Appendix C to the Environmental Assessment for Amendment to the Fishery Management Plan for Bering Sea and Aleutian Islands King and Tanner Crab Fishery Management Plan.

Proposed amendment to the BSAI Crab FMP - amendment text for updating EFH description, fishing effects, non-fishing impacts to EFH, and updating EFH research objectives (EFH Omnibus Amendment).

Make the following changes to the Fishery Management Plan for Bering Sea/Aleutian Islands King and Tanner Crabs. When edits to existing sections are proposed, words indicated with strikeout (e.g., ~~strikeout~~) should be deleted from the FMP, and words that are underlined (e.g., underlined) should be inserted into the FMP. Instructions are italicized and highlighted.

1. ***In the Executive Summary, in the text box titled "Amendments to the BSAI King and Tanner Crab FMP", insert the following description of this amendment in sequential order:***

   Update EFH descriptions based on five year review.

2. ***Replace Appendix F, Essential Fish Habitat and Habitat Areas of Particular Concern, with the new Appendix F.***

3. ***Update the Table of Contents for the FMP.***

Appendix F to the BSAI KTC FMP: Essential Fish Habitat (EFH) and Habitat Areas of Particular Concern (HAPC)

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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 amendmending this portion of the FMP.

From 2010 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.

The 2023 EFH 5-year Review spanning 2018-2023, builds on the work from the previous EFH Reviews, including the EFH roadmap, review process, and using species distribution models to map EFH and the Fishing Effects model in the evaluation of fishing effects to EFH, which was documented in the Final EFH 5-year Review Summery Report (Harrington et al. 2023). In this review, we are evaluating new environmental and habitat data, improving the models to map EFH, updating the model to evaluate fishery impacts on EFH, updating the assessment of non-fishing impacts on EFH, and assessing information gaps and research needs. The Council identified various elements of the EFH descriptions meriting revision, and recommended omnibus amendments for BSAI groundfish, GOA groundfish, BSAI crab, the Arctic, and salmon.

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 (BS) 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 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 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).

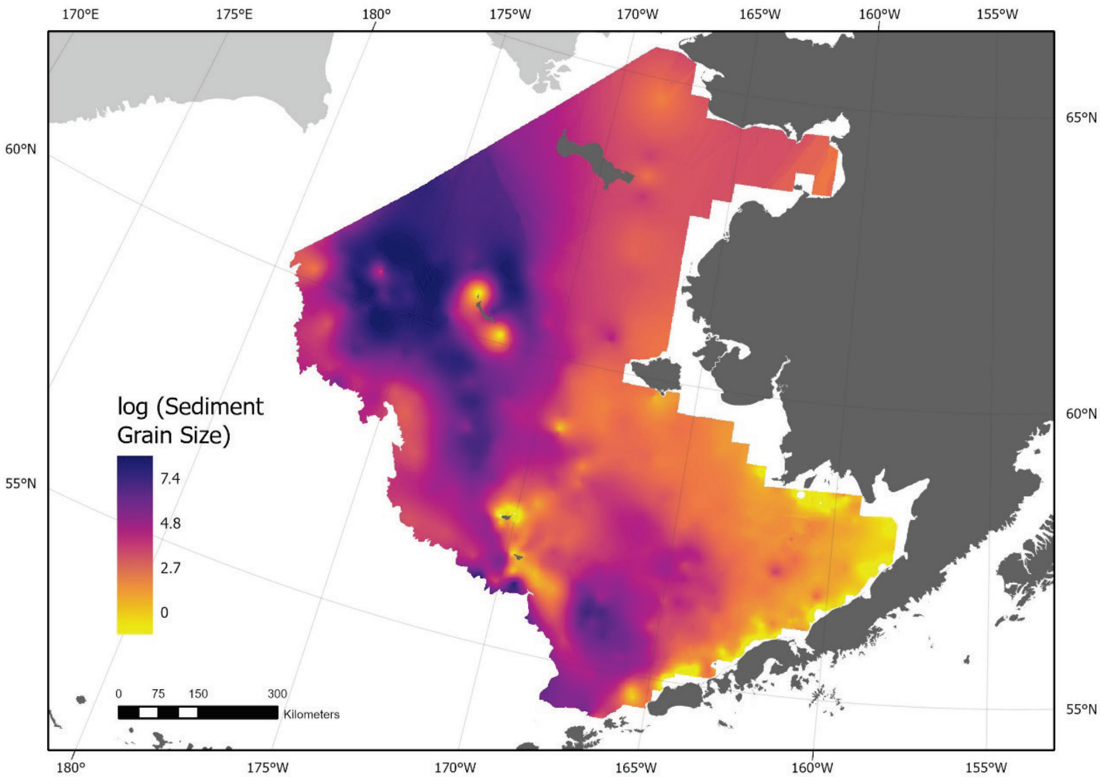
The vertical physical system regulates the biological processes leading to different cycles of nutrient regeneration. The source of nutrients for the outer shelf is the deep oceanic water; for the mid-shelf, it is the shelf-bottom water. In winter, surface waters across the shelf are high in nutrients. 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 climate change 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_2, 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_2 (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, and continued periodic warming events occurring through 2020. For more information on the physical environment of the EBS, refer to the Alaska Groundfish Fisheries Programmatic Supplemental EIS (NMFS 2004), and the ecosystem status report (ESR) (Siddon, 2022).

Figure 2-1 Distribution of Bering Sea sediments by grain size



Aleutian Islands

The AIs 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, and 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.

Adult Stage

Adult 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 2-1 Summary of habitat associations for BSAI crab species

BSAI Crab Species		Nearshore				Shelf			Slope						Stratum Reference							Location						
						Inner	Middle	Outer	Upper		Inter-mediate		Lower	Basin												Pelagic		
	Life Stage	Freshwater	Estuarine	Intertidal	Subtidal	1-50m	51-100m	101-200m	201-300m	301-500m	501-700m	701-1000m	1001-3000m	>3000m	Shallows	Island Pass	Bay/Fjord	Bank	Flat	Edge	Gully	Surafce	Near surface	Semi-demersal	Demersal	1-200m (epi)	201-1000m (meso)	>1000m (bathy)
Blue King Crab	A					x	x	x																	x			
	LJ					x	x	x																	x			
	EJ			x	x	x	x																		x			
	L					x	x																			x		
	E					x	x	x																	x			
Golden King Crab	A							x	x	x	x	x				x		x							x			
	LJ												x	x				x							x			
	EJ												x	x											x			
	L																											
	E							x	x	x	x							x							x			
Red King Crab	A					x	x	x																	x			
	LJ					x	x	x																	x			
	EJ			x	x	x	x																		x			
	L					x	x																			x		
	E					x	x	x																	x			
Snow Crab	A					x	x	x																	x			
	LJ					x	x	x																	x			
	EJ					x	x																		x			
	L					x	x																			x		
	E					x	x	x																	x			
Tanner Crab	A					x	x	x	x	x	x						x	x							x			
	LJ			x	x	x	x	x	x									x							x			
	EJ			x	x	x	x	x										x							x			
	L		x	x	x	x	x																			x		
	E				x	x	x	x	x	x															x			

BSAI Crab Species		Physical Oceanography					Substrate													Structure										Comm			
	Life Stage	Upwelling areas	Gyres	Thermo/pycnocline	Fronts	Edges (ice, bath)	Organic Debris	Mud	Sand	Gravel	Mud & sand	Mud & gravel	Sand & mud	Gravel & mud	Gravel & sand	Gravel & sand & mud	Gravel & mud & sand	Cobble	Rock	Bars	Sinks	Slumps\Rockfalls\Debris	Channels	Ledges	Pinnacles	Seamounts	Reefs	Vertical Walls	Man-made	Algal Cover	Anenomes	Enchinoderms	Soft Coral
Blue King Crab	A							x	x	x								x	x			x	x	x	x		x	x			x	x	x
	LJ							x	x	x								x	x			x	x	x	x		x	x			x	x	x
	EJ																	x	x														
	L																																
	E								x	x								x	x			x	x	x	x		x	x			x	x	x
Golden King Crab	A								x	x								x	x			x	x	x	x	x	x	x			x	x	x
	LJ								x	x								x	x			x	x	x	x		x	x			x	x	x
	EJ																																
	L																																
	E								x	x								x	x			x	x	x	x		x	x			x	x	x
Red King Crab	A						x	x	x	x	x	x	x	x	x	x	x														x	x	x
	LJ						x	x	x	x	x	x	x	x	x	x	x														x	x	x
	EJ									x								x	x											x			
	L																																
	E						x	x	x	x	x	x	x	x	x	x	x														x	x	x
Snow Crab	A						x	x	x	x	x	x	x	x	x	x	x																
	LJ						x	x	x	x	x	x	x	x	x	x	x																
	EJ						x	x	x	x	x	x	x	x	x	x	x																
	L																																
	E						x	x	x	x	x	x	x	x	x	x	x																
Tanner Crab	A				x		x	x	x	x	x	x	x	x	x	x	x	x		x	x	x	x						x		x	x	x
	LJ			x	x		x	x	x	x	x	x	x	x	x	x	x	x		x	x	x	x						x		x	x	x
	EJ						x	x	x	x	x	x	x	x	x	x	x	x		x	x	x	x						x		x	x	x
	L			x	x	x																											
	E				x		x	x	x	x	x	x	x	x	x	x	x	x		x	x	x	x						x		x	x	x

Table 2-2 Summary of reproductive traits of BSAI crab species

BSAI Crab Species	Life Stage	Reproductive Traits																			
		Age at Maturity				Fertilization/Egg Development					Spawning Behavior						Spawn				
		Female		Male																	
		50%	100%	50%	100%	External	Internal	Oviparous	Ovoviviparous	Viviparous	Batch Spawner	Broadcast Spawner	Egg Case Deposition	Nest Builder	Egg/Young Guarder	Egg/Young Bearer	January	February	March	April	May
Blue King Crab	A	6+		6+		x		x								x	x	x	x	x	x
	LJ																				
	EJ																				
	L																				
	E																				
Golden King Crab	A	6+			6+	x		x								x	x	x	x	x	x
	LJ																				
	EJ																				
	L																				
	E																				
Red King Crab	A	7 to 8		7 to 10		x		x								x	x	x	x	x	x
	LJ																				
	EJ																				
	L																				
	E																				
Snow Crab	A	5 to 6		6 to 8		x	x	x								x	x	x	x	x	x
	LJ																				
	EJ																				
	L																				
	E																				
Tanner Crab	A	5 to 7		6 to 8		x	x	x								x	x	x	x	x	x
	LJ																				
	EJ																				
	L																				
	E																				

Table 2-3 Summary of predator and prey associations for BSAI crab species

Predator to

BSAI Crab Species	Life Stage	Algae	Plants	Plankton	Zooplankton	Diatoms	Sponges	Eusphausiid	Hydroids	Amphipoda	Copepods	Starfish	Polychaetes	Squid	Philodae (gunnels)	Bi-valves	Other - Mollusks	Crustaceans	Ophiuroids (brittle stars)	Shrimps, mysidacae	Sand lance	Osmerid (eulachon)	Herring	Myctophid (lantern fishes)	Cottidae (sculpins)	Arrowtooth	Salmon	Cod	Pollock	Halibut
Blue King Crab	A	x							x			x	x			x	x	x	x	x										
	LJ	x							x			x	x			x	x	x	x	x										
	EJ																													
	L			x	x																									
	E																													
Golden King Crab	A								x			x	x			x	x	x	x											
	LJ								x			x	x			x	x	x	x											
	EJ						x		x	x			x					x	x											
	L																													
	E																													
Red King Crab	A								x			x	x			x	x	x	x	x										
	LJ								x			x	x			x	x	x	x	x										
	EJ	x				x			x	x	x		x					x												
	L	x		x	x																									
	E																													
Snow Crab	A												x			x	x	x	x	x										
	LJ								x				x			x	x	x	x	x										
	EJ								x	x			x					x												
	L			x	x																									
	E																													
Tanner Crab	A								x			x	x			x	x	x		x										
	LJ								x			x	x			x	x	x		x										
	EJ																													
	L	x		x	x	x																								
	E																													

Prey of

BSAI Crab Species	Life Stage	Jellyfish	Starfish	Chaetognaths (arrowworms)	Crab	Herring	Salmon	Pollock	Pac fic Cod	Ling Cod	Rockfish	Rock Sole	Flathead Sole	Yellowfin sole	Arrowtooth flounder	Skate	Hailbut	Cottidae (sculpins)	Eel pouts	Salmon Shark	Northern Fur Seal	Harbor Seal
Blue King Crab	M								x								x					
	LJ				x				x								x					
	EJ				x				x								x					
	L																					
	E																					
Golden King Crab	M								x								x					
	LJ								x								x					
	EJ								x								x					
	L																					
	E																					
Red King Crab	M							x	x								x					
	LJ				x			x	x			x	x	x	x	x	x					
	EJ				x			x	x			x	x	x	x	x	x	x				
	L						x															
	E																					
Snow Crab	M				x				x									x				
	LJ				x				x			x	x		x	x	x	x	x			
	EJ				x				x									x	x			
	J																					
	L																					
Tanner Crab	M				x				x									x	x			
	LJ				x			x	x		x	x	x	x	x	x	x	x	x			
	EJ				x			x	x		x	x	x		x	x	x	x	x			
	L	x		x		x	x	x						x								
	E																					

Abbreviations used in the habitat tables to specify location, position in the water column, bottom type, and other oceanographic features are provided in Table 2-4.

Table 2-4 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

2.3 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. In the 2023 SDM EFH maps, the covariates contributing most to the map for all blue king crab life stages from summer bottom-trawl surveys in the eastern Bering Sea were geographic location, sediment grain size, bottom depth, and currents (Laman et. al. 2022). Predicted BKC abundance increased in waters shallower than 150 m depth, lower maximum tidal current, and with bottom current flow toward the northeast, and decreased with decreasing average sediment grain size.

Blue king crab molt multiple times a year as newly-settled juveniles and molting frequency decreases with crab age. 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 (molting less than once per year) 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 into nearshore areas in spring to mate, then move offshore to deeper waters and soft-bottomed habitats.

Relevant Trophic Information

Pacific cod is a predator of 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 10 to 60 m depths. Shell hash appears to be a particularly important substrate type for this species. 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.

Adult: Adult 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 2-5 Blue king crab, *Paralithodes platypus (abbreviations are in* Table 2-4*).*

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

2.4 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, AI golden king crab are found at depths from 300 to 1,000 m, generally in high relief habitat such as inter-island passes, and they are usually slope-dwelling. Male size-at-maturity varies among stocks (Webb 2014) and declines with increasing latitude from about 13.0 cm carapace length (CL) in the AIs to 9.2 cm CL in the northern BS. Depending on their size, females can carry up to 20,000 eggs. Spawning appears to be non-synchronous and occurs throughout the year. Females carry large, yolk-rich, eggs, which hatch into lecithotrophic larvae (i.e., the non-pelagic larvae can develop successfully to juvenile crab without eating; but it is not known where they reside in the water column. In the 2023 SDM EFH maps, the top contributing covariates to the prediction map for all golden king crab life stages from summer bottom-trawl surveys in the Aleutian Islands were bottom depth, geographic location, and bottom current (Harris et. al. 2022). In general, predicted GKC abundance increased with depth, northeasterly bottom currents, strong tidal currents, and rocky terrain. Encounter probability from the SDM ensemble was high in the island passes, consistent with the modeled covariate effects for deep water and stronger currents.

Relevant Trophic Information

Unknown

Approximate Upper Size Limit of Juvenile Crab (in cm): The carapace length (CL) at 50 percent maturity for females and males, respectively: AIs 11 and 13 cm, Pribilof Islands 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: Early juvenile stage golden king crabs are cryptic and have been observed in complex habitats of rock crevices, course substrates, and structural invertebrates.

