile: Late juvenile stage red king crabs ages of 2 and 4 years exhibit decreasing reliance on habitat and a tendency for the crab to form pods consisting of thousands of crabs. Late juvenile crab associate with deeper waters and migrate to shallower water for molting and mating in the spring. Aggregation behavior continues into adulthood.

Mature: Mature red king crabs exhibit seasonal migration to shallow waters for reproduction. The remainder of the year, red king crabs are found in deeper waters. In Bristol Bay, red king crabs mate when they enter shallower waters (<50 m), generally beginning in January and continuing through June. Males grasp females just prior to female molting, after which the eggs (43,000 to 500,000 eggs) are fertilized and extruded on the female's abdomen. The female red king crab carries the eggs for 11 months before they hatch, generally in April.

SPECIES: Red king crab, *Paralithodes camtschaticus*

Life Stage	Duration or Age	Diet/Prey	Season/Time	Location	Water Column	Bottom Type	Oceanographic Features	Other
Eggs	11 mo	NA	May-April	NA	NA	NA	F	
Larvae	3-5 mo	Diatoms, Phytoplankto n Copepod nauplii	April-August	MCS, JCS	P	NA	F	
Juveniles	1 to 5-6 yrs	Diatoms Hydroids	All year	ICS, MCS, BCH, BAY	D	SAV (epifauna), R, CB, G	F	Found among biogenic assemblages (sea onions, tube worms, bryozoans, ascidians, sea stars)
Adults	5-6+ yrs	Mollusks, echinoderms, polychaetes, decapod, crustaceans, Algae, urchins, hydroids, sea stars	Spawning Jan-June	MCS, ICS, BAY, BCH	D	S, M, CB, G	F	

2.4 Habitat Description for Blue King Crab *(Paralithodes platypus)*

Life History and General Distribution

Blue king crab (*Paralithodes platypus*) has a discontinuous distribution throughout its range (Hokkaido, Japan to Southeast Alaska). In the BS, discrete populations exist in the cooler waters around the Pribilof Islands, St. Matthew Island, and St. Lawrence Island. Smaller populations have been found in Herendeen Bay and around Nunivak and King Island, as well as isolated populations in the GOA. Blue king crab molt multiple times as juveniles. In the Pribilof area, 50 percent maturity of females is attained at 9.6 cm CL, which occurs at about 5 years of age. Blue king crab in the St. Matthew area mature at smaller sizes (50 percent maturity at 8.1 cm CL for females) and do not get as large overall. Skip molting occurs with increasing probability for those males larger than 10 cm CL and is more prevalent for St. Matthew Island crab. Larger female blue king crab have a biennial ovarian cycle and a 14-month embryonic period. Unlike red king crab, juvenile blue king crab do not form pods, instead relying on cryptic coloration for protection from predators. Adult male blue king crab occur at an average depth of 70 m and an average temperature of 0.6°C.

Fishery

The blue king crab fisheries are prosecuted using mesh covered pots (generally 7 or 8 feet square) set on single lines. Two discrete stocks of blue king crab are fished: the Pribilof Islands and the St. Matthew Island stocks. These blue king crab fisheries have occurred in September in recent years. Bycatch in the blue king crab fisheries consist almost entirely of non-legal blue king crabs. Male only crabs >16.5 cm carapace width (CW) are harvested in the Pribilof Islands, while the St. Matthew Islands fishery is managed with a minimum size limit of 140 mm.

Bottom trawls and dredges could disrupt nursery and adult feeding areas.

Relevant Trophic Information

Pacific cod is a predator on blue king crabs.

Approximate Upper Size Limit of Juvenile Crab (in cm): The size at 50 percent maturity is 9- and 12-cm CL for female and male crabs from the Pribilof Islands, and 8- and 10.5-cm CL for St. Matthew Island.

Habitat and Biological Associations

Egg: See mature phase description; eggs are carried by adult female crab.

Larvae: Blue king crab larvae spend 3.5 to 4 months in pelagic larval stages before settling to the benthic life stage. Larvae are found in waters between 40 to 60 m deep.

Early Juvenile: Early juvenile blue king crabs require area found in substrate characterized by gravel and cobble overlaid with shell hash and sponge, hydroid, and barnacle assemblages. These habitat areas have been found at 40 to 60 m around the Pribilof Islands.

Late Juvenile: Late juvenile blue king crab are found in nearshore rocky habitat with shell hash.

Mature: Mature blue king crabs occur most often between 45 and 75 m deep on mud-sand substrate adjacent to gravel rocky bottom. Female crabs are found in a habitat with a high percentage of shell hash. Mating occurs in mid-spring. Larger older females reproduce biennially, while small females tend to reproduce annually. Fecundity of females range from 50,000 to 200,000 eggs per female. It has been suggested that spawning may depend on the availability of nearshore rocky-cobble substrate for protection of females. Larger older crabs disperse farther offshore and are thought to migrate inshore for molting and mating.

SPECIES: Blue king crab, *Paralithodes platypus*

Life Stage	Duration or Age	Diet/Prey	Season/Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs	14 mo.	NA	Starting April-May	NA	NA	NA	F	
Larvae	3.5 to 4 mo.		April-July	MCS, ICS	P	NA	F	
Juveniles	to about 5 years		All year	MCS, ICS	D	CB, G, R	F	
Adults	5+ years		Spawning Feb-Jun	MCS, ICS	D	S, M, CB, G, R	F	

2.5 Habitat Description for Golden King Crab *(Lithodes aequispina)*

Life History and General Distribution

Golden king crab (*Lithodes aequispina*), also called brown king crab, range from Japan to British Columbia. In the BS and AI, golden king crab are found at depths from 100 to 1,000 m, generally in high relief habitat such as inter-island passes, and they are usually slope-dwelling. Size at sexual maturity depends on latitude and ranges from 9.8 to 11 cm CL, with crabs in the northern areas maturing at smaller sizes. Females carry up to 20,000 eggs, depending on their size. The season of reproduction appears to be protracted and may be year-round.

Fishery

The golden king crab fisheries are prosecuted using mesh covered pots set on longlines to minimize gear loss. The primary fishery is in the AI, with minor catches coming from localized areas in the BS and GOA. Until 1996, the golden king crabs in the AI were managed as two separate stocks: Adak and Dutch Harbor. The fishing season opens September 1 and male crab >15.2 cm are harvested. Golden king crab are harvested in the BS under conditions of a permit issued by the Commissioner of the Alaska Department of Fish and Game. Bycatch consists almost exclusively of non-legal golden king crab. Escape rings were adopted by the Alaska Board of Fisheries in 1996 to reduce capture and handling mortality of non-target crab; a minimum of four 5.5-inch rings are required on pots used in golden king crab fisheries.

Relevant Trophic Information Unknown

Approximate Upper Size Limit of Juvenile Crab (in cm): The size (CL) at 50 percent maturity for females and males: Aleutians 11 and 12.5 cm, Pribilofs 10 and 10.7 cm, Northern BS 9.8 and 9.2 cm.

Habitat and Biological Associations

Golden king crabs occur on hard bottom, over steep rocky slopes, and on narrow ledges. Strong currents are prevalent. Golden king crabs coexist with abundant quantities of epifauna: sponges, hydroids, coral, sea stars, bryozoans, and brittle stars.

Egg: Information is limited. See mature phase description; eggs are carried by adult female crab.

Larvae: Information is not available.

Early Juvenile: Information is not available.

Late Juvenile: Late juvenile golden king crabs are found throughout the depth range of the species. Abundance of late juvenile crab increases with depth, and these crab are most abundant at depths >548 m.

Mature: Mature golden king crabs occur at all depths within their distribution. Males tend to congregate in somewhat shallower waters than females, and this segregation appears to be maintained throughout the year. Legal male crabs are most abundant between 274 and 639 m. Abundance of sub-legal males increases at depth >364 m. Female abundance is greatest at intermediate depths between 274 and 364 m.

SPECIES: Golden king crab, *Lithodes aequispina*

Life Stage	Duration or Age	Diet/Prey	Season/Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs		n/a	all year	LSP	D			
Larvae	U		all year	U	P			
Juveniles			all year		D			
Adults		Ophiuroids, sponges, plants	Spawning Feb.-Aug.	LSP BSN	D			

2.6 Habitat Description for Scarlet King Crab *(Lithodes couesi)*

Life History and General Distribution

Little information is available on the biology of the scarlet king crab (*Lithodes couesi*), found in the BS and AI area. Based on data from the GOA, this species occurs in deep water, primarily on the continental slope. Spawning may be asynchronous. Females can produce up to 5,000 eggs, depending on female size.

Fishery

Scarlet king crab are harvested by longlining mesh covered pots. Directed fishing may occur only under conditions of a permit issued by the Commissioner of the Alaska Department of Fish and Game. Scarlet king crab are also taken incidentally in the golden king crab fishery.

Relevant Trophic Information Unknown

Approximate Upper Size Limit of Juvenile Crab (in cm): The size (CL) of 50 percent maturity for female and males is 8 cm and 9.1 cm.

Habitat and Biological Associations

Scarlet king crab are associated with steep rocky outcrops and narrow ledges. Strong currents are prevalent.

Egg: Information is limited. See mature phase description; eggs are carried by adult female crab.

Larvae: Information is not available.

Early Juvenile: Information is not available.

Late Juvenile: Information is not available.

Mature: Information is limited. Mature scarlet king crabs are caught incidentally in the golden king crab and *C. tanneri* fisheries.

2.7 Habitat Description for Tanner Crab (*Chionoecetes bairdi*)

Life History and General Distribution

Tanner crab (*Chionoecetes bairdi*) are distributed on the continental shelf of the North Pacific Ocean and BS from Kamchatka to Oregon. Off Alaska, Tanner crab are concentrated around the Pribilof Islands and immediately north of the Alaska Peninsula. They are found in lower abundance in the GOA. Size at 50 percent maturity, as measured by CW is 11 cm for males and 9 cm for females in the BS. The corresponding age of maturity for male Tanner crab is approximately 6 to 8 years. Mature male Tanner crabs may skip a year of molting as they attain maturity. Natural mortality of adult Tanner crab is assumed to be about 25 percent per year (M=0.3).

Fishery

The Tanner crab fisheries are prosecuted using mesh covered pots (generally 7 or 8 feet square) set on single lines. Mean age at recruitment is 8 to 9 years. Male crab >14 cm CW may be harvested. Fisheries operate on three separate stocks: EBS, eastern AI, and western AI. The directed fishery was closed in 1996 due to low catch per unit effort (CPUE) relative to pre-season expectations. The Tanner crab stocks of the AI are very small, and populations are found in only a few large bays and inlets. As such, the fisheries are limited, occurring during the winter. No commercial fishery was allowed for Tanner crabs in either the east or west AI in 1995 and 1996. The directed fishery for BS Tanner crab opens 7 days after closure of the Bristol Bay red king crab fishery. However, retention of Tanner crab is allowed during the Bristol Bay red king crab fishery that opens November 1. Bycatch in the directed fishery consists of primarily of non-legal Tanner crab and red king crab. A 3-inch maximum tunnel height opening for Tanner crab pots is required to inhibit the bycatch of red king crab. Also, escape rings are required to reduce capture and handling mortality of all non-target crab; a minimum of four 5-inch rings are required on pots used in Tanner crab fisheries.

Bottom trawls and dredges could disrupt nursery and adult feeding areas.

Relevant Trophic Information

Pacific cod is the main predator on Tanner crabs in terms of biomass. Predators consume primarily age 0 and 1 juvenile Tanner crab with a less than 7-cm CW. However, flathead sole, rock sole, halibut, skates, and yellowfin sole are important in terms of numbers of small crab. Larval predators include salmon, herring, jellyfish, and chaetognaths. Cannibalism has been observed in laboratory environments among juvenile crabs during molting.

Approximate Upper Size Limit of Juvenile Crab (in cm): The size at 50 percent maturity is 9- and 11-cm CW for female and male crabs.

Habitat and Biological Associations

<u>Egg</u>: See mature phase description; eggs are carried by adult female crab.

<u>Larvae</u>: Larvae of *C. bairdi* Tanner crabs are typically found in the BSAI water column from 0 to 100 m in early summer. They are strong swimmers and perform diel migrations in the water column (down at night). They usually stay near the depth of the chlorophyll maximum during the day. The last larval stage settles

onto the bottom mud.

Early Juvenile: Early juvenile *C. bairdi* Tanner crabs occur at depths of 10 to 20 m in mud habitat in summer and are known to burrow or associate with many types of cover. Early juvenile *C. bairdi* Tanner crabs are not easily found in winter.

Late Juvenile: The preferred habitat for late juvenile *C. bairdi* Tanner crabs is mud. Late juvenile Tanner crab migrate offshore of their early juvenile nursery habitat.

Mature: Mature *C. bairdi* Tanner crabs migrate inshore, and mating is known to occur from February through June. Mature female *C. bairdi* Tanner crabs have been observed in high density mating aggregations, or pods, consisting of hundreds of crabs per mound. These mounds may provide protection from predators and also attract males for mating. Mating need not occur every year, as female *C. bairdi* Tanner crabs can retain viable sperm in spermathecae up to 2 years or more. Females carry clutches of 50,000 to 400,000 eggs and nurture the embryos for 1 year after fertilization. Primiparous females may carry the fertilized eggs for as long as 1.5 years. Brooding occurs in 100 to 150 m depths.

SPECIES: Tanner crab, *Chionoecetes bairdi*

Life Stage	**Duration or Age**	**Diet/Prey**	**Season/Time**	**Location**	**Water Column**	**Bottom Type**	**Oceano-graphic Features**	**Other**
Eggs	1 year	NA	April-March	NA	NA	NA	F	
Larvae	2 to 7 mo.	Diatoms Algae Zooplankton	Summer	MCS, ICS	P	NA	F	
Juveniles	1 to 6 years	Crustaceans polychaetes mollusks diatoms algae hydroids	All year	MCS, ICS, BAY, BCH	D	M	F	
Adults	6+ years	Polychaetes crustaceans mollusks hydroids alsae diatoms	Spawning Jan. To June (peak April-May)	MCS, ICS	D	M	F	

2.8 Habitat Description for Snow Crab (*Chionoecetes opilio*)

Life History and General Distribution

Snow crabs (*Chionoecetes opilio*) are distributed on the continental shelf of the BS, Chukchi Sea, and in the western Atlantic Ocean as far south as Maine. Snow crab are not present in the GOA. In the BS, snow crabs are common at depths less than 200 m. The EBS population within U.S. waters is managed as a single stock; however, the distribution of the population extends into Russian waters to an unknown degree. While 50 percent of the females are mature at 5-cm CW, the mean size of mature females varies from year to year over a range of 6.3- to 7.2-cm CW. Females cease growing with a terminal molt upon reaching maturity and rarely exceed 8 cm CW. The median size of maturity for males is about 8.5-cm CW (approximately 6 to 8 years old). Males larger than 6 cm grow at about 2 cm per molt, up to an estimated maximum size of 14.5-cm CW, but individual growth rates vary widely. Natural mortality of adult snow crab is assumed to be about 25 percent per year (M=0.3).

Fishery

The snow crab fishery is prosecuted using mesh covered pots (generally 7 or 8 feet square) set on single lines. Male only crab greater than 7.8-cm CW may be harvested; however, a market minimum size of about 10.2 cm CW is generally observed. Most male snow crab probably enter the fishery at around age 6 to 8 years. Snow crab are probably one stock in the BS. The season opening date is January 15. A 3-inch maximum tunnel height opening for snow crab pots is required to inhibit the bycatch of red king crab. A minimum of eight 4-inch escape rings are required on snow crab pots to reduce capture and handling mortality of non-target crab. Bycatch in the snow crab fishery consists primarily of *C. bairdi* and non-legal *C. opilio*.

Bottom trawls and dredges could disrupt nursery and adult feeding areas.

Relevant Trophic Information

Pacific cod, sculpins, skates, and halibut are the main predators on snow crabs in terms of biomass. Snow crabs less than 7-cm CW are most commonly consumed. Other predators include yellowfin sole, flathead sole, Alaska plaice, walleye pollock, rock sole, bearded seals, and walrus. Juvenile snow crabs have been observed to be cannibalistic during molting in laboratory environments.

Approximate Upper Size Limit of Juvenile Crab (in cm): The size at 50 percent maturity is 5- and 8.5-cm CW for female and male crabs, respectively.

Habitat and Biological Associations

<u>Egg</u>: See mature phase description; eggs are carried by adult female crab.

<u>Larvae</u>: Larvae of *C. opilio* snow crab are found in early summer and exhibit diel migration. The last of three larval stages settles onto bottom in nursery areas.

<u>Early Juvenile</u>: Shallow water areas of the EBS are considered nursery areas for *C. opilio* snow crabs and are confined to the mid-shelf area due to the thermal limits of early and late juvenile life stages.

Late Juvenile: A geographic cline in size of *C. opilio* snow crabs indicates that a large number of morphometrically immature crabs occur in shallow waters less than 80 m.

Mature: Female *C. opilio* snow crabs are acknowledged to attain terminal molt status at maturity. Primiparous female snow crabs mate January through June and may exhibit longer egg development period and lower fecundity than multiparous female crabs. Multiparous female snow crabs can store spermatophores in seminal vesicles and fertilize subsequent egg clutches without mating. At least two clutches can be fertilized from stored spermatophores, but the frequency of this occurring in nature is not known. Females carry clutches of approximately 36,000 eggs and nurture the embryos for approximately 1 year after fertilization. However, fecundity may decrease up to 50 percent between the time of egg extrusion and hatching, presumably due to predation, parasitism, abrasion, or decay of unfertilized eggs. Brooding probably occurs in depths greater than 50 m.

SPECIES: Snow crab, *Chionoecetes opilio*

Life Stage	**Duration or Age**	**Diet/Prey**	**Season/Time**	**Location**	**Water Column**	**Bottom Type**	**Oceano-graphic Features**	**Other**
Eggs	1 year	NA		NA	NA	NA	F	
Larvae	2 to 7 mo.	Diatoms algae zooplankton	Spring, summer	ICS, MCS	P	NA	F	
Juveniles	1 to 4 years	Crustaceans polychaetes mollusks diatoms algae hydroids	All year	ICS, MCS, OCS	D	M	F	
Adults	4+ years	Ploychaetes brittle stars mollusks crustaceans hydroids algae diatoms	Spawning Jan. To June (peak April-May)	ICS, MCS, OCS	D	M	F	

2.9 Habitat Description for Grooved Tanner Crab *(Chionoecetes tanneri)*

Life History and General Distribution

In the eastern North Pacific Ocean, the grooved Tanner crab (*Chionoecetes tanneri*) ranges from northern Mexico to Kamchatka. Little information is available on the biology of the grooved Tanner crab. This species occurs in deep water and is not common at depths exceeding 300 m. Male and female crabs are found at similar depths. Male and female grooved Tanner crab generally reach maturity at 11.9- and 7.9-cm CW, respectively.

Fishery

Directed harvest of grooved Tanner crab has been sporadic since the first reported landings in 1988. Crabs are taken in mesh covered pots deployed on a longline. Harvest can occur only under conditions of a permit issued by the Commissioner of the Alaska Department of Fish and Game.

Relevant Trophic Information Unavailable

Approximate Upper Size Limit of Juvenile Crab (in cm): Size at 50 percent maturity is 11.9-cm CW for males and 7.9-cm CW for females.

Habitat and Biological Associations

Egg: Information is not available.

Larvae: Information is not available.

Early Juvenile: Information is not available.

Late Juvenile: Information is not available.

Mature: In the EBS, mature male grooved Tanner crabs may be found somewhat more shallow than mature females, but male and female crabs do not show clear segregation by depth.

2.10 Habitat Description for Triangle Tanner Crab (*Chionoecetes angulatus*)

Life History and General Distribution

In the eastern North Pacific Ocean, the distribution of triangle Tanner crab (*Chionoecetes angulatus*) ranges from Oregon to the Sea of Okhotsk. This species occurs on the continental slope in waters deeper than 300 m and has been reported as deep as 2,974 m in the EBS. A survey limited to a particular depth range found that mature male crabs inhabit depths around 647 m shallower than the mean depth of 748 m for female crabs. Size at 50 percent maturity for male triangle Tanner crabs is 9.1-cm CW and 5.8-cm CW for females.

Fishery

A directed fishery for triangle Tanner crab was documented for the first time in 1995. Prior to 1995, these crab had been harvested as bycatch in the *C. tanneri* fishery. Directed harvest is allowed only under the conditions of a permit issued by the Commissioner of the Alaska Department of Fish and Game. Crab are taken in mesh covered pots deployed on a longline.

Relevant Trophic Information Unknown

Approximate Upper Size Limit of Juvenile Crab (in cm): In the EBS, male triangle Tanner crabs reach size at 50 percent maturity at 9.1-cm CW and females at 5.8-cm CW.

Habitat and Biological Associations

Egg: Information is not available.

Larvae: Information is not available.

Early Juvenile: Information is not available.

Late Juvenile: Information is not available.

Mature: The mean depth of mature male triangle Tanner crabs (647 m) is significantly less than for mature females (748 m), indicating some pattern of sexual segregation by depth.

3.0 Essential Fish Habitat

Essential Fish Habitat (EFH) is defined in the Magnuson-Stevens Fishery Conservation and Management 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 the general distribution of a species described by life stage. General distribution is a subset of a species population and is 95 percent of the 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), such as 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. These descriptions are risk averse, supported by scientific rationale, and account for changing oceanographic conditions, regime shifts, and the seasonality of migrating crab stocks. The methodology and data sources for the EFH descriptions are described in Appendix D to the EFH EIS (NMFS 2005).

3.1 Description of Essential Fish Habitat

EFH descriptions are based upon the best available scientific information. In support of this information, a thorough review of FMP species is contained in this Appendix and in the EFH EIS (NMFS 2005). 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 8.1. An "x" means that insufficient information is available to determine EFH for the life stage and "1" means information is available to determine EFH.

Table 8.1 EFH information levels currently available for BSAI crab, by life history stage.

BSAI Crab Species	Egg	Larvae	Early Juvenile	Late Juvenile	Adult
Red king crab	inferred	x	x	1	1
Blue king crab	inferred	x	x	1	1
Golden king crab	inferred	x	x	1	1
Tanner crab	inferred	x	x	1	1
Snow crab	inferred	x	x	1	1

3.1.1 Red King Crab

Eggs
Essential fish habitat of the red king crab eggs is inferred form the general distribution of egg-bearing female crab. (See also Adults.)

Larvae—No EFH Description Determined
Insufficient information is available.

Early Juveniles—No EFH Description Determined
Insufficient information is available.

Late Juveniles
EFH for late juvenile red king crab is the general distribution area for this life stage, located in bottom habitats along the inner (0 to 50 m), middle (50 to 100 m), and outer shelf (100 to 200 m) throughout the BSAI wherever there are substrates consisting of rock, cobble, and gravel and biogenic structures such as boltenia, bryozoans, ascidians, and shell hash, as depicted in Figure 3.

Adults
EFH for adult red king crab is the general distribution area for this life stage, located in bottom habitats along the nearshore (spawning aggregations) and the inner (0 to 50 m), middle (50 to 100 m), and outer shelf (100 to 200 m) throughout the BSAI wherever there are substrates consisting of sand, mud, cobble, and gravel, as depicted in Figure 3.

3.1.2 Blue King Crab

Eggs
Essential fish habitat of the blue king crab eggs is inferred from the general distribution of egg-bearing female crab. (See also Adults.)

Larvae—No EFH Description Determined
Insufficient information is available.

Early Juveniles—No EFH Description Determined
Insufficient information is available.

Late Juveniles
EFH for late juvenile blue king crab is the general distribution area for this life stage, located in bottom habitats along the nearshore where there are rocky areas with shell hash and the inner (0 to 50), middle (50 to 100 m), and outer shelf (100 to 200 m) throughout the BSAI wherever there are substrates consisting of rock, cobble, and gravel, as depicted in Figure 4.

