

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

## Table of Contents

<b>1</b>	<b>OVERVIEW .....</b>	<b>5</b>
<b>2</b>	<b>LIFE HISTORY FEATURES AND HABITAT REQUIREMENTS OF FMP SPECIES .....</b>	<b>7</b>
2.1	Habitat Types .....	7
2.2	General Life History Information for Crabs .....	11
2.3	Habitat Description for Red King Crab ( <i>Paralithodes camtschaticus</i> ).....	16
2.4	Habitat Description for Blue King Crab ( <i>Paralithodes platypus</i> ).....	18
2.5	Habitat Description for Golden King Crab ( <i>Lithodes aequispina</i> ).....	20
2.6	Habitat Description for Tanner Crab ( <i>Chionoecetes bairdi</i> ) .....	21
2.7	Habitat Description for Snow Crab ( <i>Chionoecetes opilio</i> ).....	22
<b>3</b>	<b>ESSENTIAL FISH HABITAT .....</b>	<b>25</b>
3.1	Description of Essential Fish Habitat .....	25
3.1.1	Red King Crab.....	26
3.1.2	Blue King Crab .....	26
3.1.3	Golden King Crab.....	27
3.1.4	Tanner Crab .....	27
3.1.5	Snow Crab .....	28
3.2	Maps of Essential Fish Habitat .....	28
3.2.1	Aleutian Islands crab EFH maps .....	29
3.2.2	Bering Sea crab EFH maps.....	30
3.3	Essential Fish Habitat Conservation and Habitat Areas of Particular Concern.....	38
3.3.1	Aleutian Islands Coral Habitat Protection Areas.....	38
3.3.2	Aleutian Islands Habitat Conservation Areas .....	39
3.3.3	Alaska Seamount Habitat Protection Area .....	40
3.3.4	Bowers Ridge Habitat Conservation Zone .....	41
3.3.5	HAPC Process .....	42
<b>4</b>	<b>EFFECTS OF FISHING ON ESSENTIAL FISH HABITAT.....</b>	<b>44</b>
4.1	Effects of Fishing Analysis.....	44
4.1.1	Habitat Categorization.....	45
4.1.2	General Fishing Gear Impacts.....	46
4.1.2.1	Bottom Trawls.....	46
	Infaunal Prey .....	46
	Epifaunal Prey.....	47
	Living Structure.....	48
	Hard Corals .....	48
	Non-living Structure.....	50
	Sand and Silt Substrates:.....	51
	Pebble to Boulder Substrates:.....	51
4.1.2.2	Pelagic Trawls .....	52
4.1.2.3	Longlines.....	52
4.1.2.4	Pots.....	52
4.1.2.5	Dinglebar.....	53
4.1.2.6	Dredge Gear.....	53
4.1.3	Fishing Effects Vulnerability Assessment.....	54
4.1.4	Impact Assessment Methods .....	55
4.1.5	Evaluation of Effects on EFH of BSAI Crab Species.....	57
4.1.5.1	Red King Crab .....	57
4.1.5.2	Blue King Crab .....	59
4.1.5.3	Golden King Crab .....	61
4.1.5.4	Tanner Crab .....	61
4.1.5.5	Snow Crab.....	62

4.1.6	Cumulative Effects of Fishing on Essential Fish Habitat .....	63
<b>5</b>	<b>NON-FISHING ACTIVITIES THAT MAY ADVERSELY AFFECT ESSENTIAL FISH HABITAT .....</b>	<b>65</b>
<b>6</b>	<b>CUMULATIVE EFFECTS OF FISHING AND NON-FISHING ACTIVITIES ON EFH .....</b>	<b>68</b>
<b>7</b>	<b>RESEARCH APPROACH FOR EFH .....</b>	<b>69</b>
	Objectives .....	69
	Research Questions .....	69
	Research Activities .....	69
	Research Time Frame .....	70
<b>8</b>	<b>REFERENCES .....</b>	<b>71</b>

## List of Tables

Table 1	Summary of habitat associations for BSAI crab species.....	13
Table 2	Summary of Reproductive Traits of BSAI Crab .....	14
Table 3	Summary of predator and prey associations for BSAI crab species .....	15
Table 4	Abbreviations used in the EFH report tables to specify location, depth, bottom type, and other oceanographic features .....	16
Table 5	Red king crab, <i>Paralithodes camtschaticus</i> (abbreviations are in Table 4).....	18
Table 6	Blue king crab, <i>Paralithodes platypus</i> (abbreviations are in Table 4) .....	19
Table 7	Golden king crab, <i>Lithodes aequispina</i> (abbreviations are in Table 4) .....	21
Table 8	Tanner crab, <i>Chionoecetes bairdi</i> (abbreviations are in Table 4) .....	22
Table 9	Snow crab, <i>Chionoecetes opilio</i> (abbreviations are in Table 4).....	24
Table 10	EFH information levels currently available for BSAI crab, by life history stage.....	25
Table 11	Aleutian Islands Coral Habitat Protection Areas .....	38
Table 12	Alaska Seamount Habitat Protection Area.....	40
Table 13	Bowers Ridge Habitat Conservation Zone.....	41
Table 14	Summary on Non-Fishing Effects on Habitat.....	67

## List of Figures

Figure 1	Distribution of Bering Sea Sediments. Source: Smith and McConnaughey 1999.....	10
Figure 2	AI adult Golden king crab fall EFH.....	29
Figure 3	AI adult Golden king crab spring EFH.....	29
Figure 4	AI adult Golden king crab summer EFH .....	30
Figure 5	EBS adult Blue king crab fall EFH .....	30
Figure 6	EBS adult Blue king crab spring EFH .....	31
Figure 7	EBS adult Blue king crab winter EFH .....	31
Figure 8	EBS adult Red king crab fall EFH.....	32
Figure 9	EBS adult Red king crab spring EFH.....	32
Figure 10	EBS adult Red king crab summer EFH.....	33
Figure 11	EBS adult Red king crab winter EFH .....	33
Figure 12	EBS adult Snow crab fall EFH .....	34
Figure 13	EBS adult Snow crab spring EFH .....	34
Figure 14	EBS adult Snow crab summer EFH.....	35
Figure 15	EBS adult Snow crab winter EFH .....	35
Figure 16	EBS adult Tanner crab fall EFH.....	36
Figure 17	EBS adult Tanner crab spring EFH.....	36
Figure 18	EBS adult Tanner crab summer EFH .....	37
Figure 19	EBS adult Tanner crab winter EFH.....	37
Figure 20	Aleutian Islands Coral Habitat Protection Areas .....	39
Figure 21	Aleutian Islands Habitat Conservation Area. Polygons are areas open to nonpelagic trawl gear.....	40
Figure 22	Alaska Seamount Habitat Protection Area in the Aleutian Islands.....	41
Figure 23	Bowers Ridge Habitat Conservation Zone.....	42
Figure 24	Three tiered method to evaluate effects of fishing on Essential Fish Habitat in Alaska .....	56
Figure 25	Estimated time series for the percent habitat reduction in the Core Essential Area for red king crab in the Bering Sea .....	58
Figure 26	Estimated habitat reduction in the Core Essential Area for red king crab in the Bering Sea.....	59
Figure 27	Estimated time series for the percent habitat reduction in the total Core Essential Area for blue king crab in the Bering Sea (of which the Pribilof Islands is one of three areas).....	60
Figure 28	Estimated time series for the percent habitat reduction in the total Core Essential Area for blue king crab in the Bering Sea (of which the St. Matthew Island is one of three areas).....	61
Figure 29	Estimated time series for the percent habitat reduction in the Core Essential Area for Tanner crab in the Bering Sea .....	62

Figure 30 Estimated time series for the percent habitat reduction in the Core Essential Area for snow crab in the Bering Sea.....63

# 1 Overview

Section 303(a)(7) of the Magnuson-Stevens Act requires that fisheries management plans (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 habitat areas of particular concern (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.

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

From 2015 through 2017, the Council undertook a second five-year review of EFH for the Council's managed species, which was documented in the Final EFH 5-year Review Summary Report (Simpson et al. 2017). The review evaluated new information on EFH, including EFH descriptions and identification, and fishing and non-fishing activities that may adversely affect EFH. The review also assessed information gaps and research needs, and identified whether any revisions to EFH are needed or suggested. The Council identified various elements of the EFH

descriptions meriting revision, and recommended omnibus amendments 115/105/49/13/2 to the BSAI Groundfish FMP, the GOA Groundfish FMP, the BSAI King and Tanner Crab FMP, the Salmon FMP, and the Arctic FMP, respectively, in 2017. Amendment 49 to the Crab FMP revised the EFH descriptions for crab species, and updated the analysis of fishing and non-fishing impacts to crab habitat in areas that are considered crab EFH.

## 2 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. Habitat summary tables that denote habitat associations, biological associations, and predator and prey associations 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, over 150 species of crustaceans and mollusks, 50 species of seabirds, and 26 species of marine mammals (Livingston and Tjelmeland 2000).

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). The net current flows eastward along the north side of the AI and turns 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 full range of potential grain sizes of mud (subgrades clay and silt), sand, and gravel. The proportion of each constituent determines the sediment type at any one location (Smith and McConnaughey 1999). Sand and silt are the primary components over most of the seafloor, with sand predominating in waters with a depth less than 60 m. In general, the fraction of finer-grade sediments increases (i.e. the average grain size decreases) 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). Because 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 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. Considerable local variability occurs in areas along the shore of Bristol Bay, the north coast of the Alaska Peninsula, and west and north of Bristol Bay, especially near the Pribilof Islands. In general, nearshore sediments in the east and southeast on the inner shelf (0 to 50 m depth) are sandy

gravel and gravelly sand, transitioning to plain sand farther offshore and west. On the middle shelf (50 to 100 m), sand transitions to muddy sand and sandy mud, which continue over much of the outer shelf (100 to 200 m) to the continental slope. Sediments on the central and northeastern shelf (including Norton Sound) have not been extensively sampled, but Sharma (1979) reports that, although sand is dominant in places, as it is in the southeast, there are deposits 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 deposited by glaciers. These departures from a classic seaward decrease in grain size are due to the large input of fluvial silt from the Yukon River and to flushing and scouring of sediment through the Bering Strait by the net northerly current.

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

Important water column properties in 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 regulates the biological processes leading to different 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. In winter, surface waters across the shelf are high in nutrients. Spring surface heating stabilizes the water column, the spring bloom follows 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 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).

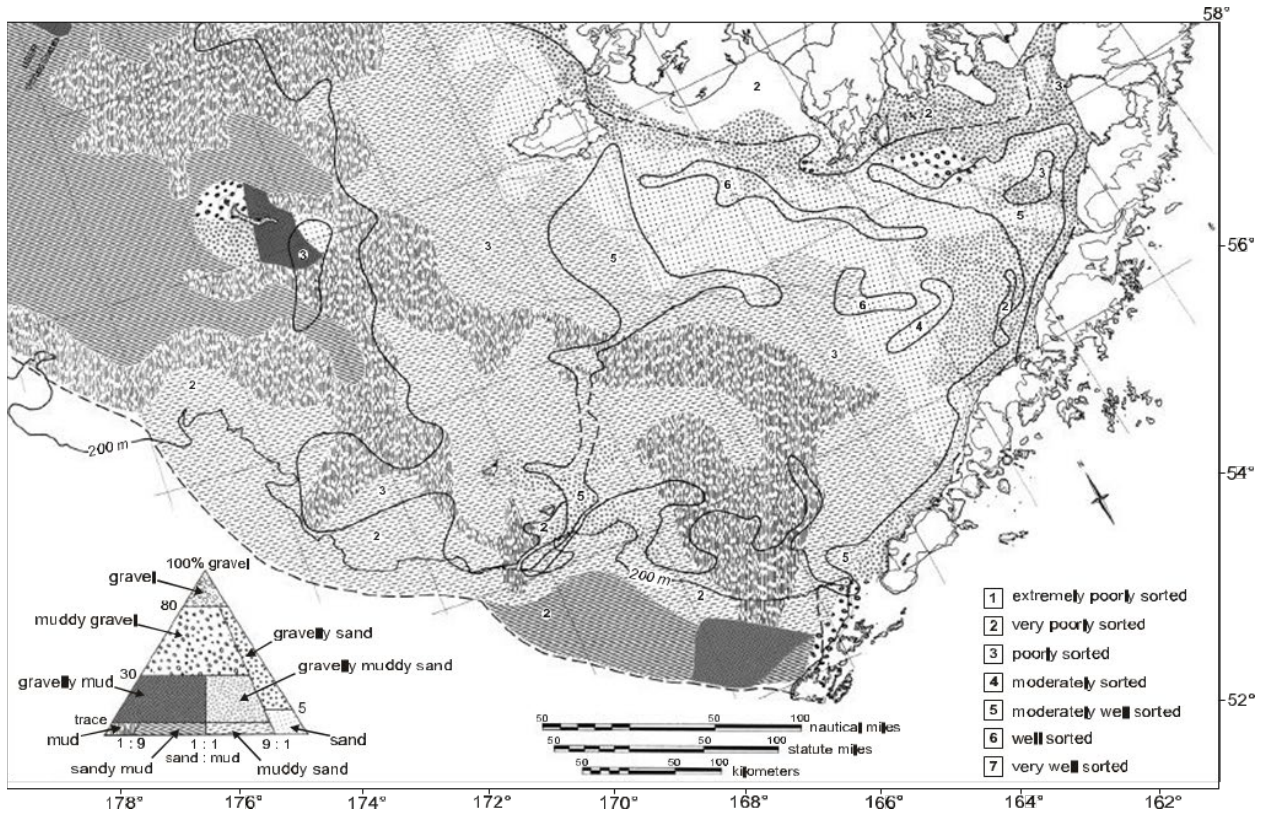


Effects of a global warming climate should be greater in the EBS than in the GOA. Located further north than the GOA, the seasonal ice cover of the EBS lowers albedo effects. Atmospheric attributes that are predicted to change ocean conditions include increased air temperature, pCO<sub>2</sub>, storm intensity, storm frequency, southerly wind, humidity, and precipitation. Increased precipitation, plus snow and ice melt, would lead to increased freshwater runoff. The predicted decrease in sea level pressure 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 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 difficult to predict. Changes in hydrography should include increases in sea level, sea surface temperature, shelf bottom temperature, pCO<sub>2</sub> (with an accompanying decrease in pH), 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).