Late Juvenile: Late juvenile golden king crab 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.

Adult: 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 size male (6in, 15.24 cm, carapace width) 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 2-6 Golden king crab, *Lithodes aequispina (abbreviations are in* Table 2-4*)*

Life Stage	Duration or Age	Diet/Prey	Season/ Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs	15 mo.	n/a	all year	LSP	D	N/A		
Larvae		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		

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

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, and may decline to less than annual for older crab as king crab may skip molt as growth slows at larger sizes. 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 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. The covariates contributing the most to the 2023 species distribution model (SDM) EFH maps for all red king crab life stages from summer bottom-trawl surveys in the eastern Bering Sea were tidal current, bottom depth, geographic location and sediment grain size (Laman et al. 2022). Predicted RKC abundance was highest in shallow Bristol bay waters (~100 m depth), and peaks in abundance at depths around 350 m and in finer sediment grain sizes.

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 predators 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 7 and 9 cm CL for female and male red king crabs, respectively, from Norton Sound and St. Matthew and St. Lawrence Islands. In comparison, size at 50 percent maturity is approximately 9 cm for females and 12 cm for males in Bristol Bay and the Pribilof and AIs.

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 may occur at depths of 50 m or less.

Late Juvenile: Late juvenile stage red king crabs of 2 to 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.

Adult: Adult red king crabs exhibit seasonal migration to shallow waters for reproduction. The remainder of the year, red king crab 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. Migration patterns in Norton Sound remain poorly understood.

Table 2-7 Red king crab, *Paralithodes camtschaticus (abbreviations are in* Table 2-4*)*

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 Starfish,Polychaete,Bi-valves, Mollusks,Crustaceans,Brittle stars, Shrimp,	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	

2.6 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. In the 2023 SDM EFH maps, the covariates contributing the most for all snow crab life stages from summer bottom-trawl surveys in the eastern Bering Sea were bottom depth, bottom temperature, geographic location, currents (Laman et. al. 2022). Predicted snow crab abundance was highest over the middle and inner shelf domains with waters around 0°C in depths less than 300 m and with maximum tidal current around 30 $cm \cdot s^{-1}$.

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.

Adult: Adult 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 2-8 **Snow crab, *Chionoecetes opilio* (abbreviations are in Table 2-4)**

Life Stage	Duration or Age	Diet/Prey	Season/ Time	Location	Water Column	Bottom Type	Oceano-graphic 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	

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

Life History and General Distribution

Tanner crab (*Chionoecetes bairdi*) are distributed on the continental shelf of the North Pacific Ocean and BS from Hokkaido, Japan to Oregon, USA. Off Alaska, Tanner crab are concentrated around the Pribilof Islands and immediately north of the Alaska Peninsula. In the 2023 SDM EFH maps, the covariates contributing the most for all tanner crab life stages from summer bottom-trawl surveys in the eastern Bering Sea were geographic location, bottom depth, and sediment grain size (Laman et. al. 2022). Tanner crab abundance was highest in the southern portions of the EBS over the outer and middle shel domains with a peak in depths around 150 m over moderately fine sediments. They occur in lower abundance in the GOA.

Prior to settlement in muddy benthic habitats, Tanner crab undergo a dispersive pelagic larval phase after hatching from eggs attached to the abdomen of a female crab. Both temperature and depth have strong effects on subsequent benthic spatial distributions; 2° C is an approximate minimum temperature threshold for Tanner crab habitat (Murphy, 2020). After settlement, Tanner crab are demersal and grow to maturity through a variable number of molts, the final molt to maturity being a terminal molt after which they cease to grow. Indiciual size at maturity is variable, but size at 50 percent mature is approximately 11 cm carapace width (CW) for males and 8 cm CW for females in the BS. The age of maturity for male Tanner crab is estimated at 6 to 8 years. Natural mortality of adult Tanner crab is estimated to be about 25 percent per year (M=0.3).

Relevant Trophic Information

Pacific cod are the main predators on Tanner crabs in terms of biomass primarilyconsumingjuvenile Tanner crab less than 7 cm CW (post-settlement ages 0-3 years). In terms of abundance, however, flathead sole, rock sole, halibut, skates, and yellowfin sole consume far greater numbers of the smallest benthic crab. Larval predators include salmon, herring, jellyfish, and chaetognaths.

Approximate Upper Size Limit of Juvenile Crab (in cm): The size at 50 percent maturity in the BS is 8- and 11cm CW for females and males, respectively. Juvenile males larger than 14.5 cm CW are rare

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 late spring and 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 preferentially onto the mud bottom on the shelf (10-70m).

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, expanding into deeper water (up t0 ~200m), as well as moving along the shelf from northwest to southeast

Adult: Adult *C. bairdi* Tanner crabs likely undergo seasonal migration from deeper offshore areas to shallower inshore areas for mating, which occurs from February through June. Mature female *C. bairdi* Tanner crabs can form high density mating aggregations, or pods, consisting of hundreds of crabs that form a 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 2-9 Tanner crab, *Chionoecetes bairdi (abbreviations are in* Table 2-4*)*

Life Stage	Duration or Age	Diet/Prey	Season/ Time	Location	Water Column	Bottom Type	Oceano-graphic 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	

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, 2017, and 2023 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, Simpson et al. 2017, Harrington et al. 2023, Pirtle et al. 2023, Limpinsel et al. 2023, and Zaleski et al. 2023). 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 3-1. An "0" means that insufficient information is available to determine EFH for the life stage, a "1" means information is available to determine EFH, and a "2" means that habitat-related density or abundance information is available to determine EFH for the life stage.

Table 3-1 EFH information levels currently available for BSAI crab, by life history stage.

BSAI Crab Species	Egg	Larvae	Early Juvenile	Late Juvenile	Adult
Blue king crab	inferred	0	1	2	
Golden king crab	inferred	0	0	2	
Red king crab	inferred	0	1	2	
Snow crab	inferred	0	0	2	
Tanner crab	inferred	0	0	2	

0 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 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 continental shelf (0 to 100 m depth). 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 m depth), middle (50 to 100 m depth), and outer continental shelf (100 to 200 m depth) 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 depth), middle (50 to 100 m depth), and outer continental shelf (100 to 200 m depth) throughout the BSAI wherever there are substrates consisting of sand and mud adjacent to rockier areas and areas of shell hash.

3.1.2 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 upper continental slope (200 to 500 m depth), intermediate slope (500 to 1,000 m depth), lower slope (1,000 to 3,000 m depth), and basins (more than 3,000 m depth) of the BSAI where there are high-relief living habitats, such as coral and sponges, 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 inner continental shelf (100 to 200 m depth), upper continental slope (200 to 500 m depth), intermediate slope (500 to 1,000 m depth), lower slope (1,000 to 3,000 m depth), and basins (more than 3,000 m depth) of the BSAI where there are high relief living habitats, such as coral and sponges, and vertical substrates such as boulders, vertical walls, ledges, and deep water pinnacles.

3.1.3 Red King Crab

Eggs
Essential fish habitat of 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 depth). 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 are generally thought to occur mainly 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 species, as late juveniles move from nearshore waters to deeper habitats along the inner (0 to 50 m depth), middle (50 to 100 m depth), and outer continental shelf (100 to 200 m depth) 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 depth), middle (50 to 100 m depth), and outer continental shelf (100 to 200 m depth) throughout the BSAI wherever there are substrates consisting of sand, mud, cobble, and gravel.

3.1.4 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 depth), middle (50 to 100 m depth), and outer continental shelf (100 to 200 m depth) throughout the BSAI wherever there are substrates consisting mainly of mud and other fine grain sizes.

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 depth), 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 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.

3.2 Maps of Essential Fish Habitat

The mapping requirements for EFH component 1 descriptions and identification are that some or all portions of the geographic range of the species are mapped (50 CFR 600.815(a)(1)). The EFH regulations provide an approach to organize the information necessary to describe and identify EFH, which should be designated at the highest level possible—

> *Level 1*: Distribution data are available for some or all portions of the geographic range of the species.
> *Level 2*: Habitat-related densities or relative abundance of the species are available.

Level 3: Growth, reproduction, or survival rates within habitats are available (Not available at this time).
Level 4: Production rates by habitat are available (Not available at this time).

New maps of species' habitat-related abundance predicted from species distribution model (SDM) ensembles was used to map EFH Level 2 information for the 2023 EFH 5-year Review for settled early juveniles, subadults, and adults in the summer from their distribution and abundance in AFSC RACE-GAP eastern Bering Sea summer bottom trawl surveys (1982–2019) and Aleutian Islands (1991-2019) summer bottom trawl surveys (Harris et al. 2022, Laman et al., 2022). The new EFH Level 2 maps have replaced the summer SDM EFH maps for species' life stages from the 2017 EFH 5-year Review. EFH maps for other seasons (fall, winter, spring) if available from the 2017 5-year Review will remain.

The definition of EFH area in Alaska is the area containing 95% of the occupied habitat (NMFS 2005). Occupied habitat was defined as all locations where a species' life stage had an encounter probability greater than 5%, where encounter rates were derived from the SDM predictions and used to remove locations that had low encounter probabilities from inclusion in the EFH area (Harris et al. 2022, Laman et al. 2022). The new 2023 EFH maps are presented using percentile areas containing 95%, 75%, 50%, and 25% of the occupied habitat. Each of the EFH subareas describes a more focused partition of the total EFH area. The area containing 75% of the occupied habitat based on SDM predictions is referred to as the "principal EFH area". For the fishing effects analysis (EFH component 2), the area containing 50% of the occupied habitat is termed the "core EFH area". The areas containing the top 25% of the occupied area are referred to as "EFH hot spots". Mapping habitat percentiles for EFH subareas like these helps demonstrate the heterogeneity of crab distributions over available habitat within the larger area identified as EFH.

3.3 Outline

Maps of essential fish habitat (EFH) are included in this section for the following species (life stage is indicated in parentheses, where all indicates all life stages from the RACE-GAP summer bottom-trawl surveys) and EFH information levels (L) 1-2 for the Aleutian Islands (AI) and eastern Bering Sea (EBS) (see Harris et al. 2022 and Laman et al. 2022 for mapping methods):

Figures 3-1 to 3-3	Golden king crab (all, adult), AI • all summer L2 3-1; • adult fall L1 3-2, adult spring L1 3-3.
Figures 3-4	Red king crab (all), AI • all summer L2 3-4
Figures 3-5 to 3-8	Blue king crab (all, adult), EBS • all summer L2 3-5; • adult fall L1 3-6, adult winter L1 3-7, adult spring L1 3-8.
Figures 3-9 to 3-12	Red king crab (all, adult), EBS • all summer L2 3-9; • adult fall L1 3-10, adult winter L1 3-11, adult spring L1 3-12.

Figures 3-13 to 3-16	Snow crab (all, adult), EBS • all summer L2 3-13; • adult fall L1 3-14, adult winter L1 3-15, adult spring L1 3-16.
Figures 3-17 to 3-20	Tanner crab (all, adult), EBS • all summer L2 3-17; • adult fall L1 3-18, adult winter L1 3-19, adult spring L1 3-20.

