Amendment 127 to the FMP for the Groundfish of the Bering Sea and Aleutian Islands Management Area - amendment text for updating EFH description, fishing effects, non-fishing impacts to EFH, and EFH research objectives (EFH Omnibus Amendment)

Make the following changes to Section 4, Section 6, Appendix A, Appendix D, Appendix E, Appendix F, and Appendix H of the Fishery Management Plan for Groundfish of the Bering Sea/Aleutian Islands Management Area. 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. Note, instructions reference four supplemental files: Appendix D, Appendix E, Appendix F, and Appendix H.

1. In Section 4.2.1, replace Figures 4-13 and 4-15 with the updated figures:

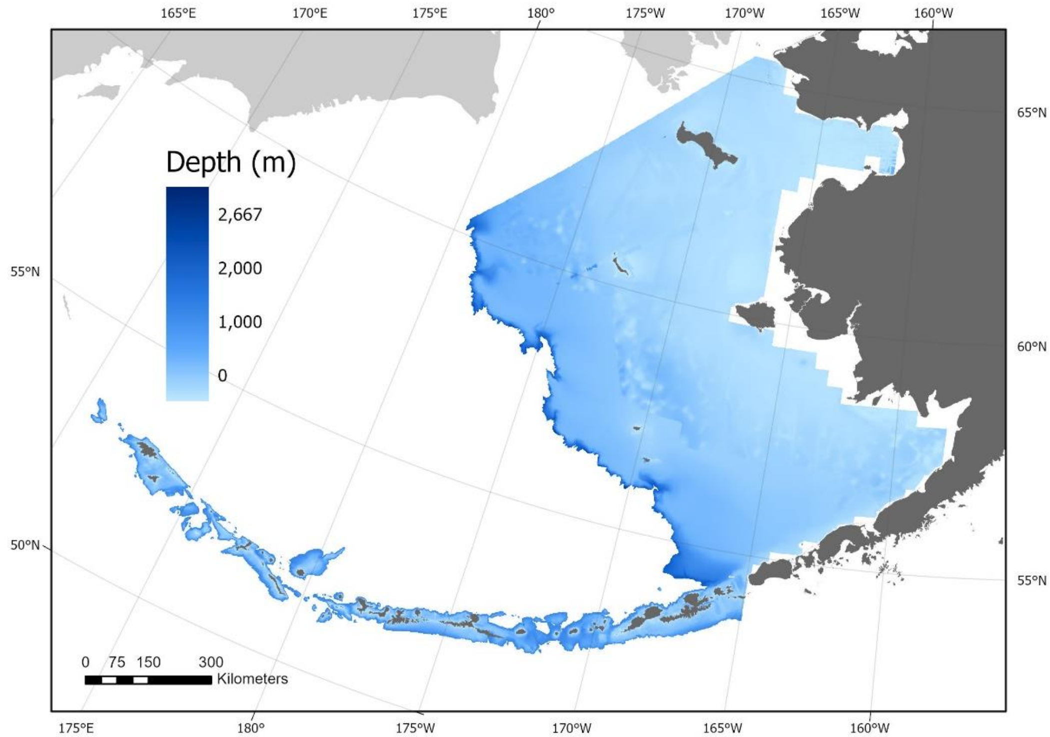

Figure 4-13 Bathymetric map of the BSAI

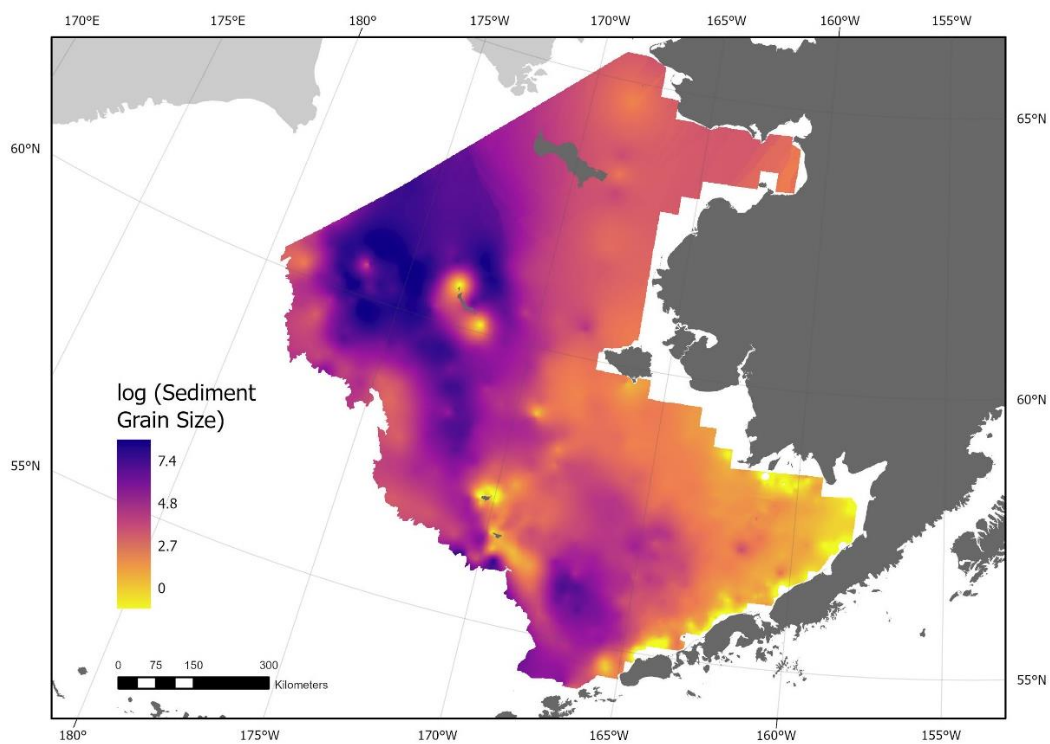

Figure 4-15 Surface sediment textural characteristics in the Eastern Bering Sea

2. In Section 4.2.2, make the following edits to the existing text:

4.2.2 Essential Fish Habitat Definitions

EFH is defined in the Magnuson-Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act) as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity." EFH for groundfish species is described for FMP-managed species 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 (~~See Appendix F to~~ NMFS 2005, NPFMC and NMFS 2010, ~~and~~ Simpson et al. 2017, and Harrington et al. 2024). EFH descriptions include both text (Section 4.2.2.2 and Appendix D) and maps (Section 4.2.2.3 and Appendix E; see section E.2 and Harris et al. 2022 and Laman et al. 2022 for mapping methods), if information is available for a species' particular life stage. These descriptions are risk averse, supported by scientific rationale, and account for changing oceanographic conditions, regime shifts, and the seasonality of migrating fish stocks.

EFH descriptions are interpretations of the best scientific information. In support of this information, a thorough review of FMP species is contained in the Environmental Impact Statement for Essential Fish Habitat Identification and Conservation (NMFS 2005) in Section 3.2.1, Biology, Habitat Usage, and Status of Magnuson-Stevens Act Managed Species and detailed by life history stage in Appendix F: EFH Habitat Assessment Reports. This EIS was supplemented in 2010, ~~and~~ 2017, and 2023 by the 5-year review cycle, which periodically re-evaluates EFH descriptions and fishing and non-fishing impacts on EFH in light of new information (NPFMC and NMFS 2010, ~~and~~ Simpson et al. 2017, Harrington et al. 2024).

3. In Section 4.2.2.1, replace Table 4-9 and the associated table caption and text with the following revised table, caption, and text:

~~A summary of the habitat information levels for each species is listed in Table 4-9.~~

Table 4-9 lists the levels of EFH information available as a result of the 2023 EFH Review for species and species complexes for which EFH is currently identified in the BSAI FMP. Shark EFH was not updated during the 2023 review.

Table 4-9 The levels of EFH information available as a result of the 2023 EFH Review, for species and species complexes in the BSAI FMP.

Species/Complex	Life Stage					
	Egg	Larvae	Early Juvenile pelagic	Early Juvenile settled	Subadult	Adult
Alaska plaice	1	1	0	2	2	2
Arrowtooth flounder	1	1	1	2	2	2
Atka mackerel	1	1	1	0	2	2
Flathead sole/Bering flounder complex	0	0	0	0	2	
Bering flounder	0	0	0	0	2	2
Flathead sole	1	1	1	2	2	2
Greenland turbot	1	1	1	0	2	2
Kamchatka flounder	1	1	1	0	2	2
Northern rock sole	0	1	1	2	2	2
Northern rockfish	1	1	1	0	2	2
Octopus	0	0	--	0	0	
Giant octopus	0	0	--	0	2	
Other flatfish complex	1	1	1	0	2	
Butter sole	0	0	0	0	2	
Deepsea sole	0	0	0	0	2	
Dover sole	0	0	0	0	2	2
English sole	0	0	0	1	1	2
Longhead dab	0	0	0	0	2	
Rex sole	0	0	0	2	2	2
Sakhalin sole	0	0	0	0	2	2
Southern rock sole	0	0	0	1	2	2
Starry flounder	0	0	0	1	2	2
Other rockfish complex	1	1	1	0	2	
Dusky rockfish	1	1	1	0	2	2
Harlequin rockfish	1	1	1	0	2	2
Shortspine thornyhead	0	0	0	0	2	2
Pacific cod	0	1	1	3	2	2
Pacific ocean perch	1	1	1	2	2	2

Species/Complex	Life Stage					
	Egg	Larvae	Early Juvenile pelagic	Early Juvenile settled	Subadult	Adult
Rougheye/Blackspotted rockfish complex	**1**	**1**	**1**	**0**	**2**	**2**
Sablefish	**0**	**0**	**0**	**2**	**2**	**2**
Shortraker rockfish	**1**	**1**	**1**	**0**	**2**	**2**
Skate complex	**1**	**1**	**--**	**1**	**2**	
Alaska skate	**0**	**0**	**--**	**0**	**2**	**2**
Aleutian skate	**0**	**0**	**--**	**0**	**2**	**2**
Bering skate	**0**	**0**	**--**	**0**	**2**	**2**
Big skate	**0**	**0**	**--**	**0**	**2**	**0**
Mud skate	**0**	**0**	**--**	**0**	**2**	**2**
Whiteblotched skate	**0**	**0**	**--**	**0**	**2**	**2**
Walleye pollock	**1**	**1**	**1**	**3**	**2**	**2**
Yellowfin sole	**1**	**1**	**1**	**2**	**2**	**2**

4. ***In Section 4.2.2.2, replace 4.2.2.2.1 through 4.2.2.2.30 with the revised text below. Note that the order of species has been revised to be alphabetical. Remove sections on Forage Fish, Grenadier, Sculpin, and Squid because they are in the ecosystem component.***

4.2.2.2.1 Alaska plaice

Eggs: EFH for Alaska plaice eggs is the general distribution area for this life stage, located in pelagic waters along the entire continental shelf (0 to 200 m depth) and upper slope (200 to 500 m depth) throughout the BSAI in the spring~~, as depicted in Figure E-93~~.

Larvae: EFH for Alaska plaice larvae is the general distribution area for this life stage. Pelagic larvae are primarily collected from depths greater than 200 m, with the majority occurring over bottom depths ranging from 50 to 100 m. Densities of preflexion stage larvae are concentrated at depths 10 to 20 m~~, as depicted in Figure E-94~~.

Settled Early Juveniles: ~~No EFH description determined. Insufficient information is available.~~ EFH for settled early juvenile Alaska plaice is the general distribution area for this life stage, located in the lower portion of the water column along the inner (0 to 50 m depth), and middle (50 to 100 m depth) continental shelf throughout the BSAI wherever there are substrates consisting of sand and mud (Laman et al. 2022).

Subadults: ~~**Late Juveniles:** No EFH description determined. Insufficient information is available.~~ EFH for subadult Alaska plaice is the general distribution area for this life stage, located in the lower portion of the water column along the inner (0 to 50 m depth), middle (50 to 100 m depth), and outer (100 to 200 m depth) continental shelf, and mainly east of the 200 m isobath (Laman et al. 2022).

Adults: EFH for adult Alaska plaice is the general distribution area for this life stage, located in the lower portion of the water column along the inner (0 to 50 m depth), middle (50 to 100 m depth), and outer (100 to 200 m depth) continental shelf throughout the BSAI wherever there are softer substrates consisting of sand and mud~~, as depicted in Figures E-89 through E-92~~. EFH areas appear to roughly mirror the historic extent of the cold pool across the EBS shelf (Laman et al. 2022).

4.2.2.2.2 Arrowtooth flounder

Eggs: No EFH description determined. Insufficient information is available.

Larvae: EFH for larval arrowtooth flounder is the general distribution area for this life stage, found in epipelagic waters located in demersal habitat throughout the continental shelf (0 to 200 m depth) and upper slope (200 to 500 m depth)~~, as depicted in Figures E-60 and E-66~~.

Settled Early Juveniles: EFH for settled early juvenile arrowtooth flounder is the general distribution area for this life stage, located in demersal habitat of the inner (0 to 50 m depth) and middle (50 to 100 m depth) continental shelf~~, as depicted in Figures E-59 and E-65~~. In the EBS, settled early juvenile EFH areas were concentrated in the middle shelf domain to the upper continental slope (Laman et al. 2022).

Subadults: ~~**Late Juveniles:**~~ EFH for subadult ~~late juvenile~~ arrowtooth flounder is the general distribution ~~habitat-related density~~ area for this life stage, located in the lower portion of the water column along the inner (0 to 50 m depth), middle (50 to 100 m depth), and outer (100 to 200 m depth) continental shelf and upper slope (200 to 500 m) throughout the BSAI wherever there are ~~softer~~ substrates consisting of gravel, sand, and mud~~, as depicted in Figures E- E-59 and E-65~~. Subadults are broadly dispersed over the continental shelf and slope with hot spots in deeper waters (Laman et al. 2022). In the AI, EFH for subadult arrowtooth flounder is similar to adults and has large hot spots around Unalaska and Atka islands (Harris et al. 2022).

Adults: EFH for adult arrowtooth flounder is the general distribution ~~habitat-related density~~ area for this life stage, located in the lower portion of the water column along the inner (0 to 50 depth), middle (50 to 100 m depth), and outer (100 to 200 m depth) continental shelf and upper slope (200 to 500 m depth) throughout the BSAI wherever there are softer substrates consisting of gravel, sand, and mud~~, as depicted in Figures E-55 through E-58 and E-61 through E-64~~. Adult EFH follow similar patterns of earlier life history stages, and there are EFH hotspots around Unalaska and Atka Islands (Harris et al. 2022, Laman et al. 2022).

4.2.2.2.3 Atka mackerel

Eggs: EFH for Atka mackerel eggs is the general distribution area for this life stage, located in demersal habitat along the continental shelf (0 to 200 m depth). There are widespread observations of nesting sites throughout the Aleutian Islands; however observations are not complete for the entire area~~, as depicted in Figure E-200~~.

Larvae: EFH for larval Atka mackerel is the general distribution area for this life stage, located in epipelagic waters (0 to 200 m depth) along the continental shelf ~~(0 to 200 m)~~, upper slope ~~(200 to 500 m)~~, and intermediate slope ~~(500 to 1000 m)~~ throughout the Aleutian Islands ~~BSAI, as depicted in Figure E-191~~.

Settled Early Juveniles: No EFH description determined. Insufficient information is available.

Subadults: ~~**Late Juveniles:**~~ EFH for subadult ~~late juvenile~~ Atka mackerel is the general distribution area for this life stage, located in the entire water column, from sea surface to the sea floor, 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 Aleutian Islands and the southern Bering Sea ~~BSAI wherever there are~~ in areas with substrates of gravel and rock and in vegetated areas of kelp~~, as depicted in Figure E-201~~. EFH for subadult Atka mackerel is similar to adult Atka mackerel in the AI (Harris et al. 2022).

Adults: EFH for adult Atka mackerel is the general distribution ~~habitat-related density~~ area for this life stage, located in the entire water column, from sea surface to the sea floor, 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 Aleutian Islands ~~BSAI~~ and southern Bering Sea generally where ~~wherever~~ there are substrates of gravel and rock and in vegetated areas of kelp. Habitat-related densities of Atka mackerel are available, usually at depths less than 200 m and generally over rough, rocky and uneven bottom near areas where tidal currents are swift~~, as depicted in Figure E-192 through E-199~~. Predicted EFH in the EBS was largely restricted to the shelf break and outer shelf domain, and EFH in the AI survey area was more eastern with a hot spot near Unimak Pass (Harris et al. 2022, Laman et al. 2022).

4.2.2.2.4 Flathead sole/Bering flounder complex

This section describes EFH for the Flathead sole/Bering flounder complex, which includes the following two species:

Bering flounder, and
Flathead sole.

Eggs: No EFH description determined. Insufficient information is available.

Larvae: No EFH description determined. Insufficient information is available.

Settled Early Juveniles: No EFH description determined. Insufficient information is available.

Subadults: EFH for the subadult life stage is the general distribution area in the eastern Bering Sea. The core EFH areas reflect the combination of the two species at this life stage in that they extend along the middle continental shelf from Bristol Bay on to the outer domain and up to the northern extent of the area (Laman et al. 2022).

Adults: EFH for the subadult life stage is the general distribution area in the eastern Bering Sea. Core EFH and EFH hot spots for this life stage extend from Bristol Bay across the middle and outer continental shelf domains, but exclude the inner shelf except along the Alaska Peninsula (Laman et al. 2022).

4.2.2.2.4.1 Bering flounder

Eggs: No EFH description determined. Insufficient information is available.

Larvae: No EFH description determined. Insufficient information is available.

Settled Early Juveniles: No EFH description determined. Insufficient information is available.

Subadults: EFH for the subadult life stage is the general distribution area that extends southward from the U.S.-Russia Convention Line and northern extent of the EBS/NBS well into the southern third of the EBS. Subadults showed prevalence in Norton Sound compared to adult Bering flounder (Laman et al. 2022).

Adults: EFH for the adult life stage is the general distribution area that extends southward from the U.S.-Russia Convention Line and northern extent of the EBS/NBS well into the southern third of the EBS (Laman et al. 2022).

4.2.2.2.4.2 Flathead sole

Eggs: EFH for flathead sole eggs is the general distribution area for this life stage, located in pelagic waters along the entire continental shelf (0 to 200 m depth) and slope (200 to 3,000 m depth) throughout the BSAI in the spring~~, as depicted in Figures E-120 and E-125~~.

Larvae: EFH for larval flathead sole is the general distribution area for this life stage, located in pelagic waters along the entire continental shelf (0 to 200 m depth) and slope (200 to 3,000 m depth) throughout the BSAI~~, as depicted in Figure E-115~~.

Settled Early Juveniles: EFH for settled early juvenile flathead sole is the general distribution ~~habitat-related density~~ area for this life stage, located in the lower portion of the water column along the inner (0 to 50 m depth) and middle (50 to 100 m depth) continental shelf throughout the BSAI wherever there are softer substrates consisting of sand and mud~~, as depicted in Figures E-114 and E-126~~.

Subadults: ~~**Late Juveniles:**~~ EFH for subadult ~~late juvenile~~ flathead sole is the general distribution ~~habitat-related density~~ area for this life stage, located in the lower portion of the water column along the inner (0 to 50 m depth), middle (50 to 100 m depth), and outer (100 to 200 m depth) continental shelf throughout the BSAI wherever there are softer substrates consisting of sand and mud~~, as depicted in Figures E-114 and E-126~~. EFH for subadult flathead sole is found in areas with depths < 300 m in the AI and along the continental slope in deeper waters in the EBS (Harris et al. 2022, Laman et al. 2022).

Adults: EFH for adult flathead sole is the general distribution ~~habitat-related density~~ area for this life stage, located in the lower portion of the water column along the inner (0 to 50 m depth), middle (50 to 100 m depth), and outer (100 to 200 m depth) continental shelf throughout the BSAI wherever there are softer substrates consisting of sand and mud~~, as depicted in Figure E-116 through E-119 and E-121 through E-124~~. EFH for adults is very similar to other life history stages and does not seem to change as they reach maturity (Harris et al. 2022). In the EBS, EFH extended from Bristol Bay along the middle and outer shelf domains towards the north (Laman et al. 2022).

4.2.2.2.5 Greenland turbot

Eggs: No EFH description determined. Insufficient information is available.

Larvae: EFH for larval Greenland turbot is the general distribution area for this life stage, located principally in ~~benthypelagic~~ bathypelagic waters along the outer continental shelf (100 to 200 m depth) and slope (200 to 3,000 m depth) throughout the BSAI and seasonally abundant in the spring~~, as depicted in Figure E-49.~~

Settled Early Juveniles: EFH for settled early juvenile Greenland turbot is the general distribution area for this life stage, located in the lower and middle portion of the water column along the inner (0 to 50 m depth), middle (50 to 100 m depth), and outer (100 to 200 m depth) continental shelf and upper slope (200 to 500 m depth) throughout the BSAI wherever there are softer substrates consisting of mud and sandy mud~~, as depicted in Figures E-48 and E-54~~.

Subadults: ~~**Late Juveniles:**~~ EFH for settled early ~~late~~ juvenile Greenland turbot is the general distribution ~~habitat-related density~~ area for this life stage, located in the lower and middle portion of the water column along the inner (0 to 50 m depth), middle (50 to 100 m depth), and outer (100 to 200 m depth) continental shelf and upper slope (200 to 500 m depth) throughout the BSAI wherever there are softer substrates consisting of mud and sandy mud~~, as depicted in Figures E-48 and E-54~~. EFH for subadult Greenland turbot extends in the EBS from the southern middle shelf domain to the north and onto the outer shelf domain and continental slope (Laman et al. 2022).

Adults: EFH for late adult Greenland turbot is the general distribution ~~habitat-related density~~ area for this life stage, located in the lower and middle portion of the water column along the outer continental shelf (100 to 200 m depth), upper slope (200 to 500 m depth), and lower slope (500 to 1,000 m depth) throughout the BSAI wherever there are softer substrates consisting of mud and sandy mud~~, as depicted in Figures E-44 through E-47 and E-50 through E-53~~. EFH hotspots were around the head of the Bering Canyon and along the continental slope in the EBS (Laman et al. 2022) and around Seguam Pass and Petrel Bank in the AI area, with EFH closely following the 300 m depth contour (Harris et al. 2022).

4.2.2.2.6 Kamchatka flounder

Eggs: No EFH description determined. Insufficient information is available.

Larvae: No EFH description determined. Insufficient information is available.

Settled Early Juveniles: EFH for settled early juvenile Kamchatka flounder is the general distribution area for this life stage, located in demersal habitat of the middle (50 to 100 m depth) and outer (100 to 200 m depth) continental shelf~~, as depicted in Figures E-71 and E-76~~.

Subadults: ~~Late Juveniles:~~ EFH for subadult ~~late juvenile~~ Kamchatka flounder is the general distribution area for this life stage, located in the lower portion of the water column along the middle (50 to 100 m depth), and outer (100 to 200 m depth) continental shelf and upper slope (200 to 500 m depth) throughout the BSAI wherever there are ~~softer~~ substrates consisting of gravel, sand, and mud~~, as depicted in Figure E-71 and E-76~~. Subadult EFH is constrained to the EBS middle and outer shelf domains, though there were AI hot spots around Atka Island, between Attu and Agattu islands, and Petrel Bank (Harris et al. 2022, Laman et al. 2022).

Adults: EFH for adult Kamchatka flounder is the general distribution area for this life stage, located in the lower portion of the water column along the middle (50 to 100 m depth), and outer (100 to 200 m depth) continental shelf and slope waters down to 600 m depth throughout the BSAI wherever there are ~~softer~~ substrates consisting of gravel, sand, and mud~~, as depicted in Figure E-67 through E-70 and E-72 through E-75~~. Adult EFH is similar to subadult EFH, though smaller in comparison in the AI, and hotspots for both life stages were located over the outer shelf domain, on the upper continental slope, and deep passes that cut through the AI such as Seguam Pass and Buldir Strait (Harris et al. 2022, Laman et al. 2022).

4.2.2.2.7 Northern rock sole

Eggs: No EFH description determined. Insufficient information is available.

Larvae: EFH for larval northern rock sole is the general distribution area for this life stage, located in pelagic waters along the entire continental shelf (0 to 200 m depth) and upper slope (200 to 1,000 m depth) throughout the BSAI~~, as depicted in Figures E-82 and E-88~~.

Settled Early Juveniles: EFH for settled early juvenile northern rock sole is the general distribution area for this life stage, located in the lower portion of the water column along the inner (0 to 50 m depth), middle (50 to100 m depth), and outer (100 to 200 m depth) continental shelf throughout the BSAI wherever there are ~~softer~~ substrates consisting of sand, gravel, and cobble. Upon settlement in nearshore areas from 1-40 m deep, juveniles preferentially select sediment suitable for feeding on meiofaunal prey and burrowing for protection but may be prevented from settling inshore by the seasonal inner front. Juveniles ~~are separate from the adult population,~~ remaining in shallow areas until they reach approximately 150-200 ~~c~~mm. ~~Most likely are habitat generalists on abundant physical habitat, as depicted in Figures E-81 and E-87.~~ Core EFH areas and EFH hotspots for settled early juveniles in the EBS extended farther north and into Norton Sound than subadults and adults (Laman et al. 2022). EFH in the AI was smaller for settled early juveniles compared to subadults and adults, and hot spots were near Umnak and Attu Islands (Harris et al. 2022).

Subadults: ~~Late Juveniles:~~ EFH for subadult ~~late juvenile~~ northern rock sole is the general distribution area for this life stage, located in the lower portion of the water column along the inner (0 to 50 m depth), middle (50 to100 m depth), and outer (100 to 200 m depth) continental shelf throughout the BSAI wherever there are ~~softer~~ substrates consisting of sand, gravel, and cobble~~, as depicted in Figures E-81 and E-87~~. Subadult EFH covers the EBS shelf, the NBS, and all areas in the AI shallower than 300 m (Harris et al. 2022, Laman et al. 2022).

Adults: EFH for adult northern rock sole is the general distribution area for this life stage, located in the lower portion of the water column along the inner (0 to 50 m depth), middle (50 to 100 m depth), and outer (100 to 200 m depth) continental shelf throughout the BSAI wherever there are ~~softer~~ substrates consisting of sand, gravel, and cobble~~, as depicted in Figures E-77 through E-80 and E-83 through E-86~~. EFH hotspots were notable around the Pribilofs and St. Matthew Island, and in Bristol Bay, as well as areas in the AI shallower than 300 m (Harris et al. 2022, Laman et al. 2022).

4.2.2.2.8 Northern rockfish

Eggs: No EFH description determined. Insufficient information is available.

Larvae: No EFH description determined. Insufficient information is available.

Settled Early Juveniles: EFH for settled early juvenile northern rockfish is the general distribution area for this life stage, located throughout the water column along the entire continental shelf (0 to 200 m depth)~~, as depicted in Figure E-147~~.

Subadults: ~~Late Juveniles~~: EFH for subadult ~~late juvenile~~ northern rockfish is the general distribution ~~habitat-related density~~ area for this life stage, located in the middle and lower portions of the water column along the outer continental shelf (100 to 200 m depth) throughout the BSAI~~, wherever there are substrates of cobble and rock, as depicted in Figure E-147~~. Subadult EFH is common throughout the AI, with hot spots around Buldir Strait and Stalemate Bank (Harris et al. 2022).

Adults: EFH for adult northern rockfish is the general distribution ~~habitat-related density~~ area for this life stage, located in the middle and lower portions of the water column along the outer continental shelf (100 to 200 m depth) throughout the BSAI wherever there are substrates of cobble and rock~~, as depicted in Figures E-139 through E-146~~. EFH extends along the shelf break and outer EBS shelf domain from Unimak Pass in the south to Navarin Canyon in the north, and high-quality EFH is located in the western AI at relatively shallow depths (Harris et al. 2022, Laman et al. 2022).

4.2.2.2.9 Octopus: Giant octopus

Eggs: No EFH description determined. Insufficient information is available.

Larvae: No EFH description determined. Insufficient information is available.

Settled Early Juveniles: No EFH description determined. Insufficient information is available.

Subadults: ~~**Late Juveniles:**~~ No EFH description determined. Insufficient information is available.

Adults: EFH for adult octopus is the general distribution ~~habitat-related density~~ area for this life stage, located in demersal habitat throughout the intertidal, subtidal, continental shelf (0 to 200 m depth)~~,~~ and slope (200 to 2,000 m depth)~~, as depicted in Figures E-268 through E-275~~. EFH hot spots were located in the central and western AI and correspond to locations where sponges are likely to be present, and progressively further offshore in the EBS (Harris et al. 2022, Laman et al. 2022).

4.2.2.2.10 Other Flatfish Complex Species

This section describes EFH for the Other flatfish complex. In the EBS, all seven species and their life stages are combined to form a single composite species complex to model EFH. In the AI, some subadults could be separated from adults, with the abundance maps being very similar. The Other flatfish complex species include—

Butter sole,
Deepsea sole,
Dover sole,
English sole,
Longhead dab,
Rex sole,
Sakhalin sole,
Southern rock sole, and
Starry flounder.

Eggs: No EFH description determined. Insufficient information is available.

Larvae: No EFH description determined. Insufficient information is available.

Settled Early Juveniles: No EFH description determined. Insufficient information is available.

Subadults: The primary hotspot for subadults in the AI is the high density area in the eastern AI. With the exception of some deeper habitats, most of the area qualifies as EFH; however, this is mostly due to rex sole, which are very common throughout the entire region (Harris et al. 2022).

Adults: Like subadults, a large EFH hotspot is located in the eastern AI, representing the area of high density of southern rock sole and rex sole. In the western AI, most EFH occurs at greater depths and mirrors the distribution of rex sole (Harris et al. 2022).

4.2.2.2.10.1 Butter sole

Eggs: No EFH description determined. Insufficient information is available.

Larvae: No EFH description determined. Insufficient information is available.

Settled Early Juveniles: No EFH description determined. Insufficient information is available.

Subadults: No EFH description determined. Insufficient information is available.

Adults: Butter sole EFH is distributed along the Alaska Peninsula and throughout Bristol Bay as well as from north of Nunivak Island out to St. Matthew Island (Laman et al. 2022).

4.2.2.2.10.2 Deepsea sole

Eggs: No EFH description determined. Insufficient information is available.

Larvae: No EFH description determined. Insufficient information is available.

Settled Early Juveniles: No EFH description determined. Insufficient information is available.

Subadults: No EFH description determined. Insufficient information is available.

Adults: Deepsea sole EFH is distributed across the deeper depths of the continental slope in the EBS. Core EFH and EFH hotspots are scattered throughout the range of their distribution (Laman et al. 2022).

4.2.2.2.10.3 Dover sole

Eggs: No EFH description determined. Insufficient information is available.

Larvae: No EFH description determined. Insufficient information is available.

Settled Early Juveniles: EFH for settled early juvenile Dover sole is the general distribution area for this life stage, located in demersal habitat of the inner (0 to 50 m depth) and middle (50 to 100 m depth) continental shelf~~, as depicted in Figures E-110 and E-113~~.

Subadults: ~~**Late Juveniles:**~~ EFH for subadult ~~late juvenile~~ Dover sole is the general distribution ~~habitat-related density~~ area for this life stage, located in the lower portion of the water column along the middle (50 to 100 m depth), and outer (100 to 200 m depth) continental shelf and upper slope (200 to 500 m depth) throughout the BSAI wherever there are substrates consisting of sand and mud~~, as depicted in Figures E-110 and E-113~~. Subadult EFH ranges from the middle shelf domain in the southern EBS into the Bering Canyon and north along the continental slope (Laman et al. 2022). In the AI, subadult Dover sole EFH is in moderately deep areas around 200 – 300 m depth, though it also includes some shallow, nearshore areas (Harris et al. 2022).

Adults: EFH for adult Dover sole is the general distribution ~~habitat-related density~~ area for this life stage, located in the lower portion of the water column along the middle (50 to 100 m depth) and outer (100 to 200 m depth) continental shelf, and upper (200 to 500 m depth) and intermediate (500 to 1000 m depth) slope throughout the BSAI wherever there are substrates consisting of sand and mud~~, as depicted in Figures E-107 through E-109 and E-111 through E-112~~. EFH hotspots were constrained mainly to the head of the Bering Canyon and northward to Pribilof Canyon, and around Petrel Bank and Amchitka Pass (Harris et al. 2022, Laman et al. 2022).

4.2.2.2.10.4 English sole

Eggs: No EFH description determined. Insufficient information is available.

Larvae: No EFH description determined. Insufficient information is available.

Settled Early Juveniles: No EFH description determined. Insufficient information is available.

Subadults: No EFH description determined. Insufficient information is available.

Adults: The EFH area for English sole is localized to the areas near shore around Unalaska and Umnak islands, with a smaller area near Atka Island. All EFH hot spots for English sole occur close to shore, with the overall EFH extending into deeper water up to 300 m depth (Harris et al. 2022).

4.2.2.2.10.5 Longhead dab

Eggs: No EFH description determined. Insufficient information is available.

Larvae: No EFH description determined. Insufficient information is available.

Settled Early Juveniles: No EFH description determined. Insufficient information is available.

Subadults: No EFH description determined. Insufficient information is available.

Adults: Longhead dab EFH extends into the middle continental shelf domain across their range in the EBS, but is primarily located over the inner shelf (Laman et al. 2022).

4.2.2.2.10.6 Rex sole

Eggs: EFH for rex sole eggs is the general distribution area for this life stage, located in epipelagic waters throughout the continental shelf (0 to 200 m depth) and upper slope (200 to 300 m depth)~~, as depicted in Figures E-99 and E-105~~.

Larvae: No EFH description determined. Insufficient information is available.

Settled Early Juveniles: EFH for settled early juvenile rex sole is the general distribution area for this life stage, located in demersal habitat of the inner (0 to 50 m depth) and middle (50 to 100 m depth) continental shelf~~, as depicted in Figures E-100 and E-106~~.

Subadults: ~~**Late Juveniles:**~~ EFH for subadult ~~late juvenile~~ rex sole is the general distribution ~~habitat-related density~~ area for this life stage, located in the lower portion of the water column along the inner (0 to 50 m depth), middle (50 to 100 m depth), and outer (100 to 200 m depth) continental shelf throughout the BSAI wherever there are substrates consisting of gravel, sand, and mud~~, as depicted in Figures E-100 and E-106~~. Subadult EFH focused on the outer shelf domain and shelf break of the EBS, Bristol Bay, and in AI areas shallower than 300 m (Harris et al. 2022, Laman et al. 2022).

Adults: EFH for adult rex sole is the general distribution ~~habitat-related density~~ area for this life stage, located in the lower portion of the water column along the inner (0 to 50 m depth), middle (50 to 100 m depth), and outer (100 to 200 m depth) continental shelf throughout the BSAI wherever there are substrates consisting of gravel, sand, and mud~~, as depicted in Figures E-95 through E-98 and E-101 through 104~~. EFH hot spots extended into Bristol Bay, with smaller hot spots farther west near Atka and Agattu Islands (Harris et al. 2022, Laman et al. 2022).

4.2.2.2.10.7 Sakhalin sole

Eggs: No EFH description determined. Insufficient information is available.

Larvae: No EFH description determined. Insufficient information is available.

Settled Early Juveniles: No EFH description determined. Insufficient information is available.

Subadults: Subadult Sakhalin EFH extends from the northern extent of the EBS into Norton Sound and to south of Nunivak Island in the central EBS over the inner and middle continental shelf domains (Laman et al. 2022).

Adults: Adult EFH does not extend as far south as that of subadults. For both subadult and adult life stages, core EFH and EFH hotspots are largely restricted to the NBS surrounding St. Lawrence Island (Laman et al. 2022).

4.2.2.2.10.8 Southern rock sole

Eggs: No EFH description determined. Insufficient information is available.

Larvae: EFH for Southern rock sole larvae is the general distribution area for this life stage. Larvae are located in the pelagic waters along the entire continental shelf (0 to 200m depth) and upper slope (200 to 1,000m) throughout the BSAI~~, as depicted in Figure E-262~~.

Settled Early Juveniles: EFH for settled early juvenile Southern rock sole is the general distribution area for this life stage, located in the lower portion of the water column within nearshore bays and along the inner (0 to 50 m depth), middle (50 to 100 m depth), and outer (100 to 200 m depth) continental shelf throughout the BSAI wherever there are soft substrates consisting mainly of sand~~, as depicted in Figures E-261 and E-267~~.

Subadults: ~~Late Juveniles:~~ EFH for subadult ~~late juvenile~~ Southern rock sole is the general distribution area for this life stage, located in the lower portion of the water column within nearshore bays and along the inner (0 to 50 m depth), middle (50 to 100 m depth), and outer (100 to 200 m depth) continental shelf throughout the BSAI wherever there are soft substrates consisting mainly of sand~~, as depicted in Figures E-261 and E-267~~. Subadult EFH is in shallow continental shelf habitats with hotspots around Unalaska and Atka islands (Harris et al. 2022).

Adults: EFH for adult Southern rock sole is the general distribution area for this life stage, located in the lower portion of the water column along the inner (0 to 50 m depth), middle (50 to 100 m depth), and outer (100 to 200 m depth) continental shelf throughout the BSAI wherever there are ~~soft~~ substrates consisting mainly of sand, gravel, and cobble. ~~as depicted in Figures E-257 through E-260 and E-263 through E-266~~. EFH is marked by large, shallow continental shelf habitats with similar hotspots to subadults (Harris et al. 2022).

4.2.2.2.10.9 Starry flounder

Eggs: No EFH description determined. Insufficient information is available.

Larvae: No EFH description determined. Insufficient information is available.

Settled Early Juveniles: No EFH description determined. Insufficient information is available.

Subadults: Subadult starry flounder EFH is constrained to the inner EBS continental shelf domain and Bristol Bay (Laman et al. 2022).

Adults: Adult starry flounder EFH extends farther offshore on to the middle continental shelf domain with contiguous patches of EFH around offshore islands. For both subadult and adult life stages, EFH hotspots are located adjacent to shore while core EFH areas were offshore of those hotspots (Laman et al. 2022).

4.2.2.2.11 Other Rockfish Complex

This section describes EFH for the Other rockfish complex. Of the rockfishes that could contribute to EFH for the other rockfish stock complex in the BSAI, only shortspine thornyhead was caught in sufficient prevalence to parameterize a species distribution model. Therefore, shortspine thornyhead EFH suffices as the proxy for the Other rockfish complex in the BSAI at this time. The Other rockfish complex species include—
Dusky rockfish,
Harlequin rockfish, and
Shortspine thornyhead.

4.2.2.2.11.1 Dusky Rockfish

Eggs: No EFH description determined. Insufficient information is available.

Larvae: No EFH description determined. Insufficient information is available.

Settled Early Juveniles: EFH for settled early juvenile dusky rockfish is the general distribution area for this life stage, located in the pelagic waters along the entire continental shelf (0 to 200 m depth) and slope (200 to 3,000 m depth) throughout the BSAI~~, as depicted in Figure E-180~~.

Subadults: ~~**Late Juveniles:**~~ EFH for subadult ~~late juvenile~~ dusky rockfish is the general distribution ~~habitat-related density~~ area for this life stage, located in the middle and lower portions of the water column along the outer continental shelf (100 to 200 m depth) and upper slope (200 to 500 m depth) throughout the BSAI wherever there are substrates of cobble, rock, and gravel~~, as depicted in Figure E-180~~. Subadult EFH is concentrated east of 170° W in the AI region (Harris et al. 2022).

Adults: EFH for adult dusky rockfish is the general distribution ~~habitat-related density~~ area for this life stage, located in the middle and lower portions of the water column along the outer continental shelf (100 to 200 m depth) and upper slope (200 to 500 m depth) throughout the BSAI wherever there are substrates of cobble, rock, and gravel~~, as depicted in Figure E-172 through E-175 and E-176 through 179~~. Adult EFH covers much of the area around the Islands of Four Mountains and Andreanof Islands before becoming sparser farther west in the AI region (Harris et al. 2022).

4.2.2.2.11.2 Harlequin Rockfish

Eggs: No EFH description determined. Insufficient information is available.

Larvae: No EFH description determined. Insufficient information is available.

Settled Early Juveniles: No EFH description determined. Insufficient information is available.

Subadults: No EFH description determined. Insufficient information is available.

Adults: Most of the area south of the AI along the edge of the continental slope is designated as EFH hotspots (Harris et al. 2022).

4.2.2.2.11.3 Thornyhead Rockfish (Shortspine)

Eggs: No EFH description determined. Insufficient information is available.

Larvae: No EFH description determined. Insufficient information is available.

Settled Early Juveniles: EFH for settled early juvenile thornyhead rockfish is the general distribution ~~habitat-related density~~ area for this life stage, located in epipelagic waters along the middle and outer continental shelf (50 to 200 m depth) and upper to lower slope (200 to 1,000 m depth) throughout the BSAI~~, as depicted in Figures E-181 and E-190~~.

Subadults: ~~**Late Juveniles:**~~ EFH for subadult ~~late juvenile~~ thornyhead rockfish is the general distribution ~~habitat-related density~~ area for this life stage, located in the lower portion of the water column along the middle and outer continental shelf (50 to 200 m depth) and upper to lower slope (200 to 1,000 m depth) throughout the BSAI wherever there are substrates of mud, sand, rock, sandy mud, muddy sand, cobble, and gravel~~, as depicted in Figures E-181 and E-190~~. Subadult EFH includes the continental slope and submarine canyon systems (Laman et al. 2022). Almost all AI EFH areas were at depths greater than 300 m (Harris et al. 2022).

Adults: EFH for adult thornyhead rockfish is the general distribution ~~habitat-related density~~ area for this life stage, located in the lower portion of the water column along the middle and outer continental shelf (50 to 200 m depth) and upper to lower slope (200 to 1,000 m depth) throughout the BSAI wherever there are substrates of mud, sand, rock, sandy mud, muddy sand, cobble, and gravel~~, as depicted in Figure E-182 through E-189~~. EFH hot spots in the EBS are associated with the continental slope and submarine canyon systems on the continental shelf (Laman et al. 2022). The AI EFH is located in deep water along the continental slope, particularly south of Unalaska Island (Harris et al. 2022).

4.2.2.2.12 Pacific Cod

Eggs: No EFH description determined. Insufficient information is available. Pacific cod eggs, which are demersal, are rarely encountered during surveys in the BSAI.

Larvae: EFH for larval Pacific cod is the general distribution ~~habitat-related density~~ area for this life stage, located in epipelagic waters along much of the middle (50 to 100 m depth) and outer (100 to 200 m depth) Eastern Bering Sea (EBS) continental shelf, with hotspots in the vicinity of the middle shelf north of Unimak Pass and the Pribilof Islands. The general distribution ~~habitat-related density~~ area of larval Pacific cod in the Aleutian Islands (AI) is unknown~~, as depicted in Figures E-20 and E-26~~.

Settled Early Juveniles: EFH for settled early juvenile Pacific cod is the general distribution ~~habitat-related density~~ area for this life stage, centered over the middle (50 to 100 m depth) EBS continental shelf between the Pribilof Islands and the Alaska Peninsula and broadly similar to the general distribution ~~habitat-related density~~ area for larval Pacific cod, but not extending as far north. Settled early juveniles are less widely distributed over the EBS outer shelf domain than either subadults or adults (Laman et al. 2022). The general distribution ~~habitat-related density~~ area of settled early juvenile Pacific cod in the AI is unknown~~, as depicted in Figures E-19 and E-25~~.

Subadults: ~~**Late Juveniles:**~~ EFH for subadult ~~late juvenile~~ Pacific cod is the general distribution ~~habitat-related density~~ area for this life stage, including nearly all of the EBS continental shelf (0 to 200 m depth) and upper slope (200 to 500 m depth), with highest abundances in the inshore portions of the central and southern domains of the EBS shelf, and broadly throughout the AI at depths up to 500 m~~, as depicted in Figures E-19 and E-25~~. Subadult EFH is widely distributed across the BSAI, with hot spots around Unimak Pass, the Andreanot Islands, and Attu Island (Harris et al. 2022, Laman et al. 2022).

Adults: EFH for adult Pacific cod is the general distribution ~~habitat-related density~~ area for this life stage, including nearly all of the EBS continental shelf and slope, with highest abundances in the central and northern domains over the middle (50 to 100 m depth) and outer (100 to 200 m depth) shelf, and broadly throughout the AI at depths up to 500 m~~, as depicted in Figures E-15 through E-18 and E-21 through E-24~~. Core EFH area extends the farthest north into the NBS for adults compared to other life history stages (Laman et al. 2022). In, the AI, adults share an EFH hot spot with subadults near Unimak Pass and there is a large hot spot around the Islands of Four Mountains, as well (Harris et al. 2022).

4.2.2.2.13 Pacific Ocean Perch

Eggs: No EFH description determined. Insufficient information is available.

Larvae: EFH for larval Pacific ocean perch is the general distribution area for this life stage, located in pelagic waters along the middle and outer continental shelf (50 to 200 m depth) and slope (200 to 3,000 m depth) throughout the BSAI~~, as depicted in Figures E-132 and E-138~~.

Settled Early Juveniles: EFH for settled early juvenile Pacific ocean perch is the general distribution area for this life stage, located at depths < 200 m in complex substrates. ~~throughout the water column along the entire shelf (0 to 200 m) , as depicted in Figures E-131 and E-137.~~ EFH generally overlaps subadult and adult EFH, though it is the smallest area for this life history stage of Pacific ocean perch and has hot spots around EBS submarine canyon heads, AI sea mounts, and east of Atka Island (Harris et al. 2022, Laman et al. 2022).

Subadults: ~~Late Juveniles:~~ EFH for subadult ~~late juvenile~~ Pacific ocean perch is the general distribution ~~habitat-related density~~ area for this life stage, located in the middle to lower portion of the water column at depths < 300 m ~~along middle shelf (50 to 100 m), outer shelf (100 to 200 m), and upper slope (200 to 500 m)~~ throughout the BSAI wherever there are substrates consisting of boulders, cobble, gravel, mud, sandy mud, or muddy sand~~, as depicted in Figures E-131 and E-137~~. Subadult EFH is in offshore areas of the AI and the outer continental shelf, shelf break, and upper continental slope of the EBS (Harris et al. 2022, Laman et al. 2022).

Adults: EFH for adult Pacific ocean perch is the general distribution ~~habitat-related density~~ area for this life stage, located in the lower portion of the water column along the outer continental shelf (100 to 200 m depth) and upper slope (200 to 500 m depth) throughout the BSAI wherever there are substrates consisting of cobble, gravel, mud, sandy mud, or muddy sand~~, as depicted in Figures E-127 through E-130 and E-133 through E-136~~. Adult EFH overlaps with settled early juvenile and subadult EFH, though adult EFH encompasses the largest overall area and has hot spots around the EBS shelf break and upper continental slope, and along the 300 m depth contour in the AI (Laman et al. 2022).

4.2.2.2.14 Rougheye/Blackspotted rockfish complex

Eggs: No EFH description determined. Insufficient information is available.

Larvae: No EFH description determined. Insufficient information is available.

Settled Early Juveniles: EFH for settled early juvenile rougheye/blackspotted~~/rougheye~~ rockfish is the general distribution area for this life stage, located in pelagic waters throughout the middle and outer (50 to 200 m depth) continental shelf and slope (200 to 3,000 m depth)~~, as depicted in Figures E-166 and E-171~~.

Subadults: ~~Late Juveniles:~~ EFH for subadult ~~late juvenile~~ rougheye/blackspotted~~/rougheye~~ rockfish is the general distribution area for this life stage, located in the lower portion of the water column along the upper continental slope (200 to 500 m depth) regions throughout the BSAI wherever there are substrates consisting of mud, sand, sandy mud, muddy sand, rock, cobble, and gravel~~, as depicted in Figure E-166~~. Subadult EFH is primarily the southern outer continental shelf domain and upper slope of the EBS, and much of the AI region including shallower waters (Harris et al. 2022, Laman et al. 2022).

Adults: EFH for adult rougheye/blackspotted~~/rougheye~~ rockfish is the general distribution ~~habitat-related density~~ area for this life stage, located in the lower portion of the water column along the upper continental slope (200 to 500 m depth) regions throughout the BSAI wherever there are substrates consisting of mud, sand, sandy mud, muddy sand, rock, cobble, and gravel~~, as depicted in Figures E 162 through E 165 and E 167 through E 170~~. The EFH area in the EBS is generally located offshore or downslope of the continental shelf break (Laman et al. 2022), and hot spots in the AI region occur offshore and track the 300 m depth contour (Harris et al. 2022).

4.2.2.2.15 Sablefish

Eggs: No EFH description determined. Insufficient information is available. Scientific information notes the rare occurrence of sablefish eggs in the BSAI.

Larvae: No EFH description determined. Insufficient information is available.

Settled Early Juveniles: ~~No EFH description determined. Information is insufficient.~~ Early juveniles have generally been observed in inshore water, bays, and passes, and on shallow continental shelf pelagic and demersal habitat~~, as depicted in Figures E-31 and E-36~~. EFH is primarily located over the southern EBS shelf near the Alaska Peninsula with hot spots located over the middle and outer shelf domains of the southern EBS (Laman et al. 2022).

Subadults: ~~Late Juveniles:~~ EFH for subadult ~~late juvenile~~ sablefish is the general distribution area for this life stage, located in the lower portion of the water column, varied habitats, generally softer substrates, and deep continental shelf gulleys along the slope (200 to 1,000 m depth) throughout the BSAI~~, as depicted in Figures E-31 and E-36~~. Subadult EFH is similar to adults though it extends into shallower waters in the AI region (Harris et al. 2022, Laman et al. 2022).

Adults: EFH for adult sablefish is the general distribution area for this life stage, located in the lower portion of the water column, varied habitats, generally softer substrates, and deep continental shelf gulleys along the slope (200 to 1,000 m depth) throughout the BSAI~~, as depicted in Figures E-27 through E-30 and E-32 through E-35~~. EFH is identified along the EBS outer shelf domain and extends northward along the shelf break and upper continental slope (Laman et al. 2022). Hot spots are associated with submarine canyon heads along the EBS shelf break and upper continental slope, and along most of the continental slope east of 180° south of the AI chain (Harris et al. 2022, Laman et al. 2022).

4.2.2.2.16 Sharks

The species representatives for sharks are:

Lamnidae: Salmon shark (*Lamna ditropis*),
Squalidae: Sleeper shark (*Somniosus pacificus*), and
Spiny dogfish (*Squalus suckleyi*).

Shark EFH was not updated during the 2023 review.

4.2.2.2.17 Shortraker Rockfish

Eggs: No EFH description determined. Insufficient information is available.

Larvae: No EFH description determined. Insufficient information is available.

Settled Early Juveniles: EFH for settled early juvenile shortraker rockfish is the general distribution area for this life stage, located in pelagic waters throughout the middle and outer (50 to 200 m depth) continental shelf and slope (200 to 3,000 m depth)~~, as depicted in Figures E-152 and E-157~~.

Subadults: ~~Late Juveniles:~~ EFH for subadult ~~late juvenile~~ shortraker rockfish is the general distribution ~~habitat-related density~~ area for this life stage, located in the lower portion of the water column along the outer continental shelf (100 to 200 m depth) and upper slope (200 to 500 m depth) regions throughout the BSAI wherever there are substrates consisting of mud, sand, sandy mud, muddy sand, rock, cobble, and gravel~~, Figures E-152 and E-157~~. Subadult EFH is constrained to the upper continental slope in deeper waters of the EBS and between depths of 300 – 500 m in the AI (Harris et al. 2022, Laman et al. 2022).

Adults: EFH for adult shortraker rockfish is the general distribution ~~habitat-related density~~ area for this life stage, located in the lower portion of the water column along the outer continental shelf (100 to 200 m depth) and upper slope (200 to 500 m depth) regions throughout the BSAI wherever there are substrates consisting of mud, sand, sandy mud, muddy sand, rock, cobble, and gravel~~, as depicted in Figures E-148 through E-151 and E-153 through E-156~~. The EFH area for adults overlaps with subadults, and hot spots are in a narrow band following the depth contours from Pribilof Canyon northward (Laman et al. 2022). There are also intermittent hot spots along the continental slope south of the AI and around the deeper passes between the islands (Harris et al. 2022).

4.2.2.2.18 Skate Complex

This section describes EFH for the Skate Complex. The Skate complex species include—
Alaska skate,
Aleutian skate,
Bering skate,
Big skate,
Mud skate, and
Whiteblotched skate.

Eggs: No EFH description determined. Insufficient information is available.

Larvae: Not applicable, skates emerge from egg fully formed.

Settled Early Juveniles: No EFH description determined. Insufficient information is available.

Subadults: The core EFH areas and EFH hot spots for subadults of this complex are primarily located over the central EBS and along the continental slope in association with submarine canyons (Laman et al. 2022). In the AI, EFH for the skate complex is high east of Atka Island and around the Islands of Four Mountains, as well as areas further west along the slope, and generally tends to be high in most areas with a moderate depth (Harris et al. 2022).

Adults: Core EFH areas for adults of this complex are very similar, but unlike subadults is more prominent in areas with shallow or moderate bottom depths. The EFH hot spots for adult skates in the complex are located west of Nunivak Island and over the outer shelf domain and upper continental slope of the EBS (Laman et al. 2022).

4.2.2.2.18.1 Alaska skate

Eggs: No EFH description determined. Insufficient information is available.

Larvae: Not applicable, skates emerge from egg fully formed.

Settled Early Juveniles: EFH for settled early juvenile skates is the general distribution area for this life stage, located in the lower portion of the water column on the continental shelf (0 to 200 m depth) and the upper slope (200 to 500 m depth) throughout the BSAI wherever there are of substrates of mud, sand, gravel, and rock~~, as depicted in Figures E-225 and E-232~~.

Subadults: ~~Late Juveniles:~~ EFH for subadult ~~late juvenile~~ skates is the general distribution ~~habitat-related density~~ area for this life stage, located in the lower portion of the water column on the continental shelf (0 to 200 m depth) and the upper slope (200 to 500 m depth) throughout the BSAI wherever there are of substrates of mud, sand, gravel, and rock~~, as depicted in Figures E-225 and E-232~~. Subadult EFH for subadult Alaska skates is across the EBS shelf and in shallow areas between 174° W and 179° E in the AI (Harris et al. 2022, Laman et al. 2022).

Adults: EFH for adult skates is the general distribution ~~habitat-related density~~ area for this life stage, located in the lower portion of the water column on the continental shelf (0 to 200 m depth) and the upper slope (200 to 500 m depth) throughout the BSAI wherever there are of substrates of mud, sand, gravel, and rock~~, as depicted in Figure E-221 through E-224 and E-226 through E-231~~. The EFH area is spread broadly over the EBS shelf and the shallow areas in the AI similar to the subadults, as well as the regions around Attu and Unalaska Islands (Harris et al. 2022, Laman et al. 2022).

4.2.2.2.18.2 Aleutian skate

Eggs: No EFH description determined. Insufficient information is available.

Larvae: Not applicable, skates emerge from egg fully formed.

Settled Early Juveniles: EFH for settled early juvenile skates is the general distribution area for this life stage, located in the lower portion of the water column on the continental shelf (0 to 200 m depth) and the upper slope (200 to 500 m depth) throughout the BSAI wherever there are of substrates of mud, sand, gravel, and rock~~, as depicted in Figures E-237 and E-242~~.

Subadults: ~~Late Juveniles:~~ EFH for subadults ~~late juvenile~~ skates is the general distribution ~~habitat-related density~~ area for this life stage, located in the lower portion of the water column on the continental shelf (0 to 200 m depth) and the upper slope (200 to 500 m depth) throughout the BSAI wherever there are of substrates of mud, sand, gravel, and rock~~, as depicted in Figures E-237 and E-242~~. Subadult EFH is the outer shelf domain and continental slope in deeper waters, with a large core area near Unimak Pass (Harris et al. 2022, Laman et al. 2022).

Adults: EFH for adult skates is the general distribution ~~habitat-related density~~ area for this life stage, located in the lower portion of the water column on the continental shelf (0 to 200 m depth) and the upper slope (200 to 500 m depth) throughout the BSAI wherever there are of substrates of mud, sand, gravel, and rock~~, as depicted in Figures E-233 though E-236 and E-238 through E-241~~. EFH is primarily focused at the EBS shelf break and onto the upper continental slope, but was patchy along the AI chain (Harris et al. 2022, Laman et al. 2022).

4.2.2.2.18.3 Bering skate

Eggs: No EFH description determined. Insufficient information is available.

Larvae: Not applicable, skates emerge from egg fully formed.

<u>Settled</u> Early Juveniles: EFH for <u>settled</u> early juvenile skates is the general distribution area for this life stage, located in the lower portion of the water column on the <u>continental</u> shelf (0 to 200 m <u>depth</u>) and the upper slope (200 to 500 m <u>depth</u>) throughout the BSAI wherever there are of substrates of mud, sand, gravel, and rock~~, as depicted in Figures E-244 and E-246~~.

<u>Subadults:</u> ~~Late Juveniles:~~ EFH for <u>settled early</u> ~~late~~ juvenile skates is the <u>general distribution</u> ~~habitat-related density~~ area for this life stage, located in the lower portion of the water column on the <u>continental</u> shelf (0 to 200 m <u>depth</u>) and the upper slope (200 to 500 m <u>depth</u>) throughout the BSAI wherever there are of substrates of mud, sand, gravel, and rock~~, as depicted in Figures E-244 and E-246~~. <u>Subadult EFH is in the outer EBS shelf domain (Laman et al. 2022).</u>

Adults: EFH for adult skates is the <u>general distribution</u> ~~habitat-related density~~ area for this life stage, located in the lower portion of the water column on the <u>continental</u> shelf (0 to 200 m <u>depth</u>) and the upper slope (200 to 500 m <u>depth</u>) throughout the BSAI wherever there are of substrates of mud, sand, gravel, and rock~~, as depicted in Figures E-243 and E-245~~. <u>The EFH area adults overlaps with subadults and is mostly constrained to the outer EBS shelf domain (Laman et al. 2022).</u>

4.2.2.2.18.4 Big skate

<u>**Eggs:** No EFH description determined. Insufficient information is available.</u>

<u>**Larvae:** Not applicable, skates emerge from egg fully formed.</u>

<u>**Settled Early Juveniles:** No EFH description determined. Insufficient information is available.</u>

<u>**Subadults:** EFH for subadult big skates extends along the Alaska Peninsula from Unimak Pass to the east along the inner continental shelf domain (Laman et al. 2022).</u>

<u>**Adults:** No EFH description determined. Insufficient information is available.</u>

4.2.2.2.18.5 Mud skate

Eggs: No EFH description determined. Insufficient information is available.

Larvae: Not applicable, skates emerge from egg fully formed.

<u>Settled</u> Early Juveniles: EFH for <u>settled</u> early juvenile skates is the general distribution area for this life stage, located in the lower portion of the water column on the <u>continental</u> shelf (0 to 200 m <u>depth</u>) and the upper slope (200 to 500 m <u>depth</u>) throughout the BSAI wherever there are of substrates of mud, sand, gravel, and rock~~, as depicted in Figures E-251 and E-256~~.