**Figure 1 Distribution of Bering Sea Sediments. Source: Smith and McConnaughey 1999**



### 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 less than 4 km 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, approximately 550 km long and 75 to 110 km wide. The summit of the ridge is 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 bottom types. The patterns of water density, salinity, and temperature are 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).

## **2.2 General Life History Information for Crabs**

Shallow inshore areas (less than 50 m depth) are very important to king crab reproduction as the adults 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 and must mate annually while Tanner and snow crab have a terminal molt to maturity and can store sperm internally 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 as important.

Larval stages are planktonic for 2-3 months and their vertical distribution in the water column is determined by swimming behavior, currents, vertical mixing, or water column stratification. Generally, the larval stages are thought to occupy the upper 40 m of the water column, within the mixed layer. After molting through multiple larval stages, post-larvae settle on the ocean bottom. Habitat with adequate shelter, food, and temperature is imperative to survival of newly settling crabs. Young of the year red and blue king crabs require habitat with crevice spaces (e.g., structural invertebrates, macroalgae, shell hash, cobble, shale) that offers protection, which typically occurs in nearshore areas. Both species rely on cryptic behavior in complex habitat to reduce predation risk. 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.

### ***Egg Stage***

Female king and Tanner crabs extrude eggs, carry and nurture them outside the maternal body under their abdominal flap. Thus the habitat for eggs is the same as for egg-bearing females. The number of eggs produced by the female increases with body size.

### ***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. Crab larvae are planktonic: horizontal swimming is inconsequential compared to horizontal advection by oceanographic conditions. Larvae vertically migrate in the water column, which impacts the extent of horizontal transport as current direction and strength can vary with depth. Behaviors such as 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 as post-larvae (glaucothoe and megalopae) up to approximate size at age 2. Habitat complexity is obligatory for red and blue

king crabs of this life stage and individuals less than 20 mm carapace length (CL) are typically distributed in nearshore waters among niches provided by sea star arms, anemones, shell hash, rocks and other complex habitat types. Early juvenile Tanner crab settle on mud, 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 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 spermatophores or oocytes can be produced. The mature stage includes crabs from the first size of functional maturity to senescence.



**Table 2 Summary of Reproductive Traits of BSAI Crab**

BSAI Crab		Reproductive Traits																										
		Age at Maturity				Fertilization/Egg Development					Spawning Behavior						Spawning Season											
		Female		Male		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
50%	100%	50%	100%																									
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	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	X					
	LJ																											
	EJ																											
	L																											
	E																											
Snow Crab	M	5 to 6		6 to 8		X	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	X						
	LJ																											
	EJ																											
	L																											
	E																											



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

Abbreviations used in the habitat tables to specify location, position in the water column, bottom type, and other oceanographic features are provided in Table 4.

**Table 4** 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)	USP = upper slope (200–1000 m)
MCS = middle continental shelf (50–100 m)	LSP = lower slope (1000–3000 m)
OCS = outer continental shelf (100–200 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
-------------	----------------------

## Life History and General Distribution

Red king crab (*Paralithodes camtschaticus*) is widely distributed throughout the BS and AI, GOA, Sea of Okhotsk, and along the Kamchatka shelf, typically at depths less than 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 more slowly than and do not get as large as males. In Bristol Bay, 50 percent maturity is attained by males at approximately 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 approximately 7 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.

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 juveniles.

### **Relevant Trophic Information**

Pacific cod is a known predator on adult red king crabs and likely primarily targets newly molted softshell 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. Other known predators of juveniles in the GOA include hermit crabs, Alaskan ronquil, Arctic shanny, northern rock sole, sculpins, and kelp greenling. It is likely that other similar crustaceans and fish are predators but data is limited.

***Approximate Upper Size Limit of Juvenile Crab (in cm):*** The size at 50 percent maturity is approximately 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 approximately 9 cm for females and 12 cm for males in Bristol Bay and the Pribilof and Aleutian Islands.

### **Habitat and Biological Associations**

***Egg:*** In southeast Alaska egg hatch of larvae is synchronized with the spring phytoplankton bloom 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 crabs spend 2 to 3 months in pelagic larval stages before settling to the benthic life stage. In the BS, larvae are thought to undergo diel vertical migration, which may serve to balance feeding opportunities and predator avoidance.

***Early Juvenile:*** Early juvenile stage red king crabs are solitary and need complex habitat, consisting of coarse substrate (i.e., boulders, cobble, shell hash) or structural invertebrates (e.g., bryozoans, stalked ascidians). Young-of-the-year crabs occur at depths of 50 m or less.

***Late Juvenile:*** Late juvenile stage red king crabs of 2 and 4 years exhibit decreasing reliance on complex habitat and a tendency for the crab to form pods consisting of hundreds to 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 (less than 50 m). Timing of mating is variable, depending on water temperature, and can occur January through June. Males grasp females just prior to female molting, after which the eggs (43,000 to 500,000 eggs) are extruded and fertilized on the female's abdomen. The female red king crab carries the eggs for approximately 10 to 12 months before they hatch, generally in April.

**Table 5 Red king crab, *Paralithodes camtschaticus* (abbreviations are in Table 4)**

Life Stage	Duration or Age	Diet/Prey	Season/Time	Location	Water Column	Bottom Type	Oceanographic Features	Other
Eggs	10–12 mo	NA	Jan–April	NA	NA	NA	F	
Larvae	3–5 mo	Diatoms, Phytoplankton Copepod nauplii	April–August	MCS, JCS	P	NA	F	
Juveniles	1 to 5–6 yrs	Diatoms Hydroids	All year	ICS, MCS, BCH, BAY	D	(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 approximately 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 approximately 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. Adult male blue king migrate offshore to deeper waters and soft-bottomed habitats.

### 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 10- and 12-cm CL for female and male crabs, respectively, from the Pribilof Islands, and 8- and 10.5-cm CL for St. Matthew Island female and male crabs, respectively.

### 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 and 60 m deep. There is some evidence that blue king crab larvae exhibit diel vertical migration, but data is limited.

**Early Juvenile:** Early juvenile blue king crabs require ample crevice spaces for refuge from predators and foraging opportunities. Such substrates are typically characterized by gravel and cobble overlaid with shell hash and sponge, hydroid, and barnacle assemblages, which have been observed around the Pribilof Islands at 40 to 60 m depths. Early juveniles also occur in shallower water up to the intertidal in Herendeen Bay in rocky substrates and they may occur in similar habitats in other areas.

**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. 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.

**Table 6 Blue king crab, *Paralithodes platypus* (abbreviations are in Table 4)**

Life Stage	Duration or Age	Diet/Prey	Season/ Time	Location	Water Column	Bottom Type	Oceanographic 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, BAY, BCH	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 9.2 to 12.5 cm CL, with crabs in the northern areas maturing at smaller sizes. Females carry up to 20,000 eggs, depending on their size. Spawning appears to be non-synchronous and to occur throughout the year. Larvae are lecithotrophic and are pelagic for 3 to 5 months, but nothing is known about where they reside in the water column.

### Relevant Trophic Information

Unknown

**Approximate Upper Size Limit of Juvenile Crab (in cm):** The size (CL) at 50 percent maturity for females and males, respectively: 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 greater than 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 depths greater than 364 m. Female abundance is greatest at intermediate depths between 274 and 364 m.

**Table 7 Golden king crab, *Lithodes aequispina* (abbreviations are in Table 4)**

Life Stage	Duration or Age	Diet/Prey	Season/Time	Location	Water Column	Bottom Type	Oceanographic Features	Other
Eggs	15 mo.	n/a	all year	LSP	D	N/A		
Larvae	3–5 mo.	lecithotrophic	all year	U	P	N/A		
Juveniles		U	all year		D			
Adults		Ophiuroids, sponges, fish, plants, crustaceans	Spawning all year	LSP, BSN	D	R		

## 2.6 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 occur in lower abundance in the GOA. Size at 50 percent maturity is variable, but approximately 11 cm for males and 9 cm carapace width (CW) for females in the BS. The age of maturity for male Tanner crab is estimated at 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 ( $M=0.3$ ).

### 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 is also common.

**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, respectively.

### Habitat and Biological Associations

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

**Larvae:** Larvae of *C. bairdi* Tanner crabs are typically found in the BSAI water column from 0 to 100 m in early summer but mostly above 20m. They usually stay near the depth of the chlorophyll maximum, and in the BS there is no evidence of diel migration. The last larval stage settles onto the bottom mud.

**Early Juvenile:** Early juvenile *C. bairdi* Tanner crabs occur at depths of 10 to 70 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 likely migrate inshore, and mating occurs from February through June. Mature female *C. bairdi* Tanner crabs can form 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 for at least 2 years. Females carry clutches of 24,000 to 400,000 eggs and brood the embryos for 1 year after fertilization (Hilsinger 1976). Primiparous females may carry the fertilized eggs for as long as 1.5 years. Brooding occurs in 100 to 150 m depths.

**Table 8** Tanner crab, *Chionoecetes bairdi* (abbreviations are in Table 4)

Life Stage	Duration or Age	Diet/Prey	Season/Time	Location	Water Column	Bottom Type	Oceanographic Features	Other
Eggs	1 year	NA	Feb-March	NA	NA	NA	F	
Larvae	3 to 5 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 algae fish	Spawning Jan. to June (peak April-May)	MCS, ICS	D	M	F	

## 2.7 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 to 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 ( $M=0.3$ ).

### **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. Snow crabs are also cannibalistic.

***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**

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

***Larvae:*** Larvae of *C. opilio* snow crab are found in early summer primarily in the upper mixed layer (greater than 20 depth) and do not exhibit diel migration. The last of three larval stages settles onto bottom in nursery areas.

***Early Juvenile:*** Shallow water areas of the EBS with muddy substrate 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 have a terminal molt to 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 10,000 to 70,000 eggs depending on size, and brood the embryos for either 1 or 2 years after fertilization depending on the water temperature. 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.

**Table 9** Snow crab, *Chionoecetes opilio* (abbreviations are in Table 4)

Life Stage	Duration or Age	Diet/Prey	Season/Time	Location	Water Column	Bottom Type	Oceanographic Features	Other
Eggs	1 to 2 years	NA		NA	NA	NA	F	
Larvae	3 to 5 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	Polychaetes brittle stars mollusks crustaceans hydroids algae diatoms	Spawning Jan. to June (peak April to May)	ICS, MCS, OCS	D	M	F	



### 3 Essential Fish Habitat

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

EFH is described for FMP-managed species by life stage as general distribution using guidance from the EFH Final Rule (50 CFR 600.815), including the EFH Level of Information definitions. New analytical tools are used and recent scientific information is incorporated for each life history stage from updated scientific habitat assessment reports. EFH descriptions include both text (see 3.1) and maps (see 3.2), if information is available for a species’ particular life stage.

EFH descriptions are interpretations of the best scientific information. In support of this information, a thorough review of FMP species is contained in the Environmental Impact Statement for Essential Fish Habitat Identification and Conservation (EFH EIS, NMFS 2005) in Section 3.2.1, Biology, Habitat Usage, and Status of Magnuson-Stevens Act Managed Species and detailed by life history stage in Appendix F: EFH Habitat Assessment Reports. This EIS was supplemented in 2010 and 2017 by the 5-year review cycle, which re-evaluated EFH descriptions and fishing and non-fishing impacts on EFH in light of new information (NPFMC and NMFS 2010, and Simpson et al. 2017). The EFH descriptions are risk averse, supported by scientific rationale, and account for changing oceanographic conditions and regime shifts.

#### 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 a “1” means information is available to determine EFH.

**Table 10 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	1	1	1
Blue king crab	inferred	x	1	1	1
Golden king crab	inferred	x	x	1	1
Tanner crab	inferred	x	x	1	1
Snow crab	inferred	x	x	1	1

x indicates insufficient information is available to describe EFH

1 indicates general distribution data are available for some or all portions of the geographic range of the species

2 indicates quantitative data (density or habitat-related density) are available for the habitats occupied by a species or life stage

### **3.1.1 Red King Crab**

#### ***Eggs***

Essential fish habitat of the red 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-***

EFH for early juvenile red king crab is the general distribution area for this life stage, located in demersal habitat along the intertidal and subtidal zones, and inner and middle shelf (0 to 100 m). Early juveniles have specific habitat requirements based on their anti-predator strategy and can only occur in places where there is significant habitat structure either in the form of substrates such as rock, cobble, and gravel, or biogenic habitats such as bryozoans, ascidians, hydroids, or shell hash. In the BS, these habitats generally only occur in nearshore areas along the north side of the AI and the Alaskan Peninsula, around Bristol Bay, around the Pribilof Islands, and in nearshore areas of Norton Sound.

#### ***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* spp., bryozoans, ascidians, and shell hash.

#### ***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.

### **3.1.2 Blue King Crab**

#### ***Eggs***

EFH 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-***

EFH for early juvenile blue king crab is the general distribution area for this life stage, located in demersal habitat along the intertidal and subtidal zones, and inner and middle shelf (0 to 100 m). Early juveniles require specific habitat types to avoid predation. In particular, they require either rock or cobble substrates or shell hash beds. Within the range of blue king crab, this only occurs in nearshore areas around the Pribilof Islands, St. Matthew Island, and St. Lawrence Island.