3.4.1 Aleutian Islands crab EFH maps

3.4.1.1 Golden King Crab

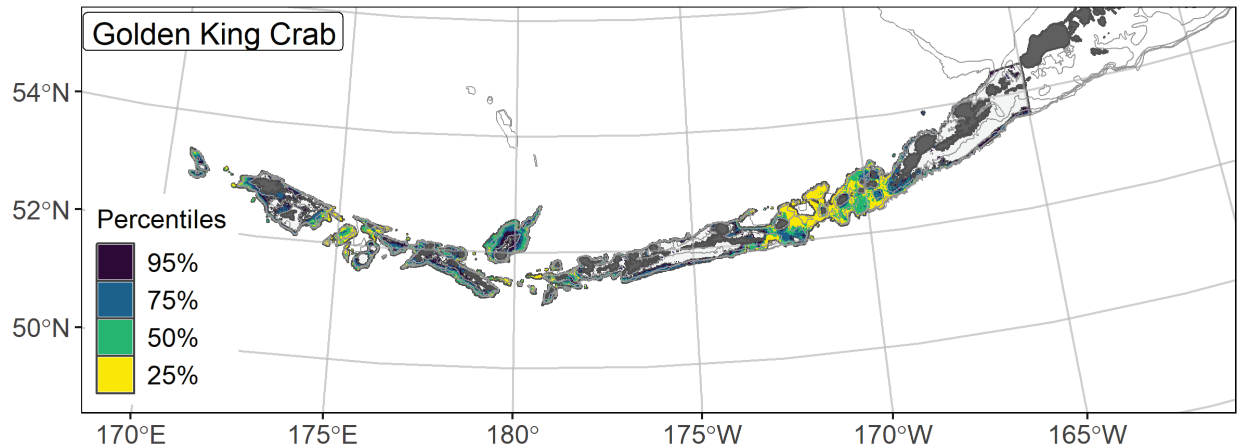


Figure 3-1 AI all life stages Golden king crab, EFH Level 2, summer

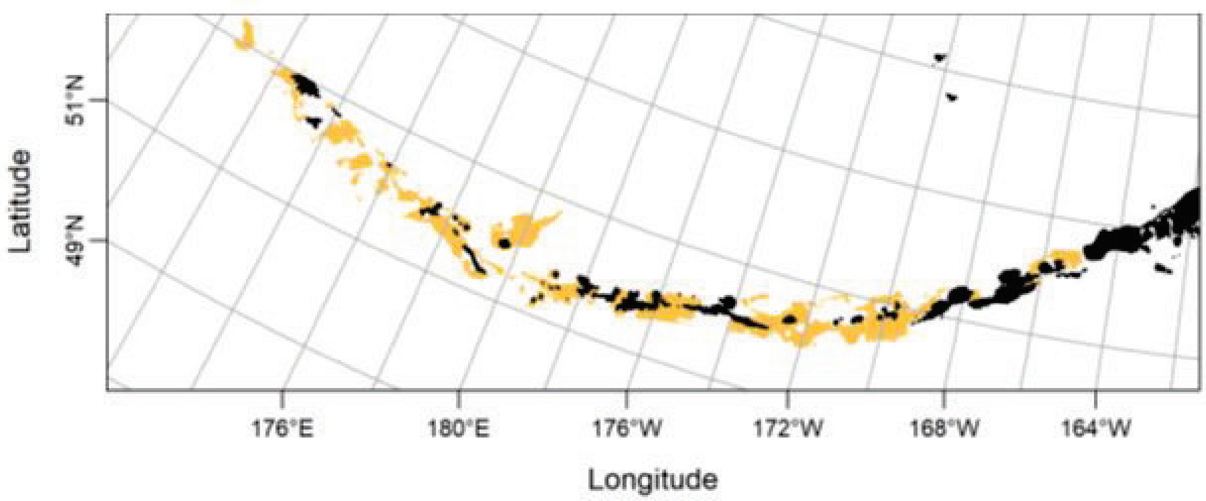


Figure 3-2 AI adult Golden king crab, EFH Level 1, fall

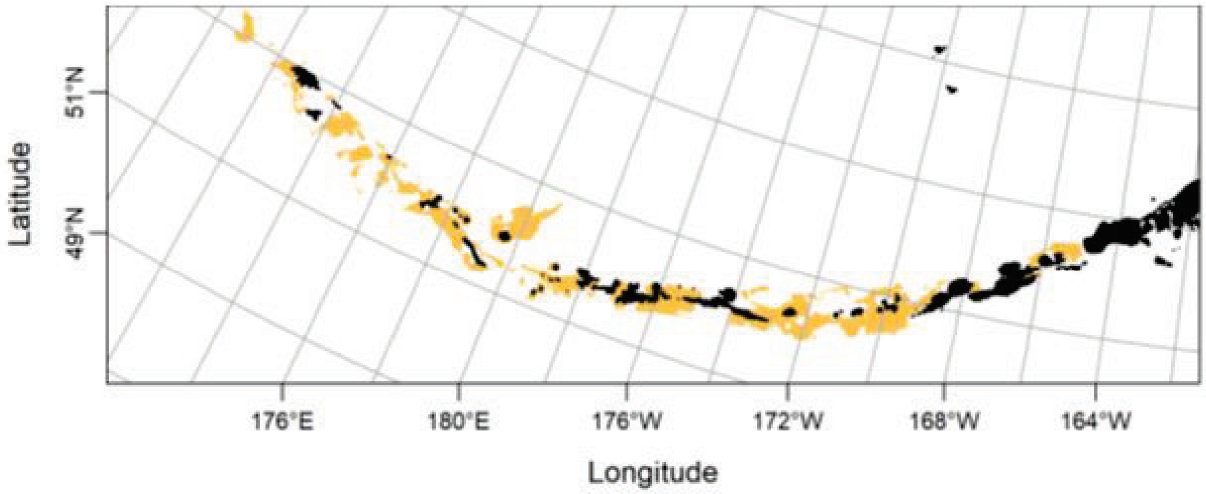


Figure 3-3 **AI adult Golden king crab, EFH Level 1, spring**

3.4.1.2 Red King Crab

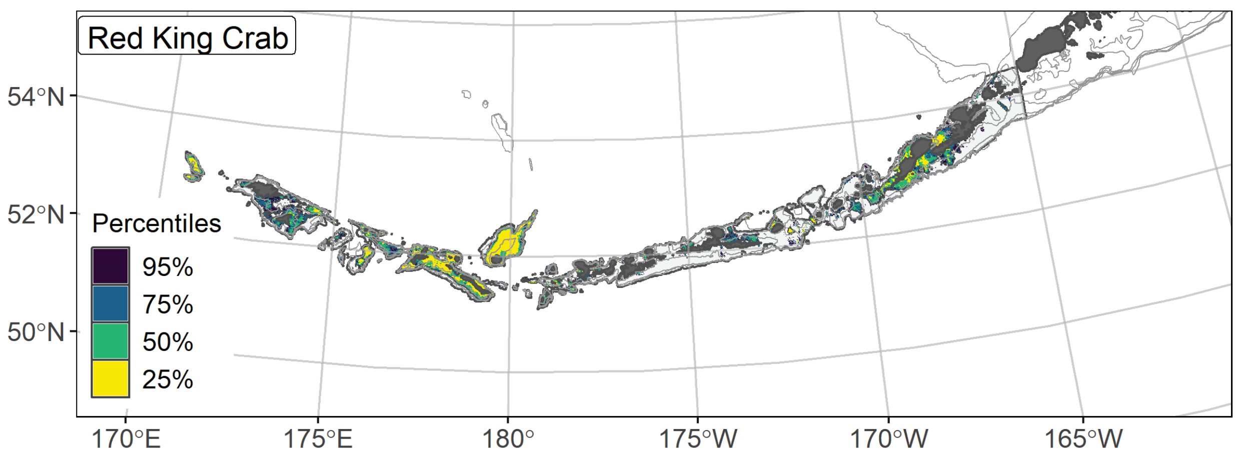


Figure 3-4 **AI all life stages Red king crab, EFH Level 2, summer**

3.4.2 Bering Sea crab EFH maps

3.4.2.1 Blue King Crab

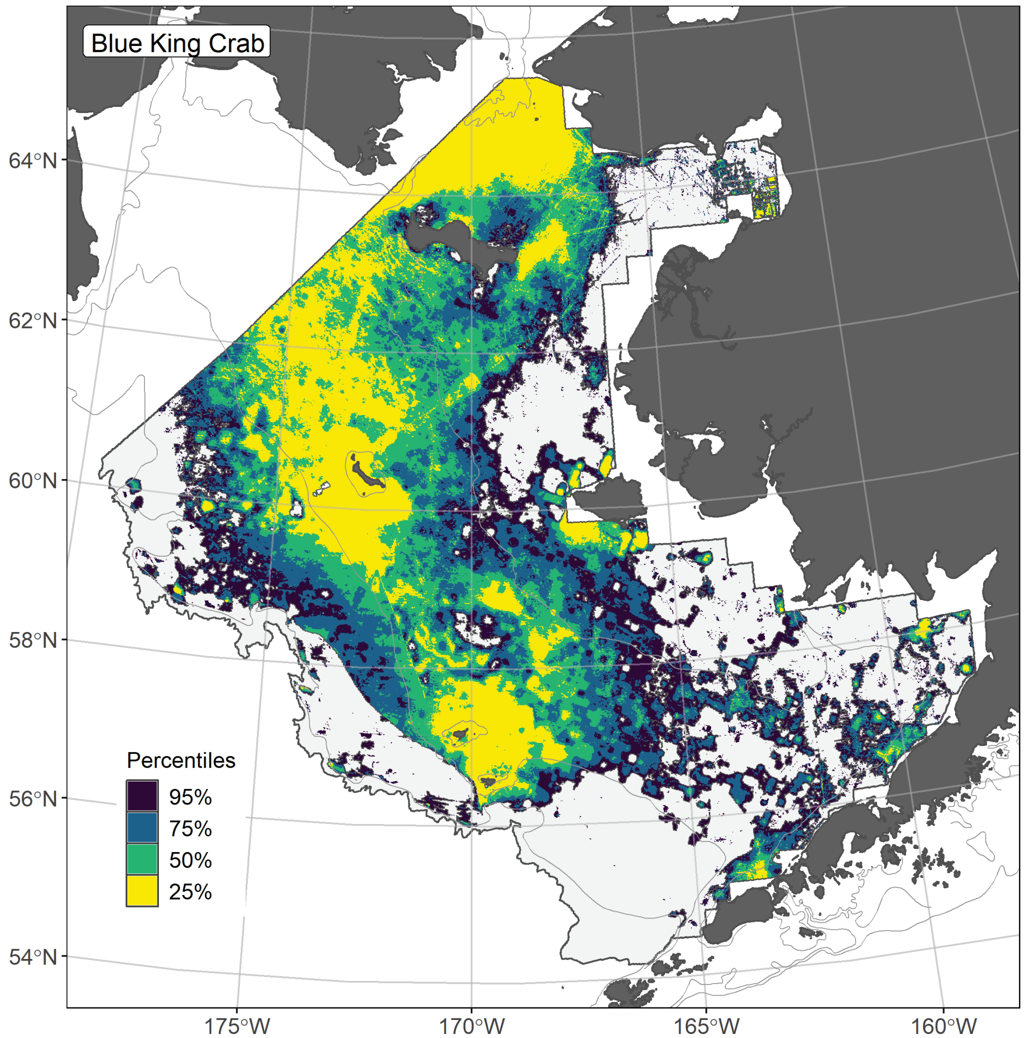


Figure 3-5 **EBS all life stages Blue king crab, EFH Level 2, summer**

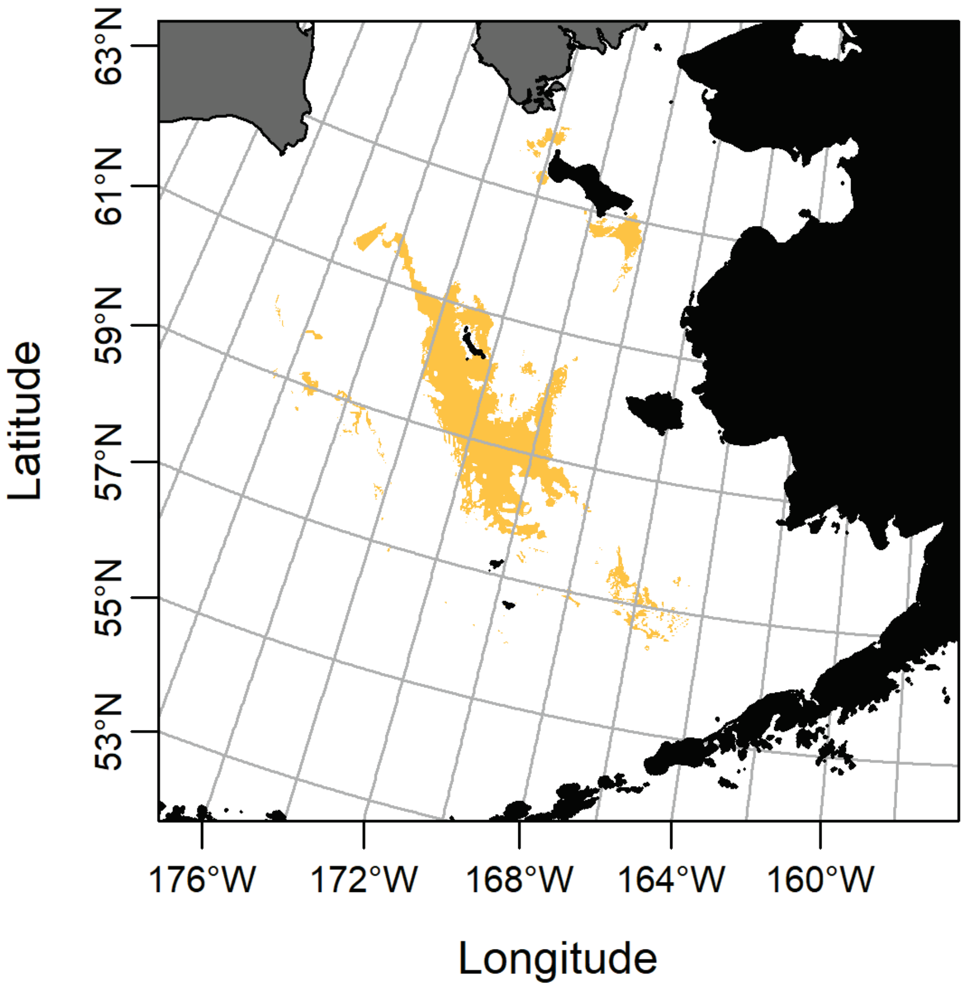