Adults
EFH for adult blue king crab is the general distribution area for this life stage, located in bottom habitats along the inner (0 to 50 m), middle (50 to 100 m), and outer shelf (100 to 200 m) throughout the BSAI wherever there are substrates consisting of sand and mud adjacent to rockier areas and areas of shell hash,

as depicted in Figure 4.

3.1.3 Golden King Crab

Eggs
Essential fish habitat of golden king crab eggs is inferred from the general distribution of egg-bearing female crab. (See also Adults.)

Larvae—No EFH Description Determined
Insufficient information is available.

Early Juveniles—No EFH Description Determined
Insufficient information is available.

Late Juveniles
EFH for late juvenile golden king crab is the general distribution area for this life stage, located in bottom habitats along the along the upper slope (200 to 500 m), intermediate slope (500 to 1,000 m), lower slope (1,000 to 3,000 m), and basins (more than 3,000 m) of the BSAI where there are high-relief living habitats, such as coral, and vertical substrates, such as boulders, vertical walls, ledges, and deep water pinnacles, as depicted in Figure 5.

Adults
EFH for adult golden king crab is the general distribution area for this life stage, located in bottom habitats along the along the outer shelf (100 to 200 m), upper slope (200 to 500 m), intermediate slope (500 to 1,000 m), lower slope (1,000 to 3,000 m), and basins (more than 3,000 m) of the BSAI where there are high relief living habitats, such as coral, and vertical substrates such as boulders, vertical walls, ledges, and deep water pinnacles, as depicted in Figure 5.

3.1.4 Tanner Crab

Eggs
Essential fish habitat of Tanner crab eggs is inferred form the general distribution of egg-bearing female crab. (See also Adults.)

Larvae—No EFH Description Determined
Insufficient information is available.

Early Juveniles—No EFH Description Determined
Insufficient information is available.

Late Juveniles
EFH for late juvenile Tanner crab is the general distribution area for this life stage, located in bottom habitats along the inner (0 to 50 m), middle (50 to 100 m), and outer shelf (100 to 200 m) throughout the BSAI wherever there are substrates consisting mainly of mud, as depicted in Figure 6.

Adults
EFH for adult Tanner crab is the general distribution area for this life stage, located in bottom habitats along

the inner (0 to 50 m), middle (50 to 100 m), and outer shelf (100 to 200 m) throughout the BSAI wherever there are substrates consisting mainly of mud, as depicted in Figure 6.

3.1.5 Snow Crab

Eggs
Essential fish habitat of snow crab eggs is inferred form the general distribution of egg-bearing female crab. (See also Adults.)

Larvae—No EFH Description Determined
Insufficient information is available.

Early Juveniles—No EFH Description Determined
Insufficient information is available.

Late Juveniles
EFH for late juvenile snow crab is the general distribution area for this life stage, located in bottom habitats along the inner (0 to 50 m), middle (50 to 100 m), and outer shelf (100 to 200 m) throughout the BSAI wherever there are substrates consisting mainly of mud, as depicted in Figure 7.

Adults
EFH for adult snow crab is the general distribution area for this life stage, located in bottom habitats along the inner (0 to 50 m), middle (50 to 100 m), and outer shelf (100 to 200 m) throughout the BSAI wherever there are substrates consisting mainly of mud, as depicted in Figure 7.

3.2 Maps of Essential Fish Habitat

[insert Figures 3, 4, 5, 6, and 7 from G:\FMGROUP\Amendments 78-73 EFH-HAPC\crab FMP text]

Figure 3. EFH Distribution - BSAI Red King Crab (Late Juveniles/Adults)

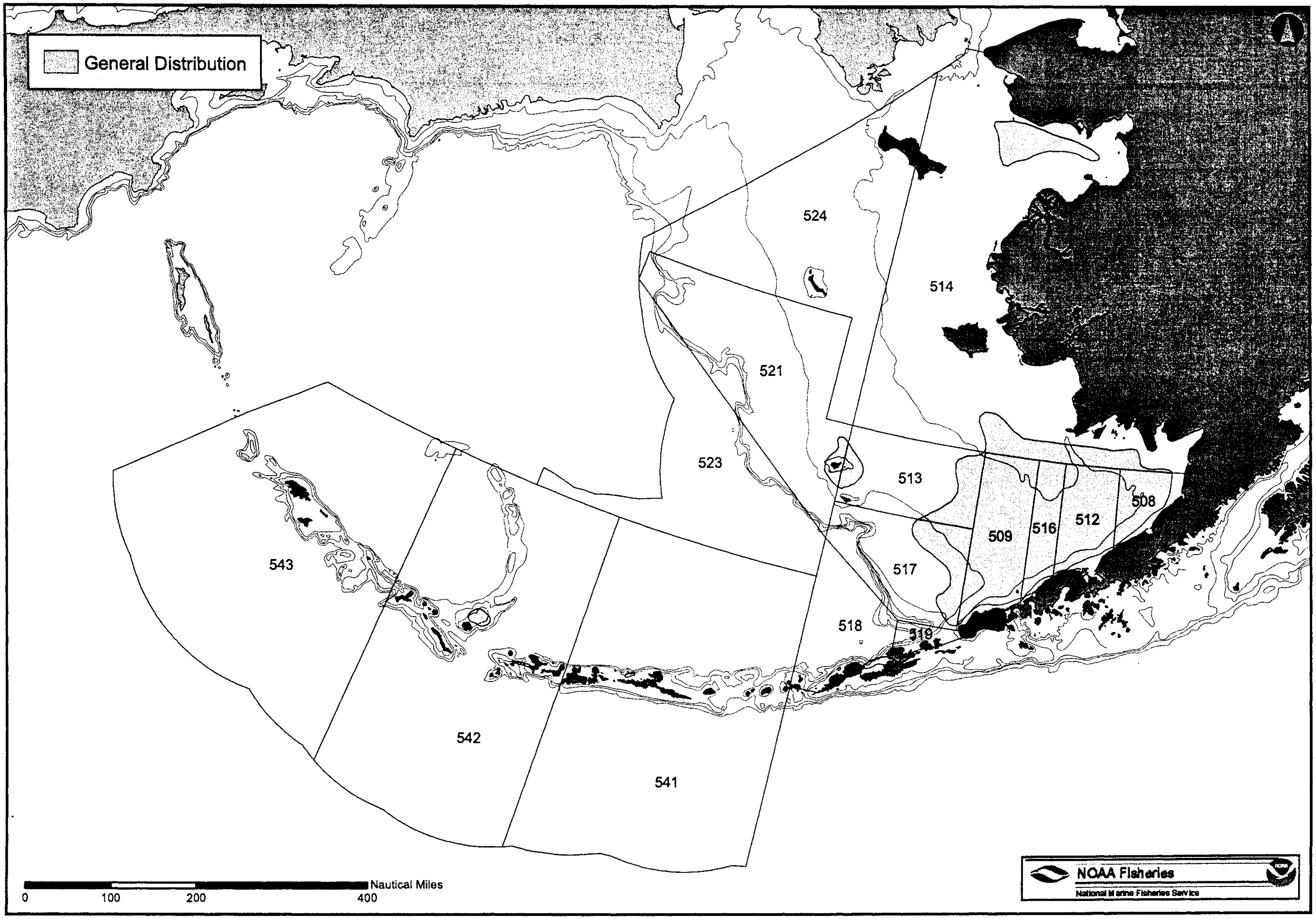


Figure 4. EFH Distribution - BSAI Blue King Crab (Late Juveniles/Adults)

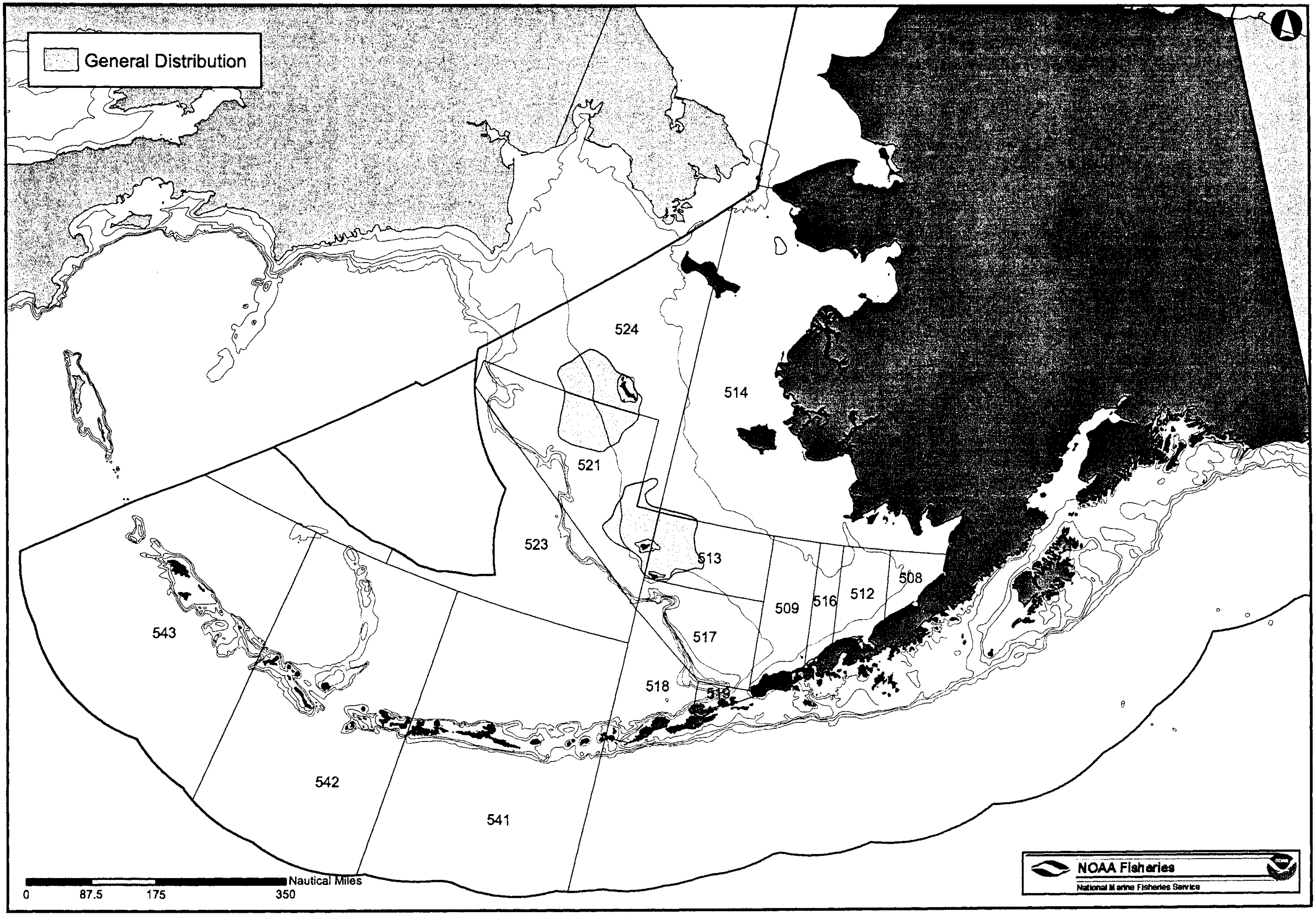


Figure 5. EFH Distribution - BSAI Golden King Crab (Late Juveniles/Adults)

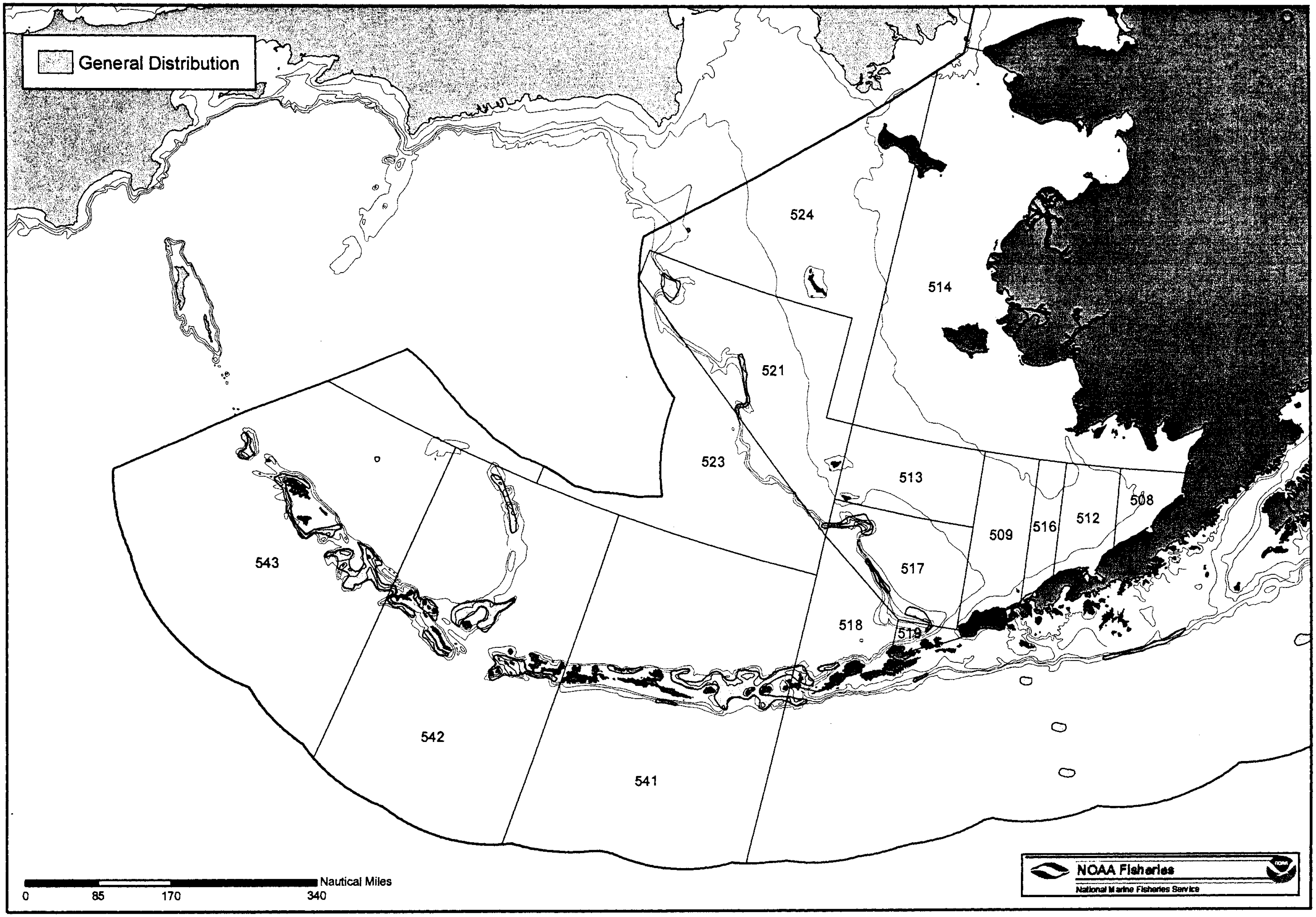


Figure 6. EFH Distribution - BSAI Tanner Crab (Late Juveniles/Adults)

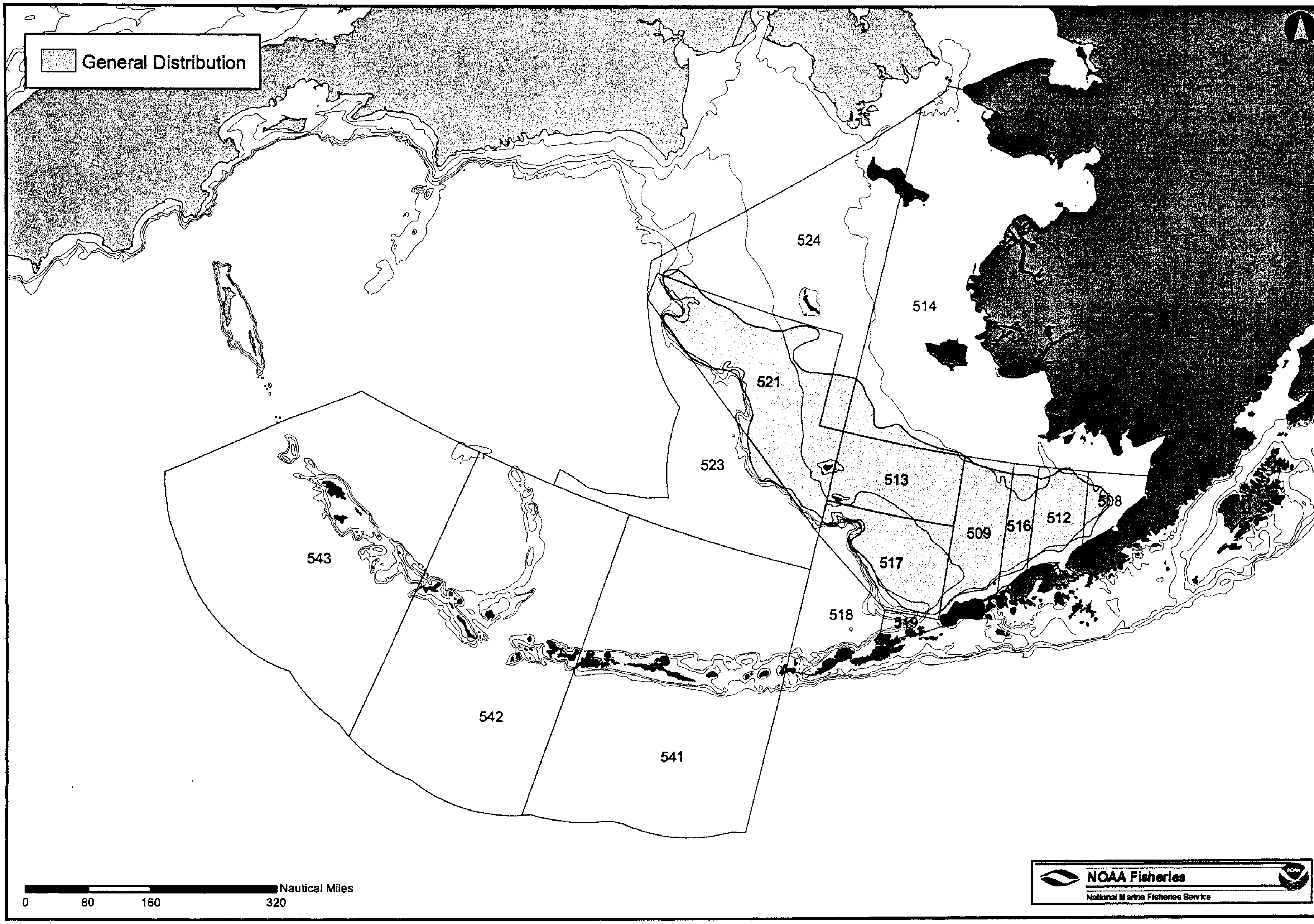
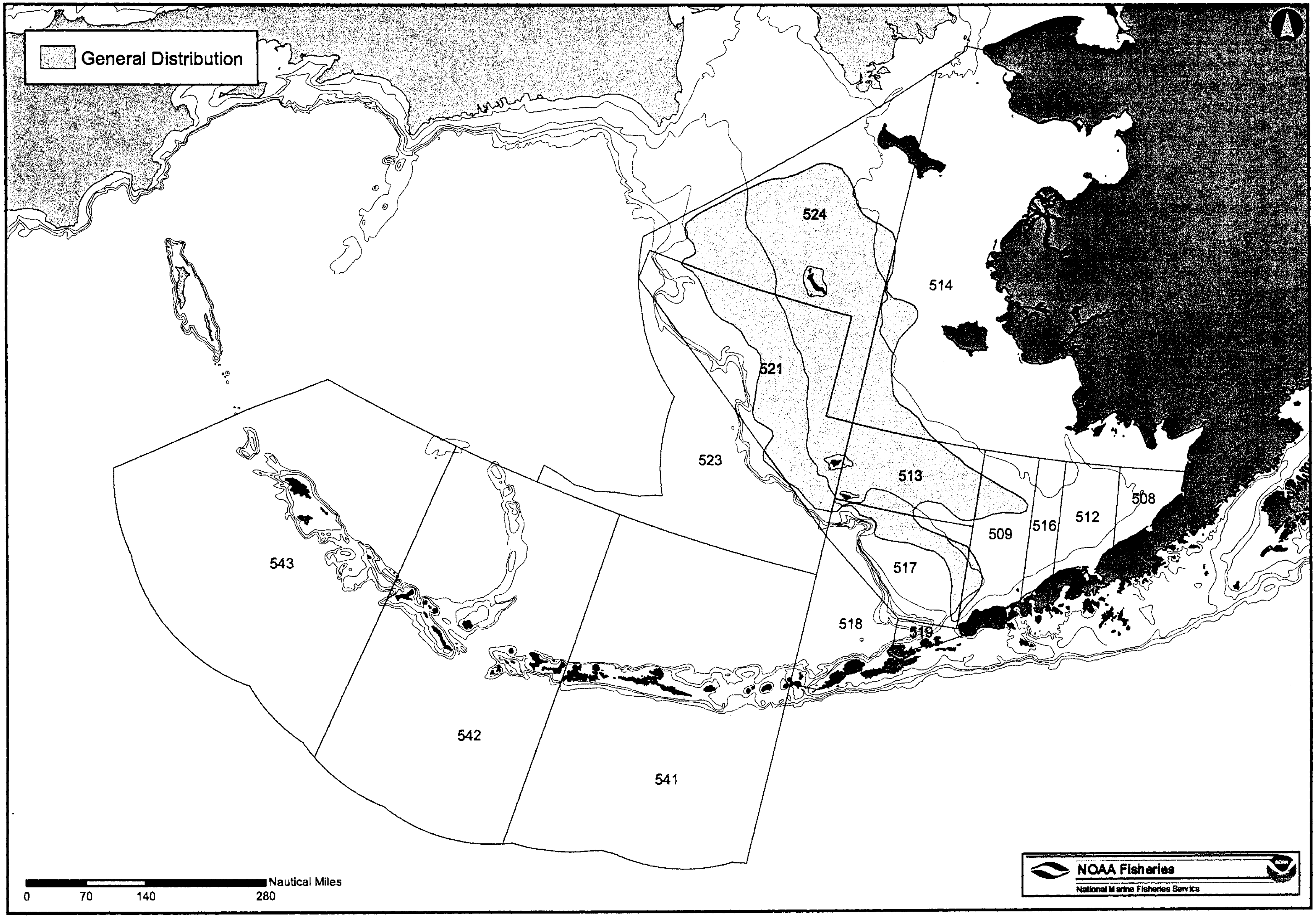


Figure 7. EFH Distribution - BSAI Snow Crab (Late Juveniles/Adults)



3.3 Essential Fish Habitat Conservation and Habitat Areas of Particular Concern

The Council established the Aleutian Islands Habitat Conservation Area and the Aleutian Islands Coral Habitat Protection Areas to protect EFH from fishing threats. The Council also established two Habitat Areas of Particular Concern (HAPCs) within crab EFH to protect those areas from fishing threats: the Alaska Seamount Protection Area and the Bowers Ridge Habitat Conservation Zone. Maps of these areas, as well at the coordinates, 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.