### ***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.

### ***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.

## **3.1.3 Golden King Crab**

### ***Eggs***

EFH 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.

### ***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.

## **3.1.4 Tanner Crab**

### ***Eggs***

EFH of Tanner 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 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.

### ***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.

## **3.1.5 Snow Crab**

### ***Eggs***

EFH of snow 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 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.

### ***Adults***

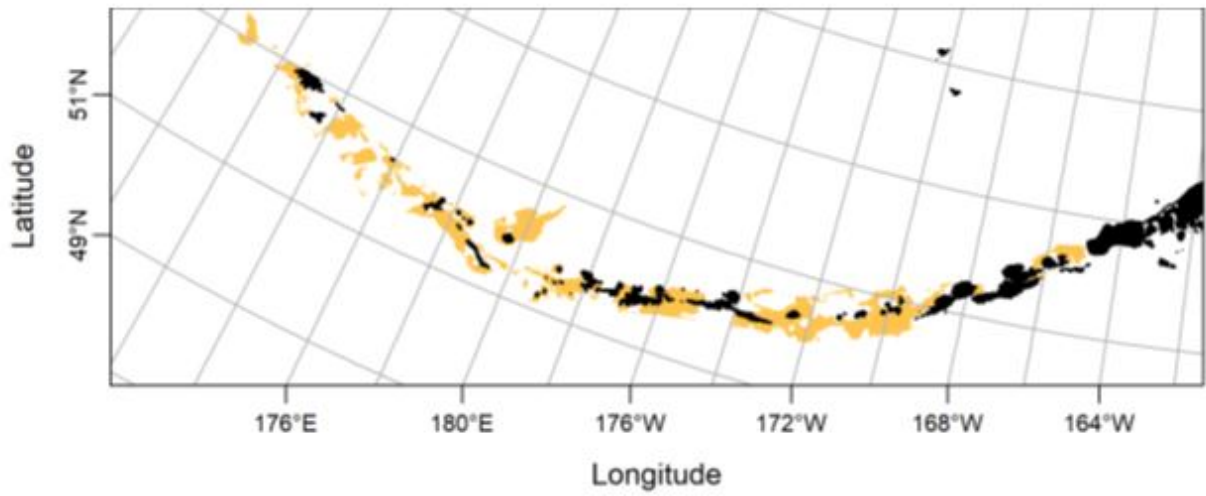
EFH for adult snow crab is the general distribution area for this life stage, located in bottom habitats along the inner (0 to 50 m), middle (50 to 100 m), and outer shelf (100 to 200 m) throughout the BSAI wherever there are substrates consisting mainly of mud.

## **3.2 Maps of Essential Fish Habitat**

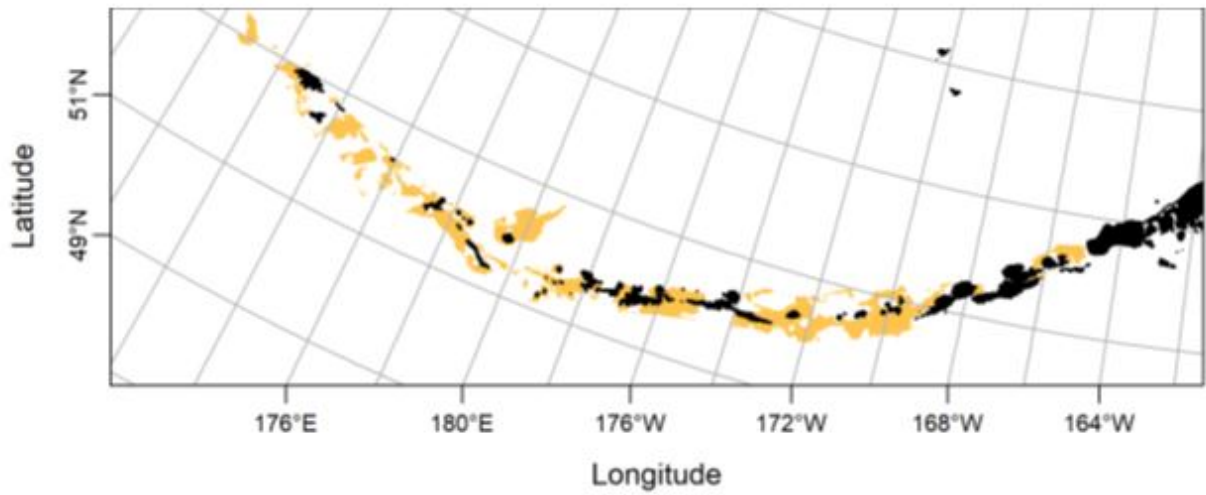
Scientists at the Alaska Fisheries Science Center created species distribution models of EFH for all major crab species in the eastern Bering Sea (Laman et al. 2017) and in the Aleutian Islands (Turner et al. 2017). With Amendment 49, the Council adopted these new model-based maps for crab EFH that represent the 95th percentile by season for each species and life stage, as information is available.

### 3.2.1 Aleutian Islands crab EFH maps

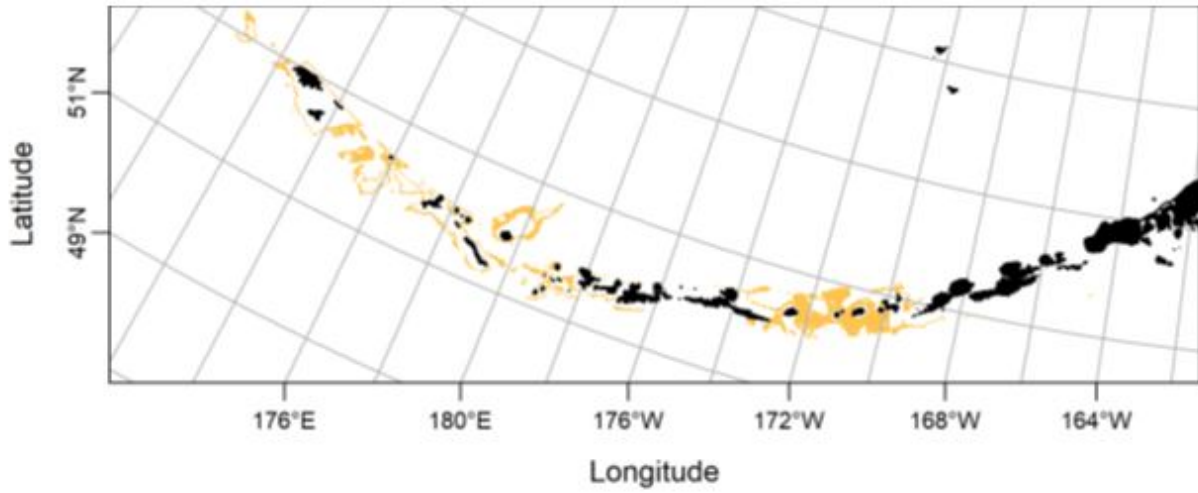
**Figure 2** AI adult Golden king crab fall EFH



**Figure 3** AI adult Golden king crab spring EFH

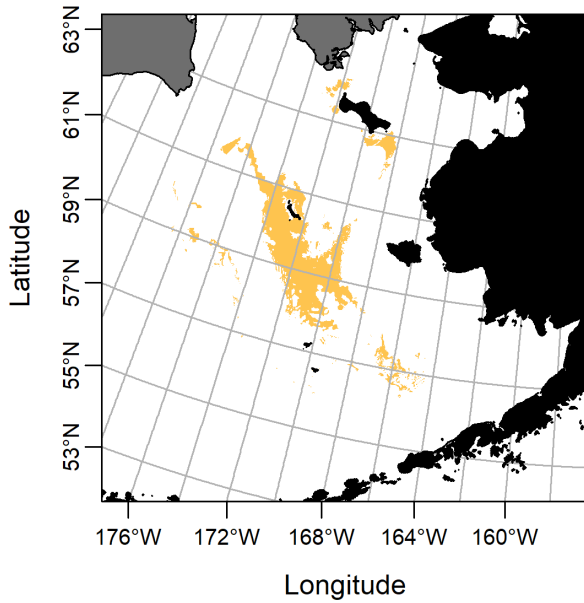


**Figure 4 AI adult Golden king crab summer EFH**

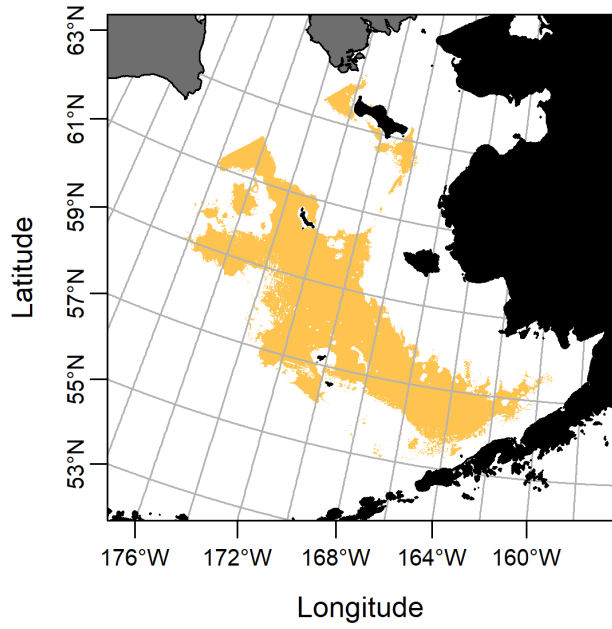


**3.2.2 Bering Sea crab EFH maps**

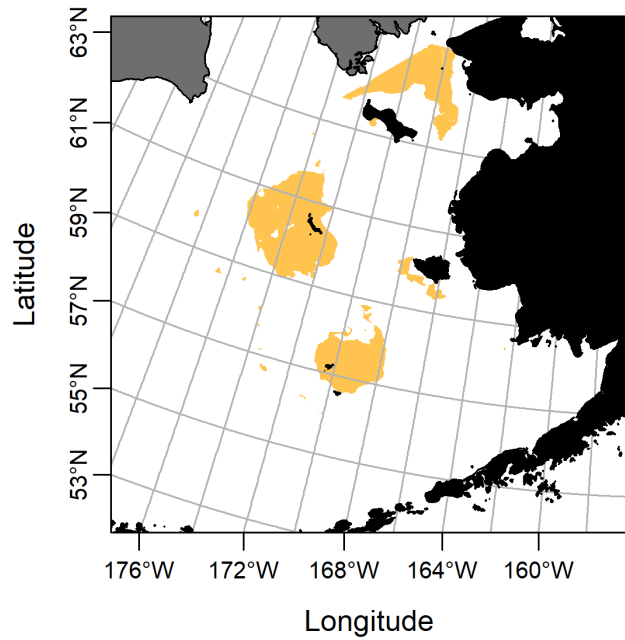
**Figure 5 EBS adult Blue king crab fall EFH**



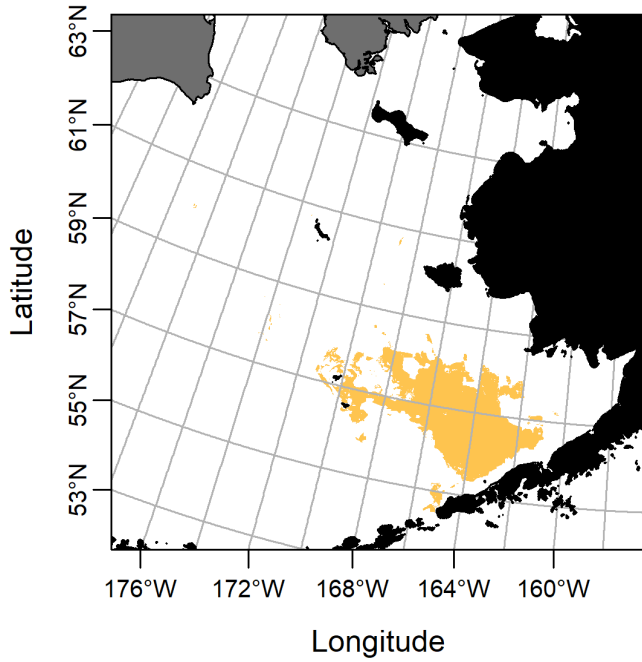
**Figure 6 EBS adult Blue king crab spring EFH**



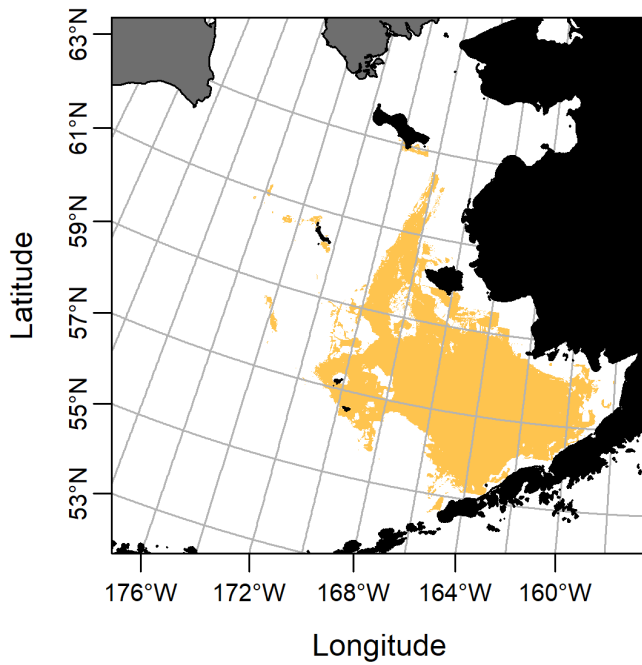
**Figure 7 EBS adult Blue king crab winter EFH**