Figure 3-6 **EBS adult Blue king crab, EFH Level 1, fall**

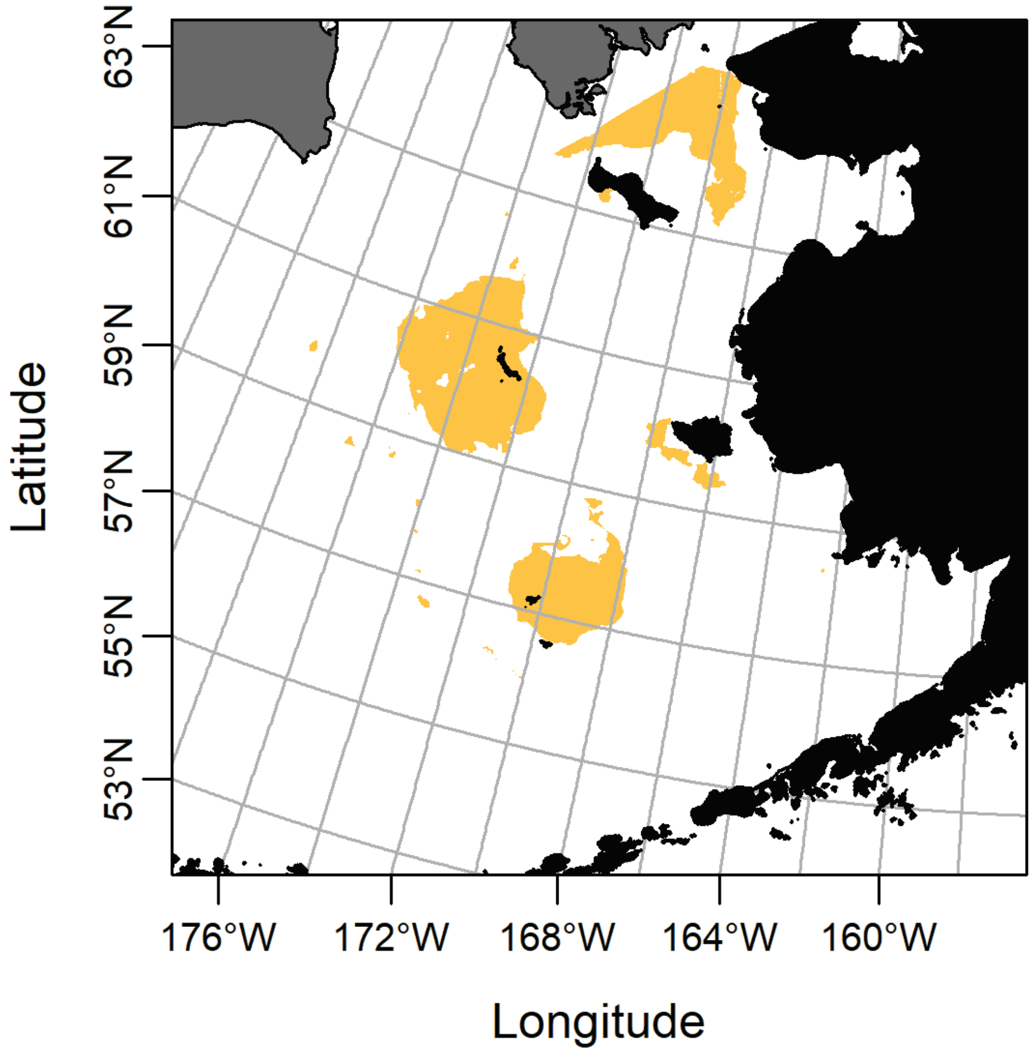


Figure 3-7 EBS adult Blue king crab, EFH Level 1, winter

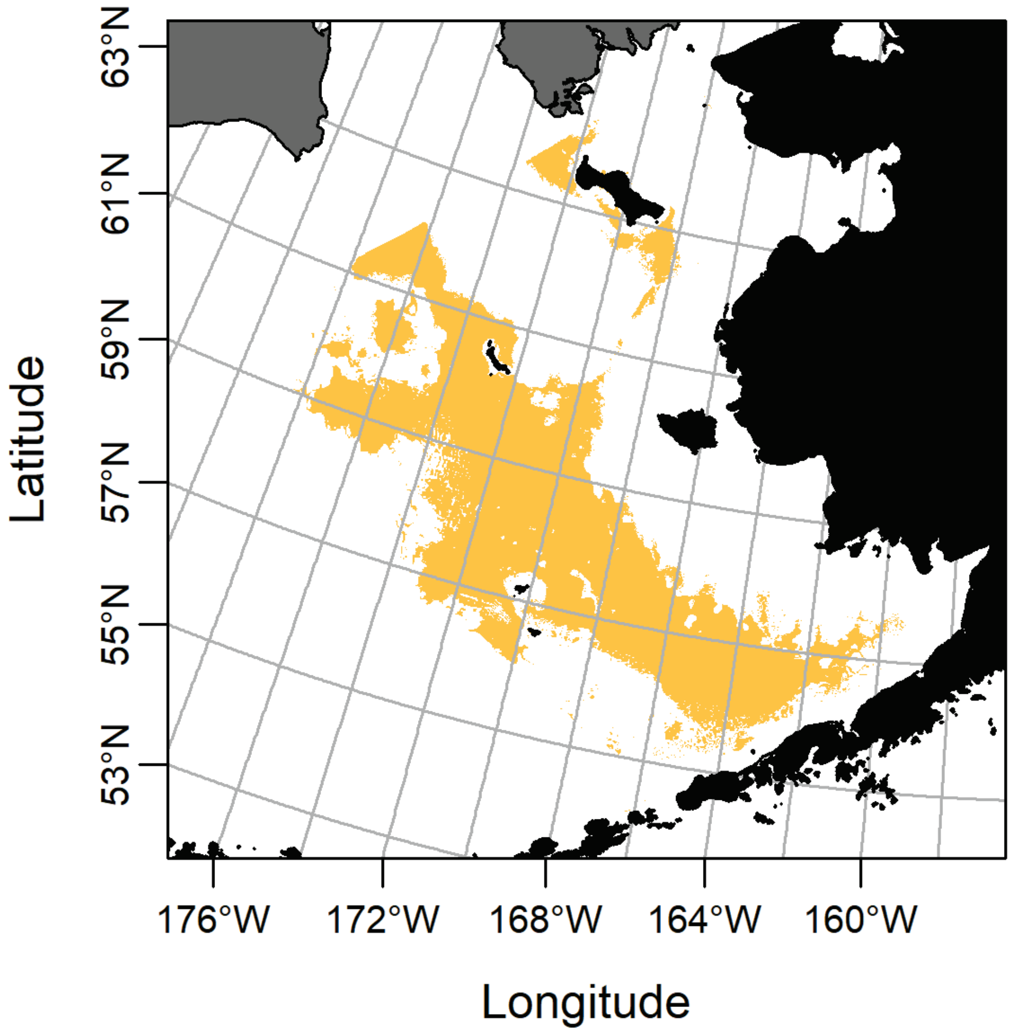


Figure 3-8 **EBS adult Blue king crab, EFH Level 1, spring**

3.4.2.2 Red King Crab

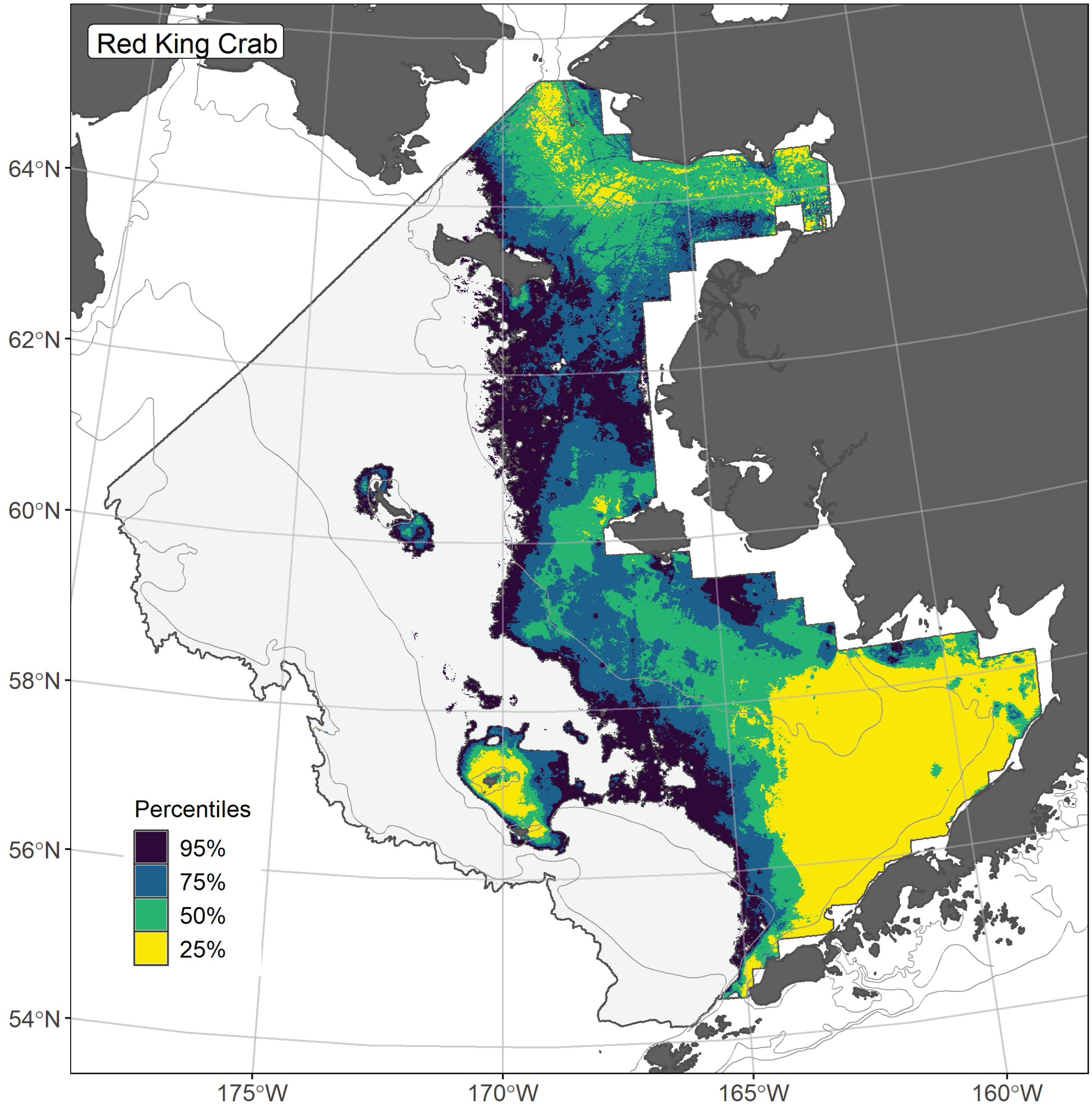


Figure 3-9 EBS all life stages Red king crab, EFH Level 2, summer

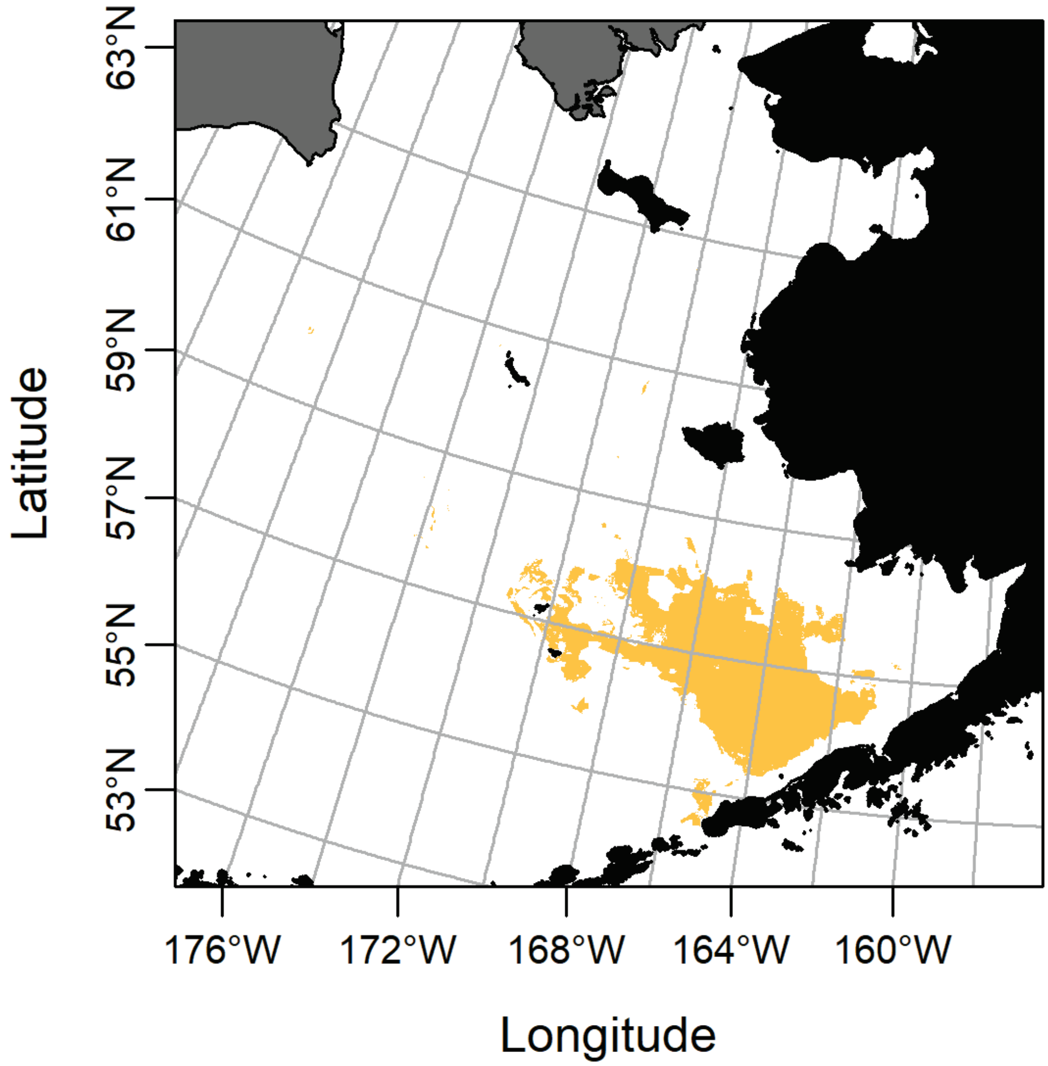


Figure 3-10 **EBS adult Red king crab, EFH Level 1, fall**

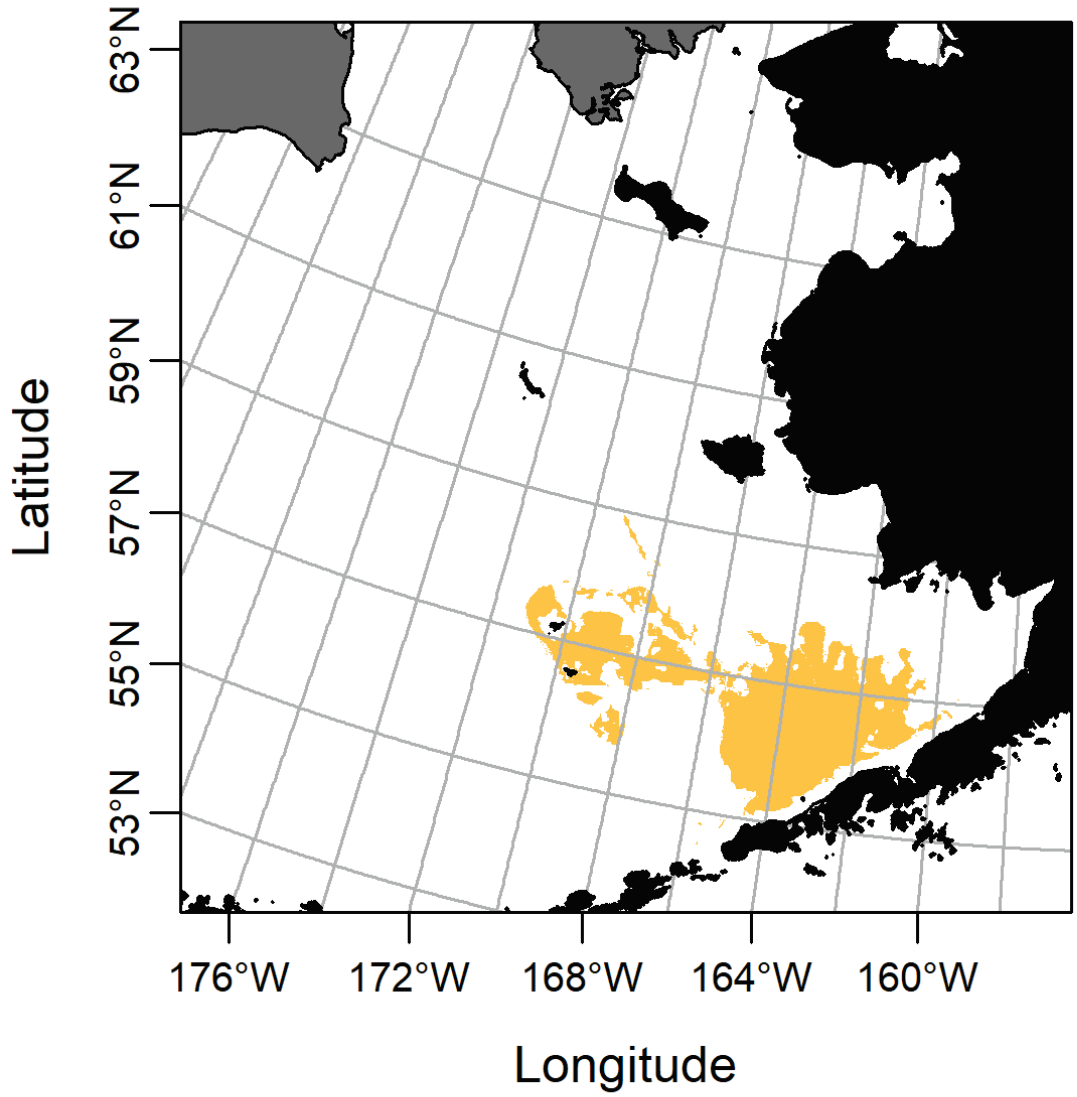


Figure 3-11 EBS adult Red king crab, EFH Level 1, winter

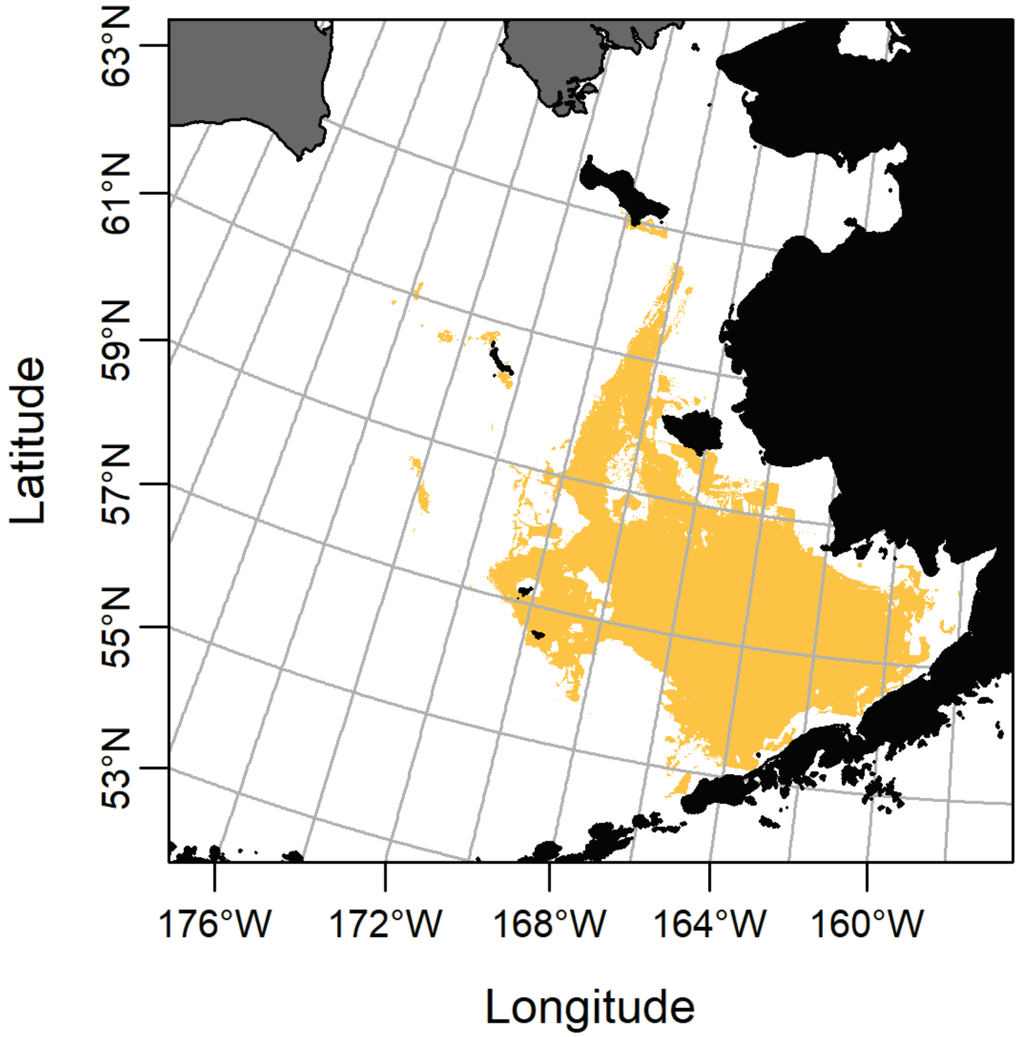


Figure 3-12 EBS adult Red king crab, EFH Level 1, spring

3.4.2.3 Snow Crab