<u>Subadults:</u> ~~Late Juveniles:~~ EFH for <u>subadult</u> ~~late juvenile~~ skates is the <u>general distribution</u> ~~habitat-related density~~ area for this life stage, located in the lower portion of the water column on the <u>continental</u> shelf (0 to 200 m <u>depth</u>) and the upper slope (200 to 500 m <u>depth</u>) throughout the BSAI wherever there are of substrates of mud, sand, gravel, and rock~~, as depicted in Figures E-251 and E-256~~. <u>Subadult EFH extends from the Bering Canyon into other canyons along the continental shelf and, in the AI, has hot spots around Seguam Pass, Amchitka Pass, and south of Adak Island (Harris et al. 2022, Laman et al. 2022).</u>

Adults: EFH for adult skates is the <u>general distribution</u> ~~habitat-related density~~ area for this life stage, located in the lower portion of the water column on the <u>continental</u> shelf (0 to 200 m <u>depth</u>) and the upper slope (200 to 500 m <u>depth</u>) throughout the BSAI wherever there are of substrates of mud, sand, gravel, and rock~~, as depicted in Figures E-247 through E-250 and E-252 through E-255~~. <u>EFH is focused around canyon heads along the EBS</u>

shelf break and upper continental slope, and hot spots in the AI hot spots around Seguam Pass, Amchitka Pass, and south of Adak Island (Harris et al. 2022, Laman et al. 2022).

4.2.2.2.18.6 Whiteblotched skate

Eggs: No EFH description determined. Insufficient information is available.

Larvae: Not applicable, skates emerge from egg fully formed.

Settled Early Juveniles: No EFH description determined. Insufficient information is available.

Subadults: EFH for subadult whiteblotched skates is primarily located along the EBS upper continental slope, with an area predicted to the south and west of Nunivak Island as well. Core EFH areas and EFH hotspots are associated with the upper continental slope (Laman et al. 2022). In the AI, subadults have hotspots in the area west of Atka Island between 175° W and 170° W, in the western AI near Attu Island, and in the open passes around Petrel Bank (Harris et al. 2022).

Adults: EFH for adult whiteblotched skates is primarily located along the EBS upper continental slope. Core EFH areas and EFH hotspots are associated with the upper continental slope (Laman et al. 2022). In the AI, subadults have hotspots in the area west of Atka Island between 175° W and 170° W, in the western AI near Attu Island, and in the open passes around Petrel Bank (Harris et al. 2022).

4.2.2.2.19 Walleye pollock

Eggs: EFH for walleye pollock eggs is the general distribution area for this life stage, located in pelagic waters along the entire continental shelf (0 to 200 m depth), upper slope (200 to 500 m depth), and intermediate slope (500 to 1,000 m depth) throughout the BSAI~~, as depicted in Figures E-5 and E-12~~.

Larvae: EFH for larval walleye pollock is the general distribution area for this life stage, located in epipelagic waters along the entire continental shelf (0 to 200 m depth), upper slope (200 to 500 m depth), and intermediate slope (500 to 1,000 m depth) throughout the BSAI~~, as depicted in Figures E-7 and E-14~~.

Settled Early Juveniles: EFH for settled early juvenile walleye pollock is the general distribution ~~habitat-related density~~ area for this life stage, located in the lower and middle portion of the water column along the inner (0 to 50 m depth), middle (50 to 100 m depth), and outer (100 to 200 m depth) continental shelf throughout the BSAI. Relative abundance of age 1 pollock is used as an early indicator of year class strength and is highly variable (presumably due to survival factors and differential availability between years)~~, as depicted in Figures E-6 and E-13~~. The core EFH area in the EBS extends from the eastern margin of the inner shelf domain on to the upper continental slope (Laman et al. 2022). In the AI, EFH is centered around Unalaska Island, with hot spots also near Atka and Attu Islands (Harris et al, 2022).

Subadults: ~~Late Juveniles:~~ EFH for subadult ~~late juvenile~~ walleye pollock is the general distribution ~~habitat-related density~~ area for this life stage, located in the lower and middle portion of the water column along the inner (0 to 50 m depth), middle (50 to 100 m depth), and outer (100 to 200 m depth) continental shelf throughout the BSAI. Substrate preferences, if they exist, are unknown~~, as depicted in Figures E-6 and E-13~~. Subadult EFH encompasses most of the EBS survey area (Laman et al. 2022). In the AI, EFH for subadult walleye pollock is similar to early juveniles though with an increased depth range, extending out towards the continental slope and deeper waters (Harris et al. 2022).

Adults: EFH for adult walleye pollock is the general distribution ~~habitat-related density~~ area for this life stage, located in the lower and middle portion of the water column along the entire continental shelf (~10 to 200 m depth) and slope (200 to 1,000 m depth) throughout the BSAI. Substrate preferences, if they exist, are unknown~~, as depicted in Figures E-1 through E-4 and E-8 through E-11~~. EFH for adults is similar to subadults, though adult hot spots in the AI are concentrated near Unalaska Island and Unimak Pass and in deeper water along the slope (Harris et al. 2022, Laman et al. 2022).

4.2.2.2.20 Yellowfin sole

Eggs: EFH for yellowfin sole eggs is the general distribution area for this life stage, found to the limits of inshore ichthyoplankton sampling over a widespread area, to at least as far north as Nunivak Island~~, as depicted in Figure E-43~~.

Larvae: EFH for yellowfin sole larvae is the general distribution area for this life stage. Larvae have been found to the limits of inshore ichthyoplankton sampling over a widespread area, to at least as far north as Nunivak Island~~, as depicted in Figure E-38~~.

Settled Early Juveniles: EFH for settled early juvenile yellowfin sole is the general distribution area for this life stage, located in the lower portion of the water column within nearshore bays and along the inner (0 to 50 m depth), middle (50 to 100 m depth), and outer (100 to 200 m depth) continental shelf throughout the BSAI wherever there are soft substrates consisting mainly of sand. Upon settlement in nearshore areas, juveniles preferentially select sediment suitable for feeding on meiofaunal prey and burrowing for protection. Juveniles are separate from the adult population, remaining in shallow areas until they reach approximately 150 ~~c~~mm. ~~Most likely are habitat generalists on abundant physical habitat, as depicted in Figure E-37.~~ Settled early juvenile EFH for subadult yellowfin sole is the majority of the EBS shelf area and NBS, with hot spots extending into Norton Sound (Laman et al. 2022).

Subadults: ~~Late Juveniles:~~ EFH for subadults ~~late juvenile~~ yellowfin sole is the general distribution area for this life stage, located in the lower portion of the water column within nearshore bays and along the inner (0 to 50 m depth), middle (50 to 100 m depth), and outer (100 to 200 m depth) continental shelf throughout the BSAI wherever there are soft substrates consisting mainly of sand~~, as depicted in Figure E-37~~. Subadult EFH for subadult yellowfin sole is the majority of the EBS shelf area and NBS (Laman et al. 2022).

Adults: EFH for adult yellowfin sole is the general distribution area for this life stage, located in the lower portion of the water column within nearshore bays and along the inner (0 to 50 m depth), middle (50 to 100 m depth), and outer (100 to 200 m depth) continental shelf throughout the BSAI wherever there are soft substrates consisting mainly of sand~~, as depicted in Figures E-39 through 42~~. Adult EFH for subadult yellowfin sole overlaps with the settled early juvenile and subadult EFH and is the majority of the EBS shelf area and NBS (Laman et al. 2022).

5. ***In Section 4.2.2.3, update figure numbers in numerical order consistent with the remaining document.***

6. ***In Section 6.1.3.2, insert the following new paragraph at the end of the section:***

From 2019 to 2023, the Council reviewed information provided by NMFS for the EFH 5-year Review for the Council's managed species, which was documented in the draft Essential Fish Habitat 5-year Review Summary Report (Harrington et al. 2024). The review evaluated new information on EFH, including EFH descriptions and identification, new species distribution models and maps, fishing and non-fishing activities that may adversely affect EFH, and research priorities. The Council recognized the new information that these updates provide, and recommended omnibus amendments to the BSAI Groundfish FMP, the GOA Groundfish FMP, the BSAI King and Tanner Crab FMP, and the Arctic FMP, respectively, in 2023. The Council noted that the Salmon FMP was updated with EFH maps from Echave et al. (2012), and that EFH maps and text descriptions for the Salmon FMP were not produced for the 2023 EFH Review. After the Council review, they adopted a motion at the December 2023 meeting to amend the FMPs to incorporate the updated EFH information identified in the 2023 EFH 5-year Review.

7. ***In Section 6.3, insert the following references alphabetically:***

6.3 Literature Cited

Echave, K., M. Eagleton, E. Farley, and J. Orsi. 2012. A refined description of essential fish habitat for Pacific salmon within the U.S. Exclusive Economic Zone in Alaska. U.S. De. Commer., NOAA Tech. Memo. NMFS-AFSC-236, 104 p.

Harrington, G. A., J. L. Pirtle, M. Zaleski, C. Felkley, S. Rheinsmith, and J. T. Thorson. 2024. Essential Fish Habitat 2023 5-year Review Summary Report. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-f/AKR-31, 135 p. https://doi.org/10.25923/ve1v-ns96.

Harris, J., E. A. Laman, J. L. Pirtle, M. C. Siple, C. N. Rooper, T. P. Hurst, and C. L. Conrath. 2022. Advancing model-based essential fish habitat descriptions for North Pacific species in the Aleutian Islands. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-458, 406 p. https://doi.org/10.25923/ffnc-cg42

Laman, E. A., J. L. Pirtle, J. Harris, M. C. Siple, C. N. Rooper, T. P. Hurst, and C. L. Conrath. 2022. Advancing model-based essential fish habitat descriptions for North Pacific species in the Bering Sea. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-459, 538 p. https://doi.org/10.25923/y5gc-nk42

8. ***In Appendix A, insert the following description of this amendment in sequential order, and include the effective date of the approved amendment.***

Amendment 127, implemented on [*insert date*], revised Amendment 126:

1. Revise EFH description and maps by species, and update life history, distribution, and habitat association information (EFH component 1), based on the 2023 EFH 5-year Review.
2. Update the model used to determine fishing effects on species' core EFH areas, and the evaluation of EFH impacts from fishing activities (EFH component 2).
3. Update description of EFH impacts from non-fishing activities, and EFH conservation recommendations for non-fishing activities (EFH component 4).
4. Update the research and information needs (EFH component 9).

9. ***Replace Appendix D with the attached file (EFH descriptions).***

10. ***Replace Appendix E with the attached file (EFH maps).***

11. ***Replace Appendix F with the attached file (fishing effects, non-fishing effects, and cumulative effects).***

12. ***Replace Section H.4 in Appendix H with the attached file (EFH research and information needs).***

13. ***Update the Table of Contents for the main document.***

14. ***Update the Table of Contents for the appendices.***

Life History Features and Habitat Requirements of Fishery Management Plan Species

This appendix describes habitat requirements and life histories of the groundfish species managed by this fishery management plan. Each species or species group is described individually, however, summary tables that denote habitat associations (Table D-1), biological associations (Table D-2), and predator-prey associations (Table D-3) are also provided.

In each individual section, a species-specific table summarizes habitat. The following abbreviations are used in these habitat tables to specify location, position in the water column, bottom type, and other oceanographic features.

Location

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

Water column

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

General

NA = not applicable
U = unknown
EBS = eastern Bering Sea
GOA = Gulf of Alaska
EFH = essential fish habitat

Bottom Type

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

Oceanographic Features

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

Life Stage

A = adult
S = subadult
SEJ = settled early juvenile
L = larvae
E = eggs

Table D.1 Summary of habitat associations for BSAI groundfish.

BSAI Groundfish Species	Life Stage	Nearshore: Freshwater	Estuarine	Intertidal	Subtidal	Shelf: Inner 1-50m	Middle 51-100m	Outer 101-200m	Slope: Upper 201-300m	301-500m	Intermediate 501-700m	701-1000m	Lower 1001-3000m	Basin >3000m
Alaska Plaice	A					x	x	x						
	S					x	x	x						
	SEJ					x	x							
	L					x	x	x						
	E					x	x	x						
Arrowtooth Flounder	A					x	x	x	x	x	x			
	S					x	x	x						
	SEJ					x	x							
	L					x	x	x	x	x				
	E					x	x	x	x	x				
Atka Mackerel	A					x	x	x	x					
	S													
	L													
	E					x	x	x						
Flathead Sole/ Bering Flounder Complex	A					x	x	x	x					
	S					x	x	x						
	SEJ					x	x							
	L					x	x	x						
	E					x	x	x						
Greenland Turbot	A							x	x	x	x	x	x	
	S					x	x							
	SEJ													
	L					x	x	x	x	x				
	E					x	x	x	x	x				
Kamchatka Flounder	A						x	x	x	x	x	x		
	S						x	x	x	x				
	SEJ						x	x						
	L						x	x	x	x				
	E						x	x	x	x				
Northern Rock Sole	A					x	x	x						
	S					x	x							
	SEJ					x								
	L					x	x	x						
	E					x	x	x						
Northern Rockfish	A						x	x						
	S						x	x						
	SEJ													
	L													

BSAI Groundfish Species	Life Stage	Stratum Reference: Shallows	Island Pass	Bay/Fjord	Bank	Flat	Edge	Gully	Location: Surafce	Near surface	Semi-demersal	Demersal	Pelagic: 1-200m (epi)	201-1000m (meso)	>1000m (bathy)
Alaska Plaice	A											x			
	S											x			
	SEJ											x			
	L												x		
	E												x		
Arrowtooth Flounder	A											x			
	S											x			
	SEJ											x			
	L												x		
	E											x			
Atka Mackerel	A		x							x	x	x			
	S								x	x					
	L								x	x					
	E		x									x			
Flathead Sole/ Bering Flounder Complex	A											x			
	S											x			
	SEJ											x			
	L												x		
	E												x		
Greenland Turbot	A						x	x				x			
	S											x			
	SEJ											x			
	L												x		
	E												x		
Kamchatka Flounder	A											x			
	S											x			
	SEJ											x			
	L													x	
	E														
Northern Rock Sole	A											x			
	S											x			
	SEJ											x			
	L												x		
	E											x			
Northern Rockfish	A				x							x			
	S				x	x						x			
	SEJ												x		
	L														

BSAI Groundfish Species	Life Stage	Physical Oceanography: Upwelling areas	Gyres	Thermo/pycnocline	Fronts	Edges (ice, bath)	Substrate: Organic Debris	Mud	Sand	Gravel	Mud & sand	Mud & gravel	Sand & mud	Gravel & mud	Gravel & sand	Gravel & sand & mud	Gravel & mud & sand	Cobble	Rock
Alaska Plaice	A							x	x				x						
	S							x	x				x						
	SEJ							x	x				x						
	L			x															
	E																		
Arrowtooth Flounder	A							x	x	x			x						
	S							x	x	x			x						
	SEJ							x	x	x			x						
	L			x															
	E																		
Atka Mackerel	A	x			x	x			x	x								x	x
	S																		
	L																		
	E									x								x	x
Flathead Sole/ Bering Flounder Complex	A					x		x	x	x			x		x				
	S							x	x	x			x		x				
	SEJ								x	x									
	L			x									x						
	E																		
Greenland Turbot	A							x	x	x		x							
	S							x	x			x							
	SEJ							x	x			x							
	L			x															
	E																		
Kamchatka Flounder	A							x	x	x			x						
	S							x	x	x			x						
	SEJ							x	x	x			x						
	L																		
	E																		
Northern Rock Sole	A							x	x				x						
	S							x	x				x						
	SEJ							x	x				x						
	L			x															
	E																		
Northern Rockfish	A																	x	x
	S																	x	x
	SEJ																		
	L																		

BSAI Groundfish Species	Life Stage	Structure: Bars	Sinks	Slumps/Rockfalls/Debris	Channels	Ledges	Pinnacles	Seamounts	Reefs	Vertical Walls	Man-made	Community Associations: Algal Cover	Anenomes	Enchinoderms	Soft Coral	Hard Coral	Mollusca	Drift Algae/Kelp	Kelp	Polychaetes	Sea Grasses	Sea Onions	Tunicates	Oceanographic Properties: Temperature (Celsius)	Salinity (ppt)	Oxygen Conc (ppm)	Life Stage
Alaska Plaice	A																										A
	S																										S
	SEJ																										SEJ
	L																										L
	E																										E
Arrowtooth Flounder	A																										A
	S																										S
	SEJ																										SEJ
	L																										L
	E																										E
Atka Mackerel	A								x							x			x					3-5	>17		A
	S																							3-12			S
	L																							2-12			L
	E																		x					3-10			E
Flathead Sole/ Bering Flounder Complex	A																										A
	S																										S
	SEJ																										SEJ
	L																										L
	E																										E
Greenland Turbot	A																										A
	S																										S
	SEJ																										SEJ
	L																										L
	E																										E
Kamchatka Flounder	A																										A
	S																										S
	SEJ																										SEJ
	L																										L
	E																										E
Northern Rock Sole	A																										A
	S																										S
	SEJ																										SEJ
	L																										L
	E																										E
Northern Rockfish	A																										A
	S																										S
	SEJ																										SEJ
	L																										L

Table D.2 (cont) Summary of habitat associations for BSAI groundfish.

BSAI Groundfish		Nearshore				Shelf			Slope						Stratum Reference							Location							Physical Oceano-graphy					Substrate													Structure										Community Associations												Oceano-graphic Properties			
						Inner	Middle	Outer	Upper		Intermediate		Lower	Basin												Pelagic																																															
Species	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)	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	Hard Coral	Mollusca	Drift Algae/Kelp	Kelp	Polychaetes	Sea Grasses	Sea Onions	Tunicates	Temperature (Celsius)	Salinity (ppt)	Oxygen Conc (ppm)	Life Stage
Octopus	A			x	x	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x				x	x	x																																															A
	S																																																																									S
	SEJ																																																																									SEJ
	L																																																																									L
	E																																																																									E
Other Flatfish Complex	A					x	x	x	x	x	x	x													x										x	x			x	x																																	A
	S					x	x	x	x	x															x										x	x			x	x																																	S
	SEJ					x	x																		x										x	x			x	x																																	SEJ
	L					x	x	x	x	x																x					x				x	x																																					L
	E					x	x	x	x	x																x																																															E
Other Rockfish Complex	A							x	x	x	x	x	x					x		x	x				x												x								x	x							x																					A
	S						x	x	x									x		x					x												x									x																x												S
	SEJ																									x																																																	SEJ
	L																									x																																																	L
	E																									x																																																	E
Pacific Cod	A					x	x	x	x	x					x	x	x	x	x	x	x			x	x										x	x	x	x	x	x	x	x	x	x	x																													A
	S					x	x	x	x	x					x	x	x	x	x	x	x			x	x										x	x	x	x	x	x	x	x	x	x	x																							x						S
	SEJ				x	x	x	x							x	x	x	x	x	x	x			x	x										x	x	x	x	x	x	x	x	x	x																														SEJ
	L					x	x	x							x	x	x	x	x	x	x					x																																																L
	E																								x																																													3-6	13-23	2-3	E
Pacific Ocean Perch	A							x	x	x								x	x	x	x			x	x	x			x						x	x	x	x							x	x														x														A
	S						x	x	x																										x	x	x	x							x	x							x																					S
	SEJ					x	x	x																x	x	x	x	x	x								x								x	x							x																					SEJ
	L																						x	x		x	x		x																																													L
Rougheye/ Blackspotted Rockfish	A								x	x						x				x					x								x		x	x	x	x	x	x	x	x	x	x	x	x							x								x													A
	S															x									x																																																	S
	SEJ						x	x	x	x	x	x											x																																																			SEJ
	L																										x																																															L
Sablefish	A								x	x	x	x	x				x				x				x				x						x	x	x								x	x							x																						A
	S							x	x	x	x						x				x				x				x						x	x	x								x	x																												S
	SEJ					x	x	x									x								x	x	x		x																																														SEJ
	L						x	x	x	x	x	x	x	x								x	x						x																																													L
	E								x	x	x	x	x	x												x	x		x																																													E
Shark Complex	A			x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x							x	x	x	x	x	x	x	x	x	x	x	x	x																												A
	S																																																																									S
	SEJ																																																																									SEJ
	E																																																																										E

Table D.3 (cont) Summary of habitat associations for BSAI groundfish.

BSAI Groundfish Species	Life Stage	Nearshore: Freshwater	Nearshore: Estuarine	Nearshore: Intertidal	Nearshore: Subtidal	Shelf Inner: 1-50m	Shelf Middle: 51-100m	Shelf Outer: 101-200m	Slope Upper: 201-300m	Slope Upper: 301-500m	Slope Intermediate: 501-700m	Slope Intermediate: 701-1000m	Slope Lower: 1001-3000m	Slope Basin: >3000m	Stratum Reference: Shallows	Stratum Reference: Island Pass	Stratum Reference: Bay/Fjord	Stratum Reference: Bank	Stratum Reference: Flat	Stratum Reference: Edge	Stratum Reference: Gully
Shortraker Rockfish	A								x	x										x	
	S																				
	SEJ						x	x	x	x	x	x	x	x							
	L																				
Skate Complex	A			x	x	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x
	S																				
	SEJ																				
	E							x	x												
Walleye Pollock	A						x	x	x	x				x		x	x	x	x	x	x
	S					x	x	x								x	x	x	x	x	x
	L						x	x								x	x	x	x	x	x
	E						x	x	x	x	x	x	x	x		x	x	x	x	x	x
Yellowfin Sole	A					x	x														
	S					x	x														
	SEJ					x															
	L					x	x														
	E					x	x														

BSAI Groundfish Species	Life Stage	Location: Surafce	Location: Near surface	Location: Semi-demersal	Location: Demersal	Location Pelagic: 1-200m (epi)	Location Pelagic: 201-1000m (meso)	Location Pelagic: >1000m (bathy)	Physical Oceanography: Upwelling areas	Physical Oceanography: Gyres	Physical Oceanography: Thermo/pycnocline	Physical Oceanography: Fronts	Physical Oceanography: Edges (ice, bath)
Shortraker Rockfish	A				x								x
	S				x								
	SEJ		x										
	L						x						
Skate Complex	A			x	x								
	S												
	SEJ												
	E												
Walleye Pollock	A		x	x	x	x	x		x	x	x	x	x
	S		x	x	x	x			x	x	x	x	x
	L		x	x	x	x			x	x	x	x	x
	E		x	x		x			x	x	x	x	
Yellowfin Sole	A				x								
	S				x								
	SEJ				x								
	L					x							
	E					x							

BSAI Groundfish Species	Life Stage	Substrate: Organic Debris	Mud	Sand	Gravel	Mud & sand	Mud & gravel	Sand & mud	Gravel & mud	Gravel & sand	Gravel & sand & mud	Gravel & mud & sand	Cobble	Rock
Shortraker Rockfish	A		x	x	x	x	x	x	x	x	x	x	x	x
	S													
	SEJ													
	L													
Skate Complex	A													
	S													
	SEJ													
	E													
Walleye Pollock	A		x	x	x	x	x	x	x	x	x	x	x	
	S		x	x	x	x	x	x	x	x	x	x	x	
	L		x	x	x	x	x	x	x	x	x	x	x	
	E													
Yellowfin Sole	A		x	x				x						
	S		x	x				x						
	SEJ		x	x				x						
	L													
	E													

BSAI Groundfish Species	Life Stage	Structure: Bars	Sinks	Slumps\Rockfalls\Debris	Channels	Ledges	Pinnacles	Seamounts	Reefs	Vertical Walls	Man-made
Shortraker Rockfish	A							x			
	S										
	SEJ										
	L										
Skate Complex	A										
	S										
	SEJ										
	E										
Walleye Pollock	A										
	S										
	L										
	E										
Yellowfin Sole	A										
	S										
	SEJ										
	L										
	E										

BSAI Groundfish Species	Life Stage	Community Associations: Algal Cover	Anenomes	Enchinoderms	Soft Coral	Hard Coral	Mollusca	Drift Algae\Kelp	Kelp	Polychaetes	Sea Grasses	Sea Onions	Tunicates	Oceanographic Properties: Temperature (Celsius)	Salinity (ppt)	Oxygen Conc (ppm)	Life Stage
Shortraker Rockfish	A					x											A
	S																S
	SEJ																SEJ
	L																L
Skate Complex	A																A
	S																S
	SEJ																SEJ
	E																E
Walleye Pollock	A													2-10			A
	S													2-10			S
	L																L
	E																E
Yellowfin Sole	A																A
	S																S
	SEJ																SEJ
	L																L
	E																E

Table D.4 Summary of reproductive traits for BSAI groundfish.

BSAI Groundfish		Reproductive Traits																										
		Age at Maturity				Fertilization/Egg Development					Spawning Behavior						Spawning Season											
		Female		Male																								
Species	Life Stage	50%	100%	50%	100%	External	Internal	Oviparous	Aplacental	Viviparous	Batch Spawner	Broadcast Spawner	Egg Case Deposition	Nest Builder	Egg/Young Guarder	Egg/Young Bearer	January	February	March	April	May	June	July	August	September	October	November	December
Alaska Plaice	A	6-7				x													x	x	x							
Arrowtooth Flounder	A	5		4		x											x	x	x	x							x	x
Atka Mackerel	A	3.6		3.6		x					x			x	x							x	x	x	x	x		
Flathead Sole/ Bering Flounder Complex	A	9.7				x					x						x	x	x	x								
Greenland Turbot	A	5-10				x						x					x	x	x							x	x	x
Kamchatka Flounder	A	10		10		x											x	x	x								x	x
Northern Rock Sole	A	9				x					x						x	x	x									
Northern Rockfish	A	8.2					x			x	x																	
Octopus	A						x				x			x	x													
Other Flatfish Complex	A	350-439 mm		350-439 mm		x											x	x	x	x	x	x	x	x				
Other Rockfish Complex	A	11-12					x			x	x							x				x						
Pacific Cod	A	5	20	5	20	x						x						x	x	x								
Pacific Ocean Perch	A	9.1					x			x	x							x	x	x	x							
Rougheye/ Blackspotted Rockfish	A	24.5					x			x	x							x	x	x	x							
Sablefish	A	585 mm		585 mm		x						x					x	x	x									
Shark Complex	A						x		x							x												
Shortraker Rockfish	A						x			x	x							x	x	x	x	x	x	x				
Skate Complex	A						x	x					x															
Walleye Pollock	A	3-4		3-4		x						x						x	x	x	x							
Yellowfin Sole	A	10.1				x					x										x	x	x					

Table D.5 Summary of predator and prey associations for BSAI groundfish

Predator to

BSAI Groundfish Species	Life Stage	Algae	Plants	Plankton	Zooplankton	Diatoms	Sponges	Eusphausiid	Hydroids	Amphipoda	Copepods	Starfish	Polychaetes	Squid	Philodae (gunnels)	Bivalves	Mollusks	Crustaceans	Ophiuroids (brittle stars)	Shrimps, mysidacae	Shrimps, Panaeid	Sand lance	Osmerid (eulachon)	Herring	Myctophid (lantern fishes)	Cottidae (sculpins)	Arrowtooth	Rockfish	Salmon	Pacific cod	Pollock	Halibut	Deepsea smelt
Alaska Plaice	A																																
	S																																
	SEJ																																
	L																																
	E																																
Arrowtooth Flounder	A												x	x				x	x	x				x	x						x		
	S												x					x	x	x				x	x						x		
	SEJ				x																												
	L	x		x																													
	E																																
Atka Mackerel	A							x			x														x								
	S							x			x																						
	L										x																						
	E																																
Flathead Sole/ Bering Flounder Complex	A							x		x	x		x			x	x	x	x			x	x								x		
	S							x		x	x		x			x	x	x	x												x		
	SEJ				x								x			x			x												x		
	L	x		x																													
	E																																
Greenland Turbot	A							x				x	x	x		x	x	x	x	x		x	x	x	x				x	x	x		
	S							x				x	x	x		x	x	x	x	x		x	x	x	x				x	x	x		
	SEJ				x																												
	L	x		x																													
	E																																
Kamchatka Flounder	A							x		x			x	x				x		x											x		
	S							x		x			x					x		x													
	SEJ				x																												
	L	x		x																													
	E																																
Northern Rock Sole	A									x			x			x	x																
	S									x			x			x	x																
	SEJ				x																												
	L	x		x																													
	E																																
Northern Rockfish	A							x			x																						
	S																																
	SEJ																																
	L																																

Prey of

BSAI Groundfish Species	Life Stage	Jellyfish	Starfish	Chaetognaths (arrowworm	Crab	Herring	Salmon	Pollock	Pacific cod	Ling cod	Rockfish	Rock Sole	Flathead Sole	Yellowfin sole	Arrowtooth flounder	Halibut	Salmon Shark	Pacific sleeper shark	Northern Fur Seal	Harbor Seal	Steller sea lion	Dalls Porpoise	Beluga whale	Killer Whale	Minke whale	Baird's beaked shale	Sperm whale	Eagles	Murres	Puffin	Kittiwake	Gull	Terrerstrial Mammals
Alaska Plaice	A																																
	S																																
	SEJ																																
	L																																
	E																																
Arrowtooth Flounder	A																																
	S							x	x																								
	SEJ																																
	L																																
	E																																
Atka Mackerel	A								x						x	x			x	x	x	x			x								
	S																		x		x								x	x			
	L																																
	E																																
Flathead Sole/ Bering Flounder Complex	A								x				x		x	x																	
	S																																
	SEJ																																
	L																																
	E																																
Greenland Turbot	A								x																								
	S																																
	SEJ							x	x					x																			
	L																																
	E																																
Kamchatka Flounder	A																																
	S							x	x						x	x																	
	SEJ																																
	L																																
	E																																
Northern Rock Sole	A																																
	S							x	x					x		x																	
	SEJ																																
	L																																
	E																																
Northern Rockfish	A																																
	S																																
	SEJ																																
	L																																

Table D.6 (cont) Summary of predator and prey associations for BSAI groundfish

Predator to

BSAI Groundfish Species	Life Stage	Algae	Plants	Plankton	Zooplankton	Diatoms	Sponges	Eusphausiid	Hydroids	Amphipoda	Copepods	Starfish	Polychaetes	Squid	Philodae (gunnels)	Bivalves	Mollusks	Crustaceans	Ophiuroids (brittle stars)	Shrimps, mysidacae	Shrimps, Panaeid	Sand lance	Osmerid (eulachon)	Herring	Myctophid (lantern fishes)	Cottidae (sculpins)	Arrowtooth	Rockfish	Salmon	Pacific cod	Pollock	Halibut	Deepsea smelt
Octopus	A															x	x	x	x	x		x				x		x		x		x	
	S																																
	SEJ																																
	L		x	x							x																						
	E																																
Other Flatfish Complex	A							x		x			x				x	x															
	S							x		x			x				x	x															
	SEJ																																
	L	x		x																													
	E																																
Other Rockfish Complex	A							x												x						x							
	S																																
	SEJ																																
	L																																
	E																																
Pacific Cod	A				x		x	x	x	x	x	x	x	x		x	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	
	S				x		x	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	
	SEJ				x			x		x	x		x	x		x	x	x	x	x		x		x	x	x	x	x		x	x	x	
	L																																
	E																																
Pacifc Ocean Perch	A							x																									
	S							x			x																						
	SEJ																																
	L			x	x																												
Rougheye/ Blackspotted Rockfish	A													x						x					x								
	S																																
	SEJ																																
	L																																
Sablefish	A							x	x	x	x		x	x				x		x			x	x		x	x		x	x	x		
	S							x	x	x	x		x	x				x		x			x	x		x	x		x	x	x		
	SEJ							x		x	x		x	x	x			x		x				x					x				
	L				x						x																						
	E																																
Shark Complex	A							x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
	S							x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
	SEJ							x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
	E																																

Prey of

BSAI Groundfish Species	Life Stage	Jellyfish	Starfish	Chaetognaths (arrowworm	Crab	Herring	Salmon	Pollock	Pacific cod	Ling cod	Rockfish	Rock Sole	Flathead Sole	Yellowfin sole	Arrowtooth flounder	Halibut	Salmon Shark	Pacific sleeper shark	Northern Fur Seal	Harbor Seal	Steller sea lion	Dalls Porpoise	Beluga whale	Killer Whale	Minke whale	Baird's beaked shale	Sperm whale	Eagles	Murres	Puffin	Kittiwake	Gull	Terrerstrial Mammals
Octopus	A							x	x	x	x		x	x		x			x	x	x		x										
	S																																
	SEJ																																
	L																																
	E																																
Other Flatfish Complex	A								x						x																		
	S								x						x																		
	SEJ																																
	L																																
	E																																
Other Rockfish Complex	A																																
	S																																
	SEJ																																
	L																																
	E																																
Pacific Cod	A															x	x		x		x		x	x	x								
	S								x						x	x	x		x		x		x	x	x								
	SEJ							x	x						x	x	x		x		x		x	x	x					x			
	L							x	x						x																		
	E																																
Pacifc Ocean Perch	A															x																	
	S																																
	SEJ						x																										
	L																																
Rougheye/ Blackspotted Rockfish	A																																
	S																																
	SEJ																																
	L																																
Sablefish	A																																
	S						x									x											x						
	SEJ																																
	L																																
	E																																
Shark Complex	A																x	x	x		x			x									
	S									x						x	x	x	x	x	x			x									
	SEJ									x						x	x	x	x	x	x			x									
	E																																

Table D.7 (cont) Summary of predator and prey associations for BSAI groundfish

Predator to

BSAI Groundfish Species	Life Stage	Algae	Plants	Plankton	Zooplankton	Diatoms	Sponges	Eusphausiid	Hydroids	Amphipoda	Copepods	Starfish	Polychaetes	Squid	Philodae (gunnels)	Bivalves	Mollusks	Crustaceans	Ophiuroids (brittle stars)	Shrimps, mysidacae	Shrimps, Panaeid	Sand lance	Osmerid (eulachon)	Herring	Myctophid (lantern fishes)	Cottidae (sculpins)	Arrowtooth	Rockfish	Salmon	Pacific cod	Pollock	Halibut	Deepsea smelt
Shortraker Rockfish	A													x						x					x								
	S																																
	SEJ																																
	L																																
Skate Complex	A									x		x	x					x		x		x		x		x	x	x	x	x	x	x	
	S																																
	SEJ																																
	E																																
Walleye Pollock	A				x			x			x			x						x		x	x	x	x		x			x	x	x	
	S				x			x			x			x						x		x	x	x	x		x			x	x	x	
	SEJ				x			x			x									x		x	x										
	L				x			x			x																						
	E																																
Yellowfin Sole	A							x		x			x			x		x		x						x					x		
	S							x		x			x			x		x		x						x							
	SEJ				x																												
	L	x		x																													
	E																																

Prey of

BSAI Groundfish Species	Life Stage	Jellyfish	Starfish	Chaetognaths (arrowworm	Crab	Herring	Salmon	Pollock	Pacific cod	Ling cod	Rockfish	Rock Sole	Flathead Sole	Yellowfin sole	Arrowtooth flounder	Hailbut	Salmon Shark	Pacific sleeper shark	Northern Fur Seal	Harbor Seal	Steller sea lion	Dalls Porpoise	Beluga whale	Killer Whale	Minke whale	Baird's beaked shale	Sperm whale	Eagles	Murres	Puffin	Kittiwake	Gull	Terrerstrial Mammals
Shortraker Rockfish	A																																
	S																																
	SEJ																																
	L																																
Skate Complex	A																																
	S																																
	SEJ																																
	E																																
Walleye Pollock	A								x						x	x	x		x	x	x												
	S							x	x						x	x			x	x	x				x				x	x	x		
	SEJ							x	x						x	x			x	x	x				x				x	x	x		
	L							x	x						x	x									x				x	x	x		
	E																																
Yellowfin Sole	A																																
	S								x							x																	
	SEJ								x							x																	
	L																																
	E																																

D.1 Alaska plaice (*Pleuronectes quadrituberculatus*)

Formerly a constituent of the “other flatfish” management category, Alaska plaice were split-out and are now managed as a separate stock.

D.1.1 Life History and General Distribution

Alaska plaice inhabit continental shelf waters of the North Pacific ranging from the Gulf of Alaska to the Bering and Chukchi Seas and in Asian waters as far south as Peter the Great Bay (Pertseva-Ostroumova 1961; Quast and Hall 1972). Adults exhibit a benthic lifestyle and live year round on the shelf and move seasonally within its limits (Fadeev 1965). From over-winter grounds near the shelf margins, adults begin a migration onto the central and northern shelf of the eastern Bering Sea, primarily at depths of less than 100 m. Spawning usually occurs in March and April on hard sandy ground (Zhang 1987). The eggs and larvae are pelagic and transparent and have been found in ichthyoplankton sampling in late spring and early summer over a widespread area of the continental shelf (Waldron and Favorite 1977). Eggs and larvae were primarily collected from depths < 200 m, with the majority occurring over bottom depths ranging 50–100 m. Eggs were present throughout the water column, though densities of preflexion stage larvae were concentrated at depths 10–20 m. There was no evidence of vertical migration for pre-flexion stages (Duffy-Anderson et al. 2010).

Fecundity estimates (Fadeev 1965) indicate female fish produce an average of 56 thousand eggs at lengths of 280 to 300 mm and 313 thousand eggs at lengths of 480 to 500 mm. The age or size at metamorphosis is unknown. The estimated length of 50 percent maturity is 319 mm (Tenbrink and Wildebuer 2015). Natural mortality rate estimates range from 0.19 to 0.22 (Wilderbuer and Zhang 1999).

D.1.2 Relevant Trophic Information

Groundfish predators include Pacific halibut (Novikov 1964) yellowfin sole, beluga whales, and fur seals (Salveson 1976).

D.1.3 Habitat and Biological Associations

Larvae: Planktonic larvae for at least 2 to 3 months until metamorphosis occurs, usually inhabiting shallow areas.

Settled Early Juveniles: The covariates contributing the most to the final SDM EFH map for this life stage were geographic position, bottom temperature, and bottom current (Laman et al. 2022). Predicted abundance increased to the northeast in the survey area with increasing bottom temperature and northeasterly currents. The highest abundance of settled early juvenile Alaska plaice was predicted in Norton Sound and along the eastern margin of the EBS shelf survey area.

Subadults: The covariates contributing the most to the final SDM EFH map for this life stage were bottom depth, geographic position, bottom temperature, and sediment grain size (Laman et al. 2022) with higher abundance predicted along the inner shelf in cooler, shallower water over moderately fine sediment grain sizes.

Adults: Summertime feeding on sandy substrates of the eastern Bering Sea shelf. Wide-spread distribution mainly on the middle, northern portion of the shelf, feeding on polychaete, amphipods, and echiurids (Livingston and DeReynier 1996). Wintertime migration to deeper waters of the shelf margin to avoid extreme cold water temperatures. Feeding diminishes until spring after spawning. The covariates contributing the most to the final SDM EFH map for this life stage were geographic position, bottom depth, sediment grain size, and bottom temperature (Laman et al. 2022). Adult Alaska plaice abundance was predicted to be highest over the transition between the inner and middle shelf in the central EBS where bottom depths were shallower (~100 m), bottom temperatures were 2.5–3.0°C, and sediment grain sizes were finer.

Habitat and Biological Associations: Alaska plaice

Stage - EFH Level	Duration or Age	Diet/Prey	Season/ Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs		NA	spring and summer	ICS, MCS OCS	P			
Larvae	2–4 months?	U phyto/zoo plankton?	spring and summer	ICS, MCS	P			
Settled Early Juveniles/Subadults	up to 7 years	polychaete amphipods echiurids	all year	ICS, MCS	D	S, SM, MS, M		
Adults	7+ years	polychaete amphipods echiurids	spawning March–May	ICS, MCS	D	S, SM,MS, M		
			non-spawning and feeding June–February	ICS, MCS			ice edge	

D.1.4 Literature

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D.2 Arrowtooth flounder (*Atheresthes stomias*)

D.2.1 Life History and General Distribution

Arrowtooth flounder are distributed in North American waters from central California to the eastern Bering Sea on the continental shelf and upper slope.

Adults exhibit a benthic lifestyle and occupy separate winter and summer distributions on the eastern Bering Sea shelf. From over-winter grounds near the shelf margins and upper slope areas, adults begin a migration onto the middle and outer shelf in April or early May each year with the onset of warmer water temperatures. A protracted and variable spawning period may range from as early as September through March (Rickey 1994, Hosie 1976). Total fecundity may range from 250,000 to 2,340,000 oocytes (Zimmerman 1997). Larvae have been found from ichthyoplankton sampling over a widespread area of the eastern Bering Sea shelf in April and May (Waldron and Vinter 1978, Kendall and Dunn 1985). The age or size at metamorphosis is unknown. Juveniles are separate from the adult population, remaining in shallow areas until they reach the 100 to 150 mm range (Martin and Clausen 1995). The estimated age at 50 percent maturity is 7.6 years (480 mm) for females collected from the Bering Sea (Stark 2012). The natural mortality rate used in stock assessments differs by sex and is estimated at 0.2 for females and 0.35 for males (Turnock et al. 2009, Wilderbuer et al. 2010, Shotwell et al. 2020).

D.2.2 Relevant Trophic Information

Arrowtooth flounder are very important as a large, and abundant predator of other groundfish species.

D.2.3 Habitat and Biological Associations.

Larvae: Planktonic larvae for at least 2 to 3 months until metamorphosis occurs.

Settled Early Juveniles: Juveniles usually inhabit shallow areas until about 100 mm in length. In the EBS, the covariates contributing the most to the final SDM EFH map for this life stage were location, bottom depth, and bottom temperature (Laman et al. 2022). The highest abundances of this life stage were predicted over the central and southern portions of the outer shelf domain at bottom water temperatures greater than 5°C and bottom depths less than 150 m. In the AI, the covariates contributing the most to the final SDM EFH map for this life stage were geographic position, bottom depth, tidal current maximum, and bottom currents (Harris et al. 2022). In general, predicted abundance was high in locations that were farther east, with shallow depths (<150 m) and with weak tides (Fig. 5). Predicted abundance was highest in shallow, sheltered inshore areas, particularly those near Unalaska Island (Fig. 5), though secondary pockets of high abundance were also predicted near Atka Island and Agattu Island.

Subadults: In the EBS, the covariates contributing the most to the final SDM EFH map for this life stage were geographic position, bottom temperature, and bottom depth (Laman et al. 2022). Their highest abundance was predicted over the central and southern portions of the outer and middle shelf domains at depths around 200 m and water temperatures above 5°C. In the AI, the covariates contributing the most to the final SDM EFH map for this life stage were geographic position and bottom depth (Harris et al. 2022). Like early juveniles, subadult ATF were associated with weak tidal forces and weak bottom currents. Based on the covariates, abundance should be highest in the eastern and central AI and at depths between 100 m and 300 m.

Adults: Widespread distribution mainly on the middle and outer portions of the continental shelf, feeding mainly on walleye pollock and other miscellaneous fish species when arrowtooth flounder attain lengths greater than 300 mm. Wintertime migration to deeper waters of the shelf margin and upper continental slope to avoid extreme cold water temperatures and for spawning. In the EBS, the covariates contributing the most to the final SDM EFH map for this life stage were geographic position, bottom temperature, and bottom depth (Laman et al. 2022). Adult abundance was highest in the southern EBS over the middle shelf and shelf break and along the shelf break in the north near the heads of Navarin and Pervenets Canyons at depths between 300 and 400 m at bottom water temperatures greater than 5°C. In the AI, the covariates contributing the most to the final SDM EFH map for this life stage were bottom depth, geographic position, current, and current variability (Harris et al. 2022). Adult ATF are predicted to be abundant in moderately deep waters, in the eastern AI, and at locations with weak bottom currents.

Habitat and Biological Associations: Arrowtooth flounder

Stage - EFH Level	Duration or Age	Diet/Prey	Season/ Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs		NA	winter, spring?	ICS, MCS, OCS	P			
Larvae	2–3 months?	U phyto/zoo plankton?	spring summer?	BAY, ICS, MCS, OCS	P			
Settled Early Juveniles	to 2 yrs	euphausiids crustaceans amphipods pollock	all year	ICS, MCS	D	GMS		
Subadults	males 2–4 yrs females 2–5 yrs	euphausiids crustaceans amphipods pollock	all year	ICS, MCS, OCS, USP	D	GMS		
Adults	males 4+ yrs females 5+ yrs	pollock misc. fish Gadidae sp. euphausiids	spawning Nov–March non-spawning April–Oct	MCS, OCS, USP	D	GMS		

D.2.4 Literature

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D.3 Atka mackerel (Pleurogrammus monopterygius)

D.3.1 Life History and General Distribution

Atka mackerel are distributed along the continental shelf across the North Pacific Ocean and Bering Sea from Asia to North America. On the Asian side they extend from the Kuril Islands to Provideniya Bay; moving eastward, they are distributed throughout the Komandorskiye and Aleutian Islands, north along the eastern Bering Sea shelf, and through the Gulf of Alaska to southeast Alaska. They are most abundant along the Aleutian Islands.

Adult Atka mackerel occur in large localized aggregations usually at depths less than 200 m and generally over rough, rocky, and uneven bottom near areas where tidal currents are swift. Associations with corals and sponges have been observed for Aleutian Islands Atka mackerel. Adults are semi-demersal, displaying strong diel behavior with vertical movements away from the bottom occurring almost exclusively during the daylight hours, presumably for feeding, and little to no movement at night (when they are closely associated with the bottom). Atka mackerel are a substrate-spawning fish with male parental care. Single or multiple clumps of adhesive eggs are laid on rocky substrates in individual male territories within nesting colonies where males brood eggs for a protracted period. Nesting colonies are widespread across the continental shelf of the Aleutian Islands and western Gulf of Alaska down to bottom depths of 144 m. Possible factors limiting the upper and lower depth limit of Atka mackerel nesting habitat include insufficient light penetration and the deleterious effects of unsuitable water temperatures, wave surge, or high densities of kelp and green sea urchins. The spawning phase begins in late July, peaks in early September, and ends in mid-October. After spawning ends, territorial males with nests continue to brood egg masses until hatching. Eggs develop and hatch in 40 to 45 days, releasing planktonic larvae which have been found up to 800 km from shore. Little is known of the distribution of young Atka mackerel prior to their appearance in trawl surveys and the fishery at about age 2 to 3 years. Atka mackerel exhibit intermediate life history traits. R-traits include young age at maturity (approximately 50 percent are mature at age 3.6), fast growth rates, high natural mortality (mortality equals 0.3) and young average and maximum ages (about 5 and 15 years, respectively). K-selected traits include low fecundity (only about 30,000 eggs/female/year, large egg diameters (1 to 2 mm) and male nest-guarding behavior).

Average length at 50% maturity in the Aleutian Islands is 344 mm (McDermott and Lowe 1997).

D.3.2 Relevant Trophic Information

Atka mackerel are consumed by a variety of piscivores, including groundfish (e.g., Pacific cod, Pacific halibut, and arrowtooth flounder), marine mammals (e.g., northern fur seals and Steller sea lions), and seabirds (e.g., thick-billed murres, tufted puffins, and short-tailed shearwaters). Adult Atka mackerel consume a variety of prey, but principally calanoid copepods and euphausiids. Predation on Atka mackerel eggs by cottids and other hexagrammids is prevalent during the spawning season as is cannibalism by other Atka mackerel.

D.3.3 Habitat and Biological Associations

Eggs: Adhesive eggs are deposited in nests built and guarded by males on rocky substrates or on kelp in shallow water.

Larvae: Planktonic larvae have been found up to 800 km from shore, usually in upper water column (neuston), but little is known of the distribution of Atka mackerel until they are about 2 years old and appear in fishery and surveys.

Subadults: The covariates contributing the most to the final SDM EFH map for this life stage in the AI were Geographic position and bottom depth (Harris et al. 2022), though tidal maximum and current variability also contributed. In general, high abundance was predicted in farther west longitudes, shallow depths, and moderate tidal currents.

Adults: Adults occur in localized aggregations usually at depths less than 200 m and generally over rough, rocky and uneven bottom near areas where tidal currents are swift. Associations with corals and sponges have been observed for Aleutian Islands Atka mackerel. Adults are semi-demersal/pelagic during much of the year, but the males become demersal during spawning; females move between nesting and offshore feeding areas. In the EBS, the covariates contributing the most to the final SDM EFH map for this life stage were geographic position, bottom depth, local slope, and bottom temperature (Laman et al. 2022). Adult Atka mackerel were predicted along the shelf break and over the southern EBS at depths around 250 m with relatively shallow slopes at bottom temperatures around 5°C. In the AI, the covariates contributing the most to the final SDM EFH map for this life stage were bottom depth and geographic position (Harris et al. 2022). Bottom current, current variability, and tidal maximum also accounted for a substantial faction of the deviance explained. Adult Atka mackerel are predicted to be abundant at shallow depths, favoring farther west areas in the AI.

Habitat and Biological Associations: Atka mackerel

Stage - EFH Level	Duration or Age	Diet/Prey	Season/ Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs	40–45 days	NA	summer	IP, ICS, MCS	D	G, R, K, CB	U	develop 3–15 °C optimum 3.9–10.5 °C
Larvae	up to 6 mos	U copepods?	fall–winter	U	U, N?	U	U	2–12 °C optimum 5–7 °C
Subadults	½–2 yrs of age	U copepods & euphausiids ?	all year	U	N	U	U	3–5 °C
Adults	3+ yrs of age	copepods euphausiids meso-pelagic fish (myctophids)	spawning (June–Oct)	ICS and MCS, IP	D (males) SD females	G, R, CB, K	F, E	3–5 °C all stages >17 ppt only
			non-spawning (Nov–May)	MCS and OCS, IP	SD/D all sexes			
			tidal/diurnal, year-round?	ICS, MCS, OCS, IP	D when currents high/day SD slack tides/night			

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D.4 Flathead sole/Bering flounder complex

Species Complex Summary

In the Bering Sea, the management category “flathead sole” is represented as a two-species complex consisting of true flathead sole (*Hippoglossoides elassodon*) and its close congener, Bering flounder (*H. robustus*), which is morphologically similar (McGilliard 2017). EBS trawl survey estimates of flathead sole and Bering flounder biomass indicate the latter comprises less than 3 percent of the combined biomass of these two species. Subadults of both species are found over most of the EBS shelf with exceptions around Nunivak Island, Norton Sound, and off the EBS shelf break. Distribution and abundance of both species is predicted to be highest in the southern EBS with elevated abundance along the U.S.-Russia Convention Line in the north.

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D.4.1 Bering flounder (*Hippoglossoides robustus*)

D.4.1.1 Life History and General Distribution

Bering flounder range from the EBS into the Chukchi and western Bering Seas at depths ranging form 18-425 m (Mecklenburg et al. 2002). An affinity for colder water temperatures has been attributed to Bering flounder when compared with flathead sole (Stark 2011).

D.4.1.2 Relevant Trophic Information

There is insufficient information on Bering flounder predator or prey relationships.

D.4.1.3 Habitat and Biological Associations

Subadults: The highest abundance of subadult Bering flounder can be found over the middle shelf at the U.S.-Russian Convention Line at depths around 150 m, water temperatures around 0°C, and over relatively flat bottom. Fewer subadult Bering flound are found in the southern EBS, and they are more common over the inner, middle, and outer shelf domains to the north. The covariates contributing the most to the final SDM EFH map for this life stage were Geographic position, bottom temperature, bottom depth, and tidal maximum (Laman et al. 2022). Their highest abundance was predicted over the middle shelf at the U.S.-Russia Convention line at depths around 150 m, water temperatures around 0°C, and over relatively flat bottom.

Adults: Similar to subadults, adult Bering flounder abundance may be highest on the middle shelf near the U.S.-Russia Convention Line at depths around 150 m and bottom water temperatures around 0°C, with fewer adults in the souther EBS and more over the inner, middle, and outer shelf domains to the north. The covariates contributing the most to the final SDM EFH map for this life stage were geographic position, bottom temperature, and bottom depth (Laman et al. 2022). Predicted abundance was highest on the middle shelf near the U.S.-Russia Convention Line at depths around 150 m and bottom water temperatures around 0°C.

D.4.1.4 Literature

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D.4.2 Flathead sole (*Hippoglossoides elassodon*)

D.4.2.1 Life History and General Distribution

Flathead sole are distributed from northern California, off Point Reyes, northward along the west coast of North America, and throughout the Gulf of Alaska and the Bering Sea, the Kuril Islands and possibly the Okhotsk Sea (Hart 1973).

Adults exhibit a benthic lifestyle and occupy separate winter spawning and summertime feeding distributions on the eastern Bering Sea shelf and in the Gulf of Alaska. From over-winter grounds near the shelf margins, adults begin a migration onto the mid- and outer continental shelf in April or May each year for feeding. The spawning period may start as early as January but is known to occur in March and April, primarily in deeper waters near the margins of the continental shelf. Eggs are large (2.75 to 3.75 mm) and females have egg counts ranging from about 72,000 (200 mm fish) to almost 600,000 (380 mm fish). Eggs hatch in 9 to 20 days depending on incubation temperatures within the range of 2.4 to 9.8°C (Forrester and Alderdice 1967) and have been found in ichthyoplankton sampling on the southern portion of the Bering Sea shelf in April and May (Waldron 1981). Larvae absorb the yolk sac in 6 to 17 days but the extent of their distribution is unknown. Size at metamorphosis is 18 to 35 mm (Matarese et al. 2003). Juveniles less than age 2 have not been found with the adult population, remaining in shallow areas. Age at 50 percent maturity is 9.7 years (Stark 2004). The natural mortality rate used in recent stock assessments is 0.2 for both sexes (Monnahan and Haehn 2020).

D.4.2.2 Relevant Trophic Information

Groundfish predators include Pacific cod, Pacific halibut, arrowtooth flounder, and cannibalism by large flathead sole, mostly on fish less than 200 mm standard length (Livingston and DeReynier 1996).

D.4.2.3 Habitat and Biological Associations

Larvae: Planktonic larvae for an unknown time period until metamorphosis occurs, usually inhabiting shallow areas.

Settled Early Juveniles: In the EBS, the covariates contributing the most to the final SDM EFH map for this life stage were geographic position, bottom depth, bottom temperature, and sediment grain size (Laman et al. 2022) which was highest to the south and west over the outer shelf domain in waters shallower than 200 m with warmer bottom temperatures over increasingly coarse sediment grain sizes. In the AI, the covariates contributing the most to the final SDM EFH map for this life stage were geographic position, bottom depth, BPI, and tidal maximum (Harris et al. 2022). In general, the ensemble predicts high abundance in the far east and far west of the AI in areas of moderate to shallow depth, weak tidal currents, and a low BPI.

Subadults: In the EBS, the covariates contributing the most to the final SDM EFH map for this life stage were geographic position, bottom depth, sediment grain size, and bottom temperature (Laman et al. 2022). Predictions of numerical abundance increased to the south and west in the study area at depths around 300 m over increasing sediment grain sizes and bottom temperatures. In the AI, the covariates contributing the most to the final SDM EFH map for this life stage were geographic position, bottom depth, tidal maximum, current speed, and current variability (Harris et al. 2022). In general, the ensemble model predicted high abundance in patches around the major islands, and in areas with depths between 100 and 200 m, weak tidal currents, and currents that run in north or south directions.

Adults: Winter spawning and summer feeding on sand and mud substrates of the continental shelf. Widespread distribution mainly on the middle and outer portion of the shelf, feeding mainly on ophiuroids, tanner crab, osmerids, bivalves, and polychaete (Pacunski 1990). In the EBS, the covariates contributing the most to the final SDM EFH map for this life stage were geographic position, bottom depth, bottom temperature, and sediment grain size (Laman et al. 2022) which was highest in the south and west of the EBS in depths shallower than 300 m with increasing bottom temperatures and sediment grain sizes. In the AI, the covariates contributing the most to the final SDM EFH map for this life stage were bottom depth, geographic position, tidal maximum, and current (Harris et al. 2022). Adult flathead sole are predicted to be abundant in 100-250 m deep waters and areas with a low tidal maximum and southerly currents.

Habitat and Biological Associations: Flathead sole

Stage - EFH Level	Duration or Age	Diet/Prey	Season/ Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs	9–20 days	NA	winter	ICS, MCS, OCS	P			
Larvae	U	U phyto/zoo plankton?	spring summer	ICS, MCS, OCS	P			
Settled Early Juveniles	to 2 yrs	polychaete bivalves ophiuroids	all year	MCS, ICS	D	S, M		
Subadults	age 3–9 yrs	polychaete bivalves ophiuroids pollock and Tanner crab	all year	MCS, ICS, OCS	D	S, M	Juveniles	
Adults	age 9–30 yrs	polychaete bivalves ophiuroids pollock and Tanner crab	spawning Jan–April	MCS, OCS, ICS	D	S, M	ice edge	
			non-spawning May–December					

D.4.2.4 Literature

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D.5 Greenland turbot (*Reinhardtius hippoglossoides*)

D.5.1 Life History and General Distribution

Greenland turbot has an amphiboreal distribution, occurring in the North Atlantic and North Pacific. In the North Pacific, species abundance is centered in the eastern Bering Sea and, secondly, in the Aleutian Islands. On the Asian side, they occur in the Gulf of Anadyr along the Bering Sea coast of Russia, in the Okhotsk Sea, around the Kurile Islands, and south to the east coast of Japan to northern Honshu Island (Hubbs and Wilimovsky 1964, Mikawa 1963, Shuntov 1965). Adults exhibit a benthic lifestyle, living in deep waters of the continental slope but are known to have a tendency to feed off the sea bottom. During their first few years as immature fish, they inhabit relatively shallow continental shelf waters (less than 200 m) until about age 4 or 5 before joining the adult population (200 to 1,000 m or more, Templeman 1973). Adults appear to undergo seasonal shifts in depth distribution moving deeper in winter and shallower in summer (Chumakov 1970, Shuntov 1965). Spawning is reported to occur in winter in the eastern Bering Sea and may be protracted starting in September or October and continuing until March with an apparent peak period in November to February (Shuntov 1965, Bulatov 1983). Females spawn relatively small numbers of eggs with fecundity ranging from 23,900 to 149,300 for fish 830 mm and smaller in the Bering Sea (D’yakov 1982).

Eggs and early larval stages are benthypelagic (Musienko 1970). In the Atlantic Ocean, larvae (100 to 180 mm) have been found in benthypelagic waters which gradually rise to the pelagic zone in correspondence to absorption of the yolk sac which is reported to occur at 15 to 18 mm with the onset of feeding (Pertseva-Ostroumova 1961). The period of larval development extends from April to as late as August or September (Jensen 1935) which results in an extensive larval drift and broad dispersal from the spawning waters of the continental slope. Metamorphosis occurs in August or September at about 70 to 80 mm in length at which time the demersal life begins. Juveniles are reported to be quite tolerant of cold temperatures to less than 0 °C (Hognestad 1969) and have been found on the northern part of the Bering Sea shelf in summer trawl surveys (Alton et al. 1988).

The age of 50 percent maturity is estimated to range from 5 to 10 years (D’yakov 1982, 600 mm used in stock assessment) and a natural mortality rate of 0.112 has been used in the most recent stock assessments (Barbeaux et al. 2015). The approximate upper size limit of juvenile fish is 590 mm.

D.5.2 Relevant Trophic Information

Groundfish predators include Pacific cod, pollock, and yellowfin sole, mostly on fish ranging from 20 to 50 mm standard length (probably age 0).