**Figure 8 EBS adult Red king crab fall EFH**

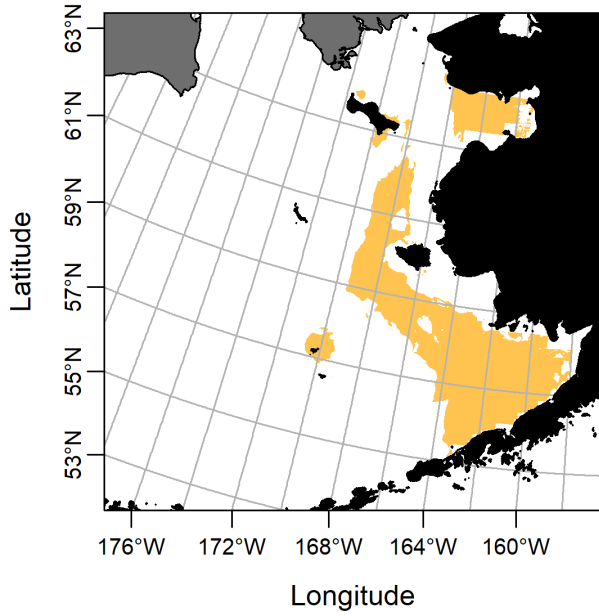


**Figure 9 EBS adult Red king crab spring EFH**

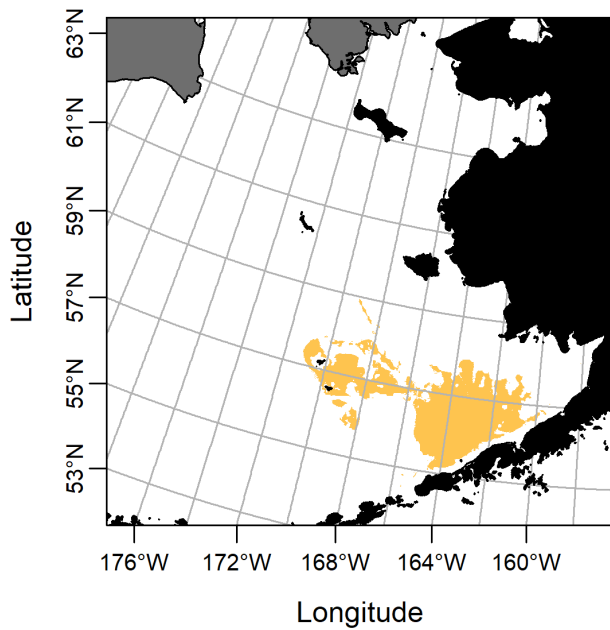




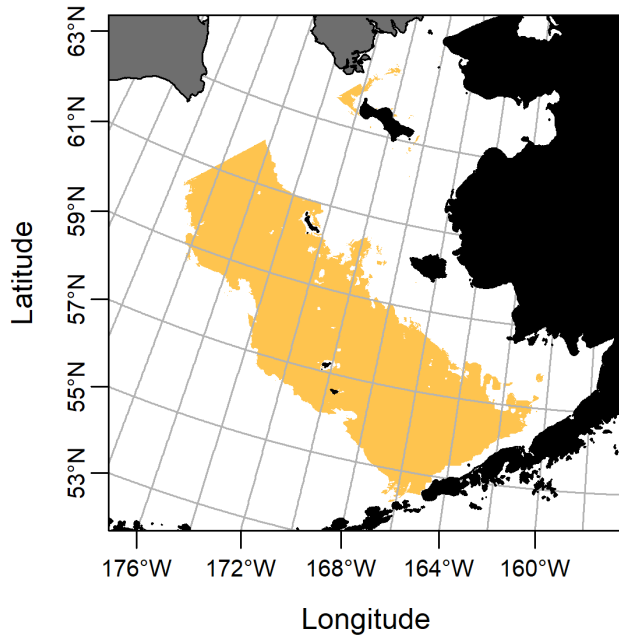
**Figure 10 EBS adult Red king crab summer EFH**



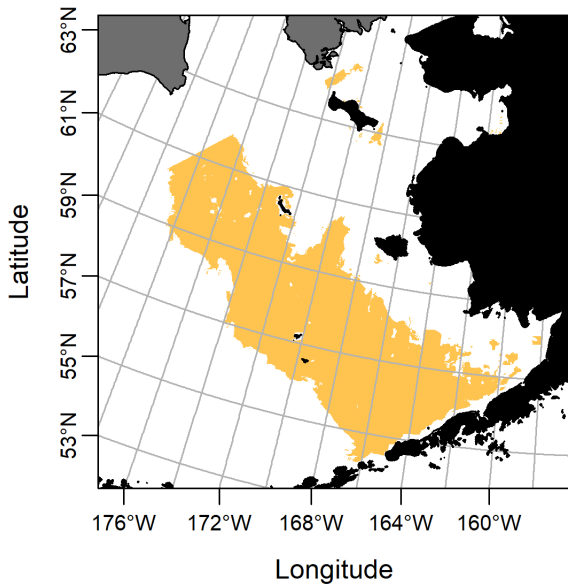
**Figure 11 EBS adult Red king crab winter EFH**



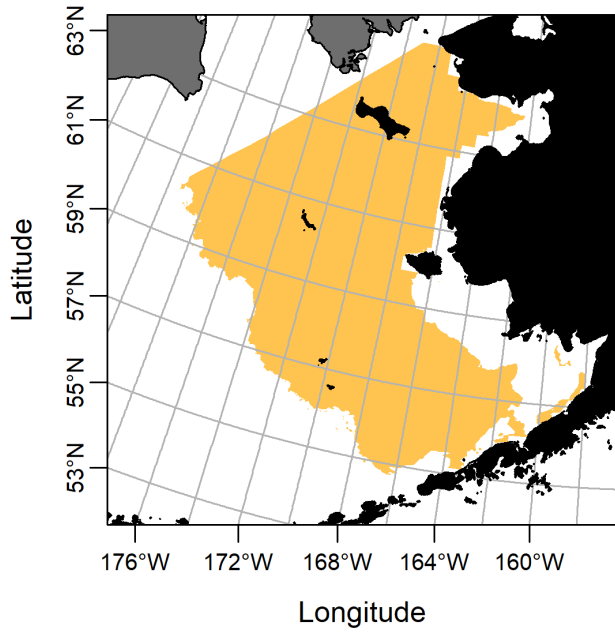
**Figure 12 EBS adult Snow crab fall EFH**



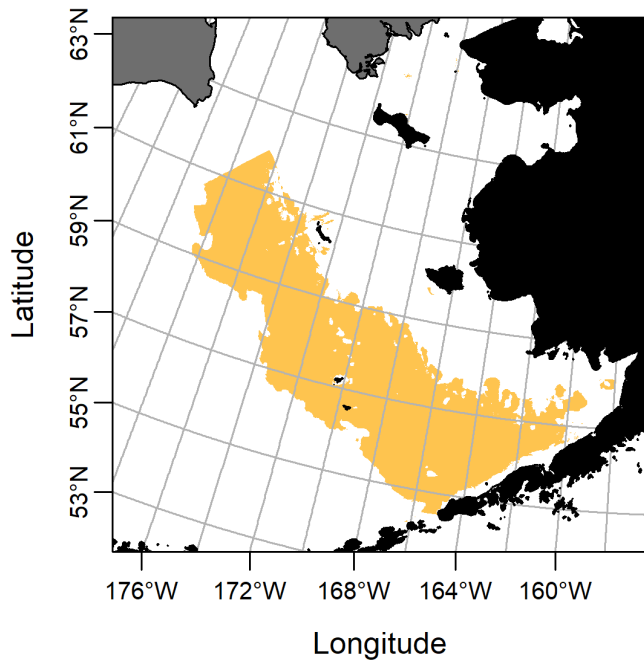
**Figure 13 EBS adult Snow crab spring EFH**



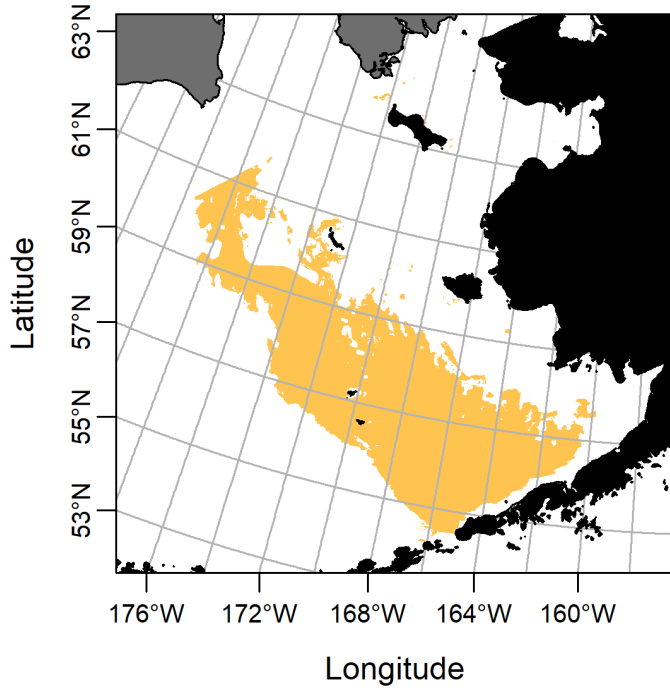
**Figure 14 EBS adult Snow crab summer EFH**



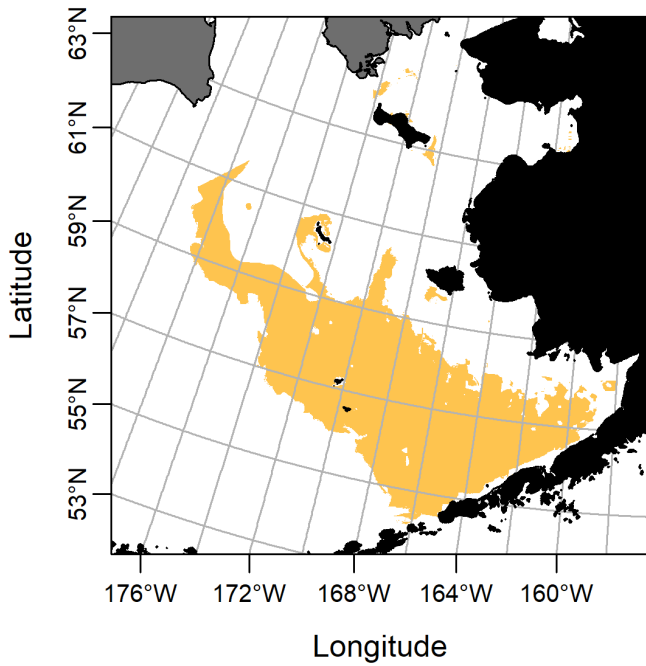
**Figure 15 EBS adult Snow crab winter EFH**



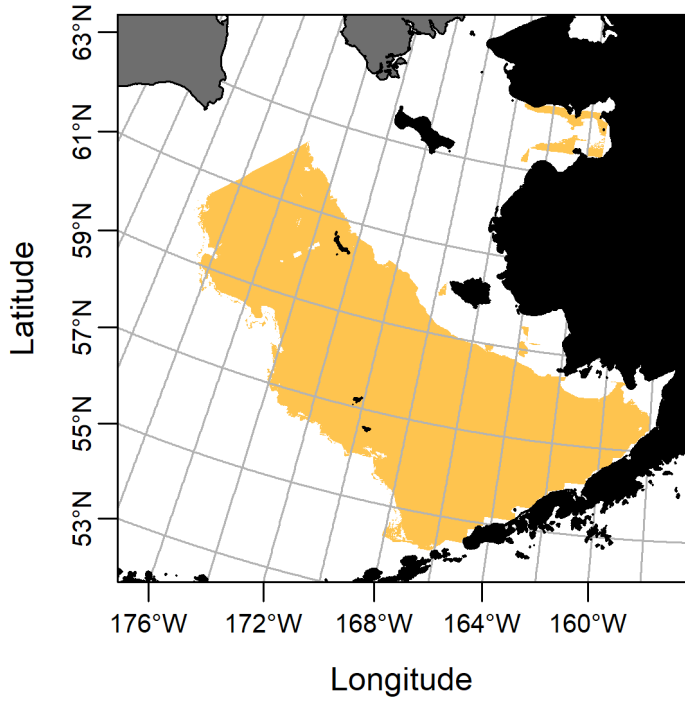
**Figure 16 EBS adult Tanner crab fall EFH**



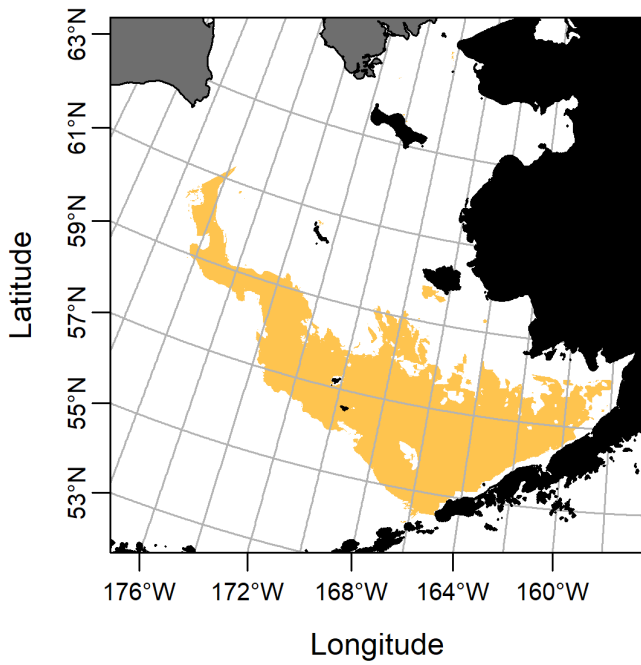
**Figure 17 EBS adult Tanner crab spring EFH**