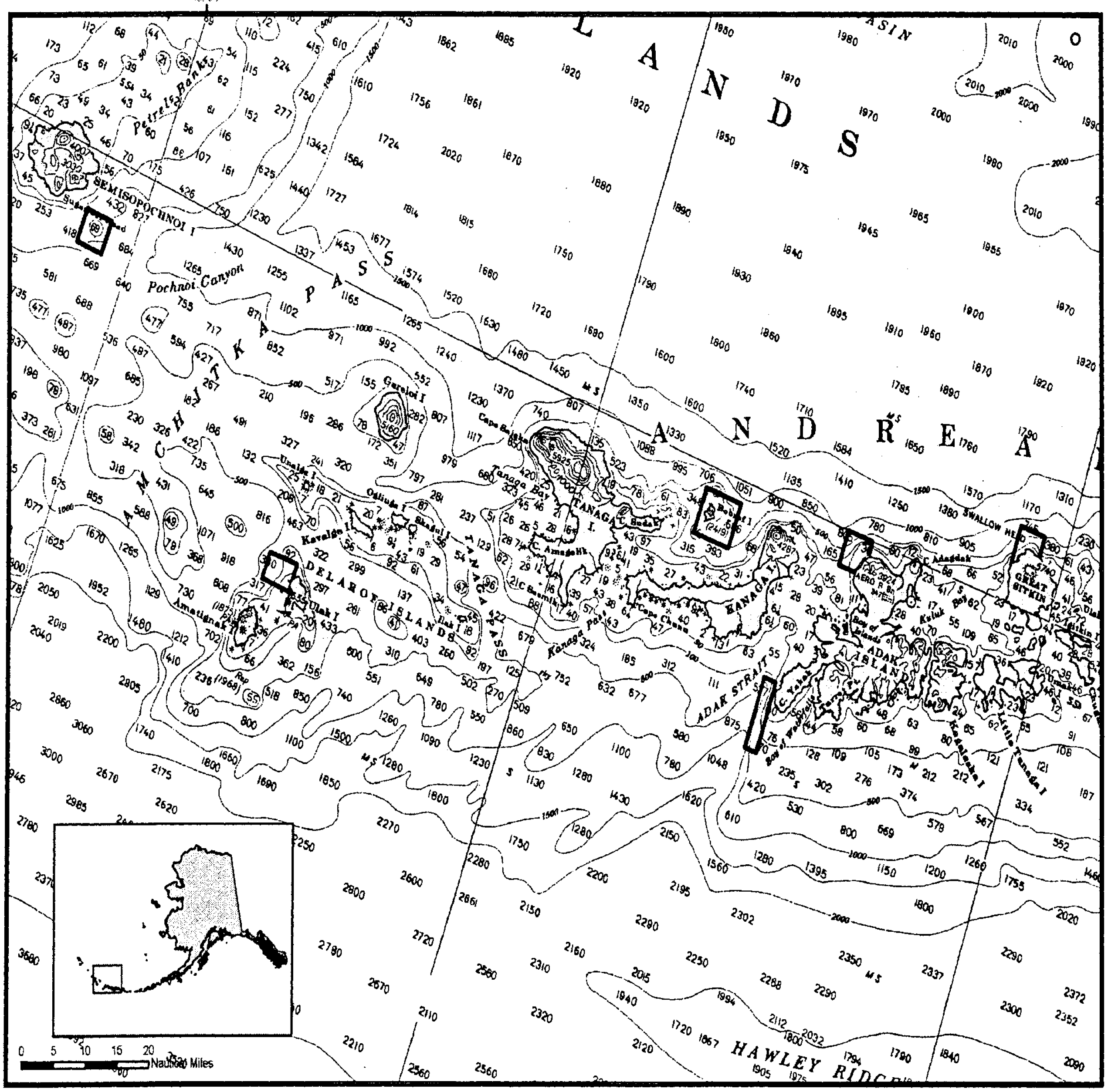
3.3.1 Aleutian Islands Coral Habitat Protection Areas

The use of bottom contact gear, including pot gear, as described in 50 CFR part 679, is prohibited year-round in the Aleutian Islands Coral Habitat Protection Areas, see Figure 8. Anchoring by a federally permitted fishing vessel, as described in 50 CFR part 679, is also prohibited. The coordinates for the areas are listed in the table below.

Area Number	Name	Latitude			Longitude		
1	Great Sitkin Is	52	9.56	N	176	6.14	W
	Great Sitkin Is	52	9.56	N	176	12.44	W
	Great Sitkin Is	52	4.69	N	176	12.44	W
	Great Sitkin Is	52	6.59	N	176	6.12	W
2	Cape Moffett Is	52	0.11	N	176	46.65	W
	Cape Moffett Is	52	0.10	N	176	53.00	W
	Cape Moffett Is	51	55.69	N	176	53.00	W
	Cape Moffett Is	51	55.69	N	176	48.59	W
	Cape Moffett Is	51	57.96	N	176	46.52	W
3	Adak Canyon	51	39.00	N	177	0.00	W
	Adak Canyon	51	39.00	N	177	3.00	W
	Adak Canyon	51	30.00	N	177	3.00	W
	Adak Canyon	51	30.00	N	177	0.00	W
4	Bobrof Is	51	57.35	N	177	19.94	W
	Bobrof Is	51	57.36	N	177	29.11	W
	Bobrof Is	51	51.65	N	177	29.11	W
	Bobrof Is	51	51.71	N	177	19.93	W
5	Ulak Is	51	25.85	N	178	59.00	W
	Ulak Is	51	25.69	N	179	6.00	W
	Ulak Is	51	22.28	N	179	6.00	W
	Ulak Is	51	22.28	N	178	58.95	W
6	Semisopochnoi Is	51	53.10	N	179	53.11	E
	Semisopochnoi Is	51	53.10	N	179	46.55	E
	Semisopochnoi Is	51	48.84	N	179	46.55	E
	Semisopochnoi Is	51	48.89	N	179	53.11	E

Note: Each area is delineated by connecting the coordinates in the order listed by straight lines. The last set of coordinates for each area is connected to the first set of coordinates for the area by a straight line. The projected coordinate system is North American Datum 1983, Albers.

Figure 8 Aleutian Islands Coral Habitat Protection Areas



3.3.2 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 described in 50 CFR 679. Areas open to nonpelagic trawl gear fishing in the Aleutian Islands shown in Figure 9; however, the use of trawl gear is prohibited in the BSAI King and Tanner crab fisheries.

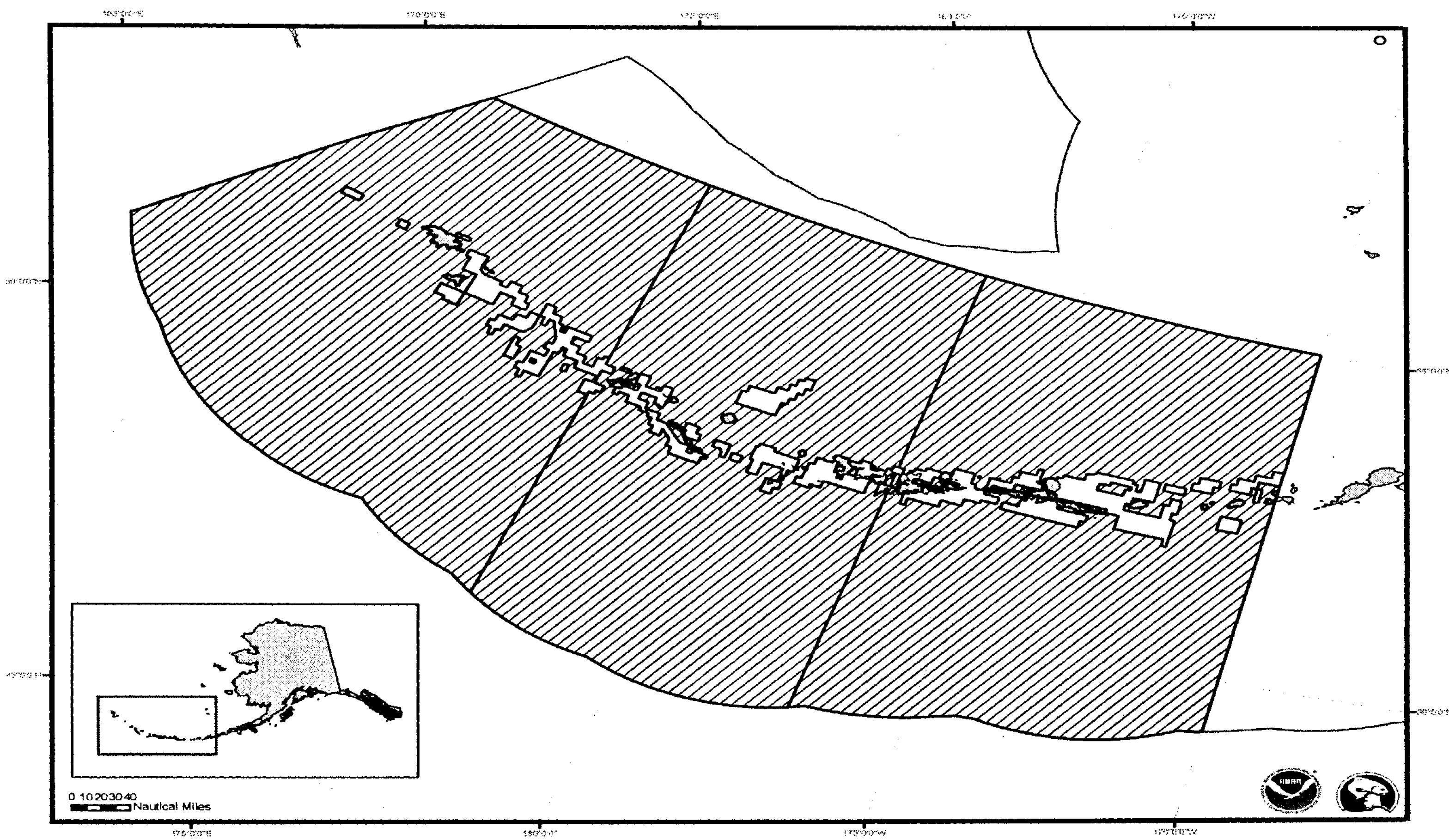


Figure 9 Aleutian Islands Habitat Conservation Area. Polygons are areas open to nonpelagic trawl gear.

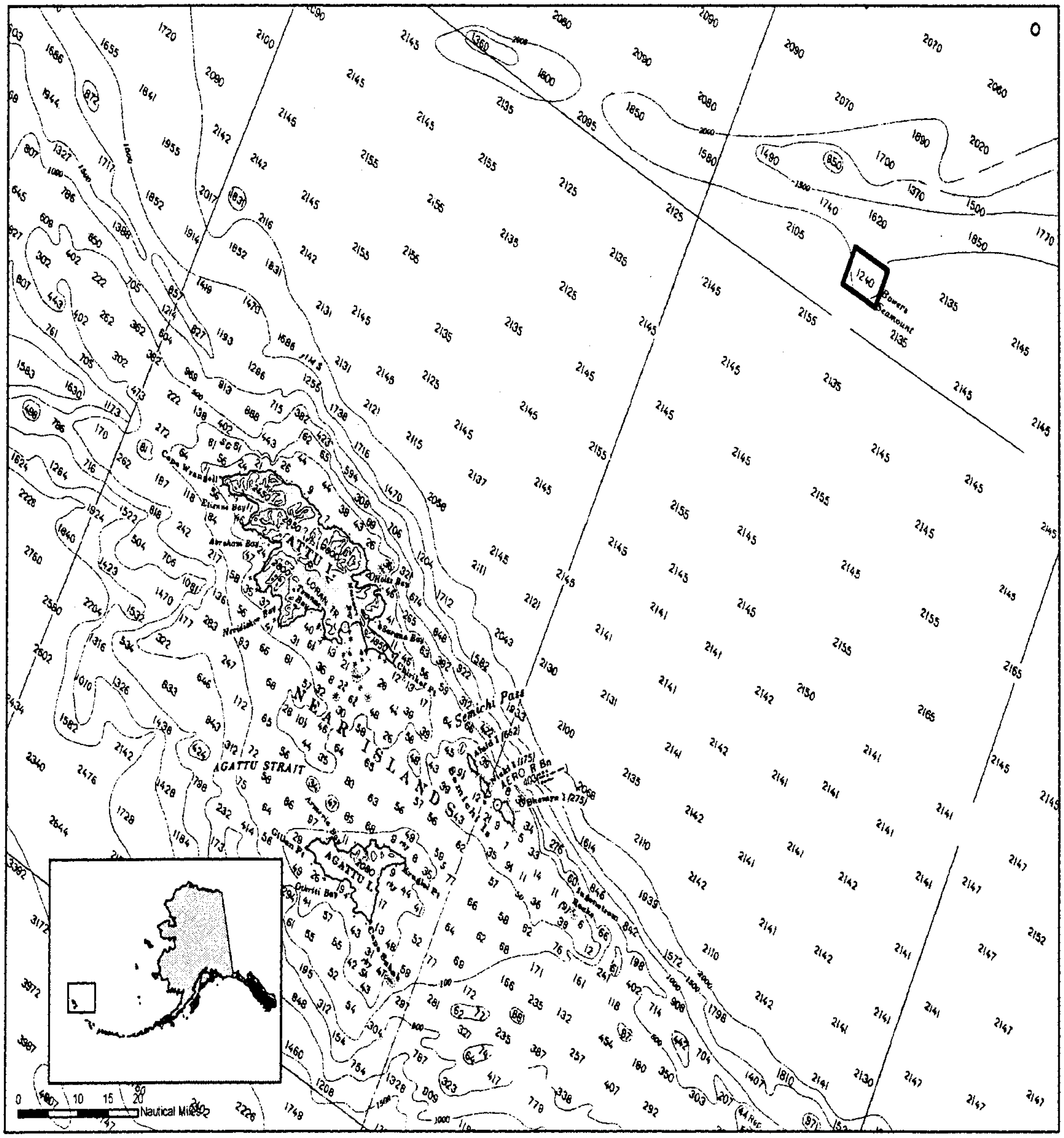
3.3.3 Alaska Seamount Habitat Protection Area

The use of bottom contact gear by a federally permitted fishing vessel, as described in 50 CFR part 679, is prohibited year-round in the Alaska Seamount Habitat Protection Area, see Figure 10. Anchoring by a federally permitted fishing vessel, as described in 50 CFR part 679, is also prohibited. Coordinates for the Alaska Seamount Habitat Protection Area are listed in the table below.

Area Number	Name	Latitude	Longitude
15	Bowers Seamount	54 9.00 N	174 52.20 E
	Bowers Seamount	54 9.00 N	174 42.00 E
	Bowers Seamount	54 4.20 N	174 42.00 E
	Bowers Seamount	54 4.20 N	174 52.20 E

Note: The area is delineated by connecting the coordinates in the order listed by straight lines. The last set of coordinates is connected to the first set of coordinates by a straight line. The projected coordinate system is North American Datum 1983, Albers.

Figure 10 Alaska Seamount Habitat Protection Area in the Aleutian Islands



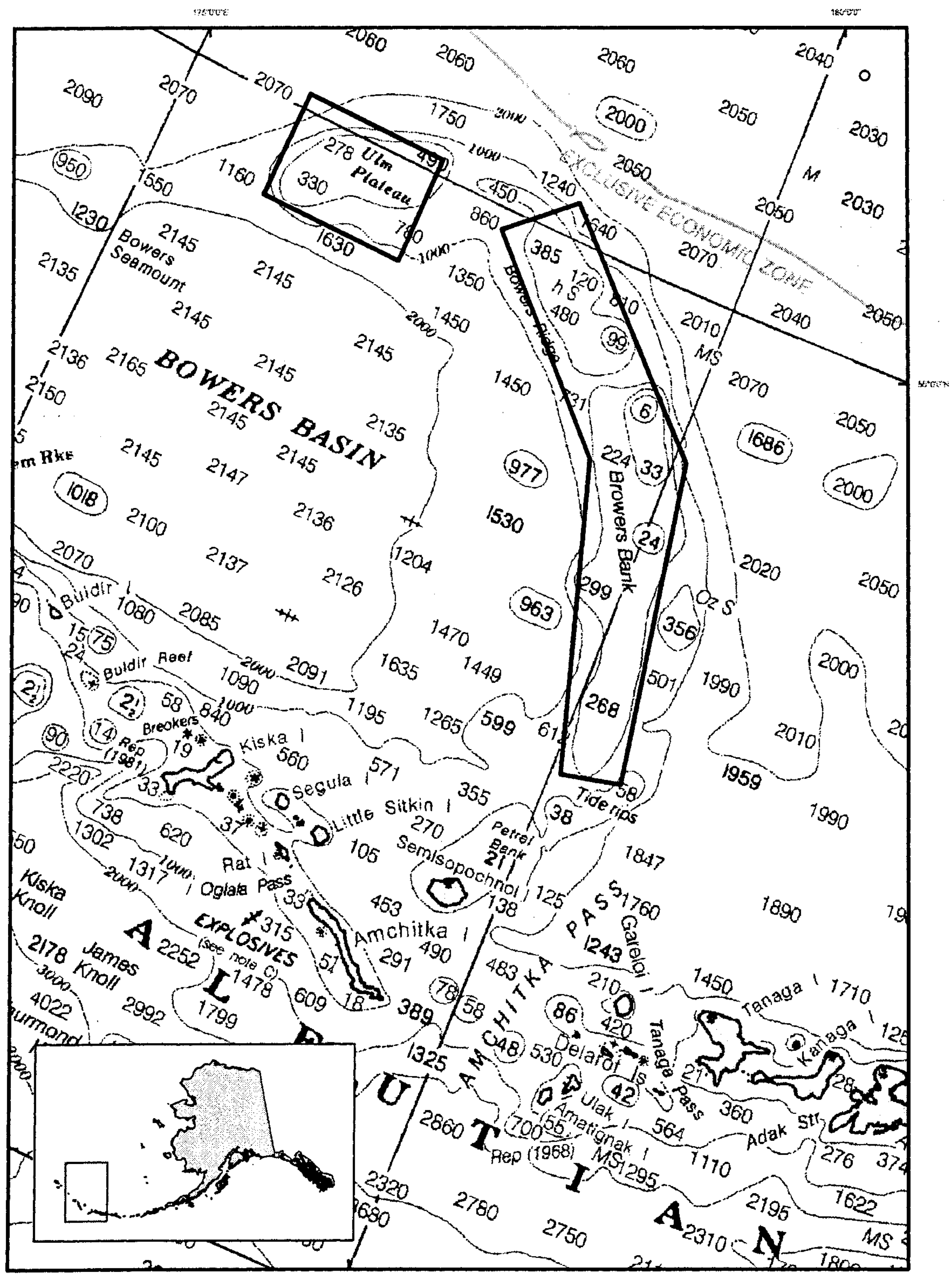
3.3.4 Bowers Ridge Habitat Conservation Zone

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 11. The areas are described in the table below.

Area Number	Name	Latitude			Longitude		
1	Bowers Ridge	55	10.50	N	178	27.25	E
	Bowers Ridge	54	54.50	N	177	55.75	E
	Bowers Ridge	54	5.83	N	179	20.75	E
	Bowers Ridge	52	40.50	N	179	55.00	W
	Bowers Ridge	52	44.50	N	179	26.50	W
	Bowers Ridge	54	15.50	N	179	54.00	W
2	Ulm Plateau	55	5.00	N	177	15.00	E
	Ulm Plateau	55	5.00	N	175	60.00	E
	Ulm Plateau	54	34.00	N	175	60.00	E
	Ulm Plateau	54	34.00	N	177	15.00	E

Note: Each area is delineated by connecting the coordinates in the order listed by straight lines. The last set of coordinates for each area is connected to the first set of coordinates for the area by a straight line. The projected coordinate system is North American Datum 1983, Albers.

Figure 11 Bowers Ridge Habitat Conservation Zone



3.3.5 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 3 years or on a schedule established by the Council. The Council may periodically review existing HAPCs for efficiency and consideration based on new scientific research.

Criteria to evaluate the HAPC proposals will be reviewed by the Council and the Scientific and Statistical Committee prior to the request for proposals. The Council will establish a process to review the proposals and may establish HAPCs and conservation measures (NPFMC 2005).

4.0 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 habitat areas of particular concern (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.

Much of the material supporting this evaluation is located in the following sections of the EFH EIS (NMFS 2005). These include:

- Descriptions of fishing activities (including gear, intensity, extent and frequency of effort) - Sections 3.4.1 and 3.4.2.
- Effects of fishing activities on fish habitat - Section 3.4.3.
- Past management actions that minimize potential adverse effects on EFH - Sections 2.2 and 4.3.
- Habitat requirements of managed species - Sections 3.2.1, 3.2.2, and Appendices D and F.
- Features of the habitat - Sections 3.1, 3.2.4 and 3.3.
- HAPCs - 2.2.2.7, 2.2.2.8, 2.3.2, and 4.2
- Cumulative effects of multiple fishing activities on EFH, Section 4.4.

Appendix B of the EFH EIS also contains a comprehensive, peer-reviewed analysis of fishing effects on EFH and detailed results for each managed species. This FMP incorporates by reference the complete analysis in Appendix B of the EFH EIS and summarizes below the results for each managed species.

Section B.1 of Appendix B of the EFH EIS has a detailed discussion regarding the relevant rules and definitions that must be considered in developing the fishing effects on EFH analysis. The analysis is based on determining whether an effect on EFH is more than minimal and not temporary (50 CFR 600.815(a)(2)(ii)).

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.

A numeric model was developed as a tool to structure the relationships among available sources of information on these factors. This model was designed to estimate proportional effects on habitat features that would persist if current fishing levels were continued until affected habitat features reached an equilibrium with the fishing effects. Details on the limitations and uncertainties of the model and the process used by the analyst are in Section B.1 of Appendix B of the EFH EIS (NMFS 2005).

4.1 Effects of Fishing Analysis

Section B.2 of Appendix B of the EFH EIS (NMFS 2005) contains details of the fishing effects on EFH analysis. Fishing operations can adversely affect the availability of various habitat features for use by fish species. Habitat features are those parts of the habitat used by a fish species for the processes of spawning, breeding, feeding, or growth to maturity. A complex combination of factors influences the effects of fishing on habitat features, including the following:

1. Intensity of fishing effort
2. Sensitivity of habitat features to contact with fishing gear

3. Recovery rates of habitat features
4. Distribution of fishing effort relative to different types of habitat

The goal of this analysis was to combine available information on each of these factors into an index of the effects of fishing on features of fish habitat that is applicable to issues raised in the EFH regulations. The effects of fishing on recovery of EFH is described by the long term effect index (LEI). Features that recover very quickly could achieve a small LEI under any fishing intensity. Features that recover very slowly may have a high LEI even with small rates of fishing effects. The LEI is used in the summaries to describe the fishing effects on EFH for managed species. They represent the ability of fishing to reduce however much of each feature was present in an area as a proportional reduction. LEIs were calculated for all areas where fishing occurred, including some areas where the subject feature may never have existed.

Section B.2.4.3 of Appendix B of the EFH EIS contains information regarding recovery rates for various habitat types. Long and short recovery times were 3 to 4 months for sand, 6 to 12 months for sand/mud, and 6 to 18 months for mud habitats. In general, very little data are available on the recovery periods for living structure. Recovery rates of structure-forming invertebrates associated with the soft bottom, based on their life history characteristics, is estimated at 10 to 30 percent per year with a mean of 20 percent per year. Hard-bottom recovery rates are estimated to be slower, 1 to 9 percent per year, with a mean of 5 percent per year based on hard-bottom invertebrate life history characteristics. Recovery rates of gorgonian corals are potentially much longer, with rates of 50, 100, and 200 years estimated.

The habitat and regional boundaries were overlaid using geographic information systems (GIS) (ArcMap), resulting in the classification of each of the 5-by-5-km blocks by habitat type. Where a boundary passed through a block, the area within each habitat was calculated, and those areas were analyzed separately. For the GOA and AI habitats, the estimates of proportions of hard and soft substrate habitat types were entered into the classification matrix for each block. The total area of each benthic habitat was calculated through GIS based on coastlines, regional boundaries, habitat boundaries, and depth contours (Table B.2-7 of the EFH EIS).