D.5.3 Habitat and Biological Associations

Larvae: Planktonic larvae for up to 9 months until metamorphosis occurs, usually with a widespread distribution inhabiting shallow waters.

Settled Early Juveniles/Subadults: Juveniles live on the continental shelf until about age 4 or 5 feeding primarily on euphausiids, polychaetes, and small walleye pollock. The covariates contributing the most to the final SDM EFH map for the subadult life stage (older juveniles) in the EBS were geographic position, bottom temperature, bottom depth, and sediment grain size (Laman et al. 2022). Ensemble-predicted subadult Greenland turbot abundance was highest over the outer shelf domain and upper continental slope in the northern part of the EBS in cooler bottom temperatures (< 2°C), depths around 450 m, and over coarser bottom sediments.

Adults: Inhabit continental slope waters with annual spring/fall migrations from deeper to shallower waters. In the Bering Sea diet consists of primarily walleye pollock, squid, crustaceans, and other miscellaneous fish species. In the Aleutian Islands although there is walleye pollock in the diet, there is a higher proportion of squid and Atka mackerel. In the EBS, the covariates contributing the most to the final SDM EFH map for this life stage were bottom depth, geographic position, bottom temperature, ROMS current variation, and sediment grain size (Laman et al. 2022), and predicted abundance was highest at depths around 500 m along the continental slope with relatively stable bottom currents and coarser sediment grain sizes. In the AI, the covariate contributing the most to the final SDM EFH map for this life stage was bottom depth (Harris et al. 2022). In general, abundance was expected to be higher in locations with high bottom depth, low temperature, weak currents, and farther west.

Habitat and Biological Associations: Greenland turbot

Stage - EFH Level	Duration or Age	Diet/Prey	Season/ Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs		NA	winter	OCS, MCS	SD, SP			
Larvae	8–9 months	U phyto/zoo plankton?	spring summer	OCS, ICS MCS	P			
Settled Early Juveniles/Subadults	1–5 yrs	euphausiids polychaetes small pollock	all year	ICS, MCS OCS, USP	D, SD	MS, M		
Adults	5+ years	pollock small fish	spawning Nov–February	OCS, USP LSP	D, SD	MS, M		
			non-spawning March–Oct	USP, LSP				

D.5.4 Literature

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D.6 Kamchatka flounder (*Atheresthes evermani*)

D.6.1 Life History and General Distribution

Kamchatka flounder (*Atheresthes evermani*) is a large-bodied flatfish found from the Sea of Okhotsk through the Bering Sea and into the western Gulf of Alaska (Zimmermann and Goddard 1996). In U.S. waters, they occur in high concentrations in the western Aleutians, generally declining in abundance east of there (Bryan et. al. 2018). The species is morphologically similar to the more common arrowtooth flounder (*A. stomias*) and the two species were not routinely distinguished in assessment surveys until 1992 (Bryan et al. 2018). The majority of Kamchatka flounder become sexually mature at a relatively large size (L_{50} = 550 mm; Stark 2012b), and can eventually grow to be 860 mm or more. This species was managed as a stock complex with arrowtooth flounder until 2011, when the start of a directed fishery prompted the development of separate management plans (Bryan et. al. 2018).

D.6.2 Relevant Trophic Information

Given its large size and predatory habits, this species is thought to be an important part of the marine food web and is a major predator of juvenile walleye pollock (*Gadus chalcogrammus*; Yang and Livingston 1986).

D.6.3 Habitat and Biological Associations

Subadults: Subadult Kamchatka flounder is often found north of Atka and Adak Islands, as well as around Agattu Island in the AI. Subadults show a preference for areas on the northern side of the islands, and seem to occupy habitats where the 100 m depth contour runs close to the shore. In the EBS, subadults are most common over the EBS outer shelf domain and upper continental slope. In the EBS, the covariates contributing the most to the final SDM EFH map for this life stage were geographic position, bottom depth, and bottom temperature (Laman et al. 2022). Ensemble-predicted abundance of subadult Kamchatka flounder was highest over the outer shelf domain and along the EBS shelf break at depths around 450 m with increasing bottom temperatures. In the AI, the covariates contributing the most to the final SDM EFH map for this life stage were geographic position and bottom current (Harris et al. 2022). In general, high abundance was predicted for areas farther west, with northerly currents, and with bottom depths between 150 and 300 m.

Adults: Contrary to subadults, adult Kamchatka flounder appear in high densities around the deep passes in the AI island chain, including around Seguam Island and to the east and west of Rat Islands. The majority of adults are found at depths greater than 300 m, and typically close to 100 percent at depths greater than 300 m. In the EBS, adults are common on the upper continental slope and are also over the outer shelf domain in the northern portion of the EBS. In the EBS, the covariates contributing the most to the final SDM EFH map for this life stage were bottom depth and geographic position (Laman et al. 2022). Ensemble-predicted adult Kamchatka flounder abundance was highest on the upper continental slope at depths around 500 m. In the AI, the covariates contributing the most to the final SDM EFH map for this life stage were geographic position, bottom current covariates, and terrain aspect (Harris et al. 2022). High abundance was associated with increasing bottom depth, western longitudes, southerly currents, and north-facing terrain.

D.6.4 Literature

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D.7 Northern rock sole (*Lepidopsetta polyxystra*)

D.7.1 Life History and General Distribution

Members of the genus *Lepidopsetta* are distributed from California waters north into the Gulf of Alaska and Bering Sea to as far north as the Gulf of Anadyr. The distribution continues along the Aleutian Islands westward to the Kamchatka Peninsula and then southward through the Okhotsk Sea to the Kurile Islands, Sea of Japan, and off Korea. Centers of abundance occur off the Kamchatka Peninsula (Shubnikov and Lisovenko 1964), British Columbia (Forrester and Thompson 1969), the central Gulf of Alaska, and in the southeastern Bering Sea (Alton and Sample 1976). Two forms were found to exist in Alaska by Orr and Matarese (2000), a southern rock sole (*L. bilineatus*) and a northern rock sole (*L. polyxystra*). Resource assessment trawl surveys indicate that northern rock sole comprise more than 95 percent of the Bering Sea population. Adults exhibit a benthic lifestyle and, in the eastern Bering Sea, occupy separate winter (spawning) and summertime feeding distributions on the continental shelf. Northern rock sole spawn during the winter and early spring period of December through March. Soviet investigations in the early 1960s established two spawning concentrations: an eastern concentration north of Unimak Island at the mouth of Bristol Bay and a western concentration eastward of the Pribilof Islands between 55°30' N. and 55°0' N. and approximately 165°2' W. (Shubnikov and Lisovenko, 1964). Rock sole spawning in the eastern and western Bering Sea was found to occur at depths of 125 to 250 m, close to the shelf/slope break. Spawning females deposit a mass of eggs which are demersal and adhesive (Alton and Sample 1976). Fertilization is believed to be external. Incubation time is temperature dependent and may range from 6.4 days at 11 °C to about 25 days at 2.9 °C (Forrester 1964). Newly hatched larvae are pelagic and have occurred sporadically in eastern Bering Sea plankton surveys (Waldron and Vinter 1978). Kamchatka larvae are reportedly 20 mm in length when they assume their side-swimming, bottom-dwelling form (Alton and Sample 1976). Norcross et al. (1996) and Cooper et al. (2014) found newly settled larvae in the 40 to 50 mm size range. Forrester and Thompson (1969) report that by age 1 they are found with adults on the continental shelf during summer, but this has not been observed in the eastern Bering Sea.

In the springtime, after spawning, rock sole begin actively feeding and commence a migration to the shallow waters of the continental shelf. This migration has been observed on both the eastern (Alton and Sample 1976) and western (Shvetsov 1978) areas of the Bering Sea. During this time they spread out and form much less dense concentrations than during the spawning period. Summertime trawl surveys indicate most of the population can be found at depths from 50 to 100 m (Armistead and Nichol 1993). The movement from winter/spring to summer grounds is in response to warmer temperatures in the shallow waters and the distribution of prey on the shelf seafloor (Shvetsov 1978). In September, with the onset of cooling in the northern latitudes, rock sole begin the return migration to the deeper wintering grounds. Fecundity varies with size and was reported to be 450,00 eggs for fish 420 mm long. Northern rock sole mature (L_{50}) at about 309 mm (Stark 2012). Larvae are pelagic but their occurrence in plankton surveys in the eastern Bering Sea were rare in the early 1960s (Musienko 1963). However, ichthyoplankton surveys conducted since the early 2000s have captured northern rock sole larvae (Lanksbury et al. 2007). Juveniles are separate from the adult population, remaining in shallow areas until they reach age 1 (Forrester 1969). The estimated age of 50 percent maturity is 9 years (approximately 350 mm) for southern rock sole females and 7 years for northern rock sole females (Stark and Somerton 2002). Natural mortality rate is believed to range from 0.18 to 0.20.

D.7.2 Relevant Trophic Information

Groundfish predators include Pacific cod, walleye pollock, skates, Pacific halibut, and yellowfin sole, mostly on fish ranging from 50 to 150 mm standard length.

D.7.3 Habitat and Biological Associations

Larvae: Planktonic larvae for at least 2 to 3 months until metamorphosis occurs.

Settled Early Juveniles: Juveniles inhabit shallow areas at least until age 1. In the EBS, the covariates contributing the most to the final SDM EFH map for this life stage were bottom depth, geographic position, and bottom temperature (Laman et al. 2022). Settled early juvenile NRS abundance was predicted to be highest over the central and southern portions of the EBS inner shelf domain in shallow depths and warmer bottom temperatures. In the AI, the covariate contributing the most to the final SDM EFH map for this life stage was bottom depth along with bottom current, terrain aspect, tidal maximum, and geographic position (Harris et al. 2022). In general, predicted abundance was high in shallow locations with southerly currents, northwest-facing terrain, and weak tides.

Subadults: In the EBS, the covariates contributing the most to the final SDM EFH map for this life stage were bottom depth, geographic position, and bottom temperature (Laman et al. 2022). Ensemble-predicted subadult NRS abundance was highest in Bristol Bay and along the Alaska Peninsula in shallower water and bottom temperatures around 3°C. In the AI, the covariate contributing the most to the final SDM EFH map for this life stage was bottom depth (Harris et al. 2022). Predicted abundance was highest in shallow locations, consistent south westerly currents, and locations farther west in the AI like Attu Island and the Rat Islands.

Adults: Summertime feeding on primarily sandy substrates of the eastern Bering Sea shelf. Widespread distribution mainly on the middle and inner portion of the shelf, feeding on bivalves, polychaete, amphipods, and miscellaneous crustaceans. Wintertime migration to deeper waters of the shelf margin for spawning and to avoid extreme cold water temperatures, feeding diminishes. In the EBS, the covariates contributing the most to the final SDM EFH map for this life stage were geographic position, bottom depth, and sediment grain size (Laman et al. 2022). The highest adult NRS abundances were predicted in shallower, warmer waters along the inner shelf around Bristol Bay and in the vicinities of the Pribilofs and St. Matthew Island. In the AI, the covariates contributing the most to the final SDM EFH map for this life stage were bottom depth, geographic position, current, and current variability (Harris et al. 2022). Adult northern rock sole were predicted to be abundant in shallow waters in the western AI and favor locations with low variability westerly bottom currents.

Habitat and Biological Associations: Rock sole

Stage - EFH Level	Duration or Age	Diet/Prey	Season/ Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs		NA	winter	OCS	D			
Larvae	2–3 months?	U phyto/zoo plankton?	winter/spring	OCS, MCS, ICS	P			
Settled Early Juveniles	to 3.5 yrs	polychaete bivalves amphipods misc. crustaceans	all year	BAY, ICS	D	S G		
Subadults	to 9 years	polychaete bivalves amphipods misc. crustaceans	all year	BAY, ICS, MCS, OCS	D	S, SM,MS G		
Adults	9+ years	polychaete bivalves amphipods misc. crustaceans	feeding May–September	MCS, ICS	D	S,SM,MS,M G		
			spawning Dec.–April	OCS			ice edge	

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D.8 Northern rockfish (*Sebastes polyspinus*)

D.8.1 Life History and General Distribution

Northern rockfish range from northern British Columbia through the Gulf of Alaska and Aleutian Islands to eastern Kamchatka, including the Bering Sea. The species is most abundant from about Portlock Bank in the central Gulf of Alaska to the western end of the Aleutian Islands. Within this range, adult fish appear to be concentrated at discrete, relatively shallow offshore banks of the outer continental shelf. The preferred depth range is approximately 75 to 125 m in the Gulf of Alaska, and approximately 100 to 150 m in the Aleutian Islands. The fish appear to be semipelagic, and along the EBS slope they have been observed to move into the water column during the day and onto the bottom at night. In common with many other rockfish species, northern rockfish tend to have a localized, patchy distribution, even within their preferred habitat, and most of the population occurs in aggregations. Summer bottom trawl surveys conducted by the Alaska Fisheries Science Center indicate that high density BSAI catches occurred primarily in the western Aleutian Islands, with large differences in density between high and low density catches. Species distribution models indicate that abundance of adult northern rockfish inthe AI was high, especially near seamounts in Buldir Strait and Stalemate Bank. Northern rockfish are not commonly encountered in the eastern Bering Sea during sumnmer surveys, although species distribution models indicate that predicted adult abundance in the EBS is highest on the shelf break between Bering Canyon and Pribilof Canyon. Most of what is known about northern rockfish is based on data collected during the summer months from the commercial fishery or in research surveys. Consequently, there is little information on seasonal movements or changes in distribution for this species.

Life history information on northern rockfish is extremely sparse. The fish are assumed to be viviparous, as are other *Sebastes*, with internal fertilization and incubation of eggs. Northern rockfish can show skipped spawning in some years, although this is less common in larger individuals. The length of 50% maturity for AI northern rockfish is estimated at 277 mm (Tenbrink and spencer 2013). Observations during research surveys in the Gulf of Alaska suggest that parturition (larval release) occurs in the spring, and is mostly completed by summer. Pre-extrusion larvae have been described, but field-collected larvae cannot be identified to species at present. Length of the larval stage is unknown, but the fish apparently metamorphose to a pelagic juvenile stage, which also has been described. There is no information on when the juveniles become benthic or what habitat they occupy. Older juveniles are found on the continental shelf, generally at locations inshore of the adult habitat.

Northern rockfish have a low population growth rate, with a low rate of natural mortality (estimated at 0.5), a relatively old age at 50 percent maturity (8.2 years for females in the Aleutian Islands), and an old maximum age of 74 years in the Aleutian Islands. No information on fecundity is available for AI northern rockfish, although estimates in the Gulf of Alaska ranged from 110 - 165 oocytes/g, depending on season of sampling.

D.8.2 Relevant Trophic Information

Although no comprehensive food study of northern rockfish has been done, several smaller studies have all shown euphausiids to be the predominant food item of adults in both the Gulf of Alaska and Bering Sea. Copepods, hermit crabs, and shrimp have also been noted as prey items in much smaller quantities.

Predators of northern rockfish have not been documented, but likely include species that are known to consume rockfish in Alaska, such as Pacific halibut, sablefish, Pacific cod, and arrowtooth founder.

D.8.3 Habitat and Biological Associations

Eggs: No information known, except that parturition probably occurs in the spring.

Larvae: No information known.

Pelagic/Settled Early Juveniles: No information known for small juveniles (less than 200 mm), except that juveniles apparently undergo a pelagic phase immediately after metamorphosis from the larval stage. Larger juveniles have been taken in bottom trawls at various localities of the continental shelf, usually inshore of the adult fishing grounds.

Subadults: The covariates contributing the most to the final SDM EFH map for this life stage in the AI were geographic position, bottom depth, and current (Harris et al. 2022). Predicted, abundance increased farther west in the AI and in shallow depths and southerly currents.

Adults: Commercial fishery and research survey data have indicated that adult northern rockfish are primarily found over hard, rocky, or uneven bottom of offshore banks of the outer continental shelf at depths of 75 to 200 m. Generally, the fish appear to be semipelagic, extending into the water column, and most of the population occurs in large aggregations. There is no information on seasonal migrations. Northern rockfish often co-occur with dusky rockfish. In the EBS, the covariates contributing the most to the final SDM EFH map for this life stage were bottom depth, geographic position, and bottom current vector (Laman et al. 2022). Adult northern rockfish were predicted to be present in higher abundance along the shelf break from the Bering Canyon to north of Pribilof Canyon in waters shallower than 300 m with variable northerly bottom currents and decreasing tidal maxima. In the AI, the covariates contributing the most to the final SDM EFH map for this life stage were geographic position and bottom depth (Harris et al. 2022). According to the model, abundance is expected to increase from east to west, in depths between 100 and 200 m, and with strong but variable southerly currents.

Habitat and Biological Associations: Northern Rockfish

Stage - EFH Level	Duration or Age	Diet/Prey	Season/ Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs	U	NA	U	NA	NA	NA	NA	NA
Larvae	U	U	spring–summer?	U	P (assumed)	NA	U	U
Pelagic/ Settled Early Juveniles	from end of larval stage to ?	U	all year	MCS, OCS	P? (early juvenile only), D	U (juvenile< 200 mm); substrate (juvenile> 200 mm)	U	U
Subadults	to 8 yrs	U	all year	OCS	D	CB, R	U	U
Adults	8 – 57 years of age	euphausiids	U, except that larval release is probably in the spring in the Gulf of Alaska	OCS, USP	SD/SP	CB, R	U	U

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D.9 Octopuses

There are at least seven species of octopuses currently identified from the Bering Sea (Jorgensen 2009). The species most abundant at depths less than 200m is the giant Pacific octopus *Enteroctopus dofleini* (formerly *Octopus dofleini*). Several species are found primarily in deeper waters along the shelf break and slope, including, *Sasakiopus salebrosus*, *Benthoctopus leioderma*, *Benthoctopus oregonensis*, *Graneledone boreopacifica*, and the cirrate octopus *Opisthoteuthis* cf *californiana*. *Japetella diaphana* is also reported from pelagic waters of the Bering Sea. Preliminary evidence (Conners and Jorgensen 2008) indicates that octopuses taken as incidental catch in groundfish fisheries are primarily *Enteroctopus dofleini*. This species has been extensively studied in British Columbia and Japan, and is used as the primary indicator for the assemblage. Species identification of octopuses in the Bering Sea and Gulf of Alaska (GOA) has changed since the previous EFH review and is still developing. The state of knowledge of octopuses in the Bering Sea and Aleutian Islands (BSAI), including the true species composition, is very limited.

D.9.1 Life History and General Distribution

Octopuses are members of the molluscan class Cephalopoda, along with squid, cuttlefish, and nautiloids. The octopuses (order Octopoda) have only eight appendages or arms and unlike other cephalopods, they lack shells, pens, and tentacles. There are two groups of Octopoda, the cirrate and the incirrate. The cirrate have cirri and are by far less common than the incirrate, which contain the more traditional forms of octopus. Octopuses are found in every ocean in the world and range in size from less than 200 mm (total length) to over 3 m (total length); the latter is a record held by *Enteroctopus dofleini*.

In the Bering Sea octopuses are found from subtidal waters to deep areas near the outer slope (Conners et al. 2014). The highest diversity is along the shelf break region where three to four species of octopus can be collected in approximately the same area. The highest diversity is found between 200 m and 750 m. The observed take of octopus from both commercial fisheries and Alaska Fisheries Science Center Resource Assessment and Conservation Engineering Division surveys indicates few octopus occupy federal waters of Bristol Bay and the inner front region. Some octopuses have been observed in the middle front, especially in the region south of the Pribilof Islands. The majority of observed commercial and survey hauls containing octopus are concentrated in the outer front region and along the shelf break, from the horseshoe at Unimak Pass to the northern limit of the federal regulatory area. Octopuses have been observed throughout the western GOA and Aleutian Islands chain. Of the octopus species found in shallower waters, the distribution between state waters (within three miles of shore) and federal waters remains unknown. *Enteroctopus dofleini* in Japan undergo seasonal depth migrations associated with spawning; it is unknown whether similar migrations occur in Alaskan waters.

In general, octopus life spans are either 1 to 2 years or 3 to 5 years depending on species. Life histories of six of the seven species in the Bering Sea are largely unknown. *Enteroctopus dofleini* has been studied in waters of northern Japan and western Canada, but reproductive seasons and age/size at maturity in Alaskan waters are still undocumented. General life histories of the other six species are inferred from what is known about other members of the genus.

E. dofleini samples collected during research in the Bering Sea indicate that *E. dofleini* are reproductively active in the fall with peak spawning occurring in the winter to early spring months. Like most species of octopods, *E. dofleini* are terminal spawners, dying after mating (males) and the hatching of eggs (females) (Jorgensen 2009). *E. dofleini* within the Bering Sea have been found to mature between 10 to 13 kg with 50% maturity values of 12.8 kg for females and 10.8 kg for males (Brewer and Norcross 2013). *E. dofleini* are problematic to age due to a documented lack of beak growth checks and soft chalky statoliths (Robinson and Hartwick 1986). Therefore the determination of age at maturity is difficult for this species. In Japan this species is estimated to mature at 1.5 to 3 years and at similar size ranges (Kanamaru and Yamashita 1967, Mottet1975). Within the Bering Sea, female *E. dofleini* show significantly larger gonad weight and maturity in the fall months (Brewer and Norcross 2013). Due to differences in the timing of peak gonad development between males and females it is likely that females have the capability to store sperm. Fecundity for this species in the Gulf of Alaska ranges from 40,000 to 240,000 eggs per female with an average fecundity of 106,800 eggs per female (Conrath and Conners 2014). Hatchlings are approximately 3.5 mm. Mottet (1975) estimated survival to 6 mm at 4% while survival to 10 mm was estimated to be 1%; mortality at the 1 to 2 year stage is also estimated to be high (Hartwick, 1983). Since the highest mortality occurs during the larval stage it is likely that ocean conditions have the largest effect on the number of *E. dofleini* in the Bering Sea and large fluctuations in numbers of *E. dofleini* should be expected. Based on larval data, *E. dofleini* is the only octopus in the Bering Sea with a planktonic larval stage.

Sasakiopus salebrosus is a small benthic octopus recently identified from the Bering Sea slope in depths ranging from 200 to1200 m (Jorgensen 2010). It was previously identified in surveys as *Benthoctopus sp*. or as *Octopus sp. n.* In recent groundfish surveys of the Bering Sea slope this was the most abundant octopus collected; multiple specimens were collected in over 50% of the tows. *Sasakiopus salebrosus* is a small-sized species with a maximum total length < 250 mm. Mature females collected in the Bering Sea carried 100 to 120 eggs (Laptikhovsky 1999). Hatchlings and paralarvae have not been collected or described (Jorgensen 2009).

Benthoctopus leioderma is a medium sized species, with a maximum total length of approximately 600 mm. Its life span is unknown. It occurs from 250 to 1400 m and is found throughout the shelf break region. It is a common octopus and often occurs in the same areas where *E. dofleini* are found. The eggs are brooded by the female but mating and spawning times are unknown. Members of this genus in the North Pacific Ocean have been found to attach their eggs to hard substrate under rock ledges and crevices (Voight and Grehan 2000). *Benthoctopus* tend to have small numbers of eggs (< 200) that develop into benthic hatchlings.

Benthoctopus oregonensis is larger than *B. leioderma*, with a maximum total length of approximately 1 m. This is the second largest octopus in the Bering Sea and based on size could be confused with *E.*

dofleini. We know very little about this species of octopus. Other members of this genus brood their eggs and we would assume the same for this species. The hatchlings are demersal and likely much larger than those of *E. dofleini*. The samples of *B. oregonensis* all come from deeper than 500 m. This species is the least collected incirrate octopus in the Bering Sea and may occur in depths largely outside of the sampling range of AFSC surveys.

Graneledone boreopacifica is a deep water octopus with only a single row of suckers on each arm (the other benthic incirrate octopuses have two rows of suckers). It is most commonly collected north of the Pribilof Islands but occasionally is found in the southern portion of the shelf break region. This species has been shown to occur at hydrothermal vent habitats and prey on vent fauna (Voight 2000). Samples of *G. boreopacifica* all come from deeper than 650 m and this deep water species has not been found on the continental shelf. *Graneledone* species have also been shown to individually attach eggs to hard substrate and brood their eggs throughout development. Recently collected hatchlings of this species were found to be very large (55 mm long) and advanced (Voight 2004) and this species has been shown to employ multiple paternity (Voight and Feldheim 2009).

Opisthoteuthis californiana is a cirrate octopus with fins and cirri (on the arms). It is common in the Bering Sea but would not be confused with *E. dofleini*. It is found from 300 to 1100 m and likely common over the abyssal plain. *Opisthoteuthis californiana* in the northwestern Bering Sea have been found to have a protracted spawning period with multiple small batch spawning events. Potential fecundity of this species was found to range from 1,200 to 2,400 oocytes (Laptikhovsky 1999). There is evidence that *Opisthoteuthis* species in the Atlantic undergo ‘continuous spawning’ with a single, extended period of egg maturation and a protracted period of spawning (Villanueva 1992). Other details of its life history remain unknown.

Japetella diaphana is a small pelagic octopus. Little is known about members of this family. In Hawaiian waters gravid females are found near 1,000 m and brooding females near 800 m. Hatchlings have been observed to be about 3 mm mantle length (Young 2008). This is not a common octopus in the Bering Sea and would not be confused with *E. dofleini*.

D.9.2 Relevant Trophic Information

Octopus are eaten by pinnipeds (principally Steller sea lions, and spotted, bearded, and harbor seals) and a variety of fishes, including Pacific halibut and Pacific cod (Yang 1993). When small, octopods eat planktonic and small benthic crustaceans (mysids, amphipods, copepods). As adults, octopus eat benthic crustaceans (crabs) and molluscs (clams). Large octopuses are also able to catch and eat benthic fishes; the Seattle Aquarium has documented a giant Pacific octopus preying on a 4-foot dogfish. . The pelagic larvae of *E. dofleini* are presumed to prey on planktonic zooplankton.

D.9.3 Habitat and Biological Associations

Eggs: shelf, *E. dofleini* lays strings of eggs in cave or den in boulders or rubble, which are guarded by the female until hatching. The exact habitat needs and preferences for denning are unknown.

Larvae: pelagic for *Enteroctopus dofleini*, demersal for other octopus species.

Pelagic/Settled Early Juveniles: semi-demersal; widely dispersed on shelf, upper slope

Subadults and Adults: demersal, widely dispersed on shelf and upper slope, preferentially among rocks, cobble, but also on sand/mud. In the EBS, the covariates contributing the most to the final SDM EFH map for all life stages combined were geographic position, bottom depth, ROMS bottom current, and bottom temperature (Laman et al. 2022). The predicted abundance of giant octopus was highest along the EBS shelf break and upper continental slope in depths around 300 m with northerly bottom currents and increasing bottom temperatures. In the AI, the covariate contributing the most to the final SDM EFH map for all life stages combined was presence of sponges, though a variety of other covariates contributed such as bottom depth, geographic position, bottom temperature, currents, and tidal maximum (Harris et al.

2022). Predicted abundance was high in areas with moderate depth and in patches near Atka, Adak, and the Rat islands.

Habitat and Biological Associations: *Octopus dofleini*, *O. gilbertianus*

Stage - EFH Level	Duration or Age	Diet/Prey	Season/ Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs	U (1–2 months?)	NA	spring–summer ?	U, ICS, MCS	P*,D	R, G?	U	euhaline waters
Pelagic/Settled Early juveniles	U	zooplankton	summer –fall?	U, ICS, MCS, OCS, USP	D, SD	U	U	euhaline waters
Subadults and Adults	3–5 yrs for *E.dofleini,* 1–2 yrs for other species	crustaceans, mollusks, fish	all year	ICS, MCS, OCS, USP	D	R, G, S, MS?	U	euhaline waters

D.9.4 Literature

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D.10 Other Flatfish complex

The Other flatfish complex includes:

Butter sole,
Deepsea sole,
Dover sole,
English sole,
Longhead dab,
Rex sole,
Sakhalin sole,
Southern rock sole, and
Starry flounder.

Species Complex Summary

The other flatfish stock complex in the BSAI (Conners et al. 2016, Wilderbuer and Nichol 2015) represents eight flatfish species (butter sole, deepsea sole, Dover sole, longhead dab, rex sole, Sakhalin sole, and starry flounder). Species in this complex are commonly found over the inner shelf on the eastern margin of the EBS and along the Alaska Peninsula, as well as in association with the shelf break and outer shelf domain. In the Bering Sea region, starry flounder is the most abundant species, but it is largely absent from the AI. In contrast, rex sole is the most common species in this complex in the AI, and it constitutes a majority of the “other flatfish” catch. Rex sole and southern rock sole are typically caught in the eastern AI and can appear in very high densitities, whereas Dover sole is primarily caught in deeper water and further west, and rarely more than a few fish at at time. Because of these traits, EFH maps for the complex tend to favor the more numerous species.

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D.10.1 Butter sole (*Isopsetta isolepis*)

D.10.1.1 Life History and General Distribution

Butter sole (*Isopsetta isolepis*) range from the southeastern Bering Sea and Aleutian Islands at Amchitka Island to southern California over soft bottom habitats in relatively shallow (< 150 m) water (Mecklenburg et al. 2002). In EBS RACE-GAP summer bottom trawl surveys, butter sole are not uncommon in catches from southeastern Bristol Bay and have been collected as far north as the waters around St. Matthew Island. There is no directed fishery for butter sole in the EBS and they are managed in the "other flatfishes" stock complex (Wilderbuer and Nichol 2015). Length-based definitions of ontogenetic stages of butter sole were not available so all life stages collected are modeled in composite for EFH of this species.

D.10.1.2 Relevant Trophic Information

There is insufficient information on butter sole predator or prey relationships.

D.10.1.3 Habitat and Biological Associations

Subadults/Adults: The covariates contributing the most to the final SDM EFH map for this life stage were geographic position, bottom currents, bottom temperature, and sediment size (Laman et al. 2022). The predicted abundance of butter sole was highest along the Alaska Peninsula at depths of 200 m and in areas with warm temperatures or fine sediments.

D.10.1.4 Literature

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D.10.2 Deepsea sole (*Embassichthys bathybius*)

D.10.2.1 Life History and General Distribution

Deepsea sole (*Embassichthys bathybius*) is a deep-dwelling (320–1433 m) flatfish species ranging from Japan to southern California and the Bering Sea and reaches a maximum length of 470 mm F.L (Mecklenberg et al. 2002). In RACE-GAP EBS summer bottom trawl surveys, they occur only on the upper continental slope in depths greater than 500 m. Little is known of their biology and life history (Orlov and Tokranov 2007) and they are uncommon in RACE-GAP bottom trawl catches. There is no directed fishery for deepsea sole in the EBS and they are managed in composite in the "other flatfishes" stock complex in the BSAI (Wilderbuer and Nichol 2015).

D.10.2.2 Relevant Trophic Information

There is insufficient information on deepsea sole predator or prey relationships.

D.10.2.3 Habitat and Biological Associations

Adults: The covariates contributing the most to the final SDM EFH map for this life stage in the EBS were bottom depth and currents (i.e., ROMS bottom current and variability) (Laman et al. 2022). The predicted abundance of deepsea sole was highest at around 600 m depth on the continental slope with moderately variable northerly bottom currents.

D.10.2.4 Literature

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D.10.3 Dover sole (*Microstomus pacificus*)

D.10.3.1 Life History and General Distribution

Dover sole are distributed in deep waters of the continental shelf and upper slope from northern Baja California to the Bering Sea and the western Aleutian Islands (Hart 1973, Miller and Lea 1972), and exhibit a widespread distribution throughout the Gulf of Alaska. Adults are demersal and are mostly found in water deeper than 300 meters. The spawning period off Oregon is reported to range from January through May (Hunter et al. 1992). Spawning in the Gulf of Alaska has been observed from January through August, with a peak period in May (Hirschberger and Smith 1983). Eggs have been collected in neuston and bongo nets in the summer, east of Kodiak Island (Kendall and Dunn 1985), but the duration of the incubation period is unknown. Larvae were captured in bongo nets only in summer over mid-shelf and slope areas (Kendall and Dunn 1985). The age or size at metamorphosis is unknown but the pelagic larval period is known to be protracted and may last as long as two years (Markle et al. 1992). Pelagic postlarvae as large as 48 mm have been reported and the young may still be pelagic at 100 mm (Hart 1973). Dover sole are batch spawners and Hunter et al. (1992) concluded that the average 1 kg female spawns its 83,000 advanced yolked oocytes in about nine batches. Maturity studies from Oregon indicate that females were 50 percent mature at 330 mm total length. Juveniles less than 250 mm are rarely found with the adult population from bottom trawl surveys (Martin and Clausen 1995). The natural mortality rate used in recent stock assessments is 0.2 (Turnock et al. 1996).

D.10.3.2 Relevant Trophic Information

Groundfish predators include Pacific cod and most likely arrowtooth flounder.

D.10.3.3 Habitat and Biological Associations

Larvae: Planktonic larvae for up to 2 years until metamorphosis occurs

Early Juveniles: Early juvenile distribution is unknown.

Subadults: In the EBS, the covariates contributing the most to the final SDM EFH map for this life stage were geographic position, bottom depth, and sediment size (Laman et al. 2022). Subadult Dover sole abundance was predicted over the middle and outer shelf domains of the southern EBS, extending into the Bering Canyon and on to the continental slope at depths around 400 m with coarser bottom sediments and low bottom currents. In the AI, the covariates contributing the most to the final SDM EFH map for this life stage were geographic position, bottom depth, and current vector (Harris et al. 2022). Predicted abundance was highest around Petrel Bank.

Adults: Winter and spring spawning and summer feeding on soft substrates (combination of sand and mud) of the continental shelf and upper slope. Shallower summer distribution mainly on the middle to outer portion of the shelf and upper slope, feeding mainly on polychaete, annelids, crustaceans, and molluscs (Livingston and Goiney 1983). In the EBS, the covariates contributing the most to the final SDM EFH map for this life stage were bottom depth, geographic position, and bottom currents (Laman et al. 2022). In the AI, the covariates contributing the most to the final SDM EFH map for this life stage were geographic position, bottom depth, and current (Harris et al. 2022). The ensemble predicted higher abundance around Petrel Bank, and higher abundance with increasing depth and in places with variable, southerly bottom currents.

Habitat and Biological Associations: Dover sole

Stage - EFH Level	Duration or Age	Diet/Prey	Season/ Time	Location	Water Column	Bottom Type	Oceano - graphic Feature s	Other
Eggs		NA	spring summer	ICS? MCS, OCS, UCS	P			
Larvae	up to 2 years	U phyto/ zooplankton?	all year	ICS? MCS, OCS, UCS	P			
Early Juveniles	to 3 years	polychaetes amphipods annelids	all year	MCS? ICS?	D	S, M		
Subadults	3–5 years	polychaetes amphipods annelids	all year	MCS? ICS?	D	S, M		
Adults	5+ years	polychaetes amphipods annelids molluscs	spawning Jan–August non-spawning July–Jan	MCS, OCS, UCS	D	S, M		

D.10.3.4 Literature

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D.10.4 English sole (*Parophrys vetulus*)

D.10.4.1 Life History and General Distribution

English sole (*Parophrys vetulus*) is a moderately-sized flatfish that reaches an adult size of up to 630 mm FL in RACE-GAP bottom trawl surveys. It is found from the central AI to Baja California and in the Bering Sea (Hart 1973). Little is known about English sole life history in Alaska, but along the coasts of Oregon and Washington, the spawning season lasts from September to April (Krygier and Pearcy 1986), and juveniles spend their first year in nursery areas near estuaries before eventually spreading out along the coast (Gunderson et al. 1990). No settled early juveniles (< 140 mm FL; Yeung and Cooper 2020) and very few subadults (< 230 mm FL; L_{50}; Sampson and Al-Jufaily 1998) were captured in the AI bottom trawl survey, and only adults had sufficient data to construct a species distribution model. In the BSAI region, English sole are managed as part of the Other Flatfish stock complex and do not receive a species-specific fishing target (Monnahan 2020).

D.10.4.2 Relevant Trophic Information

There is insufficient information on English sole predator or prey relationships.

D.10.4.3 Habitat and Biological Associations

<u>Adults</u>: The small number of English sole catches in the AI are almost all near shore around Unalaska Island, making presence easy to predict. It is hard to say if this distribution pattern should be expected to be consistent over time with so few occurrences, however. The covariates contributing the most to the final SDM EFH map for this life stage were weak currents, weak tides, shallow water, and warm temperatures (Harris et al. 2022). Predicted abundance is highest near shore around Unalaska and Umnak Islands, and low below 100 m depth. Predicted encounter probabilities for adult English sole were high in a few places near Unalaska Island and zero over most of the AI region.

D.10.4.4 Literature

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D.10.5 Longhead dab (*Limanda proboscidea*)

D.10.5.1 Life History and General Distribution

Longhead dab (*Limanda proboscidea*) range from the Beaufort Sea off Point Barrow to the Sea of Okhotsk and into Bristol Bay north of Unimak Pass over soft bottom habitats in waters shallower than 100 m (Mecklenburg et al. 2002). They reach a reported maximum length of 410 mm and their life history is not well described. Length at maturity has not been reported for longhead dabs so for this species collected from RACE-GAP summer bottom trawl surveys they are modeled as a single, combined life stage. Longhead dabs are managed in aggregate as part of the BSAI “other flatfish” stock complex (Conners et al. 2017).

D.10.5.2 Relevant Trophic Information

There is insufficient information on longhead dab predator or prey relationships.

D.10.5.3 Habitat and Biological Associations

Adults: The covariate contributing the most to the final SDM EFH map for this life stage in the EBS was geographic position alone (Laman et al. 2022). Abundance of longhead dab was predicted to be highest on the inner shelf from Nunivak Island south into Bristol Bay at depths shallower than 300 m in bottom water temperatures around 3°C.

D.10.5.4 Literature

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D.10.6 Rex Sole (*Glyptocephalus zachirus*)

D.10.6.1 Life History and General Distribution

Rex sole (*Glyptocephalus zachirus*) are distributed from Baja California to the Bering Sea and western Aleutian Islands (Hart 1973, Miller and Lea 1972), and are widely distributed throughout the Gulf of Alaska. Adults exhibit a benthic lifestyle and are generally found in water deeper than 300 meters. From over-winter grounds near the shelf margins, adults begin a migration onto the mid- and outer continental shelf in April or May each year. The spawning period off Oregon is reported to range from January through June with a peak in March and April (Hosie and Horton 1977). Spawning in the Gulf of Alaska was observed from February through July, with a peak period in April and May (Hirschberger and Smith 1983). Eggs have been collected in neuston and bongo nets mainly in the summer, east of Kodiak Island (Kendall and Dunn 1985), but the duration of the incubation period is unknown. Larvae were captured in bongo nets only in summer over midshelf and slope areas (Kendall and Dunn 1985). Fecundity estimates from samples collected off the Oregon coast ranged from 3,900 to 238,100 ova for fish 240 to 590 mm (Hosie and Horton 1977). The age or size at metamorphosis is unknown. Maturity studies from Oregon indicate that males were 50 percent mature at 160 mm and females at 240 mm. Abookire (2006) estimated the female length at 50 percent maturity from Gulf of Alaska samples at 350 mm and 5.6 years. Juveniles less than 150 mm are rarely found with the adult population. The natural mortality rate used in recent stock assessments is 0.17 (Wilderbuer et al. 2010).

The approximate upper size limit of juvenile fish is 150 mm for males and 230 mm for females.

D.10.6.2 Relevant Trophic Information

Groundfish predators include Pacific cod and most likely arrowtooth flounder. Adult rex sole feed mainly on polychaete, amphipods, euphausids and snow crabs.

D.10.6.3 Habitat and Biological Associations

Larvae: Planktonic larvae for an unknown time period (at least 8 months from October through May) until metamorphosis occurs.

Settled Early Juveniles: The covariates contributing the most to the final SDM EFH map for this life stage were geographic position, bottom depth, tidal maximum, and pennatulacean (Laman et al. 2022). Settled early juvenile rex sole were predicted over the outer EBS shelf domain near the shelf break in shallower depths.

Subadults: In the EBS, the covariates contributing the most to the final SDM EFH map for this life stage were geographic position, bottom depth, ROMS bottom current, and bottom temperature (Laman et al. 2022), where ensemble-predicted subadult rex sole abundance was highest along the EBS shelf break in depths around 300 m with northeasterly bottom currents and bottom temperatures around 4°C. In the AI, the covariates contributing the most to the final SDM EFH map for this life stage were geographic position and bottom depth (Harris et al. 2022). Abundance was predicted to be higher at more eastern longitudes, at depths between 150 and 300 m, in weak currents, and at a low tidal maximum.

Adults: Spring spawning and summer feeding on a combination of sand, mud and gravel substrates of the continental shelf. Widespread distribution mainly on the middle and outer portion of the shelf. In the EBS, the covariates contributing the most to the final SDM EFH map for this life stage were Geographic position, bottom depth, and ROMS bottom currents (Laman et al. 2022). Predicted adult rex sole abundance was highest over the outer EBS shelf domain at the head of the Bering Canyon and northward focused on the shelf break in depths around 350 m with northerly bottom currents. In the AI, the covariates contributing the most to the final SDM EFH map for this life stage were geographic position and bottom depth, though current, tidal maximum, and slope aspect were also important (Harris et al.

2023). Like subadults, adult rex sole are predicted to be abundant in the eastern AI and are associated with areas with weak bottom currents and deeper habitats, with high abundances south of Unalaska Island.

Habitat and Biological Associations: Rex sole

Stage - EFH Level	Duration or Age	Diet/Prey	Season/ Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs		NA	Feb–May	ICS? MCS, OCS	P			
Larvae	U	U phyto/zoo plankton?	spring summer	ICS? MCS, OCS	P			
Settled Early Juveniles /Subadults	2 years	polychaete amphipods euphausiids Tanner crab	all year	MCS, ICS, OCS	D	G, S, M		
Adults	2+ years	polychaete amphipods euphausiids Tanner crab	spawning Feb–May non-spawning May–January	MCS, OCS USP MCS, OCS, USP	D	G, S, M		

D.10.6.4 Literature

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D.10.7 Sakhalin sole (*Limanda sakhalinensis*)

D.10.7.1 Life History and General Distribution

Sakhalin sole (*Limanda sakhalinensis*) range from the Chukchi Sea to the southeastern Bering Sea and to Russia over soft bottom habitats in relatively shallow (<100 m) water (Mecklenburg et al. 2002) and their biology is not well known (Yusupov et al. 2020). In EBS RACE-GAP summer bottom trawl surveys, Sakhalin sole are primarily collected in the northern half of the survey area north of the Pribilof Islands in less than 200 m water. For this species we separated the subadult and adult life stages by the L_{50} for females (196 mm) reported by Yusupov et al. (2020) in the northern Sea of Okhotsk. Sakhalin sole are managed in aggregate with the “other flatfish” stock complex in the BSAI (Conners et al. 2017) and are typically caught as bycatch in directed flatfish and Pacific cod fisheries.

D.10.7.2 Relevant Trophic Information

There is insufficient information on Sakhalin sole predator or prey relationships.

D.10.7.3 Habitat and Biological Associations

Subadults: Subadult Sakhalin sole are distributed from the central middle EBS shelf domain into the NBS and were most abundant in EBS RACE-GAP summer bottom trawl survey catches (1982–2019) to the southwest of St. Lawrence Island. The covariates contributing the most to the final SDM EFH map for this life stage were geographic position, bottom temperature, and tidal maximum (Laman et al. 2022). Abundance for this species life stage is predicted to be highest in the NBS south and west of St. Lawrence Island with decreasing bottom temperatures and tidal maxima. Encounter probabilities for subadult Sakhalin sole are highest around St. Lawrence Island in the NBS but are near zero in the remainder of the EBS study area.

Adults: Adult Sakhalin sole are primarily distributed in the NBS and are most abundant in EBS RACE-GAP summer bottom trawl survey catches (1982–2019) to the southwest of St. Lawrence Island. The covariates contributing the most to the final SDM EFH map for this life stage were geographic position, tidal maximum, current, and bottom depth (Laman et al. 2022). Abundance for this species life stage is predicted to be highest in the NBS southwest of St. Lawrence Island over a range of tidal maxima at depths around 150 m with bottom temperatures approaching 0°C. Encounter probabilities for adult Sakhalin sole are highest around St. Lawrence Island in the NBS but are near zero in the remainder of the EBS study area.

D.10.7.4 Literature

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D.10.8 Southern rock sole (*Lepidopsetta bilineata*)

D.10.8.1 Life History and General Distribution

Southern rock sole (*Lepidopsetta bilineata*) is found in coastal waters from the eastern Aleutian Islands to Baja California (Orr and Matarese 2000). The species is morphologically similar to northern rock sole (*L. polyxstra*) and the two were not routinely distinguished in groundfish surveys until 1996. There is broad overlap between the two species in the Gulf of Alaska and the eastern Aleutian Islands. Adults may grow to as much as 580 mm total length (Orr and Matarese 2000), and females become mature at approximately 300 mm T.L. Compared to northern rock sole, there has been comparatively little research specific to southern rock sole, and the species are often confounded in older literature. In the BSAI region, almost all catch of southern rock sole is from the eastern Aleutian Islands, and it is managed as a minor part of the much more numerous and commercially valuable northern rock sole stock (Wilderbuer & Nichol 2018).

D.10.8.2 Relevant Trophic Information

There is insufficient information on southern rock sole predator or prey relationships.

D.10.8.3 Habitat and Biological Associations

<u>*Subadults*</u>: The covariates contributing the most to the final SDM EFH map for this life stage were bottom depth and geographic position (Harris et al. 2022). In general, high abundance of subadults is predicted by shallow water, being further east, a rocky substrate, and relatively weak currents southwesterly currents. Predicted abundance is highest in the eastern Aleutian Islands, particularly around Unalaska Island.

<u>*Adults*</u>: The covariates contributing the most to the final SDM EFH map for this life stage were bottom depth and geographic position (Harris et al. 2022). Southern rock sole adults are predicted to be abundant in shallow water and in eastern areas. Similar to subadults, predicted abundance is highest in the eastern Aleutians Islands, particularly around Unalaska Island.

D.10.8.4 Literature

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D.10.9 Starry flounder (*Platichthys stellatus*)

D.10.9.1 Life History and General Distribution

Starry flounder (*Platichthys stellatus*) range from the Beaufort Sea to Southern California, typically over soft bottom habitats in relatively shallow (<100 m) water (Mecklenburg et al. 2002). In catches from EBS RACE-GAP summer bottom trawl surveys, starry flounder are typically caught over the inner domain of the EBS shelf from Bristol Bay to Norton Sound. This euryhaline species is capable of tolerating a wide range of salinities and has been collected from marine to essentially freshwater environments (Orcutt 1950, Ralston 2005). Orcutt (1950) reported a settled early juvenile length range of 20–150 mm along with a reproductive maturity for female starry flounder in California at 3 years and 350 mm T.L. We used this length to separate subadult and adult starry flounder in our analyses. There were insufficient settled early juvenile starry flounder in EBS bottom trawl catches to parameterize an SDM for this life stage. This species is managed in aggregate with the "other flatfish" stock complex in the BSAI (Conners et al. 2017).

D.10.9.2 Relevant Trophic Information

There is insufficient information on southern starry flounder predator or prey relationships.

D.10.9.3 Habitat and Biological Associations

Subadults: Subadult starry flounder are distributed close to shore throughout the EBS inner shelf domain. The covariates contributing the most to the final SDM EFH map for this life stage were geographic position, bottom temperature, ROMS bottom current, sediment grain size, and curature (Laman et al. 2023). Abundance of subadult starry flounder is predicted to be highest in Norton Sound with warming bottom temperatures, northerly currents, finer sediment grain sizes, and little terrain curvature.

Adults: Adult starry flounder are primarily distributed along shore in the EBS over the inner shelf. The covariates contributing the most to the final SDM EFH map for this life stage were geographic position, bottom temperature, bottom depth, and sediment grain size (Laman et al. 2023). Adult starry flounder abundance is predicted to be highest in Norton Sound with increasing bottom temperatures and decreasing bottom depths over finer sediment grain sizes.

D.10.9.4 Literature

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D.11 Other Rockfish complex

The Other Rockfish Complex includes:

Dusky rockfish,
Harlequin rockfish, and
Shortspine thornyhead.

Species Complex Summary

The "other rockfish stock complex" in the Bering Sea (Sullivan et al. 2020) is comprised of shortspine and longspine thornyheads (*Sebastolobus alascanus* and *S. altivelis*) and essentially all other rockfish species (Genus *Sebastes*) occuring in the region that are not Pacific ocean perch (*S. alutus*), northern rockfish (*S. polyspinis*), rougheye rockfish (*S. aleutianus*), the rougheye/blackspotted rockfish complex

(Conners et al. 2016), or shortraker rockfish (*S. borealis*). The other rockfishes in this stock complex are uncommon in the EBS but represent a broad geographic distribution (north of Zhemchug Canyon to the eastern and western Aleutian Islands) and range of depths (1–1,500 m; Love et al. 2002, Mecklenburg et al. 2002).

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D.11.1 Dusky rockfish (*Sebastes variabilis*)

D.11.1.1 Life History and General Distribution

In 2004, Orr and Blackburn described two distinct species that were being labeled as a single species (*Sebastes ciliatus*) with two color varieties: dark and light dusky rockfish. What was labeled as the light dusky rockfish is now considered to be a distinct species *Sebastes variabilis* and is commonly referred to as dusky rockfish. Dusky rockfish range from central Oregon through the North Pacific Ocean and Bering Sea in Alaska and Russia to Japan. The center of abundance for dusky rockfish appears to be the Gulf of Alaska (Reuter 1999). The species is much less abundant in the Aleutian Islands and Bering Sea (Reuter and Spencer 2002). Adult dusky rockfish have a very patchy distribution, and are usually found in large aggregations at specific localities of the outer continental shelf. These localities are often relatively shallow offshore banks. Because the fish are taken with bottom trawls, they are presumed to be mostly demersal. Whether they also have a pelagic distribution is unknown, but there is no evidence of a pelagic tendency based on the information available at present. Most of what is known about dusky rockfish is based on data collected during the summer months from the commercial fishery or in research surveys. Consequently, there is little information on seasonal movements or changes in distribution for this species.

Life history information on dusky rockfish is extremely sparse. The fish are assumed to be viviparous, as are other *Sebastes*, with internal fertilization and incubation of eggs. Observations during research surveys in the Gulf of Alaska suggest that parturition (larval release) occurs in the spring, and is probably completed by summer. Another, older source, however, lists parturition as occurring “after May.” Pre-extrusion larvae have been described, but field-collected larvae cannot be identified to species at present. Length of the larval stage, and whether a pelagic juvenile stage occurs, are unknown. There is no information on habitat and abundance of young juveniles (less than 250 mm fork length), as catches of these have been virtually nil in research surveys. Even the occurrence of older juveniles has been very uncommon in surveys, except for one year. In this latter instance, older juveniles were found on the continental shelf, generally at locations inshore of the adult habitat.

Dusky rockfish is a slow growing species, with a low rate of natural mortality estimated at 0.09. However, it appears to be faster growing than many other rockfish species. Maximum age is 49 to 59 years. Dusky rockfish become mature (L_{50}) around 365 mm (Chilton et al. 2010). The approximate upper size limit for juvenile fish is 470 mm for females; unknown for males, but presumed to be slightly smaller than for females based on what is commonly the case in other species of *Sebastes*.

D.11.1.2 Relevant Trophic Information

Although no comprehensive food study of dusky rockfish has been done, one smaller study in the Gulf of Alaska showed euphausiids to be the predominate food item of adults. Larvaceans, cephalopods, pandalid shrimp, and hermit crabs were also consumed.

Predators of dusky rockfish have not been documented, but likely include species that are known to consume rockfish in Alaska, such as Pacific halibut, sablefish, Pacific cod, and arrowtooth founder.

D.11.1.3 Habitat and Biological Associations

Eggs: Internal fertilization and live birth are common to *Sebaastes* sp. (Chilton 2010).

Settled Early Juveniles: No information known for small juveniles less than 250 mm fork length.

Subadults: Larger juveniles have been taken infrequently in bottom trawls at various localities of the continental shelf, usually inshore of the adult fishing grounds. The covariates contributing the most to the final SDM EFH map for this life stage were geographic position, bottom depth, and bottom currents (Harris et al. 2022). The associate with shallower depths and places with south to southeasterly currents in the eastern AI. Predicted abundance was highest around Unalaksa Island, though localized areas of high abundance are also predicted near Umnak and Amchitka Islands.

Adults: Commercial fishery and research survey data suggest that adult dusky rockfish are primarily found over reasonably flat, trawlable bottom of offshore banks of the outer continental shelf at depths of 75 to 200 m. Type of substrate in this habitat has not been documented. During submersible dives on the outer shelf (40 to 50 m) in the eastern Gulf, dusky rockfish were observed in association with rocky habitats and in areas with extensive sponge beds where adult dusky rockfishes were observed resting in large vase sponges (V. O’Connell, ADFG, personal communication). Generally, the fish appear to be demersal, and most of the population occurs in large aggregations. Dusky rockfish are the most highly aggregated of the rockfish species caught in Gulf of Alaska trawl surveys. Outside of these aggregations, the fish are sparsely distributed. Because the fish are taken with bottom trawls, they are presumed to be mostly demersal. Whether they also have a pelagic distribution is unknown, but there is no evidence of a pelagic tendency based on the information available at present. There is no information on seasonal migrations. Dusky rockfish often co-occur with northern rockfish.

The covariates contributing the most to the final SDM EFH map for this life stage were geographic position, bottom depth, bottom currents, and slope (Harris et al. 2022). Adults associated with bottom depths between 100-200 m, a slope of at least 5°, and strong southerly currents. Similar to subadults, areas of high abundance for adult dusky rockfish are south of Unalaska Island and Umnak Island.

Habitat and Biological Associations: Dusky Rockfish

Stage - EFH Level	Duration or Age	Diet/Prey	Season/ Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs	U	NA	U	NA	NA	NA	NA	NA
Larvae	U	U	spring–summer?	U	P (assumed)	NA	U	U
Settled Early Juveniles	U	U	all year	ICS, MCS, OCS,	U (small juvenile< 250 mm): D? (larger juvenile)	U (juvenile<250 mm); Trawlable substrate? (juvenile>250 mm)	U	U
Subadults	U	U	U	U	U	CB, R, G	U	observed associated with *primnoa* coral
Adults	Up to 49–50 years.	euphausiids	U, except that larval release may be in the spring in the Gulf of Alaska	OCS, USP	SD, SP	CB, R, G	U	observed associated with large vase type sponges

D.11.1.4 Literature

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D.11.2 Harlequin rockfish (*Sebastes variegatus*)

D.11.2.1 Life History and General Distribution

Harlequin rockfish (*Sebastes variegatus*) is found from the Oregon coast to the western Aleutian Islands (Love et al. 2002). Harlequin rockfish is one of the smaller species and becomes mature at a length of 230 mm and achieves a maximum size of 420 mm (Rooper 2008). This species becomes mature at a relatively young age for sebastid rockfishes (4.5 years), but can still live as long as 72 years (Tribuzio and Echave 2019). One complication for the assessment of this species is that it often has preference for habitat that is untrawlable using standard RACE-GAP survey gear, including areas that are rocky or have a high density of structure forming invertebrates such as corals (Conrath et al. 2019). Harlequin rockfish may be particularly susceptible to this problem, as in multiple studies they were found to be closely associated with the bottom or amidst rocks (Johnson et al. 2003, Jones et al. 2012).

D.11.2.2 Relevant Trophic Information

There is insufficient information on southern harlequin rockfish predator or prey relationships.

D.11.2.3 Habitat and Biological Associations

Adults: The covariates contributing the most to the final SDM EFH map for this life stage were geographic position, bottom depth, bottom currents, BPI, slope angle, and slope aspect (Harris et al. 2022). Predicted abundance was highest along the edge of the continental slope, particularly south of Unalaska and Umnak islands.

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D.11.3 Shortspine thornyhead (*Sebastolobus alascanus*)

D.11.3.1 Life History and General Distribution

Thornyhead rockfish of the northeastern Pacific Ocean are comprised of two species, the shortspine thornyhead (*Sebastolobus alascanus*) and the longspine thornyhead (*S. altivelis*). The longspine thornyhead is not common in the Bering Sea and Aleutian Islands. The shortspine thornyhead is a demersal species which inhabits deep waters from 93 to 1,460 m from the Bering Sea to Baja California. This species is common throughout the Gulf of Alaska, eastern Bering Sea, and Aleutian Islands. The population structure of shortspine thornyheads, however, is not well defined. Thornyhead rockfish are slow-growing and long-lived with maximum age in excess of 50 years and maximum size greater than 750 mm and 2 kg. Thornyheads spawn buoyant masses of eggs during the late winter and early spring that resemble bilobate “balloons” which float to the surface (Pearcy 1962). Juvenile shortspine thornyhead rockfish have a pelagic period of about 14 to 15 months and settle out on the shelf (100 m) at about 22 to 27 mm (Moser 1974). The approximate upper size limit of juvenile fish is 27 mm at the pelagic stage, and 60 mm at the benthic stage (Moser 1974). Fifty percent of female shortspine thornyheads are sexually mature at about 215 mm (Pearson and Gunderson 2003).

D.11.3.2 Relevant Trophic Information

Shortspine thornyhead rockfish prey mainly on epibenthic shrimp and fish. Yang (1996, 2003) showed that shrimp were the top prey item for shortspine thornyhead rockfish in the Gulf of Alaska; whereas, cottids were the most important prey item in the Aleutian Islands region. Differences in abundance of the main prey between the two areas might be the main reason for the observed diet differences. Predator size might by another reason for the difference since the average shortspine thornyhead in the Aleutian Islands area was larger than that in the Gulf of Alaska (334 mm vs 297 mm).

D.11.3.3 Habitat and Biological Associations

Eggs: Eggs float in masses of various sizes and shapes. Frequently the masses are bilobed with the lobes 150 to 610 mm in length, consisting of hollow conical sheaths containing a single layer of eggs in a gelatinous matrix. The masses are transparent and not readily observed in the daylight. Eggs are 1.2 to 1.4 mm in diameter with a 0.2 mm oil globule. They move freely in the matrix. Complete hatching time is unknown but is probably more than 10 days.

Larvae: Three day-old larvae are about 3 mm long and apparently float to the surface. It is believed that the larvae remain in the water column for about 14 to 15 months before settling to the bottom.

Settled Early Juveniles: Very little information is available regarding the habitats and biological associations of younger juvenile shortspine thornyheads.

Subadults: In the EBS, the covariate contributing the most to the final SDM EFH map for this life stage was bottom depth alone,which predicted high subadult SST abundance along the continental slope in depths around 450 m (Laman et al. 2022). In the AI, the covariates contributing the most to the final SDM EFH map for this life stage was also bottom depth alone (Harris et al. 2022). High abundances were predicted along the slope south of Unalaska Island.