**Figure 18 EBS adult Tanner crab summer EFH**



**Figure 19 EBS adult Tanner crab winter EFH**



### 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 as 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

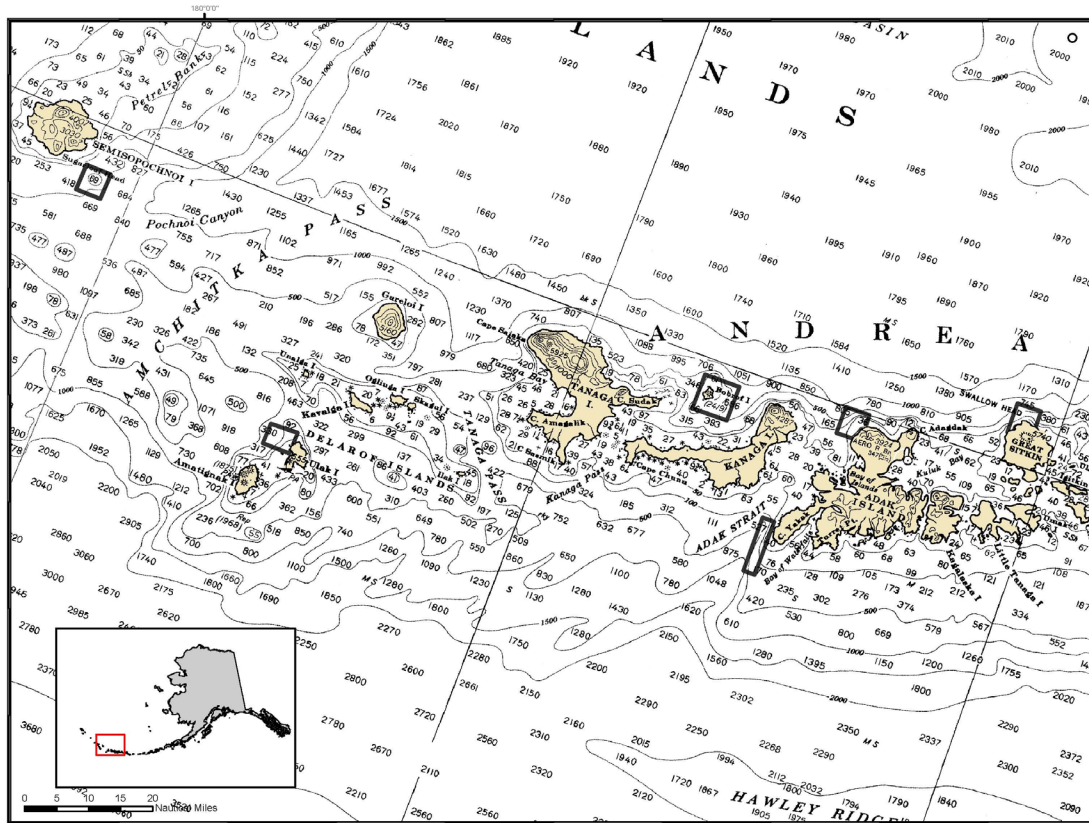
The use of bottom contact gear, including pot gear, as described in 50 CFR part 679, is prohibited year-round in the Aleutian Islands Coral Habitat Protection Areas, see Figure 20. Anchoring by a federally permitted fishing vessel, as described in 50 CFR part 679, is also prohibited. The coordinates for the areas are listed in the table below.

**Table 11 Aleutian Islands Coral Habitat Protection Areas**

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.

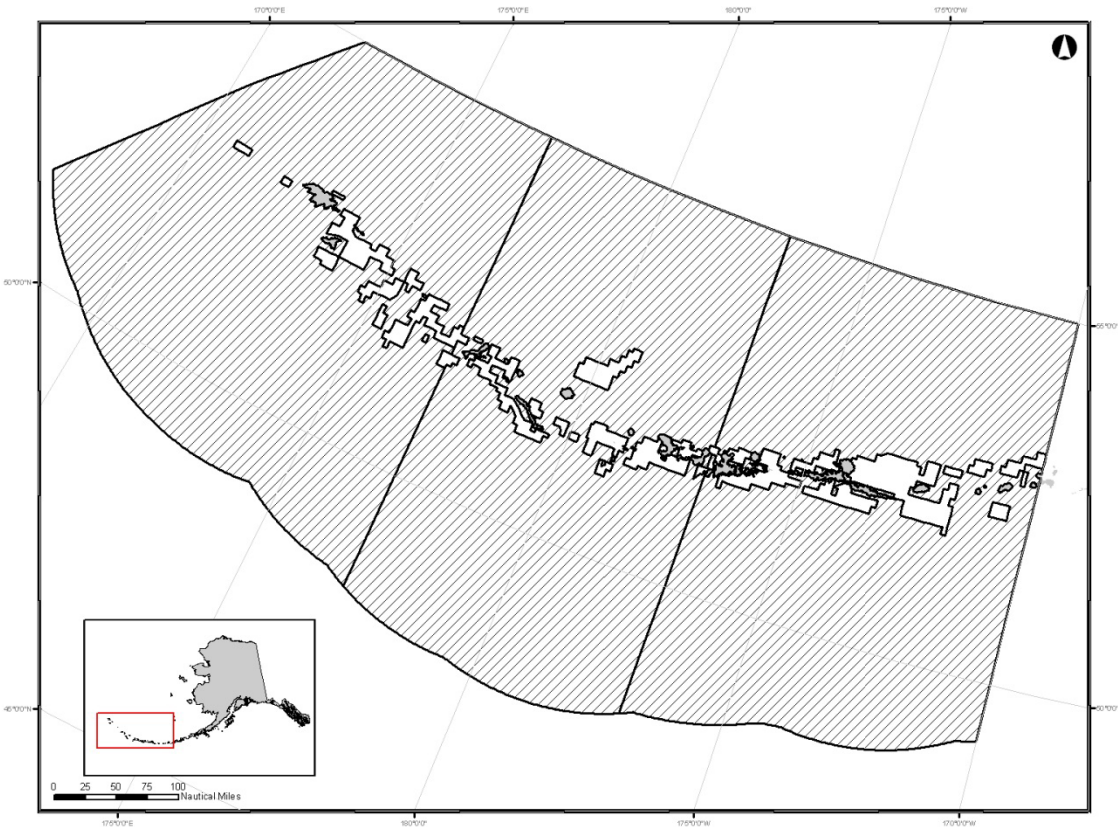
**Figure 20 Aleutian Islands Coral Habitat Protection Areas**



### 3.3.2 Aleutian Islands Habitat Conservation Areas

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 21; however, the use of trawl gear is prohibited in the BSAI King and Tanner crab fisheries.

**Figure 21 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 22. 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.

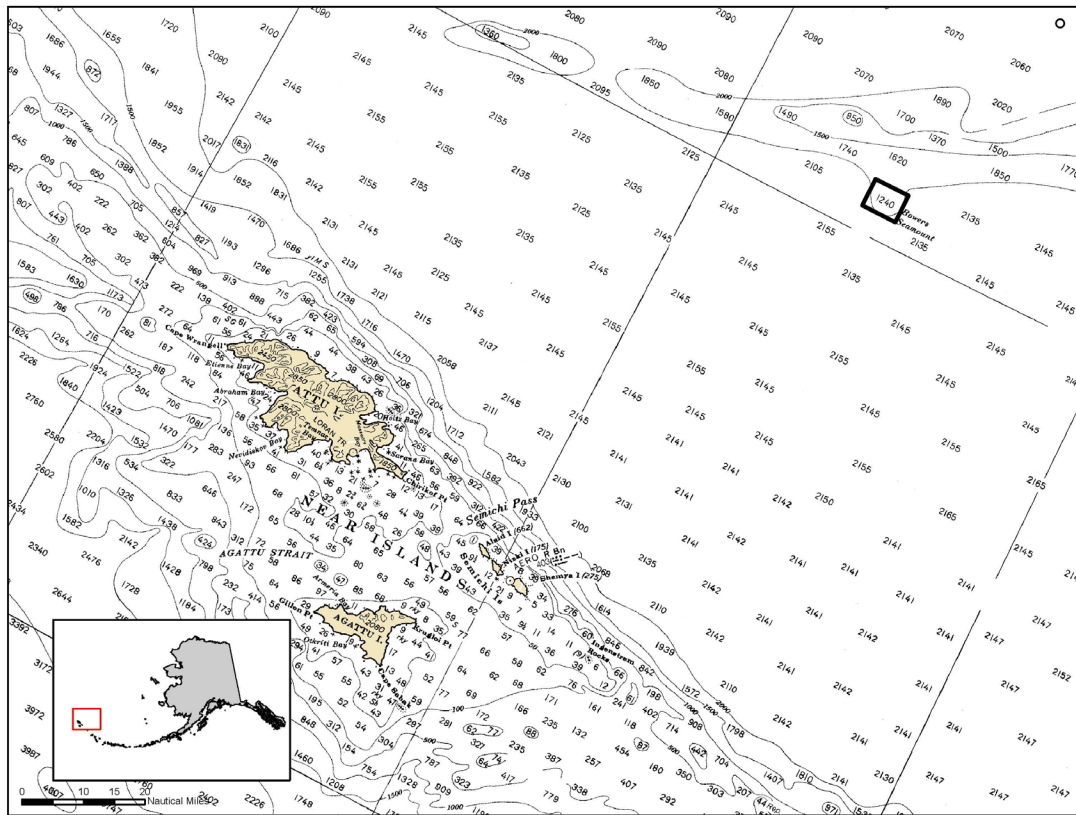
**Table 12 Alaska Seamount Habitat Protection Area**

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 22 Alaska Seamount Habitat Protection Area in the Aleutian Islands**



**3.3.4 Bowers Ridge Habitat Conservation Zone**

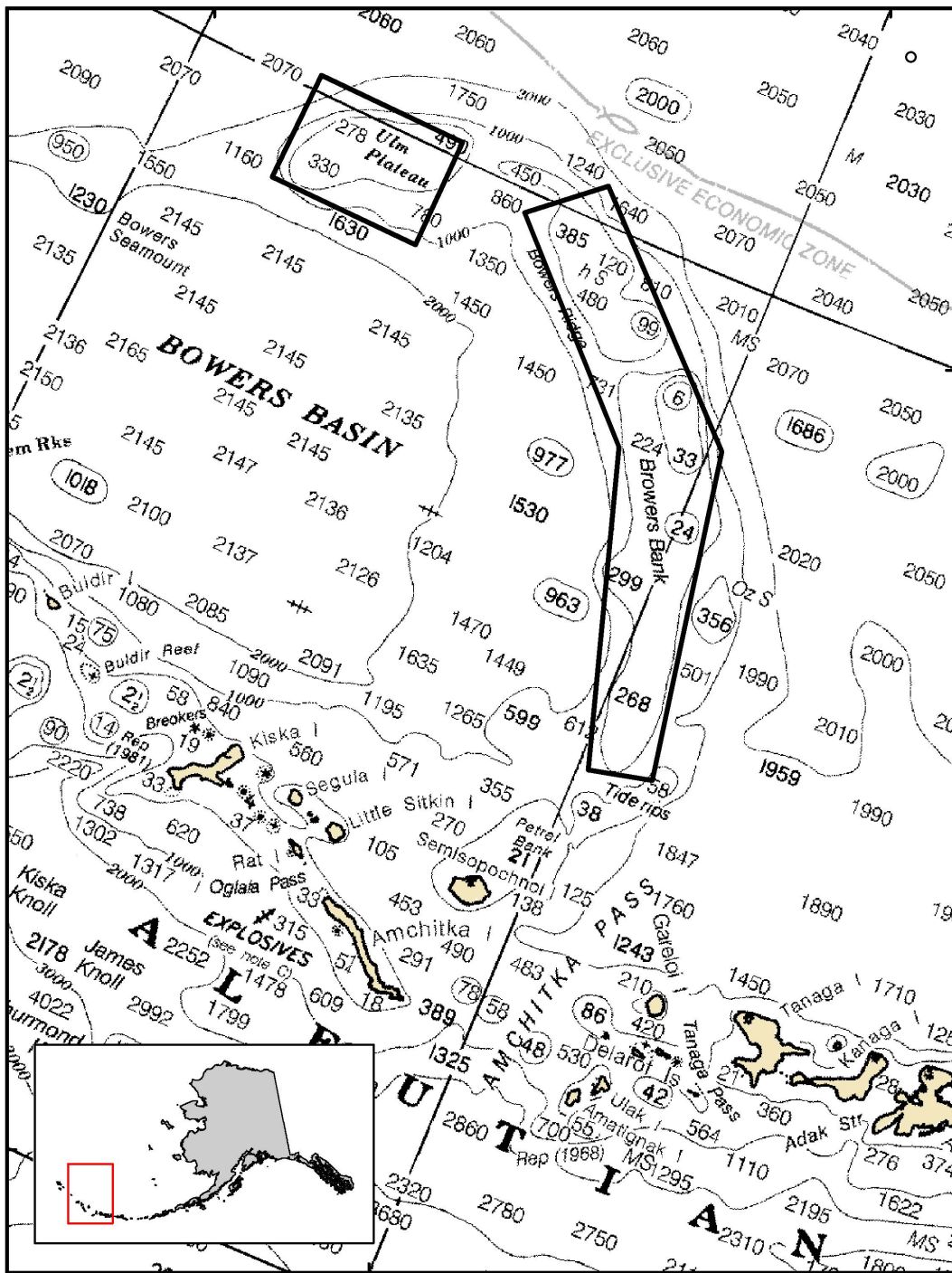
The use of mobile bottom contact gear, as described in 50 CFR part 679, is prohibited year-round in the Bowers Ridge Habitat Conservation Zone, see Figure 23. The areas are described in the table below.