Additional details on the quantity and quality of data and studies used to develop the analysis, how the analysis model was derived and applied, and considerations for the LEIs are contained in Section B.2 of Appendix B of the EFH EIS.

4.2 Fishing Gear Impacts

The following sections summarize pertinent research on the effects of fishing on seafloor habitats.

4.2.1 Bottom Trawls

The EFH EIS effects of fishing analysis evaluates the effects of bottom trawls on several categories of habitats: infaunal prey, epifaunal prey, living structure, hard corals, and nonliving structure.

Infaunal Prey

Infaunal organisms, such as polychaetes, other worms, and bivalves, are significant sources of prey for Alaska groundfish species. Because researchers were not able to determine which crustaceans cited in trawl effects studies were actually infauna, all crustaceans were categorized as epifaunal prey. Studies of the

effects of representative trawl gear on infauna included Kenchington et al. (2001), Bergman and Santbrink (2000), Brown (2003), Brylinsky et al. (1994), and Gilkinson et al. (1998).

Kenchington et al. (2001) examined the effects on over 200 species of infauna from trawl gear that closely resembled the gear used off of Alaska. Three separate trawling events were conducted at intervals approximating 1 year. Each event included 12 tows through an experimental corridor, resulting in an average estimate of three to six contacts with the seafloor per event. Of the approximately 600 tests for species effects conducted, only 12 had statistically significant results. The statistical methods were biased toward a Type 1 error of incorrectly concluding an impact. Ten of the significant results are from a year when experimental trawling was more concentrated in the center of the corridors where the samples of infauna were taken. It is likely that more trawl contacts occurred at these sampled sites than the 4.5 estimate (average of three to six contacts) used to adjust the multiple contact results. As such, the results that were available from the study (non-significant values were not provided) represent a sample biased toward larger reductions when used to assess median reductions of infauna. The resulting median effect was 14 percent reduction in biomass.

Bergman and Santbrink (2000) studied effects on infauna (mostly bivalves) from an otter trawl equipped with 20-centimeter (cm) rollers in the North Sea. Because the study was conducted on fishing grounds with a long history of trawling, the infaunal community may already have been affected by fishing. Experimental trawling was conducted to achieve average coverage of 1.5 contacts within the experimental area over the course of the study. Results were provided for two substrate types: coarse sand with 1 to 5 percent of the area contacted, and silt and fine sand with 3 to 10 percent of the area contacted. The five infauna biomass reductions in the first area had a median of 8 percent. The ten infauna biomass reductions from the second area had a median of 5 percent.

In a recent master's thesis, Brown (2003) studied the effects of experimental trawling in an area of the nearshore EBS with sandy sediments. Trawling covered 57 percent of the experimental area. Several bivalves had lower abundance after trawling, while polychaetes were less affected. The median of the reduction in percentages for each species, after adjusting for coverage, was a 17 percent reduction in biomass per gear contact.

Brylinsky et al. (1994) investigated effects of trawling on infauna, mainly in trawl door tracks, at an intertidal estuary. Only three results were provided for infauna in roller gear tracks, but the results were so variable (-50 percent, +12 percent, +57 percent) that they were useless for the purpose of this analysis. Eight results on the effects of trawl doors on species biomass were available for polychaetes and nemerteans. These results had a median of 31 percent reduction in biomass and a 75th percentile of 42 percent reduction in biomass. Gilkinson et al. (1998) used a model trawl door on a prepared substrate to estimate that 64 percent of clams in the door's path were exposed after one pass, but only 5 percent were injured. Doors make up less than 4 percent of the area of the seafloor contacted by Alaska trawls.

The results of Kenchington et al. (2001), Bergman and Santbrink (2000), and Brown (2003) were combined for inclusion in the model, resulting in a median of 10 percent reduction in biomass per gear contact for infaunal species due to trawling, and 25th and 75th percentiles of 5 and 21 percent, respectively (Table B.2-5 of the EFH EIS).

Epifaunal Prey

Epifaunal organisms, such as crustaceans, echinoderms, and gastropods, are significant prey of Alaska groundfish species. However, one of the most common classes of echinoderms, asteroids, are rarely found in fish stomachs. While some crustaceans may be infauna, an inability to consistently identify these species resulted in all crustaceans being categorized as epifaunal prey. Studies of the effects of representative trawl gear on epifauna included Prena et al. (1999), Brown (2003), Freese et al. (1999), McConnaughey et al. (2000), and Bergman and Santbrink (2000).

Prena et al. (1999), as a component of the Kenchington et al. (2001) study, measured the effects of trawling on seven species of epifauna. The median of these results was a 4 percent biomass reduction per gear contact. There appeared to be in-migration of scavenging crabs and snails in this and other studies. Removing crab and snails left only two measurements, 6 and 7 percent reductions in biomass. Bergman and Santbrink (2000) measured effects on four epifaunal species in the experimental coarse sand area (median reduction in biomass was 12 percent) and five epifaunal species in the experimental fine sand area (median reduction in biomass was 16 percent). When crabs and snails were removed, the coarse sand area was unchanged, and the median value for the fine sand area was 15 percent biomass reduction. Brown (2003) studied six epifaunal species, resulting in a median reduction in biomass per gear contact of 5 percent. Combining results from Prena et al. (1999), Brown (2003), and Bergman and Santbrink (2000), and removing crabs and snails, gives a median reduction in biomass of epifaunal species of 10 percent, and 25th and 75th percentiles of 4 and 17 percent, respectively. These are the q values used for the analysis of the effects of full trawls on epifaunal prey, except for those fisheries using tire gear (see below).

The study of McConnaughey et al. (2000) compared the effects of fishing on an area that received heavy fishing pressure between 4 and 8 years previously, using an adjacent unfished area as a control. Therefore, results included a combination of species reductions and recovery, were not adjusted for multiple contacts, and were not directly comparable to the results of the studies above. However, for comparison with previously discussed studies, the resulting median and 75th percentile reductions in biomass for six species of epifauna (excluding snails and crabs) were 12 and 28 percent, respectively. The median result was within the same range as those from the more direct studies, and the 75th percentile result was not sufficiently higher as to indicate substantial error in the direct estimates.

Freese et al. (1999) studied the effects of tire gear on the epifauna of a pebble and boulder substrate. Eight epifaunal species gave a median response of 17 percent reduction in biomass and a 75th percentile of 43 percent reduction in biomass. Before snails were removed, the 25th percentile indicated an increase in biomass of 82 percent due to colonization by snails. The resulting values when two snail taxa were removed were 38 and 43 percent medians and a 5 percent reduction in epifaunal biomass for the 75th and 25th percentiles. The authors noted a strong transition to apparently smaller effects outside of the direct path of the tire gear. For fisheries in hard-bottom areas, where tire gear is most common, epifaunal effects were adjusted for this increased effect within the path of the tire gear. Typical tire gear covers about 25 percent of the full trawl path (i.e., 14 m out of 55 m total), so the resulting q values are 17 percent reduction in epifaunal biomass for the median (0.25 times 38 plus 0.75 times 10), 23 percent reduction for epifaunal biomass for the 75th percentile (0.25 times 43 plus 0.75 times17), and 5 percent reduction for the 25th percentile.

Living Structure

Organisms that create habitat structure in Alaska waters include sponges, bryozoans, sea pens, soft and stony corals, anemones, and stalked tunicates. Studies of the effects of representative trawls on these groups include Van Dolah et al. (1987), Freese et al. (1999), Moran and Stephenson (2000), Prena et al. (1999), and McConnaughey et al. (2000). The first three studies examined the effects on epifauna on substrates such as pebble, cobble, and rock that support attached erect organisms, while the last two studies were located on sandy substrates. Effect estimates were available for only one type of structure-providing organism, the soft coral *Gersemia*, from Prena et al. (1999). After adjustment for multiple contacts, *Gersemia* had a q of 10 percent reduction in biomass per gear contact.

Both the Van Dolah et al. (1987) and Freese et al. (1999) studies identified removal rates and rates of damage to organisms remaining after contact, raising the question of how damage incurred from contact with gear reduces the structural function of organisms. In Freese et al. (1999), sponges were indicated as damaged if they had more than 10 percent of the colony removed, or if tears were present through more than 10 percent of the colony length. Van Dolah et al. (1987) classified organisms as heavily damaged (more than 50 percent damage or loss) or lightly damaged (less than 50 percent damage or loss). Lacking better information, the damaged organisms from Freese et al. (1999) were assigned a 50 percent loss of structural function, and the heavily and lightly damaged organisms from VanDolah et al. (1987) were assigned 75 and 25 percent losses of their function respectively.

Adjustments to the Freese et al.(1999) results were based on observations of a further decrease in vase sponge densities 1 year post-study. Freese (2001) indicates that some of the damaged sponges had suffered necrotization (decay of dead tissues) to the extent that they were no longer identifiable. This percentage was added to the category of removed organisms, resulting in q estimates for epifauna structures in the path of tire gear of a 35 percent median reduction in biomass per contact and a 75th percentile of 55 percent reduction in biomass per contact. Summary results of the VanDolah data show a median of 17 percent reduction in biomass per gear contact and a 75th percentile of 22 percent reduction in biomass per gear contact. Moran and Stephenson (2000) combined all erect epifauna taller than 20 cm and studied their reductions subsequent to each of a series of trawl contacts. They estimated a per contact reduction in biomass (q) of 15 percent. Combining the non-tire gear studies gives a full gear q median per contact reduction estimate of 15 percent and a 75th percentile per contact reduction estimate of 21 percent. Using the same methods as applied to epifauna for combining non-tire gear data with the tire gear data produced effect estimates for trawls employing tire gear of a median per contact reduction of 20 percent and a 75th percentile per contact reduction of 30 percent.

Data from McConnaughey et al. (2000) combining initial effects of high-intensity trawling and recovery had a median value for structure-forming epifauna per contact reduction of 23 percent and a 75th percentile reduction of 44 percent. While these results show greater reductions than the single pass estimates from the other studies, the effects of multiple years of high-intensity trawling can reasonably account for such a difference; thus, the above values for q were not altered.

Hard Corals

While numerous studies have documented damage to hard corals from trawls (e.g., Fossa 2002, Clark and O'Driscoll 2003), only one (Krieger 2001) was found that related damage to a known number of trawl encounters. Fortunately, this study occurred in the GOA with a common species of gorgonian coral

(*Primnoa rubi*) and with gear not unlike that used in Alaska commercial fisheries. Krieger used a submersible to observe a site where large amounts of *Primnoa* were caught during a survey trawl. An estimated 27 percent of the original volume of coral was removed by the single trawl effort. The site was in an area closed to commercial trawling, so other trawling effects were absent. This value was used for coral sensitivity in the analysis bracketed by low and high values of 22 and 35 percent.

Non-living Structure

A variety of forms of the physical substrates in Alaska waters can provide structure to managed species, particularly juveniles. These physical structures range from boulder piles that provide crevices for hiding to sand ripples that may provide a resting area for organisms swimming against currents. Unfortunately, few of these interactions are understood well enough to assess the effects of substrate changes on habitat functions. A number of studies describe changes to the physical substrates resulting from the passage of trawls. However, there is no consistent metric available to relate the use of such structures by managed species to their abundance or condition. This lack of relationship effectively precludes a quantitative description of the effects of trawling on non-living structure. The following discussion describes such effects qualitatively and proposes preliminary values of q for the analysis.

Sand and Silt Substrates:
Schwinghamer et al. (1998) described physical changes to the fine sand habitats caused by trawling as part of the same study that produced Prena et al. (1999) and Kenchington et al. (2001). Door tracks, approximately 1 m wide and 5 cm deep, were detected with sidescan sonar, adding to the surface relief of the relatively featureless seafloor. Finer scale observations, made with video cameras, indicated that trawling replaced small hummocky features a few cm tall with linear alignments of organisms and shell hash. A dark organic floc that was present before trawling was absent afterwards. While no changes in sediment composition were detected, measurements of the internal structure of the top 4.5 cm of sediment were interpreted to indicate loss of small biogenic sediment structures such as mounds, tubes, and burrows. Brylinsky et al. (1994) describe trawl tracks as the most apparent effect of trawls on a silty substrate and the tracks of rollers as resulting in much shallower lines of compressed sediment than tracks of trawls without rollers. A wide variety of papers describes trawl marks; these papers include Gilkinson et al. (1998), who describe the scouring process in detail as part of a model door study.

For effects on sedimentary forms, the action of roller gear trawls replaces one set of cm-scale forms, such as hummocks and sand ripples, with door and roller tracks of similar scales. In habitats with an abundance of such structures, this can represent a decrease in seabed complexity, while in relatively smooth areas, an increase in complexity will result (Smith et al. 2000). The effects on internal sediment structure are considered too small in scale to provide shelter directly to the juveniles of managed species. The extent to which they affect the availability of prey for managed species is better measured by directly considering the abundance or those prey species. This consideration was done by studies cited in the prey sections above. Since the observed effects of a single gear contact are relatively subtle, with ambiguous effects on function, the parameter selected for this analysis represents a small negative effect (-2 percent). This provides some effect size that can be scaled up or down if greater or lesser effects are hypothesized or measured.

Pebble to Boulder Substrates:
In substrates composed of larger particles (large pebbles to boulders), the interstitial structure of the substrate has a greater ability to provide shelter to juveniles and adults of managed species. The association of species aggregations with such substrates provides evidence of their function as structure (Krieger 1992, 1993).

Freese et al. (1999) documented that the tire gear section of a trawl disturbed an average of 19 percent of the large boulders (more than 0.75-m longest axis) in its path. They noted that displaced boulders can still provide cover, while breaking up boulder piles can reduce the number and complexity of crevices.

In areas of smaller substrate particles (pebble to cobble), the track of the tire gear was distinguishable from the rest of the trawl path due to the removal of overlying silt from substrates with more cobble or the presence of a series of parallel furrows 1 to 8 cm deep from substrates with more pebble. Of the above effects, only breaking up boulder piles was hypothesized to decrease the amount of non-living functional structure for managed species. A key unknown is the proportional difference in functional structure between boulder piles and the same boulders, if separated. If that difference comprised 20 percent of the functional structure, and 19 percent of such piles were disturbed over one-third of the trawl paths (tire gear section), a single trawl pass would reduce non-living structure by only about 1 percent. Even if piles in the remaining trawl path were disturbed at half the rate of those in the path of the tire gear (likely an overestimate from descriptions in Freese et al. 1999), the effect would only increase to 2 percent. Lacking better information, this speculative value was applied in the analysis.

4.2.2 Pelagic Trawls

Studies using gear directly comparable to Alaska pelagic trawls, and thus identifying the resulting effect of such gear contact with the seafloor, are lacking. By regulation, these trawls must not use bobbins or other protective devices, so footropes are small in diameter (typically chain or sometimes cable or wrapped cable). Thus, their effects may be similar to other footropes with small diameters (i.e., shrimp or Nephrops trawls). However, these nets have a large enough mesh size in the forward sections that few, if any, benthic organisms that actively swim upward would be retained in the net. Thus, benthic animals that were found in other studies to be separated from the bottom and removed by trawls with small-diameter footropes would be returned to the seafloor immediately by the Alaska pelagic trawls. Pelagic trawls are fished with doors that do not contact the seafloor, so any door effects are eliminated. Finally, because the pelagic trawl's unprotected footrope effectively precludes the use of these nets on rough or hard substrates, they do not affect the more complex habitats that occur on those substrates.

Two studies of small footrope trawls were used to represent the effects of pelagic trawl footropes on infaunal prey. Since most infaunal prey are too small to be effectively retained by bottom trawls, the large mesh size of pelagic trawls was not considered a relevant difference for the feature. Ball et al. (2000) investigated the effects of two tows of a Nephrops trawl in the Irish Sea on a muddy sand bottom in two different years. Eighteen taxonomic groups were measured in each year, including bivalves, gastropods, crustaceans, and annelids. For the 27 abundance reductions cited, the median effect was a 19 percent reduction abundance per gear contact, and the 75th percentile was a 40 percent reduction in abundance per gear contact, with the adjustment for multiple tows. The infauna responses measured from four passes of a whiting trawl on a clay-silt bottom in the Bay of Maine included three bivalves and seven polychaetes and nemerteans. The median response was a 24 percent reduction in abundance per gear contact, and the 75th percentile was a 31 percent reduction in abundance per gear contact, with the adjustment for multiple tows. Combining the two studies gave a median per contract reduction of 21 percent and a 75th percentile per contact reduction of 36 percent. These values were higher than those for roller gear trawls since there is continuous contact across the footrope and a greater ability of smaller footropes to penetrate the substrate.

Sessile organisms that create structural habitat may be uprooted or pass under pelagic trawl footropes, while those that are more mobile or attached to light substrates may pass over the footrope, with less resulting

damage. Non-living structures may be more affected by pelagic trawl footropes than by bottom trawl footropes because of the continuous contact and smaller, more concentrated, surfaces over which weight and towing force are applied. In contrast, bottom trawls may capture and remove more of the large organisms that provide structural habitat than pelagic trawls because of their smaller mesh sizes. The bottom trawl doors and footropes could add complexity to sedimentary bedforms as mentioned previously, while pelagic trawls have an almost entirely smoothing effect. Based on these considerations, values of 20 percent reduction per gear contact and 30 percent reduction per gear contact were selected for both living and non-living structure.

4.2.3 Longlines

Studies that quantitatively assess the effects of longlines on seafloor habitat features were not found. Due to the light weight of the lines used with longline gear, effects on either infaunal or epifaunal prey organisms are considered to be limited to anchors and weights. Since these components make up less than 1/500th of the length of the gear, their effects are considered very limited (0.05 percent reduction per contact was the value used). Similarly, effects on the non-living structure of soft bottoms are also likely to be very limited.

Organisms providing structure may be hooked or otherwise affected by contact with the line. Observers have recorded anemones, corals, sea pens, sea whips, and sponges being brought to the surface hooked on longline gear, indicating that the lines move some distance across the seafloor and can affect some of the benthic organisms. The effects on non-living structure in hard-bottom areas due to hang-ups on smaller boulder piles and other emergent structures are limited to what may occur at forces below those necessary to break the line. Similar arguments to those used for bottom trawl effects on hard non-living structure would justify an even lower effect than the value generated for bottom-trawling (1 percent). Unfortunately, there are no data to indicate what proportion the retained organisms represent of those contacted on the seafloor or the level of damage to any of the affected organisms. Values for reduction of living structure equal to one-half of those for bottom trawls were used for the area contacted by longlines.

4.2.4 Pots

The only studies on pots (Eno et al. 2001) have examined gear much smaller and lighter than that used in Alaska waters and are, thus, not directly applicable in estimating effects of pots on habitat. Alaska pots are approximately 110 times as heavy and cover 19 times the area as those used by Eno et al. (2001) (2.6 kilograms [kg], 0.25 m^2). The Eno et al. (2001) study did show that most sea pens recovered after being pressed flat against the bottom by a pot. Most Alaska pots have their mesh bottoms suspended 2.5 to 5 cm above their weight rails (lower perimeter and cross pieces that contact the substrate first); hence, the spatial extent to which the greater weight of those pots is applied to organisms located underneath the pots is limited, but more intense.

The area of seafloor disturbed by the weight rails is of the greatest concern, particularly to the extent that the pot is dragged across the seafloor by bad weather, currents, or during hauling. Based on the estimated weight of the pots in water, and the surface area of the bottom of these rails, the average pressure applied to the seafloor along the weight rails (about 1 pound per square inch [lb/in^2] [0.7 kilogram per square centimeter (kg/cm^2)]) is sufficient to penetrate into most substrates during lateral movement. The effects of pots as they move across the bottom were speculated to be most similar to those of pelagic trawls with smaller contact diameter and more weight concentrated on the contact surface. Therefore, structure reduction values 5 percent greater than those determined for pelagic trawls were used.

4.2.5 Dinglebar

Dinglebar troll gear consists of a single line that is retrieved and set with a power or hand troll gurdy, with a terminally attached weight (cannon ball -12 lbs. or iron bar), from which one or more leaders with one or more lures or baited hooks are pulled through the water while a vessels is underway. Dinglebar troll gear is essentially the same as power or hand troll gear, the difference lies in the species targeted and the permit required. For example, dinglebar troll gear can be used in the directed fisheries for groundfish (e.g. cod) or halibut. These species may only be taken incidentally while fishing for salmon with power or hand troll gear. There is a directed fishery for ling cod in Southeast Alaska using dinglebar troll gear. Trolling can occur over any bottom type and at almost any depths. Trollers work in shallower coastal waters; but may also fish off the coast, such as on the Fairweather Grounds. The dinglebar is usually made of a heavy metal, such as iron, is used in nearly continuous contact with the bottom, and therefore, is likely to disturb bottom habitat.

4.2.6 Dredge Gear

Dredging for scallops may affect habitat by causing unobserved mortality to marine life and modification of the benthic community and sediments. Similar to trawling, dredging places fine sediments into suspension, buries gravel below the surface and overturns large rocks that are embedded in the substrate. Dredging can also result in dislodgement of buried shell material, burying of gravel under re-suspended sand, and overturning of larger rocks with an appreciable roughening of the sediment surface. A study of scallop dredging in Scotland showed that dredging caused significant physical disturbance to the sediments, as indicated by furrows and dislodgement of shell fragments and small stones (Eleftheriou and Robertson 1992). The authors note, however, that these changes in bottom topography did not change sediment disposition, sediment size, organic carbon content, or chlorophyll content. Observations of the Icelandic scallop fishery off Norway indicated that dredging changed the bottom substrate from shell-sand to clay with large stones within a 3-year period (Aschan 1991). Mayer *et al.* (1991), investigating the effects of a New Bedford scallop dredge on sedimentology at a site in coastal Maine, found that vertical redistribution of bottom sediments had greater implications than the horizontal translocation associated with scraping and plowing the bottom. The scallop dredge tended to bury surficial metabolizable organic matter below the surface, causing a shift in sediment metabolism away from aerobic respiration that occurred at the sediment-water interface and instead toward subsurface anaerobic respiration by bacteria (Mayer *et al.* 1991). Dredge marks on the sea floor tend to be short-lived in areas of strong bottom currents, but may persist in low energy environments (Messieh *et al.* 1991).

Two studies have indicated that intensive scallop dredging may have some direct effects on the benthic community. Eleftheriou and Robertson (1992), conducted an experimental scallop dredging in a small sandy bay in Scotland to assess the effects of scallop dredging on the benthic fauna. They concluded that while dredging on sandy bottom has a limited effect on the physical environment and the smaller infauna, large numbers of the larger infauna (mollusks) and some epifaunal organisms (echinoderms and crustaceans) were killed or damaged after only a few hauls of the dredge. Long-term and cumulative effects were not examined, however. Aschan (1991) examined the effects of dredging for islandic scallops on macrobenthos off Norway. Aschan found that the faunal biomass declined over a four-year period of heavy dredging. Several species, including urchins, shrimp, seastars, and polychaetes showed an increase in abundance over the time period. In summary, scallop gear, like other gear used to harvest living aquatic resources, may effect the benthic community and physical environment relative to the intensity of the fishery.

Adverse effects of scallop dredges on benthic communities in Alaska may be lower in intensity than trawl gear. Studies on effects of trawl and dredge gear have revealed that, in general, the heavier the gear in contact with the seabed, the greater the damage (Jones 1992). Scallop dredges generally weigh less than most trawl doors, and the relative width they occupy is significantly smaller. A 15 ft wide New Bedford style scallop dredge weighs about 1,900 lbs (Kodiak Fish Co. data). Because scallop vessels generally fish two dredges, the total weight of the gear is 3,800 lbs. Trawl gear can be significantly heavier. An 850 horsepower vessel pulling a trawl with a 150 ft sweep may require a pair of doors that weigh about 4,500 pounds. Total weight of all trawl gear, including net, footrope, and mud gear would weigh even more (T. Kandianis, personal communication). Hence, based on weight of gear alone, scallop fishing may have less effect than bottom trawling, however its effects may be more concentrated.