Adults: Adults are demersal and can be found at depths ranging from about 90 to 1,500 m. Groundfish species commonly associated with thornyheads include: arrowtooth flounder (*Atheresthes stomias*), Pacific ocean perch (*Sebastes alutus*), sablefish *(Anoplopoma fimbria*), rex sole (*Glyptocephalus zachirus*), Dover sole (*Microstomus pacificus*), shortraker rockfish (*Sebastes borealis*), rougheye rockfish

(*Sebastes aleutianus*), and grenadiers (family Macrouridae). Two congeneric thornyhead species, the longspine thornyhead (*Sebastolobus altivelis*) and a species common off of Japan, broadbanded thornyhead, *S. macrochir*, are infrequently encountered in the Gulf of Alaska.

In the EBS, the covariates contributing the most to the final SDM EFH map for this life stage were bottom depth and geographic position (Laman et al. 2023). Adult SST abundance was high on the continental slope at depths around 600 m. In the AI, the covariates contributing the most to the final SDM EFH map for this life stage were geographic position and bottom depth (Harris et al. 2022).Highest abundances were predicted along the continental slope houth of Unalaska Island.

Habitat and Biological Associations: Thornyhead Rockfish

Stage - EFH Level	Duration or Age	Diet/Prey	Season/ Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs	U	U	spawning: late winter and early spring	U	P	U	U	
Larvae	<15 months	U	early spring through summer	U	P	U	U	
Settled Early Juveniles/ Subadults	> 15 months when settling to bottom occurs (?)	U shrimp, amphipods, mysids, euphausiids?	U	MCS, OCS, USP	D	M, S, R, SM, CB, MS, G	U	
Adults	U	shrimp fish (cottids), small crabs	year-round?	MCS, OCS, USP, LSP	D	M, S, R, SM, CB, MS, G	U	

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D.12 Pacific cod (*Gadus macrocephalus*)

D.12.1 Life History and General Distribution

Pacific cod (*Gadus macrocephalus*) is a transoceanic species, occurring at depths from shoreline to 500 m. The southern limit of the species' distribution is about 34° N. latitude, with a northern limit of about 65° N. latitude. Adults are largely demersal and form aggregations during the peak spawning season, which extends approximately from February through April. Pacific cod eggs are demersal and adhesive. Eggs hatch in about 16 to 28 days. Pacific cod larvae undergo metamorphosis at about 25 to 35 mm. Juvenile Pacific cod start appearing in trawl surveys at a fairly small size, as small as 100 mm in the eastern Bering Sea. Pacific cod can grow to be more than a meter in length, with weights in excess of 10 kg. The instantaneous rate of natural mortality is currently estimated to be 0.35 in the Bering Sea and Aleutian Islands (BSAI). Approximately 50 percent of Pacific cod are mature by age 5 in the BSAI. The maximum recorded age of a Pacific cod is 17 years in the BSAI.

Some studies of Pacific cod in the Gulf of Alaska and also some studies of Atlantic cod suggest that young-of-the-year individuals are dependent on eelgrass, but this does not appear to be the case in the EBS. In contrast to other parts of the species' range, where sheltered embayments are key nursery grounds, habitat use of age 0 Pacific cod in the EBS seems to occur along a gradient from coastal-demersal (bottom depths < 50 m) to shelf-pelagic (bottom depths 60-80 m), although densities near the coastal waters of the Alaska peninsula are much higher than elsewhere. Evidence of density-dependent habitat selection at the local scale has been found, but there is no consistent shift in distribution of juvenile Pacific cod in response to interannual climate variability.

Adult Pacific cod are widely distributed across the EBS, to depths of 500 m, and are routinely captured in every stratum of the annual EBS shelf bottom trawl survey. However, adult Pacific cod do display temperature preferences, and EBS shelf bottom trawl survey catch rates in excess of 50 kg/ha are seldom observed inside the 0 degree bottom temperature isotherm. On average, adult Pacific cod are strongly associated with the seafloor. However, diel vertical migration has also been observed, with patterns varying significantly by location, bottom depth, and time of year (daily depth changes averaging 8 m).

Pacific cod in the EBS form large spawning aggregations. Spawning concentrations have been observered north of Unimak Island, in the vicinity of the Pribilof Islands, at the shelf break near Zhemchug Canyon, and adjacent to islands in the central and western Aleutian Islands along the continental shelf. It has been speculated that variations in spawning time may be temperature-related, and temperature impacts on survival and hatching of eggs and development of embryos and larvae have been demonstrated.

D.12.2 Relevant Trophic Information

Age 0 (juvenile) Pacific cod in the EBS have been shown to consume primarily age 0 walleye pollock, euphausiids, large copepods, snow and Tanner crab larvae, sea snails, and arrow worms. This diet may vary with temperature, with high proportions of age 0 walleye pollock during warm years and a shift to euphausiids and large copepods during cool years. For comparison to other parts of the species' range, age 0 Pacific cod in the Gulf of Alaska have been found to prey mainly on small calanoid copepods, mysids, and gammarid amphipods; and near the Kuril Islands and Kamchatka, age 0 walleye pollock have been found to play a major role in the diet of juvenile Pacific cod.

Adult Pacific cod in the EBS have been shown to be significant predators of snow and Tanner crab in the eastern Bering Sea. Based on stomach contents of adult Pacific cod sampled in annual EBS shelf bottom trawl surveys from 1997-2001, hermit crab, snow crab, Tanner crab, walleye pollock, eelpout, and fishery offal all contributed at least 5% of the diet by weight in at least one survey year, with walleye pollock being by far the most important prey item by weight (average across years = 45%). For comparison to other parts of the species' range, adult Pacific cod in the western Gulf of Alaska have been shown to consume primarily eelpouts, Tanner crab, crangonid shrimp, hermit crab, and polychaetes.

Predators of Pacific cod include halibut, salmon shark, northern fur seals, sea lions, harbor porpoises, various whale species, and tufted puffin.

D.12.3 Habitat and Biological Associations

Egg/Spawning: Spawning takes place in the sublittoral-bathyal zone (40 to 290 m) near the ocean floor. Eggs sink to the bottom after fertilization, and are somewhat adhesive. Optimal temperature for incubation is 3 to 6 C, optimal salinity is 13 to 23 ppt, and optimal oxygen concentration is from 2 to 3 ppm to saturation. Little is known about the optimal substrate type for egg incubation.

Larvae: Larvae are epipelagic, occurring primarily in the upper 45 m of the water column shortly after hatching, moving downward in the water column as they grow.

Settled Early Juveniles: Juveniles occur mostly over the inner continental shelf at depths of 60 to 150 m. In the EBS, the covariates contributing the most to the final SDM EFH map for this life stage were geographic position, bottom temperature, and bottom depth (Laman et al. 2022). Predicted abundance was highest over the inner shelf and around St. Matthew Island at shallower depths cooler bottom water temperatures. Comparing the maps of early juvenile Pacific cod population growth potential and condition to the EFH map suggests that the highest growth potential and best condition for this life stage in the EBS corresponded to the EFH hot spots within the larger EFH area.

Subadults: In the EBS, the covariates contributing the most to the final SDM EFH map for this life stage were Bottom depth, geographic position, bottom temperature, and sediment grain size (Laman et al.

2022). The highest abundance was predicted on the middle shelf around 150 m and at bottom temperatures near 2°C. In the AI, the covariate contributing the most to the final SDM EFH map for this life stage was bottom depth (Harris et al. 2022). In general, predicted abundance was high in locations less than 250 m depth, with westerly currents and a sloping bottom.

Adults: Adults occur in depths from the shoreline to 500 m. Average depth of occurrence tends to vary directly with age for at least the first few years of life, with mature fish concentrated on the outer continental shelf. Preferred substrate is soft sediment, from mud and clay to sand. In the EBS, the covariates contributing the most to the final SDM EFH map for this life stage were bottom depth, bottom temperature, and geographic position with the highest abundance predicted over the outer shelf domain from Pribilof Canyon north in waters shallower than 200 m at bottom temperatures around 3°C (Laman et al. 2022). In the AI, the covariates contributing the most to the final SDM EFH map for this life stage were bottom depth and geographic position (Harris et al. 2022). They occurred in places shallower than 300 m with somewhat rocky substrates.

Habitat and Biological Associations: Pacific cod

Stage - EFH Level	Duration or Size	Diet/Prey	Season/ Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs	16-28 days	NA	winter–spring	U	D	M, SM, MS ,S	U	optimum 3–6°C optimum salinity 13–23 ppt
Larvae	U77-132 days, to 35 mm	NA	winter–spring	MCS, OCS	P	M, SM, MS, S	U	
Palagic/Settled Early Juveniles	to 90 mm	small calanoid copepods, mysids, gammarid amphipods	winter-spring	ICS, MCS, OCS	D	M, SM, MS, S	U	
Subadults	to 580mm	invertebrates, pollock, flatfish, fishery discards,	all year	ICS, MCS, OCS	D	M, SM, MS, S, CB, G, SAV	U	
Adults	>800 mm	pollock, flatfish, fishery discards, crab	spawning (Feb-Apr)	ICS, MCS, OCS	D	M, SM, MS, S, CB, G	U	
			non-spawning (May-Jan)	ICS, MCS, OCS				

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D.13 Pacific ocean perch (*Sebastes alutus*)

D.13.1 Life History and General Distribution

Pacific ocean perch (*Sebastes alutus*) has a wide distribution in the North Pacific from southern California around the Pacific rim to northern Honshu Island, Japan, including the Bering Sea. The species appears to be most abundant in northern British Columbia, the Gulf of Alaska, and the Aleutian Islands. Pacific ocean perch display diel movements, coming off bottom during the day. Adults are found primarily offshore along the continental slope in depths of 180 to 420 m. Seasonal differences in depth distribution have been noted by many investigators. In the summer, adults inhabit shallower depths, especially those between 180 m and 300 m. In the fall, the fish apparently migrate farther offshore to depths of approximately 300 to 420 m. They reside in these deeper depths until about May, when they return to their shallower summer distribution. This seasonal pattern is probably related to summer feeding and winter spawning. Although small numbers of Pacific ocean perch are dispersed throughout their preferred depth range on the continental slope, most of the population occurs in patchy, localized aggregations. Pacific ocean perch is a semipelagic species, and along the EBS slope they have been observed to move into the water column during the day and onto the bottom at night.

Species distribution modeling indicates that high abundances of early juveniles and subadults in the AI are associated with complex habitats and seamounts, whereas adults are associated with high slopes. Pacific ocean perch are less commonly observed in summer surveys along the EBS slope than along the AI slope, Predicted abundance from EBS species distribution models for early juveniles was higher north of Pribilof Canyon in areas with sponges; predicted abundance of EBS subadults and adults was predicted o be high at depths near 300 m.

There is much uncertainty about the life history of Pacific ocean perch, although generally more is known than for other rockfish species. The species appears to be viviparous, with internal fertilization and the release of live young. Insemination occurs in the fall, and sperm are retained within the female until fertilization takes place approximately 2 months later. The eggs develop and hatch internally, and parturition (release of larvae) occurs in April and May. Information on early life history is very sparse, especially for the first year of life. Positive identification of Pacific ocean perch larvae is not possible at present, but the larvae are thought to be pelagic and to drift with the current. Transformation to an adult form and the assumption of a demersal existence may take place within the first year. Small juveniles probably reside in relatively shallow areas of mixed sand and boulder substrates, and by age 3 begin to migrate to deeper offshore waters of the continental shelf. As they grow, they continue to migrate deeper, eventually reaching the continental slope, where they attain adulthood.

Pacific ocean perch has a low population growth rate, with a low rate of natural mortality (estimated at 0.06), a relatively old age at 50 percent maturity (9 years for females in the Aleutian Islands), and a very old maximum age of 104 years in Aleutian Islands. Despite their viviparous nature, the fish is relatively fecund with number of eggs per female in Alaska ranging from 10,000 to 300,000, depending upon size of the fish.

D.13.2 Relevant Trophic Information

All food studies of Pacific ocean perch have shown them to be overwhelmingly planktivorous. Small juveniles eat mostly calanoid copepods, whereas larger juveniles and adults consume euphausiids as their major prey items. Adults, to a much lesser extent, may also eat small shrimp and squids. It has been suggested that Pacific ocean perch and walleye pollock compete for the same euphausiid prey. Consequently, the large removals of Pacific ocean perch by foreign fishermen in the Gulf of Alaska in the 1960s may have allowed walleye pollock stocks to greatly expand in abundance.

Documented predators of adult Pacific ocean perch include Pacific halibut and sablefish, and it is likely that Pacific cod and arrowtooth flounder also prey on Pacific ocean perch. Pelagic juveniles are consumed by salmon, and benthic juveniles are eaten by lingcod and other large demersal fish.

D.13.3 Habitat and Biological Associations

Eggs: Little information is known. Insemination is thought to occur after adults move to deeper offshore waters in the fall. Parturition is reported to occur from 20 to 30 m off the bottom at depths of 360 to 400 m.

Larvae: Little information is known. Earlier information suggested that after parturition, larvae rise quickly to near surface, where they become part of the plankton. Data from British Columbia indicates that larvae may remain at depths greater than 175 m for some period of time (perhaps two months), after which they slowly migrate upward in the water column.

Pelagic Early Juveniles: After metamorphosis from the larval stage, juveniles may reside in a pelagic stage for an unknown length of time. They eventually become demersal.

Settled Early Juveniles: At age 1 through 5 probably live in very rocky shallower areas. Afterward, they move to progressively deeper waters of the continental shelf. Juvenile Pacific ocean perch are associated with boulders, sponges, and upright coral, and these habitat structures may play an important role for this life stage.

In the EBS, the covariates contributing the most to the final SDM EFH map for this life stage were bottom depth, geographic position, sponge presence, and BPI (Laman et al. 2022). Predicted abundance was highest along the shelf break and upper continental slope from Pribilof Canyon northward where sponges were present and bathymetric features were relatively flat. In the AI, the covariates contributing the most to the final SDM EFH map for this life stage were geographic position, bottom depth, and bottom currents (Harris et al. 2022). Abundance was predicted in locations farther west in 100 – 3—m depths with corals and sponges.

Subadults: Move to progressively deeper waters of the continental shelf. Older juveniles (subadults) are often found together with adults at shallower locations of the continental slope in the summer months. Juvenile Pacific ocean perch are associated with boulders, sponges, and upright coral, and these habitat structures may play an important role for this life stage. In the EBS, the covariates contributing the most to the final SDM EFH map for this life stage were bottom depth and geographic position (Laman et al. 2022). Ensemble-predicted subadult Pacific ocean perch abundance was highest along the shelf break and upper continental slope at around 300 m. In the AI, the covariates contributing the most to the final SDM EFH map for this life stage were geographic position and bottom depth (Harris et al. 2022).

Adults: Commercial fishery data have consistently indicated that adult Pacific ocean perch are found in aggregations over reasonably smooth, trawlable bottom of the continental slope. Generally, they are found in shallower depths (180 to 250 m) in the summer, and deeper (300 to 420 m) in the fall, winter, and early spring. In addition, POP on the EBS slope have been observed to move into the water column during the day, and onto the bottom at night. The best information available at present suggests that adult Pacific ocean perch are a semipelagic species that prefer a flat, pebbled substrate along the continental slope.

In the EBS, the covariates contributing the most to the final SDM EFH map for this life stage were bottom depth and geographic position (Laman et al. 2022). The highest adult Pacific ocean perch abundance was predicted along the shelf break and on to the upper continental slope at depths around 300 m. In the AI, the covariate contributing the most to the final SDM EFH map for this life stage was bottom depth alone with high abundances predicted at moderate epths of 200 – 300 m (Harris et al. 2022).

Habitat and Biological Associations: Pacific ocean perch

Stage - EFH Level	Duration or Age	Diet/Prey	Season/ Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs	Internal incubation ; ~90 d	NA	Winter	NA	NA	NA	NA	NA
Larvae	U; assumed between 60 and 180 days	U; assumed to be micro-zooplankton	spring–summer	MCS, OCS, USP, LSP, BSN	P	NA	U	U
Settled Early Juveniles /Subadults	3–6 months to 10 years	early juvenile: calanoid copepods; late juvenile: euphausiids	All year	MCS, OCS, USP	P? (early juv. only), D	R (<age 3)	U	U
Adults	10–98 years of age	euphausiids	insemination (fall); fertilization, incubation (winter); larval release (spring); feeding in shallower depths (summer)	OCS, USP	SD/SP	CB, G, M?, SM?, MS?	U	U

D.13.4 Literature

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D.14 Rougheye rockfish (*Sebastes aleutianus*) and Blackspotted rockfish (*Sebastes melanostictus*)

D.14.1 Life History and General Distribution

Fish in Alaska previously referred to as rougheye rockfish have recently been recognized as consisting of two species, rougheye rockfish (*Sebastes aleutianus*) and blackspotted rockfish (*Sebastes melanostictus*) (Orr and Hawkins 2008). Most of the information on rougheye/blackspotted rockfish was obtained prior to recognition of blackspotted rockfish as a separate species, and thus refers to the two species complex. Love et al. (2002) reports that rougheye rockfish are found along the northwest slope of the eastern Bering Sea, throughout the Aleutian Islands, west to the Kamchatka Peninsula and Japan, and south to Point Conception, California, although this distribution likely reflects the combined blackspotted/rougheye group. Recent trawl surveys indicate that rougheye rockfish are uncommon in the Aleutian Islands, where the two species complex is predominately composed of blackspotted rockfish. Methods for distinguishing the two species from each other are still being refined, and are evaluated by verifying field IDs with genetic IDs.

Information for the larval and juvenile stages of rougheye/blackspotted rockfish is very limited. Rougheye/blackspotted rockfish are viviparous, as females release larvae rather than eggs. Parturition (the release of larvae) can occur from December through April (McDermott 1994). Identification of larvae can be made with genetic techniques (Gray et al. 2006), although this technique has not been used to produce a broad scale distribution of the larval stage. Species identification based on morphological characteristics is difficult because of overlapping characteristics among species, as few rockfishes species in the north Pacific have published descriptions of the complete larval developmental series. Subadult blackspotted and rougheye rockfish are found in Alaska Fisheries Science Center summer trawl surveys throughout the AI, but are less commonly observed in the EBS. Length frequency distributions from Aleutian Islands summer trawl survey indicate that small blackspotted/rougheye rockfish (less than 350 mm) are found throughout a range of depths but primarily in shallower water (200 to 300 m) than larger fish. As adults, rougheye/blackspotted rockfish occur primarily at depths from 300 to 500 m. These observations are consistent with species distribution models, which indicate subadults have a larger EFH area than adults because they extend to shallower depths. In the EBS, habitat models predicted higher densities in areas near the head of submarine canyons. In the AI, habitat models predict high densities in areas near ocean passes, with weak but variable currents.

Though relatively little is known about their biology and life history, rougheye/blackspotted rockfish appear to be *K*-selected with late maturation, slow growth, extreme longevity, and low natural mortality. Age at 50 percent maturity has been estimated at 20.3 years for female blackspotted/rougheye rockfish in the Gulf of Alaska (McDermott 1994), as this study occurred prior to recognition of blackspotted rougheye as a separate species. Conrath (2017) estimated maturity separately for the two species, and obtained lengths at 50% maturity of 450 mm for each species, and age of 50% maturity of 19.6 years for rougheye rockfish and 27.4 for blackspotted rockfish. Maturity information is not available for the Bering Sea and Aleutian Islands (BSAI) management area. A maximum age of 121 has been reported from sampling in the Aleutian Islands trawl survey.

D.14.2 Relevant Trophic Information

Pandalid and hippolytid shrimp are the largest components of the rougheye/blackspotted rockfish diet (Yang 1993, 1996, Yang and Nelson 2000). In a study of diet data collected from specimens from the Aleutian Islands trawl survey, Yang (2003) found that the diet of large rougheye/blackspotted rockfish had proportionally more fish (e.g., myctophids) than small rougheye/blackspotted, whereas smaller blackspotted/rougheye consumed proportionally more shrimp. It is uncertain the main predators of rougheye/blackspotted rockfish.

D.14.3 Habitat and Biological Associations

Eggs: The timing of reproductive events is apparently protracted. Parturition (the release of larvae) in the GOA may occur from March to May (Conrath 2017).

Larvae: Limited information is available regarding the habitats and biological associations of blackspotted/rougheye rockfish larvae, in part because of the difficulty of using morphological characteristics to identify blackspotted/rougheye rockfish larvae.

Settled Early Juveniles: Very little information is available regarding the habitats and biological associations of younger juvenile rougheye/blackspotted rockfish.

Subadults: Species distribution models indicate that subadult rougheye/blackspotted rockfish occur at shallower depths than adults (i.e., as shallow as 200 - 250 m). In the EBS, the covariates contributing the most to the final SDM EFH map for this life stage were bottom depth, geographic position, bottom current, and slope (Laman et al. 2022). Abundance was highest at around 300 m over the southern outer shelf domain and upper continental slope with southeasterly bottom current over increasing slope. In the AI, the covariates contributing the most to the final SDM EFH map for this life stage were bottom depth, geographic position, current, and current variability (Harris et al. 2022). Predicted abundances were high around 300 m depth and at areas along the edge of the continental slope between 300 – 500 m depth contours.

Adults: Adults are demersal and generally occur at depths between 300 m and 500 m. Submersible work in southeast Alaska indicates that rougheye/blackspotted rockfish were associated with habitats containing frequent boulders, steep slopes (more than 20°) and sand-mud substrates (Krieger and Ito 1999). Krieger and Wing (2002) found that large rockfish had a strong association with *Primnoa* spp. coral growing on boulders, and it is likely than many of these large rockfish were rougheye/blackspotted rockfish. Species distribution modeling indicates that high density areas in the AI are predicted to occur near ocean passes, with weak but variable currents.

In the EBS, the covariates contributing the most to the final SDM EFH map for this life stage were bottom depth, geographic position, and bottom current (Laman et al. 2022) and abundance was highest at depths around 400 m along the southern part of the upper continental slope with southwesterly bottom currents. In the AI, the covariates contributing the most to the final SDM EFH map for this life stage were bottom depth, geographic position, current variability, and bottom temperature (Harris et al. 2022). Their distribution was similar to subadults with an ideal bottom depth around 300 m.

Habitat and Biological Associations: Rougheye and Blackspotted Rockfish

Stage - EFH Level	Duration or Age	Diet/Prey	Season/ Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs	NA	NA	NA	NA	NA	NA	NA	
Larvae	U	U	parturition: Mar-May	U	probably P	NA	U	
Settled Early Juveniles	U	U	U	U, OCS, USP?	probably N	U	U	
Subadults	up to ~ 20 years	U	U	U, OCS, USP?	probably D	U	U	
Adults	> 20 years	shrimp squid myctophids	year-round?	OCS, USP	D	M, S, R, SM, CB, MS, G	U	

D.14.4 Literature

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D.15 Sablefish (*Anoplopoma fimbria*)

D.15.1 Life History and General Distribution

Sablefish are distributed from Mexico through the GOA to the Aleutian Chain, Bering Sea, along the Asian coast from Sagami Bay, and along the Pacific sides of Honshu and Hokkaido Islands and the Kamchatka Peninsula. Adult sablefish occur along the continental slope, shelf gullies, and in deep fjords such as Prince William Sound and southeast Alaska, at depths generally greater than 200 m. Adults are assumed to be demersal because they are caught in bottom trawls and with bottom longline gear. Spawning or very ripe sablefish are observed in late winter or early spring along the continental slope. Eggs are apparently released near the bottom where they incubate. After hatching and yolk adsorption, the larvae rise to the surface, where they have been collected with neuston nets. Larvae are oceanic through the spring and by late summer, small pelagic juveniles (100 to 150 mm) have been observed along the outer coasts of Southeast Alaska, where they move into shallow waters to spend their first winter. During most years, there are only a few places where juveniles have been found during their first winter and second summer. It is not clear if the juvenile distribution is highly specific or appears so because sampling is sparse. During the occasional times of large year-classes, the juveniles are easily found in many inshore areas during their second summer. They are typically 300 to 400 mm long during their second summer, after which they leave the nearshore bays. One or two years later, they begin appearing on the continental shelf and move to their adult distribution as late juveniles or mature adults (Hanselman et al. 2015).

While pelagic oceanic conditions determine the egg, larval, and juvenile survival through their first summer, juvenile sablefish spend 3 to 4 years in demersal habitat along the shorelines and continental shelf before they recruit to their adult habitat, primarily along the upper continental slope, outer continental shelf, and deep gullies. As juveniles in the inshore waters and on the continental shelf, they are subject to a myriad of factors that determine their ability to grow, compete for food, avoid predation, and otherwise survive to adulthood. A potential driver of recruitment is sea surface temperature (SST) using short-term projections (1-5 years) (Shotwell et al. 2014). Recruitment success did not appear to be directly related to the presence of El Niño or eddies, but these phenomena could potentially influence recruitment indirectly in years following their occurrence (Sigler et al. 2001). Evaluating the overlap of fisheries can provide predictors of sablefish recruitment as well. When evaluating predictors of sablefish recruitment for the Ecosystem and Socioeconomic Profile of the Sablefish stock in Alaska, the highest ranked variables were the summer juvenile sablefish CPUE from the ADF&G large mesh survey and the catch from the arrowtooth flounder fishery in the GOA (Shotwell et al. 2021). Sablefish recruitment has a weak relationship with spawning stock biomass, some of these factors may help explain and predict recruitment by determining the quality instead of the quantity of the annual spawning stock (Shotwell et al. 2021).

The estimated productivity and sustainable yield of the combined EBS, AI, and GOA sablefish stock have declined steadily since the late 1970s, but has rebuilt rapidly since the mid-2010s. There were episodic years of strong recruitment in the current physical regime starting in 1977. Over the last decade, there have been at least three extremely large and well above average year classes (i.e., in 2014, 2016, and 2017). The recent period of high recruitment could be related to environmental conditions, particularly marine heatwaves, which may provide an advantage to fast growing sablefish larvae that exhibit opportunistic feeding strategies during early life history stages (Shotwell et al. 2021).

Size ranges for EBS and AI sablefish life history stages are 150 - 399 mm fork length for settled early juveniles, 400 - 585 mm for subadults, and > 585 mm for adults (size at 50% maturity being 585 mm) (Sasaki 1985, Rodgveller et al. 2016, Pirtle et al. 2019).

D.15.2 Relevant Trophic Information

Larval sablefish feed on a variety of small zooplankton ranging from copepod nauplii to small amphipods. The epipelagic juveniles feed primarily on macrozooplankton and micronekton (i.e., euphausiids).

Gao et al. (2004) studied stable isotopes in otoliths of juvenile sablefish from Oregon and Washington and found that as the fish increased in size they shifted from midwater prey to more benthic prey. In nearshore southeast Alaska, juvenile sablefish (200-450 mm) diets included fish such as Pacific herring and smelts and invertebrates such as krill, amphipods and polychaete worms (Coutré et al. 2015). In late summer, juvenile sablefish also consumed post-spawning pacific salmon carcass remnants in high volume revealing opportunistic scavenging (Coutré et al. 2015). Young-of-the-year sablefish are commonly found in the stomachs of salmon taken in the Southeast Alaska troll fishery during the late summer. Nearshore residence during their second year provide the opportunity to feed on salmon fry and smolts during the summer months.

In their demersal stage, juvenile sablefish less than 600 mm feed primarily on euphausiids, shrimp, and cephalopods (Yang and Nelson 2000, Yang et al. 2006), while sablefish greater than 600 mm feed more on fish. Both juvenile and adult sablefish are considered opportunistic feeders. Fish most important to the sablefish diet include pollock, eulachon, capelin, Pacific herring, Pacific cod, Pacific sand lance, and some flatfish, with pollock being the most predominant (10 to 26 percent of prey weight, depending on year). Squid, euphausiids, pandalid shrimp, Tanner crabs, and jellyfish were also found; squid being the most important of the invertebrates (Yang and Nelson 2000, Yang et al. 2006). Feeding studies conducted in Oregon and California found that fish made up 76 percent of the adult sablefish diet (Laidig et al. 1997). Off the southwest coast of Vancouver Island, euphausiids were the dominant prey (Tanasichuk 1997). Among other groundfish in the GOA, the diet of sablefish overlaps mostly with that of large flatfish, arrowtooth flounder, and Pacific halibut (Yang and Nelson 2000). Nearshore residence during their second year provides the opportunity to feed on salmon fry and smolts during the summer months.

D.15.3 Habitat and Biological Associations

Settled Early Juveniles: In the EBS, the covariates contributing the most to the final SDM EFH map for this life stage were geographic position, bottom temperature, ROMS bottom current, and presence of sea whips/sea pens (Laman et al. 2022). Predicted abundance was highest in the southern EBS along the Alaska Peninsula with increasing bottom temperatures, southerly flowing bottom currents, and where sea whips and sea pens were present.

Subadults: In the EBS, the covariates contributing the most to the final SDM EFH map for this life stage were geographic position, bottom depth, bottom temperature, and bottom currents (Laman et al. 2022). Ensemble-predicted subadult sablefish abundance was highest over the outer shelf and upper continental slope near the head of the Bering Canyon at depths around 600 m with increasing bottom temperatures and with bottom currents generally flowing to the north east. In the AI, the covariates contributing the most to the final SDM EFH map for this life stage were bottom depth, geographic position, and bottom temperature (Harris et al. 2022). The ensemble predicted that abundance would be highest in areas east of 180°, with deeper depths and warmer bottom temperatures, and higher on the south side of the AI chain like south of Unalaska Island.

Adults: In the EBS, the covariates contributing the most to the final SDM EFH map for this life stage were bottom depth, geographic position, and ROMS bottom current, with the highest abundance predicted at around 700 m along the upper continental slope with current flow generally to the north and northeast (Laman et al. 2022). In the AI, the covariates contributing the most to the final SDM EFH map for this life stage were bottom depth and geographic position (Harris et al. 2022). Similar to subadults, adult sablefish were predicted to be abundant in the eastern AI and in deep water and along the continental slope east of 180°.

Habitat and Biological Associations: Sablefish

Stage - EFH Level	Duration or Age	Diet/Prey	Season/ Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs	14–20 days	NA	late winter–early spring: Dec–Apr	USP, LSP, BSN	P, 200–3,000 m	NA	U	
Larvae	up to 3 months	copepod nauplii, small copepodites	spring–summer: Apr–July	MCS, OCS, USP, LSP, BSN	N, neustonic near surface	NA	U	
Settled Early Juveniles	to 3 yrs	small prey fish, sandlance, salmon, herring, polychaete worms, krill, and salmon caracasess near stream mouths		OCS, MCS, ICS, during first summer, then observed in BAY, IP, till end of 2nd summer; not observed till found on shelf	P when offshore during first summer, then D, SD/SP when inshore	NA when pelagic. The bays where observed were soft bottomed, but not enough observed to assume typical.	U	
Subadults	3–5 yrs	opportunistic: other fish, shellfish, worms, jellyfish, fishery discards	all year	continental slope, and deep shelf gulleys and fjords.	caught with bottom tending gear. presumably D	varies	U	
Adults	5 yrs to 35+	opportunistic: other fish, shellfish, worms, squid, jellyfish, fishery discards	apparently year round, spawning movements (if any) are undescribed	continental slope, and deep shelf gulleys and fjords.	caught with bottom tending gear. presumably D	varies	U	

D.15.4 Literature

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D.16 Shark complex

The species representatives for sharks are:

Lamnidae: Salmon shark (*Lamna ditropis*),
Squalidae: Sleeper shark (*Somniosus pacificus*), and
Spiny dogfish (*Squalus suckleyi*).

D.16.1 Life History and General Distribution

Sharks of the order Squaliformes (which includes the two families Lamnidae and Squalidae) are the higher sharks with five gill slits and two dorsal fins. Spiny dogfish are widely distributed throughout the North Pacific Ocean and are the representative species for the GOA shark complex. In the North Pacific, spiny dogfish may be most abundant in the GOA, with southeast Alaska the center of their abunance; they also occur in the Bering Sea. Spiny dogfish are pelagic species found at the surface and to depths of 700 m but mostly at 200 m or less on the shelf and the neritic zone; they are often found in aggregations. Spiny dogfish are aplacental viviparous. Litter size is proportional to the size of the female and range from 2 to 23 pups, with 10 average. Gestation may be 22 to 24 months. Young are 240 to 300 mm at birth, with growth initially rapid, then slows dramatically. Maximum adult size is about 1.6 m and 10 kg; maximum age is 80+ years. Fifty percent of females are mature at 970 mm and 36 years old; 50 percent of males are mature at 740 mm and 21 years old. Females give birth in shallow coastal waters, usually in September through January. Tagging experiments indicate local indigenous populations in some areas and widely migrating groups in others. They may move inshore in summer and offshore in winter.

Salmon sharks are large (up to 3 m in length), aplacental, viviparous (with small litters of one to four pups and embryos nourished by yolk sac and 5 oophagy), widely migrating sharks, with homeothermic capabilities and highly active predators (salmon and white sharks). Salmon sharks are distributed epipelagically along the shelf (can be found in shallow waters) from California through the Gulf of Alaska (GOA) to the northern Bering Sea and off Japan. In groundfish fishery and survey data, salmon sharks occur across much of the shelf in the Bering Sea, but near the coast to the outer shelf in the GOA, particularly near Kodiak Island. Salmon sharks are not commonly seen in Aleutian Islands.

The Pacific sleeper shark is distributed from California around the Pacific Rim to Japan and in the Bering Sea principally on the outer shelf and upper slope. However, they do often occur in near shore, and shallow waters in the GOA. Tagging data suggests that they spend a significant amount of time moving vertically through the water column. Adult Pacific sleeper shark have been reported as long as 7 m, however, size at maturity is unknown, as well as reproductive mode. Other members of the Squalidae are aplacental viviparous, and it is likely a safe assumption that Pacific sleeper shark are as well. In groundfish fishery and survey data, Pacific sleeper sharks are spread across a large portion of the shelf in the Bering Sea, but from the coast to the outer shelf in the GOA, particularly near Kodiak Island in Shelikof Strait, inside waters of Southeast Alaska and Prince William Sound.

D.16.2 Relevant Trophic Information

Sharks are top level predators in the GOA. The only likely predator would be larger fish, including larger sharks, or mammals preying on young/small sharks. Spiny dogfish are opportunistic generalist feeders, eating a wide variety of foods, including fish (smelts, herring, sand lance, and other small schooling fish), crustaceans (crabs, euphausiids, shrimp), and cephalopods (octopus). Salmon shark are believed to eat primarily fish, including salmon, herring, sculpins, and gadids. Pacific sleeper shark are predators of flatfish, cephalopods, rockfish, crabs, seals, and salmon and may also prey on pinnipeds.

D.16.3 Habitat and Biological Associations

Pelagic early juveniles: Salmon sharks and spiny dogfish are aplacental viviparous; reproductive strategy of Pacific sleeper sharks is not known. Spiny dogfish give birth in shallow coastal waters, while salmon sharks pupping grounds are located in the offshore transitional domain south of the GOA.

Subadults and /or Adults: Spiny dogfish are widely dispersed throughout the water column on shelf in the GOA, and along outer shelf in the eastern Bering Sea; apparently not as commonly found in the Aleutian Islands and not commonly at depths greater than 200 m.

Salmon sharks are found throughout the GOA, as well as the eastern Bering Sea and Aleutian Islands; epipelagic, primarily over shelf/slope waters in GOA, and outer shelf in the eastern Bering Sea. Salmon shark do exhibit seasonal abundances in areas with high density of salmon returns, such as Prince William Sound.

Pacific sleeper sharks are widely dispersed on shelf/upper slope in the GOA, and across the shelf in the eastern Bering Sea; generally demersal, but may utilize the full water column.

Habitat and Biological Associations: Sharks

Stage - EFH Level	Duration or Age	Diet/Prey	Season / Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs								
Salmon shark	9 mo gestation		Late spring pupping	Pelagic transition zone	P	NA	U	
Pacific sleeper shark	U		U	U	U	U	U	
Spiny dogfish	18-24 mo gestation		Fall/early winter pupping	Near shore bays	P/D	U	U	
Larvae	NA							
Juveniles and Adults								
Salmon shark	30+ years	fish (salmon, sculpins, and gadids)	all year	ICS, MCS, OCS, USP in GOA; OCS, USP in BSAI	P	NA	U	4-24°C
Pacific sleeper shark	U	omnivorous; flatfish, cephalopods, rockfish, crabs, seals, salmon, pinnipeds	all year	ICS, MCS, OCS, USP in GOA; OCS, USP in BSAI	D	U	U	
Spiny dogfish	80+ years	fish (smelts, herring, sand lance, and other small schooling fish), crustaceans (crabs, euphausiids, shrimp), and cephalopods (octopus)	all year	ICS, MCS, OCS in GOA; OCS in BSAI give birth ICS in fall/winter?	P/D	U	U	4–16°C

D.16.4 Literature

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D.17 Shortraker rockfish (*Sebastes borealis*)

D.17.1 Life History and General Distribution

Shortraker rockfish are found along the northwest slope of the eastern Bering Sea, throughout the Aleutian Islands and south to Point Conception, California. Information for the larval and juvenile stages of shortraker rockfish is very limited. Shortraker rougheye are viviparous, as females release larvae rather than eggs. Parturition (the release of larvae) can occur from February through August (McDermott 1994). Identification of larvae can be made with genetic techniques (Gray et al. 2006), although this technique has not been used to produce a broad scale distribution of the larval stage. Species identification based on morphological characteristics is difficult because of overlapping characteristics among species, as few rockfish species in the north Pacific have published descriptions of the complete larval developmental series. However, Kendall (2003) was able to identify archived *Sebastes* ichthyoplankton from the Gulf of Alaska to four distinct morphs. One of the morphs consists solely of shortraker rockfish, although the occurrence of this morph was relatively rare (18 of 3,642 larvae examined). Post-larval and juvenile shortraker rockfish do occur in the Aleutian Islands trawl survey, but these data have not been spatially analyzed with respect to their habitat characteristics. As adults, shortraker rockfish occur primarily at depths from 300 to 500 m.

Though relatively little is known about their biology and life history, shortraker rockfish appear to be *K*-selected with late maturation, slow growth, extreme longevity, and low natural mortality. Age at 50 percent maturity has been estimated at 21.4 years for female shortraker rockfish in the Gulf of Alaska (Hutchinson 2004); maturity information is not available for the Bering Sea and Aleutian Islands (BSAI) management area. Hutchinson (2004) estimated a maximum age of 116 years. Shortraker rockfish are among the largest *Sebastes* species in Alaskan waters; samples as large as 1,090 mm have been obtained in Aleutian Islands trawl surveys.

D.17.2 Relevant Trophic Information

The limited information available suggests that the diet of shortraker rockfish consists largely of squid, shrimp, and myctophids. From data collected in the 1994 and 1997 Aleutian Islands trawl surveys, Yang (2003) also found that the diet of large shortraker rockfish had proportionally more fish (e.g. myctophids) than small shortrakers, whereas smaller shortrakers consumed proportionally more shrimp. It is uncertain the main predators of shortraker rockfish.

D.17.3 Habitat and Biological Associations

Egg/Spawning: The timing of reproductive events is apparently protracted. Parturition (the release of larvae) may occur from February through August (McDermott 1994), although Westrheim (1975) found that April was the peak month for parturition.

Larvae: Limited information is available regarding the habitats and biological associations of shortraker rockfish larvae, in part because of the difficulty of using morphological characteristics to identify shortraker rockfish larvae

Settled Early Juveniles: Very little information is available regarding the habitats and biological associations of younger juvenile shortraker rockfish.

Subadults: In the EBS, the covariates contributing the most to the final SDM EFH map for this life stage were bottom depth, local slope, and geographic position, which was highest along the upper continental slope and EBS shelf break (Laman et al. 2022). In the AI, the covariate contributing the most to the final SDM EFH map for this life stage was bottom depth (Harris et al. 2022). Most shortraker rockfish were predicted deeper than 300 m, with the highest abundance occurring in scattered patches along the 500 m depth contour.

Adults: Adults are demersal and generally occur at depths between 300 m and 500 m. Krieger (1992) used a submersible to find that shortraker rockfish occurred over a wide range of habitats, with the highest density of fish on sand or sand or mud substrates. Additional submersible work in southeast Alaska indicates that rougheye/shortraker rockfish were associated with habitats containing frequent boulders, steep slopes (more than 20°) and sand-mud substrates (Krieger and Ito 1999). Krieger and Wing (2002) found that large rockfish had a strong association with *Primnoa* spp. coral growing on boulders, and it is likely that many of these large rockfish were shortraker rougheye.

In the EBS, the covariates contributing the most to the final SDM EFH map for this life stage were bottom depth, current, slope, and geographic position (Laman et al. 2022). Adult shortraker abundance was predicted to be highest along the upper continental slope and at the EBS shelf break in depths around 400 m with southerly flowing currents, steeper local slope, and bottom temperatures around 4°C. In the AI, the covariates contributing the most to the final SDM EFH map for this life stage were bottom depth, geographic position, bottom currents, and slope (Harris et al. 2022). High abundances were predicted in locations with deeper water, below the 300 m depth contour, with southwesterly currents and a sloped bottom.

Habitat and Biological Associations: Shortraker and Rougheye Rockfish

Stage - EFH Level	Duration or Age	Diet/Prey	Season/ Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs	NA	NA	NA	NA	NA	NA	NA	
Larvae	U	U	parturition: Feb–Aug	U	probably P	NA	U	
Settled Early Juveniles	U	U	U	U, MCS, OCS?	probably N	U	U	
Subadults	Up to ~ 20 years	U	U	U, MCS, OCS?	probably D	U	U	
Adults	> 20 years	shrimp squid myctophids	year-round?	OCS, USP	D	M, S, R, SM, CB, MS, G	U	

D.17.4 Literature

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D.18 Skate complex (*Rajidae*)

The skate complex is described below and the species in the complex are:

Alaska skate,
Aleutian skate,
Bering skate,
Big skate,
Mud skate, and
Whiteblotched skate.

Species Complex Summary

Skates (Rajidae) in the Bering Sea and Aleutian Islands (BSAI) occur in two main taxonomic groups: skates of the genus *Bathyraja* (soft nosed) and those of the genera *Raja* and *Beringraja* (hard nosed). *Bathyraja* skates make up the vast majority of the skate biomass in the BSAI. Skates are oviparous: fertilization is internal and eggs are encased in leathery, horned pouches. Eggcases are then deposited at highly localized nursery sites along the upper contintal slope, where the embryos develop for up to 3.5 years. Nursery sites are small, have a high density of eggcases, and appear to be used over many years. Six sites have been designated as Habitat Areas of Particular Concern (HAPC) by the North Pacific Fishery Management Council, although no protections (i.e. fishing gear restrictions) were mandated for the sites. Adults and juveniles are demersal, and feed on bottom invertebrates and fish. The habitat utilized by skates depends on the species. The biomass of BSAI skates estimated from the survey more than doubled between 1982 and 1996 and has been stable since. The approximate upper size limit of juvenile fish is unknown.

Skates are managed in aggregate as members of the BSAI Skate Stock Complex. Alaska skate is the dominant species and is assessed separately, but harvest specifications are made for the complex as a whole (Ormseth 2020). Six skate species are included in this complex EBS (Alaska skate, Aleutian skate, Bering skate, big skate, mud skate, and whiteblotched skate) (Ormseth 2020).

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D.18.1 Alaska skate (*Bathyraja parmifera*)

D.18.1.1 Life History and General Distribution

Adult Alaska skates are mostly distributed at a depth of 50 to 200 m on the shelf in eastern Bering Sea (EBS), where it is the dominant skate species, and is less abundant in the Aleutian Islands (AI). In the EBS, Alaska skates appear to make ontogenetic migrations from the nursery sites on the upper slope to the inner EBS shelf, reaching the inner shelf at approximately the age of maturity (9 years). Adults then likely make long-distance seasonal movements for reproduction and feeding.

D.18.1.2 Relevant Trophic Information

Skates feed on bottom invertebrates (crustaceans, molluscs, and polychaetes) and fish. Adult skates have few or no predators, but juvenile skates (particularly those in the 20-30 cm size range) are preyed on by Pacific cod and Pacific halibut.

D.18.1.3 Habitat and Biological Associations

<u>*Subadults*</u>: In the EBS, the covariates contributing the most to the final SDM EFH map for this life stage were geographic position, bottom temperature, and bottom depth (Laman et al. 2022). The highest abundances were predicted in the central EBS and northward over the inner and middle shelf in warmer, shallow water. In the AI, the covariates contributing the most to the final SDM EFH map for this life stage were geographic position, bottom depth, bottom current, and slope aspect (Harris et al. 2022). In general, high abundance of subadults is predicted by being located in the central part of the AI, in shallow depths, with weak bottom currents and steep terrain oriented towards the northeast.

Adults: In the EBS, the covariates contributing the most to the final SDM EFH map for this life stage were bottom temperature, bottom depth, and geographic position (Laman et al. 2022). Adult abundance was highest at water temperatures around 5°C in shallower depths over the outer shelf. In the AI, a variety of covariates were important to the model, including geographic position, bottom depth, current, current variability, slope, and BPI (Harris et al. 2022). Predicted abundance of adults is highest in the central AI and above the 100 m depth contour. Adult Alaska skates encounter probability is usually highest close to shore and close to zero in most places greater than 300 m depth.

D.18.1.4 Literature

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D.18.2 Aleutian skate (*Bathyraja aleutica*)

D.18.2.1 Life History and General Distribution

The Aleutian skate is found mainly in the outer shelf and upper slope of the eastern Bering Sea and the Aleutian Islands at depths of 100 to 350 m. Aleutian skates mature slowly and do not reproduce until attaining a large size (> 1,320 mm), depositing their egg sacs in distinct nursery grounds (Ebert et al. 2007, Haas et al. 2016).

D.18.2.2 Relevant Trophic Information

Skates feed on bottom invertebrates (crustaceans, molluscs, and polychaetes) and fish. Adult skates have few or no predators, but juvenile skates (particularly those in the 20-30 cm size range) are preyed on by Pacific cod and Pacific halibut.

D.18.2.3 Habitat and Biological Associations

Subadults: In the EBS, the covariates contributing the most to the final SDM EFH map for this life stage were geographic position, ROMS bottom current, and bottom depth, which had high abundance all along the upper continental slope with cross shelf currents toward the southwest (Laman et al. 2022). In the AI, the covariates contributing the most to the final SDM EFH map for this life stage were geographic position and bottom depth, with higher abundance predicted in deeper and warmer water (Harris et al. 2022).

Adults: In the EBS, the covariates contributing the most to the final SDM EFH map for this life stage were bottom depth, geographic position, and sediment grain size, which predicted adult Aleutian skate numerical abundance to be highest along the shelf break with current flowing across shelf to the southwest (Laman et al. 2022). In the AI, the covariates contributing the most to the final SDM EFH map for this life stage were bottom depth, current, geographic position, and tidal maximum (Harris et al. 2022). They were abundant in moderate and deeper water, and highest around Attu Island.

D.18.2.4 Literature

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D.18.3 Bering skate (*Bathyraja interrupta*)

D.18.3.1 Life History and General Distribution

The Bering skate (*Bathyraja interrupta*) is distributed from California to the Bering Sea over a wide range of depths (37–1372 m; Mecklenburg et al. 2002) and reaches a maximum length of 800 mm TL (Stevenson et al. 2007). Bering skates are only modeled and mapped for the EBS region.

D.18.3.2 Relevant Trophic Information

Skates feed on bottom invertebrates (crustaceans, molluscs, and polychaetes) and fish. Adult skates have few or no predators, but juvenile skates (particularly those in the 20-30 cm size range) are preyed on by Pacific cod and Pacific halibut.

D.18.3.3 Habitat and Biological Associations

Subadults: The covariates contributing the most to the final SDM EFH map for this life stage were bottom depth, geographic position, and ROMS bottom current (Laman et al. 2022). Highest abundances were predicted along the shelf break in depths around 300 m with a northeast-flowing bottom current.

Adults: The covariates contributing the most to the final SDM EFH map for this life stage were geographic position, bottom depth, bottom current and sediment grain size (Laman et al. 2022). Adult Bering skate abundance was predicted to be highest along the shelf break in depths around 300°m over moderate sediment grain sizes (phi) with relatively little current flow.

D.18.3.4 Literature

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D.18.4 Big skate (*Beringraja binoculata*)

D.18.4.1 Life History and General Distribution

The big skate (*Beringraja binoculata*) ranges from the eastern Bering Sea and Aleutians Islands to Baja California though rarely south of Point Conception (Mecklenburg et al. 2002) and is one of the largest skates (maximum reported TL around 2.4 m). Though they are found between 3 and 800 m across their geographic range, they typically occur in waters shallower than 200 m over the Bering Sea shelf where they are uncommon.

D.18.4.2 Relevant Trophic Information

Skates feed on bottom invertebrates (crustaceans, molluscs, and polychaetes) and fish. Adult skates have few or no predators, but juvenile skates (particularly those in the 20-30 cm size range) are preyed on by Pacific cod and Pacific halibut.

D.18.4.3 Habitat and Biological Associations

Subadults: The covariates contributing the most to the final SDM EFH map for this life stage were geographic position, bottom temperature, and bottom depth (Laman et al. 2022). Subadult big skate were predicted along the Alaska Peninsula in warmer waters with slower, less variable bottom currents.

D.18.4.4 Literature

Laman, E. A., J. L. Pirtle, J. Harris, M. C. Siple, C. N. Rooper, T. P. Hurst, and C. L. Conrath. 2022. Advancing model-based essential fish habitat descriptions for North Pacific species in the Bering Sea. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-459, 538 p. https://doi.org/10.25923/y5gc-nk42

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D.18.5 Mud skate (*Bathyraja taranetzi*)

D.18.5.1 Life History and General Distribution

The mud skate (*Bathyraja taranetzi*) is the smallest species of skate commonly found in Alaska waters, with a maximum TL of 700 mm (Ebert 2005). This species is widely distributed across the north Pacific and ranges from the western GOA to the Kuril Islands (Stevenson et al. 2007).

D.18.5.2 Relevant Trophic Information

Skates feed on bottom invertebrates (crustaceans, molluscs, and polychaetes) and fish. Adult skates have few or no predators, but juvenile skates (particularly those in the 20-30 cm size range) are preyed on by Pacific cod and Pacific halibut.

D.18.5.3 Habitat and Biological Associations

Subadults: In the EBS, the covariates contributing the most to the final SDM EFH map for this life stage were geographic position, bottom depth, and ROMS bottom current (Laman et al. 2022). Subadult mud skates habitat was predicted around the Pribilof Islands and in submarine canyon heads along the continental slope at around 450 m depths with bottom currents flowing toward the northeast. In the AI, the covariates contributing the most to the final SDM EFH map for this life stage were geographic position and bottom depth (Harris et al. 2022). Cooler temperatures and a less rocky substrate are associated with high abundance of subadults. Predicted abundance was highest in the eastern and central AI, particularly around Seguam Pass, Amchitka Pass, and along the continental slope south of Atka Island.

<u>Adults</u>: In the EBS, the covariates contributing the most to the final SDM EFH map for this life stage were geographic position, bottom depth, and currents (ROMS bottom current and current variability) (Laman et al. 2022). Adult mud skates were predicted near submarine canyon heads along the shelf break, in depths around 300 m, with cross-shelf currents flowing to the west and increasing tidal maxima. In the AI, the covariates contributing the most to the final SDM EFH map for this life stage were bottom depth, geographic position, and slope aspect (Harris et al. 2022). Adult mud skates were predicted to be abundant in deeper waters in the central AI, particularly around Amchitka Pass and along the continental slope south of Adak Island, and were often found on slopes that ascend in a northerly direction, such as those on the south side of the AI.

D.18.5.4 Literature

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D.18.6 Whiteblotched skate (*Bathyraja maculata*)

D.18.6.1 Life History and General Distribution

Whiteblotched skate (*Bathyraja maculata*) is a moderately large skate found from the western GOA to the Kuril Islands (Stevenson 2007). Whiteblotched skate is the dominant species of skate in the AI, representing over 50% of total skate biomass in the region (Ormseth 2018). Like many species in the genus *Bathyraja*, it is predominantly found along the continental slope, or near the interface between slope and shelf areas.

D.18.6.2 Relevant Trophic Information

Skates feed on bottom invertebrates (crustaceans, molluscs, and polychaetes) and fish. Adult skates have few or no predators, but juvenile skates (particularly those in the 20-30 cm size range) are preyed on by Pacific cod and Pacific halibut.

D.18.6.3 Habitat and Biological Associations

<u>Subadults</u>: In the EBS, the covariates contributing the most to the final SDM EFH map for this life stage were bottom depth and geographic position, with high abundances predicted along the continental slope in depths around 450 m an to the southwest of Nunivak (Laman et al. 2022). In the AI, the covariate contributing the most to the final SDM EFH map for this life stage was geographic position, though current, current variability, bottom temperature, and tidal maximum were also important (Harris et al. 2022). Subadult abundance was predicted around Seguam Pass and at Stalemate Bank.

<u>Adults</u>: In the EBS, the covariates contributing the most to the final SDM EFH map for this life stage were bottom depth and geographic position with high abundances predicted along the upper continental slope and shelf break associated with submarine canyon systems along the shelf break in depths around 450 m (Laman et al. 2022). In the AI, the covariate contributing the most to the final SDM EFH map for

this life stage was geographic position, predicting high adult abundances in and around Seguam Pass, Stalemate Bank, and Amchitka Pass (Harris et al. 2022).

D.18.6.4 Literature

Harris, J., E. A. Laman, J. L. Pirtle, M. C. Siple, C. N. Rooper, T. P. Hurst, and C. L. Conrath. 2022. Advancing model-based essential fish habitat descriptions for North Pacific species in the Aleutian Islands. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-458, 406 p. https://doi.org/10.25923/ffnc-cg42

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D.19 Walleye pollock (*Gadus chalcogrammus*)

The eastern Bering Sea and Aleutian Islands pollock stocks are managed under the Fishery Management Plan for Groundfish of the Bering Sea and Aleutian Islands Management Area (FMP). Pollock occur throughout the area covered by the FMP and straddle into the Canadian and Russian exclusive economic zone (EEZ), international waters of the central Bering Sea, and into the Chukchi Sea.

D.19.1 Life History and General Distribution

Pollock is the most abundant species within the eastern Bering Sea comprising 75 to 80 percent of the catch and 60 percent of the biomass.

Four stocks of pollock are recognized for management purposes: Gulf of Alaska, eastern Bering Sea, Aleutian Islands, and Aleutian Basin. For the contiguous sub-regions (i.e., areas adjacent to their management delineation), there appears to be some relationship among the eastern Bering Sea, Aleutian Islands, and Aleutian Basin stocks. Some strong year classes appear in all three places suggesting that pollock may expand from one area into the others or that discrete spawning areas benefit (in terms of recruitment) from similar environmental conditions. There appears to be stock separation between the Gulf of Alaska stocks and stocks to the north.

The most abundant stock of pollock is the eastern Bering Sea stock which is primarily distributed over the eastern Bering Sea outer continental shelf between approximately 70 m and 200 m. Information on pollock distribution in the eastern Bering Sea comes from commercial fishing locations, annual bottom trawl surveys and regular (every two or three years) echo-integration mid-water trawl surveys. There are also ancillary surveys for different life stages including those of the BASIS program (typically conducted in late summer and early fall) and some cooperative surveys with the Russian Federation scientists (typically covering the region a few hundred miles within the US zone from the Convention line).

The Aleutian Islands stock extends through the Aleutian Islands from 170° W. to the end of the Aleutian Islands (Attu Island), with the greatest abundance in the eastern Aleutian Islands (170° W. to Seguam Pass). Most of the information on pollock distribution in the Aleutian Islands comes from regular (every two or three years) bottom trawl surveys. These surveys indicate that pollock are primarily located on the Bering Sea side of the Aleutian Islands, and have a spotty distribution throughout the Aleutian Islands chain, particularly during the summer months when the survey is conducted. Thus, the bottom trawl data may be a poor indicator of pollock distribution because a significant portion of the pollock biomass is likely to be unavailable to bottom trawls. Also, many areas of the Aleutian Islands shelf are untrawlable due to the rough bottom.

The Aleutian Basin stock appears to be distributed throughout the Aleutian Basin which encompasses the U.S. EEZ, Russian EEZ, and international waters in the central Bering Sea. This stock appears throughout the Aleutian Basin apparently for feeding, but concentrates near the continental shelf for spawning. The principal spawning location is thought to be near Bogoslof Island in the eastern Aleutian Islands, but data from pollock fisheries in the first quarter of the year indicate that there are other concentrations of deepwater spawning concentrations in the central and western Aleutian Islands. The Aleutian Basin spawning stock appears to be derived from migrants from the eastern Bering Sea shelf stock, and possibly some western Bering Sea pollock. Recruitment to the stock occurs generally around age 5 with younger fish being rare in the Aleutian Basin. Most of the pollock in the Aleutian Basin appear to originate from strong year classes also observed in the Aleutian Islands and eastern Bering Sea shelf region.

The Gulf of Alaska stock extends from southeast Alaska to the Aleutian Islands (170° W.), with the greatest abundance in the western and central regulatory areas (147° W. to 170° W.). Most of the information on pollock distribution in the Gulf of Alaska comes from annual winter echo-integration mid-water trawl surveys and regular (every two or three years) bottom trawl surveys. These surveys indicate that pollock are distributed throughout the shelf regions of the Gulf of Alaska at depths less than 300 m. The bottom trawl data may not provide an accurate view of pollock distribution because a significant portion of the pollock biomass may be pelagic and unavailable to bottom trawls. The principal spawning location is in Shelikof Strait, but other spawning concentrations in the Shumagin Islands, the east side of Kodiak Island, and near Prince William Sound also contribute to the stock.

In the southeastern Bering Sea and Aleutian Islands, peak pollock spawning occurs along the outer continental shelf around mid-March. North of the Pribilof Islands spawning occurs later (April and May) in smaller spawning aggregations. The deep spawning pollock of the Aleutian Basin appear to spawn slightly earlier, late February and early March.

Spawning occurs in the pelagic zone and eggs develop throughout the water column (70 to 80 m in the Bering Sea shelf). Development is dependent on water temperature. In the Bering Sea, eggs take about 17 to 20 days to develop at 4 °C in the Bogoslof area and 25.5 days at 2 °C on the shelf. Larvae are also distributed in the upper water column. In the Bering Sea the larval period lasts approximately 60 days. The larvae eat progressively larger naupliar stages of copepods as they grow and then small euphausiids as they approach transformation to juveniles (approximately 25 mm standard length). Fisheries-Oceanography Coordinated Investigations survey data indicate larval pollock may utilize the stratified warmer upper waters of the mid-shelf to avoid predation by adult pollock which reside in the colder bottom water.

At age 1 pollock are found throughout the eastern Bering Sea both in the water column and on the bottom depending on temperature. Age 1 pollock from strong year-classes appear to be found in great numbers on the inner shelf, and further north on the shelf than weak year classes which appear to be more concentrated on the outer continental shelf. From age 2 to 3 pollock are primarily pelagic during which time they are most abundant on the outer and mid-shelf northwest of the Pribilof Islands. As pollock reach maturity (age 4) in the Bering Sea, they appear to move from the northwest to the southeast shelf to recruit to the adult spawning population. Strong year-classes of pollock persist in the population in significant numbers until about age 12, and very few pollock survive beyond age 16. The oldest recorded pollock was age 31.

Growth varies by area with the largest pollock occurring on the southeastern shelf. On the northwest shelf the growth rate is slower. The upper size limit for juvenile pollock in the eastern Bering Sea is about 381 mm coinciding with the size of 50 percent maturity (Stahl and Kruse 2008). There is evidence that this varies over time.