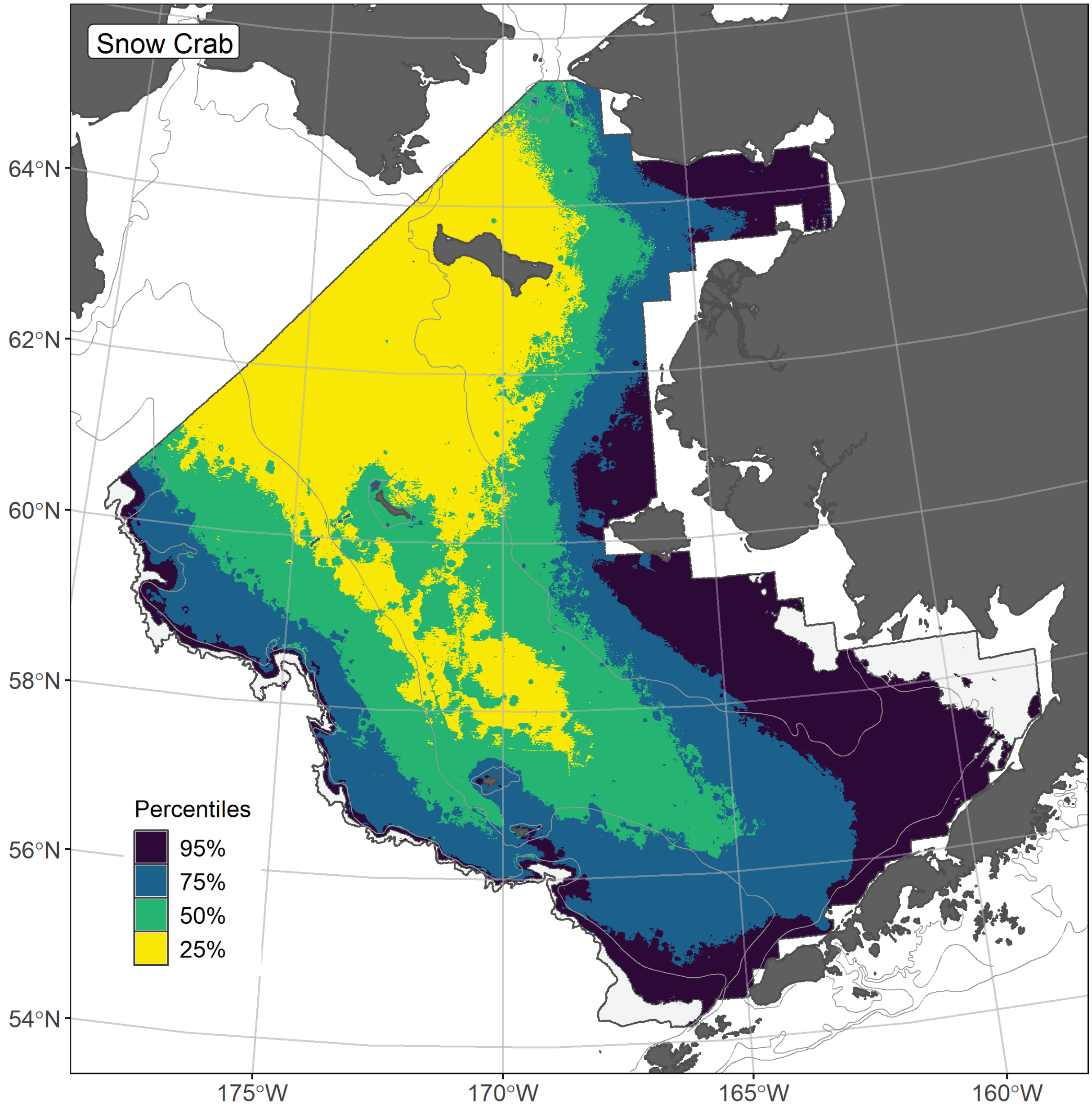


Figure 3-13 EBS all life stages Snow crab, EFH Level 2, summer

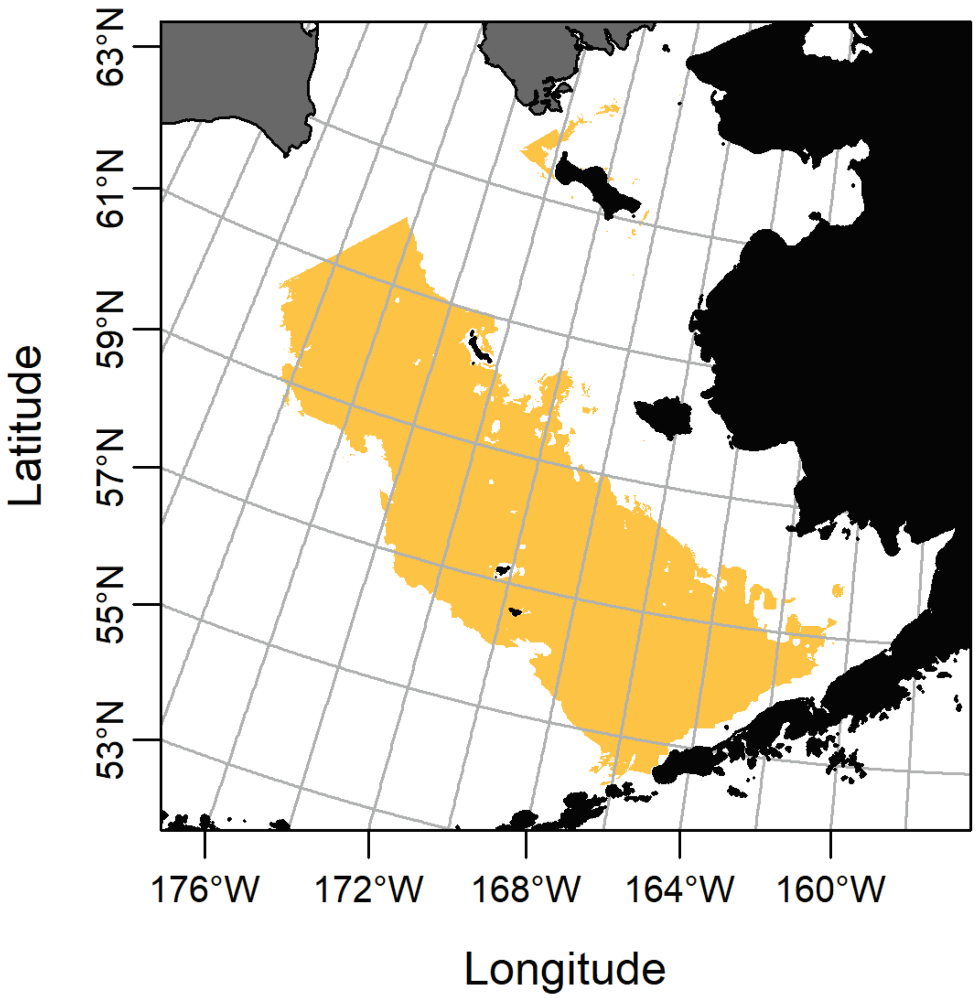


Figure 3-14 EBS adult Snow crab, EFH Level 1, fall

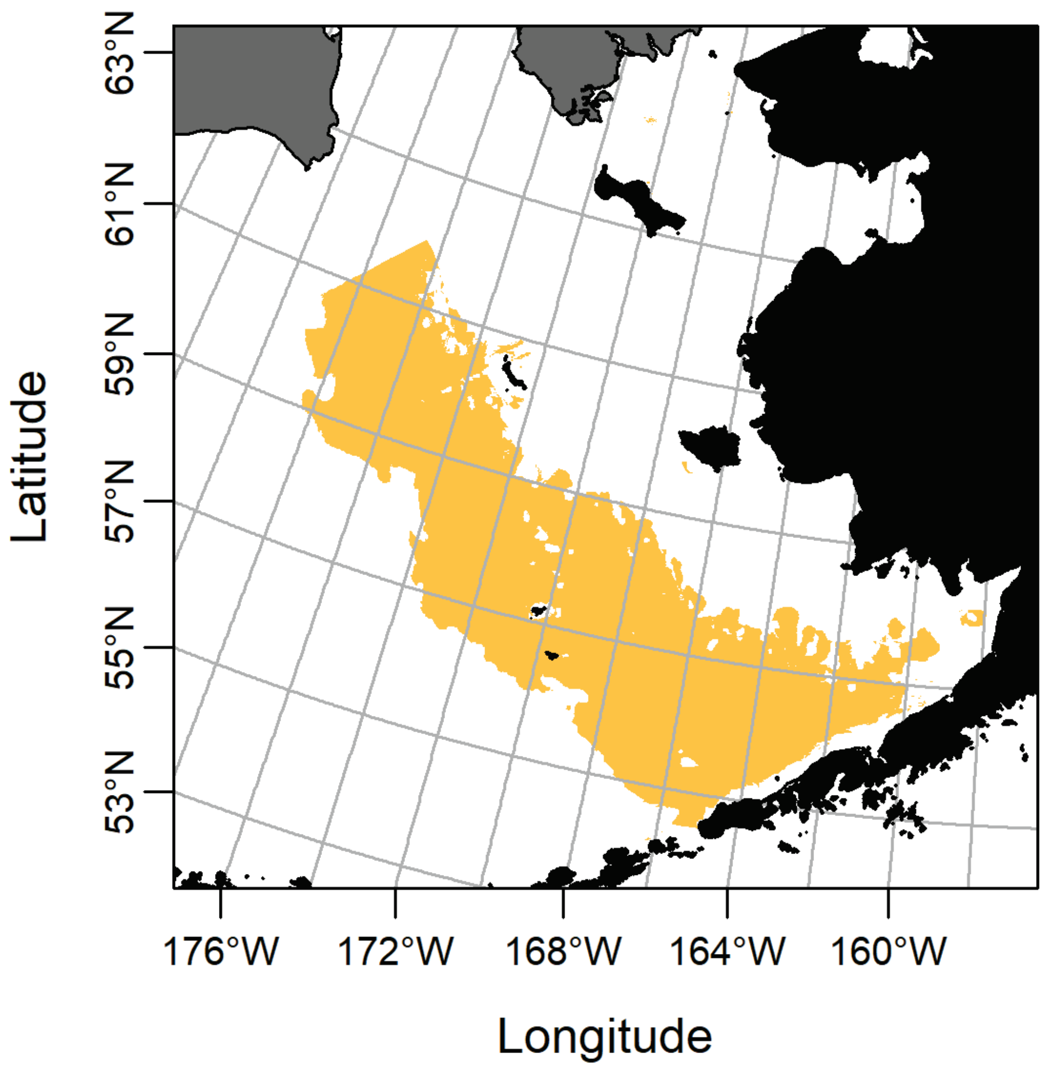


Figure 3-15 EBS adult Snow crab, EFH Level 1, winter

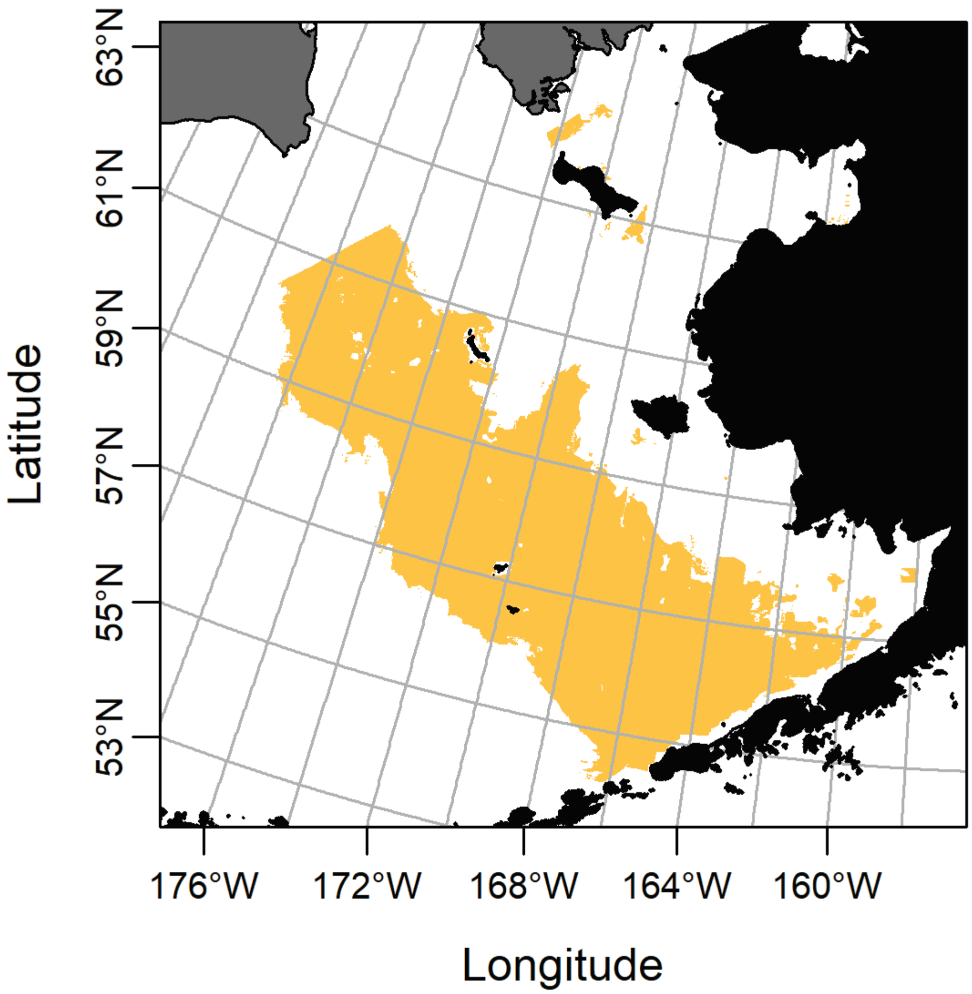


Figure 3-16 EBS adult Snow crab, EFH Level 1, spring

3.4.2.4 Tanner Crab

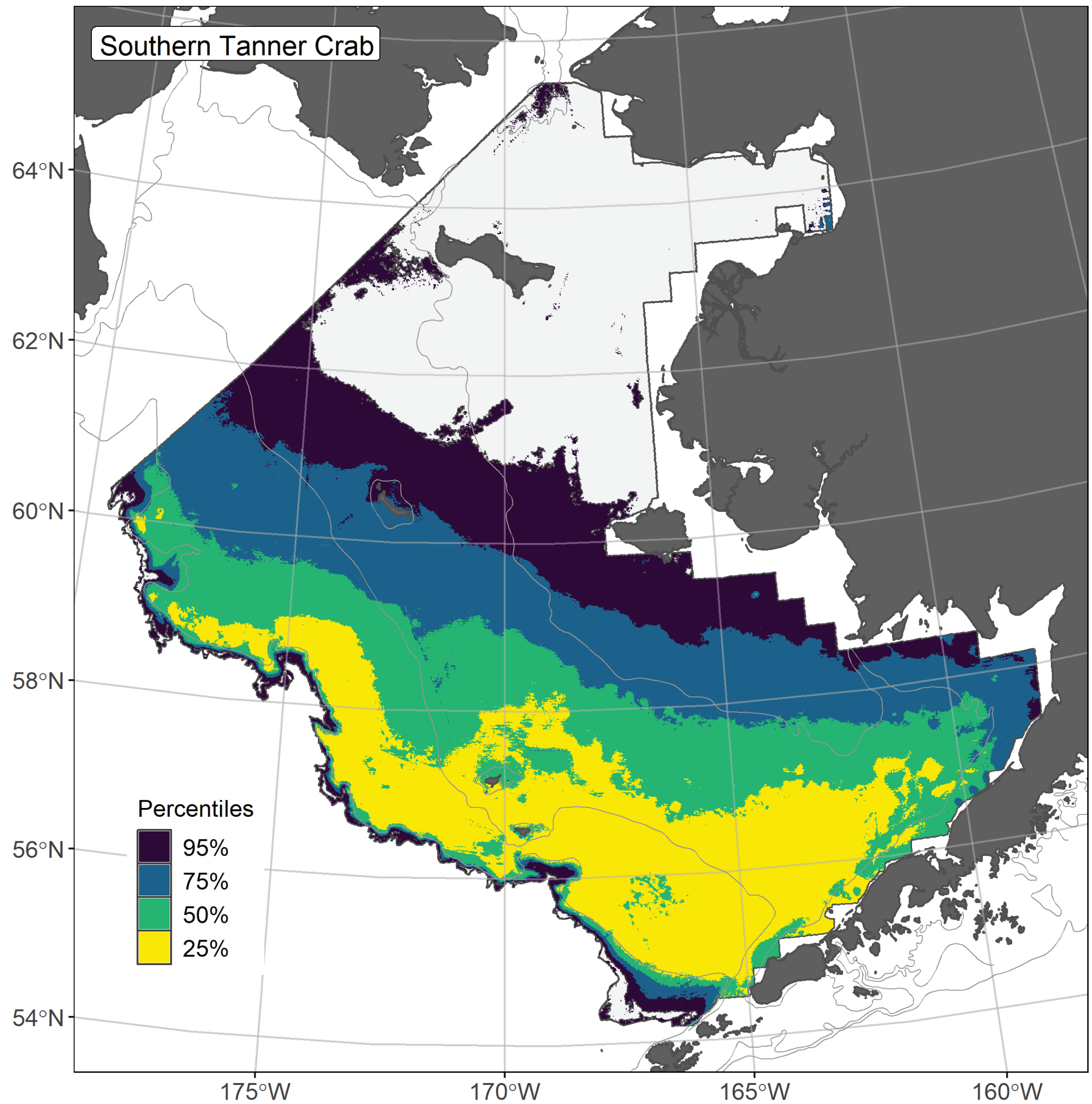


Figure 3-17 EBS all life stages, Tanner Crab, EFH Level 2, summer

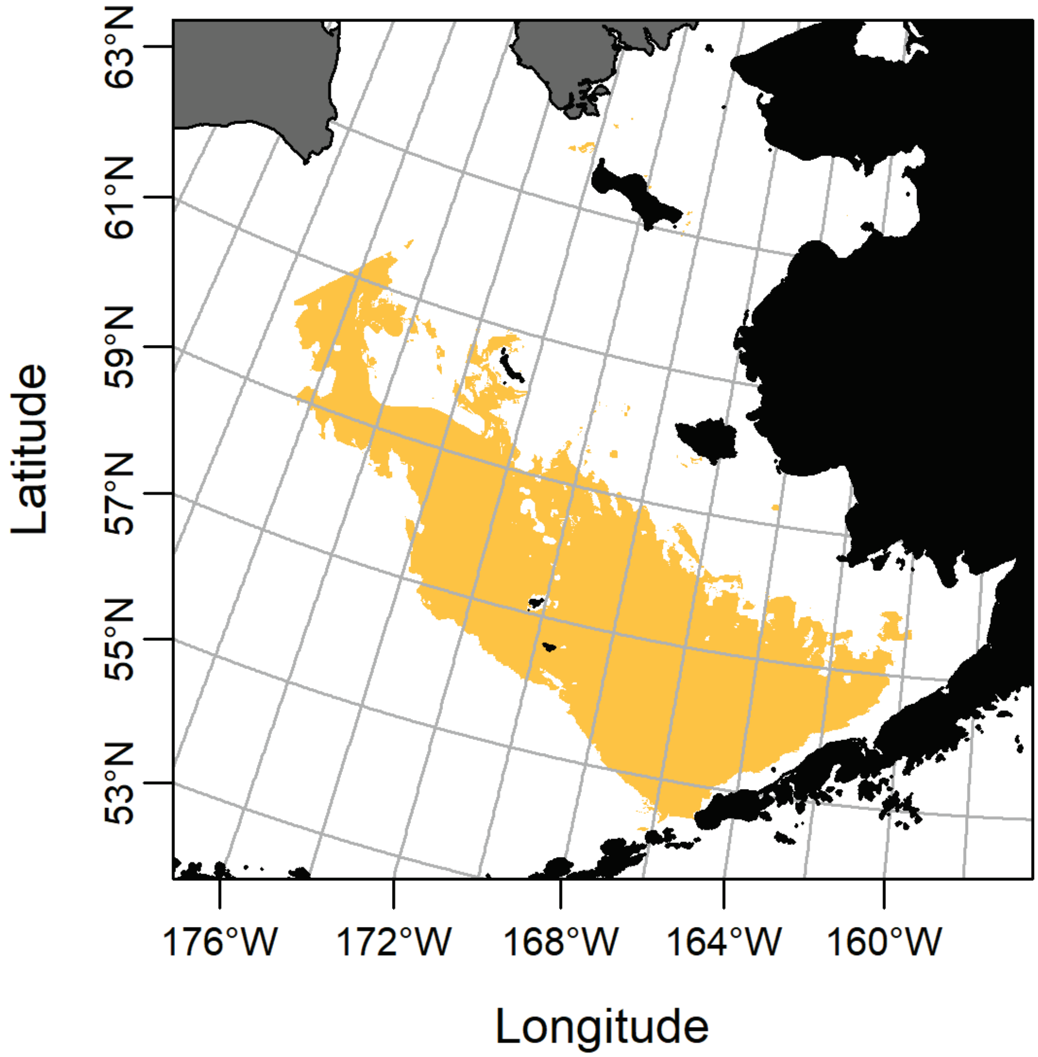


Figure 3-18 EBS adult Tanner crab, EFH Level 1, fall

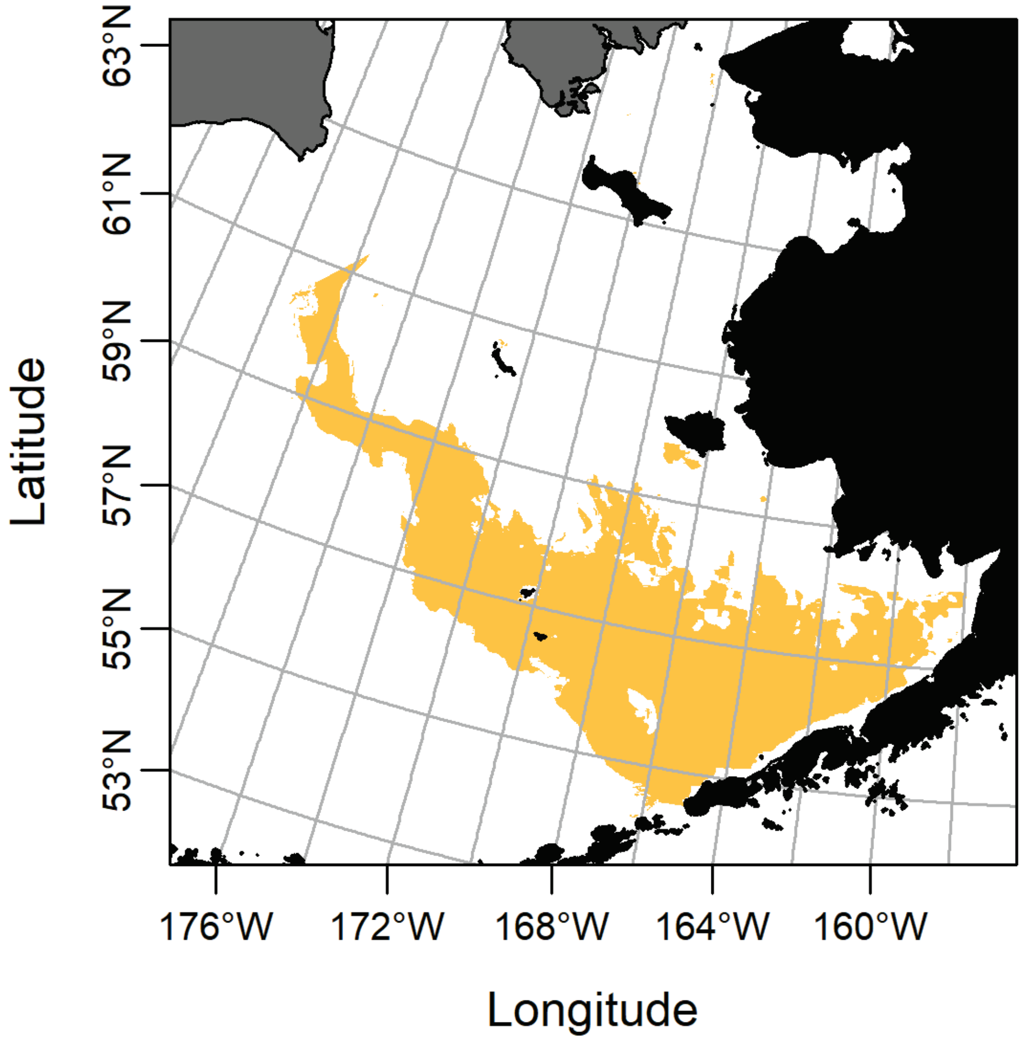


Figure 3-19 **EBS adult Tanner crab, EFH Level 1, winter**