4.3 Results of the Analysis of Effects of Fishing on Habitat Features

No fishing occurred in blocks covering a large proportion of the seafloor area shallower than 1,000 m from 1998 to 2002 (Table B.2-8 of the EFH EIS), and even more blocks were unaffected by trawling. Most of the fished blocks experienced intensities less than 0.1, and only a small proportion of the area (2.5 percent BS, 0.8 percent AI, and 0.9 percent GOA) was in blocks with intensities above 1.0. These fishing intensities determined the spatial distribution of the indices of fishing effects estimated by the model.

The analysis estimated an LEI of the effects of fishing on infaunal prey, epifaunal prey, living structure (coral treated separately), and non-living structure across different habitats and between fisheries. The LEI estimated the percentage by which these habitat features would be reduced from a hypothetical unfished abundance if recent intensity and distribution of fishing effort were continued over a long enough term to achieve equilibrium. Equilibrium is defined as a point where the rate of loss of habitat features from fishing effects equal the gain from feature recovery. The spatial pattern of long-term effect indices largely reflects the distribution of fishing effort scaled by the sensitivity and recovery rates assigned to different features in different habitat types. Thus, patterns on the charts of LEI for each feature class were very similar, with higher overall LEIs for more sensitive or slower recovering features (Figures B.2-2 to B.2-5 of the EFH EIS). Prey LEIs were substantially lower than structure LEIs, reflecting their lower sensitivity and faster recovery rates.

All habitats included substantially unfished and lightly fished areas that have low LEIs (less than 1 percent) as well as some areas of high fishing that resulted in high LEIs (more than 50 percent or even more than 75 percent). In the AI, GOA, and EBS slope, substantial LEIs were primarily concentrated into many small, discrete pockets. On the EBS shelf, there were two larger areas where high LEIs were concentrated: (1) an area of sand/mud habitat between Bristol Bay and the Pribilof Islands and (2) an area of sand habitat north of Unimak Island and Unimak Pass, mostly inside of the 100-m contour.

Some of the patterns in fishing effects can be related to areas closed to bottom trawl fishing. In the GOA, no bottom trawling is allowed east of 140°E longitude, and fishing effects are light there. Bottom trawling has been substantially restricted within specified radii (10 and 20 nm) of Steller sea lion rookeries and haulouts. The effects of these actions on LEI values are most clearly seen in the AI, where high LEI values are concentrated in small patches where the narrow shelf does not intersect these closures. Two large EBS areas around the Pribilof Islands and in and adjacent to Bristol Bay both mostly in sand substrates, are closed to bottom trawling to protect red king crab habitat. These closures concentrate fishing in the southern part of the EBS into the remaining sand, sand/mud, and slope habitats, which likely increases the predicted LEI in those areas.

Aggregate LEIs for each of the habitats are shown in Table B.2-9 of the EFH EIS. As discussed above, prey declined less than biostructure due to lower sensitivity and faster recovery rates. No prey feature was reduced by more than 3.5 percent (BS slope habitat). Biological structure features had LEIs between 7 and 9 percent in the hard substrate habitats where recovery rates were slow. LEIs above 10 percent were indicated for the biological structure of the sand/mud and slope habitats of the EBS where fishing effort is concentrated, and recovery rates are moderately slow.

Because of uncertainties in key input parameters, some evaluation was needed to determine how widely the resulting estimates might vary. In addition to the LEIs cited above, which were generated with median or central estimates for each input parameter (referred to below as central LEIs), LEI was estimated for both large and small values of sensitivity and recovery. High estimates of sensitivity were combined with low recovery rates to provide an upper LEI, and low estimates of sensitivity were combined with high recovery rates to produce a lower LEI. Lower LEIs for the habitat features (except for coral, which is discussed below) ranged from 8 to 50 percent of the original median estimates. Infaunal and epifaunal prey lower LEIs were all at or below 0.5 percent proportional reduction habitat, those for non-living structure were below 2 percent, and those for living structure were below 4 percent. The corresponding upper LEIs ranged from 1.5 to 3 times the original median estimate. The largest upper LEI values for infauna and epifauna prey were for the EBS sand/mud and slope habitats and ranged from 3.5 to 7 percent, with all other upper LEIs below 2 percent. Non-living structure upper LEIs were greatest on the GOA hard substrates, the AI shallow water habitat, and the EBS slope, ranging from 7 to 14 percent, with all other upper LEIs below 4 percent. In six habitats (the three GOA hard substrates, the AI shallow water habitats, and the EBS sand/mud and slope habitats), the upper LEI exceeded 10 percent, with the highest value (21 percent) on the GOA slope.

The analysis also calculated the proportion of each LEI attributable to each fishery. Fishery-specific LEI values for the habitat/feature combinations with the highest overall LEIs (all involving living structure) in each region are presented in Table B.2-10 of the EFH EIS. While the pollock pelagic trawl fishery was the largest single component (4.6 percent) of the total effects on living structure in the EBS sand/mud habitat, the combined effects of the bottom trawl fisheries made up all of the remaining 6.3 percent (total LEI of 10.9 percent). This was not true for living structure on the EBS slope, where nearly all (7.2 percent out of 10.9 percent) of the LEI was due to the pollock pelagic trawl fishery. Living structure on hard bottom substrates of the GOA slope was affected by bottom trawling for both deepwater flatfish and rockfish. While the LEIs of these two fisheries were nearly equal, it is likely that much more of the rockfish effort occurred on hard substrates as compared with trawling for deepwater flatfish. [Because the spatial distribution of hard and soft substrate was unknown, such differences are not explicitly accounted for in the fishing effects analysis.] Therefore, most of the effects on this feature were attributed to the rockfish trawl fishery. In the shallow, hard substrate habitat of the AI, most of the effects (4.2 out of 7.3 percent) on living structure were attributable to the trawl fishery for Pacific cod. The remainder was attributed to Atka mackerel trawling at 2.5 percent. Living structure was the only habitat feature in which the effect of a passive gear fishery, longlining for Pacific cod, had an LEI above 0.1 percent. This fishery accounts for the consistent light blue (less than 1 percent LEI) coverage in Figure B.2-3 (a, b, and c) of the EFH EIS of many shallow areas of the AI not open to trawling.

Results for ultra-slow recovering structures, represented by hard corals, were different from those of other living structure in several ways. Corals had the highest LEI values of the fishing effects analyses. Because the very slow recovery rate of these organisms results in very high (more than 75 percent LEI) eventual effects with more than the most minimal amount of trawl fishing (annual trawl effort less than one tenth the area of the block), the distribution of high LEI values directly reflects the distribution of blocks subject to

more than minimal trawl effort (Figure B.2-6 [a, b, and c] of the EFH EIS). The LEI values by habitat range from 6 to 20 percent with the highest values in the shallow AI and GOA slopes. These results mostly reflect the proportion of blocks in each habitat type subject to more than minimal trawl effort. Even though fairly wide ranges of both sensitivity and recovery rates were used for the upper and lower LEI estimates for coral, the range between upper and lower LEI was not as wide as for the other living structure organisms, ranging from plus 40 to -33 percent of the central value.

This analysis combined available information to assess the effects of Alaska fisheries on marine fish habitat. It estimated the effects (as measured by LEIs) of fisheries on habitat features that may be used by fish for spawning, breeding, feeding, or growth to maturity. These LEIs represent the proportion of feature abundances (relative to an unfished state) that would be lost if recent fishing patterns were continued indefinitely (to equilibrium). Therefore, all LEIs represent effects that are not limited in duration and satisfy the EFH regulation's definition of "not temporary." The magnitude and distribution of feature LEIs can, thus, be compared with the distribution of the use of that feature by fish species to assess whether the effects are "more than minimal" relative to that species' EFH (Section B.3 of the EFH EIS). Effects meeting this second element would necessarily meet both elements (more than minimal and not temporary) due to the nature of the LEI estimates.

4.4 Evaluation of Effects on EFH of BSAI Crab Species

This section evaluates whether the fisheries, as they are currently conducted off of Alaska, will affect habitat that is essential to the welfare of the managed fish populations in a way that is more than minimal and not temporary. The previous statement describes the standard set in the EFH regulations which, if met, requires Councils to act to minimize such effects. The above analysis has identified changes to habitat features that are not expected to be temporary. The habitat features were selected as those which a) can be affected by fishing and b) may be important to fish in spawning, breeding, feeding, and growth to maturity. This section evaluates the extent that these changes relate to the EFH of each managed species and whether they constitute an effect to EFH that is more than minimal.

Two conclusions are necessary for this evaluation: (1) the definition of EFH draws a distinction between the amount of habitat necessary for a species to "support a sustainable fishery and the managed species' contribution to a healthy ecosystem" (50 CFR 600.10) and all habitat features used by any individuals of a species; (2) this distinction applies to both the designation of EFH and the evaluation of fishing effects on EFH. If these conclusions are valid, the "more than minimal" standard relates to impacts that potentially affect the ability of the species to fulfill its fishery and ecosystem roles, not just impacts on a local scale. The forgoing analysis has indicated substantial effects to some habitat features in some locations, many of which are within the spatial boundaries of the EFH of a species that may use them in a life-history function. These habitat changes may or may not affect the welfare of that species (a term used to represent "the ability of a species to support a sustainable fishery and its role in a healthy ecosystem").

The evaluation method is detailed in Section B.3.1 of Appendix B of the EFH EIS (NMFS 2005).

The Effects of Fishing on EFH analysis in the EFH EIS was made to answer the question: "Is there evidence that fishing adversely affects EFH in a manner that is more than minimal and not temporary in nature?" The following text summarizes the results of the analysis for each managed species. The details of the analysis for each species, including the habitat connections and the evaluation of effects, are contained in Section B.3.3 of Appendix B of the EFH EIS (NMFS 2005) and are incorporated by reference.

4.4.1 Red King Crab

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

Summary of Effects - There is only a small area of overlap between current female red king crab distribution and areas where trawling occurs. Mating areas experience little impact; however, trawling in deeper waters somewhat overlaps the migration route to mating areas. There are essentially no fishing effects in areas important to juvenile red king crab. All known juvenile rearing areas are currently protected by trawl closure areas. Most of the distribution of red king crab is to the north and east of the high fishing effects areas. Given the current very small overlap and fishing intensity in areas with red king crab of all life stages, professional judgement indicates that fisheries do not currently adversely affect the EFH of red king crab.

4.4.2 Blue King Crab

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

Summary of Effects—Fishing activities are considered to have overall minimal and temporary effects on the EFH for blue king crab, although both the Pribilof Islands stock and the St. Matthew stock of blue king crabs are considered to be below MSST. Habitat loss or degradation by fishing activities probably did not play any role in the decline of these stocks. For the Pribilof Islands blue king crab, any fishing activities thought to have adverse consequences have previously been mitigated by establishment of the Pribilof Islands trawl closure area. For St. Matthew blue king crab, there has never been a groundfish bottom trawl fishery in the area. Given the current very small overlap and fishing intensity in areas with blue king crab of all life stages, professional judgement indicates that fisheries do not currently adversely affect the EFH of blue king crab.

4.4.3 Golden King Crab

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

Summary of Effects—Fishing activities are considered to have overall minimal and temporary effects on the EFH for golden king crab. Groundfish trawl fishing in the EBS slope is of some concern; however, any effects are thought to be minimal. Professional judgement indicates that fisheries do not adversely affect the EFH of golden king crab.

4.4.4 Scarlet King Crab

Issue	Evaluation
Spawning/breeding	MT (Minimal, temporary, or no effect)

Feeding	U (Unknown effect)
Growth to maturity	U (Unknown effect)

Summary of Effects—Fishing activities are considered to have overall minimal and temporary effects on the EFH for scarlet king crab. This is a deepwater species with almost no overlap with commercial fisheries, so habitat effects are unlikely. Professional judgement indicates that fisheries are unlikely to adversely affect the EFH of scarlet king crab.

4.4.5 Tanner Crab

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— Fishing activities are considered to have overall minimal and temporary effects on the EFH for Tanner crabs. Tanner crab settle and grow on mud habitat, which was the least affected habitat in the EBS. This analysis of the spatial distribution of Tanner crabs relative to expected habitat impacts indicates that Tanner crabs have not demonstrated shifts away from regions heavily impacted by fishing. The closure of the Bristol Bay region and its associated reduction in habitat impacts did not attract crabs to the region. The effects of fishing activities on Tanner crab feeding activities is minimal.

4.4.6 Snow Crab

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

Summary of Effects - Fishing activities are considered to have overall minimal and temporary effects on the EFH for snow crabs. The current distribution of snow crab does not overlap the high trawl effects area to any extent. Juvenile snow crab distribution occurs on mud substrate and does not overlap areas of high trawling effects. Fishing effects on snow crab habitat and the subsequent impacts on snow crab feeding are expected to be minimal.

4.4.7 Deepwater Tanner Crabs

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

Summary of Effects—Fishing activities are considered to have overall minimal and temporary effects on the EFH for deepwater Tanner crabs. These are deepwater species with almost no overlap with commercial fisheries, so habitat effects are unlikely. Professional judgement led to the conclusion that fisheries are unlikely to adversely affect the EFH of deepwater Tanner crabs.

4.5 Conclusions

Species Evaluations

Evaluations were completed for 26 managed species (or species groups) and 8 forage species, all managed under the 5 FMPs developed by the Council (Table B.4-1 of the EFH EIS). See Sections B.3.2 to B.3.4 of the EFH EIS for more detailed information. Based on the available information, the analysis found no indication that continued fishing at the current rate and intensity would affect the capacity of EFH to support the life history processes of any species. In other words, the effects of fishing on EFH would not be more than minimal. Reasons for minimal ratings were predominantly either lack of a connection to affected habitat features, or findings from stock analyses that current fishing practices (including effects on habitat) do not jeopardize the ability of the stock to produce MSY over the long term. Other evaluations indicated that, even though a connection may exist between a habitat feature and a life-history process, the expected feature reductions were considered too small to make effects at the population level likely. There were also cases where the effects did not overlap significantly with the distribution of the species.

Most of unknown ratings were for species that have received relatively little study; hence, their life history needs and population status are poorly known. Most species with unknown ratings support small or no fisheries. Conversely, species that support significant fisheries have been studied more. In some cases, associations between the habitat features and life history processes were indicated, but the evaluator did not have enough information to assess whether the linkage and the amount of feature reduction would affect species welfare.

Even for well studied species, the knowledge to trace use of habitat features confidently for spawning, breeding, feeding, and growth to maturity to population level effects is not yet available. Several evaluators specifically cited uncertainty regarding the effect of particular noted linkages, and some urged caution.

General Effects on Fish Habitat

While this evaluation identified no specific instances of adverse effects on EFH that were more than minimal and not temporary, the large number of unknown ratings and expressions of concern make it prudent to look for more general patterns across all of the species and habitat features.

Specific areas with high fishing effort were identified in the effects-of-fishing analysis. These included two large areas of the EBS, one north of Unimak Island and Unimak Pass and the other between the Pribilof Islands and Bristol Bay. Both of these areas have continued to be highly productive fishing grounds through decades of intensive fishing. While that may initially seem at odds with the LEI results, it is consistent with the evaluation that the habitat features affected by fishing either are not those important to the species fished in those areas, or are not being affected in a way that limits species welfare.

Fishing concentrations in other areas were smaller, but made up higher proportions of the EBS slope. The largest effect rates were on living structure, including coral. The high reliance on limited areas for fishing production and their high estimated LEIs make it prudent to obtain better knowledge of what processes occur in those locations.

Table B.3-1 of the EFH EIS shows the habitat connections identified for each life stage of managed species and species groups. Each row represents a species life stage and each column one of the habitat types from

the fishing-effects analysis. At their intersections, evaluators entered letters representing each of the habitat features (prey or structure classes) used by that life stage in that habitat. Most species of groundfish have pelagic larval and egg stages. Only one species, Atka mackerel, had a connection with a benthic habitat feature for its egg or larval stages. Crab species are attached to the female in the egg stage, pelagic in the larval stage and benthic in the juvenile and adult stages. A combined tally at the bottom of Table B.3-1 notes how many species/life-stages were identified for each habitat feature in each habitat. Prey features represented about twice as many connections as structure features. The habitat feature/type combinations that had LEIs above 5 percent, outlined in the table, tended to have few connections. The highest number of connections (six) were for living structures on the GOA deep shelf, which had the lowest LEI of the outlined habitat feature/type combinations (6.2 percent). Connections with the highlighted blocks mostly involved rockfish species, with a few connections from Atka mackerel and blue king crab.

Cropping and summing effects on habitat features by distributions of the adults of each species (Table B.3-3 in the EFH EIS) depicted how the fishing effects overlapped in the locations where each species is present. The general distribution values related to the broader areas occupied, while the concentration values related to areas of higher abundance. Concentration LEIs were generally higher than the estimates based on general distribution because adult species concentrations determine where fisheries operate. It is unfortunate that distributions were not available for juveniles because connections to the habitat feature with the highest LEIs (living structure) mostly involved the growth to maturity process. Characterizing juvenile distributions should be a high priority for future research.

Reductions across adult species distributions for the living structure were mostly between 10 and 17 percent. Higher values occurred for red king crab (29 percent for both coverages). NMFS noted that the distribution of juveniles was mostly outside of the affected areas. Prey class effects by species distributions were all at or below 5 percent.

While LEIs for hard corals are subject to the limitations mentioned in Section B.2.6 in the EFH EIS, they had the highest LEIs when considered by species distributions. Intersections where meaningful effects are most likely to occur are those between areas where hard corals are prevalent and species for which a significant portion of their distribution occurs in the same areas, including populations of golden king crab, Atka mackerel, sablefish, and the rockfish species. Coral LEIs at these points ranged from 23 to 59 percent. While few evaluators cited coral as specifically linked to life history functions, in some areas it may be an important component of the living structure that is potentially linked to growth to maturity for some of these species. Because of their very slow recovery, corals warrant particular consideration for protection and for the development of improved knowledge of their habitat functions and distribution.

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5.0 Non-fishing Impacts

The diversity, widespread distribution, and ecological linkages with other aquatic and terrestrial environments make the waters and substrates that comprise EFH susceptible to a wide array of human activities unrelated to fishing.

Non-fishing activities have the potential to adversely affect the quantity or quality of EFH in riverine,

estuarine, and marine systems. 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 each activity, known and potential adverse impacts to EFH are described in the EFH EIS, Appendix G (NMFS 2005). The descriptions explain the mechanisms or processes that may cause the adverse effects and how these may affect habitat function. This FMP incorporates by reference the complete analysis of non-fishing impacts in Appendix G of the EFH EIS and summarizes the results for each type of non-fishing activity (NMFS 2005).

Non-fishing activities discussed in this document are subject to a variety of regulations and restrictions designed to limit environmental impacts under federal, state, and local laws. Many current requirements help to avoid or minimize adverse effects to aquatic habitats, including EFH. The conservation recommendations contained in this document are rather general and may overlap with certain existing standards for specific development activities. Nevertheless, the recommendations highlight practices that can help to avoid and minimize adverse effects to EFH. During EFH consultations between NMFS and other agencies, NMFS strives to provide reasonable and scientifically based recommendations that account for restrictions imposed under various state and federal laws by agencies with appropriate regulatory jurisdiction. Moreover, the coordination and consultation required by Section 305(b) of the Magnuson-Stevens Act do not supersede the regulations, rights, interests, or jurisdictions of other federal or state agencies. NMFS will not recommend that state or federal agencies take actions beyond their statutory authority, and NMFS' EFH conservation recommendations are not binding.

The conservation measures discussed in this document should be viewed as options to avoid, minimize, or compensate for adverse impacts and promote the conservation and enhancement of EFH. Ideally, non-water-dependent actions should not be located in EFH if such actions may have adverse impacts on EFH. Activities that may result in significant adverse effects on EFH should be avoided where less environmentally harmful alternatives are available. If there are no alternatives, the impacts of these actions should be minimized. Environmentally sound engineering and management practices should be employed for all actions that may adversely affect EFH. If avoidance or minimization is not practicable, or will not adequately protect EFH, compensatory mitigation (as defined for Section 404 of the Clean Water Act – the restoration, creation, enhancement, or in exceptional circumstances, preservation of wetlands and/or other aquatic resources for the purpose of compensating for unavoidable adverse impacts which remain after all appropriate and practicable avoidance and minimization has been achieved) should be considered to conserve and enhance EFH.

Section 303(a)(7) of the Magnuson-Stevens Act requires FMPs to identify activities other than fishing that may adversely affect EFH and define actions to encourage the conservation and enhancement of EFH, including recommended options to avoid, minimize, or compensate for the adverse effects identified. During consultation, agencies strive to consider all potential non-fishing impacts to EFH so that the appropriate recommendations can be made. Because impacts that may adversely affect EFH can be direct, indirect, and cumulative, the biologist must consider and analyze these interrelated impacts.

The conservation recommendations included with each activity present a series of site-specific measures the action agency can undertake to avoid, offset, or mitigate impacts to EFH. Not all of these suggested measures are necessarily applicable to any one project or activity that may adversely affect EFH. More specific or different measures based on the best and most current scientific information may be developed

before or during EFH consultations and communicated to the appropriate agency. The conservation recommendations provided herein represent a short menu of actions that can contribute to the conservation, enhancement, and proper functioning of EFH.

While it is necessary to distinguish between activities to identify possible adverse impacts, it is equally important to consider and analyze these activities as they interrelate within habitats. This document is organized by activities that may potentially impact EFH occurring in four discrete ecosystems. The separation of these ecosystems is artificial, and many of the impacts and their related activities are not exclusive to one system.

The format for presenting the information in this document provides an introductory description of each activity, identification of potential adverse impacts, and suggested general conservation measures that would help minimize and avoid adverse effects of non-fishing activities on EFH. Table 3.4-36 in the EFH EIS identifies the categories from Appendix G and correlates them with possible changes in physical, chemical, and biological parameters, and Table 3.4-37 in the EFH EIS takes the same categories from Appendix G and broadly interprets whether the effects from the activities in Alaska have been positive, insignificant, negative, or unknown.

5.1 UPLAND ACTIVITIES

5.1.1 Nonpoint Source Pollution

Nonpoint source pollution generally results from land runoff, precipitation, atmospheric deposition, seepage, or hydrologic modification. Technically, the term nonpoint source means anything that does not meet the legal definition of point source in Section 502(14) of the Clean Water Act (CWA), which refers to discernable, confined, and discrete conveyance from which pollutants are or may be discharged. The major categories of nonpoint pollution are as follows:

- Agricultural runoff
- Urban runoff, including developed and developing areas (Section G.2.2 of the EFH EIS)
- Silvicultural (forestry) runoff (Section G.2.1.1 of the EFH EIS)
- Marinas and recreational boating
- Road construction
- Channel and streambank modifications, including channelization (Section G.4.7 of the EFH EIS)
- Streambank and shoreline erosion

Nonpoint source pollution is usually lower in intensity than an acute point source event, but it may be more damaging to fish habitat in the long term. Nonpoint source pollution is often difficult to detect. It may affect sensitive life stages and processes, and the impacts may go unnoticed for a long time. When severe pollution impacts are finally noticed, they may not be tied to any one event; hence, it may be difficult to correct, clean up, or mediate.

5.1.2 Silviculture/Timber Harvest

Recent revisions of Alaska's federal and state timber harvest regulations and best management practices (BMPs) have resulted in increased protection of EFH on federal, state, and private timber lands. Current forest management practices, when fully implemented and effective, avoid or minimize adverse effects to

EFH that can result from the harvest and cultivation of timber and other forestry products. However, timber harvest can have both short- and long-term impacts throughout many coastal watersheds and estuaries if management practices are not fully implemented or effective. Past timber harvest in Alaska was not conducted under the current protective standards, and some effects from past harvesting continue to affect EFH.