D.19.2 Relevant Trophic Information

Pollock juveniles and newly maturing pollock primarily eat copepods and euphausiids. Older pollock become increasingly piscivorous, with pollock (cannibalism) comprising much of the diet in the Bering Sea. Most of the pollock consumed by pollock are age 0 and 1 pollock, and past research suggests that cannibalism can regulate year-class size. In some years, weak year-classes occur within the range of adults, while strong year-classes are those that are transported to areas outside the range of adult abundance.

Being the dominant species in the eastern Bering Sea, pollock is an important food source for other fish, marine mammals, and birds. On the Pribilof Islands hatching success and fledgling survival of marine birds has been tied to the availability of age 0 pollock to nesting birds.

D.19.3 Habitat and Biological Associations

Eggs: Pelagic on outer continental shelf generally over 100 to 200 m depth in Bering Sea.

Larvae: Pelagic outer to mid-shelf region in Bering Sea.

Pelagic Early Juveniles: Age 0 appears to be pelagic, as is age 2 and 3. Age 1 pelagic and demersal with a widespread distribution and no known benthic habitat preference.

Settled Early Juveniles: In the EBS, the covariates contributing the most to the final SDM EFH map for this life stage were geographic position, bottom depth, tidal current maximum, and bottom temperature (Laman et al. 2022). Predicted abundance of settled early juvenile walleye pollock was highest over the middle shelf in the northern half of the EBS in depths shallower than 300 m with maximum tidal current around 0.5 kts (~30 cm/s) and decreasing bottom temperatures. In the AI, the covariates contributing the most to the final SDM EFH map for this life stage were bottom depth, geographic position, terrain aspect, current, and bottom temperature (Harris et al. 2022). Predicted abundance was highest in the eastern AI, near-shore to Unalaska Island, with additional pockets of high abundance around Atka and Attu islands. Higher habitat-related growth potential was predicted to occur in the eastern AI.

Subadults: In the EBS, the covariates contributing the most to the final SDM EFH map for this life stage were geographic position, bottom temperature, and bottom depth (Laman et al. 2022). Ensemble-predicted subadult walleye pollock abundance was highest over the outer shelf in the northwest portion of the EBS in depths less than 200 m and at increasing bottom temperatures. In the AI, the covariate contributing the most to the final SDM EFH map for this life stage was bottom depth, with almost all subadults predicted above the 300 m depth contour (Harris et al. 2022). Estimated abundances were high in the far west around Attu Island and in the east around Unalaska Island.

Adults: Adults occur both pelagically and demersally on the outer and mid-continental shelf of the Gulf of Alaska, eastern Bering Sea and Aleutian Islands. In the eastern Bering Sea few adult pollock occur in waters shallower than 70 m. Adult pollock also occur pelagically in the Aleutian Basin. Adult pollock range throughout the Bering Sea in both the U.S. and Russian waters; however, the maps provided for this document detail distributions for pollock in the U.S. EEZ and the Aleutian Basin. In the EBS, the covariates contributing the most to the final SDM EFH map for this life stage were geographic position, bottom temperature, bottom depth, and current (Laman et al. 2022). Predicted adult walleye pollock abundance was highest over the middle shelf-outer shelf domain transition in the northern half of the EBS with increasing bottom temperatures and sediment grain sizes at depths around 150 m with current flowing to the southwest. In the AI, the covariates contributing the most to the final SDM EFH map for this life stage were bottom depth, geographic position, and current, with predicted abundamces between 200 – 300 m depths with southerly currents (Harris et al. 2022). Adult walleye pollock had high densities near Unimak Pass and in the eastern AI.

Habitat and Biological Associations: Walleye Pollock

Stage - EFH Level	Duration or Age	Diet/Prey	Season / Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs	14 days at 5 °C	None	Feb–Apr	OCS, USP	P	NA	G?	
Larvae	60 days	copepod naupli and small euphausiids	Mar–Jul	MCS, OCS	P	NA	G? F	pollock larvae with jellyfish
Settled Early Juveniles /Subadults	0.4 to 4.5 years	pelagic crustaceans, copepods and euphausiids	Aug. +	OCS, MCS, ICS	P, SD	NA	CL, F	
Adults	4.5–16 years	pelagic crustaceans and fish	spawning Feb–Apr	OCS, BSN	P, SD	UNK	F UP	increasingly demersal with age.

D.19.4 Literature

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D.20 Yellowfin sole (*Limanda aspera*)

D.20.1 Life History and General Distribution

Yellowfin sole are distributed in North American waters from off British Columbia, Canada, (approximately latitude 49° N.) to the Chukchi Sea (about latitude 70° N.) and south along the Asian coast to about latitude 35° N. off the South Korean coast in the Sea of Japan. Adults exhibit a benthic lifestyle and occupy separate winter spawning and summertime feeding distributions on the eastern Bering Sea shelf. From over-winter grounds near the shelf margins, adults begin a migration onto the inner shelf in April or early May each year for spawning and feeding. A protracted and variable spawning period may range from as early as late May through August occurring primarily in shallow water. Fecundity varies with size and was reported to range from 1.3 to 3.3 million eggs for fish 250 to 450 mm long. Eggs have been found to the limits of inshore ichthyoplankton sampling over a widespread area to at least as far north as Nunivak Island. Larvae have been measured at 2.2 to 5.5 mm in July and 2.5 to 12.3 mm in late August and early September. The age or size at metamorphosis is unknown. Upon settlement in nearshore areas, juveniles preferentially select sediment suitable for feeding on meiofaunal prey and burrowing for protection. Juveniles are separate from the adult population, remaining in shallow areas until they reach approximately 150 mm. The estimated age of 50 percent maturity is 10.5 years (approximately 290 mm) for females based on samples collected in 1992 and 1993 and 10.14 from an updated study using 2012 collections. Natural mortality rate is believed to range from 0.12 to 0.16.

The approximate upper size limit of juvenile fish is 270 mm.

D.20.2 Relevant Trophic Information

Groundfish predators include Pacific cod, skates, and Pacific halibut, mostly on fish ranging from 70 to 250 mm standard length. Adult walleye pollock feed mainly on bivalves, polychaete, amphipods, and echiurids.

D.20.3 Habitat and Biological Associations

Larvae: Planktonic larvae for at least 2 to 3 months until metamorphosis occurs, usually inhabiting shallow areas.

Settled Early Juveniles: The covariates contributing the most to the final SDM EFH map for this life stage were geographic position and bottom depth (Laman et al. 2022). Settled early juvenile yellowfin sole abundance predictions were highest on the inner shelf around Nunivak Island in shallower waters.

Subadults: The covariates contributing the most to the final SDM EFH map for this life stage were bottom depth and geographic position (Laman et al. 2022). Subadult YFS abundance predictions were highest over the EBS inner shelf domain south of Nunivak Island in shallower waters.

Adults: Summertime spawning and feeding on sandy substrates of the eastern Bering Sea shelf. Widespread distribution mainly on the middle and inner portion of the shelf, then a wintertime migration to deeper waters of the shelf margin to avoid extreme cold water temperatures. The covariates contributing the most to the final SDM EFH map for this life stage were bottom depth and geographic position, which predicted the highest abundances of adult YFS in shallower waters along the inner and middle shelf domains south of Nunivak Island and in to Bristol Bay (Laman et al. 2022).

Habitat and Biological Associations: Yellowfin sole

Stage - EFH Level	Duration or Age	Diet/Prey	Season/Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs		NA	summer	BAY, BCH	P			
Larvae	2–3 months?	U phyto/zoo plankton?	summer autumn?	BAY, BCH ICS	P			
Settled Early Juveniles	to 5.5 yrs	polychaete bivalves amphipods echiurids	all year	BAY, ICS OCS	D	S, SM		
Subadult s	5.5 to 10 yrs	polychaete bivalves amphipods echiurids	all year	BAY, ICS OCS	D	S, SM, MS		
Adults	10+ years	polychaete bivalves amphipods echiurids	spawning/ feeding May–August non-spawning Nov–April	BAY BCH ICS, MCS OCS	D	S, SM, MS, M	ice edge	

D.20.4 Literature

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Appendix E Maps of Essential Fish Habitat

E.1 Outline

Maps of essential fish habitat are included in this section for the following species (life stage is indicated in parentheses) and EFH information levels (L) 1-3 for the eastern Bering Sea (EBS) and Aleutian Islands (AI) (see Harris et al. 2022 and Laman et al. 2022 for mapping methods):

Figure E-1 to E-8	Alaska plaice (egg, larvae, settled early juvenile, subadult, adult) EBS • settled early juvenile summer L2 E-1, subadult summer L2 E-2, adult summer L2 E-3; • egg summer L1 E-4, larvae summer L1 E-5; • adult fall L1 E-6, adult winter L1 E-7, adult spring L1 E-8.
Figure E-9 to E-22	Arrowtooth flounder (larvae, settled early juvenile, subadult, adult) EBS • settled early juvenile summer L2 E-9, subadult summer L2 E-10, adult summer L2 E-11; • larvae summer L1 E-12, adult fall L1 E-13, adult winter L1 E-14, adult spring L1 E-15. AI • settled early juvenile summer L2 E-16, subadult summer L2 E-17, adult summer L2 E-18; • larvae summer L1 E-19, adult fall L1 E-20, adult winter L1 E-21, adult spring L1 E-22.
Figure E-23 to E-33	Atka mackerel (egg, larvae, subadult, adult) EBS • adult summer L2 E-23; • larvae summer L1 E-24, adult fall L1 E-25, adult winter L1 E-26, adult spring L1 E-27. AI • subadult summer L2 E-28, adult summer L2 E-29; • egg summer L1 E-30, adult fall L1 E-31, adult winter L1 E-32, adult spring L1 E-33.
Figure E-34 to E-52	Flathead sole/Bering flounder complex (subadult, adult) EBS • subadult summer L2 E-34, adult summer L2 E-35.
Figure E-36 to E-37	Bering flounder (subadult, adult) EBS • subadult summer L2 E-36, adult summer L2 E-37.

Figure E-38 to E-52	Flathead sole (egg, larvae, settled early juvenile, subadult, adult) EBS • settled early juvenile summer L2 E-38, subadult summer L2 E-39, adult summer L2 E-40; • egg summer L1 E-41, larvae summer L1 E-42, adult fall L1 E-43, adult winter L1 E-44, adult spring L1 E-45. AI • settled early juvenile summer L2 E-46, subadult summer L2 E-47, adult summer L2 E-48; • egg summer L1 E-49, adult fall L1 E-50, adult winter L1 E-51, adult spring L1 E-52.
Figure E-53 to E-62	Greenland turbot (larvae, subadult, adult) EBS • subadult summer L2 E-53, adult summer L2 E-54; • larvae summer L1 E-55, adult fall L1 E-56, adult winter L1 E-57, adult spring L1 E-58. AI • adult summer L2 E-59; • adult fall L1 E-60, adult winter L1 E-61, adult spring L1 E-62.
Figure E-63 to E-72	Kamchatka flounder (subadult, adult) EBS • subadult summer L2 E-63, adult summer L2 E-64; • adult fall L1 E-65, adult winter L1 E-66, adult spring L1 E-67. AI • subadult summer L2 E-68, adult summer L2 E-69; • adult fall L1 E-70, adult winter L1 E-71, adult spring L1 E-72.
Figure E-73 to E-86	Northern rock sole (larvae, settled early juvenile, subadult, adult) EBS • settled early juvenile summer L2 E-73, subadult summer L2 E-74, adult summer L2 E-75; • larvae summer L1 E-76, adult fall L1 E-77, adult winter L1 E-78, adult spring L1 E-79. AI • settled early juvenile summer L2 E-80, subadult summer L2 E-81, adult summer L2 E-82; • larvae summer L1 E-83, adult fall L1 E-84, adult winter L1 E-85, adult spring L1 E-86.
Figure E-87 to E-94	Northern rockfish (adult) EBS • adult summer L2 E-87; • adult fall L1 E-88, adult winter L1 E-89, adult spring L1 E-90. AI • adult summer L2 E-91; • adult fall L1 E-92, adult winter L1 E-93, adult spring L1 E-94.

Figure E-95 to E-102	Octopus (adult) EBS • adult summer L2 E-95; • adult fall L1 E-96, adult winter L1 E-97, adult spring L1 E-98. AI • adult summer L1 E-99, adult fall L1 E-100, adult winter L1 E-101, adult spring L1 E-102.
Figure E-103 to E-132	Other flatfish complex (subadult, adult) EBS • subadult/adult summer L2 E-103. AI • subadult summer L2 E-104, adult summer L2 E-105.
Figure E-106	Butter sole (subadult/adult) EBS • subadult/adult summer L2 E-106.
Figure E-107	Deepsea sole (subadult/adult) EBS • subadult/adult summer L2 E-107.
Figure E-108 to E-114	Dover sole (subadult, adult) EBS • subadult summer L2 E-108, adult summer L2 E-109; • adult winter L1 E-110, adult spring L1 E-111. AI • subadult summer L2 E-112, adult summer L2 E-113; • adult spring L1 E-114.
Figure E-115	Longhead dab (subadult/adult) EBS • subadult/adult summer L2 E-115
Figure E-116 to E-128	Rex sole (egg, settled early juvenile, subadult, adult) EBS • settled early juvenile L2 E-116, subadult summer L2 E-117, adult summer L2 E-118; • egg summer L1 E-119, adult fall L1 E-120, adult winter L1 E-121, adult spring L1 E-122. AI • subadult summer L2 E-123, adult summer L2 E-124; • egg summer L1 E-125, adult fall L1 E-126, adult winter L1 E-127, adult spring L1 E-128.
Figure E-129 to E-130	Sakhalin sole (subadult, adult) EBS • subadult summer L2 E-129, adult summer L2 E-130.

Figure E-131 to E-132	Starry flounder (subadult, adult) EBS • subadult summer L2 E-131, adult summer L2 E-132.
Figure E-133 to E-153	Other rockfish complex (subadult/adult) AI • subadult/adult summer L2 E-133.
Figure E-134 to E-142	Dusky rockfish (subadult, adult) EBS • adult summer L1 E-134, adult fall L1 E-135, adult winter L1 E-136, adult spring L1 E-137. AI • subadult summer L2 E-138, adult summer L2 E-139. • adult fall L1 E-140, adult winter L1 E-141, adult spring L1 E-142.
Figure E-143	Harlequin rockfish (adult) AI • adult summer L2 E-143.
Figure E-144 to E-153	Shortspine thornyhead (subadult, adult) EBS • subadult summer L2 E-144, adult summer L2 E-145. • adult fall L1 E-146, adult winter L1 E-147, adult spring L1 E-148. AI • subadult summer L2 E-149, adult summer L2 E-150. • adult fall L1 E-151, adult winter L1 E-152, adult spring L1 E-153.
Figure E-154 to E-168	Pacific cod (larvae, settled early juvenile, subadult, adult) EBS • settled early juvenile summer L2 E-154, subadult summer L2 E-155, adult summer L2 E-156. • larvae summer L1 E-157, adult fall L1 E-158, adult winter L1 E-159, adult spring L1 E-160. • settled early juvenile summer L3 growth E-161, settled early juvenile L3 condition E-162. AI • subadult summer L2 E-163, adult summer L2 E-164. • larvae summer L1 E-165, adult fall L1 E-166, adult winter L1 E-167, adult spring L1 E-168.
Figure E-169 to E-182	Pacific ocean perch (larvae, settled early juvenile, subadult, adult) EBS • settled early juvenile summer L2 E-169, subadult summer L2 E-170, adult summer L2 E-171.

	• larvae summer L1 E-172, adult fall L1 E-173, adult winter L1 E-174, adult spring L1 E-175. AI • settled early juvenile summer L2 E-176, subadult summer L2 E-177, adult summer L2 E-178. • larvae summer L1 E-179, adult fall L1 E-180, adult winter L1 E-181, adult spring L1 E-182.
Figure E-183 to E-186	Rougheye/Blackspotted rockfish (subadult, adult) EBS • subadult summer L2 E-183, adult summer L2 E-184. AI • subadult summer L2 E-185, adult summer L2 E-186.
Figure E-187 to E-192	Rougheye rockfish (adult) EBS • adult fall L1 E-187, adult winter L1 E-188, adult spring L1 E-189. AI • adult fall L1 E-190, adult winter L1 E-191, adult spring L1 E-192.
Figure E-193 to E-203	Sablefish (settled early juvenile, subadult, adult) EBS • settled early juvenile summer L2 E-193, subadult summer L2 E-194, adult summer L2 E-195. • adult fall L1 E-196, adult winter L1 E-197, adult spring L1 E-198. AI • subadult summer L2 E-199, adult summer L2 E-200. • adult fall L1 E-201, adult winter L1 E-202, adult spring L1 E-203.
Figure E-204 to E-213	Shortraker rockfish (subadult, adult) EBS • subadult summer L2 E-204, adult summer L2 E-205. • adult fall L1 E-206, adult winter L1 E-207, adult spring L1 E-208. AI • subadult summer L2 E-209, adult summer L2 E-210. • adult fall L1 E-211, adult winter L1 E-212, adult spring L1 E-213.
Figure E-214 to E-217	Skate complex (subadult, adult) EBS • subadult summer L2 E-214, adult summer L2 E-215. AI • subadult summer L2 E-216, adult summer L2 E-217.

Figure E-218 to E-227	Alaska skate (subadult, adult) EBS • subadult summer L2 E-218, adult summer L2 E-219. • adult fall L1 E-220, adult winter L1 E-221, adult spring L1 E-222. AI • subadult summer L2 E-223, adult summer L2 E-224. • adult fall L1 E-225, adult winter L1 E-226, adult spring L1 E-227.
Figure E-228 to E-237	Aleutian skate (subadult, adult) EBS • subadult summer L2 E-228, adult summer L2 E-229. • adult fall L1 E-230, adult winter L1 E-231, adult spring L1 E-232. AI • subadult summer L2 E-233, adult summer L2 E-234. • adult fall L1 E-235, adult winter L1 E-236, adult spring L1 E-237.
Figure E-238 to E-239	Bering skate (subadult, adult) EBS • subadult summer L2 E-238, adult summer L2 E-239.
Figure E-240 to E-249	Mud skate (subadult, adult) EBS • subadult summer L2 E-240, adult summer L2 E-241. • adult fall L1 E-242, adult winter L1 E-243, adult spring L1 E-244. AI • subadult summer L2 E-245, adult summer L2 E-246. • adult fall L1 E-247, adult winter L1 E-248, adult spring L1 E-249.
Figure E-250 to E-253	Whiteblotched skate (subadult, adult) EBS • subadult summer L2 E-250, adult summer L2 E-251. AI • subadult summer L2 E-252, adult summer L2 E-253.
Figure E-254 to E-271	Walleye pollock (eggs, larvae, settled early juvenile, subadult, adult) EBS • settled early juvenile summer L2 E-254, subadult summer L2 E-255, adult summer L2 E-256. • eggs summer L1 E-257, larvae summer L1 E-258, adult fall L1 E-259, adult winter L1 E-260, adult spring L1 E-261. AI • settled early juvenile summer L2 E-262, subadult summer L2 E-263, adult summer L2 E-264.

	• eggs summer L1 E-265, larvae summer L1 E-266, adult fall L1 E-267, adult winter L1 E-268, adult spring L1 E-269. • settled early juvenile summer L3 growth E-270, settled early juvenile summer L3 condition E-271.
Figure E-272 to E-279	Yellowfin sole (eggs, larvae, settled early juvenile, subadult, adult) EBS • settled early juvenile summer L2 E-272, subadult summer L2 E-273, adult summer L2 E-274. • eggs summer L1 E-275, larvae summer L1 E-276, adult fall L1 E-277, adult winter L1 E-278, adult fall spring L1 E-279.

E.2 Essential Fish Habitat (EFH) Maps

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.
>
> *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 1991-2019 in the Aleutian Islands (AI) (Harris et al. 2022) and in 1982-2019 in the eastern Bering Sea (EBS) (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) 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 fish distributions over available habitat within the larger area identified as EFH.

While EFH must be designated for each managed species, EFH may be designated for assemblages of species with justification or scientific rationale provided (50 CFR 600.815(a)(1)(iv)(E)). EFH maps from the 2023 5-year Review are presented for the first time for multi-species stock complexes using aggregated single species SDMs to serve as proxies for individual species in the stock complex where an SDM EFH map was not possible due to data limitations. In the following sections the EFH maps for the stock complex are presented first, followed by individual species in the stock complex where an EFH map was possible.

EFH Level 3 maps of habitat-related vital rates for settled early juveniles were mapped for the first time in the 2023 Review by combining spatial projections of temperature dependent growth and lipid accumulation (condition) rates with SDMs (Harris et al. 2022, Laman et al. 2022).