**Table 13 Bowers Ridge Habitat Conservation Zone**

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 23 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 5 years, to coincide with the EFH 5-year review, or may be initiated at any time by the Council. The Council will establish a process to review the proposals. The Council may periodically review existing HAPCs for efficacy and considerations based on new scientific research.

## 4 Effects of Fishing on Essential Fish Habitat

This section addresses 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. 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, and use the best scientific information available, as well as other appropriate information sources.

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

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

### 4.1 Effects of Fishing Analysis

The 2005 EFH FEIS and 2010 EFH Review effects of fishing on EFH analyses included application of a numerical model that provided spatial distributions of an index of the effects of fishing on several classes of habitat features, such as infauna prey and shelter created by living organisms. The Long-term Effect Index (LEI) estimated the eventual proportional reduction of habitat features from a theoretical unaffected habitat state, should the recent pattern of fishing intensities be continued indefinitely (Fujioka 2006). For the 2005 and 2010 analyses, the LEI generated represented a 5-year time period.

During the 2015 EFH Review, the Council requested several updates to the LEI model to make the input parameters more intuitive and to draw on the best available data. In response to their requests, the Fishing Effects (FE) model was developed (Harris et al. 2017). Like the LEI model, it is run on 25 km<sup>2</sup> grid cells throughout the North Pacific and is based on interaction between habitat impact and recovery, which depend on the amount of fishing effort, the types of gear used, habitat sensitivity, and substrate. The FE model updates the LEI model in the following ways:

1. The FE model is cast in a discrete time framework. This means rates such as impact or recovery are defined over a specific time interval, compared to the LEI model which used continuous time. Using discrete time makes fishing impacts and habitat recovery more intuitive to interpret compared to continuous time.
2. The FE model implements sub-annual (monthly) tracking of fishing impacts and habitat disturbance. While this was theoretically possible in the LEI model, the LEI model was developed primarily to estimate long term habitat disturbance given a constant rate of fishing and recovery. The FE model allows for queries of habitat disturbance for any month from the start of the model run (January 2003). This aids in the implications of variable fishing effort within season and among years.
3. The FE model draws on the spatially explicit Catch-In-Areas (CIA) database to use the best available spatial data of fishing locations. The CIA database provides line segments representing the locations of individual tows or other bottom contact fishing activities. This provides a more accurate allocation of fishing effort among grid cells. In comparison, the LEI model used haulback locations summarized to the 25 km<sup>2</sup> grids to represent fishing activity. The description of fishing gears that may contact benthic habitat was also greatly improved with significant input from fishing industry representatives.
4. The FE model incorporates an extensive, global literature review from Grabowski et al. (2014) to estimate habitat susceptibility and recovery dynamics. The FE model identifies 27 unique biological and geological habitat features and incorporates impact and recovery rates to predict habitat reduction and recovery over time. The FE model is also designed to be flexible to produce output based on any single habitat feature or unique combination of features.

Once the FE model has been run and a surface of predicted habitat reduction is produced, the 95% species descriptions for each species can be used as a mask and the cumulative fishing effect on that species can be calculated. It is important to note that because the FE model incorporates both impact to and recovery of benthic structures, the calculated habitat reduction for any grid is the cumulative value at that point in time.

#### **4.1.1 Habitat Categorization**

The FE and LEI model both consider habitat impacts and recovery at the level of habitat features, where habitat is the sum total of all habitat features. Aside from structural differences between models (i.e. continuous vs discrete time), both LEI and FE treat habitat features in the same way, just define them differently. The 2005 EFH FEIS analyzed approximately 2,000

sediment point data and divided Bering Sea habitat types into 4 sediment types – sand, mixed sand and mud, and mud. Additional categories were added for the slope below 200 m depth and the northern shelf. The ability to classify habitats in the Aleutian Islands and Gulf of Alaska was highly constrained due to the lack of comprehensive sediment distribution data, so the RACE survey strata, split into shallow, deep, and slope were used. The LEI model defined four broad habitat features: infaunal prey, epifaunal prey, biological structure, and physical structure. The FE model, in contrast, defines 27 habitat features which can be grouped into biological or geological features. These 27 habitat features were drawn from the literature review described above. The FE model, however, is flexible to produce results over any combination of habitat features, if for example a specific subset of habitat features was important for a specific species.

For the 2015 EFH Review, sediment data were compiled from various surveys collected across the North Pacific, and now includes over 240,000 individual points. The data consist of spatially explicit points attributed with sediment descriptions although the various surveys varied widely in methodology, sediment descriptions, and point density. Sediment points in the Eastern Bering Sea are separated on average by ~10.5 km, while some localized sampling efforts, especially near shore, collected data at much greater densities. Very few points were located deeper than 500 meters or in areas of boulder or hard rock habitat.

Initial processing of the data consisted of parsing through the various sediment descriptions to map them to a sediment category used in the FE model (mud, sand, granule/pebble, cobble, or boulder). The mapping was not one-to-one, however, such that more than one sediment category could be described by a single sediment description. Each point was attributed as present or absent for each sediment category. An indicator Kriging algorithm was used (Geostatistical Wizard, ArcMap v10.2) to interpolate a probability surface for each sediment category over a 2.5 km grid aligned to the 5 km grid used for the FE model. A probability threshold of 0.5 to indicate presence/absence of each sediment category was set, so four sediment grid cells were located within each 5 km grid cell, providing a pseudo-area weighted measure of each sediment type within each 5 km grid cell. For each 5 km grid cell, the proportion of each sediment type was calculated as the sum of all 2.5 km grid cells with sediment present (up to four for each sediment class) divided by the sum of all present cells across all sediments (up to 20 possible, 4 cells X 5 sediment classes). In ~10% of the 5 km grid cells, no sediment class was predicted present. In these cases, sediment proportions from the nearest 5 km grid cell were used.

#### **4.1.2 General Fishing Gear Impacts**

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

##### **4.1.2.1 Bottom Trawls**

The EFH EIS 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. 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.

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.

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. 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.

### ***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.

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.

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. The authors noted a strong transition to apparently smaller effects outside of the direct path of the tire gear.

### ***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).

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).

### ***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.

In the 2005 EFH FEIS, the effects of fishing analysis noted that the LEI results required separate consideration for particularly long-lived and slow-growing living structures, exemplified by corals in hard bottom areas. Even relatively low fishing intensities still eventually reduced corals to very low levels in exposed areas. As a result, this class of living structure is treated separately from those with faster recovery rates. Research on coral distribution and fishing impacts moved forward, with studies by Stone (2006), expanded in Heifitz et al. (2009). Areas of highest coral density in the central Aleutian Islands were found to be deeper than most trawling effort. These studies found coral ubiquitous throughout transects across the central Aleutian Islands and damage to these correlated to the intensity of bottom trawling effort. Damage was also noted in depths with little trawling effort, where longline and pot fisheries were the only fishing effort contacting the seafloor. Damage from those gears was harder to identify and attribute due to the less continuous pattern of their effects.

These studies are consistent with the effects of fishing analysis of the 2005 EFH FEIS in that bottom trawling damages corals and that the slow growth rates of coral make them particularly vulnerable. In the development of the 2005 EFH FEIS, a suggestion was made to evaluate the effects of fishing on EFH by identifying areas of high coral bycatch, or “hotspots”. In response, NMFS analysts utilized the observer and survey databases to plot observed catch of corals and assess the capability of the data to support area closures based on high coral observed catch. The results of this analysis were that observer and survey data are not useful for “hotspot” analysis of coral catch.

NMFS and the Council continue to track coral & sponge observed catch through both observer and survey programs. This information is reported yearly in several publications, including the SAFE reports, and those data are made available to the public. Recently, species distribution models have been developed for coral and sponge species in the Eastern Bering Sea, Gulf of Alaska, and Aleutian Islands (Rooper et al. 2014, Sigler et al. 2015). NMFS’s Deep Sea Coral Research and Technology Program (DSCRTP) funds research in Alaska to examine the location, distribution, ecosystem role, and status of deep-sea coral and sponge habitats based upon research priorities identified by the DSCRTP, the Council, and the EFH 5-year review process. Research priorities include:

- Determine the distribution, abundance, and diversity of sponge and deep-sea coral in Alaska (and their distribution relative to fishing activity);
- Compile and interpret habitat and substrate maps for the Alaska region;
- Determine deep-sea coral and sponge associations with species regulated by fishery management plans (especially juveniles) and the contribution of deep-sea coral and sponge ecosystems to fisheries production;

- Determine impacts of fishing by gear type and test gear modifications to reduce impacts;
- Determine recovery rates of deep-sea coral and sponge communities in Alaska from disturbance or mortality; and
- Establish a long-term monitoring program to determine the impacts of climate change and ocean acidification on deep-coral and sponge ecosystems.

At the October 2016 Council meeting, the SSC supported the use of the FE model as a tool for assessing the effects of fishing on EFH. In response to public comment, however, the SSC raised concern that the longest recovery time incorporated into the model (10 years) may not capture the recovery needed for long-lived species like some hard corals that live on rocky substrate at deep depths. The authors of the model explained that recovery is addressed in the model as an exponential decay function and that 10 years is a recovery to 50% of original coral biomass; a site would recover to 80% of the original biomass after 34 years in the absence of further damage or removals. However, to further address these concerns, a deep and rocky substrate habitat category was added using published information from Stone (2014).

This study was focused on the central Aleutian Islands, but is the most comprehensive source of information on corals in Alaska. Results indicate that corals have the highest density and depths of 400- 700m, on bedrock or cobbles, with moderate to very high roughness, and slopes greater than 10 percent.

To account for long-lived species expected to be found in these habitats, a new “Long-Lived Species” habitat feature was added with a new recovery score of “4”, corresponding to a recovery time of 10-50 years. The 50-year upper limit of recovery time was calculated with the expectation that 5% of the long-lived species would require 150 years to recover. Inclusion of this new category resulted in an average increase of 0.03% more habitat in a disturbed state compared to the original model predictions. Predicted habitat reduction was about 70% less in grid cells that contained Deep/Rocky substrate compared to the entire domain, reflecting the reduced fishing effort in those areas.

At the April 2017 Council meeting, the SSC mentioned that techniques are emerging that would allow future assessment of corals as an ecosystem component, as opposed to a living structure. The SSC encouraged FE analysts to consider this in future assessments.

### ***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.

### ***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.

### ***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).

#### **4.1.2.2 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.

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.

#### **4.1.2.3 Longlines**

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 (Stellar sea lion protection measures SEIS, 2001), 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.

#### **4.1.2.4 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<sup>2</sup> m). 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<sup>2</sup>] [0.7 kilogram per square centimeter (kg/cm<sup>2</sup>)]) 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.

#### **4.1.2.5 Dinglebar**

Dinglebar troll gear (Figure 3-9 of the HAPC EA) 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 vessel is underway (NPFMC 2003). 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.

#### **4.1.2.6 Dredge Gear**

Dredging for scallops may affect groundfish 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 (NEFMC 1982, Caddy 1973). 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 (Caddy 1968). 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 (molluscs) 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. Achan (1991) examined the effects of dredging for islandic scallops on macrobenthos off Norway. Achan 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 affect the benthic community and physical environment relative to the intensity of the fishery.

#### **4.1.3 Fishing Effects Vulnerability Assessment**

A goal of the vulnerability assessment is to base estimates of susceptibility and recovery of features to gear impacts on the scientific literature to the extent possible. In previous EFH fishing effects analyses (2005 and 2010), an overview of new and existing research on the effects of fishing on habitat was included in this document. Each of the inputs to the fishing effects model were evaluated, including the distribution of fishing intensity for each gear type, spatial habitat classifications, classification of habitat features, habitat- and feature-specific recovery rates, and gear- and habitat- specific sensitivity of habitat features. Many of these estimates were best professional judgement by fisheries managers and scientists.

For the 2015 EFH Review, a more empirical literature review method was incorporated to assess the effects of fishing on habitat. A vulnerability assessment and associated global literature review was developed by members of the New England Fishery Management Council's Habitat Plan Development Team while developing the Swept Areas Seabed Impacts model, which was in part based on the LEI model. Studies were selected for evaluation based on their broad relevance to Northeast Region habitats and fishing gears, but have been adapted for use in the North Pacific. Synthesis papers and modeling studies are excluded from the review, but the research underlying these publications is included when relevant. Most of the studies reviewed are published as peer-reviewed journal articles, but conference proceedings, reports, and these are considered as well.

A Microsoft Access database was developed to organize the review and to identify in detail the gear types and habitat features evaluated in each study. In addition to identifying gear types and features, the database included field codes for basic information about study location and related

research; study design, relevance and appropriateness to the vulnerability assessment; depth; whether recovery of features is addressed; and substrate types found in the study area. Analysts interacted with the database via an Access form.

Over 115 studies are evaluated, although additional literature referenced in the previous section on feature descriptions was used in some cases to inform recovery scores, and not all of the studies are used equally to inform the matrix-based vulnerability assessment. The long-term intention is to create new records in the database as additional gear impacts studies are published. This database is published as Grabowski et al (2014).

As a model parameterization tool, the vulnerability assessment quantifies both the magnitude of the impacts that result from the physical interaction of fish habitats and fishing gears, and the duration of recovery following those interactions. This vulnerability information from this database has been modified to condition area swept (i.e. fishing effort) in the FE model via a series of susceptibility and recovery parameters.