If appropriate environmental standards are not followed, forest conditions after harvest may result in altered or impaired instream habitat structure and watershed function. In general, timber harvest can have a variety of effects such as removing the dominant vegetation; converting mature and old-growth upland and riparian forests to tree stands or forests of early seral stage; reducing permeability of soils and increasing the area of impervious surfaces; increasing sedimentation from surface runoff and mass wasting processes; altering hydrologic regimes; and impairing fish passage through inadequate design, construction, and/or maintenance of stream crossings (Northcote and Hartman 2004). Timber harvest may result in inadequate or excessive surface and stream flows, increased streambank and streambed erosion, loss of complex instream habitats, sedimentation of riparian habitat, and increased surface runoff with associated contaminants (e.g., herbicides, fertilizers, and fine sediments). Hydrologic characteristics (e.g., water temperature), annual hydrograph change, and greater variation in stream discharge can be associated with timber harvest. Alterations in the supply of large woody debris (LWD) and sediment can have negative effects on the formation and persistence of instream habitat features. Excess debris in the form of small pieces of wood and silt can cover benthic habitat and reduce dissolved oxygen levels.

Potential Adverse Impacts

There are many complex and important interactions, in both small and large watersheds, between fish and forests (Northcote and Hartman, 2004). Five major categories of activities can adversely affect EFH: 1) construction of logging roads, 2) creation of fish migration barriers, 3) removal of streamside vegetation, 4) hydrologic changes and sedimentation and 5) disturbance associated with log transfer facilities (LTFs) (Section G.4.9 of the EFH EIS). Potential impacts to EFH have been greatly reduced by the adoption of best management practices (BMPs) designed to protect fish habitat.

Recommended Conservation Measures

The following recommended conservation measures should be viewed as options to avoid and minimize adverse impacts and promote the conservation, enhancement, and proper functioning of EFH.

1. For timber operations near streams with EFH, adhere to modern forest management practices and BMPs, including the maintenance of vegetated buffers to reduce sedimentation and supply LWD.
2. Avoid timber operations to the extent practicable in wetlands contiguous with anadromous fish streams.
3. For timber operations near estuaries or beaches, maintain vegetated buffers as needed to protect EFH.
4. Maintain riparian buffers along all streams to the extent practicable. In Alaska, buffer width is site-specific and dependent on use by anadromous and resident fish and stream process type.
5. Incorporate watershed analysis into timber and silviculture projects whenever possible or practicable. Particular attention should be given to the cumulative effects of past, present, and future timber sales within the watershed.
6. For forest roads, see Section G.2.3 in the EFH EIS, Road Building and Maintenance.

5.1.3 Pesticide Application (includes insecticides, herbicides, fungicides)

Pesticides are frequently detected in freshwater and estuarine systems that provide EFH. Pesticides are substances intended to prevent, destroy, control, repel, or mitigate any pest. They include the following: insecticides, herbicides, fungicides, rodenticides, repellents, bactericides, sanitizers, disinfectants, and growth regulators. More than 800 different pesticides are currently registered for use in the U.S. Legal mandates covering pesticides are the CWA and the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA). Water quality criteria for the protection of aquatic life have only been developed for a few of the currently used chemicals (EPA, Office of Pesticide Programs). The most common pesticides are insecticides, herbicides, and fungicides. These are used for pest control on forested lands, agricultural crops, tree farms and nurseries, highways and utility rights of way, parks and golf courses, and residences. Pesticides can enter the aquatic environment as single chemicals or as complex mixtures. Direct applications, surface runoff, spray drift, agricultural return flows, and groundwater intrusions are all examples of transport processes that deliver pesticides to aquatic ecosystems.

Habitat alteration from pesticides is different from more conventional water quality parameters, such as temperature, suspended solids, or dissolved oxygen, because, unlike temperature or dissolved oxygen, the presence of pesticides can be difficult to detect due to limitations in proven methodologies. This monitoring may also be expensive. As analytical methodologies have improved in recent years, however, the number of pesticides documented in fish and their habitats has increased.

Potential Adverse Impacts

There are three basic ways that pesticides can adversely affect EFH. These are (1) a direct toxicological impact on the health or performance of exposed fish, (2) an indirect impairment of the productivity of aquatic ecosystems, and (3) a loss of aquatic vegetation that provides physical shelter for fish.

Recommended Conservation Measures

The following recommended conservation measures should be viewed as options to avoid and minimize adverse impacts and promote the conservation, enhancement, and proper functioning of EFH.

1. Incorporate integrated pest management and BMPs as part of the authorization or permitting process to ensure the reduction of pesticide contamination in EFH (Scott et al. 1999).
2. Carefully review labels and ensure that application is consistent. Follow local, supplemental instructions such as state-use bulletins where they are available.
3. Avoid the use of pesticides in and near EFH.
4. Refrain from aerial spraying of pesticides on windy days.

5.1.4 Urban/Suburban Development

Urban development is most likely the greatest non-fishing threat to EFH. Urban growth and development in the U.S. continue to expand in coastal areas at a rate approximately four times greater than in other areas. Urban and suburban development and the corresponding infrastructure result in four broad categories of impacts to aquatic ecosystems: hydrological, physical, water quality, and biological indicators (Center for Watershed Protection [CWP] 2003). Runoff from impervious surfaces is the most widespread source of pollution into the nation's waterways (EPA 1995). When a watershed's impervious cover exceeds 10 percent, impacts to stream quality can be expected (CWP 2003).

Potential Adverse Impacts

Development activities within watersheds and in coastal marine areas often impact the EFH of managed species on both long- and short-term scales. The CWP made a comprehensive review of the impacts associated with impervious cover and urban development and found a negative relationship between watershed development and about 26 stream quality indicators (CWP 2003). Many of the impacts listed here are discussed in greater detail in other sections of this document. The primary impacts include (1) the loss of riparian and shoreline habitat and vegetation and (2) runoff. Upland and shoreline vegetation removal can increase stream water temperatures, reduce supplies of LWD, and reduce sources of prey and nutrients to the water system. An increase in impervious surfaces, such as the addition of new roads (see Section G.2.3 of the EFH EIS), roofs, bridges, and parking facilities, results in a decreased infiltration to groundwater and increased runoff volumes. This also has the potential to adversely affect water quality and water quantity/timing in downstream water bodies (i.e., estuaries and coastal waters).

Recommended Conservation Measures

The following recommended conservation measures should be viewed as options to avoid and minimize adverse impacts and promote the conservation, enhancement, and proper functioning of EFH.

1. Implement BMPs (EPA 1993) for sediment control during construction and maintenance operations.
2. Avoid using hard engineering structures for shoreline stabilization and channelization when possible.
3. Encourage comprehensive planning for watershed protection to avoid filling and building in floodplain areas affecting EFH.
4. Where feasible, remove impervious surfaces such as abandoned parking lots and buildings from riparian and shoreline areas, and reestablish wetlands and native vegetation.
5. Protect and restore vegetated buffer zones of appropriate width along all streams, lakes, and wetlands that include or influence EFH.
6. Manage stormwater to duplicate the natural hydrologic cycle, maintaining natural infiltration and runoff rates to the maximum extent practicable.
7. Where in-stream flows are insufficient to maintain water quality and quantity needed for EFH, establish conservation guidelines for water use permits and encourage the purchase or lease of water rights and the use of water to conserve or augment instream flows in accordance with state and federal water laws.
8. Encourage municipalities to use the best available technologies in upgrading their wastewater systems to avoid combined sewer overflow problems and chlorinated sewage discharges into rivers, estuaries, and the ocean.
9. Design and install proper on-site disposal systems.

5.1.5 Road Building and Maintenance

The building and maintenance of roads can affect aquatic habitats by increasing rates of natural processes such as debris slides or landslides and sedimentation, introducing exotic species, degrading water quality, and introducing chemical contamination (e.g., petroleum-based contaminants; Section G.2.2 of the EFH EIS). Paved and dirt roads introduce an impervious or semipervious surface into the landscape. This surface intercepts rain and creates runoff, carrying soil, sand and other sediments, and oil-based materials quickly downslope. If roads are built near streams, wetlands, or other sensitive areas, they may experience increased sedimentation that occurs from maintenance and use, as well as during storm and snowmelt events. Even carefully designed and constructed roads can become sources of sediment and pollutants if they are not

properly maintained.

Potential Adverse Impacts

The effects of roads on aquatic habitat can be profound. They include (1) increased deposition of fine sediments, (2) changes in water temperature, (3) elimination or introduction of migration barriers such as culverts, (4) changes in streamflow, (5) introduction of non-native plant species, and (6) changes in channel configuration (see Section G.2.1.1 and the standards referenced in the EFH EIS).

Recommended Conservation Measures

The following conservation measures for road building and maintenance should be viewed as options to avoid and minimize adverse impacts and promote the conservation, enhancement, and proper functioning of EFH.

1. To the extent practicable, avoid locating roads near fish-bearing streams.
2. Incorporate appropriate erosion control and stabilization measures into road construction plans to reduce erosion potential.
3. Build bridges when possible.
4. Locate stream crossings in stable stream reaches.
5. Design bridge abutments to minimize disturbances to streambanks and place abutments outside of the floodplain whenever possible.
6. To the extent practicable, avoid road construction across alluvial floodplains, mass wastage areas, or braided stream bottom lands unless site-specific protection can be implemented to ensure protection of soils, water, and associated resources.
7. Avoid side-casting of road construction and maintenance materials on native surfaces and into streams.
8. To the extent practicable, use native vegetation in stabilization plantings.
9. Ensure that maintenance operations avoid adverse affects to EFH.

5.2 RIVERINE ACTIVITIES

5.2.1 Mining

Mining and mineral extraction activities take many forms, such as commercial dredging and recreational suction dredging, placer, area surface removal, and contour operations (Section G.5.6 of EIS EFH). Activities include gravel mining (NMFS 2004), exploration, site preparation, mining, milling, waste management, decommissioning or reclamation, and mine abandonment (American Fisheries Society [AFS] 2000). Mining and its associated activities have the potential to cause environmental impacts from exploration through post-closure. These impacts may include adverse effects to EFH. The operation of metal, coal, rock quarries, and gravel pit mining has caused varying degrees of environmental damage in urban, suburban, and rural areas. Some of the most severe damage, however, occurs in remote areas, where some of the most productive fish habitat is often located (Sengupta 1993). In Alaska, existing regulations, promulgated and enforced by other federal and state agencies, have been designed to control and manage these changes to the landscape to avoid and minimize impacts. These regulations are regularly updated as new technologies are developed to improve mineral extraction, reclaim mined lands, and limit environmental impacts. However, while environmental regulations may avoid, limit, control, or offset many of these potential impacts, mining will, to some degree, always alter landscapes and environmental resources

(National Research Council [NRC] 1999).

Mineral Mining

Potential Adverse Impacts

The effects of mineral mining on EFH depend on the type, extent, and location of the activities. Potential impacts from mining include (1) adverse modification of hydrologic conditions so as to cause erosion of desirable habitats, (2) removal of substrates that serve as habitat for fish and invertebrates, (3) conversion of habitats,(4) release of harmful or toxic materials, and (5) creation of harmful turbidity levels.

Recommended Conservation Measures

The following conservation measures should be viewed as options to avoid and minimize adverse impacts and promote the conservation, enhancement, and proper functioning of EFH.

1. To the extent practicable, avoid mineral mining in waters, riparian areas, and floodplains containing EFH.
2. Schedule necessary in-water activities when the fewest species/least vulnerable life stages of federally managed species will be present.
3. Use an integrated environmental assessment, management, and monitoring package in accordance with state and federal law and regulations.
4. Minimize spillage of dirt, fuel, oil, toxic materials, and other contaminants into EFH.
5. Treat and test wastewater (acid neutralization, sulfide precipitation, reverse osmosis, electrochemical, or biological treatments) and recycle on site to minimize discharge to streams.
6. Minimize opportunities for sediments to enter or affect EFH.
7. If possible, reclaim, rather than bury, mine waste that contains heavy metals, acid materials, or other toxic compounds if leachate can enter EFH through groundwater.
8. Restore natural contours and plant native vegetation on site after use to restore habitat function to the extent practicable.
9. Minimize the aerial extent of ground disturbance (e.g., through phasing of operations), and stabilize disturbed lands to reduce erosion.

Sand and Gravel Mining

Potential Adverse Impacts

Sand and gravel mining is extensive and occurs by several methods. These include wet-pit mining (i.e., removal of material from below the water table), dry-pit mining on beaches, exposed bars, and ephemeral streambeds, and subtidal mining. Sand and gravel mining in riverine, estuarine, and coastal environments can create EFH impacts, including (1) turbidity plumes and resuspension effects, (2) removal of spawning habitat, and (3) alteration of channel morphology.

Recommended Conservation Measures

The following recommended conservation measures should be viewed as options to avoid and minimize adverse impacts and promote the conservation, enhancement, and proper functioning of EFH.

1. To the extent practicable, avoid sand/gravel mining in waters containing EFH.
2. Identify upland or off-channel (where the channel will not be captured) gravel extraction sites as alternatives to gravel mining in or adjacent to EFH, if possible.
3. Design, manage, and monitor sand and gravel mining operations to minimize potential direct and indirect impacts to EFH, if operations in EFH cannot be avoided.
4. Minimize the areal extent and depth of extraction.
5. Include restoration, mitigation, and monitoring plans, as appropriate in sand/gravel extraction plans.

5.2.2 Organic and Inorganic Debris

Natural occurring flotsam, such as LWD and macrophyte wrack (i.e., kelp), plays an important role in aquatic ecosystems, including EFH. LWD and wrack promote habitat complexity and provide structure to various aquatic and shoreline habitats. The natural deposition of LWD creates habitat complexity by altering local hydrologic conditions, nutrient availability, sediment deposition, turbidity, and other structural habitat conditions. Conversely, inorganic flotsam and jetsam debris can negatively impact EFH. Inorganic marine debris is a problem along much of the coastal U.S., where it litters shorelines, fouls estuaries, entangles fish and wildlife, and creates hazards in the open ocean. Marine debris consists of a wide variety of man-made materials, including general litter, plastics, hazardous wastes, and discarded or lost fishing gear. The debris enters waterbodies indirectly through rivers and storm drains, as well as directly via ocean dumping and accidental release. Although laws and regulatory programs exist to prevent or control the problem, marine debris continues to affect aquatic resources.

Organic Debris Removal

Natural occurring flotsam, such as LWD and macrophyte wrack (i.e., kelp), is sometimes intentionally removed from streams, estuaries, and coastal shores. This debris is removed for a variety of reasons, including dam operations, aesthetic concerns, and commercial and recreational uses. However, the presence of organic debris is important for maintaining aquatic habitat structure and function. Removal can alter the ecological conditions of riverine, estuarine, and coastal ecosystems and habitats.

Potential Adverse Impacts

The removal of organic debris from natural systems can reduce habitat function, adversely impacting habitat quality. Reductions in woody debris inputs to estuaries may also affect the ecological balance of estuarine systems by altering rates and patterns of nutrient transport, sediment deposition, and availability of in-water cover for larval and juvenile fish. Beach grooming and wrack removal can substantially alter the macrofaunal community structure of exposed sand beaches by reducing species richness, abundance, and biomass of macrofauna associated with beach wrack (e.g., sand crabs, isopods, amphipods, and polychaetes).

Recommended Conservation Measures

The following recommended conservation measures should be viewed as options to avoid and minimize adverse impacts and promote the conservation, enhancement, and proper functioning of EFH.

1. Leave LWD whenever possible, removing it only when it presents a threat to life or property.
2. Encourage appropriate federal, state, and local agencies to prohibit or minimize commercial removal of LWD from rivers, estuaries, and beaches.
3. Encourage appropriate federal, state, and local agencies to aid in the downstream movement of LWD around dams, culverts, and bridges wherever possible, rather than removing it from the system.
4. Educate landowners and recreationalists about the benefits of maintaining LWD.
5. Localize beach grooming practices, and minimize them whenever possible.

Inorganic Debris

Numerous national and international laws are intended to prevent the disposal of marine debris in ocean waters, including ocean dumping and land-based sources. Nationally, land-based sources of marine debris account for about 80 percent of the marine debris on beaches and in U.S. waters. Debris can originate from combined sewer overflows and storm drains, stormwater runoff, landfills, solid waste disposal, poorly maintained garbage bins, floating structures, and general littering of beaches, rivers, and open waters. Typical debris from these land-based sources includes raw or partially treated sewage, litter, hazardous materials, and discarded trash.

Potential Adverse Impacts

Land and ocean based marine debris is a very diverse problem, and adverse effects to EFH are likewise varied. Floating or suspended trash can directly affect fish that consume or are entangled in it. Toxic substances in plastics can kill or impair fish and invertebrates that use habitat polluted by these materials. The chemicals leach from plastics, persist in the environment, and can bioaccumulate through the food web.

Once floatable debris settles to the bottom of estuaries, coastal, and open ocean areas it may cover and suffocate immobile animals and plants, creating large spaces devoid of life. Currents can carry suspended debris to underwater reef habitats where the debris can become snagged, damaging these sensitive habitats. The typical floatable debris from combined sewer overflows includes street litter, sewage containing viral and bacterial pathogens, pharmaceutical by-products from human excretion, and pet wastes. Pathogens can also contaminate shellfish beds and reefs.

Recommended Conservation Measures

The following recommended conservation measures should be viewed as options to avoid and minimize adverse impacts and promote the conservation, enhancement, and proper functioning of EFH.

1. Encourage proper trash disposal in coastal and ocean settings.
2. Advocate and participate in coastal cleanup activities.
3. Encourage enforcement of regulations addressing marine debris pollution and proper disposal.
4. Provide resources and technical guidance for development of studies and solutions addressing the problem of marine debris.

5. Provide resources to the public explaining the impact of marine debris and giving guidance on how to reduce or eliminate the problem.

5.2.3 Dam Operation

Dams are constructed and operated to provide sources for hydropower, water storage, and flood control. Their operation, however, can affect water quality and quantity in riverine systems.

Potential Adverse Impacts

The effects of dam construction and operation on EFH can include (1) migratory impediments, (2) water flow and current pattern shifts, (3) thermal impacts, and (4) limits on sediment and woody debris transport.

Recommended Conservation Measures

The following recommended conservation measures should be viewed as options to avoid and minimize adverse impacts and promote the conservation, enhancement, and proper functioning of EFH.

1. Operate facilities to create flow conditions that provide for passage, water quality, proper timing of life history stages, and properly functioning channel conditions to avoid strandings and redd dewatering.
2. Develop water and energy conservation guidelines for integration into dam operation plans and into regional and watershed-based water resource plans.
3. Provide mitigation (including monitoring and evaluation) for nonavoidable adverse effects on EFH.

5.2.4 Commercial and Domestic Water Use

Commercial and domestic water use demands to support the needs of homes, farms, and industries require a constant supply of water. Freshwater is diverted directly from lakes, streams, and rivers by means of pumping facilities, or is stored in impoundments. Because human populations are expected to continue increasing in Alaska, it is reasonable to assume that water uses, including water impoundments and diversion, will similarly increase (Gregory and Bisson 1997).

Potential Adverse Impacts

Water diversions can involve either withdrawals (reducing flow) or discharges (increasing flow). The withdrawal of water can affect EFH by (1) altering natural flows and the process associated with flow rates, (2) affecting shoreline riparian habitats, (3) affecting prey bases, (4) affecting water quality, and (5) entrapping fishes. Problems associated with return flows include increased water temperature, increased salinity, introduction of pathogens, decreased dissolved oxygen, increased toxic contaminants from pesticides and fertilizers, and increased sedimentation (Northwest Power Planning Council [NPPC] 1986). Diversions can also physically divert or entrap EFH-managed species (Section G.5.3 of the EFH EIS).

Recommended Conservation Measures

The recommended conservation measures should be viewed as options to avoid and minimize adverse impacts and promote the conservation, enhancement, and proper functioning of EFH.

1. Design projects to create flow conditions that provide for adequate passage, water quality, proper timing of life history stages, and properly functioning channels to avoid juvenile stranding and redd dewatering, as well as to maintain and restore proper channel, floodplain, riparian, and estuarine conditions.
2. Establish adequate instream flow conditions for anadromous fish.
3. Screen water diversions on fish-bearing streams, as needed.
4. Incorporate juvenile and adult fish passage facilities on all water diversion projects (e.g., fish bypass systems).
5. Where practicable, ensure that mitigation is provided for nonavoidable impacts.

5.3 ESTUARINE ACTIVITIES

5.3.1 Dredging

Dredging navigable waters creates a continuous impact primarily affecting benthic and water-column habitats in the course of constructing and operating marinas, harbors, and ports. Routine dredging (i.e., the excavation of soft-bottom substrates) is used to create deepwater navigable channels or to maintain existing channels that periodically fill with sediments. In addition, port expansion has become an almost continuous process due to economic growth, competition between ports, and significant increases in vessel size (Section G.4.3 of the EFH EIS). Elimination or degradation of aquatic and upland habitats is commonplace because port expansion almost always affects open water, submerged bottoms, and, possibly, riparian zones.

Potential Adverse Impacts

The environmental effects of dredging on EFH can include (1) direct removal/burial of organisms; (2) turbidity/siltation effects, including light attenuation from turbidity; (3) contaminant release and uptake, including nutrients, metals, and organics; (4) release of oxygen consuming substances; (5) entrainment; (6) noise disturbances; and (6) alteration to hydrodynamic regimes and physical habitat.

Recommended Conservation Measures

The following recommended conservation measures should be viewed as options to avoid and minimize adverse impacts and promote the conservation, enhancement, and proper functioning of EFH.

1. Avoid new dredging to the maximum extent practicable.
2. Where possible, minimize dredging by using natural and existing channels.
3. Site activities that would likely require dredging (such as placement of piers, docks, marinas, etc.) in deep-water areas or design such structures to alleviate the need for maintenance dredging.
4. Incorporate adequate control measures by using BMPs to minimize turbidity and dispersal of dredged material in areas where the dredging equipment would cause such effects.
5. For new dredging projects, undertake multi-season, pre-, and post-dredging biological surveys to assess the cumulative impacts to EFH and allow for implementation of adaptive management techniques.
6. Provide appropriate compensation for significant impacts (short-term, long-term, and cumulative) to benthic environments resulting from dredging.
7. Perform dredging at times when impacts to federally managed species or their prey are least likely. Avoid dredging in areas with submerged aquatic vegetation.
8. Reference all dredging latitude-longitude coordinates at the site so that information can be incorporated into a geographical information system format.

9. Test sediments for contaminants as per EPA and USACE requirements.
10. Identify excess sedimentation in the watershed that prompts excessive maintenance dredging activities, and implement appropriate management actions, if possible, to ensure that actions are taken to curtail those causes.
11. Ensure that bankward slopes of the dredged area are slanted to acceptable side slopes (e.g., 3:1) to prevent sloughing.
12. Avoid placing pipelines and accessory equipment used in conjunction with dredging operations to the maximum extent possible close to kelp beds, eelgrass beds, estuarine/salt marshes, and other high value habitat areas.

5.3.2 Material Disposal/Fill Material

The discharge of dredged materials subsequent to dredging operations or the use of fill material in aquatic habitats can result in sediments (e.g., dirt, sand, mud) covering or smothering existing submerged substrates, loss of habitat function, and adverse effects on benthic communities.

Disposal of Dredged Material

Potential Adverse Impacts

The disposal of dredged material can adversely affect EFH by (1) altering or destroying benthic communities, (2) altering adjacent habitats, and (3) creating turbidity plumes and introducing contaminants and/or nutrients.

Recommended Conservation Measures

The following recommended conservation measures should be viewed as options to avoid and minimize adverse impacts and promote the conservation, enhancement, and proper functioning of EFH.