E.3 Figures

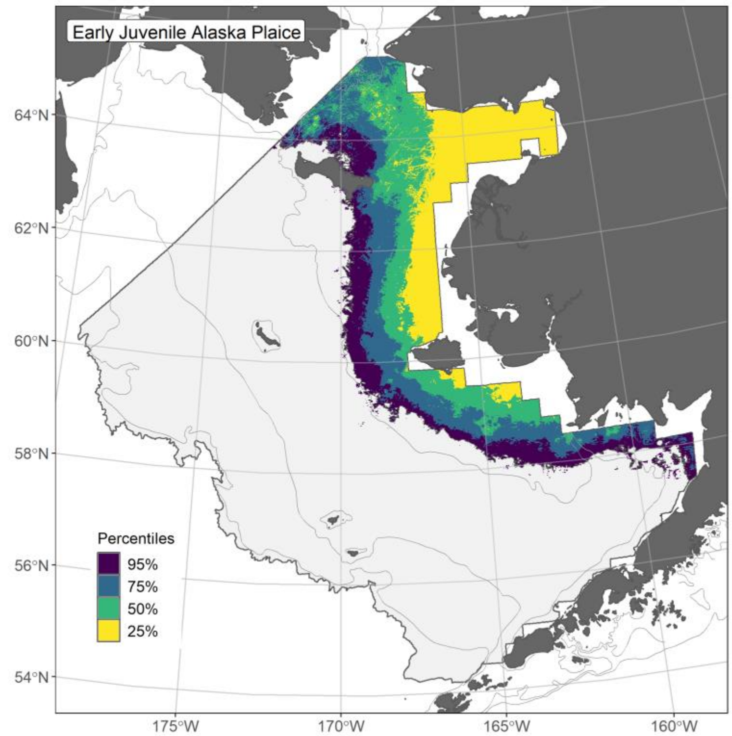

Figure E-1 EFH area of EBS settled early juvenile Alaska plaice, summer

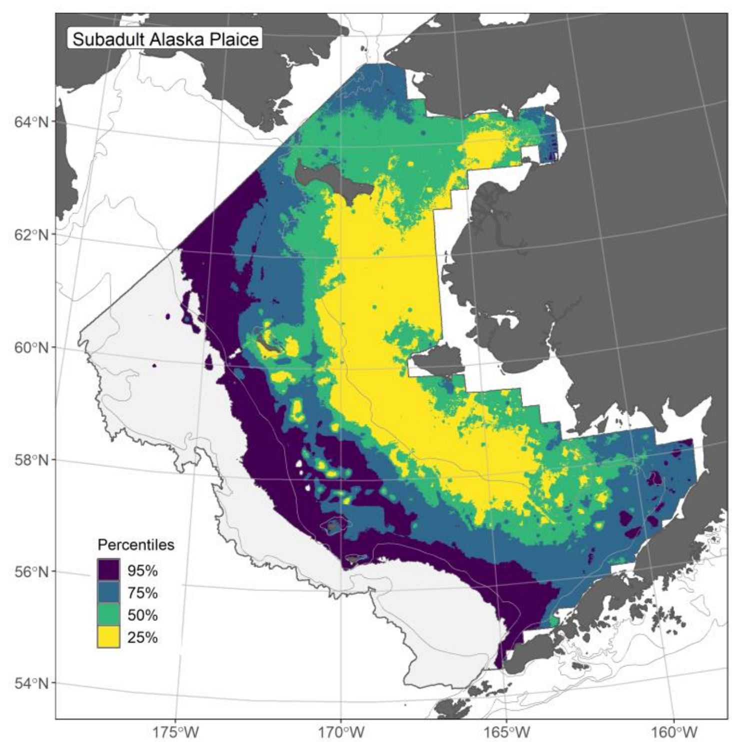

Figure E-2 EFH area of EBS subadult Alaska plaice, summer

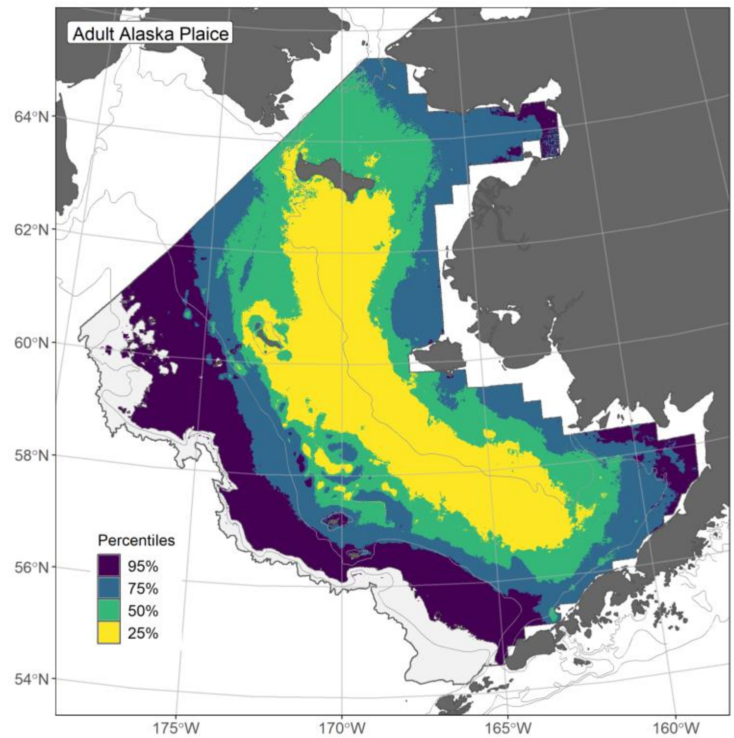

Figure E-3 EFH area of EBS adult Alaska plaice, summer

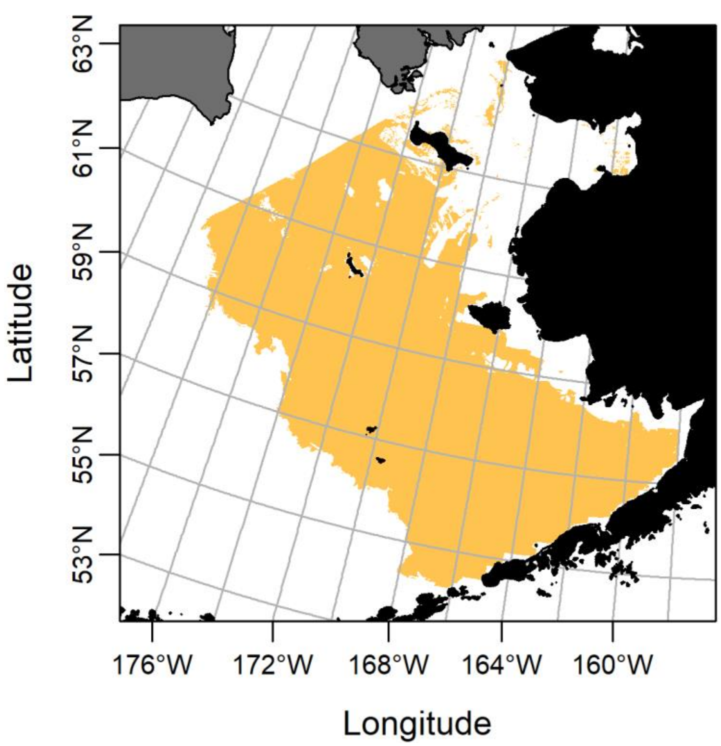

Figure E-4 EFH area of EBS Alaska plaice eggs, summer

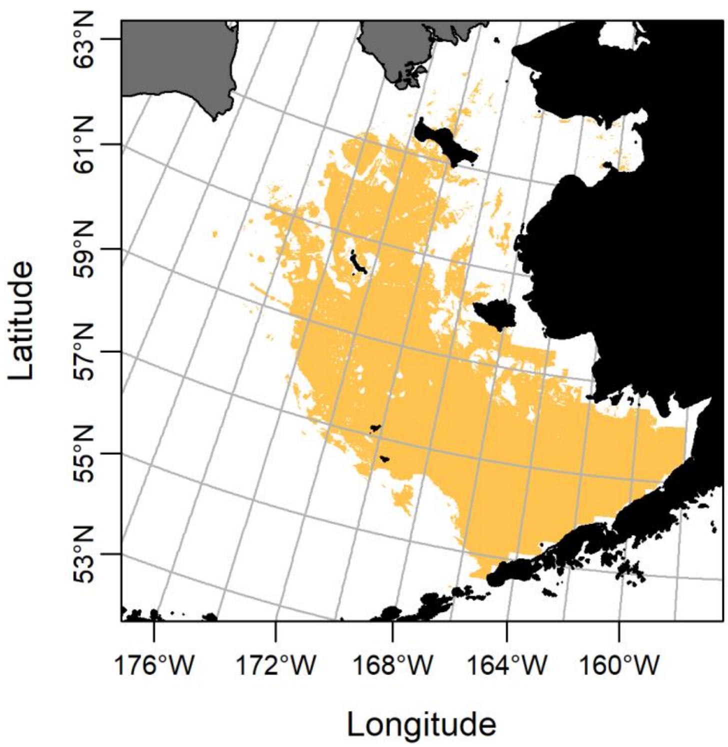

Figure E-5 EFH area of EBS Alaska plaice larvae, summer

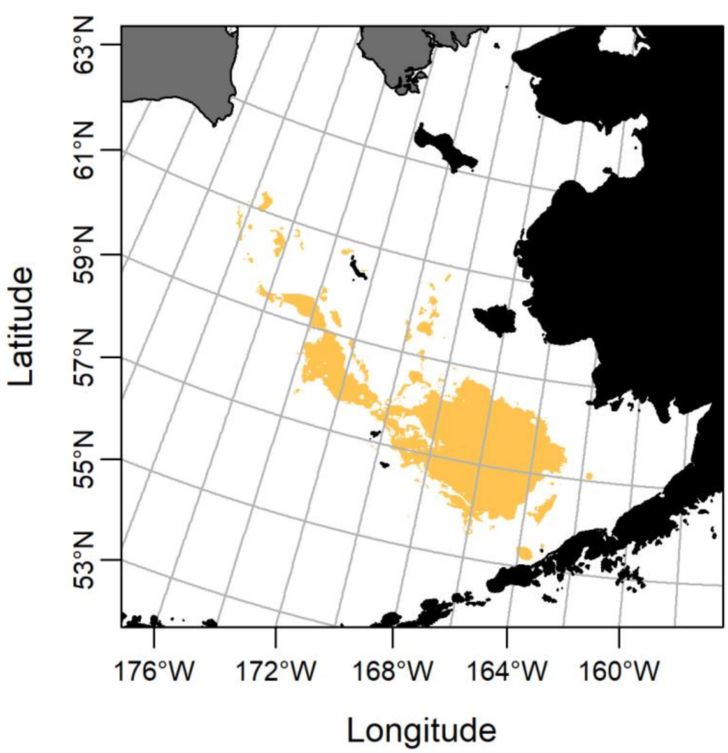

Figure E-6 EFH area of EBS adult Alaska plaice, fall

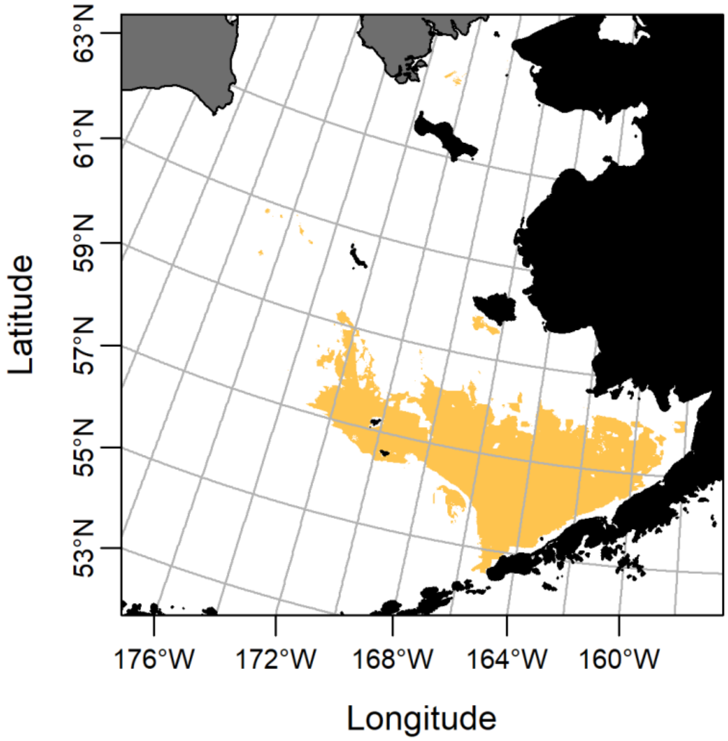

Figure E-7 EFH area of EBS adult Alaska plaice, winter

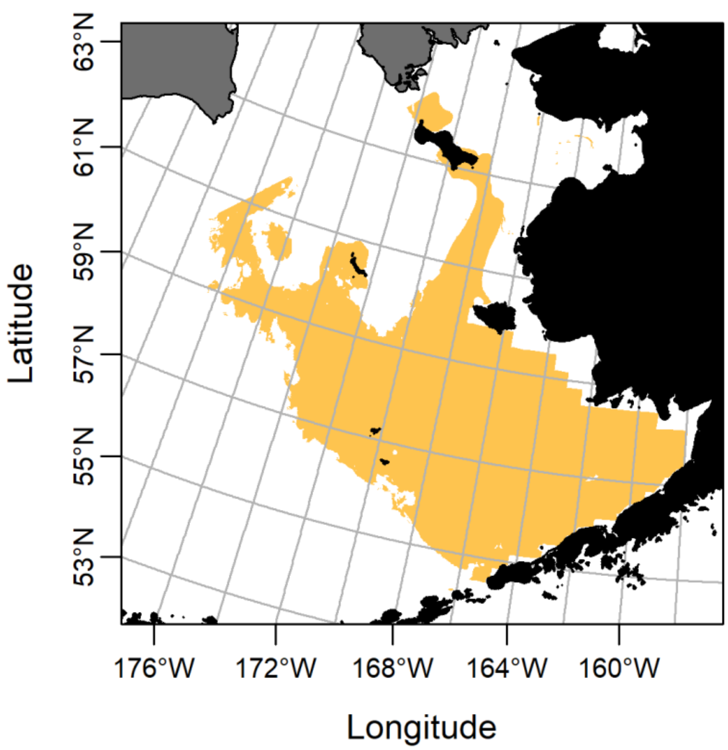

Figure E-8 EFH area of EBS adult Alaska plaice, spring

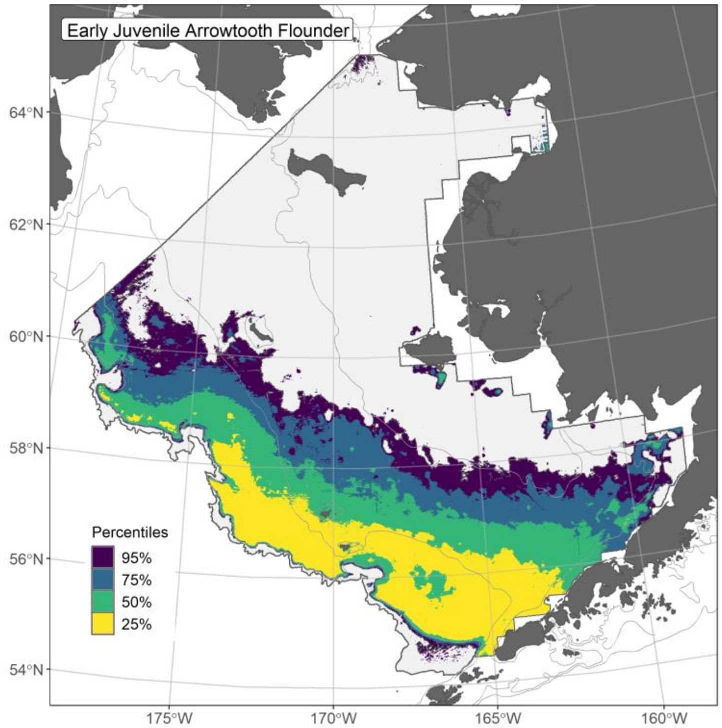

Figure E-9 EFH area of EBS settled early juvenile arrowtooth flounder, summer

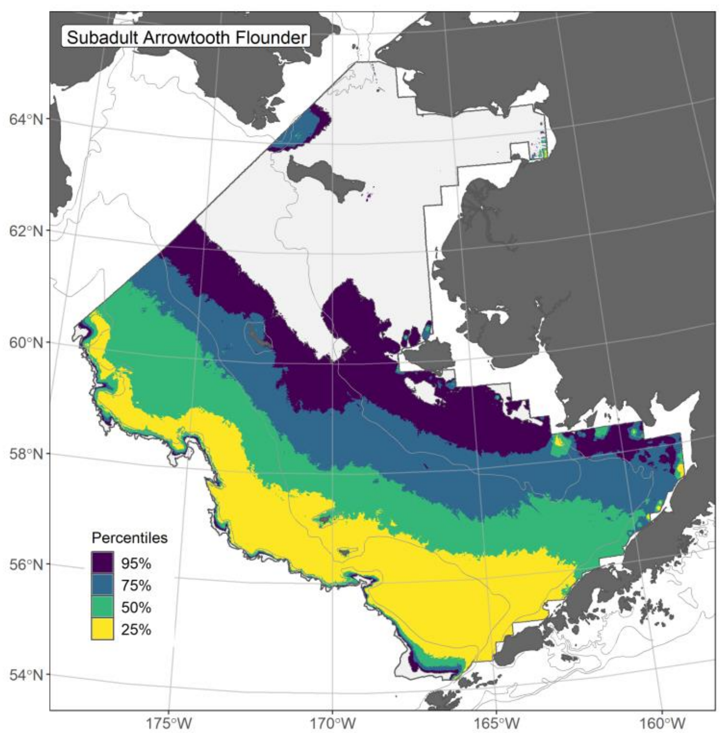

Figure E-10 EFH area of EBS subadult arrowtooth flounder, summer

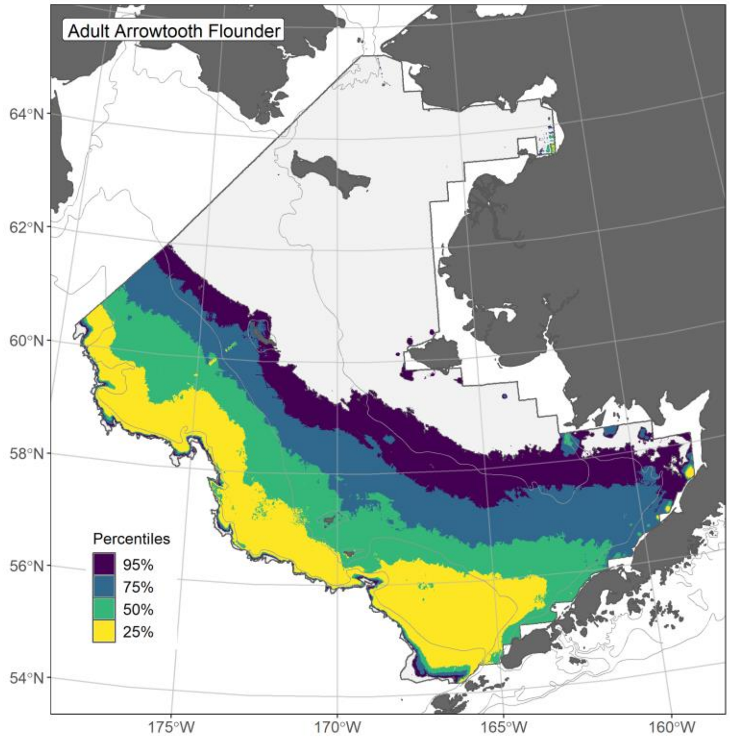

Figure E-11 EFH area of EBS adult arrowtooth flounder, summer

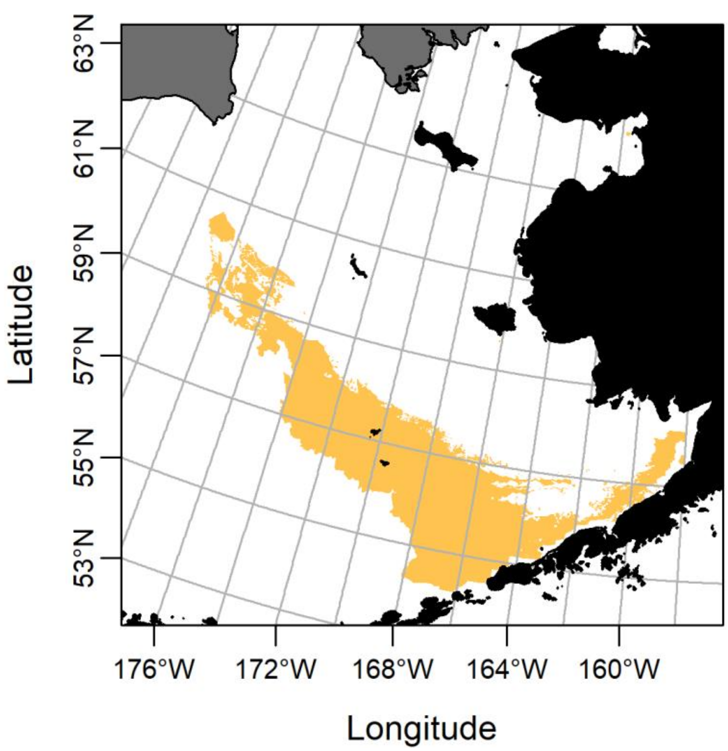

Figure E-12 EFH area of EBS arrowtooth flounder larvae, summer

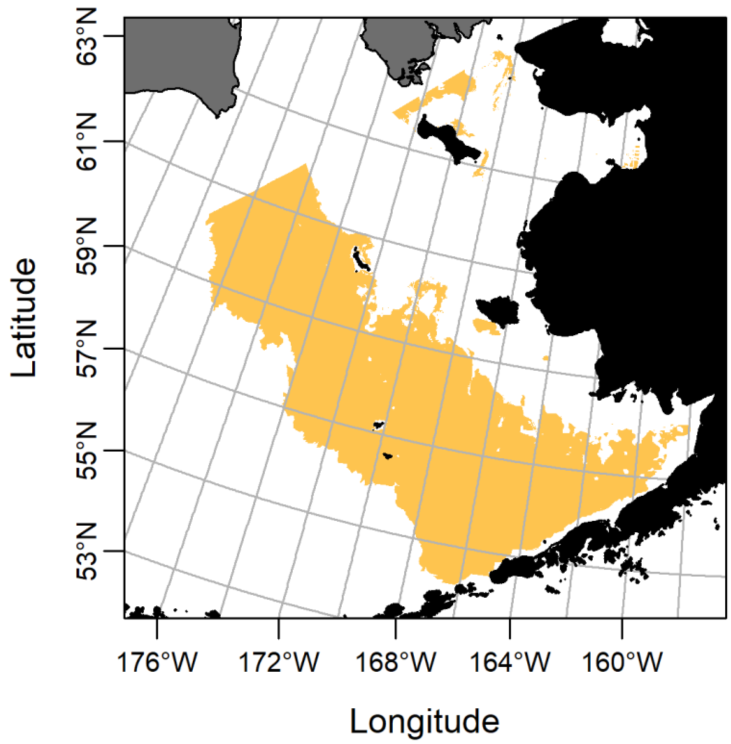

Figure E-13 EFH area of EBS adult arrowtooth flounder, fall

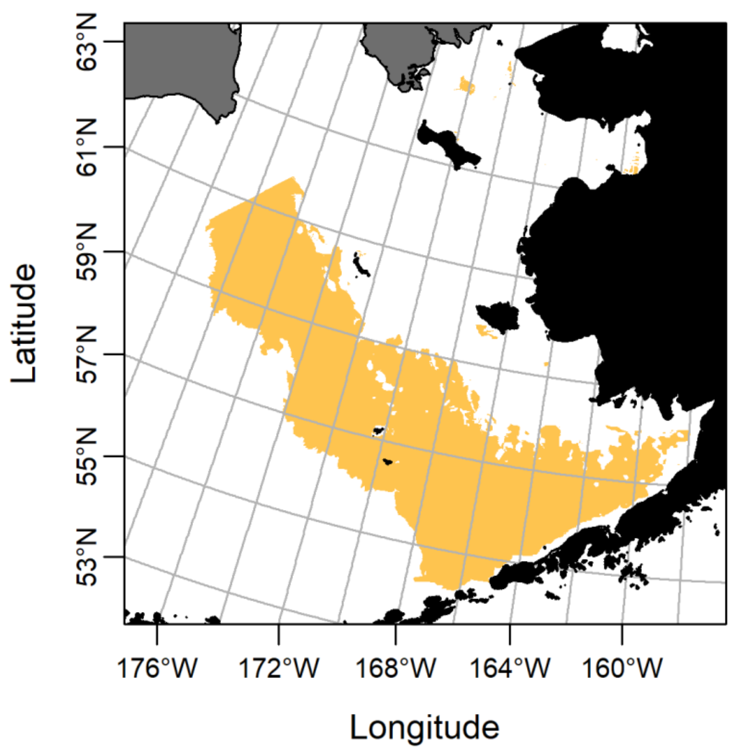

Figure E-14 EFH area of EBS adult arrowtooth flounder, winter

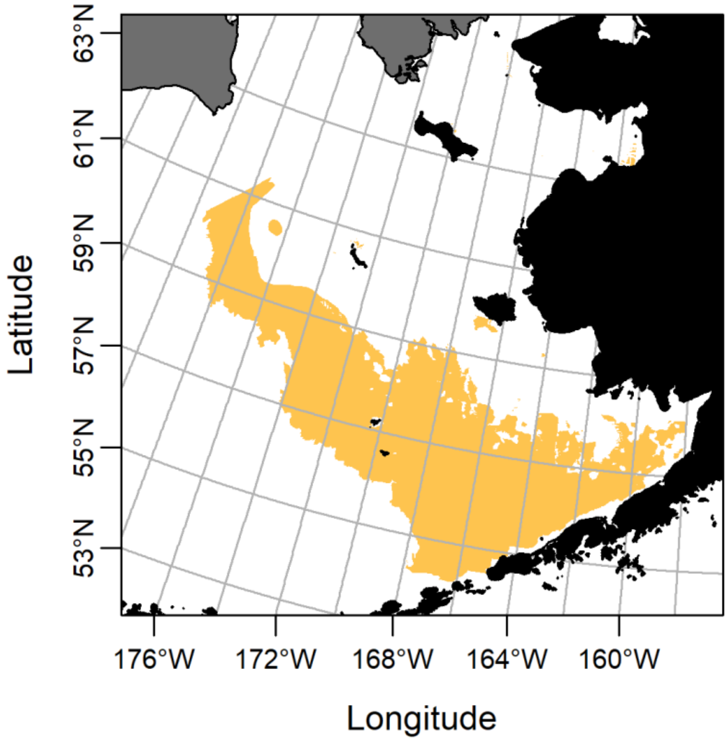

Figure E-15 EFH area of EBS adult arrowtooth flounder, spring

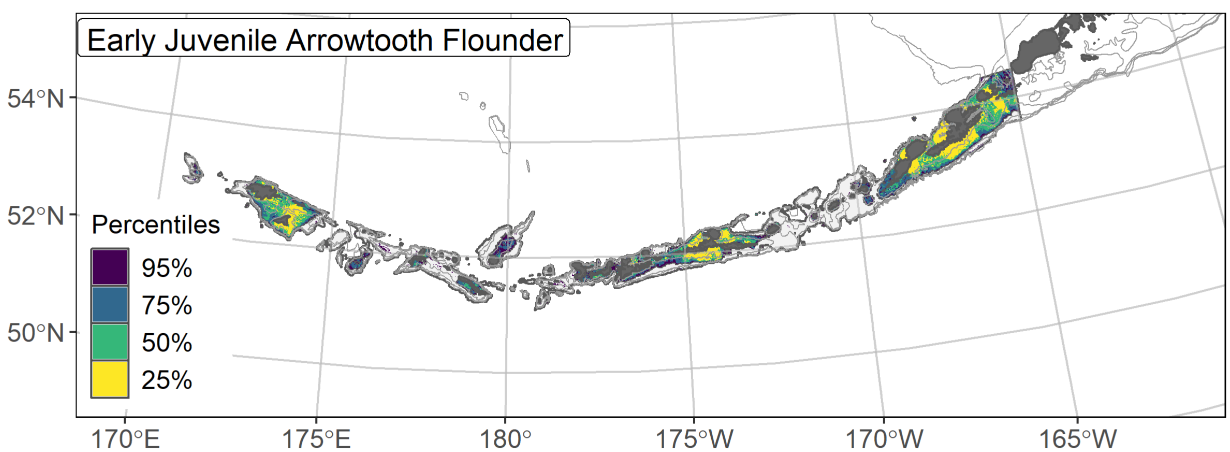

Figure E-16 EFH area of AI settled early juvenile arrowtooth flounder, summer

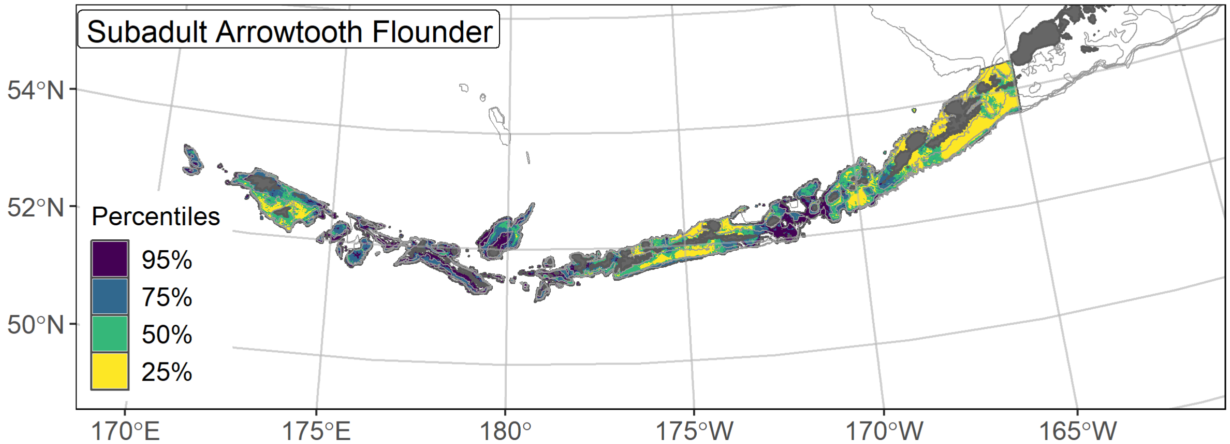

Figure E-17 EFH area of AI subadult arrowtooth flounder, summer

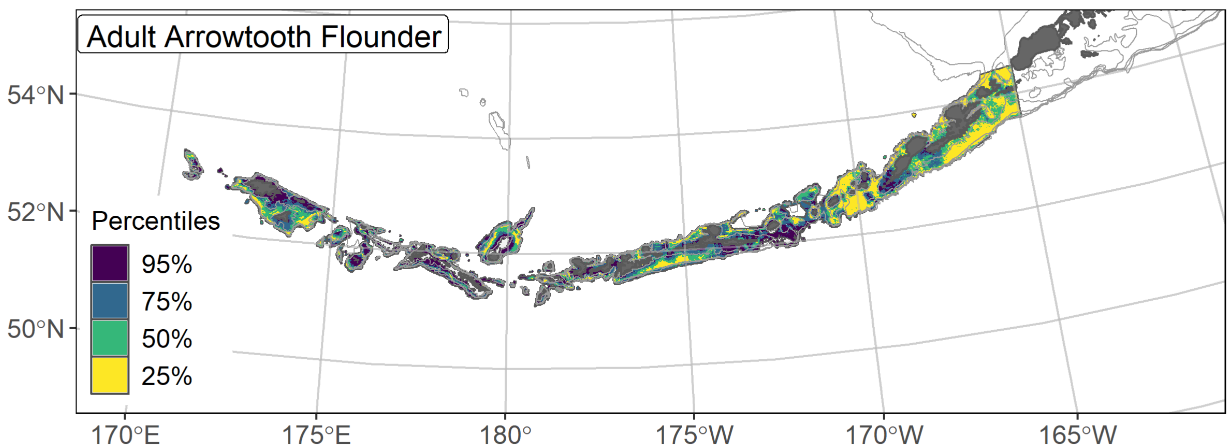

Figure E-18 EFH area of AI adult arrowtooth flounder, summer

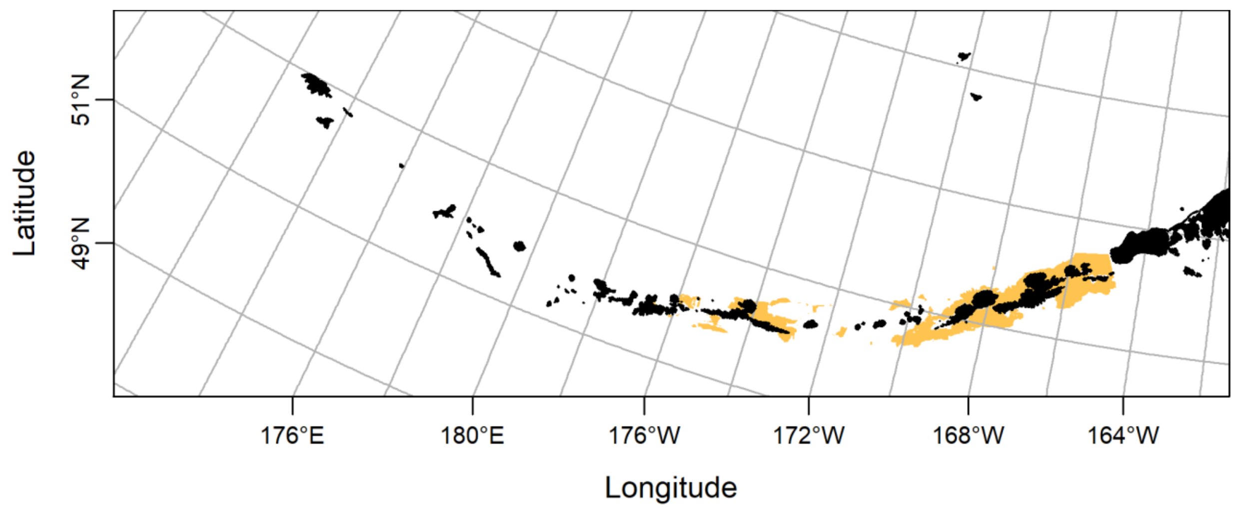

Figure E-19 EFH area of AI arrowtooth flounder larvae, summer

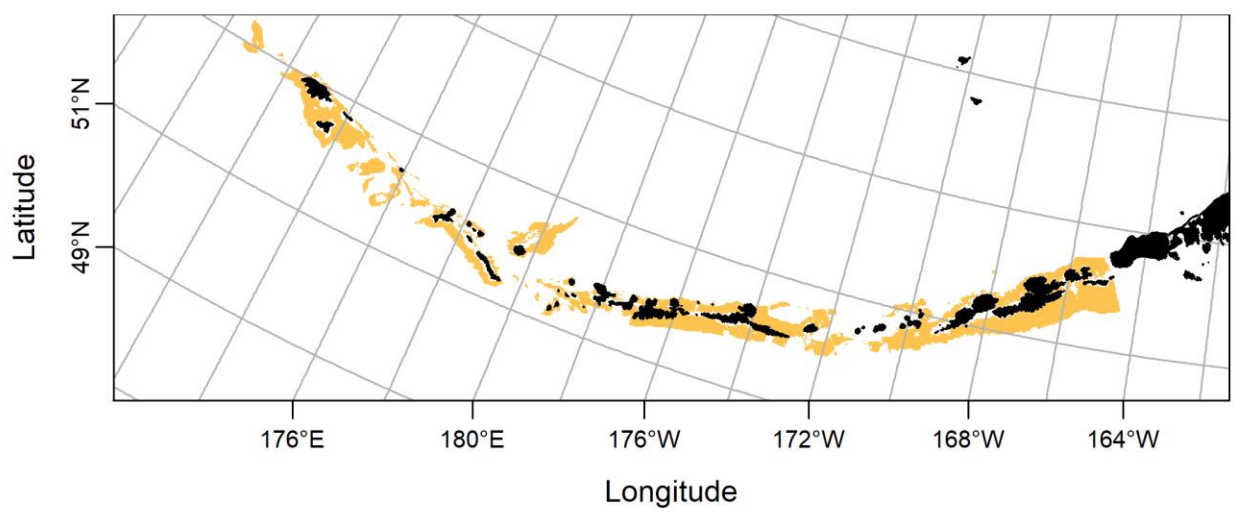

Figure E-20 EFH area of AI adult arrowtooth flounder, fall

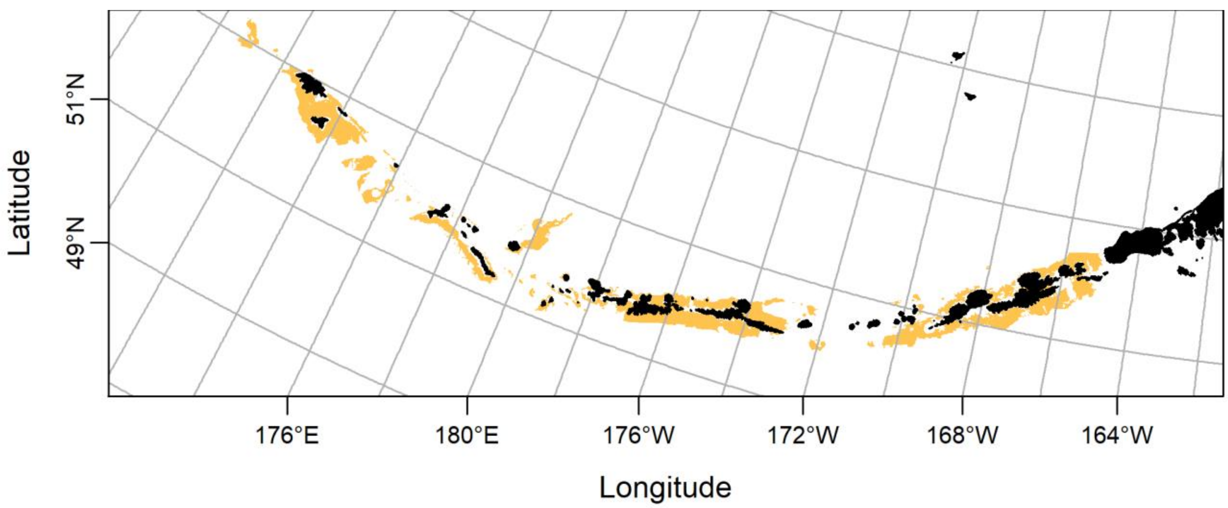

Figure E-21 EFH area of AI adult arrowtooth flounder, winter

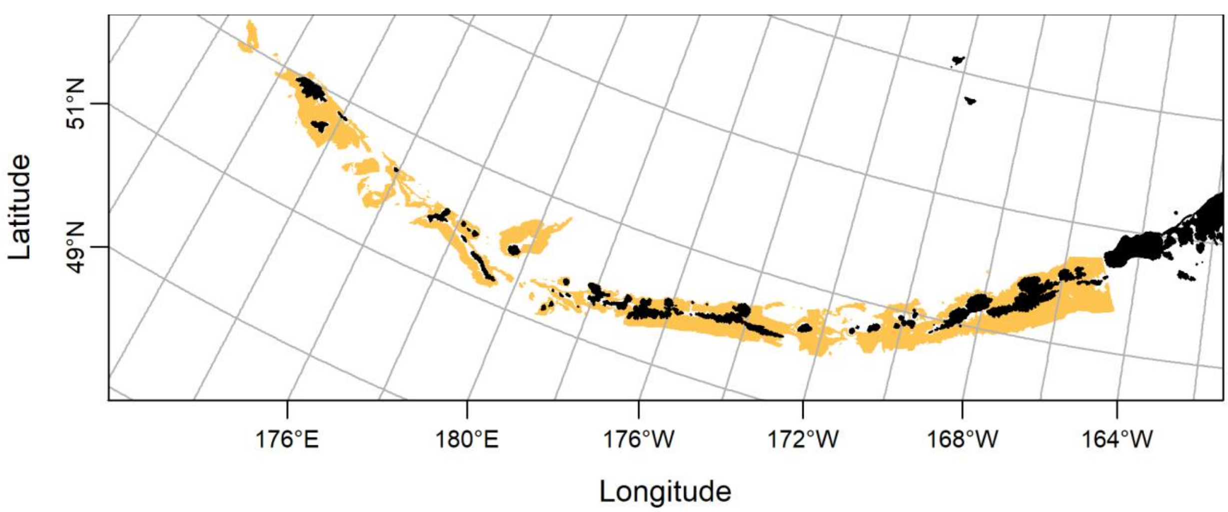

Figure E-22 EFH area of AI adult arrowtooth flounder, spring

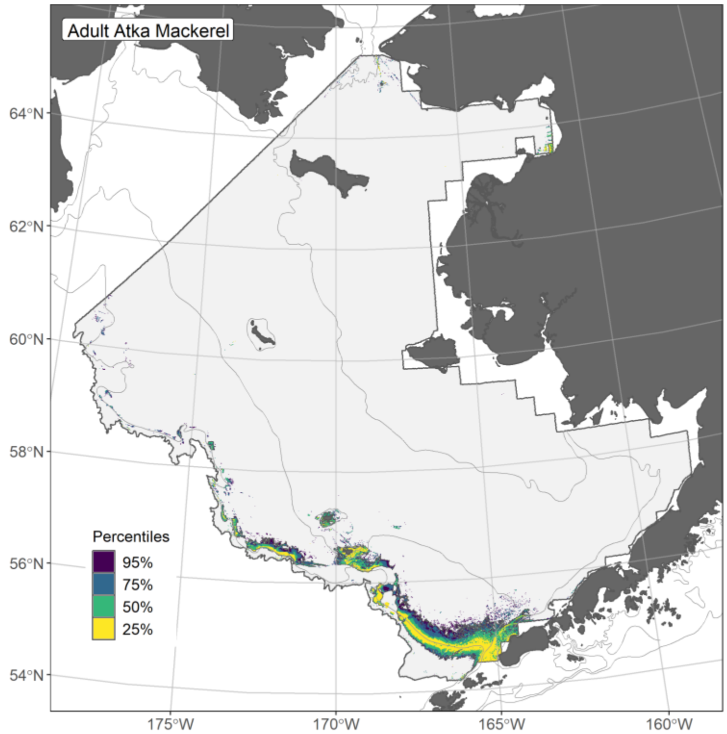

Figure E-23 EFH area of EBS adult Atka mackerel, summer

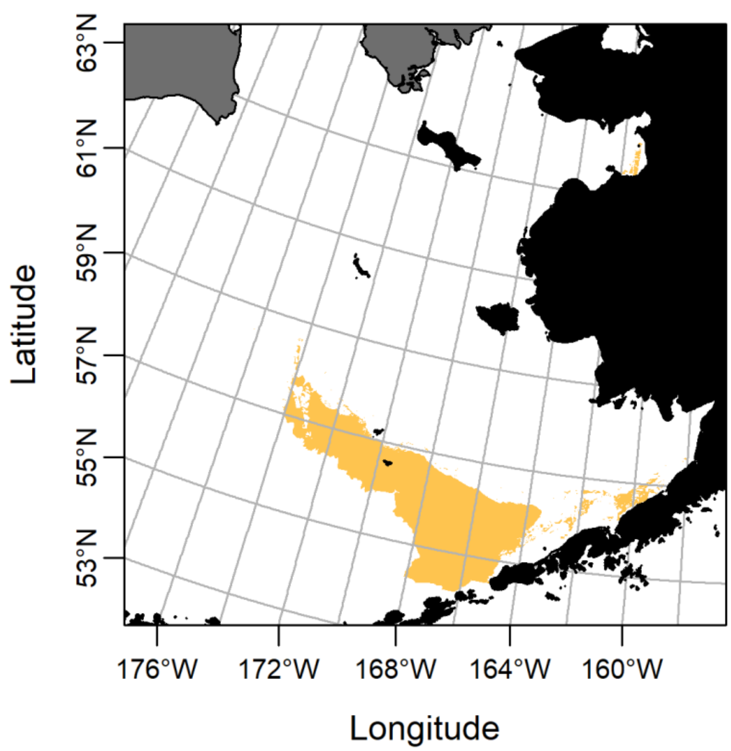

Figure E-24 EFH area of EBS Atka mackerel larvae, summer

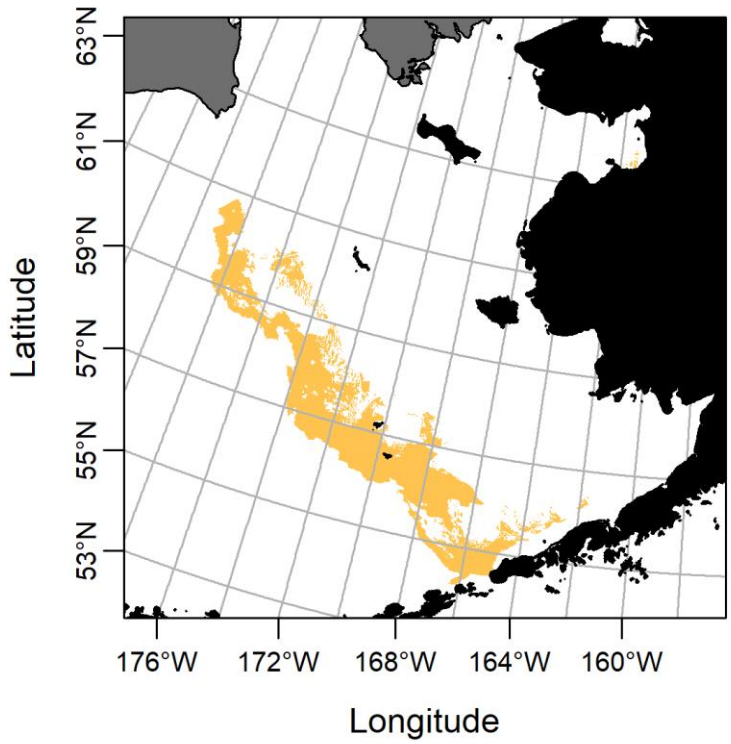

Figure E-25 EFH area of EBS adult Atka mackerel, fall

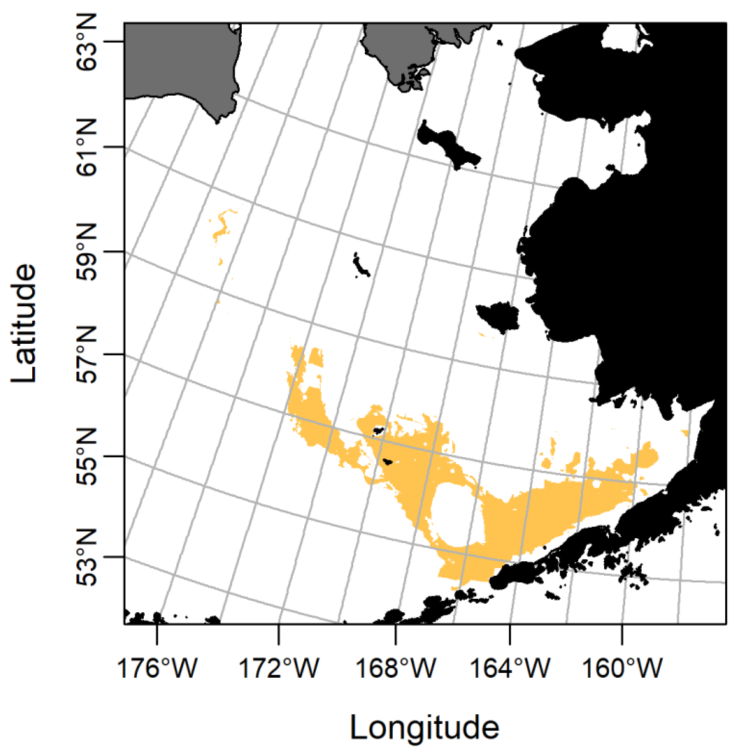

Figure E-26 EFH area of EBS adult Atka mackerel, winter

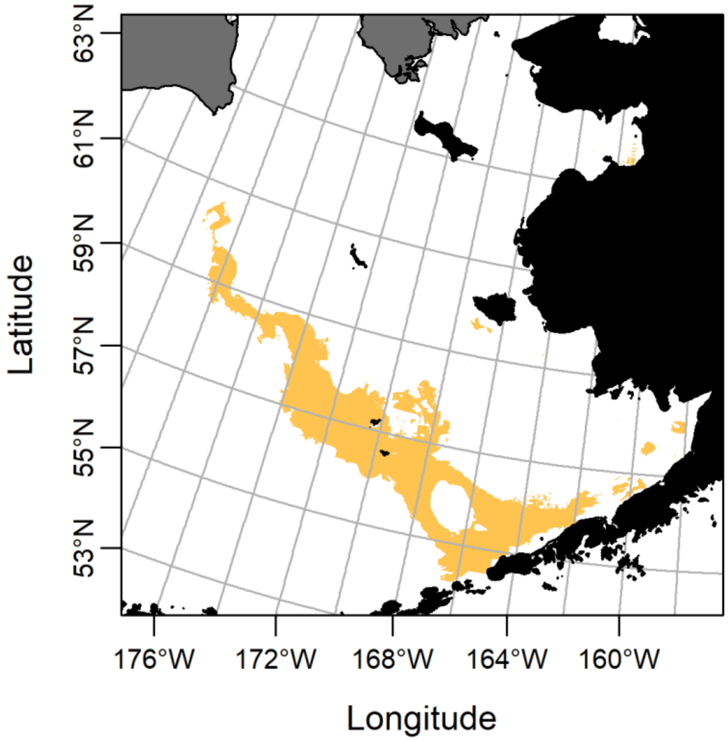

Figure E-27 EFH area of EBS adult Atka mackerel, spring

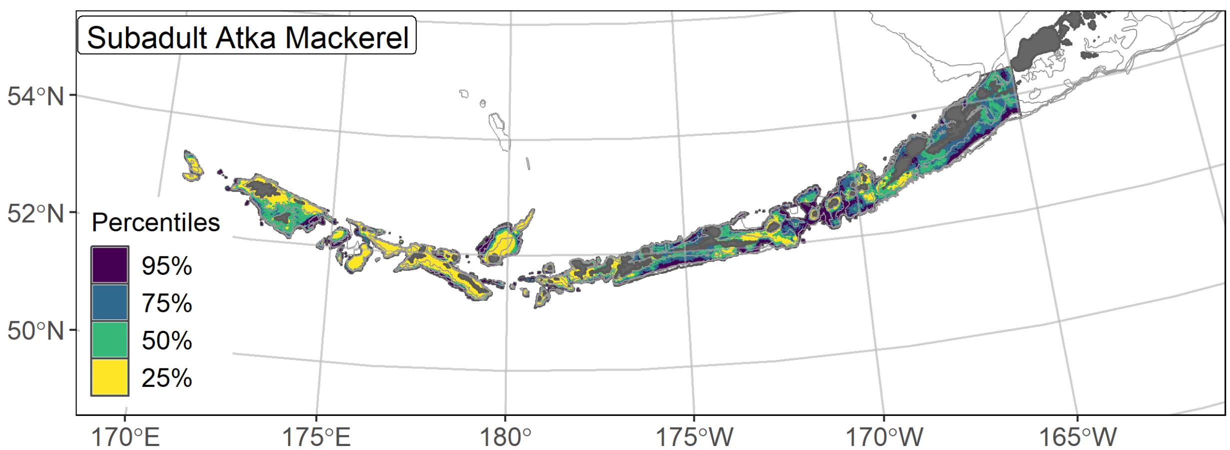

Figure E-28 EFH area of AI subadult Atka mackerel, summer

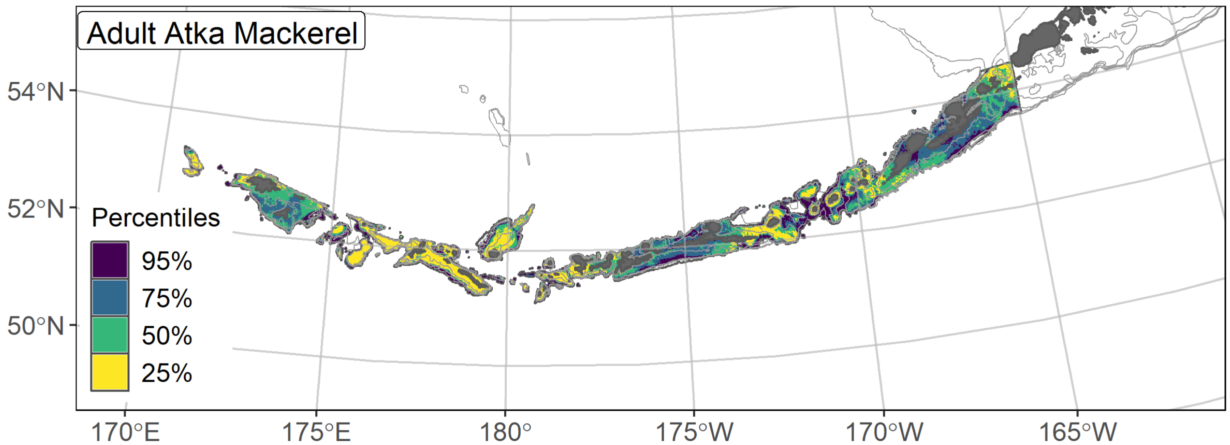

Figure E-29 EFH area of AI adult Atka mackerel, summer

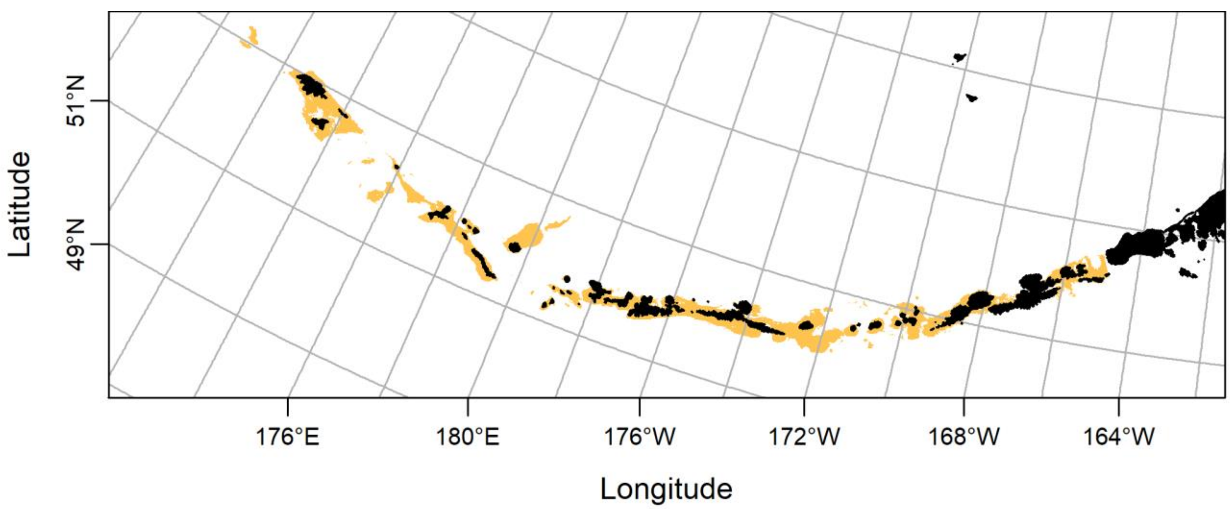

Figure E-30 EFH area of AI Atka mackerel eggs, summer

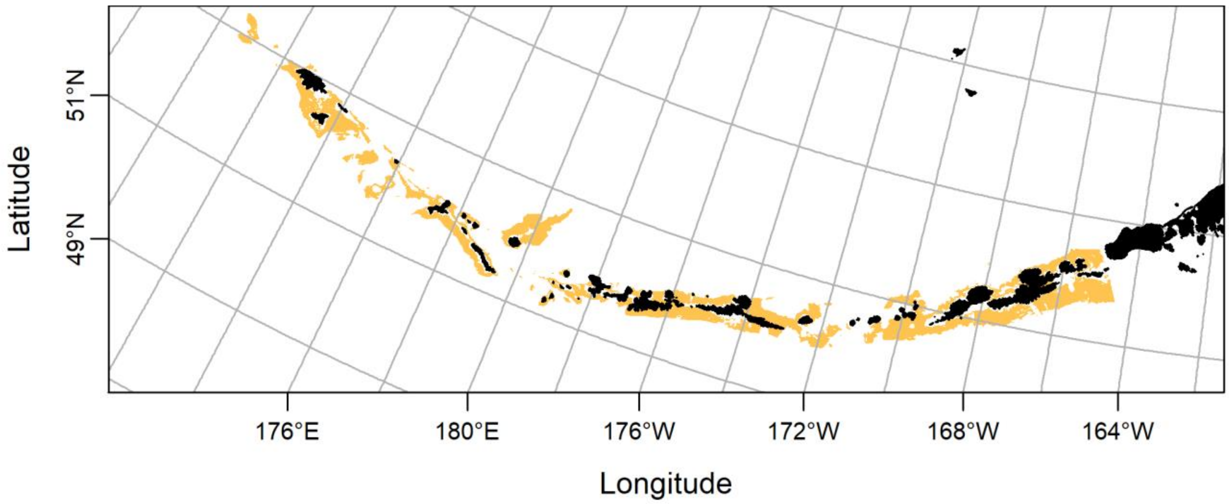

Figure E-31 EFH area of AI adult Atka mackerel, fall

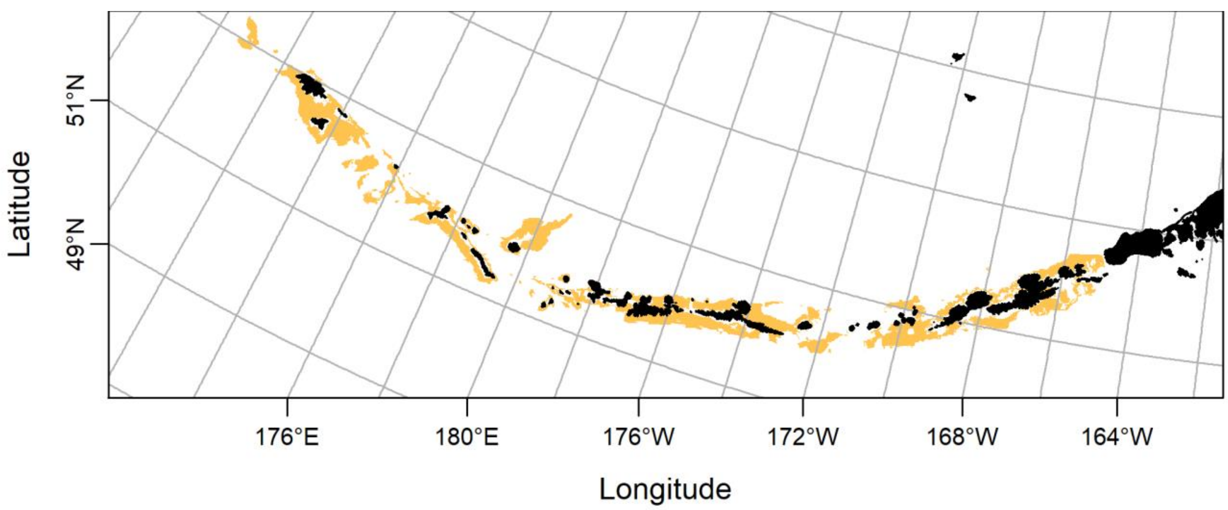

Figure E-32 EFH area of AI adult Atka mackerel, winter

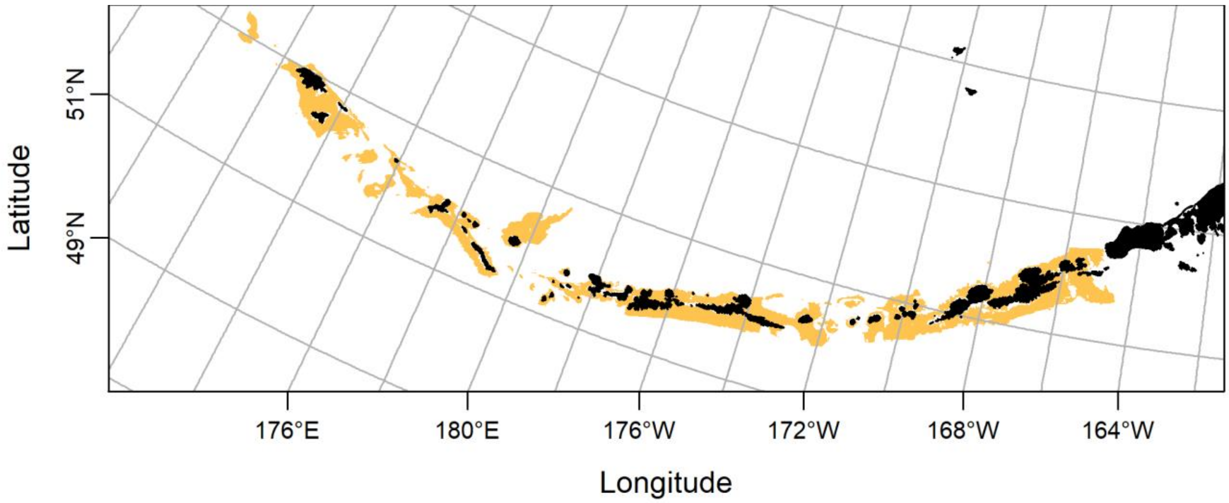

Figure E-33 EFH area of AI adult Atka mackerel, spring

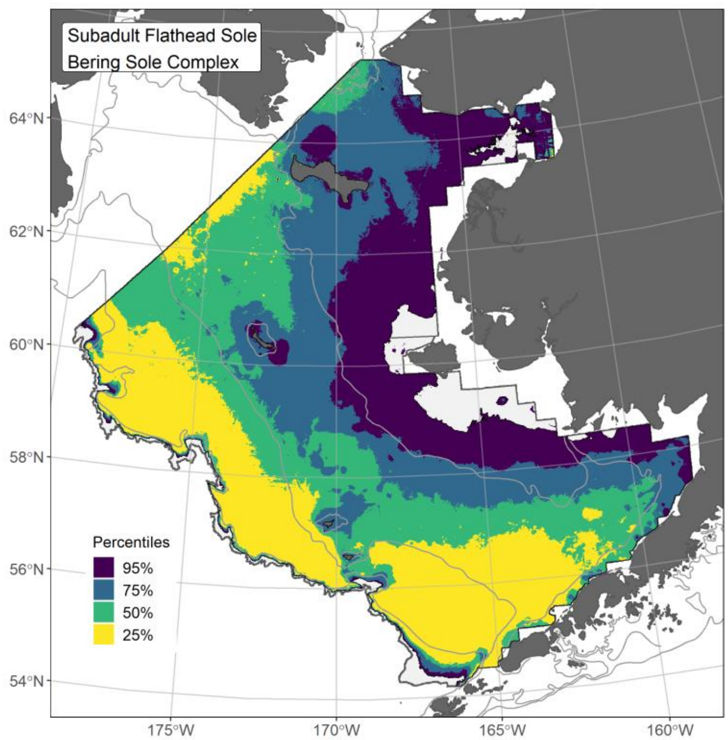

Figure E-34 EFH area of EBS subadult flathead sole/Bering flounder complex, summer