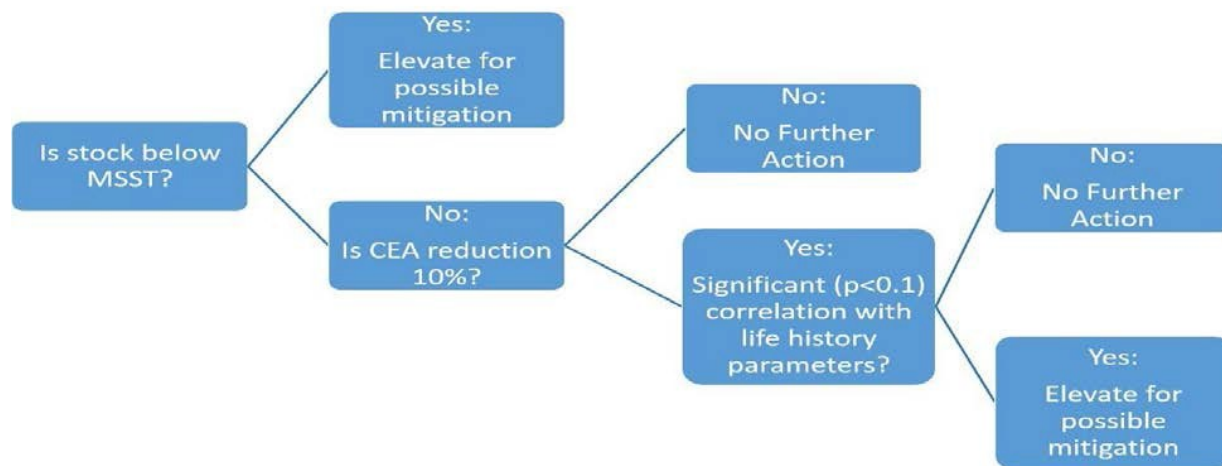
A critical point about the vulnerability assessment and accompanying FE model is that they consider EFH and impacts to EFH in a holistic manner, rather than separately identifying impacts to EFH designated for individual species and life stages. This is consistent with the EFH final rule, which indicates “adverse effects to EFH may result from actions occurring within EFH or outside of [designated] EFH and may include site-specific or habitat-wide impacts, including individual, cumulative, or synergistic consequences of actions” (§600.810). To the extent that key features of species’ EFH can be related to the features in the vulnerability assessment, post-hoc analysis of model outputs can be conducted to better evaluate the vulnerability of a particular species’ essential habitat components to fishing gear effects.

#### **4.1.4 Impact Assessment Methods**

In 2005, distribution of LEI values for each class of habitat feature were provided to experts on each managed species, to use in their assessment of whether such effects were likely to impact life history processes in a way that indicated an adverse change to EFH. Experts were asked to assess connections between the life history functions of their species at different life stages and the classes of habitat features used in the LEI model. Then, considering the distribution of LEIs for each of those features, they were asked whether such effects raised concerns for their species. Experts also considered the history of the status of species stocks in their assessments. While this process provided the first information available of the effects of fishing on stocks, it was not overly analytical.

In December 2016, the Council approved a three-tiered method to evaluate whether there are adverse effects of fishing on EFH (Figure 24). This analysis considers impacts of commercial fishing first at the population level, then uses objective criteria to determine whether additional analysis is warranted to evaluate if habitat impacts caused by fishing are adverse and more than minimal or not temporary.

**Figure 24 Three tiered method to evaluate effects of fishing on Essential Fish Habitat in Alaska**



Because EFH is defined for populations managed by Council FMPs, stock authors first considered whether the population is above or below the Minimum Stock Size Threshold (MSST), defined as  $0.5 \times \text{MSY}$  stock size, or the minimum stock size at which rebuilding to MSY would be expected to occur within 10 years if the stock were exploited at the Maximum Fishing Mortality Threshold (MFMT). Stock authors were asked to identify any stock that is below MSST for review by the Plan Teams. Mitigation measures may be recommended by the Plan Team if they concur that there is a plausible connection to reductions of EFH as the cause.

To investigate the potential relationships between fishing effects and stock production, the stock assessment authors examined trends in life history parameters and the amount of disturbed habitat in the “core EFH Area” (CEA) for each species. The CEA is identified as the predicted 50 percent quantile threshold of suitable habitat or summer abundance (Laman et al., 2017, Turner et al. 2017, Rooney et al., In Press). Stock assessment authors evaluated whether 10 percent or more of the CEA was impacted by commercial fishing in November 2016 (the end of the time series). The 10 percent threshold was selected based on the assumption that impacts to less than 10 percent of the CEA means that more than 90 percent of the CEA (top 50 percent of suitable habitat or summer abundance) was undisturbed, and therefore represented minimal disturbance. If 10 percent or more of the CEA was impacted, the stock assessment authors examined indices of growth-to-maturity, spawning success, breeding success, and feeding success to determine whether there are correlations between those parameters and the trends in the proportion of the CEA impacted by fishing. If a correlation exists, positive or negative, stock assessment authors determined whether the correlation is significant at a p-value of 0.1. If a significant correlation was found, stock assessment authors used their expert judgement to determine whether there is a plausible connection to reductions in EFH as the cause. Stock assessment authors identified the correlation, and the significance in their reports.

Reports from the stock assessment authors were collated and presented to representatives of the GOA and BSAI Groundfish Plan Teams and the Crab Plan Team. Plan Team representatives reviewed the reports in March, 2017. Representatives concurred with the stock assessment



authors determinations in all cases. None of the stock assessment authors concluded that habitat reduction within the CEA for their species was affecting their stocks in ways that were more than minimal or not temporary. None of the authors recommended any change in management with regard to fishing within EFH.

#### **4.1.5 Evaluation of Effects on EFH of BSAI Crab Species**

This section evaluates whether the fisheries, as they are currently conducted off 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. 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 related 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 (40 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 following text summarizes the results of the analysis for each managed species.

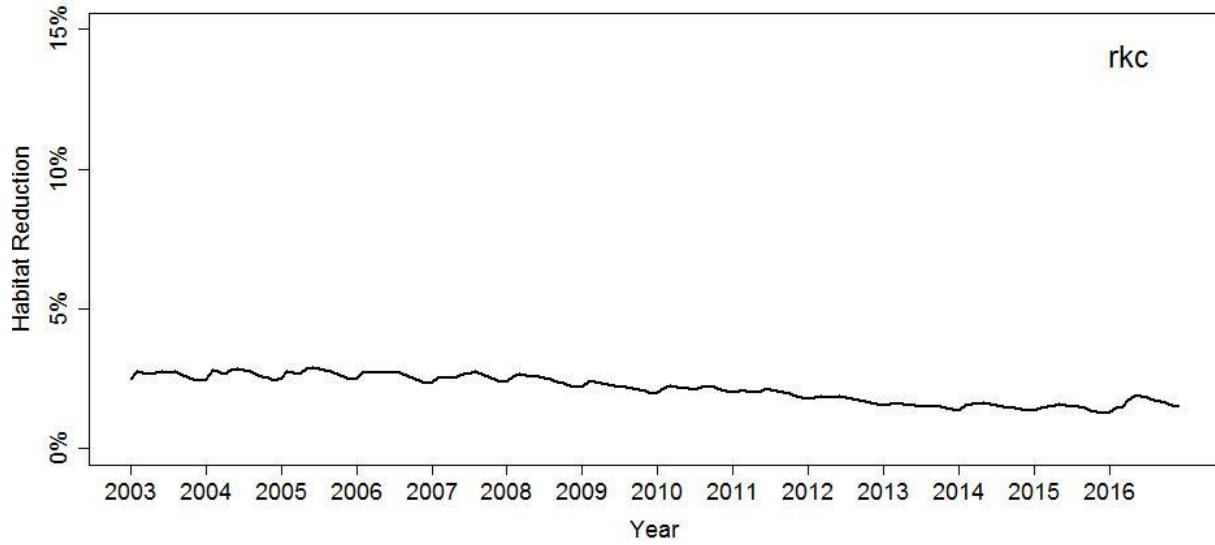
##### **4.1.5.1 Red King Crab**

The first step in the three-tiered approach is to determine whether or not the stock is below MSST. There are three red king crab stocks in the eastern Bering Sea: Bristol Bay, Norton Sound, and Pribilof Islands. In the 2016 assessments (Hamazaki and Zheng, 2016; Turnock, Szuwalski and Foy, 2016; Zheng and Siddeek, 2016), all three stocks were determined to be above MSST.

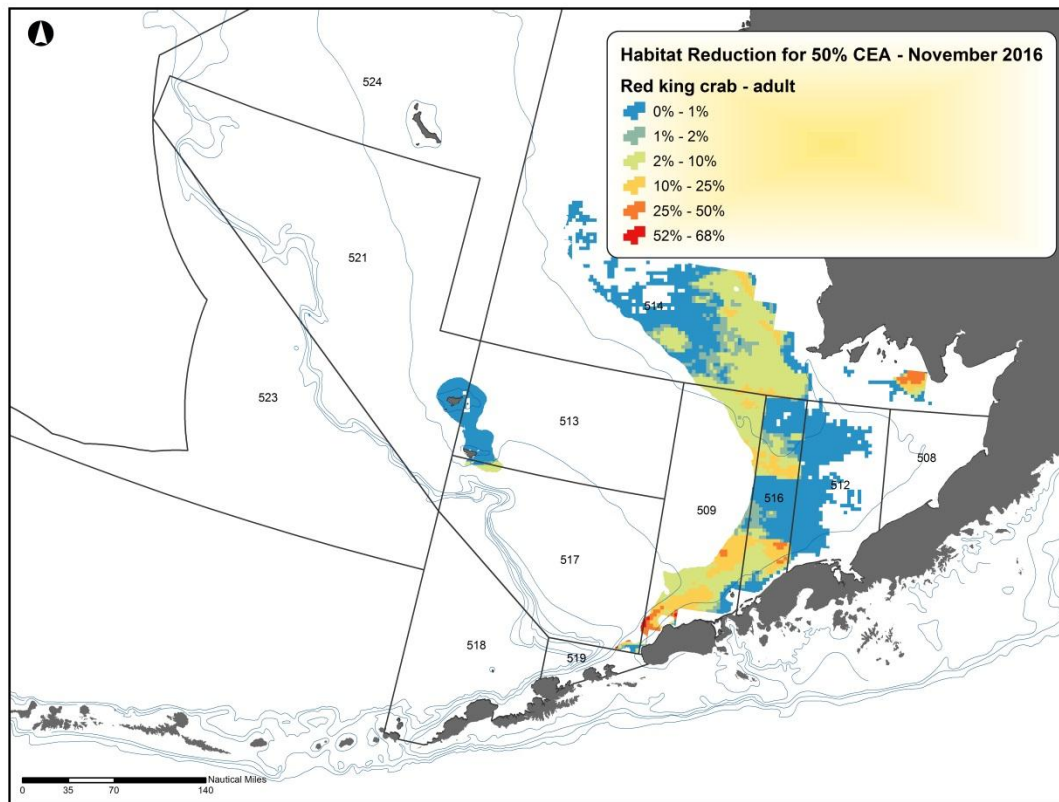
The next step in the three-tiered approach, having determined that the stock is above MSST, is to determine whether or not the amount of habitat disturbed by commercial fishing within the stock's 50 percent quantile Core Essential Area is greater than 10 percent. As shown in Figure 25, the percent habitat reduction with the red king crab Core Essential Area during the 2003-2016 time period has always been less than 10 percent. Because the habitat reduction within the Core Essential Area is less than 10 percent, professional judgement indicates that fisheries do not adversely affect the EFH of the red king crab stocks, and the remaining tiers are not addressed.

A concern was raised regarding the use of the 50 percent Core Essential Area for red king crab stocks. Some habitat is much more important for red king crab spawning success than others. Even though the habitat reduction for all red king crab habitat areas is less than ten percent, the most critical area for Bristol Bay red king crab spawning is southern Bristol Bay, where the habitat reduction is over ten percent (Figure 26). Additional analysis may be beneficial for understanding fishery impacts on Bristol Bay red king crab beyond Figures 25 and 26.

**Figure 25** Estimated time series for the percent habitat reduction in the Core Essential Area for red king crab in the Bering Sea



**Figure 26** Estimated habitat reduction in the Core Essential Area for red king crab in the Bering Sea

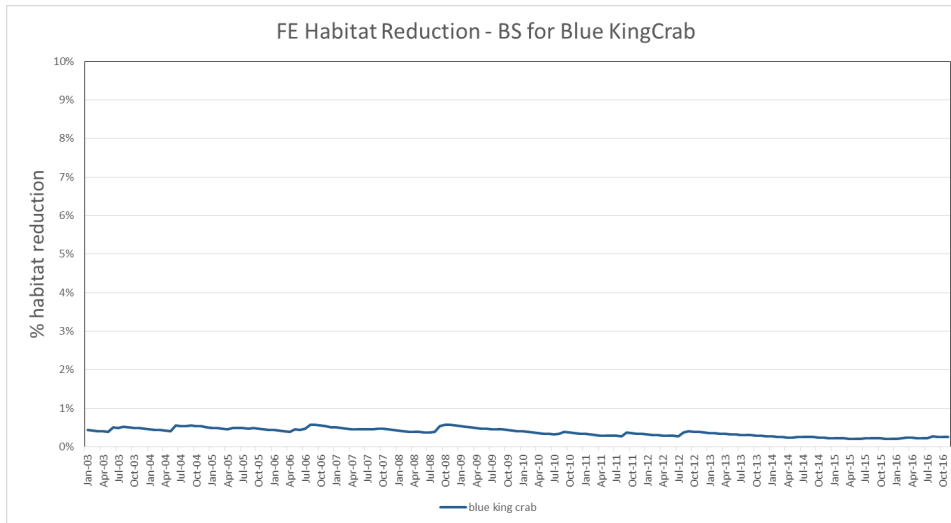


#### 4.1.5.2 Blue King Crab

##### 4.1.5.2.1 Pribilof Islands stock

The first step in the three-tiered approach is to determine whether or not the stock is below MSST. In the 2016 assessment (Stockhausen, 2016), the Pribilof Islands blue king crab (PIBKC) stock was determined to be below MSST. The three-tiered approach is consequently terminated, and the stock should be elevated for possible mitigation. However, habitat reduction in the total Core Essential Area, as well as directly around the Pribilof Islands, appears to be (and have been) less than 1 percent (Figure 27). Thus, it is unlikely that habitat reduction due to commercial fishing plays a role in the decline of the PIBKC stock. Additionally, the Pribilof Islands Habitat Conservation Zone is closed to fishing with either non-pelagic trawl gear or Pacific cod pot gear.