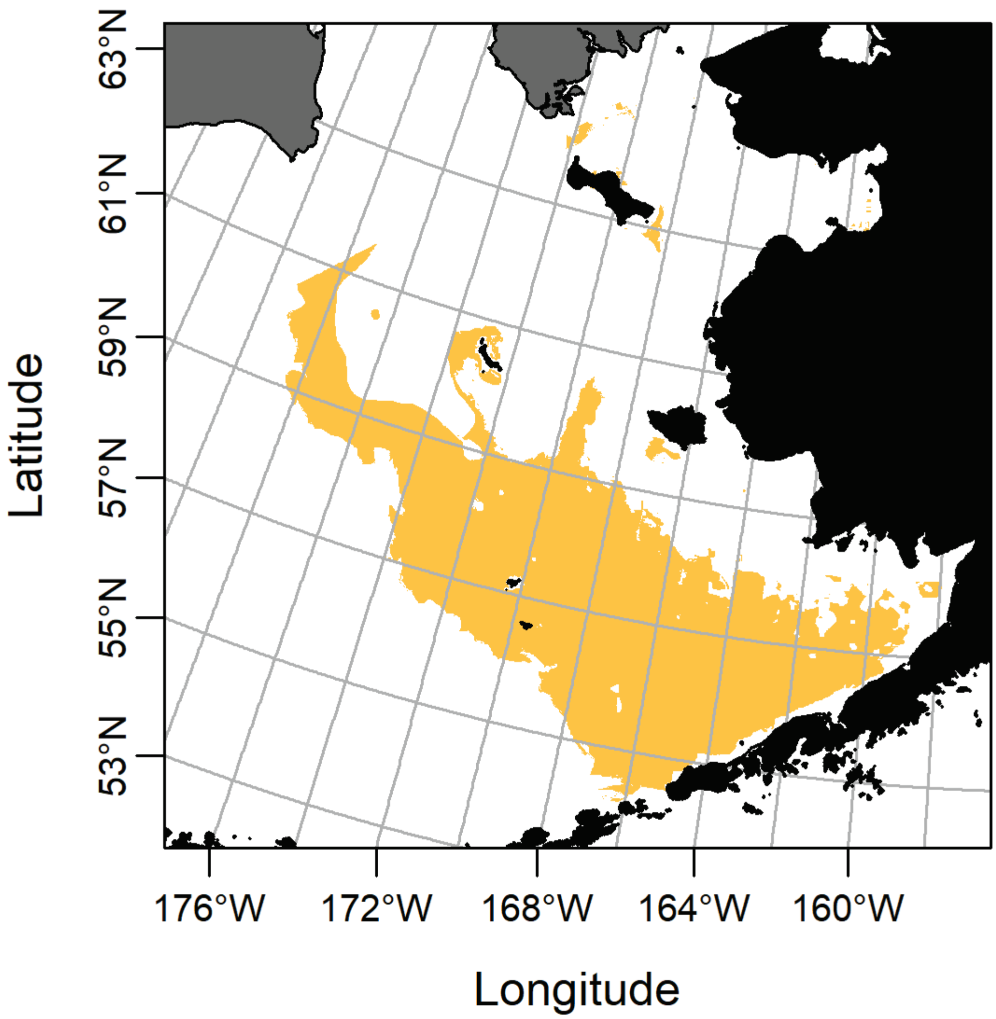


Figure 3-20 EBS adult Tanner crab, EFH Level 1, spring

3.5 Essential Fish Habitat Conservation and Habitat Areas of Particular Concern

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

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

3.5.1 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 3-21. 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 3-2 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.

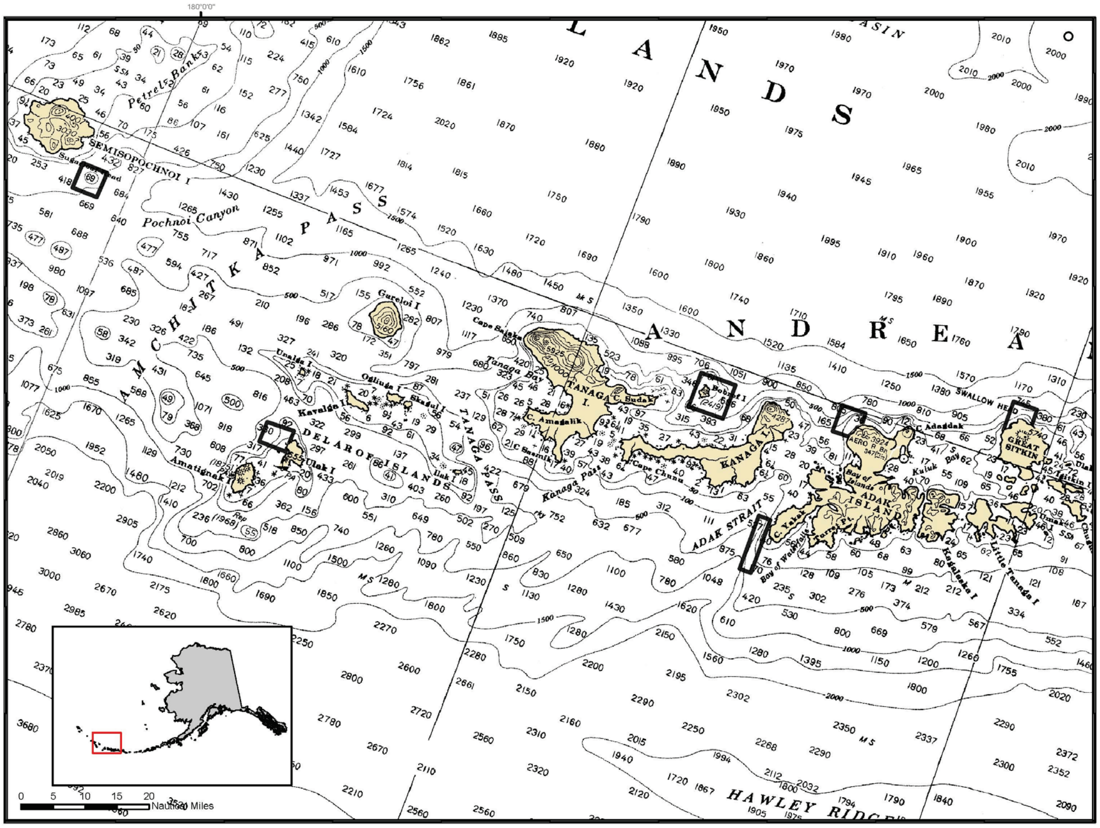


Figure 3-21 Aleutian Islands Coral Habitat Protection Areas

3.5.2 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 AIs shown in Figure 3-22; however, the use of trawl gear is prohibited in the BSAI King and Tanner crab fisheries.