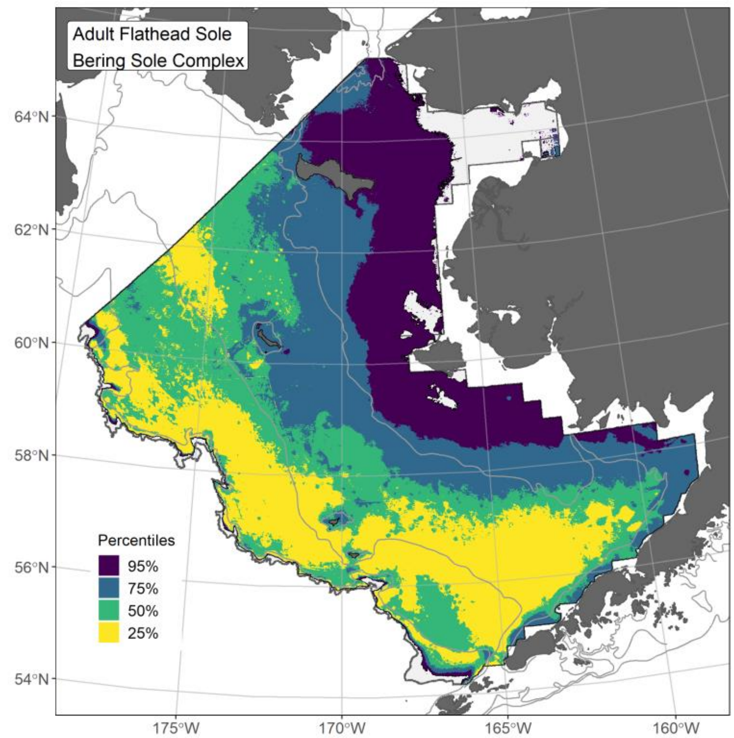

Figure E-35 EFH area of EBS adult flathead sole/Bering flounder complex, summer

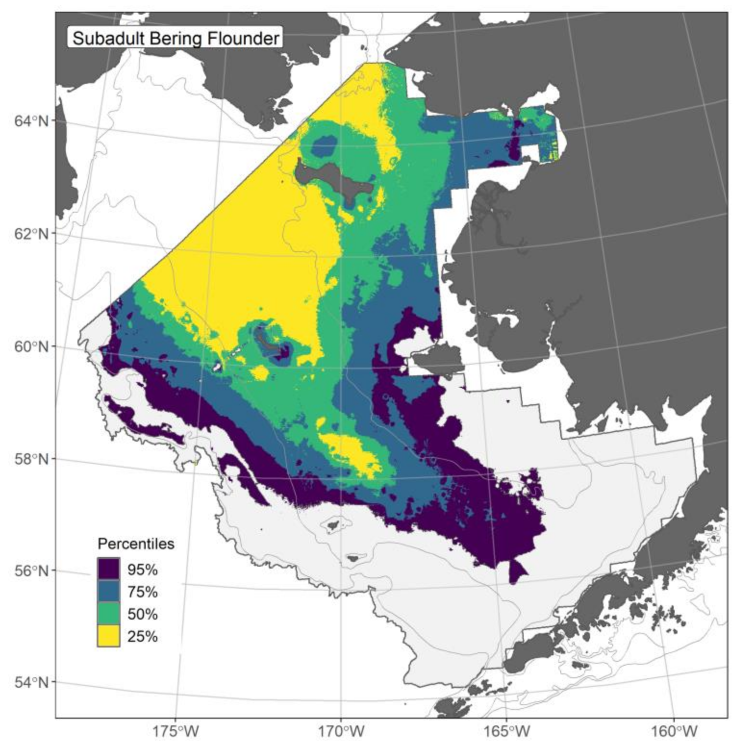

Figure E-36 EFH area of EBS subadult Bering flounder, summer

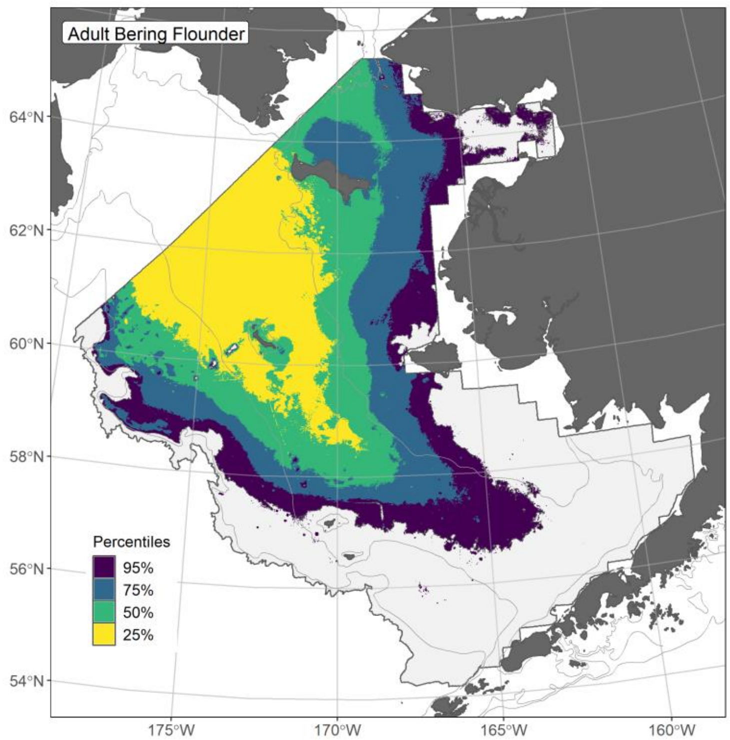

Figure E-37 EFH area of EBS adult Bering flounder, summer

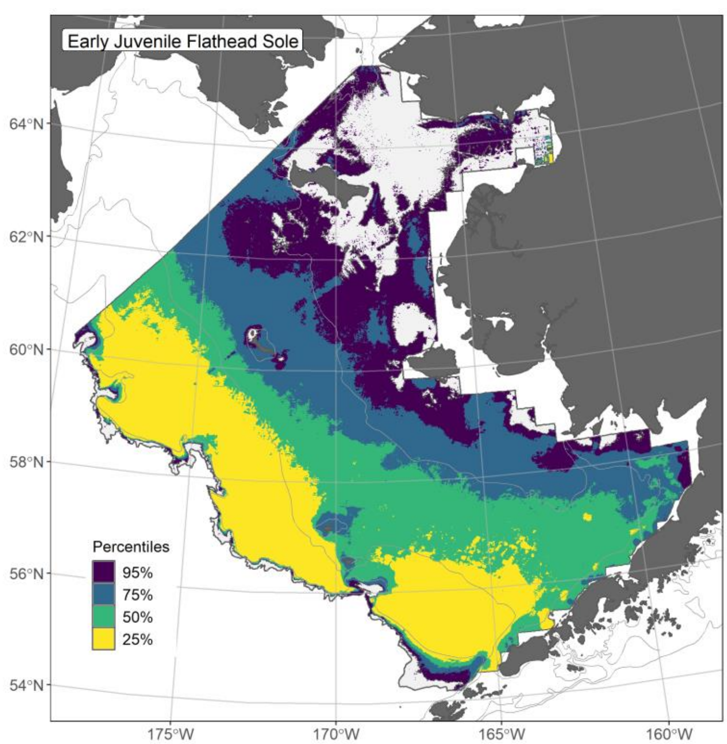

Figure E-38 EFH area of EBS settled early juvenile flathead sole, summer

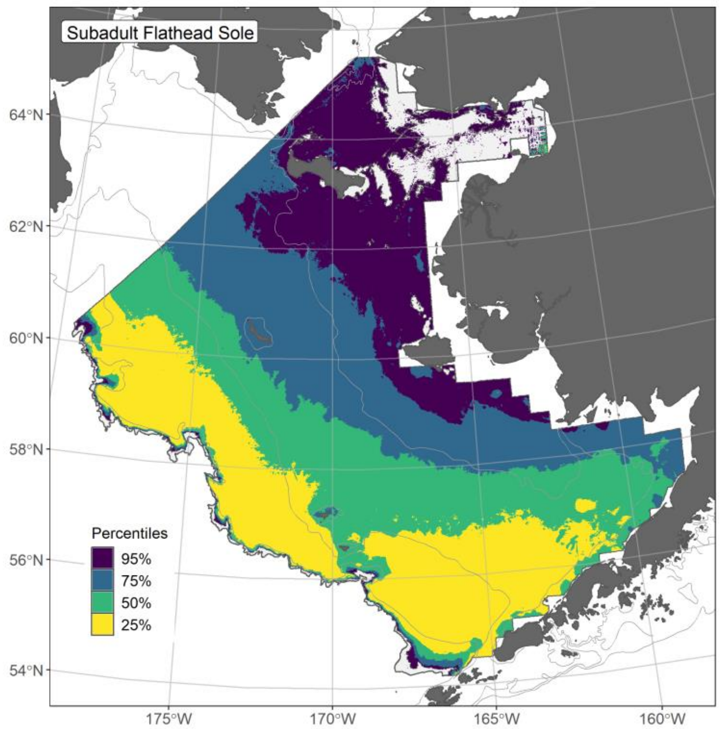

Figure E-39 EFH area of EBS subadult flathead sole, summer

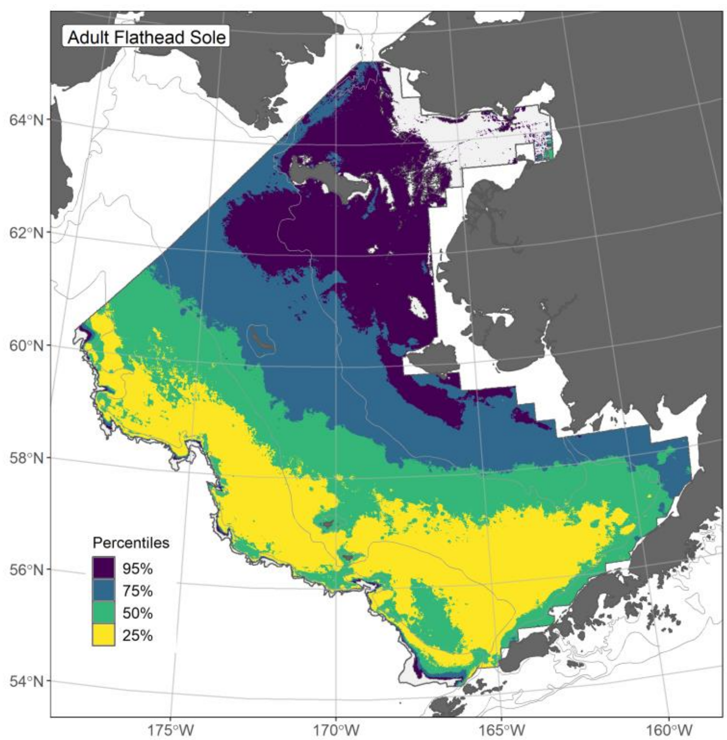

Figure E-40 EFH area of EBS adult flathead sole, summer

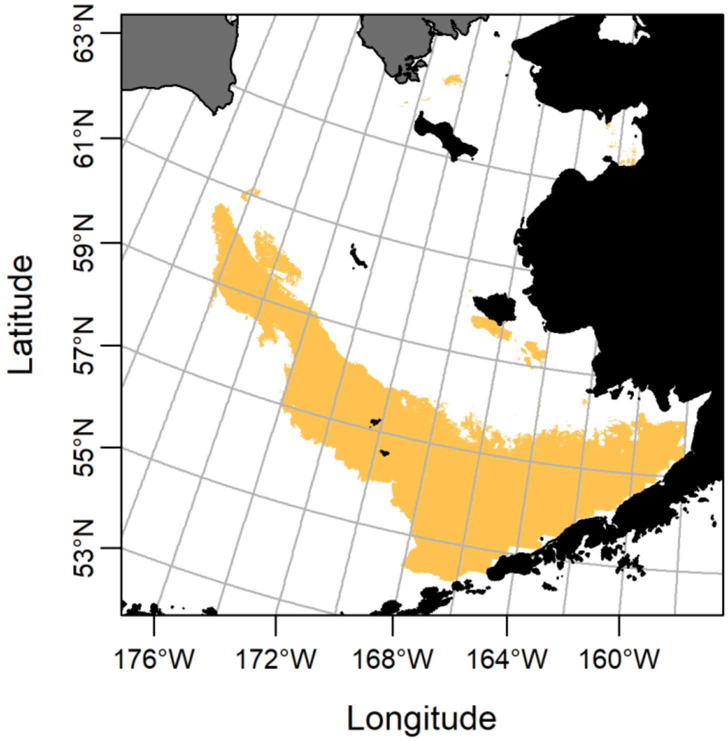

Figure E-41 **EFH area of EBS flathead sole eggs, summer**

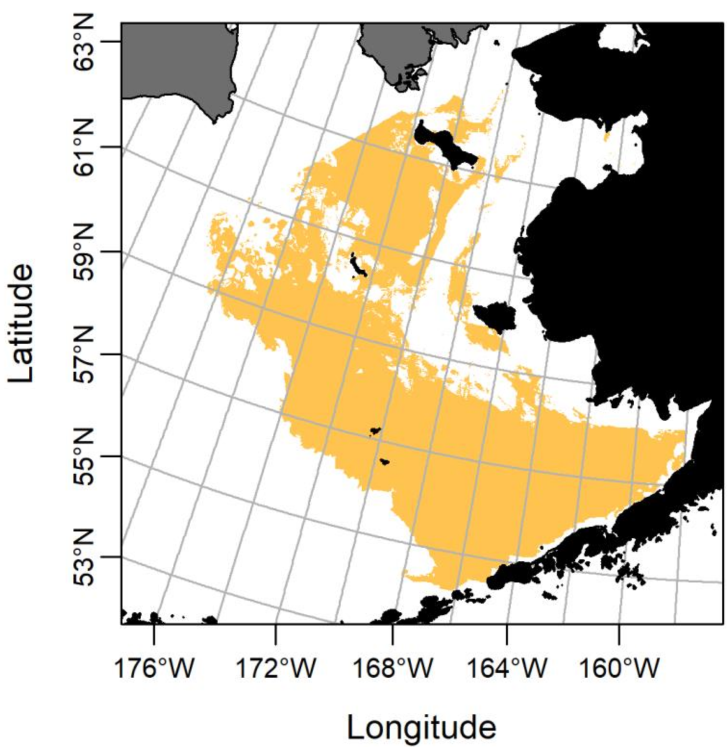

Figure E-42 **EFH area of EBS flathead sole larvae, summer**

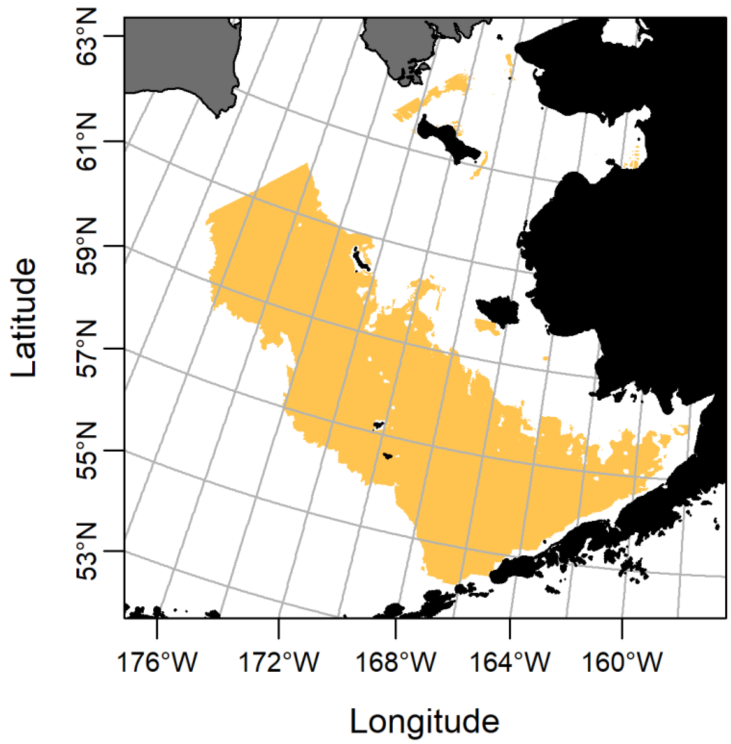

Figure E-43 EFH area of EBS adult flathead sole, fall

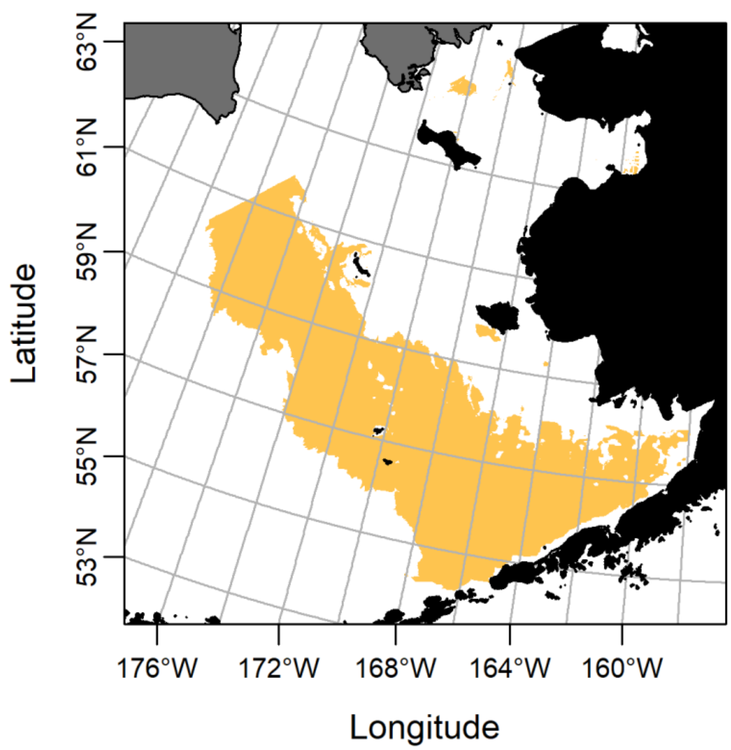

Figure E-44 EFH area of EBS adult flathead sole, winter

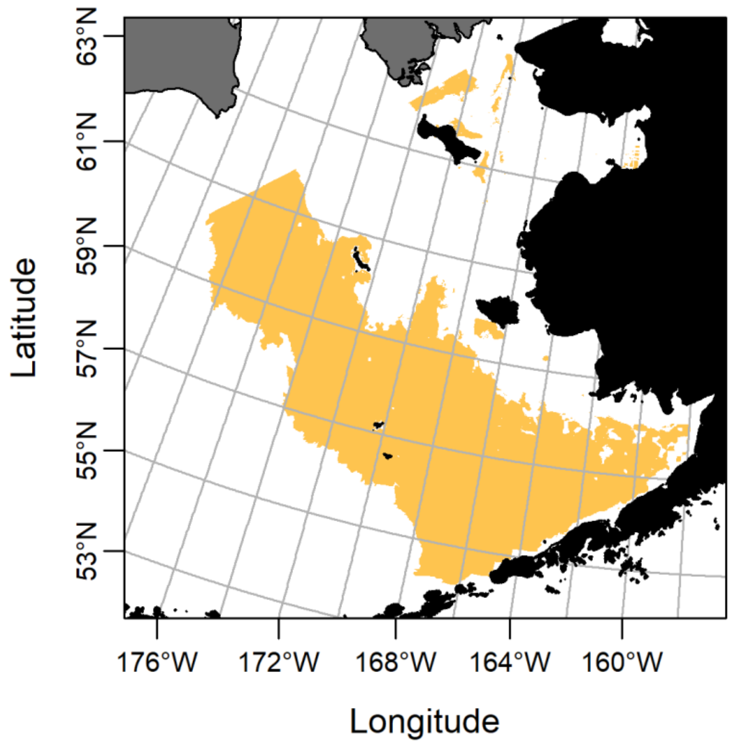

Figure E-45 EFH area of EBS adult flathead sole, spring

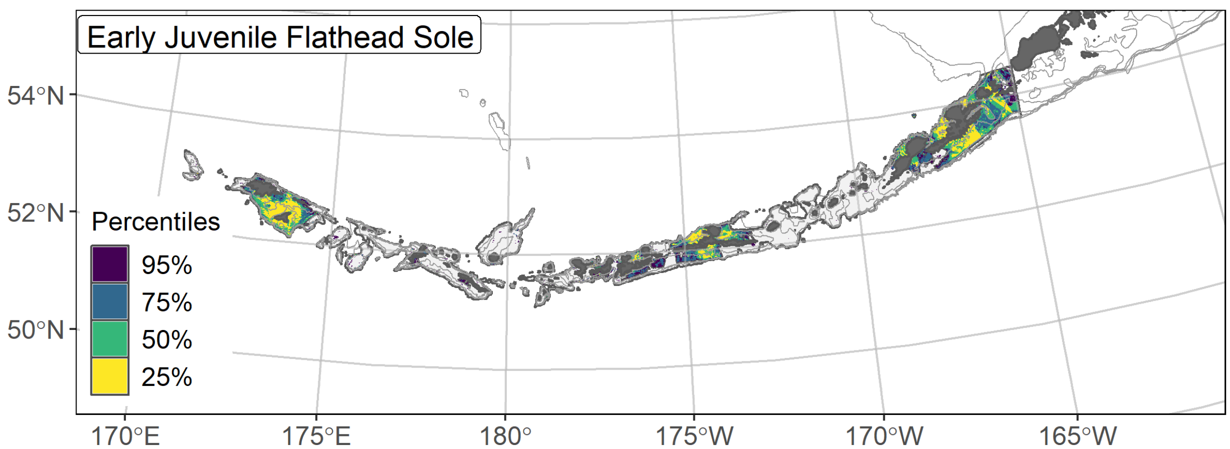

Figure E-46 EFH area of AI settled early juvenile flathead sole, summer

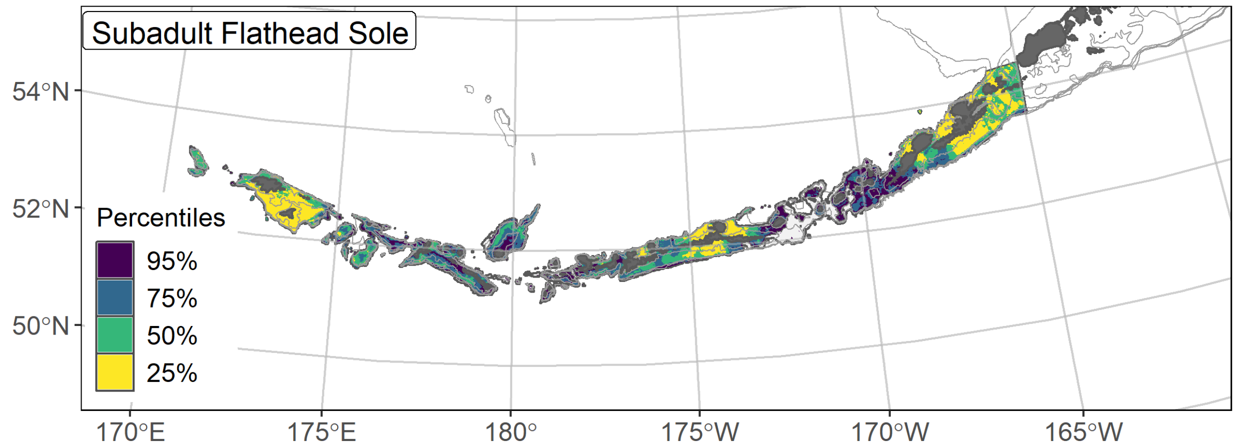

Figure E-47 EFH area of AI subadult flathead sole, summer

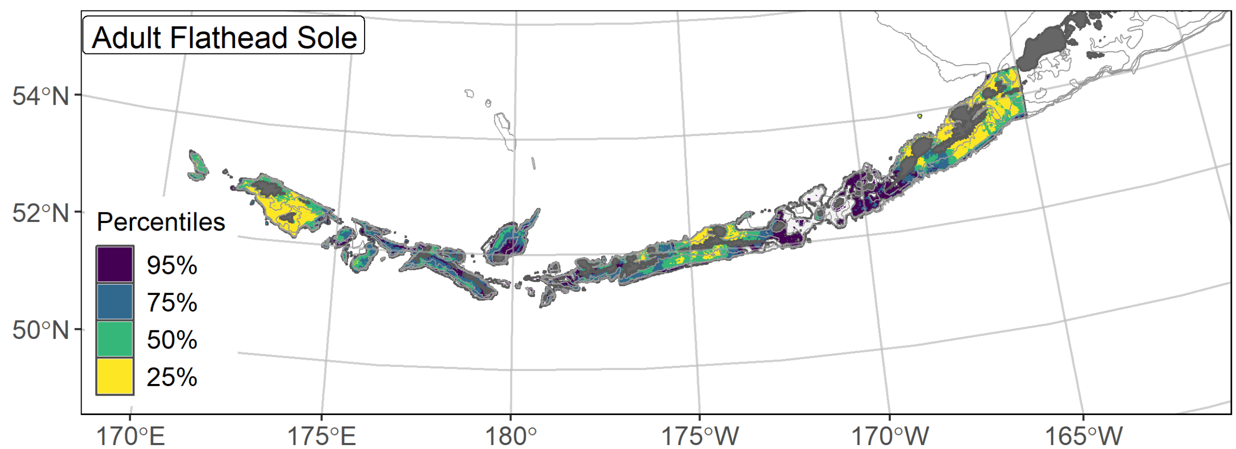

Figure E-48 EFH area of AI adult flathead sole, summer

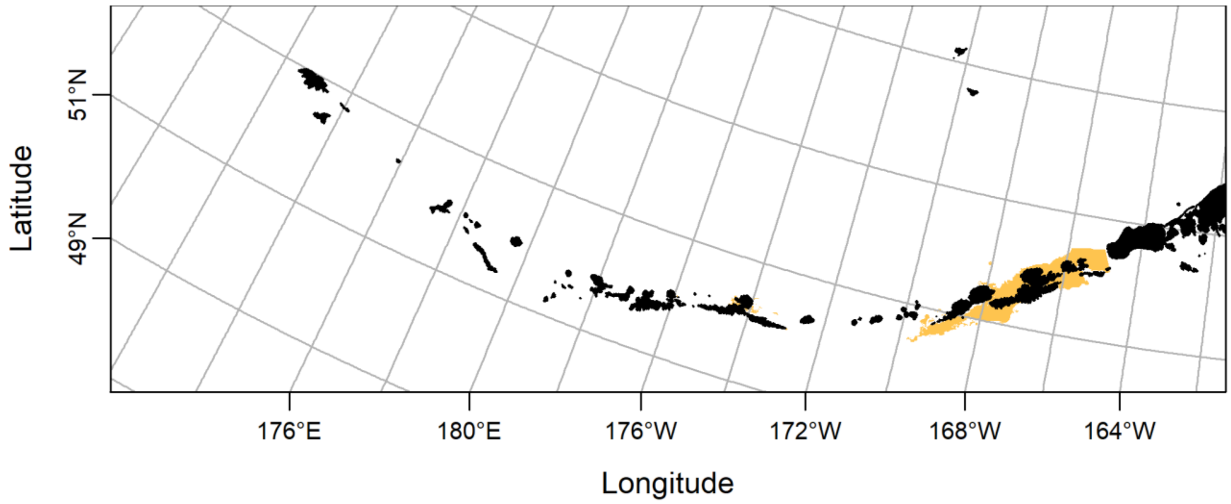

Figure E-49 EFH area of AI flathead sole eggs, summer

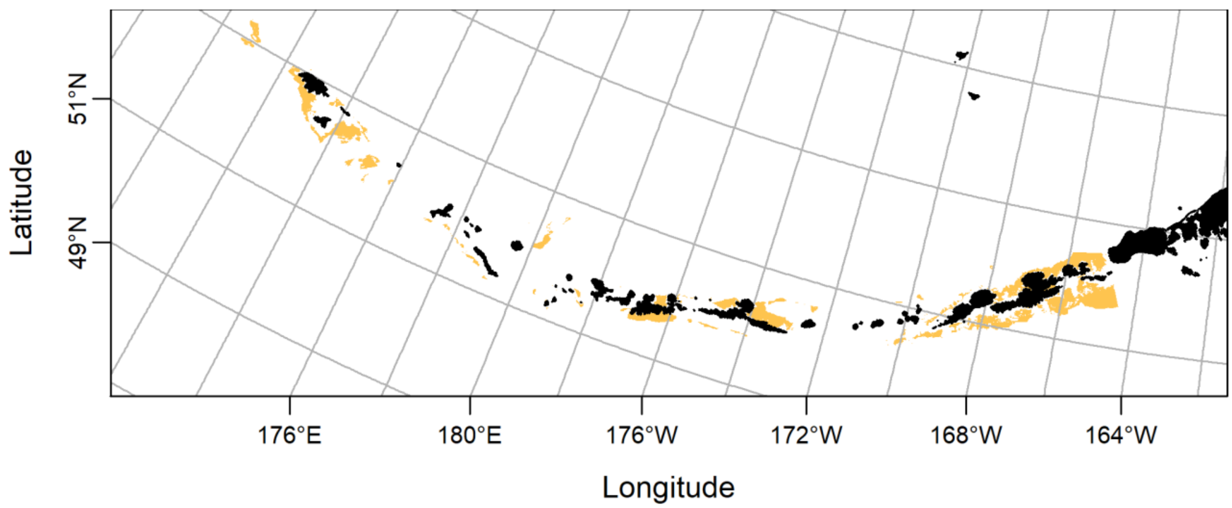

Figure E-50 EFH area of AI adult flathead sole, fall

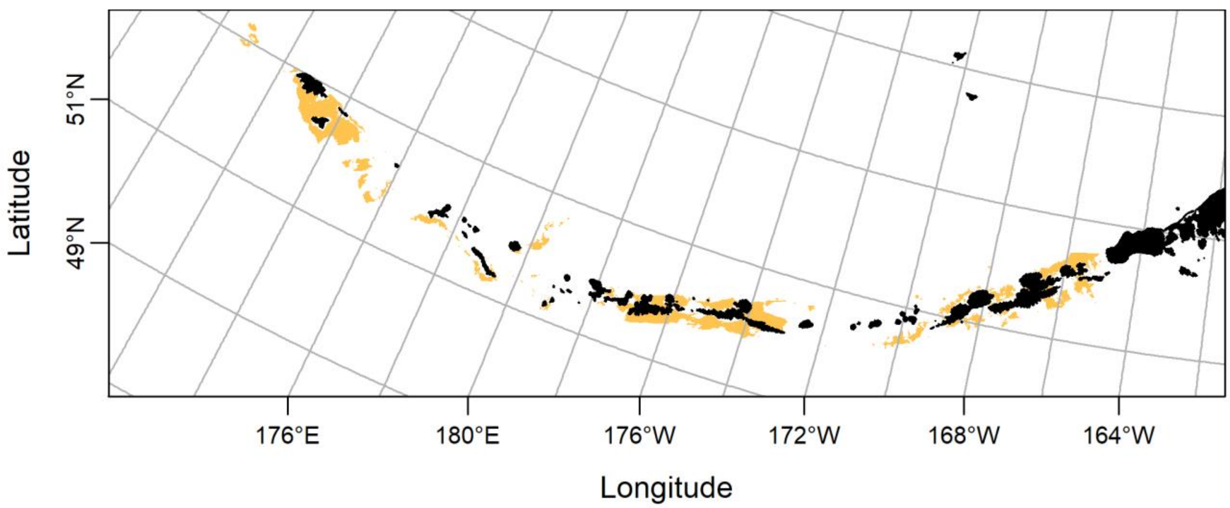

Figure E-51 EFH area of AI adult flathead sole, winter

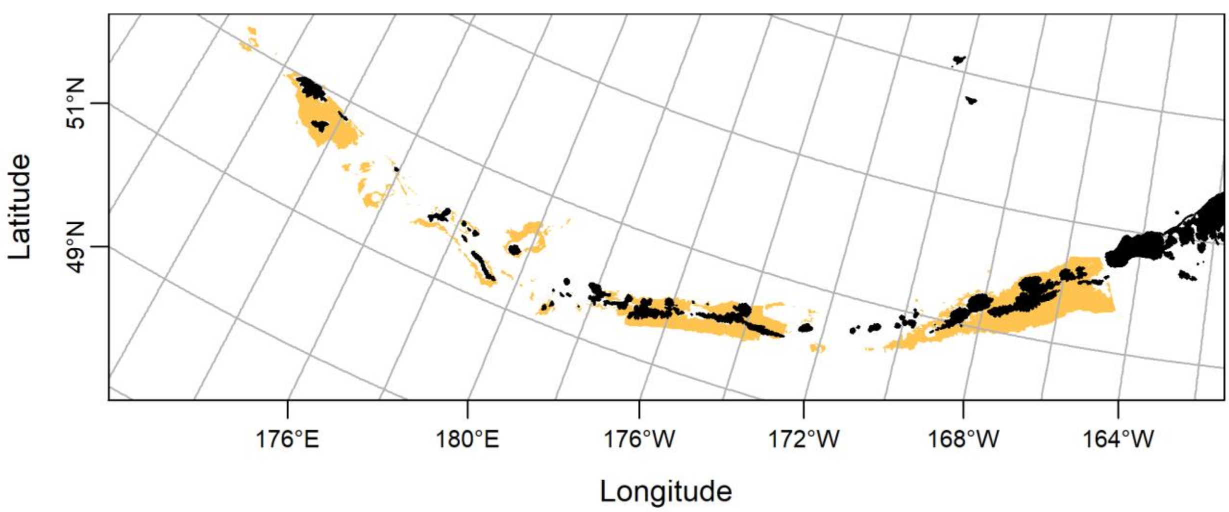

Figure E-52 EFH area of AI adult flathead sole, spring

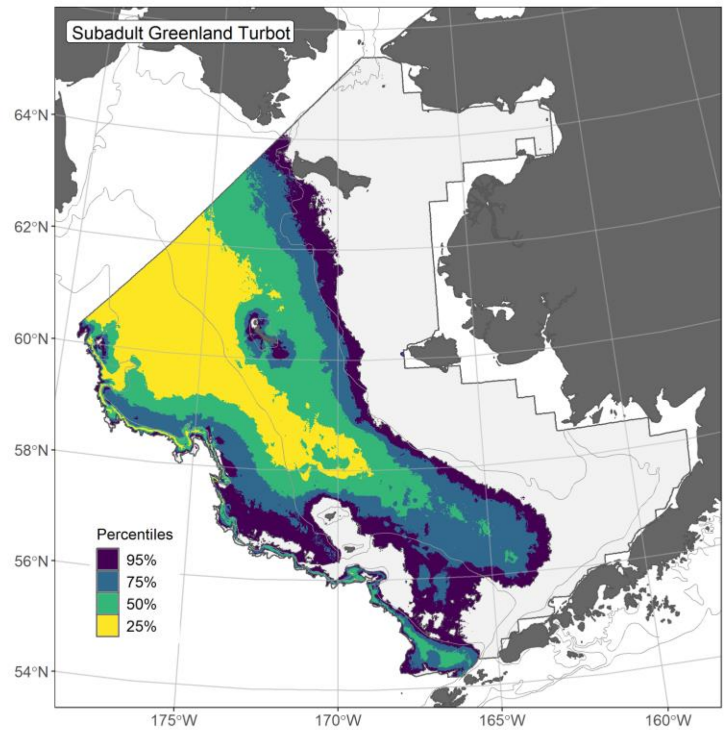

Figure E-53 EFH area of EBS subadult Greenland turbot, summer

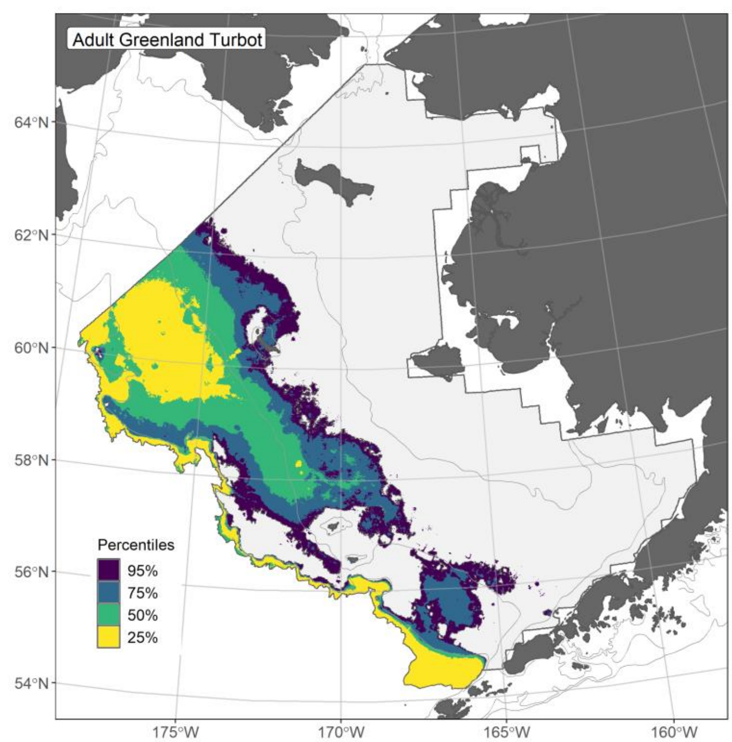

Figure E-54 EFH area of EBS adult Greenland turbot, summer

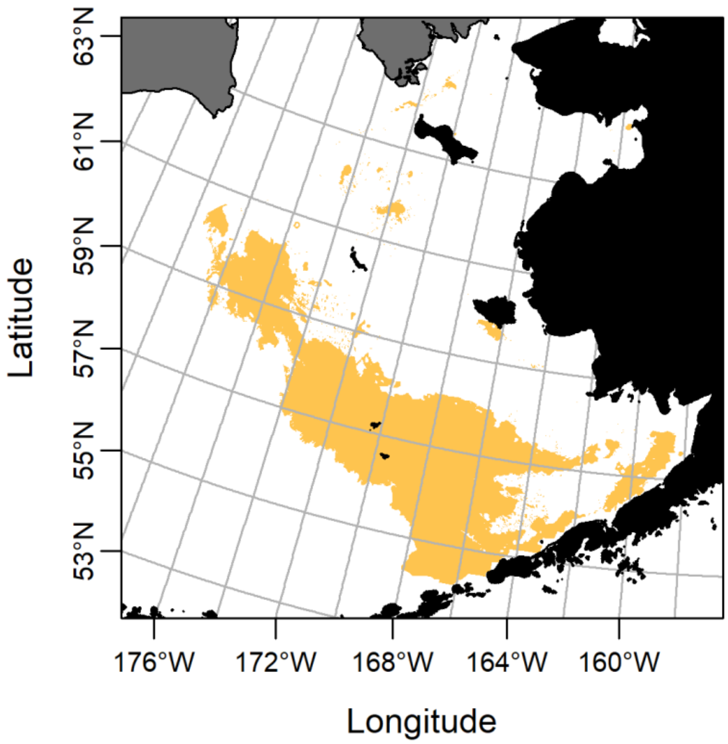

Figure E-55 EFH area of EBS Greenland turbot larvae, summer

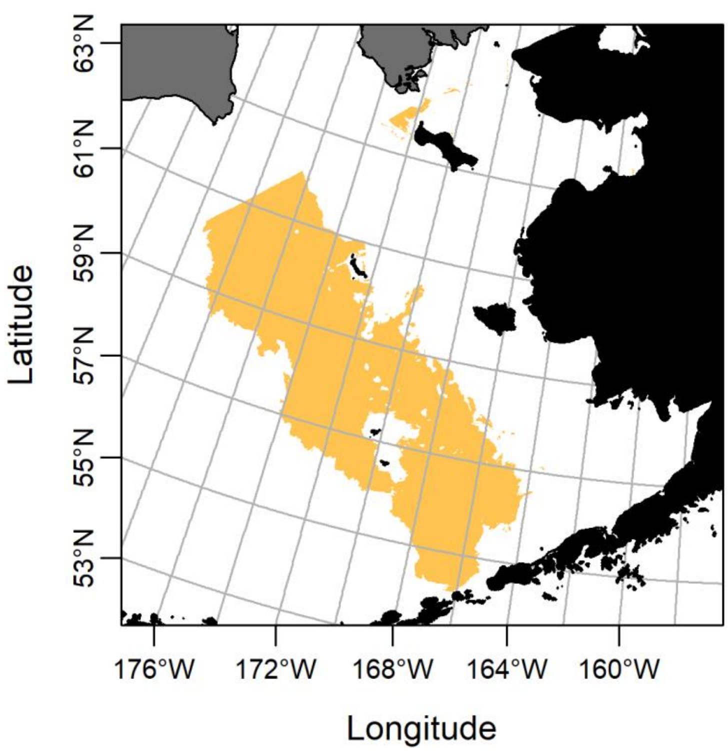

Figure E-56 EFH area of EBS adult Greenland turbot, fall

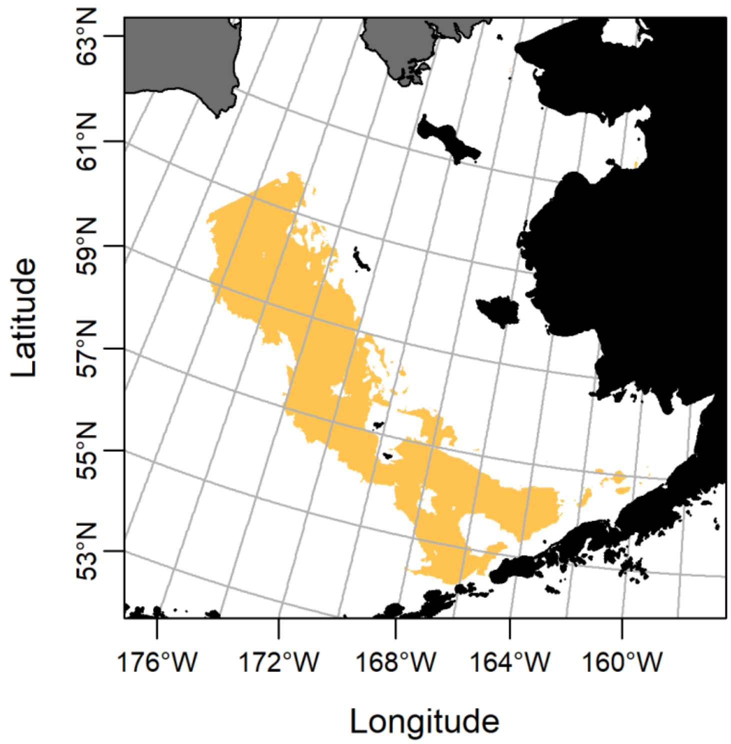

Figure E-57 EFH area of EBS adult Greenland turbot, winter

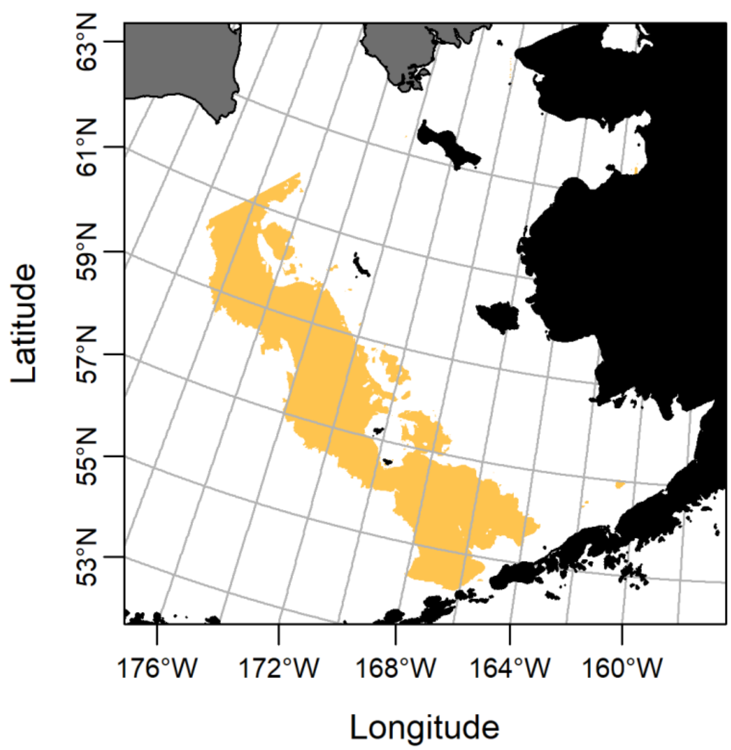

Figure E-58 EFH area of EBS adult Greenland turbot, spring

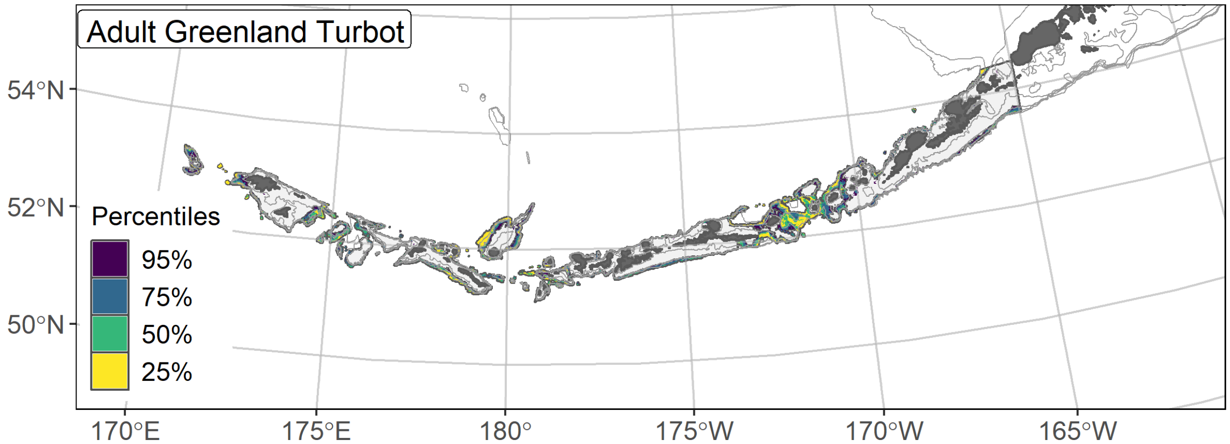

Figure E-59 EFH area of AI adult Greenland turbot, summer

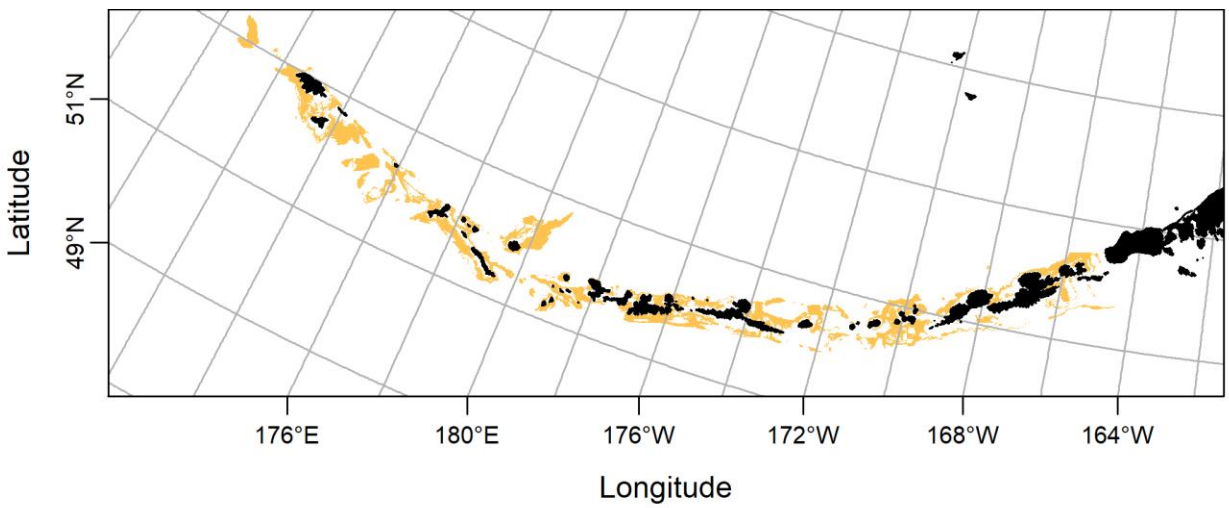

Figure E-60 EFH area of AI adult Greenland turbot, fall

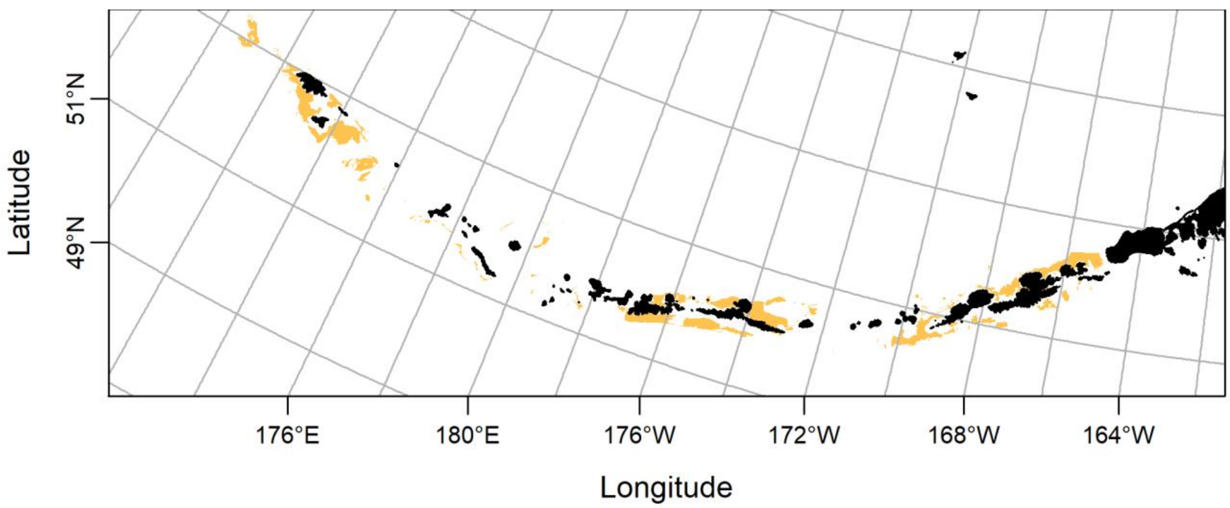

Figure E-61 EFH area of AI adult Greenland turbot, winter

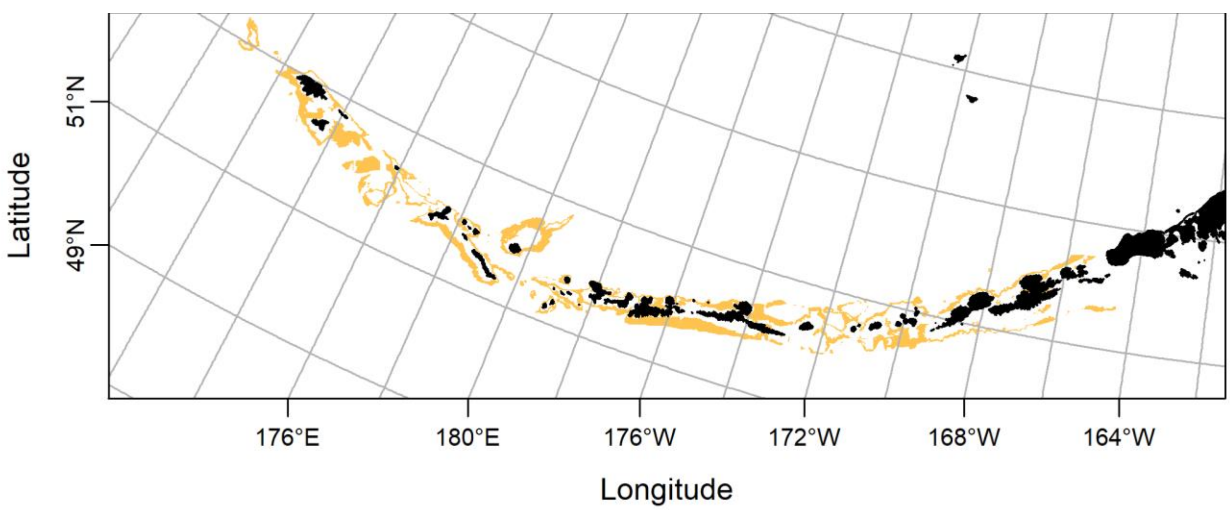

Figure E-62 EFH area of AI adult Greenland turbot, spring

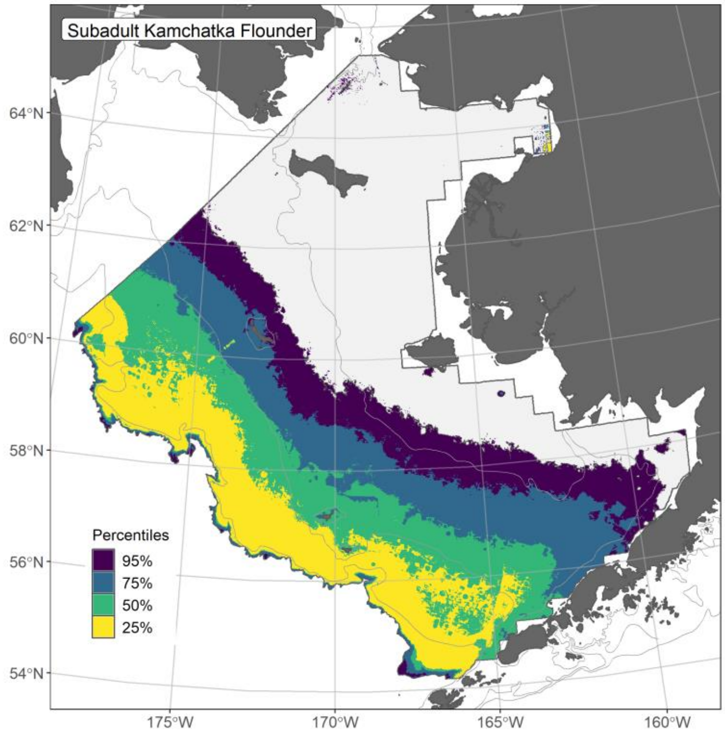

Figure E-63 EFH area of EBS subadult Kamchatka flounder, summer

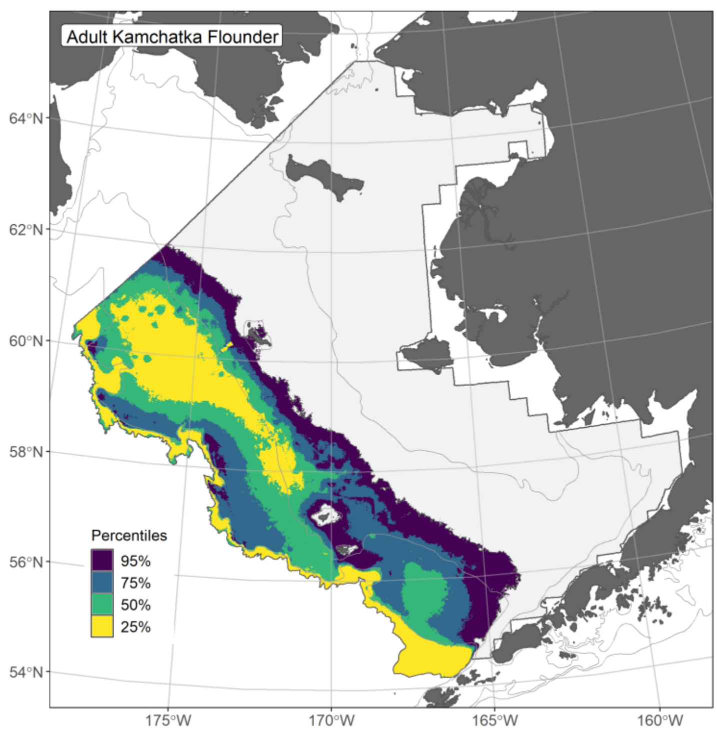

Figure E-64 EFH area of EBS adult Kamchatka flounder, summer

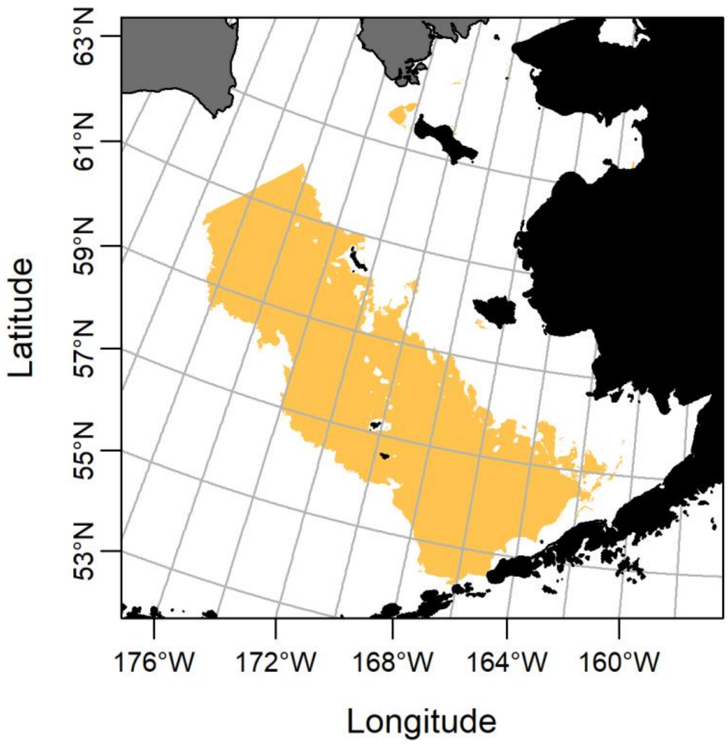

Figure E-65 EFH area of EBS adult Kamchatka flounder, fall

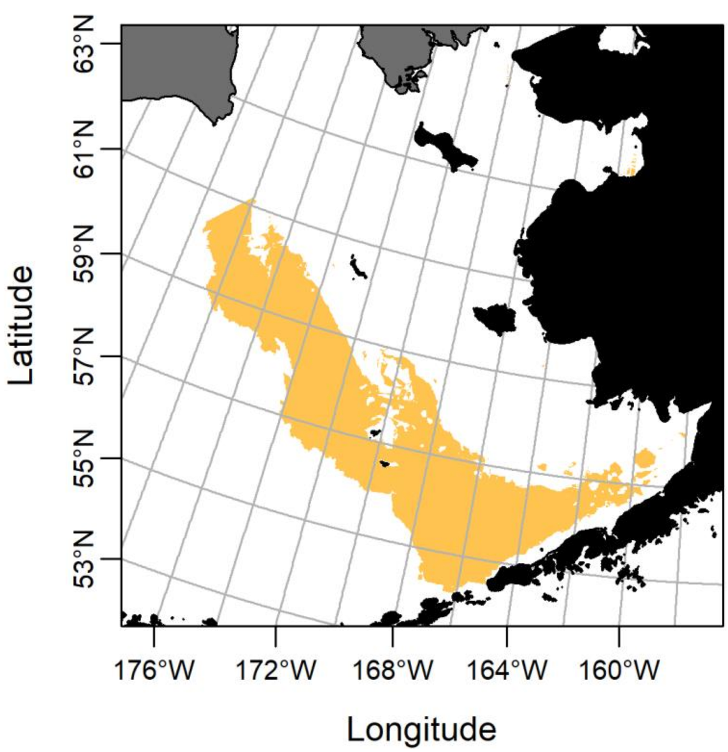

Figure E-66 EFH area of EBS adult Kamchatka flounder, winter

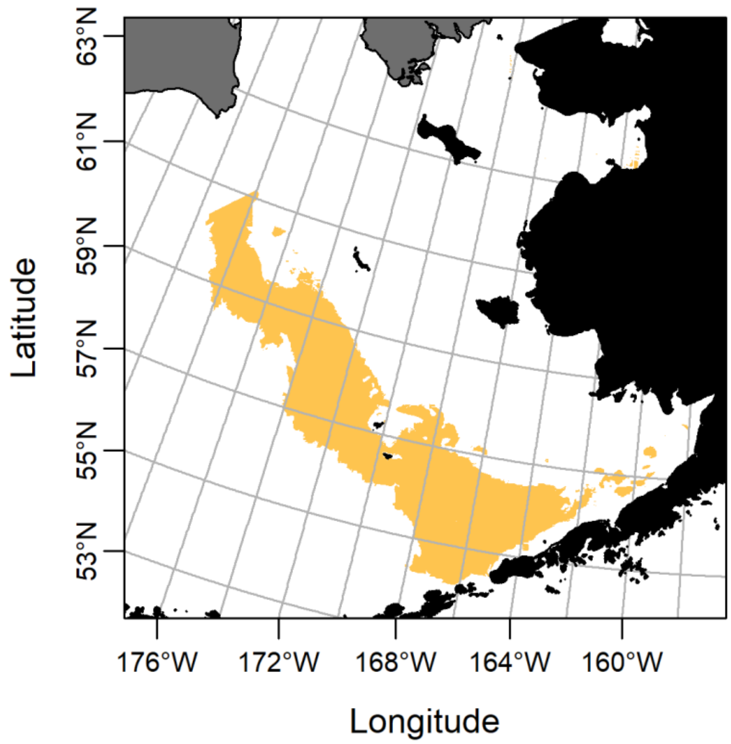

Figure E-67 EFH area of EBS adult Kamchatka flounder, spring

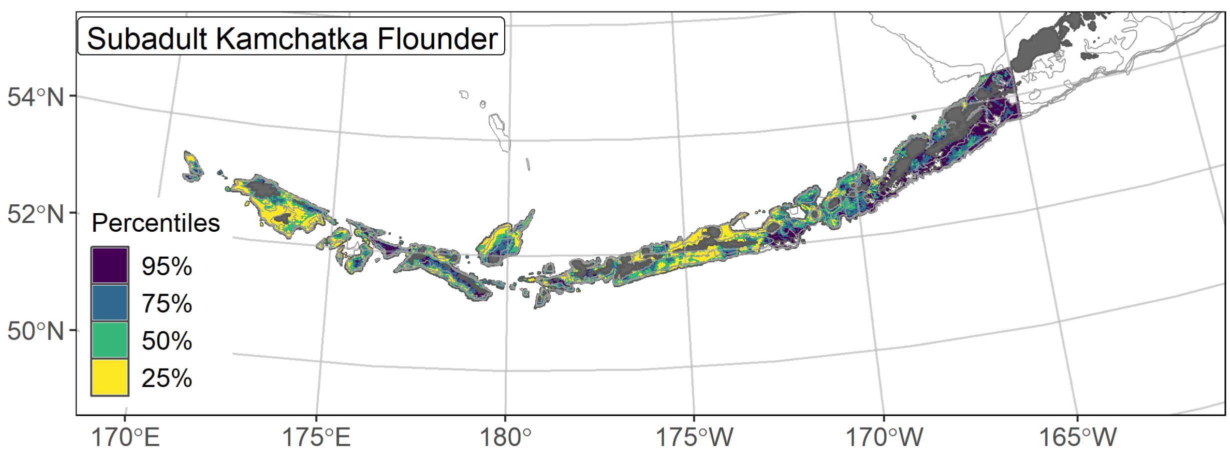

Figure E-68 EFH area of AI subadult Kamchatka flounder, summer

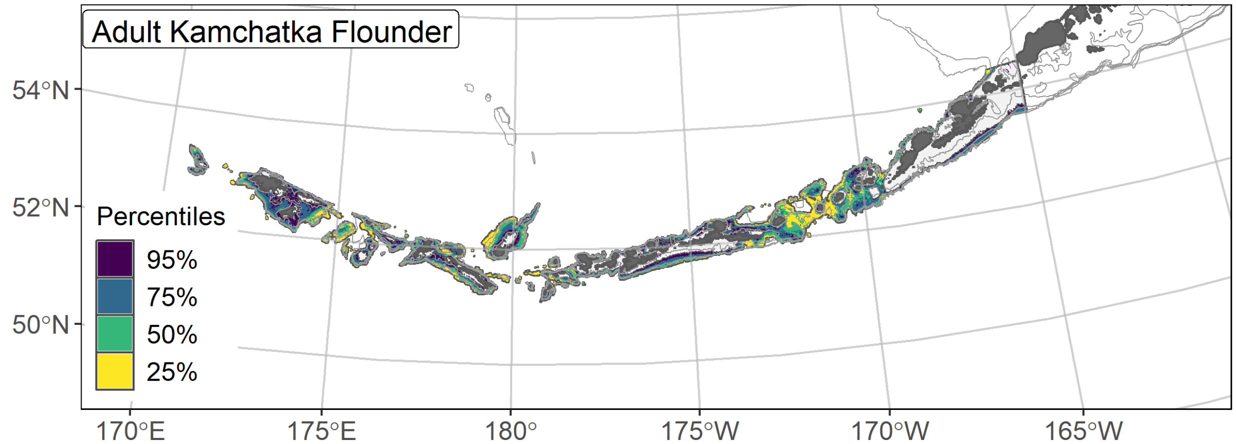

Figure E-69 EFH area of AI adult Kamchatka flounder, summer

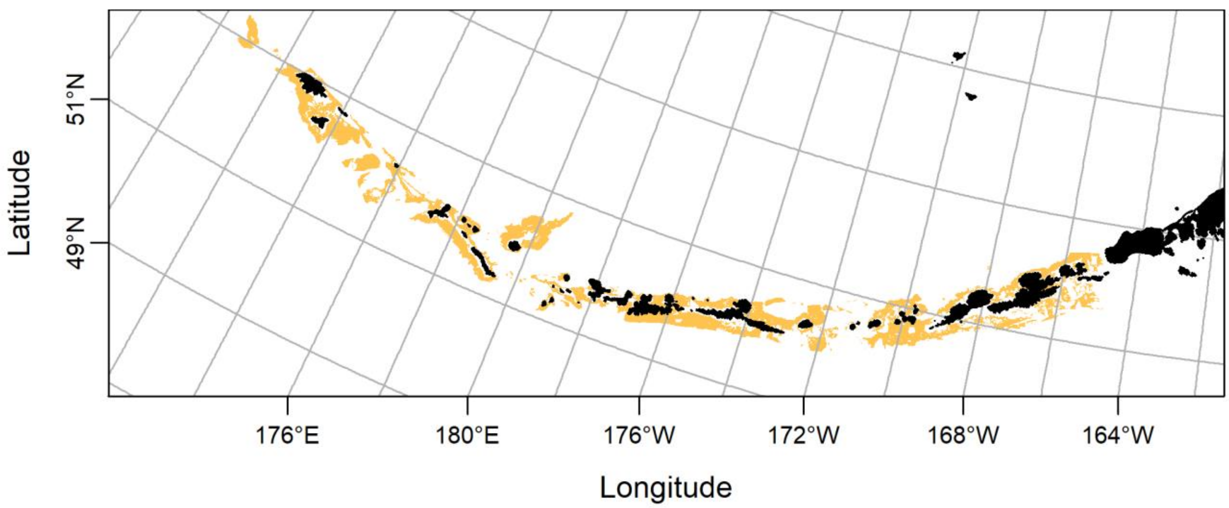

Figure E-70 EFH area of AI adult Kamchatka flounder, fall

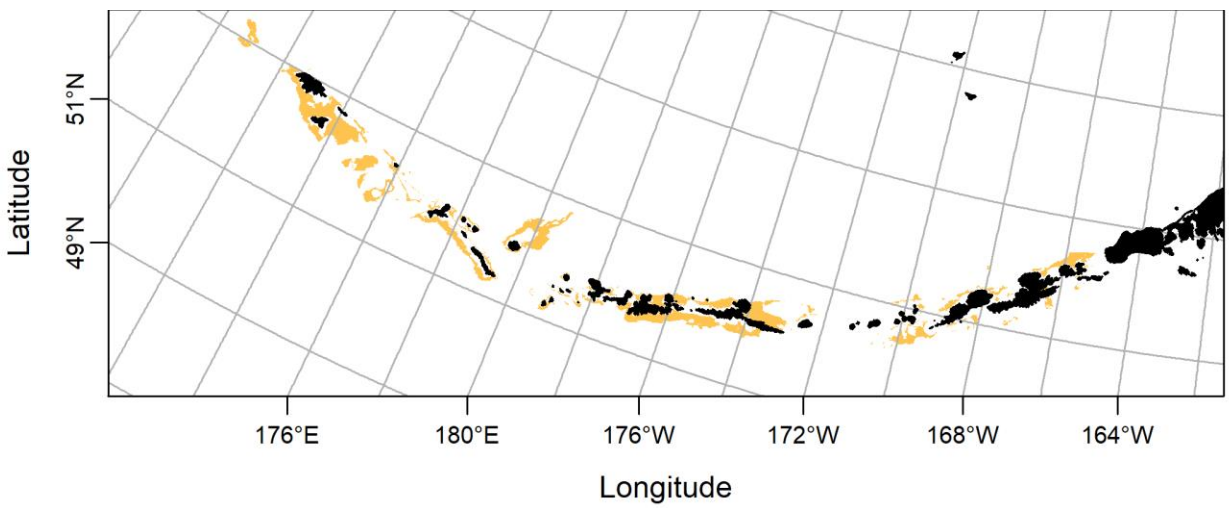

Figure E-71 EFH area of AI adult Kamchatka flounder, winter

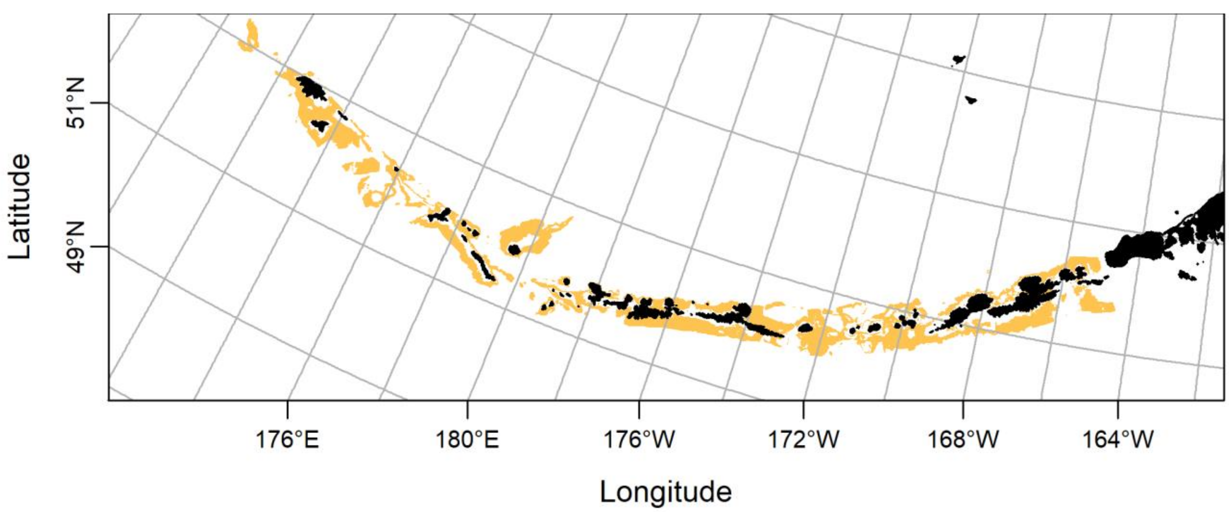

Figure E-72 EFH area of AI adult Kamchatka flounder, spring

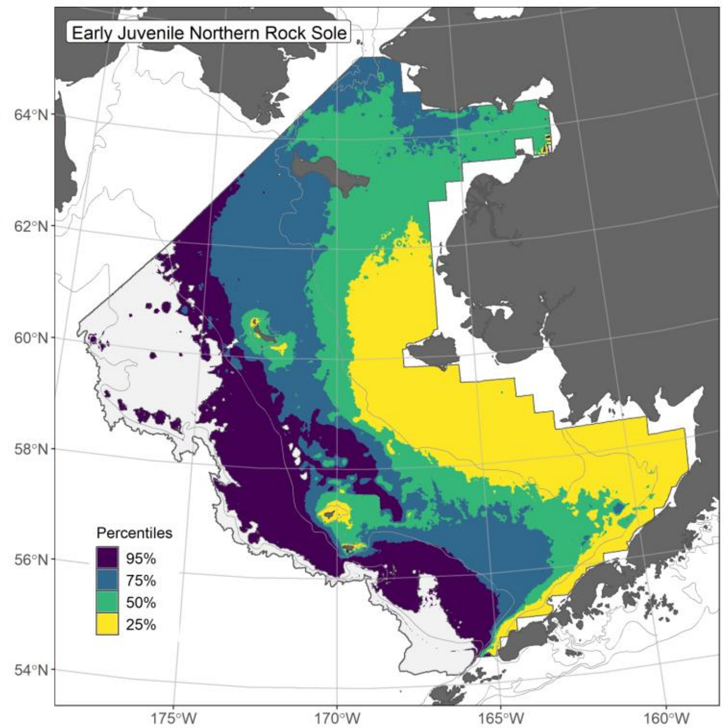

Figure E-73 EFH area of EBS settled early juvenile northern rock sole, summer

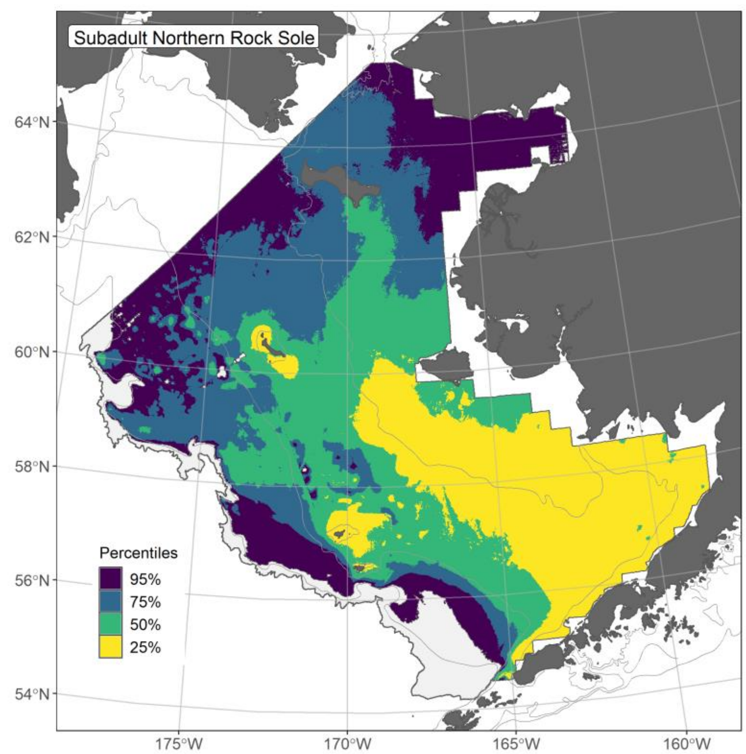

Figure E-74 EFH area of EBS subadult northern rock sole, summer

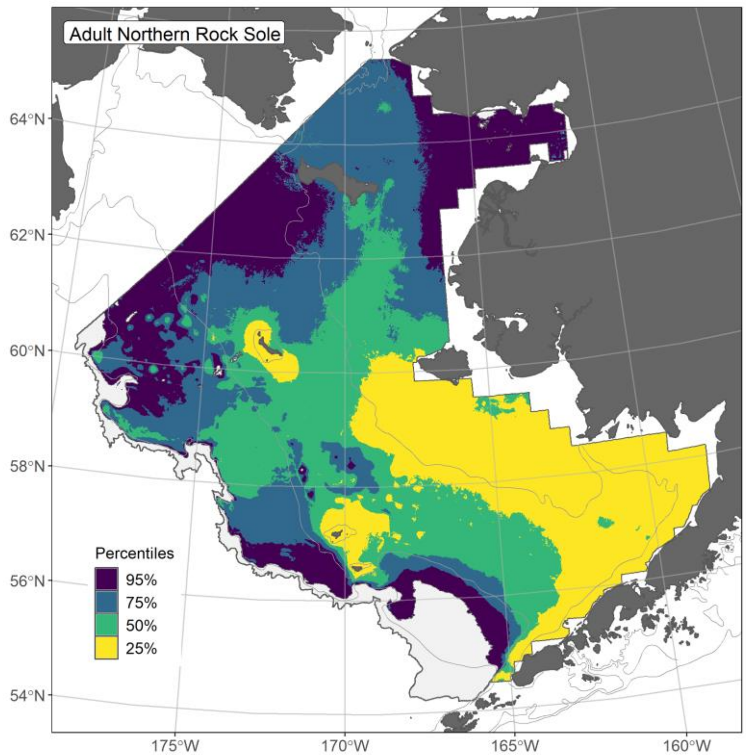