**Figure 27** Estimated time series for the percent habitat reduction in the total Core Essential Area for blue king crab in the Bering Sea (of which the Pribilof Islands is one of three areas)

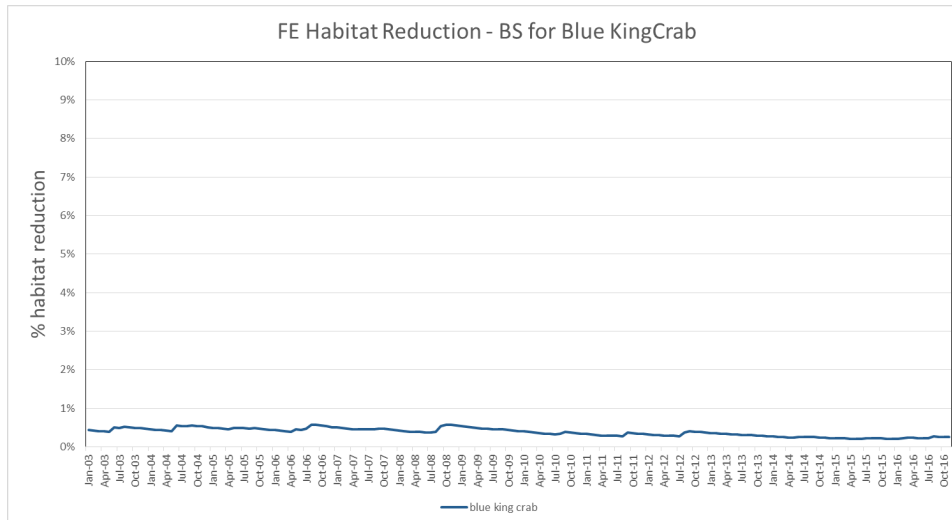


**4.1.5.2.2 St. Matthew Island stock**

The first step in the three-tiered approach is to determine whether or not the stock is below MSST. In the 2016 assessment (Webber et al., 2016), the St. Matthew Pribilof Island blue king crab (SMBKC) stock was determined to be above MSST.

The next step in the three-tiered approach, having determined that the stock is not below MSST, is to determine whether or not the amount of habitat disturbed by commercial fishing within the stock’s 50 percent quantile Core Essential Area is greater than 10 percent. As shown in Figure 28, the percent habitat reduction with the SMBKC Core Essential Area during the 2003-2016 time period has always been less than 10 percent. Because the habitat reduction within its Core Essential Area is less than 10 percent, professional judgement indicates that fisheries do not adversely affect the EFH of the SMBKC stock, and the remaining tiers are not addressed.

**Figure 28** Estimated time series for the percent habitat reduction in the total Core Essential Area for blue king crab in the Bering Sea (of which the St. Matthew Island is one of three areas)



#### 4.1.5.3 Golden King Crab

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

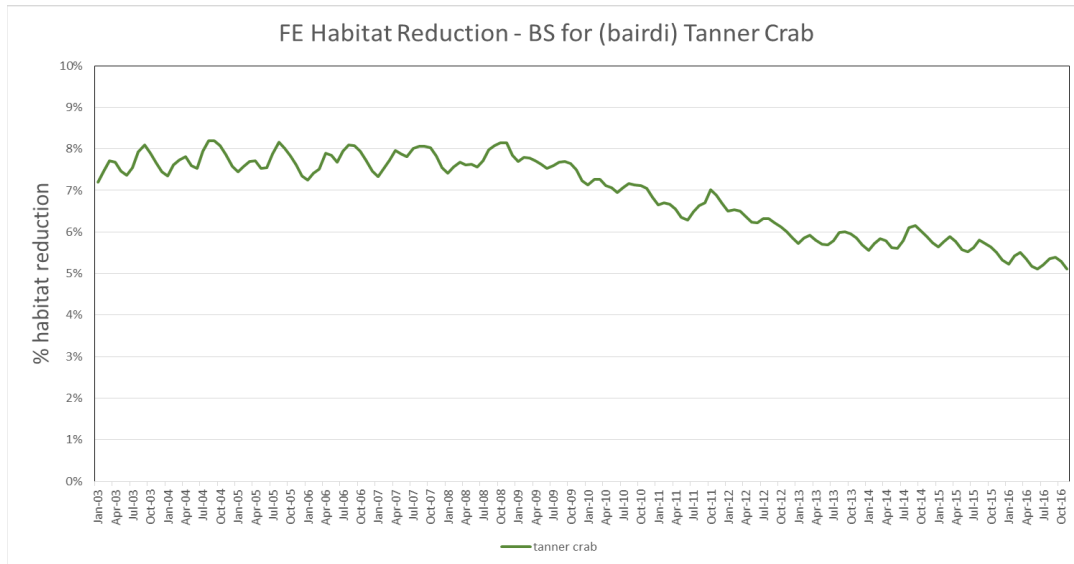
Information was insufficient to conduct the three-tiered approach for golden king crab. However, based on the analysis in the 2005 EFH EIS, fishing activities are considered to have overall minimal and temporary effects on the EFH for golden king crab. Groundfish trawl fishing in the EBS slope is of 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.

#### 4.1.5.4 Tanner Crab

The first step in the three-tiered approach is to determine whether or not the stock is below MSST. In the 2016 assessment (Stockhausen 2016a), the Tanner crab stock was determined to be above MSST.

The next step in the three-tiered approach, having determined that the stock is above MSST, is to determine whether or not the amount of habitat disturbed by commercial fishing within the stock’s 50 percent quantile Core Essential Area is greater than 10 percent. As shown in Figure 29, the percent habitat reduction with the Tanner crab Core Essential Area during the 2003-2016 time period has always been less than 10 percent. Because the habitat reduction within its Core Essential Area is less than 10 percent, professional judgement indicates that fisheries do not adversely affect the EFH of the Tanner crab stock, and the remaining tiers are not addressed.

**Figure 29 Estimated time series for the percent habitat reduction in the Core Essential Area for Tanner crab in the Bering Sea**

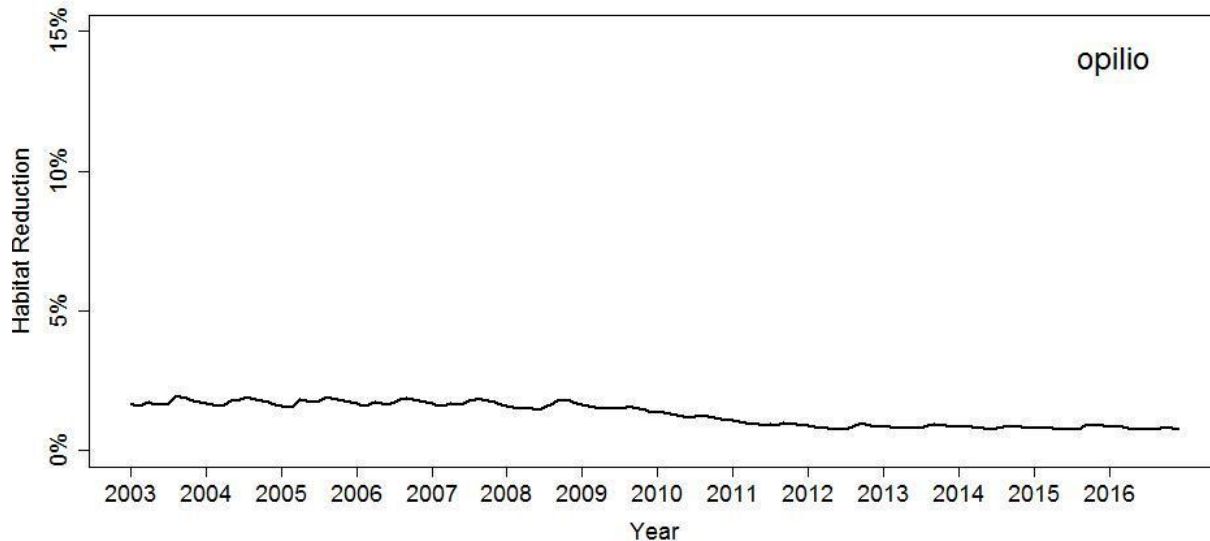


**4.1.5.5 Snow Crab**

The first step in the three-tiered approach is to determine whether or not the stock is below MSST. In the 2016 assessment (Szuwalski and Turnock 2016), the snow crab stock was determined to be above MSST.

The next step in the three-tiered approach, having determined that the stock is above MSST, is to determine whether or not the amount of habitat disturbed by commercial fishing within the stock’s 50 percent quantile Core Essential Area is greater than 10 percent. As shown in Figure 30, the percent habitat reduction with the snow crab Core Essential Area during the 2003-2016 time period has always been less than 10 percent. Because the habitat reduction within its Core Essential Area is less than 10 percent, professional judgement indicates that fisheries do not adversely affect the EFH of the snow crab stock, and the remaining tiers are not addressed.

**Figure 30** Estimated time series for the percent habitat reduction in the Core Essential Area for snow crab in the Bering Sea



#### 4.1.6 Cumulative Effects of Fishing on Essential Fish Habitat

The 2005 EFH FEIS, 2010 EFH Review, and 2015 EFH Review concluded that fisheries do have long term effects on habitat, and these impacts were determined to be minimal and not detrimental to fish populations or their habitats. While the 2010 EFH Review provided incremental improvements to our understanding of habitat types, sensitivity and recovery of seafloor habitat features, these new results were consistent with the sensitivity and recovery parameters and distributions of habitat types used in the prior analysis of fishing effects for the 2005 EFH EIS. None of this new information revealed significant errors in the parameters used in that analysis; rather, it marginally increased support for their validity.

This still left the LEI model well short of a rigorously validated, predictive structure.

The previous EFH analyses, as well as the CIE review, indicated the need for improved fishing effects model parameters. With the FE model, our ability to analyze fishing effects on habitat has grown exponentially. Vessel Monitoring System data provides a much more detailed treatment of fishing intensity, allowing better assessments of the effects of overlapping effort and distribution of effort between and within grid cells. The development of literature-derived fishing effects database has increased our ability to estimate gear-specific susceptibility and recovery parameters. The distribution of habitat types, derived from increased sediment data availability, has improved. The combination of these parameters has greatly enhanced our ability to estimate fishing impacts.

In April 2016, the SSC recommended that new methods and criteria be developed to evaluate whether the effects of fishing on EFH are more than minimal and not temporary. Criteria were developed by NMFS and researchers at Alaska Pacific University, and reviewed by the Council and its advisory committees in 2016, and the stock assessment authors in 2017. In April 2017,

based on the analysis with the FE model, the Council concurred with the Plan Team consensus that the effects of fishing on EFH do not currently meet the threshold of more than minimal and not temporary, and mitigation action is not needed at this time.

While these analyses found no indication that continued fishing activities at the current rate and intensity would alter the capacity of EFH to support healthy populations of managed species over the long term, the Council acknowledges that scientific uncertainty remains regarding the consequences of habitat alteration for the sustained productivity of managed species. Consequently, the Council has adopted, and NMFS has implemented, a number of management measures designed to reduce adverse impacts to habitat.



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

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

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

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

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

Table 14 identifies activities other than fishing that may adversely affect EFH and identifies known and potential adverse effects to EFH. More information on these activities and the potential adverse effects is provided in the non-fishing impacts report (Limpinsel et al. 2017).

**Table 14 Summary on Non-Fishing Effects on Habitat**

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

\* - short term impact

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

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

As previously identified in Section 4.4 EFH-EIS (NMFS 2005), historical fishing practices may have had effects on EFH that have led to declining trends in some of the criteria examined (Table 4.4-1). For fishing impacts to EFH, the FE model calculates habitat reductions at a monthly time step since 2003 and incorporates susceptibility and recovery dynamics, allowing for an assessment of cumulative effects from fishing activities for the first time. As identified in Section 5, the effects of current fishing activities on EFH are considered as minimal and temporary or unknown using the new methods.

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

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

## 7 Research Approach for EFH

The EFH EIS (NMFS 2005) identified a research approach for EFH regarding minimizing fishing impacts. The research approach was revised in 2010 following the Council's EFH 5-year Review for 2010, documented in a Final Summary Report (NPFMC and NMFS 2010).

### ***Objectives***

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

**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***

- Fishing effort data from observers and remote sensing would be used to study changes in bottom trawl and other fishing gear activity in the closed (and open) areas. Effects of displaced fishing effort would have to be considered. The basis of comparison would be changes in the structure and function of benthic communities and populations, as well as important physical features of the seabed, after comparable harvests of target species are taken with each gear type.
- Monitor the structure and function of benthic communities and populations in the newly closed areas, as well as important physical features of the seabed, for changes that may indicate recovery of benthic habitat. Whether these changes constitute recovery from fishing or just natural variability/shifts requires comparison with an area that is undisturbed by fishing and otherwise comparable.
- Validate the LEI model and improve estimates of recovery rates, particularly for the more sensitive habitats, including coral and sponge habitats in the Aleutian Islands region,

possibly addressed through comparisons of benthic communities in trawled and untrawled areas.

- Obtain high resolution mapping of benthic habitats, particularly in the on-shelf regions of the Aleutian Islands.
- Time series of maturity at age should be collected to facilitate the assessment of whether habitat conditions are suitable for growth to maturity.
- In the case of red king crab spawning habitat in southern Bristol Bay, research the current impacts of trawling on habitat in spawning areas and the relationship of female crab distribution with respect to bottom temperature.

### ***Research Time Frame***

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

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