1. Study all options for disposal of dredged materials, including upland disposal sites, and select disposal sites that minimize adverse effects to EFH.
2. Where long-term maintenance dredging is anticipated, acquire and maintain disposal sites for the entire project life.
3. Encourage beneficial uses of dredged materials.
4. State and federal agencies should identify the direct and indirect impacts open-water disposal permits for dredged material may have on EFH during proposed project reviews.
5. Minimize the areal extent of any disposal site in EFH, or avoid the site entirely. Mitigate all non-avoidable adverse impacts as appropriate.

Fill Material

Potential Adverse Impacts

Adverse impacts to EFH from the introduction of fill material include (1) loss of habitat function and (2) changes in hydrologic patterns.

Recommended Conservation Measures

The following recommended conservation measures should be viewed as options to avoid and minimize adverse impacts and promote the conservation, enhancement, and proper functioning of EFH:

1. Federal, state, and local resource management and permitting agencies should address the cumulative impacts of past and current fill operations on EFH and consider them in the permitting process for individual projects.
2. Minimize the areal extent of any fill in EFH, or avoid it entirely. Mitigate all non-avoidable adverse impacts as appropriate.
3. Consider alternatives to the placement of fill into areas that support EFH.

5.3.3 Vessel Operations/Transportation/Navigation

The growth in Alaska coastal communities is putting demands on port districts to increase infrastructure capacity to accommodate additional vessel operations for cargo handling activities and marine transportation. Port expansion has become an almost continuous process due to economic growth, competition between ports, and significant increases in vessel size (Council 1999). In addition, increasing boat sales have put more pressure on improving and building new commercial fishing and small boat harbors.

Potential Adverse Impacts

Port facilities, vessel/ferry operations, and recreational marinas can impact to EFH, especially by filling productive shallow water habitats. Potential adverse impacts to EFH can occur during both the construction and operation phases. These include direct, indirect, and cumulative impacts on shallow subtidal, deep subtidal, eelgrass beds, mudflats, sand shoals, rock reefs, and salt marsh habitats. There is considerable evidence that docks and piers block sunlight penetration, alter water flow, introduce chemicals, and restrict access and navigation (Section G.4.6 of the EFH EIS). The increase in hard surfaces close to the marine environment increases nonpoint surface discharges (Section G.2.2 of the EFH EIS), adds debris sources, and reduces buffers between land use and the aquatic ecosystem. Additional impacts include vessel groundings, modification of water circulation (breakwaters, channels, and fill), vessel wake generation, pier lighting, anchor and prop scour, discharge of contaminants and debris, and changing natural patterns of fish movement.

Recommended Conservation Measures

The following recommended conservation measures should be viewed as options to avoid and minimize adverse impacts and promote the conservation, enhancement, and proper functioning of EFH.

1. Locate marinas in areas of low biological abundance and diversity; if possible, for example, avoid the disturbance of eelgrass or other submerged aquatic vegetation including macroalgae, mudflats, and wetlands as part of the project design.
2. If practicable, excavate uplands to create marina basins rather than converting intertidal or shallow subtidal areas to deeper subtidal areas for basin creation.
3. Leave riparian buffers in place to help maintain water quality and nutrient input.
4. Should mitigation be required, include a monitoring plan to gauge the success of mitigation efforts.
5. Include low-wake vessel technology, appropriate routes, and BMPs for wave attenuation structures as part of the design and permit process.

6. Incorporate BMPs to prevent or minimize contamination from ship bilge waters, antifouling paints, shipboard accidents, shipyard work, maintenance dredging and disposal, and nonpoint source contaminants from upland facilities related to vessel operations and navigation.
7. Locate mooring buoys in water deep enough to avoid grounding and to minimize the effects of prop wash.
8. Use catchment basins for collecting and storing surface runoff from upland repair facilities.
9. Locate facilities in areas with enough water velocity to maintain water quality levels within acceptable ranges.
10. Locate marinas where they do not interfere with drift sectors determining the structure and function of adjacent habitats.
11. To facilitate the movement of fish around breakwaters, provide a shallow shelf or "fish bench" on the outside of the breakwater.
12. Harbor facilities should be designed to include practical measures for reducing, containing, and cleaning up petroleum spills.
13. Use appropriate timing windows for construction and dredging activities to avoid potential impacts on EFH.

5.3.4 Introduction of Exotic Species

Introductions of exotic species into estuarine, riverine, and marine habitats have been well documented and can be intentional (e.g., for the purpose of stock or pest control) or unintentional (e.g., fouling organisms). Exotic fish, shellfish, pathogens, and plants can enter the environment from industrial shipping (e.g., as ballast), recreational boating, aquaculture (Section G.4.10 of the EFH EIS), biotechnology, and aquariums. The transportation of nonindigenous organisms to new environments can have many severe impacts on habitat (Omori et al. 1994).

Potential Adverse Impacts

Long-term impacts from the introduction of nonindigenous and reared species can change the natural community structure and dynamics, lower the overall fitness and genetic diversity of natural stocks, and pass and/or introduce exotic lethal disease. Overall, exotic species introductions create five types of negative effects: (1) habitat alteration, (2) trophic alteration, (3) gene pool alteration, (4) spatial alteration, and (5) introduction of diseases.

Recommended Conservation Measures

The following recommended conservation measures should be viewed as options to avoid and minimize adverse impacts and promote the conservation, enhancement, and proper functioning of EFH.

1. Uphold fish and game regulations of the Alaska Board of Fisheries (AS 16.05.251) and Board of Game (AS 16.05.255), which prohibit and regulate the live capture, possession, transport, or release of native or exotic fish or their eggs.
2. Adhere to regulations and use best management practices outlined in the State of Alaska Aquatic Nuisance Species Management Plan (Fay 2002).
3. Encourage vessels to perform a ballast water exchange in marine waters (in accordance with the U.S. Coast Guard's voluntary regulations) to minimize the possibility of introducing exotic estuarine species into similar habitats.

4. Discourage vessels that have not performed a ballast water exchange from discharging their ballast water into estuarine receiving waters.
5. Require vessels brought from other areas over land via trailer to clean any surfaces that may harbor non-native plant or animal species (propellers, hulls, anchors, fenders, etc.).
6. Treat effluent from public aquaria displays and laboratories and educational institutes using exotic species before discharge to prevent the introduction of viable animals, plants, reproductive material, pathogens, or parasites into the environment.
7. Prevent introduction of non-native plant species into aquatic and riparian ecosystems by avoiding use of non-native seed mixes or invasive, non-native landscaping materials near waterways and shorelines.
8. Encourage proper disposal of seaweeds and other plant materials used for packing purposes when shipping fish or other animals.

5.3.5 Pile Installation and Removal

Pilings are an integral component of many overwater and in-water structures. They provide support for the decking of piers and docks, function as fenders and dolphins to protect structures, support navigation markers, and help in the construction of breakwaters and bulkheads. Materials used in pilings include steel, concrete, wood (both treated and untreated), plastic, or a combination thereof. Piles are usually driven into the substrate by using either impact hammers or vibratory hammers. Impact hammers consist of a heavy weight that is repeatedly dropped onto the top of the pile, driving it into the substrate. Vibratory hammers use a combination of a stationary, heavy weight and vibration, in the plane perpendicular to the long axis of the pile, to force the pile into the substrate. Impact hammers are able to drive piles into most substrates (including hardpan, glacial till, etc.), vibratory hammers are limited to softer, unconsolidated substrates (e.g., sand, mud, and gravel).

Piles can be removed using a variety of methods, including vibratory hammer, direct pull, clam shell grab, or cutting/breaking the pile below the mudline, leaving the buried section in place.

Pile Driving

Potential Adverse Impacts

Pile driving can generate intense underwater sound pressure waves that may adversely affect EFH. These pressure waves have been shown to injure and kill fish (CalTrans 2001, Longmuir and Lively 2001, Stotz and Colby 2001, Stadler, pers. obs. 2002). Injuries associated directly with pile driving are poorly studied, but include rupture of the swimbladder and internal hemorrhaging (CalTrans 2001; Abbott and Bing-Sawyer 2002; Stadler, pers. obs. 2002). The type and intensity of the sounds produced during pile driving depend on a variety of factors, including, but not limited to, the type and size of the pile, the firmness of the substrate into which the pile is being driven, the depth of water, and the type and size of the pile-driving hammer. Driving large hollow-steel piles with impact hammers produces intense, sharp spikes of sound that can easily reach levels injurious to fish. Vibratory hammers, on the other hand, produce sounds of lower intensity, with a rapid repetition rate.

Systems successfully designed to reduce the adverse effects of underwater sounds on fish have included the use of air bubbles. Both confined (i.e., metal or fabric sleeve) and unconfined air bubble systems have been shown to attenuate underwater sound pressures (Longmuir and Lively 2001, Christopherson and Wilson 2002, Reyff and Donovan 2003).

Recommended Conservation Measures

The following recommended conservation measures should be viewed as options to avoid and minimize adverse impacts and promote the conservation, enhancement, and proper functioning of EFH.

1. Install hollow-steel piles with an impact hammer at a time of year when larval and juvenile stages of fish species with designated EFH are not present.
2. Drive piles during low tide when they are located in intertidal and shallow subtidal areas.
3. Use a vibratory hammer when driving hollow-steel piles.
4. Implement measures to attenuate the sound should it exceed threshold levels. If sound pressure levels are anticipated to exceed acceptable limits, implement appropriate mitigation measures when practicable. Methods to reduce the sound pressure levels include, but are not limited to, the following:
   a) Surround the pile with an air bubble curtain system or air-filled coffer dam.
   b) Because the sound produced has a direct relationship to the force used to drive the pile, use a smaller hammer to reduce the sound pressures.
   c) Use a hydraulic hammer if impact driving cannot be avoided. The force of the hammer blow can be controlled with hydraulic hammers; reducing the impact force will reduce the intensity of the resulting sound.
5. Drive piles when the current is reduced (i.e., centered around slack current) in areas of strong current to minimize the number of fish exposed to adverse levels of underwater sound.

Pile Removal

Potential Adverse Impacts

The primary adverse effect of removing piles is the suspension of sediments, which may result in harmful levels of turbidity and release of contaminants contained in those sediments. Vibratory pile removal tends to cause the sediments to slough off at the mudline, resulting in relatively low levels of suspended sediments and contaminants. Breaking or cutting the pile below the mudline may suspend only small amounts of sediment, providing that the stub is left in place, and little digging is required to access the pile. Direct pull or use of a clamshell to remove broken piles may, however, suspend large amounts of sediment and contaminants. When the piling is pulled from the substrate using these two methods, sediments clinging to the piling will slough off as it is raised through the water column, producing a potentially harmful plume of turbidity and/or contaminants. The use of a clamshell may suspend additional sediment if it penetrates the substrate while grabbing the piling.

While there is a potential to adversely affect EFH during the removal of piles, many of the piles removed are old creosote-treated timber piles. In some cases, the long-term benefits to EFH obtained by removing a chronic source of contamination may outweigh the temporary adverse effects of turbidity.

Recommended Conservation Measures

The following recommended conservation measures should be viewed as options to avoid and minimize adverse impacts and promote the conservation, enhancement, and proper functioning of EFH.

1. Remove piles completely rather than cutting or breaking them off, if they are structurally sound.
2. Minimize the suspension of sediments and disturbance of the substrate when removing piles. Measures

to help accomplish this include, but are not limited to, the following:

a) When practicable, remove piles with a vibratory hammer, rather than using the direct pull or clamshell method.
b) Remove the pile slowly to allow sediment to slough off at, or near, the mudline.
c) The operator should first hit or vibrate the pile to break the bond between the sediment and the pile to minimize the potential for the pile to break, as well as to reduce the amount of sediment sloughing off the pile during removal.
d) Encircle the pile, or piles, with a silt curtain that extends from the surface of the water to the substrate.

3. Complete each pass of the clamshell to minimize suspension of sediment if pile stubs are removed with a clamshell.
4. Place piles on a barge equipped with a basin to contain all attached sediment and runoff water after removal.
5. Using a pile driver, drive broken/cut stubs far enough below the mudline to prevent release of contaminants into the water column as an alternative to their removal.

5.3.6 Overwater Structures

Overwater structures include commercial and residential piers and docks, floating breakwaters, barges, rafts, booms, and mooring buoys. These structures typically are located in intertidal areas out to about 49 feet (15 meters) below the area exposed by the mean lower low tide (i.e., the shallow subtidal zone). Light, wave energy, substrate type, depth, and water quality are the primary factors controlling the plant and animal assemblages found at a particular site. Overwater structures and associated activities can alter these factors and interfere with key ecological functions such as spawning, rearing, and refugia. Site-specific factors (e.g., water clarity, current, depth, etc.) and the type and use of a given overwater structure determine the occurrence and magnitude of these impacts.

Potential Adverse Impacts

Overwater structures and associated developments may adversely affect EFH in a variety of ways, primarily by (1) changes in ambient light conditions, (2) alteration of the wave and current energy regime, and (3) activities associated with the use and operation of the facilities (Nightingale and Simenstad 2001).

Recommended Conservation Measures

The following recommended conservation measures should be viewed as options to avoid and minimize adverse impacts and promote the conservation, enhancement, and proper functioning of EFH.

1. Use upland boat storage whenever possible to minimize need for overwater structures.
2. Locate overwater structures in deep enough waters to avoid intertidal and shade impacts, minimize or preclude dredging, minimize groundings, and avoid displacement of submerged aquatic vegetation, as determined by a preconstruction survey.
3. Design piers, docks, and floats to be multiuse facilities to reduce the overall number of such structures and to limit impacted nearshore habitat.
4. Incorporate measures that increase the ambient light transmission under piers and docks. These measures include, but are not limited to, the following:

a) Maximize the height of the structure, and minimize the width of the structure to decrease the shade

footprint and using grated decking material.

b) Use reflective materials (e.g., concrete or steel instead of materials that absorb light such as wood) on the underside of the dock to reflect ambient light.
c) Use the fewest number of pilings necessary to support the structures to allow light into under-pier areas and minimize impacts to the substrate.
d) Align piers, docks, and floats in a north-south orientation to allow the arc of the sun to cross perpendicular to the structure and to reduce the duration of light limitation.

5. Use floating rather than fixed breakwaters whenever possible, and remove them during periods of low dock use. Encourage seasonal use of docks and off-season haul-out.
6. Locate floats in deep water to avoid light limitation and grounding impacts to the intertidal or shallow subtidal zone.
7. Maintain at least 1 foot (0.30 meter) of water between the substrate and the bottom of the float at extreme low tide.
8. Conduct in-water work when managed species and prey species are least likely to be impacted.
9. To the extent practicable, avoid the use of treated wood timbers or pilings and use alternative materials such as untreated wood, concrete, or steel.
10. Mitigate for unavoidable impacts to benthic habitats. Mitigation should be adequate, monitored, and adaptively managed.

5.3.7 Flood Control/Shoreline Protection

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

Potential Adverse Impacts

Dikes, levees, ditches, or other water controls at the upper end of a tidal marsh can cut off all tributaries feeding the marsh, preventing freshwater flushing and annual flushing, annual renewal of sediments and nutrients, and the formation of new marshes. Water controls within the marsh proper intercept and carry away freshwater drainage, block freshwater from flowing across seaward portions of the marsh, increase the speed of runoff of freshwater to the bay or estuary, lower the water table, permit saltwater intrusion into the marsh proper, and create migration barriers for aquatic species. In deeper channels where reducing conditions prevail, large quantities of hydrogen sulfide are produced. These quantities are toxic to marsh grasses and other aquatic life. Acid conditions of these channels can also result in release of heavy metals from the sediments.

Long-term effects on the tidal marsh include land subsidence (sometimes even submergence), soil

compaction, conversion to terrestrial vegetation, greatly reduced invertebrate populations, and general loss of productive wetland characteristics. Loss of these low-salinity environments reduces estuarine fertility, restricts suitable habitat for aquatic species, and creates abnormally high salinity during drought years. Low-salinity environments form a barrier that prevents the entrance of many marine species, including competitors, predators, parasites, and pathogens.

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

Recommended Conservation Measures

The following recommended conservation measures should be viewed as options to avoid and minimize adverse impacts and promote the conservation, enhancement, and proper functioning of EFH.

1. Minimize the loss of riparian habitats as much as possible.
2 Do not undertake diking and draining of tidal marshlands and estuaries.
3. Wherever possible, use soft approaches (such as beach nourishment, vegetative plantings, and placement of LWD) to shoreline modifications.
4. Include efforts to preserve and enhance EFH by providing new gravel for spawning areas, removing barriers to natural fish passage, and using weirs, grade control structures, and low-flow channels to provide the proper depth and velocity for fish.
5. Construct a low-flow channel to facilitate fish passage and help maintain water temperature in reaches where water velocities require armoring of the riverbed.
6. Offset unavoidable impacts to in-stream fish habitat by providing rootwads, deflector logs, boulders, and rock weirs and by planting shaded riverine aquatic cover vegetation.
7. Use an adaptive management plan with ecological indicators to oversee monitoring and to ensure that mitigation objectives are met. Take corrective action as needed.

5.3.8 Log Transfer Facilities/In-water Log Storage

Rivers, estuaries, and bays were historically the primary ways to transport and store logs in the Pacific Northwest. Log storage within the bays and estuaries remains an issue in several Pacific Northwest bays. Using estuaries and bays and nearby uplands for storage of logs is common in Alaska, with most LTFs found in Southeast Alaska and a few located in Prince William Sound.

Potential Adverse Impacts

Log handling and storage in the estuary and intertidal zones of rivers can result in modification of benthic habitat and water quality degradation within the area of bark deposition (Levings and Northcote 2004). EFH may also be physically impacted by activities associated with facilities, constructed in the water, that are used

to transfer commercially harvested logs to or from a vessel or log raft, including log rafts. Bark and wood debris may accumulate as a result of the abrasion of log surfaces from transfer equipment and impact EFH. After the logs have entered the water, they usually are bundled into rafts and hooked to a tug for shipment. In the process, bark and other wood debris can pile up on the ocean floor. The piles can smother clams, mussels, some seaweed, kelp, and grasses, with the bark sometimes remaining for decades. Accumulation of bark debris in shallow and deep-water environments has resulted in locally decreased epifaunal macrobenthos richness and abundance (Kirkpatrick et al. 1998, Jackson 1986). Log storage may also result in a release of soluble organic compounds within the bark pile. The physical, chemical, and biological impacts of log operations can be substantially reduced by adherence to appropriate siting and operational constraints. Adherence operational and siting guidelines will reduce (1) the amount of bark and wood debris that enters the marine and coastal environment, (2) the potential for displacement or harm to aquatic species, and (3) the accumulation of bark and wood debris on the ocean floor.

Recommended Conservation Measures

The following recommended conservation measures should be viewed as options to avoid and minimize adverse impacts and promote the conservation, enhancement, and proper functioning of EFH.

1. Restrict or eliminate storage and handling of logs from waters where state and federal water quality standards cannot be met at all times outside of the authorized zone of deposition.
2. Minimize potential impacts of log storage by employing effective bark and wood debris control, collection, and disposal methods at log dumps, raft building areas, and mill-side handling zones; avoiding free-fall dumping of logs; using easy let-down devices for placing logs in the water; and bundling logs before water storage (bundles should not be broken except on land and at millside).
3. Do not store logs in the water if they will ground at any time or shade sensitive aquatic vegetation such as eelgrass.
4. Avoid siting log-storage areas and LTFs in sensitive habitat and areas important for specified species, as required by the ATTF guidelines.
5. Site log storage areas and LTFs in areas with good currents and tidal exchanges.
6. Use land-based storage sites where possible, with the goal of eliminating in-water storage of logs.

5.3.9 Utility Line/Cables/Pipeline Installation

With the continued development of coastal regions comes greater demand for the installation of cables, utility lines for power and other services, and pipelines for water, sewage, etc. The installation of pipelines, utility lines, and cables can have direct and indirect impacts on the offshore, nearshore, estuarine, wetland, beach, and rocky shore coastal zone habitats. Many of the primary and direct impacts occur during the construction phase of installation, such as ground disturbance in the clearing of the right-of-way, access roads, and equipment staging areas. Indirect impacts can include increased turbidity, saltwater intrusion, accelerated erosion, and introduction of urban and industrial pollutants.

Potential Adverse Impacts

Adverse effects on EFH from the installation of pipelines, utility lines, and cables can occur through (1) destruction of organisms and habitat, (2) turbidity impacts, (3) resuspension of contaminants, and (4) changes in hydrology.

Recommended Conservation Measures

The following recommended conservation measures should be viewed as options to avoid and minimize adverse impacts and promote the conservation, enhancement, and proper functioning of EFH.

1. Align crossings along the least environmentally damaging route. Avoid sensitive habitats such as hard-bottom (e.g., rocky reefs), cold-water corals, submerged aquatic vegetation, oyster reefs, emergent marsh, and mud flats.
2. Use horizontal directional drilling where cables or pipelines would cross anadromous fish streams, salt marsh, vegetated inter-tidal zones, or steep erodible bluff areas adjacent to the inter-tidal zone to avoid surface disturbances.
3. Avoid construction of permanent access channels since they disrupt natural drainage patterns and destroy wetlands through excavation, filling, and bank erosion.
4. Store and contain excavated material on uplands.
5. Backfill excavated wetlands with either the same or comparable material capable of supporting similar wetland vegetation and at original marsh elevations.
6. Use existing rights-of-way whenever possible to lessen overall encroachment and disturbance of wetlands.
7. Bury pipelines and submerged cables where possible.
8. Remove inactive pipelines and submerged cables unless they are located in sensitive areas (e.g., marsh, reefs, sea grass, etc.) or in areas that present no safety hazard.
9. Use silt curtains or other type barriers to reduce turbidity and sedimentation whenever possible near the project site.
10. Limit access for equipment to the immediate project area.
11. Limit construction equipment to the minimum size necessary to complete the work.
12. Conduct construction during the time of year when it will have the least impact on sensitive habitats and species.
13. Suspend transmission lines beneath existing bridges or conduct directional boring under streams to reduce the environmental impact.
14. For activities on the Continental Shelf, shunt drill cuttings through a conduit and either discharge the cuttings near the sea floor, or transport them ashore.
15. For activities on the Continental Shelf, and to the extent practicable, locate drilling and production structures, including pipelines, at least 1 mile (1.6 kilometers) from the base of a hard-bottom habitat.
16. For activities on the Continental Shelf, and to avoid and minimize adverse impacts to managed species, implement the following to the extent practicable:
    a) Bury pipelines at least 3 feet (0.9 meter) beneath the sea floor, whenever possible. Particular considerations (i.e., currents, ice scour) may require deeper burial or weighting to maintain adequate cover. Buried pipeline and cables should be examined periodically for maintenance of adequate earthen cover.
    b) Where burial is not possible, such as in hard-bottomed areas, attach pipelines and cables to substrate to minimize conflicts with fishing gear.
    c) Locate alignments along routes that will minimize damage to marine and estuarine habitat.
    d) Where user conflicts are likely, consult and coordinate with fishing stakeholder groups during the route-planning process to minimize conflict.

5.3.10 Commercial Utilization of Habitat

Productive embayments are often used for commercial culturing and harvesting operations. These locations provide protected waters which serve as sites for oyster and mussel culturing. These operations may occur in areas of productive eelgrass beds. In 1988, Alaska passed the Alaska Aquatic Farming Act which is designed to encourage establishment and growth of an aquatic farming industry in the state. The Act establishes four criteria for issuance of an aquatic farm permit, including the requirement that the farm may not significantly affect fisheries, wildlife, or other habitats in an adverse manner.

Potential Adverse Impacts

Adverse impacts to EFH by operations that directly or indirectly use habitat include (1) discharge of organic waste, (2) shading and direct impacts to the seafloor, (3) risk of introducing undesirable species, and (4) impacts on estuarine food webs.