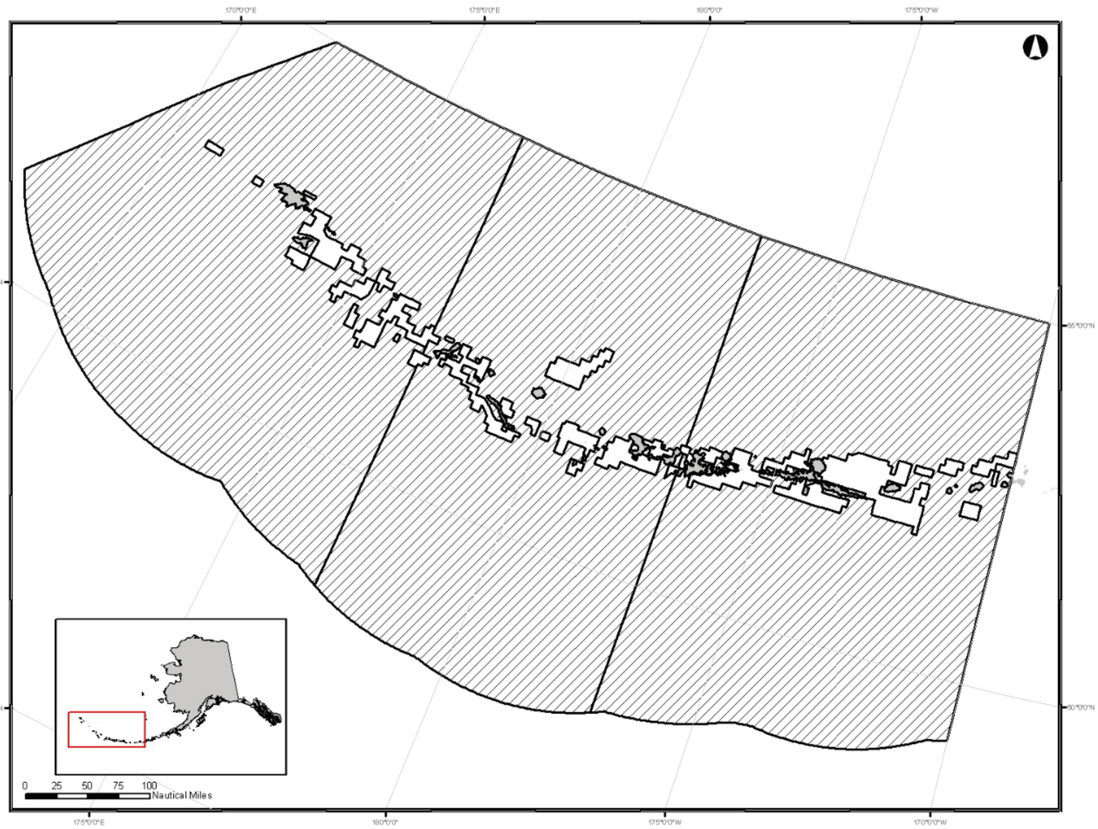


Figure 3-22 **Aleutian Islands Habitat Conservation Area. Polygons are areas open to nonpelagic trawl gear.**

3.5.3 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 3-23. 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 3-3 **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.

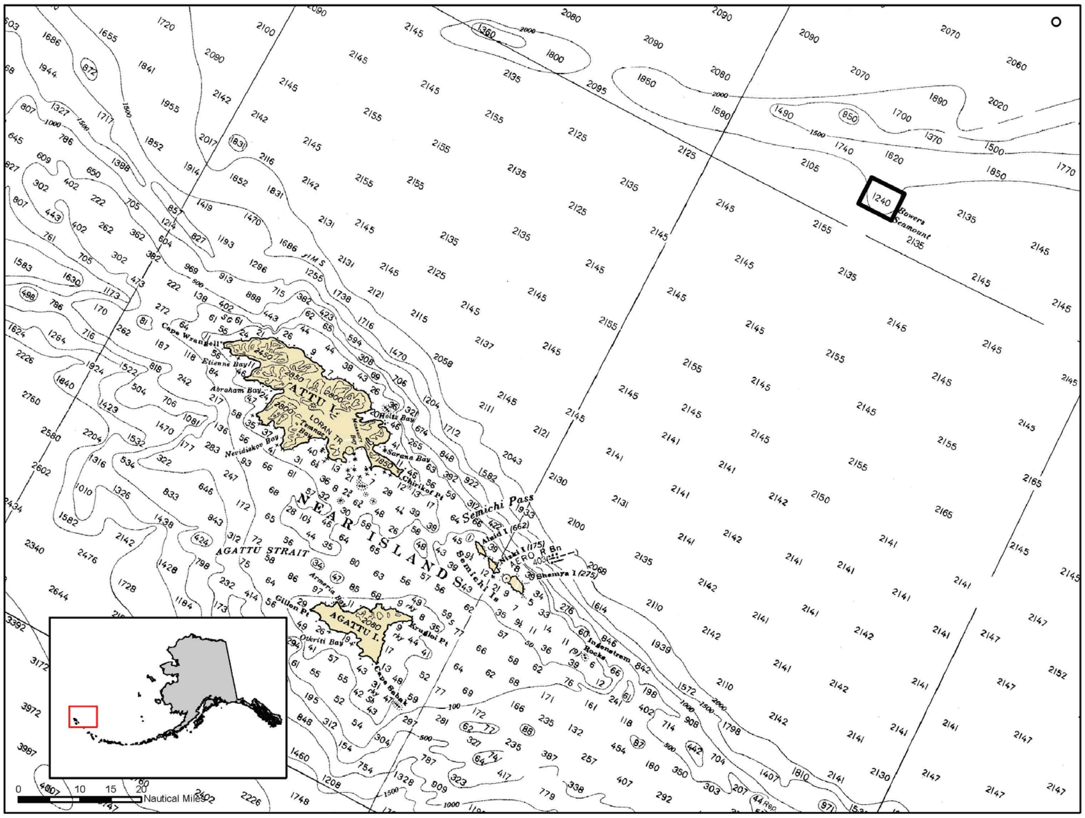


Figure 3-23 Alaska Seamount Habitat Protection Area in the Aleutian Islands

3.5.4 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 3-24. The areas are described in the table below.

Table 3-4 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.

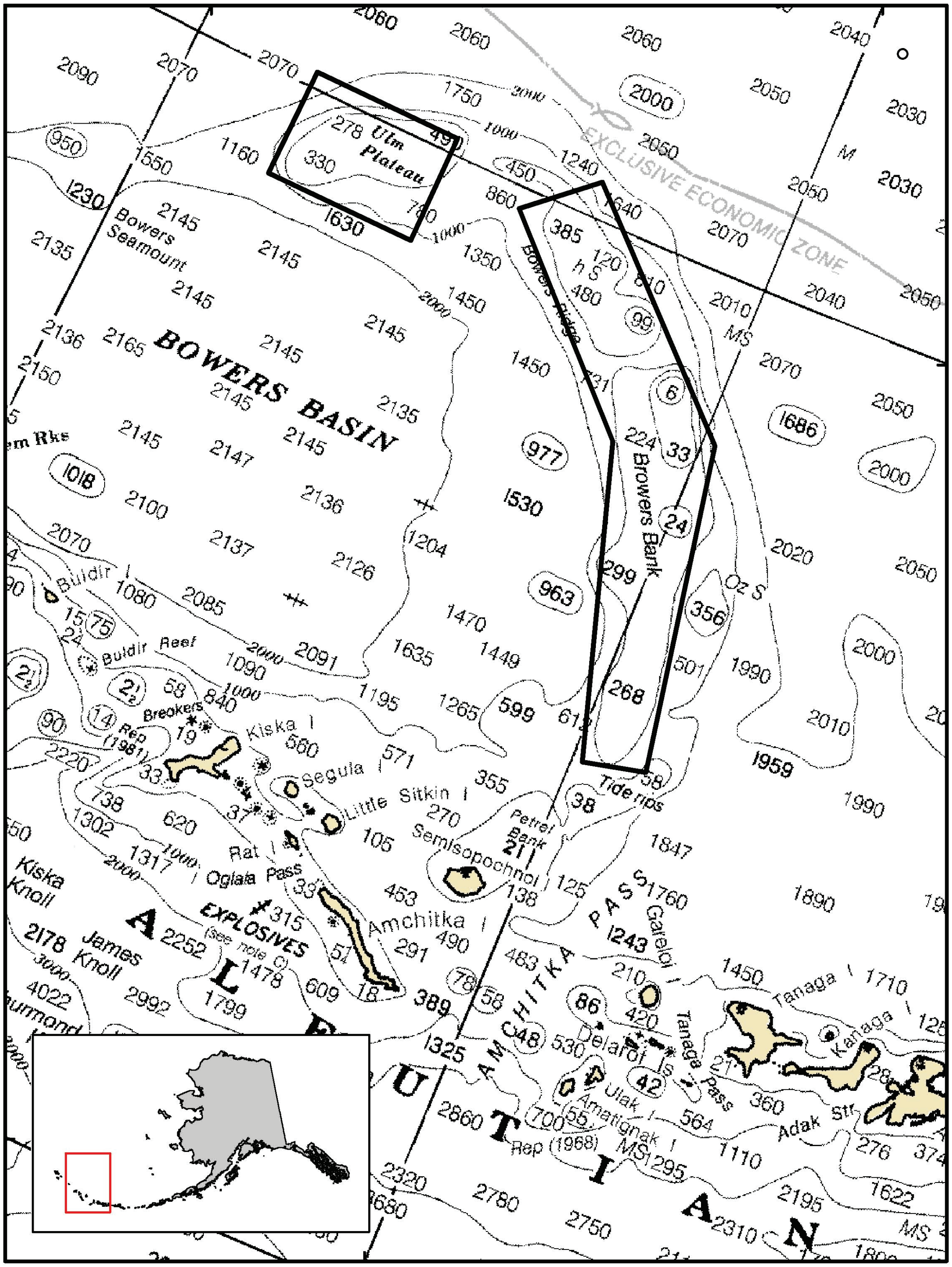


Figure 3-24 **Bowers Ridge Habitat Conservation Zone**

3.5.5 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

4.1 Overview

This appendix addresses the requirement in Essential Fish Habitat (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 should consider the effects of each fishing activity on each type of habitat found within EFH. FMPs must describe each fishing activity, review and discuss all available relevant information (such as information regarding 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), and provide conclusions regarding whether and how each fishing activity adversely affects EFH.

The EFH regulations base the evaluation of the adverse effects of fishing on EFH on a 'more than minimal and not temporary' standard (50 CFR 600.815). Fishing operations may change the abundance or availability of certain habitat features (e.g., the presence of living or non-living habitat structures) used by managed fish species to accomplish spawning, breeding, feeding, and growth to maturity. The outcome of these changes depends on the characteristics of the fishing activities, the habitat, fish use of the habitat, and fish population dynamics. The duration and degree of fishing 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. The fishing effects model developed for this evaluation takes all of those variables into consideration (Smeltz et al. 2019).

4.2 Evaluation of fishing effects on EFH

The fishing effects (FE) model was developed by the NMFS Alaska Regional Office – HCD and scientists at Alaska Pacific University for the 2017 EFH 5-year Review. Updates and corrections to the model were made in 2022. The full FE model description can be found in the technical memorandum 2022 Evaluation of Fishing Effects on Essential Fish Habitat (Zaleski et al. 2023). The technical memorandum also includes the full process for estimating habitat disturbance within the core EFH areas (upper 50th percentile of EFH) modeled for each species or species complex within this FMP and the result of those estimates.

The full evaluation of the estimated fishing effects on species' core EFH areas are in the FE Report (Zaleski et al. 2023). It includes a description of the stock assessment author review process, whereby stock authors were provided with the FE model output and requested to quantitatively or qualitatively evaluate if the estimated habitat disturbance was adversely affecting EFH more than minimally and not temporarily. This report includes each stock author's evaluations in Appendix 5. For the BSAI groundfish species or species complexes, 15 had estimates of habitat disturbance ≥ 10% of their core EFH area. No stock authors concluded that fishing effects are more than minimal and not temporary for their species or recommended to elevate their species to the Council for possible mitigation to reduce fishing effects to EFH.

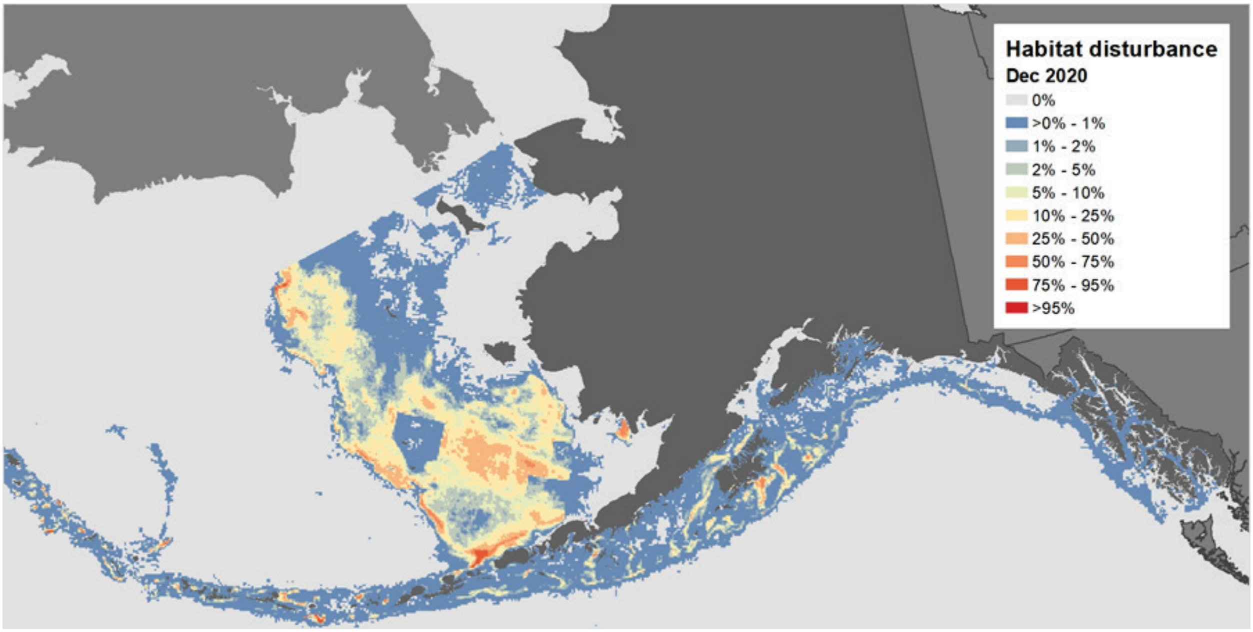


Figure 4-1 **Eastern Bering Sea cumulative percentage habitat disturbed. All gears combined.**

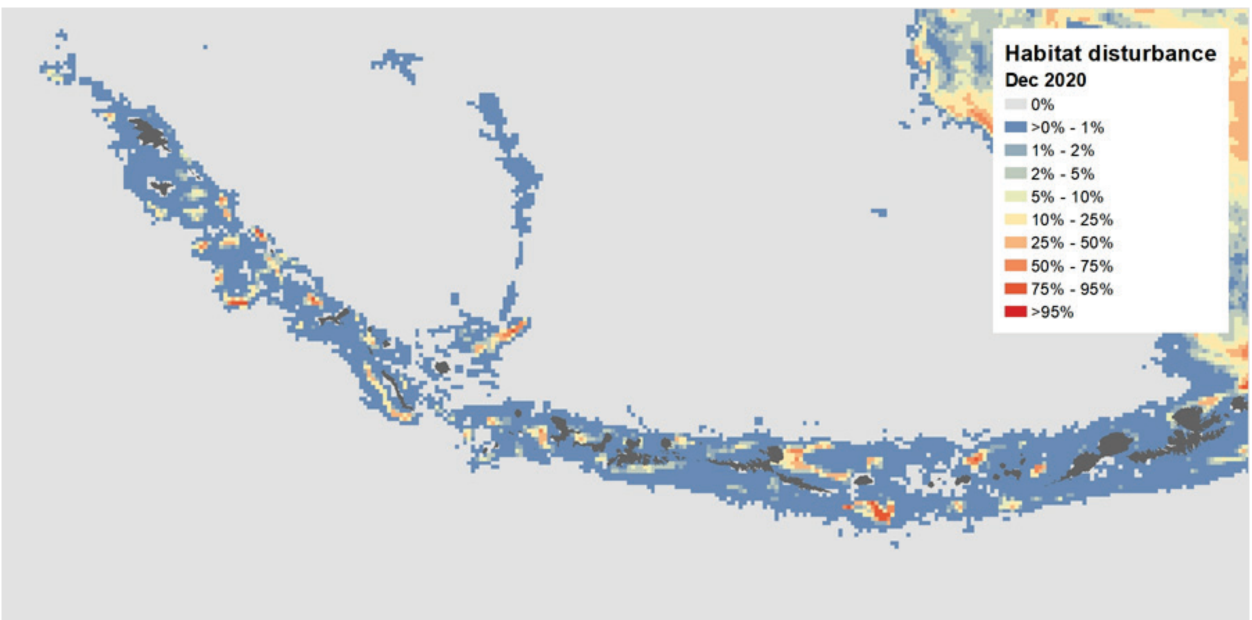


Figure 4-2 **Aleutian Islands cumulative percentage habitat disturbed. All gears combined.**

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

The waters, substrates, and ecosystem processes that support EFH and sustainable fisheries are susceptible to a wide array of human activities and climate-related influences unrelated to the act of fishing. These activities range from easily identified, point source discharges in watersheds or nearshore coastal zones to less visible influences of changing ocean conditions, and increased variability in regional temperature or weather patterns. Broad categories of such activities include mining, dredging, fill, impoundments, water diversions, thermal additions, point source and nonpoint source pollution, sedimentation, introduction of invasive species, and the conversion of aquatic habitat that may eliminate, diminish, or disrupt the functions of EFH. For Alaska, non-fishing impacts are reviewed in the Non-Fishing Impacts Report, which NMFS updates during an EFH 5-year Review.

5.1 Non-Fishing Impacts and EFH 5-year review from 2018-2023

The most recent report, *Impacts to Essential Fish Habitat from Non-Fishing Activities in Alaska* (Limpinsel et al. 2023), presents a brief history of the Magnuson-Stevens Act and the language, provisions, and purpose supporting conservation of EFH. The report emphasizes the growing importance and implementation of Ecosystem Based Fisheries Management. This iteration recognizes climate change as an anthropogenic threat influencing EFH. Chapter 2 provides a discussion on how greenhouse gas emissions are warming the Arctic and influencing the atmosphere, ocean, and fisheries across Alaska.

Chapters 3, 4 and 5 of this report address watersheds, estuaries and nearshore zones, and offshore zones, starting by highlighting the more commonly recognized physical, chemical, and biological processes that make each zone distinct. Each chapter discusses ecosystem processes, EFH attributes, sources of anthropogenic impacts that could compromise EFH, and proposes conservation recommendations to reduce the severity of those impacts. This report reflects the best available science.

5.2 Regulatory Alignment

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 Magnuson-Stevens Act requires Federal agencies to consult with NMFS on any action that they authorize, fund, or undertake, or propose to authorize, fund, or undertake, that may adversely affect EFH. Each Council shall comment on and make recommendations to the Secretary of Commerce, through NMFS, 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 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 mandate measures to minimize impacts of non-fishing activities. Most non-fishing activities identified in this report are subject to numerous Federal, state, and local environmental laws and regulations designed to minimize and mitigate impacts to fish, wildlife and habitat.

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. Cumulative impacts analysis is Component 5 of the ten EFH components. 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 2017 5-year Review 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). Cumulative impacts analysis was not a component of focus for the 2023 EFH 5-year Review. The 2017 evaluation is summarized below with updated references for the new reports.

Historical fishing practices may have had effects on EFH that have led to declining trends in some of the criteria examined in the EFH EIS (see Table 4.4-1 in NMFS 2005). For fishing impacts to EFH, the FE model calculates habitat disturbance at a monthly time step since 2003 and incorporates susceptibility and recovery dynamics, allowing for an assessment of cumulative effects from fishing activities. During the 2017 EFH 5-year Review, the effects of fishing activities on EFH were considered as minimal and temporary or unknown. This conclusion is similar to the 2022 evaluations (Zaleski et al. 2023).

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. 2023). 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 or may not significantly affect the function of EFH. The synergistic effect of the combination of all of these activities is also 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 2017 EFH 5-year Review concluded that the cumulative level of concern is unknown.

7 Research Needs

7.1 Essential Fish Habitat Research and Information Needs

One of the required components of the EFH provisions of each FMP is to include research and information needs. Each FMP should contain recommendations for research efforts that the Councils and NMFS view as necessary to improve upon the description and identification of EFH, the identification of threats to EFH from fishing and other activities, and the development of conservation and enhancement measures for EFH.

7.2 Alaska EFH Research Plan

A new Alaska EFH Research Plan that revises and supersedes earlier plans will guide research to support the next EFH 5-year Review and other fishery management information needs where advancements in habitat science are helpful (Pirtle et al. 2023). The Alaska EFH Research Plans have included five long term research goals that remain consistent with minor, meaningful updates since 2005. EFH research recommendations were informed during the 2023 EFH 5-year Review by contributing researchers, stock assessment scientists, and Council advisory bodies. These recommendations were summarized as three objectives for the new Alaska EFH Research Plan. In addition, as part of the 2023 EFH 5-year Review, each stock assessment author provided a stock-specific evaluation of EFH research needs. Table 7-1 identifies these needs by species. These research needs also contributed to the research objectives in the revised Alaska EFH Research Plan. These long term research goals, timely objectives, and species specific recommendations are informative as updates to the EFH research recommendations in the BSAI Crab FMP.

7.3 EFH Research Recommendations

Five long-term research goals have been included in Alaska EFH Research Plans since 2005 (e.g., Sigler et al. 2017, Pirtle et al. 2023)—

1. Characterize habitat utilization and productivity at regional scales;
2. Assess sensitivity, impact, and recovery of disturbed benthic habitat;
3. Improve modeling and validation of human impacts on marine habitat;
4. Improve information regarding habitat and seafloor characteristics; and
5. Assess coastal and marine habitats facing human development.

These goals represent the need to understand habitat characteristics and their influence on observed habitat utilization and productivity for fishes and invertebrates. These goals also emphasize the importance of understanding human impacts on habitat (e.g., fishing, coastal development, and ongoing climate change), how these impacts in turn affect habitat utilization and productivity, and assessing the consequences of these impacts at regional scales.
To achieve these goals the complementary role and equal importance of targeted field and laboratory experiments, long-term monitoring, and analytical work should be emphasized to model and map the progressive levels of EFH information (EFH component 1) and impacts at a regional scale (EFH components 2, 4, and 5). In particular:

- Field and laboratory experiments are necessary to understand ecological mechanisms that underlie habitat association, vital rates and productivity, and how human activities (including fishing, development, and climate change) cause changes in habitat conditions and resulting utilization and productivity. In particular, understanding causality is not possible without experimental support. Understanding ecological mechanisms (i.e., causality) is also necessary to predict the likely impact of human impacts that have not previously been observed;
- Long-term monitoring is necessary to understand habitat utilization and productivity at regional scales;
- Analysis including statistical and mathematical modeling is needed to map the geographic distribution of the area of occupied habitat (EFH) for life stages of targeted FMP species and their prey and is also necessary to identify changes in habitat utilization likely resulting from human activities and climate change.

Without these three elements, applied habitat research cannot be successful.
In addition to the five long term research goals, three objectives are emphasized as important for research progress and preparation for future EFH 5-year Reviews and are described in the Alaska EFH Research Plan (Pirtle et al. 2023). These objectives were informed by recommendations from contributing researchers, stock assessment scientists, and Council advisory bodies during the 2023 EFH 5-year Review and are written with consideration of research needs across FMPs.

Objective 1: Improve EFH information for targeted species and life stages
The first objective seeks to improve EFH information for species and life stages that were identified as requiring further research during the 2023 EFH 5-year Review, as well as other targeted FMP species that were not updated in 2023 (i.e., salmon ocean life stages and scallops) under EFH component 1. Studies should focus on methods development with practical application to improve EFH information for a select set of species life stages, where the following pathways are recommended:

1. **Additional field data:** Collecting and incorporating additional field data in the models used to identify and describe EFH, beyond the large-mesh bottom trawl summer survey data that were used primarily during the 2017 and 2023 EFH 5-year Reviews. The importance of including alternative gear types to the extent practicable is emphasized, including longlines, pots, small-mesh and pelagic trawls, focusing on under-sampled life stages and habitats. The application of alternative data sources such as predator stomach contents and fishery-dependent catch and effort data is also encouraged. Sampling may also be used to improve understanding of seasonal variation in habitat use. This will presumably involve measuring (via paired experiments) or estimating a fishing-power correction between multiple sampling gears. When analyzed properly, these additional data sources can provide complementary information to characterize habitat profiles for life stages of targeted FMP species.
2. **Demographic processes driving variation over time:** Research focused on identifying processes that drive shifts in habitat use and productivity is recommended. This may

involve hindcasting and forecasting methods, including (but not limited to) fitting models with covariates that vary over time, conditioning predictions upon spatio-temporal residuals, incorporating information about trophic interactions, and separately analyzing numerical density and size information. This might also involve process research, e.g., incorporating information about individual movement from tags, behavioral and eco-physiological experiments, or other process research. This likely requires methodological development and testing and could be focused on a few case-study species or species' life stages that are likely to be shifting substantially, for consideration during the future 5-year Reviews.

3. **Improved methods to integrate both monitoring and process research:** Continued development of new analytical methods to integrate process research is recommended when identifying species habitat utilization, vital rates, and productivity. Analytical methods might include individual- and agent-based models (IBMs) that "scale up" laboratory measurements, particularly when IBM output is used as a covariate or otherwise combined with survey and other species sampling information. This process research might include juvenile survival, growth, and movement experiments and habitat-specific observations. Ideally, these new methods would include process information and monitoring data simultaneously, rather than either a. seeking to validate an IBM via comparison with monitoring data without explicitly incorporating these data, or b. fitting to monitoring data without incorporating field or laboratory experimental data.

Objective 2: Improve fishing effects assessment

The second objective addresses the ongoing need to develop and improve methods to assess fishing impacts on habitat utilization and productivity (EFH component 2). Research pathways might include:

1. **Advance methods to assess fishing impacts:** It is often helpful to compare results from a variety of analytical methods and approaches. Advancing the existing Fishing Effects model (Smeltz et al. 2019) is recommended as well as developing new analytical approaches to address potential impacts of fishing to EFH.
2. **Cumulative effects:** Methods development is recommended to identify the cumulative effect of fishing and non-fishing human activities to EFH, including ongoing climate change (EFH component 5).

Objective 3: Improve understanding of nearshore habitat and forage species

The third objective acknowledges that additional research is needed regarding critical nearshore life stages and for the prey species that represent an important component of habitat suitability and EFH. Research may include the following pathways:

1. **Nearshore habitat:** Ongoing and expanded scientific efforts to understand habitat utilization and productivity into nearshore environments (EFH component 1). This nearshore habitat is critical for juvenile life stages of many targeted FMP species (e.g.,

Pacific cod, flatfishes, salmonids) and prey species (EFH component 7) and is also subject to substantial impacts from human development. Improved understanding of nearshore habitat is intended to support the EFH consultations that are done near areas with human development (urban areas as well as shipping activities) (EFH components 4 and 5). Understanding nearshore habitat may also support improved understanding of recruitment processes and population connectivity. Data are available in the Nearshore Fish Atlas of Alaska and ShoreZone, and analytical methods have already been demonstrated (e.g., Grüss et al. 2021), but there remains substantial work to scale these methods to more species and within geographic areas of specific interest.

2. **Prey species:** Increased efforts are recommended to understand habitat utilization and productivity for those species that represent the primary prey for targeted FMP species (EFH component 7). This can include pelagic forage fishes (e.g., herring, eulachon, sand lance, etc.), juvenile stages of numerically abundant species (e.g., pollock, Pacific cod, salmonids), as well as invertebrates (e.g., Euphausiids, snow crab). Improved understanding of habitat-specific densities (i.e., Level-2 EFH information) can then be used as a covariate for understanding habitat suitability for their predators (i.e., targeted FMP species).

As part of the 2023 EFH Review, each stock assessment author provided a stock-specific evaluation of EFH research needs. Table 7-1 identifies these needs by species and FMP. These research needs also contributed to the research objectives in the revised Alaska EFH Research Plan (Pirtle et al. 2023).

Table 7-1 Stock assessment author research recommendations for Bering Sea/Aleutian Island crab species. These include focus areas of research and identify data sources for future EFH map iterations.

Bering Sea & Aleutian Island Crab	Research Notes from Stock Assessment Authors
blue king crab	Explore using FE model outputs for smaller areas within the EFH regions such as known nursery habitats where blue king [crab] utilize cobble and shell hash. Map early benthic life stages. Research female spawning and juvenile habitat needs.
golden king crab	Incorporate observer data from the fishery and pot survey in the eastern portions of the grounds.
red king crab	Model immature and mature crab separately. Model FE for different seasons. Explore using FE model outputs in smaller areas of interest within the EFH regions such as important spawning areas and molting areas. Research female distributions, critical spawning habitat, and movement outside of the summer months.
snow crab	Model immature and mature crab separately. Explore using FE model outputs in smaller spatial and temporal results.

Bering Sea & Aleutian Island Crab	Research Notes from Stock Assessment Authors
Tanner crab	Research immediate and longer term responses to nearby fishing effects (effects of increased sediment load in the water column on respiration, fishing effects on prey abundance and quality, fishing effects on predator distributions).

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