Recommended Conservation Measures

The following recommended conservation measures should be viewed as options to avoid and minimize adverse impacts and promote the conservation, enhancement, and proper functioning of EFH.

1. Site mariculture operations away from exisiting kelp or eelgrass beds. If mariculture operations are to be located adjacent to existing kelp or eelgrass beds, monitor these beds on an annual basis and resite the mariculture facility if monitoring reveals adverse effects.
2. Do not enclose or impound tidally influenced wetlands for mariculture. Take into account the size of the facility, migratory patterns, competing uses, hydrographic conditions, and upstream uses when siting facilities.
3. Undertake a thorough scientific review and risk assessment before any non-native species are introduced.
4. Encourage development of harvesting methods to minimize impacts on plant communities and the loss of food and/or habitat to fish populations during harvesting operations.
5. Provide appropriate mitigation for the unavoidable, extensive, or permanent loss of plant communities.

5.4 COASTAL/MARINE ACTIVITIES

5.4.1 Point-source Discharges

Point-source discharges from municipal sewage treatment facilities or storm water discharges are controlled through EPA's regulations under the CWA and by state water regulations. The primary concerns associated with municipal point-source discharges involve treatment levels needed to attain acceptable nutrient inputs and overloading of treatment systems due to rapid development of the coastal zone. Storm drains are contaminated from communities using settling and storage ponds, street runoff, harbor activities, and honey buckets. Annually, wastewater facilities introduce large volumes of untreated excrement and chlorine through sewage outfall lines, as well as releasing treated freshwater into the nation's waters. This can significantly alter pH levels of marine waters (Council 1999).

Potential Adverse Impacts

There are many potential impacts from point-source discharge, but point-source discharges and resulting

altered water quality in aquatic environments do not necessarily result in adverse impacts, either to marine resources or EFH. Because most point-source discharges are regulated by the state or EPA, effects to receiving waters are generally considered on a case-by-case basis. Point-source discharges can adversely affect EFH by (1) reducing habitat functions necessary for growth to maturity, (2) modifying community structure, (3) bioaccumulation, and (4) modifying habitat.

Recommended Conservation Measures

The following recommended conservation measures should be viewed as options to avoid and minimize adverse impacts and promote the conservation, enhancement, and proper functioning of EFH.

1. Locate discharge points in coastal waters well away from shellfish beds, sea grass beds, coral reefs, and other similar fragile and productive habitats.
2. Reduce potentially high velocities by diffusing effluent to acceptable velocities.
3. Determine benthic productivity by sampling before any construction activity related to installation of new or modified facilities. Develop outfall design (e.g., modeling concentrations within the predicted plume or likely extent of deposition along a productive nearshore) with input from appropriate resource and Tribal agencies.
4. Provide for mitigation when degradation or loss of habitat occurs from placement and operation of the outfall structure and pipeline.
5. Institute source-control programs that effectively reduce noxious materials to avoid introducing these materials into the waste stream.
6. Ensure compliance with pollutant discharges regulated through discharge permits which set effluent discharge limitations and/or specify operation procedures, performance standards, or BMPs. These efforts rely on the implementation of BMPs to control polluted runoff (EPA 1993).
7. Treat discharges to the maximum extent practicable, including implementation of up-to-date methodologies for reducing discharges of biocides (e.g., chlorine) and other toxic substances.
8. Use land-treatment and upland disposal/storage techniques where possible. Limit the use of vegetated wetlands as natural filters and pollutant assimilators for large-scale discharges to those instances where other less damaging alternatives are not available, and the overall environmental and ecological suitability of such actions has been demonstrated.
9. Avoid siting pipelines and treatment facilities in wetlands and streams. Since pipelines and treatment facilities are not water-dependent with regard to positioning, it is not essential that they be placed in wetlands or other fragile coastal habitats. Avoiding placement of pipelines within streambeds and wetlands will also reduce inadvertent infiltration into conveyance systems and retain natural hydrology of local streams and wetlands.

5.4.2 Fish Processing Waste—Shoreside and Vessel Operation

Seafood processing facilities are either shore-based facilities discharging through stationary outfalls or mobile vessels engaged in the processing of fresh or frozen seafood (Science Applications International Corporation 2001). Discharge of fish waste from shoreside and vessel processing has occurred in marine waters since the 1800s (Council 1999). With the exception of fresh market fish, some form of processing involving butchering, evisceration, precooking, or cooking is necessary to bring the catch to market. Precooking or blanching facilitates the removal of skin, bone, shell, gills, and other materials. Depending on the species, the cleaning operation may be manual, mechanical, or a combination of both (EPA 1974). Seafood processing facilities generally consist of mechanisms to offload the harvest from fishing boats; tanks

to hold the seafood until the processing lines are ready to accept them; processing lines, process water, and waste collection systems; treatment and discharge facilities; processed seafood storage areas; and necessary support facilities such as electrical generators, boilers, retorts, water desalinators, offices, and living quarters. In addition, marinas that cater to patrons who fish a large amount can produce an equally large quantity of fish waste at the marina from fish cleaning.

Potential Adverse Impacts

Generally, seafood processing wastes consist of biodegradable materials that contain high concentrations of soluble organic material. Seafood processing operations have the potential to adversely affect EFH through (1) direct and/or nonpoint source discharge, (2) particle suspension, and (3) increased turbidity and surface plumes.

Recommended Conservation Measures

The following recommended conservation measures should be viewed as options to avoid and minimize adverse impacts and promote the conservation, enhancement, and proper functioning of EFH.

1. To the maximum extent practicable, base effluent limitations on site-specific water quality concerns.
2. To the maximum extent practicable, avoid the practice of discharging untreated solid and liquid waste directly into the environment.
3. Do not allow designation of new ZODs. Explore options to eliminate or reduce ZODs at existing facilities.
4. Control stickwater by physical or chemical methods.
5. Promote sound fish waste management through a combination of fish-cleaning restrictions, public education, and proper disposal of fish waste.
6. Encourage the alternative use of fish processing wastes (e.g., fertilizer for agriculture and animal feed).
7. Explore options for additional research.
8. Locate new plants outside rearing and nursery habitat. Monitor both biological and chemical changes to the site.

5.4.3 Water Intake Structures/Discharge Plumes

The withdrawal of riverine, estuarine, and marine waters by water intake structures is a common aquatic activity. Water may be withdrawn and used, for example, to cool power-generating stations and create temporary ice roads and ice ponds. In the case of power plants, the subsequent discharge of heated and/or chemically treated discharge water can also occur.

Potential Adverse Impacts

Water intake structures and effluent discharges can interfere with or disrupt EFH functions in the source or receiving waters by (1) entrainment, (2) impingement, (3) discharge, (4) operation and maintenance, and (5) construction-related impacts.

Recommended Conservation Measures

The following recommended conservation measures should be viewed as options to avoid and minimize

adverse impacts and promote the conservation, enhancement, and proper functioning of EFH.

1. Locate facilities that rely on surface waters for cooling in areas other than estuaries, inlets, heads of submarine canyons, rock reefs, or small coastal embayments where managed species or their prey concentrate.
2. Design intake structures to minimize entrainment or impingement.
3. Design power plant cooling structures to meet the best technology available requirements as developed pursuant to Section 316(b) of the CWA.
4. Regulate discharge temperatures (both heated and cooled effluent) so they do not appreciably alter the temperature to an extent that could cause a change in species assemblages and ecosystem function in the receiving waters.
5. Avoid the use of biocides (e.g., chlorine) to prevent fouling where possible. Implement the least damaging antifouling alternatives.
6. Mitigate for impacts related to power plants and other industries requiring cooling water.
7. Treat all discharge water from outfall structures to meet state water quality standards at the terminus of the pipe.

5.4.4 Oil/Gas Exploration/Development/Production

Offshore exploration, development, and production of natural gas and oil reserves have been, and continue to be, an important aspect of the U.S. economy. As demand for energy resources grows, the debate over trying to balance the development of oil and gas resources and the protection of the environment will also continue. Projections indicate that U.S. demand for oil will increase by 1.3 percent per year between 1995 and 2020. Gas consumption is projected to increase by an average of 1.6 percent during the same time frame (Waisley 1998). Much of the 1.9 billion acres within the offshore jurisdiction of the U.S. remains unexplored (Oil and Gas Technologies for the Arctic and Deepwater 1985). Some of the older oil and gas platforms in operation will probably reach the end of their productive life in the near future, and decommissioning them is also an issue.

Potential Adverse Impacts

Offshore oil and gas operations can be classified into exploration, development, and production activities (which includes transportation). These activities occur at different depths in a variety of habitats. Not all of the potential disturbances in this list apply to every type of activity. These areas are subject to an assortment of physical, chemical, and biological disturbances, including the following (Council 1999, Helvey 2002):

- Noise from seismic surveys, vessel traffic, and construction of drilling platforms or islands
- Physical alterations to habitat from the construction, presence, and eventual decommissioning and removal of facilities such as islands or platforms, storage and production facilities, and pipelines to onshore common carrier pipelines, storage facilities, or refineries
- Waste discharges, including well drilling fluids, produced waters, surface runoff and deck drainage, domestic waste waters generated from the offshore facility, solid waste from wells (drilling muds and cuttings), and other trash and debris from human activities associated with the facility
- Oil spills
- Platform storage and pipeline decommissioning

The potential disturbances and associated adverse impacts on the marine environment have been reduced through operating procedures required by regulatory agencies and, in many cases, self-imposed by facilities operators. Most of the activities associated with oil and gas operations are conducted under permits and regulations that require companies to minimize impacts or avoid construction in sensitive marine habitats. New technological advances in operating procedures also reduce the potential for impacts.

Recommended Conservation Measures

The following recommended conservation measures should be viewed as options to avoid and minimize adverse impacts and promote the conservation, enhancement, and proper functioning of EFH:

1. As part of pre-project planning, identify all species of concern regulated under federal or state fishery management plans that inhabit, spawn, or migrate through areas slated for exploration, development, or production.
2. Avoid the discharge of produced waters into marine waters and estuaries. Reinject produced waters into the oil formation whenever possible.
3. Avoid discharge of muds and cuttings into the marine and estuarine environment.
4. To the extent practicable, avoid the placement of fill to support construction of causeways or structures in the nearshore marine environment.
5. As required by federal and state regulatory agencies, encourage the use of geographic response strategies that identify EFH and environmentally sensitive areas.
6. To the extent practicable, use methods to transport oil and gas that limit the need for handling in environmentally sensitive areas, including EFH.
7. Ensure that appropriate safeguards have been considered before drilling the first development well into the targeted hydrocarbon formations whenever critical life history stages of federally managed species are present.
8. Ensure that appropriate safeguards have been considered before drilling exploration wells into untested formations whenever critical life stages of federally managed species are present.
9. Oil and gas transportation and production facilities should be designed, constructed, and operated in accordance with applicable regulatory and engineering standards.
10. Evaluate and minimize impacts to EFH during the decommissioning phase of oil and gas facilities, including possible impacts during the demolition phase.

5.4.5 Habitat Restoration/Enhancement

Habitat loss and degradation are major, long-term threats to the sustainability of fishery resources (NMFS 2002). Viable coastal and estuarine habitats are important to maintaining healthy fish stocks. Good water quality and quantity, appropriate substrate, ample food sources, and substantial hiding places are needed to sustain fisheries. Restoration and/or enhancement of coastal and riverine habitat that supports managed fisheries and their prey will assist in sustaining and rebuilding fisheries stocks and recovering certain threatened or endangered species by increasing or improving ecological structure and functions. Habitat restoration/enhancement may include, but is not limited to, improvement of coastal wetland tidal exchange or reestablishment of historic hydrology, dam or berm removal, fish passage barrier removal/ modification, road-related sediment source reduction, natural or artificial reef/substrate/habitat creation, establishment or repair of riparian buffer zones, improvement of freshwater habitats that support anadromous fishes, planting of native coastal wetland and submerged aquatic vegetation, creation of oyster reefs, and improvements to feeding, shade or refuge, spawning, and rearing areas that are essential to fisheries.

Potential Adverse Impacts

The implementation of restoration/enhancement activities may have localized and temporary adverse impacts on EFH. Possible impacts can include (1) localized nonpoint source pollution such as influx of sediment or nutrients, (2) interference with spawning and migration periods, (3) temporary or permanent removal feeding opportunities, and (4) indirect effects from actual construction portions of the activity.

Recommended Conservation Measures

The following recommended conservation measures should be viewed as options to avoid and minimize adverse impacts and promote the conservation, enhancement, and proper functioning of EFH.

1. Use BMPs to minimize and avoid potential impacts to EFH during restoration activities. BMPs should include, but are not limited to, the following:
   a) Use turbidity curtains, haybales, and erosion mats to protect the water column.
   b) Plan staging areas in advance, and keep them to a minimum size.
   c) Establish buffer areas around sensitive resources; flag and avoid rare plants, archeological sites, etc.
   d) Remove invasive plant and animal species from the proposed action area before starting work. Plant only native plant species. Identify and implement measures to ensure native vegetation or revegetation success (Section G.4.4 of the EFH EIS).
   e) Establish temporary access pathways before restoration activities to minimize adverse impacts from project implementation.
2. Avoid restoration work during critical life stages for fish such as spawning, nursery, and migration. Determine these periods before project implementation to reduce or avoid any potential impacts.
3. Provide adequate training and education for volunteers and project contractors to ensure minimal impact to the restoration site. Train volunteers in the use of low-impact techniques for planting, equipment handling, and any other activities associated with the restoration.
4. Conduct monitoring before, during, and after project implementation to ensure compliance with project design and restoration criteria. If immediate post-construction monitoring reveals that unavoidable impacts to EFH have occurred, ensure that appropriate coordination with NMFS occurs to determine appropriate response measures, possibly including mitigation.
5. To the extent practicable, mitigate any unavoidable damage to EFH within a reasonable time after the impacts occur.
6. Remove and, if necessary, restore any temporary access pathways and staging areas used in the restoration effort.
7. Determine benthic productivity by sampling before any construction activity in the case of subtidal enhancement (e.g., artificial reefs). Avoid areas of high productivity to the maximum extent possible. Develop a sampling design with input from state and federal resource agencies. Before construction, evaluate of the impact resulting from the change in habitat (sand bottom to rocky reef, etc.). During post-construction monitoring, examine the effectiveness of the structures for increasing habitat productivity.

5.4.6 Marine Mining

Mining activity, which is also described in Sections G.3.1.1 and G.3.1.2 of the EFH EIS, can lead to the direct loss of EFH for certain species. Offshore mining, such as the extraction of gravel and gold in the Bering Sea and the mining of gravel from beaches, can increase turbidity of water. Thus, the resuspension of organic materials could affect less motile organisms (i.e., eggs and recently hatched larvae) in the area.

Benthic habitats could be damaged or destroyed by these actions. Mining large quantities of beach gravel may significantly affect the removal, transport, and deposition of sand and gravel along the shore, both at the mining site and down-current (Council 1999). Neither the future extent of this activity nor the effects of such mortality on the abundance of marine species is known.

Potential Adverse Impacts

Mining practices that can affect EFH include physical impacts from intertidal dredging and chemical impacts from the use of additives such as flocculates (Council 1999). Impacts may include the removal of substrates that serve as habitat for fish and invertebrates; habitat creation or conversion in less productive or uninhabitable sites, such as anoxic holes or silt bottom; burial of productive habitats, such as in near-shore disposal sites (as in beach nourishment); release of harmful or toxic materials either in association with actual mining, or in connection with machinery and materials used for mining; creation of harmful turbidity levels; and adverse modification of hydrologic conditions so as to cause erosion of desirable habitats. Submarine disposal of mine tailings can also alter the behavior of marine organisms. Submarine mine tailings may not provide suitable habitat for some benthic organisms. In laboratory experiments, benthic dwelling flatfishes (Johnson et al. 1998a) and crabs (Johnson et al. 1998b) strongly avoided mine tailings.

During beach gravel mining, water turbidity increases and the resuspension of organic materials can affect less motile organisms (i.e., eggs and recently hatched larvae) in the area. Benthic habitats can be damaged or destroyed by these actions. Changes in bathymetry and bottom type may also alter population and migrations patterns (Hurme and Pullen 1988).

Recommended Conservation Measures

The following recommended conservation measures for marine mining should be viewed as options to avoid and minimize adverse impacts and promote the conservation, enhancement, and proper functioning of EFH.

1. To the extent practicable, avoid mining in waters containing sensitive marine benthic habitat including EFH (e.g., spawning, migrating, and feeding sites).
2. Minimize the areal extent and depth of extraction to reduce recolonization times.
3. Monitor turbidity during operations, and cease operations if turbidity exceeds predetermined threshold levels. Use sediment or turbidity curtains to limit the spread of suspended sediments and minimize the area affected.
4. Monitor individual mining operations to avoid and minimize cumulative impacts. For instance, three mining operations in an intertidal area could impact EFH, whereas one may not. Disturbance of previously contaminated mining areas may cause additional loss of EFH.
5. Use seasonal restrictions, as appropriate, to avoid and minimize impacts to EFH during critical life history stages of managed species (e.g., migration and spawning).

5.4.7 Persistent Organic Pollutants

The single biggest pollution threat to marine waters in Alaska is the deposition of persistent pollutants from remote sources. A large variety of contaminants can be found in Alaska's marine environment, including persistent organic pollutants (POPs) and heavy metals. North Pacific and Alaska marine waters are perceived as pristine because most of Alaska's 6,640 miles (10,686 kilometers) of coastline are devoid of point-source pollution, unlike much of North America. Effluents from pulp mills, marinas and boat harbors, municipal

outfalls, and other industrial activities are generally considered to be the primary sources of contamination in Alaska waters, so most efforts at monitoring and mitigation have been focused on the local level. However, there is an increasing body of evidence suggesting that the greatest contaminant threat in Alaska comes from atmospheric and marine transport of contaminants from areas quite distant from Alaska.

The geography of Alaska makes it particularly vulnerable to contaminants volatilized from Asia. Pesticides applied to crops in Southeast Asia can be volatilized into the air, bound to suspended particulates, transported in the atmosphere to Alaska, and deposited in snow or rain directly into marine ecosystems or indirectly from freshwater flow to nearshore waters. Revolatilization of these compounds is inhibited by the cold temperatures associated with Alaska latitudes, resulting in a net accumulation of these compounds in northern habitats. This same distillation process also transfers volatilized contaminants from the atmosphere to the Pacific at lower latitudes, and ocean currents also deliver the contaminants to Alaska. Concentrations will be very low, but there will extensive geographical marine or land areas to act as cold deposit zones. The effect of these transport mechanisms has been the appearance of persistent organic contaminants in northern latitudes, despite the absence of local sources.

With over 100,000 chemicals on the market and an additional 1,000 to 2,000 new ones introduced annually, there are likely other toxic compounds in the environment whose concentrations are increasing. In addition, combustion and industrial processes result in the inadvertent production of unregulated chemicals (Arctic Monitoring and Assessment Programme [AMAP] 2002).

Potential Adverse Impacts

It is not clear if the levels of contaminants in Alaska waters are causing deleterious effects to populations, because research in this area is still in its infancy. Relatively small and spotty contaminant surveys have established that POPs are present in Alaska waters, forage, and predators. No comprehensive geographical and temporal studies have been done to date to examine trends or sources of variation. The potential for the problem has been exposed; the extent and significance remain to be determined.

The existence of organic contaminants in biological tissues means these contaminants are being transported within the food webs in Alaska fish habitats. The trophic structure of Alaska marine food webs, coupled with the tendency of contaminants to accumulate in Alaska habitats, causes apex predators to concentrate significant amounts of POPs in their tissues. Contamination is probably widespread among forage species at low levels, but apex predators are likely be the most affected as a result of their longevity, lipid storage, and the relatively high concentrations they bear. Contamination can cause immunological and reproductive impairment, acute toxic effects, and population declines. This issue is particularly relevant when the contaminant loads experienced by Alaska natives subsisting on foods derived from marine habitats are considered. Impacts may also occur at lower trophic levels, but there has been even less research in this area.

The impacts of persistent contaminants on populations in Alaska waters are not likely to be acute. The impacts are more likely be expressed as sublethal impacts in apparently healthy animals. These sublethal impacts ultimately lead to reduced reproductive fitness or decreased survival to maturity; therefore, they manifest themselves indirectly. Science is certain that the physical properties of these compounds couple with global climate patterns to ensure that they will be deposited in Alaska habitats, while maintaining their toxicity and perfusing through Alaska food webs, which include some of the most valuable fisheries on the planet. What is uncertain is how these compounds impact the health of organisms deriving sustenance from those food webs and how those impacts might feed back into the food web.

Recommended Conservation Measures

No mitigation strategies are proposed at this time relative to contaminants. There are too many unknowns. POP contaminants are present in Alaska waters and forage species and in predators up through apex predators, but the significance of the present loads is not known. Also, the relative concentrations in forage species (pollock for example) from the EBS, near Russia, or the northern GOA are not known. Comprehensive studies on a geographical, temporal, or widespread species scale to determine any relationship between contaminant loads and population changes have not been conducted. POP contaminants may contribute to poor recovery in some species, but mitigation strategies, whether they would be changes in fishing regulations or international regulation to curb contaminant releases, will likely need a better research foundation to support changes.

6.0 Cumulative Effects of Fishing and Non-fishing Activities on EFH

This section discusses the cumulative effects of fishing and non-fishing activities on EFH. As identified in Section 4.0, historical fishing practices may have had effects on EFH that have led to declining trends in some of the criteria examined. As described in earlier sections, the effects of current fishing activities on EFH are classified as minimal and temporary or unknown. Additional information and analysis is provided in Appendix B of the EFH EIS (NMFS 2005).

A review of the effects of non-fishing activities on EFH is found in Section 5.0. Additional information and analysis is provided in Appendix G of the EFH EIS. Section 5.0 identifies 29 non-fishing activities for which potential effects. However, the magnitude of these effects cannot currently be quantified with available information. Of the 29 activities, most are described as likely having less than substantial potential effects on EFH. Some of these activities such as urban/suburban development, road building and maintenance (including the placement of fill material), vessel operations/transportation/navigation, silviculture (including LTFs), and point source discharge may have potential cumulative impacts due to the additive and chronic nature of these activities. 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 level of concern is not known at this point.

7.0 Research Approach for EFH

The EFH EIS (NMFS 2005) identified the following research approach for EFH regarding minimizing fishing impacts.

Objectives

Reduce impacts. (1) Limit bottom trawling in the AI to areas historically fished and prevent expansion into new areas. (2) Limit bottom contact gear in specified coral garden habitat areas. (3) Restrict higher impact

trawl fisheries from a portion of the GOA slope. (4) Increase monitoring for enforcement. (5) Establish a scientific research program.

Benthic habitat recovery. Allow recovery of habitat in a large area with relatively low historic effort.

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

Reduce impacts. 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. First, the recent gear-specific fishing pattern must be characterized to establish a baseline for comparison with observed changes in effort after closures occur. An effective analysis of change requires comprehensive effort data with high spatial resolution, including accurate information about the tow path or setting location, as well as complete gear specifications. Effects of displaced fishing effort would have to be considered. The relative effects of bottom trawl and alternative gear/footrope designs and, thus, the efficacy of the measure should be investigated experimentally in a relatively undisturbed area that is representative of the closed areas. 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. Ultimately, there should be detectable increases in FMP species that are directly attributable to the reduced impacts on sponge and coral habitat.

Benthic habitat recovery. 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. A reference site would have to remain undisturbed by fishing during the entire course of the recovery experiment. Such a reference site may or may not exist, and the essential elements of comparability for identifying this area are presently unknown. Without proper reference sites, it may still be possible to deduce recovery dynamics based on changes observed in comparable newly closed areas with different histories of fishing disturbance.

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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mnbrown: 10/13/05 based on Council comments.

Jlepore: 10/21/05