Figure E-75 EFH area of EBS adult northern rock sole, summer

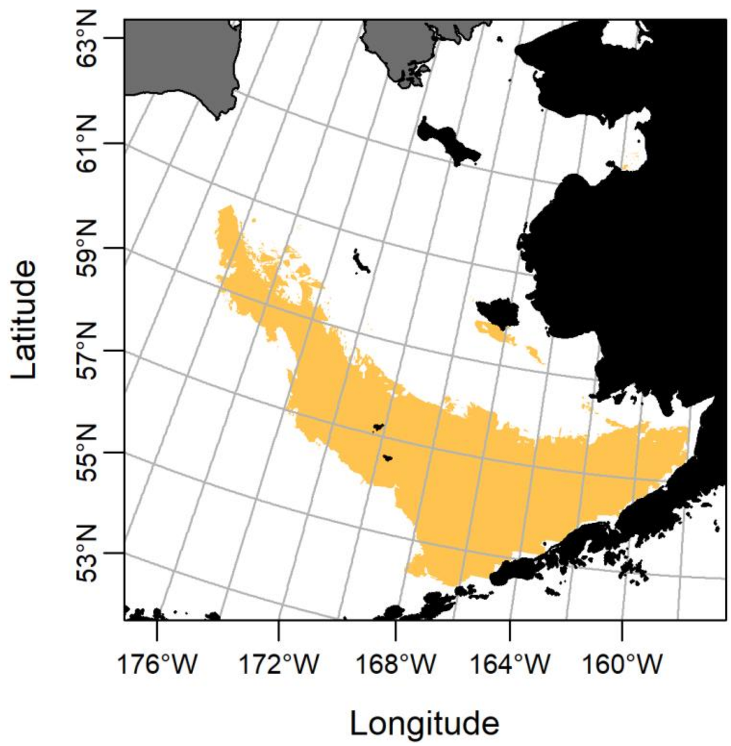

Figure E-76 EFH area of EBS larval northern rock sole, summer

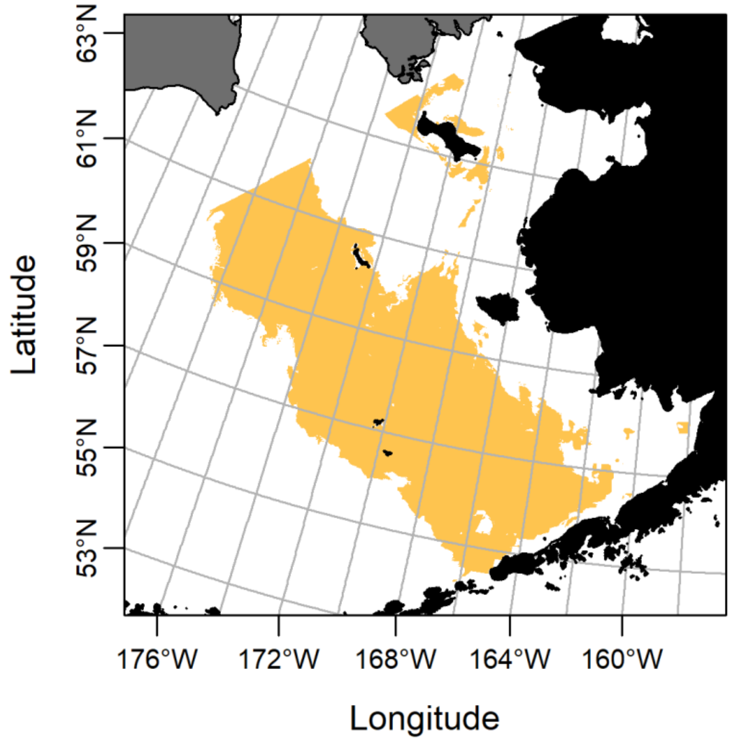

Figure E-77 EFH area of EBS adult northern rock sole, fall

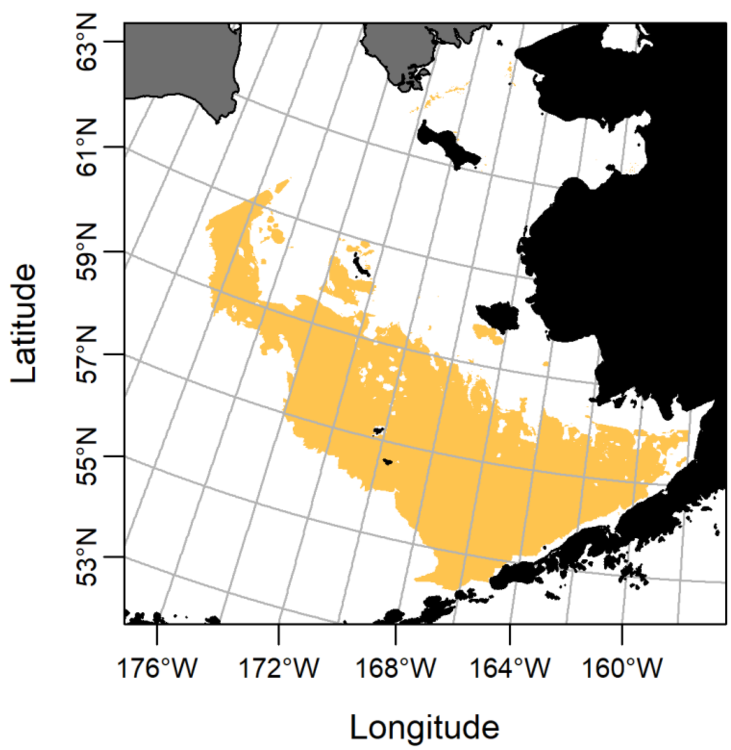

Figure E-78 EFH area of EBS adult northern rock sole, winter

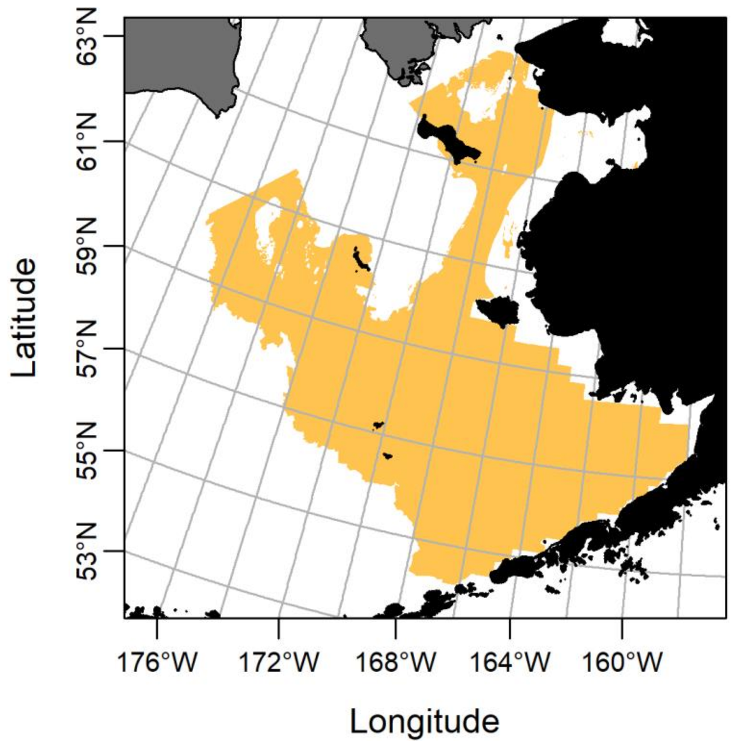

Figure E-79 EFH area of EBS adult northern rock sole, spring

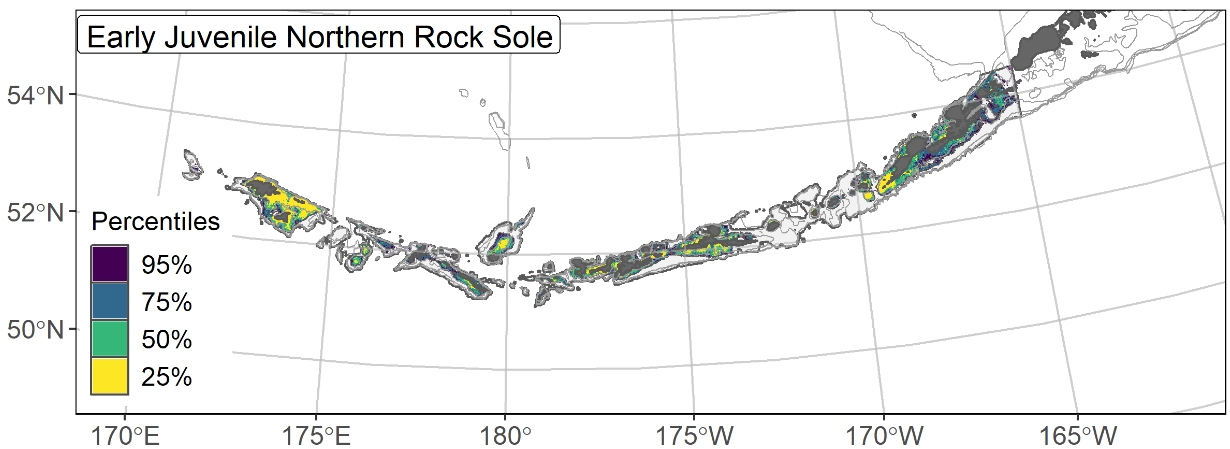

Figure E-80 EFH area of AI settled early juvenile northern rock sole, summer

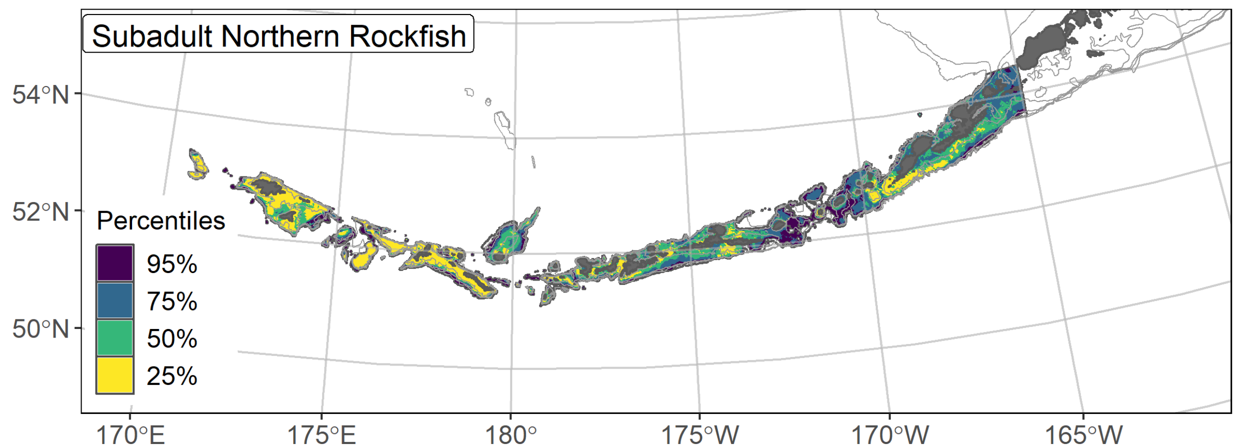

Figure E-81 EFH area of AI subadult northern rock sole, summer

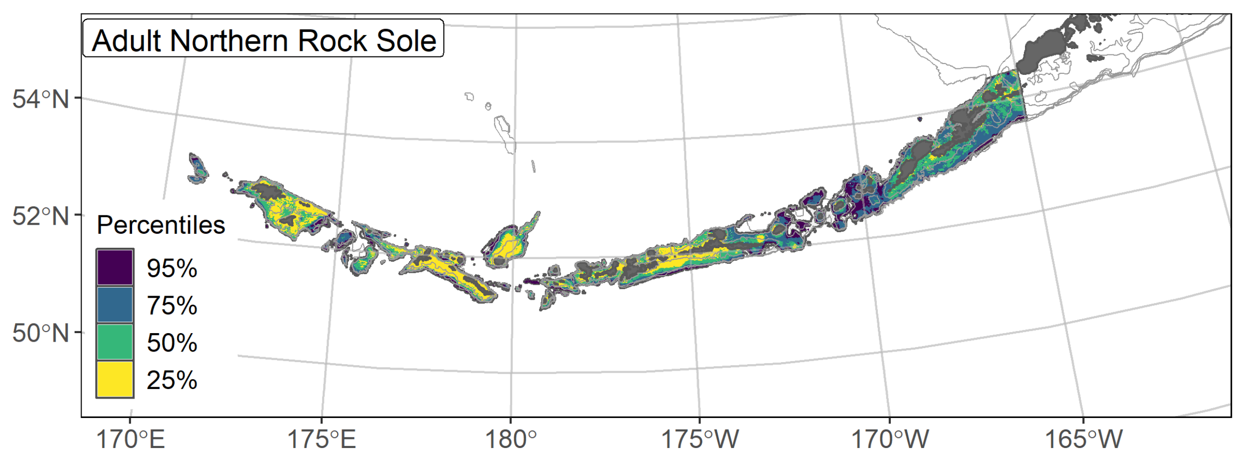

Figure E-82 EFH area of AI adult northern rock sole, summer

Map of Aleutian Islands

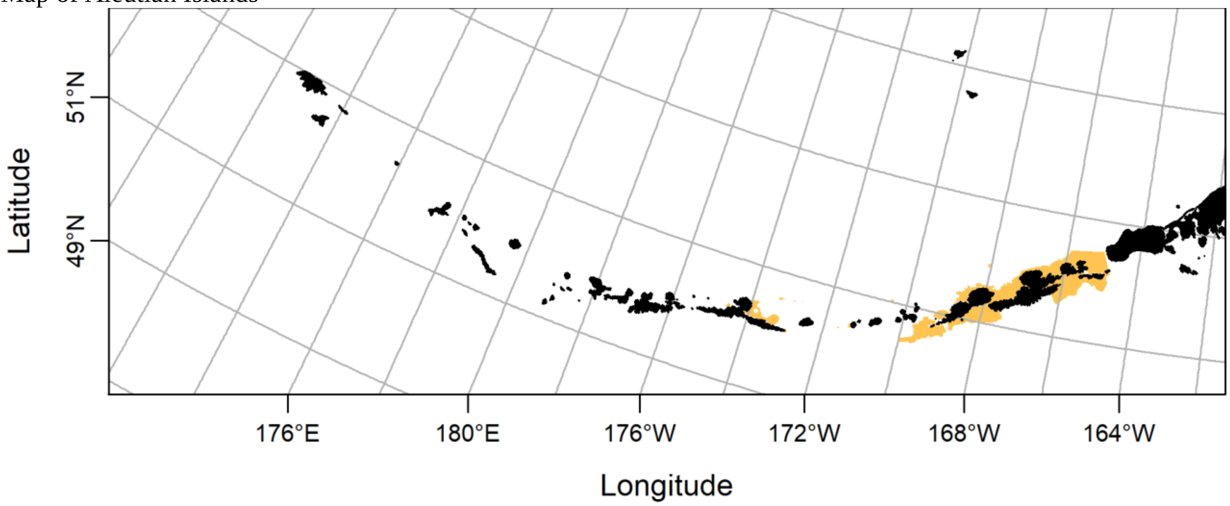

Figure E-83 EFH area of AI northern rock sole larvae, summer

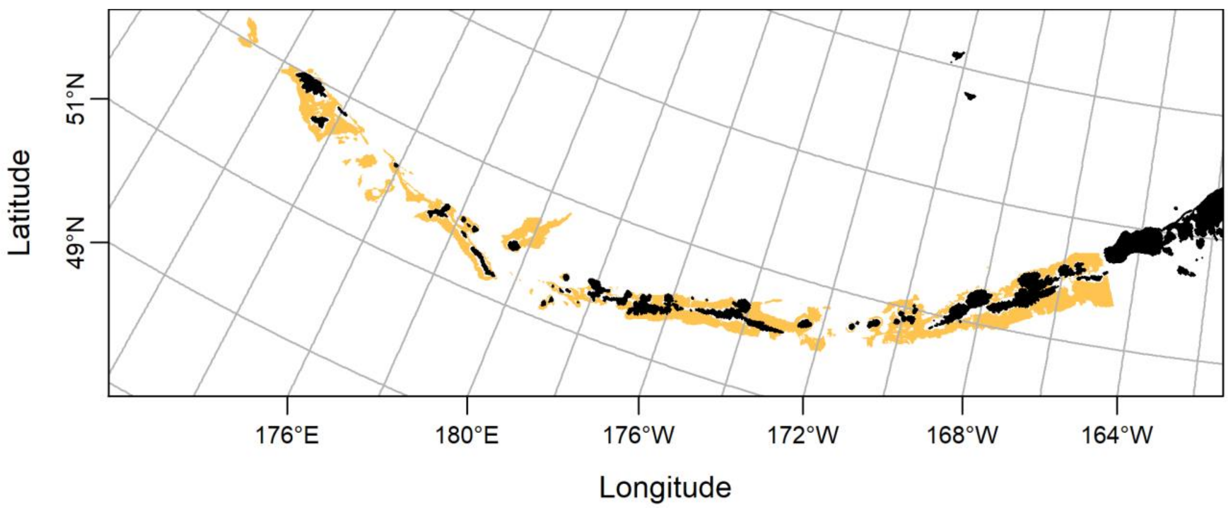

Figure E-84 EFH area of AI adult northern rock sole, fall

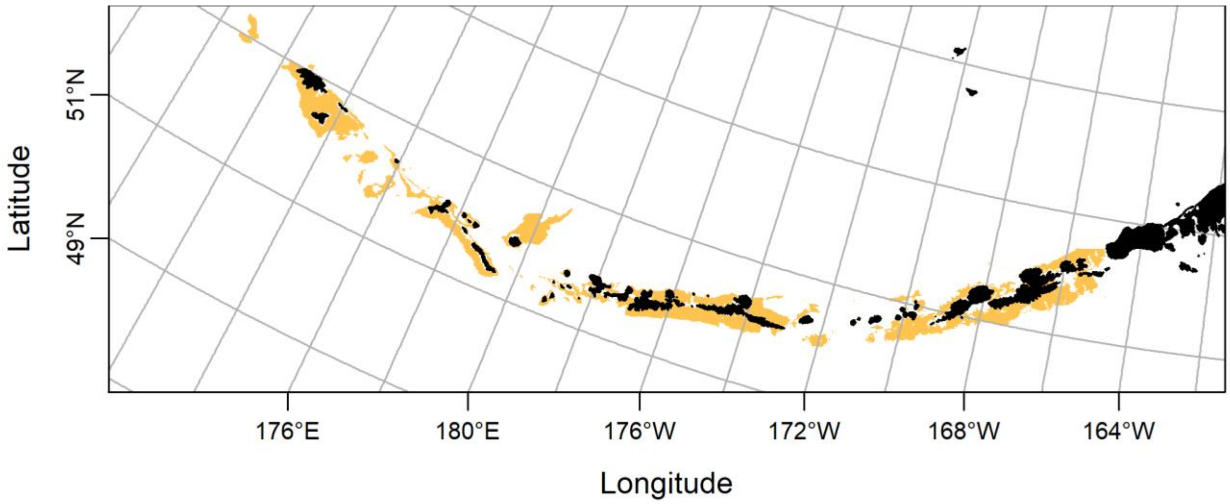

Figure E-85 EFH area of AI adult northern rock sole, winter

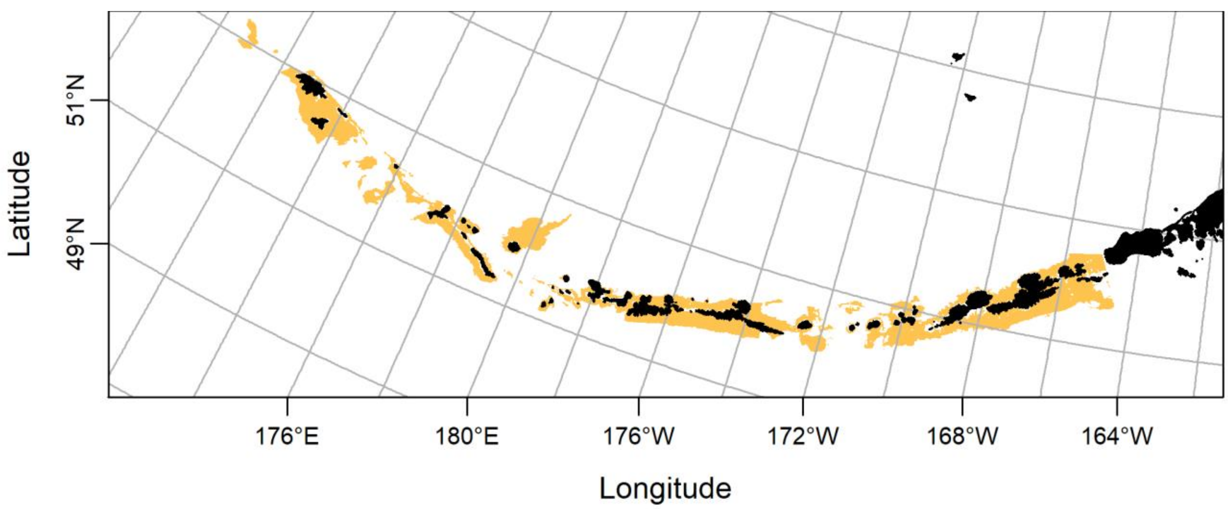

Figure E-86 EFH area of AI adult northern rock sole, spring

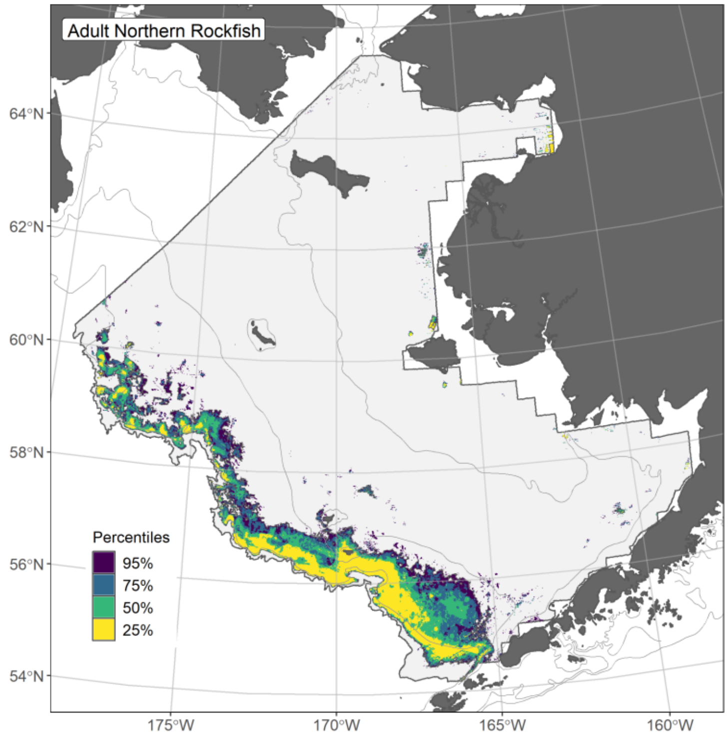

Figure E-87 EFH area of EBS adult northern rockfish, summer

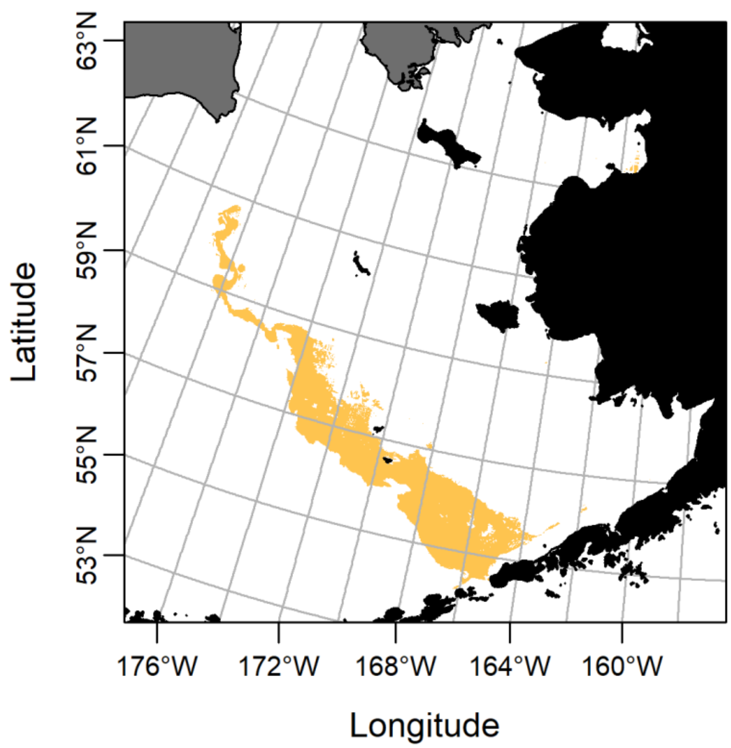

Figure E-88 EFH area of EBS adult northern rockfish, fall

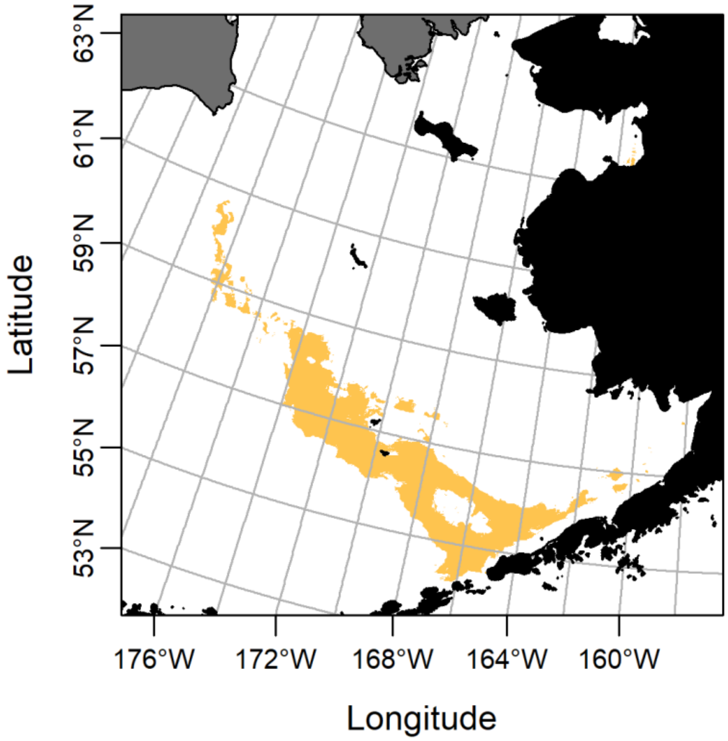

Figure E-89 EFH area of EBS adult northern rockfish, winter

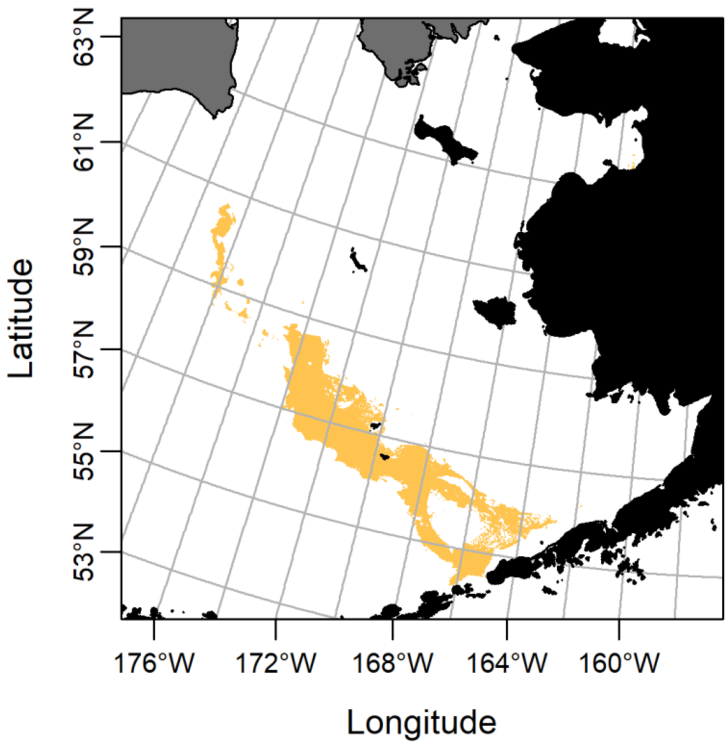

Figure E-90 EFH area of EBS adult northern rockfish, spring

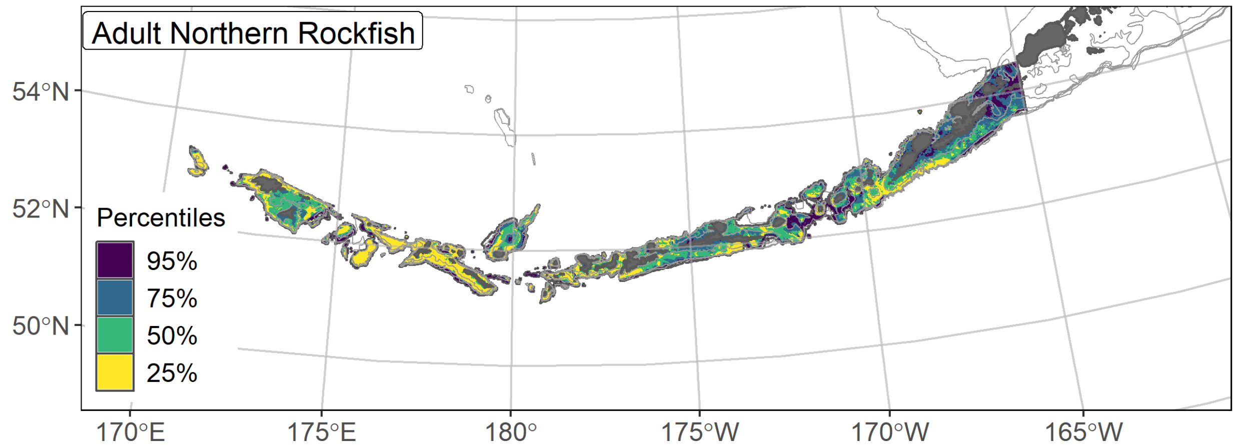

Figure E-91 EFH area of AI adult northern rockfish, summer

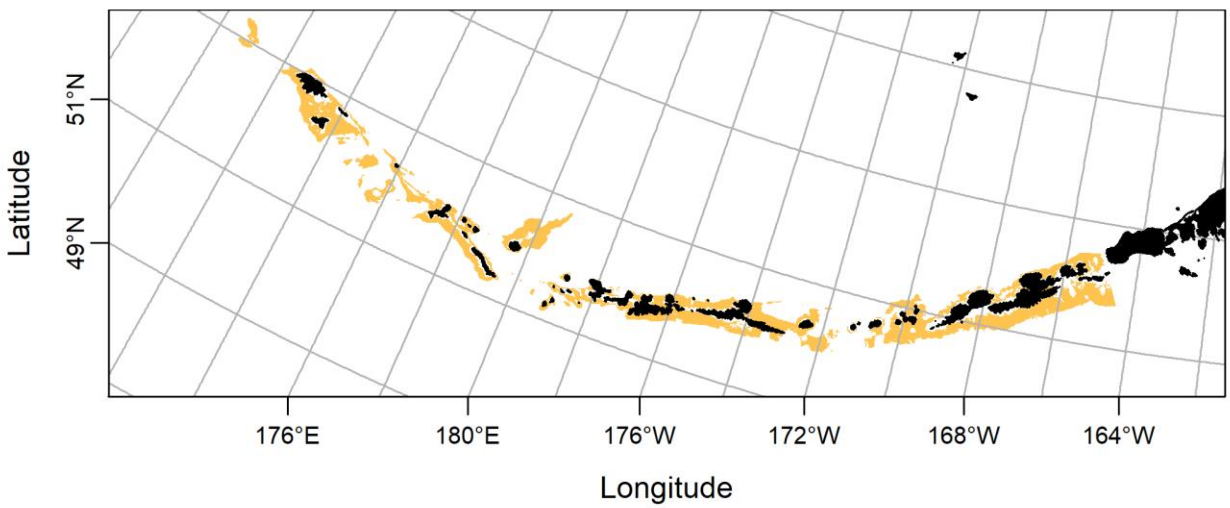

Figure E-92 EFH area of AI adult northern rockfish, fall

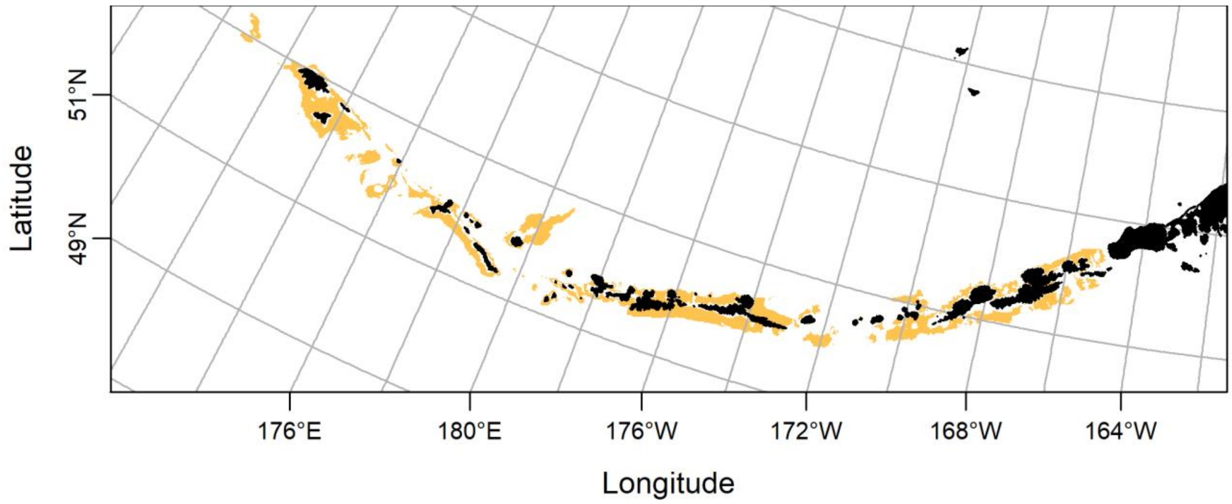

Figure E-93 EFH area of AI adult northern rockfish, winter

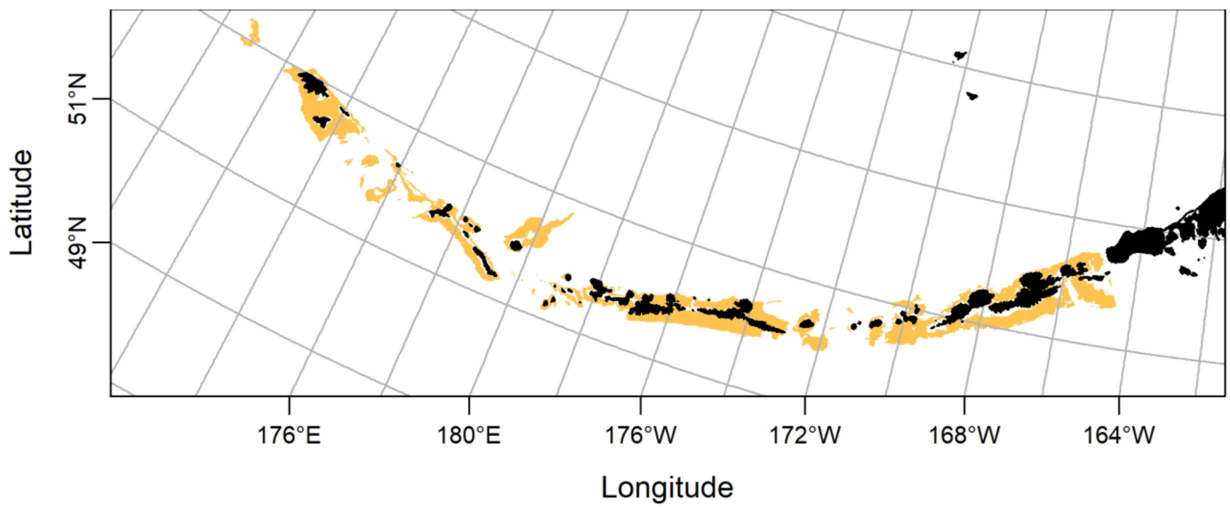

Figure E-94 EFH area of AI adult northern rockfish, spring

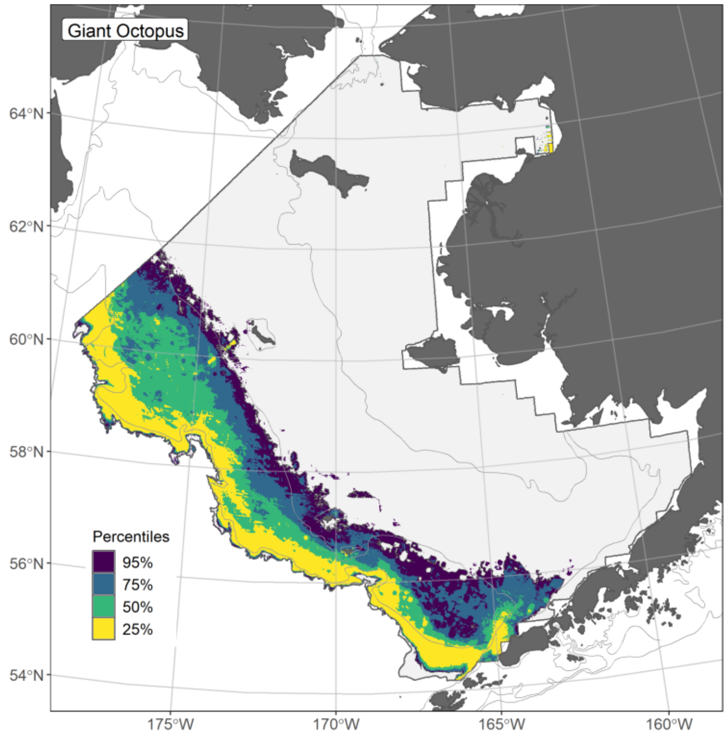

Figure E-95 EFH area of EBS adult giant octopus, summer

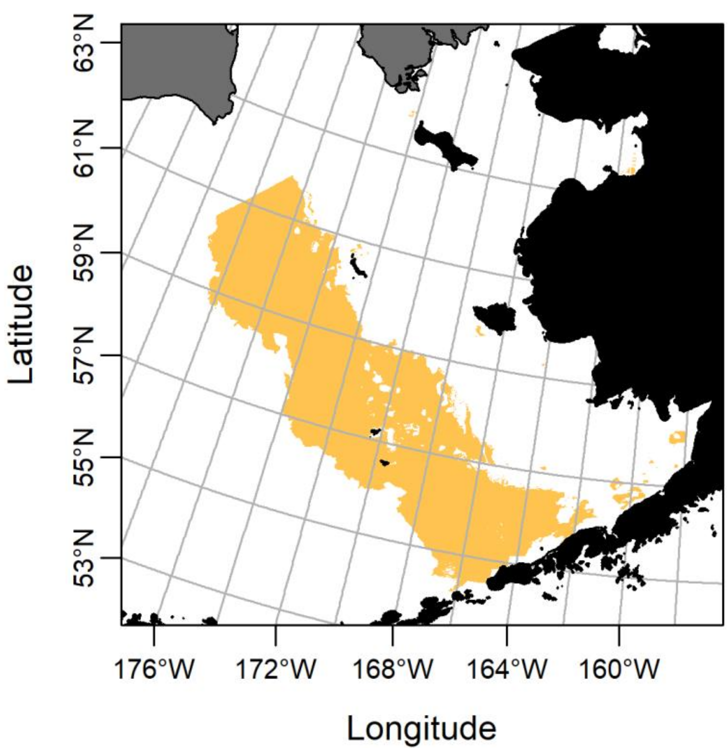

Figure E-96 EFH area of EBS adult giant octopus, fall

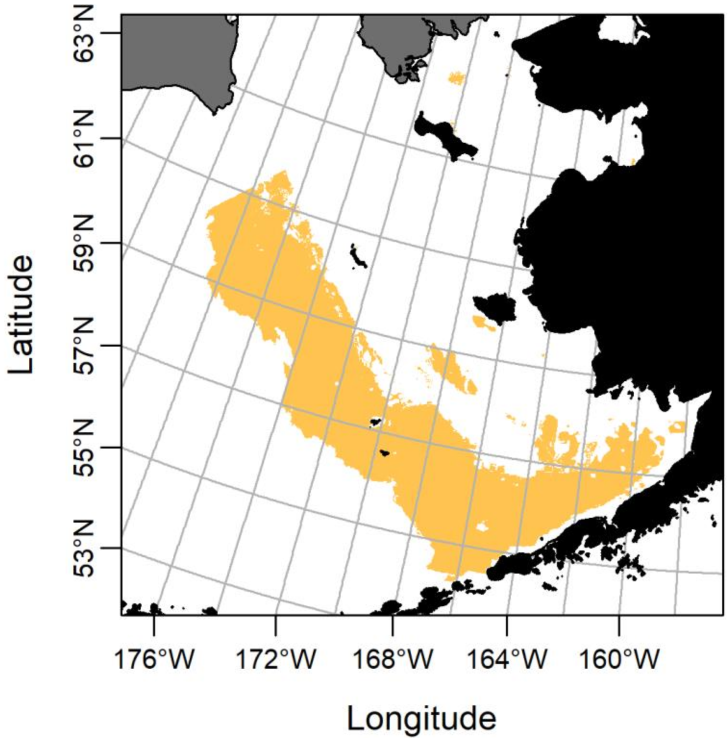

Figure E-97 EFH area of EBS adult giant octopus, winter

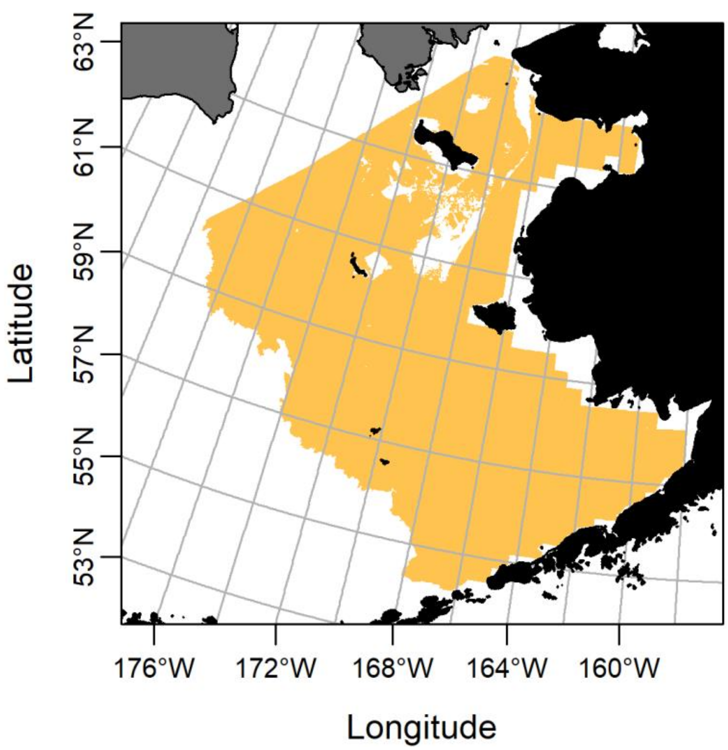

Figure E-98 EFH area of EBS adult giant octopus, spring

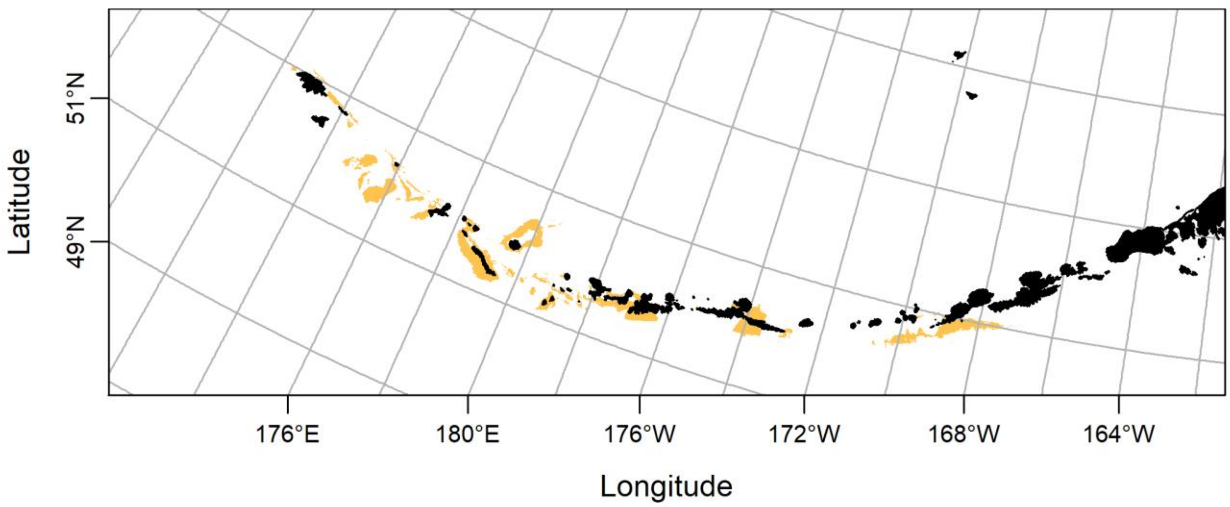

Figure E-99 EFH area of AI adult giant octopus, summer

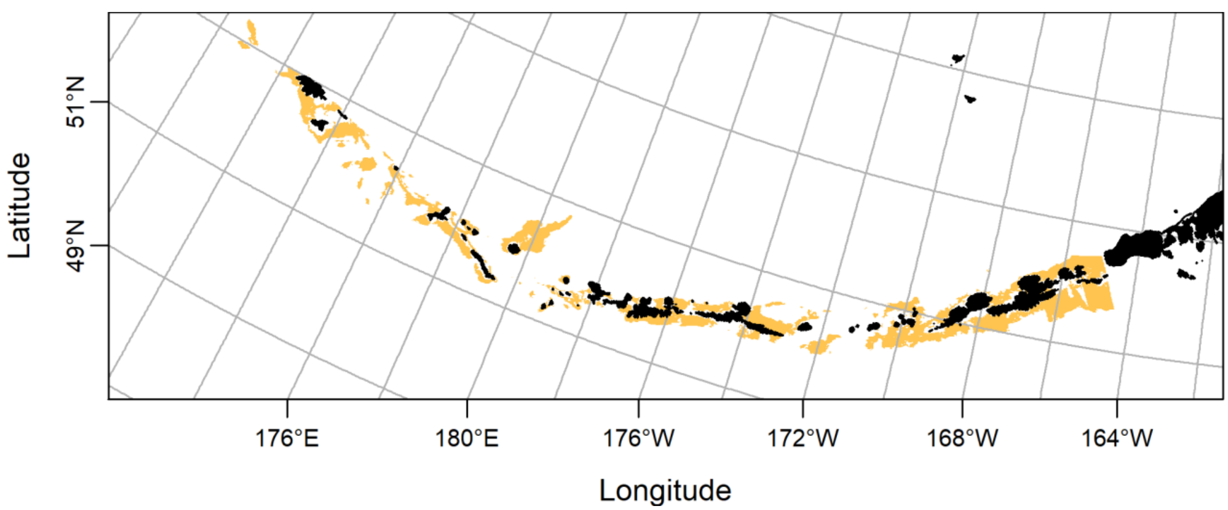

Figure E-100 EFH area of AI adult giant octopus, fall

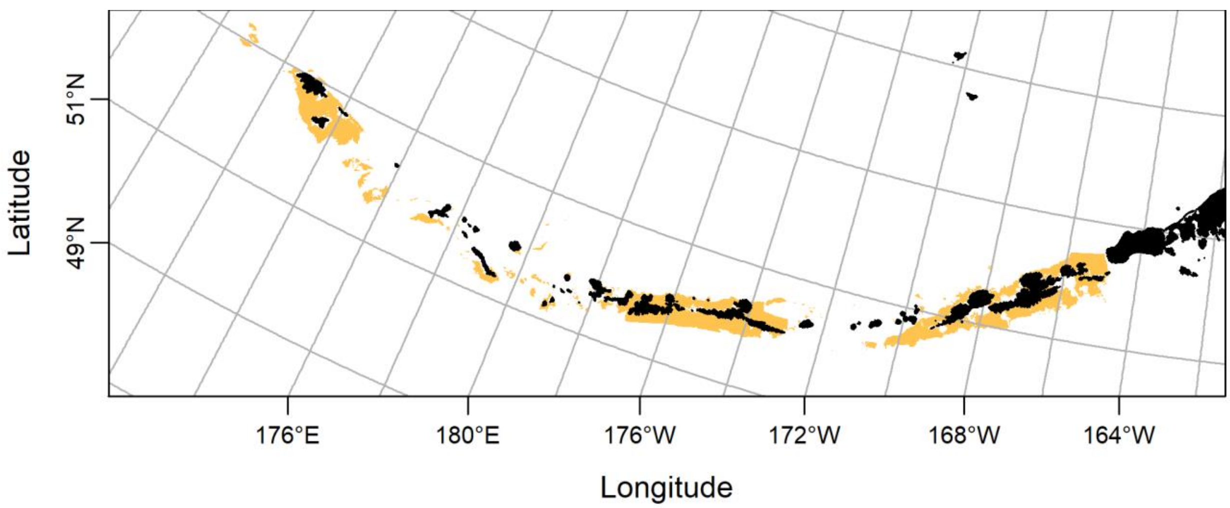

Figure E-101 EFH area of AI adult giant octopus, winter

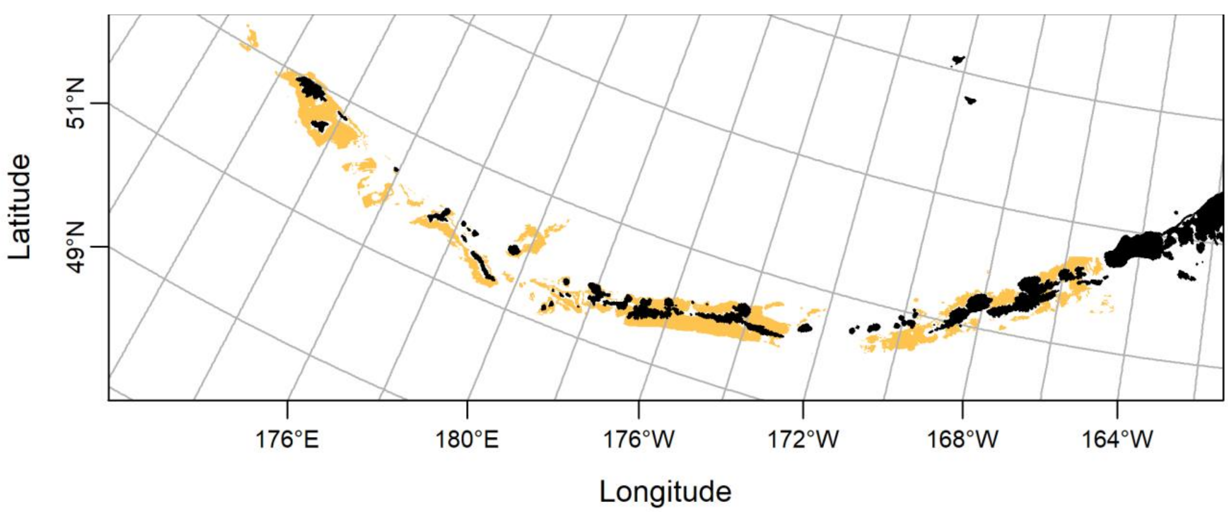

Figure E-102 EFH area of AI adult giant octopus, spring

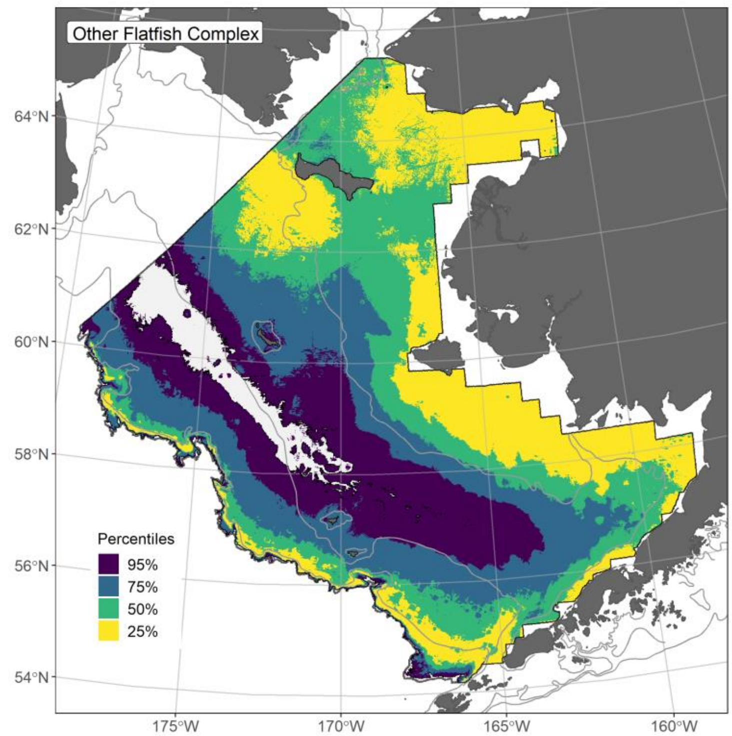

Figure E-103 EFH area of EBS subadult/adult other flatfish complex, summer

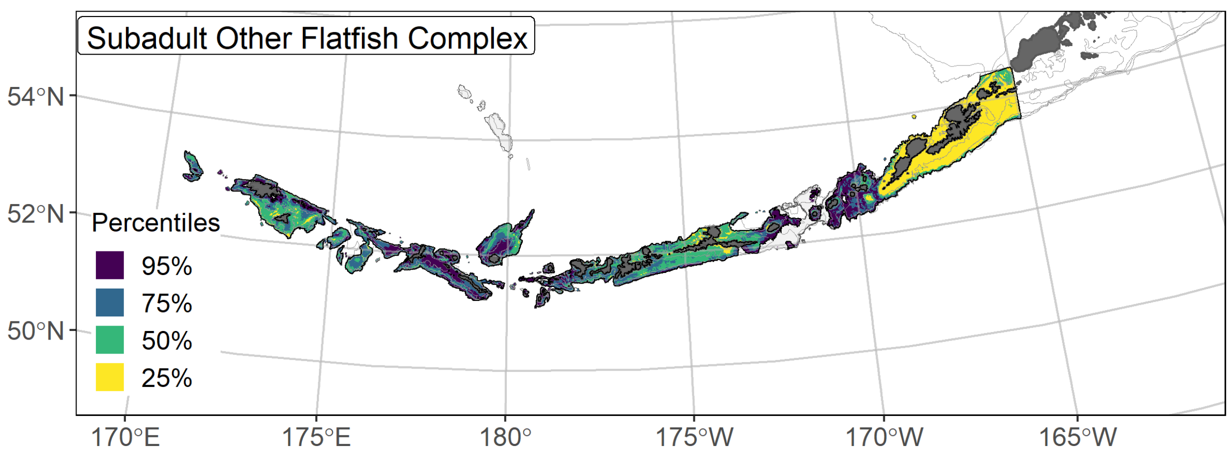

Figure E-104 EFH area of AI subadult other flatfish complex, summer

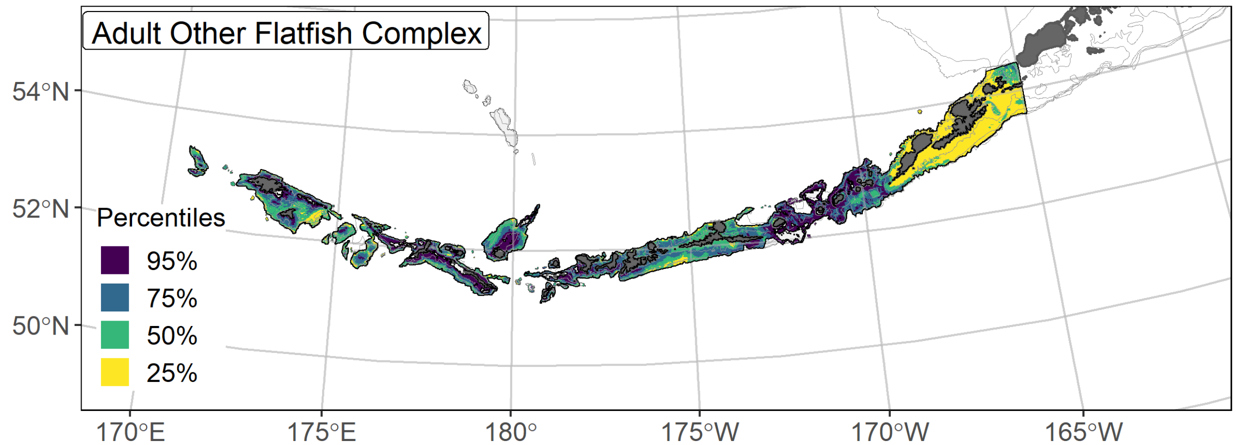

Figure E-105 EFH area of AI adult other flatfish complex, summer

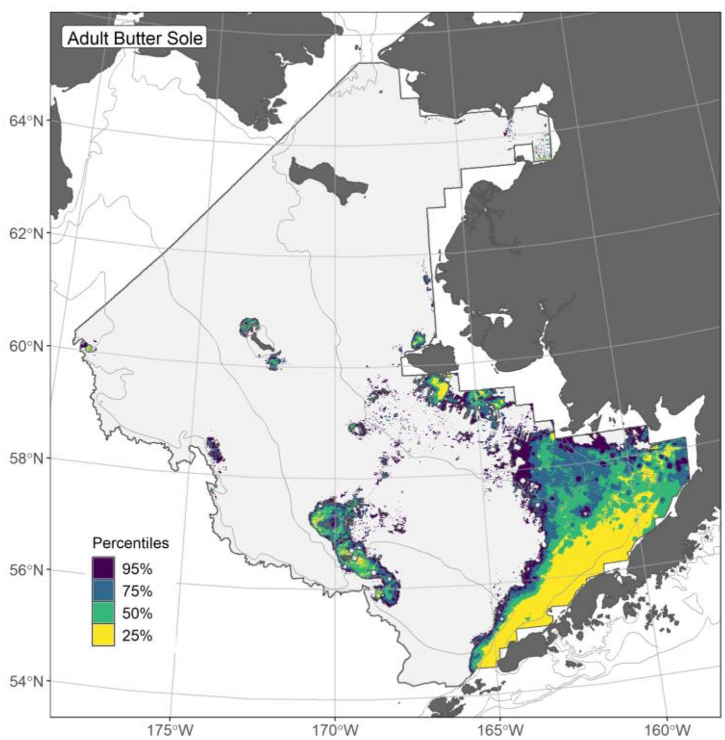

Figure E-106 EFH area of EBS subadult/adult butter sole, summer

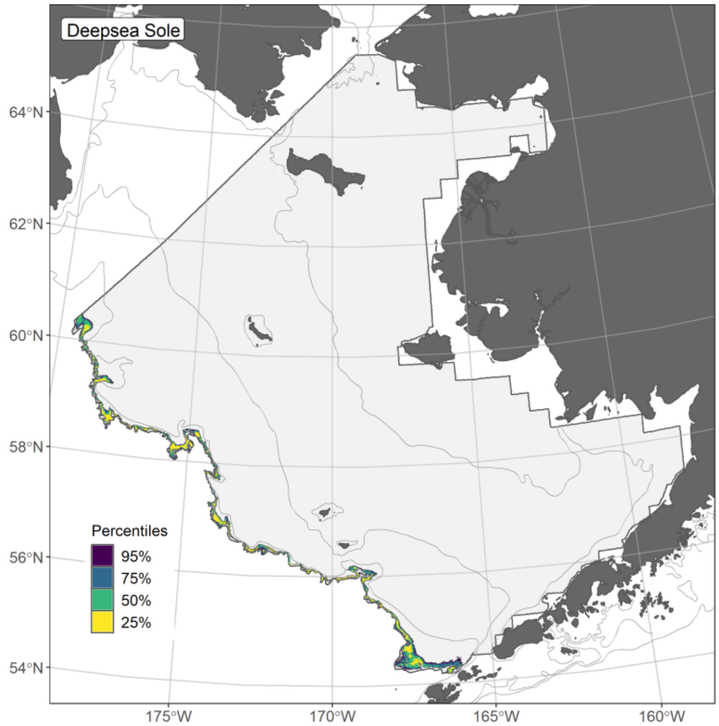

Figure E-107 EFH area of EBS subadult/adult deepsea sole, summer

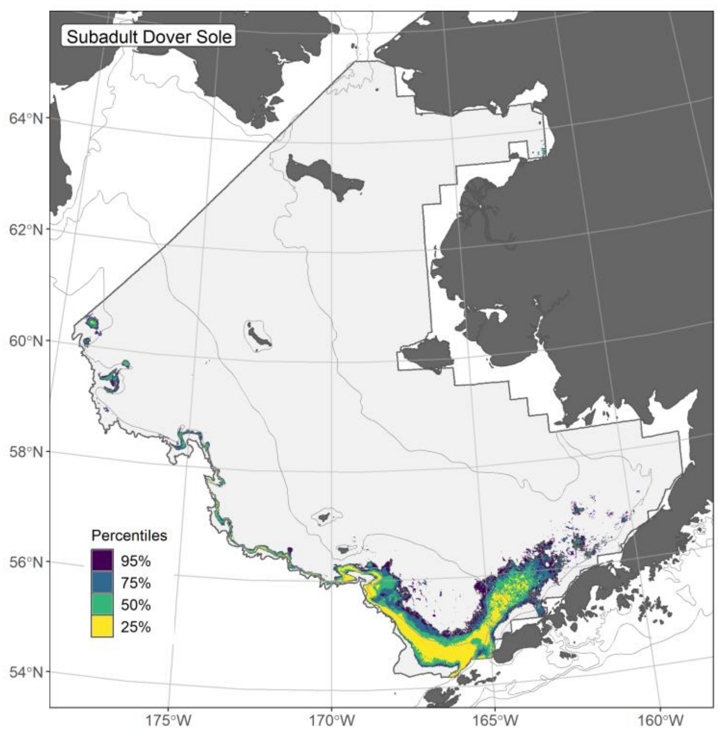

Figure E-108 EFH area of EBS subadult Dover sole, summer

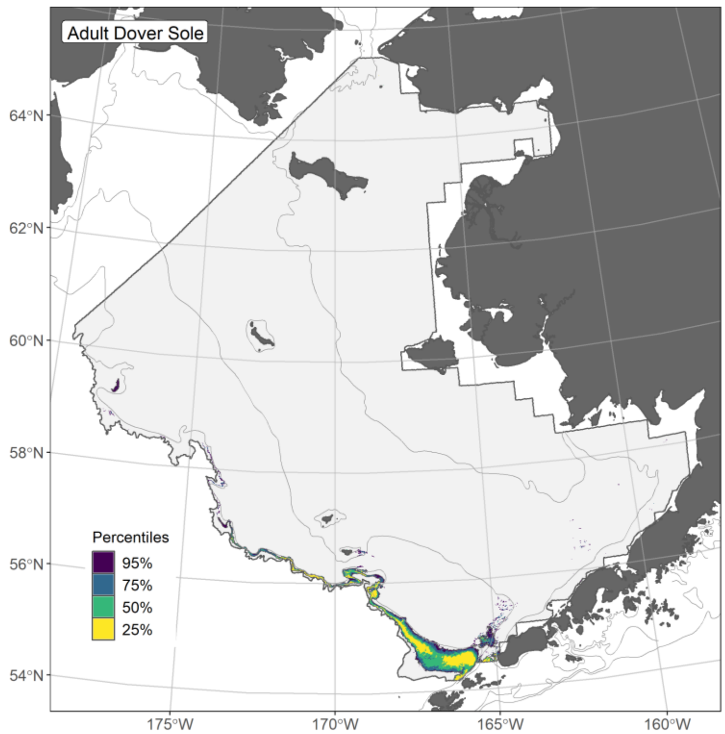

Figure E-109 EFH area of EBS adult Dover sole, summer

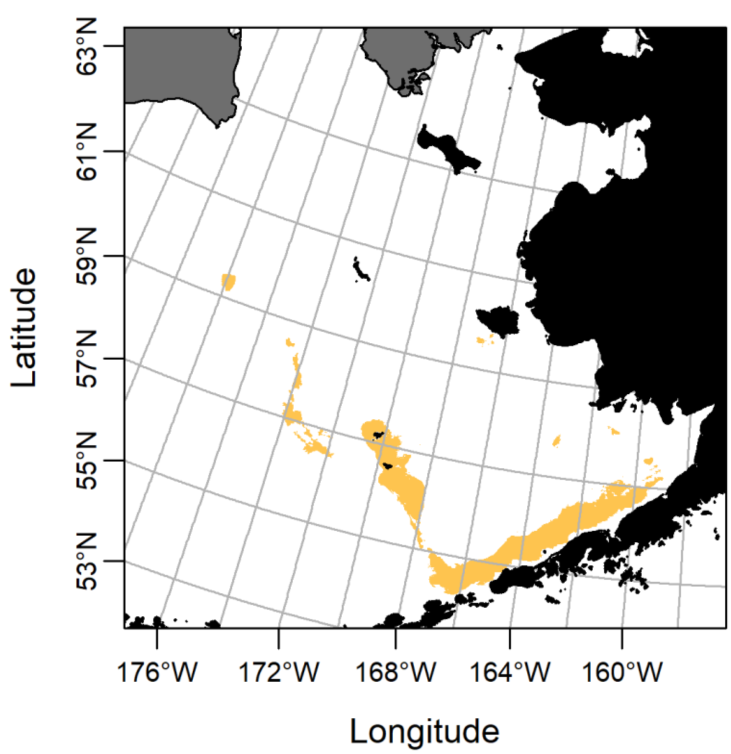

Figure E-110 EFH area of EBS adult Dover sole, winter

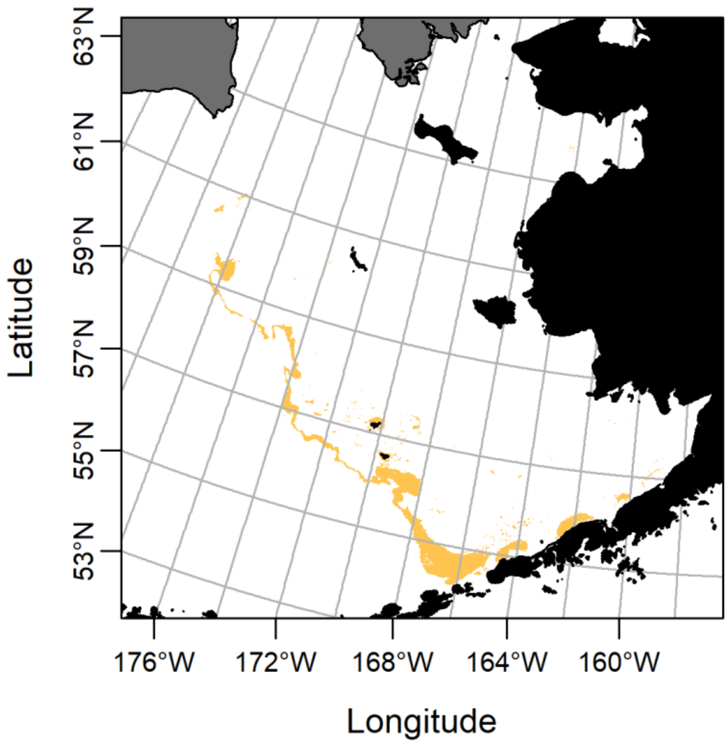

Figure E-111 EFH area of EBS adult Dover sole, spring

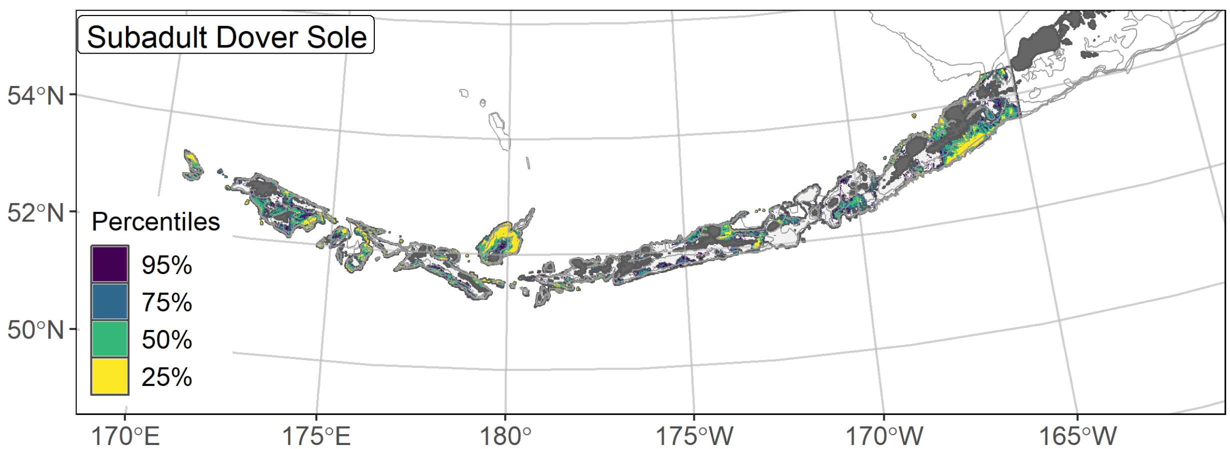

Figure E-112 EFH area of AI subadult Dover sole, summer

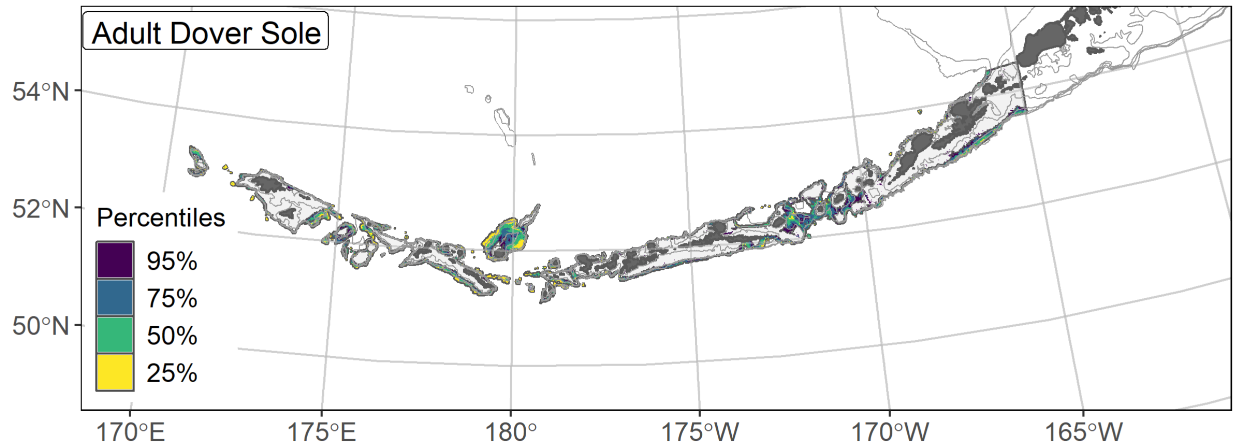

Figure E-113 EFH area of AI adult Dover sole, summer

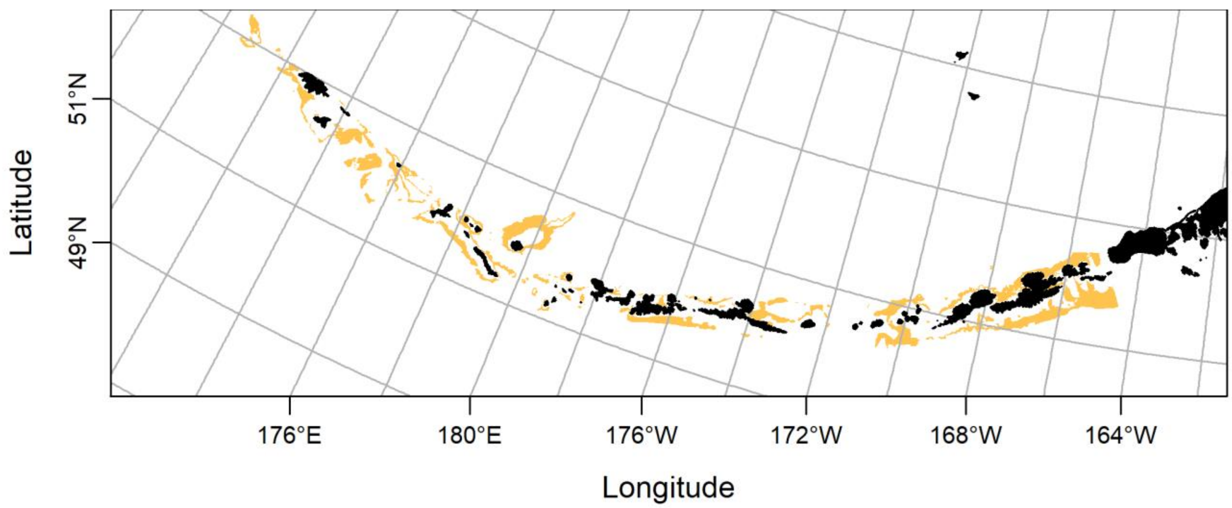

Figure E-114 EFH area of AI adult Dover sole, spring

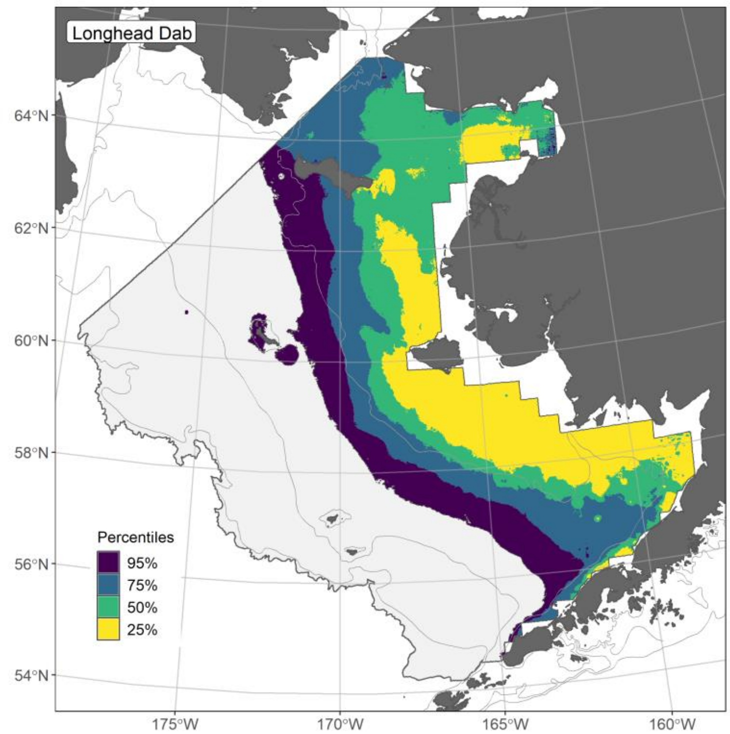

Figure E-115 EFH area of EBS subadult/adult longhead dab, summer

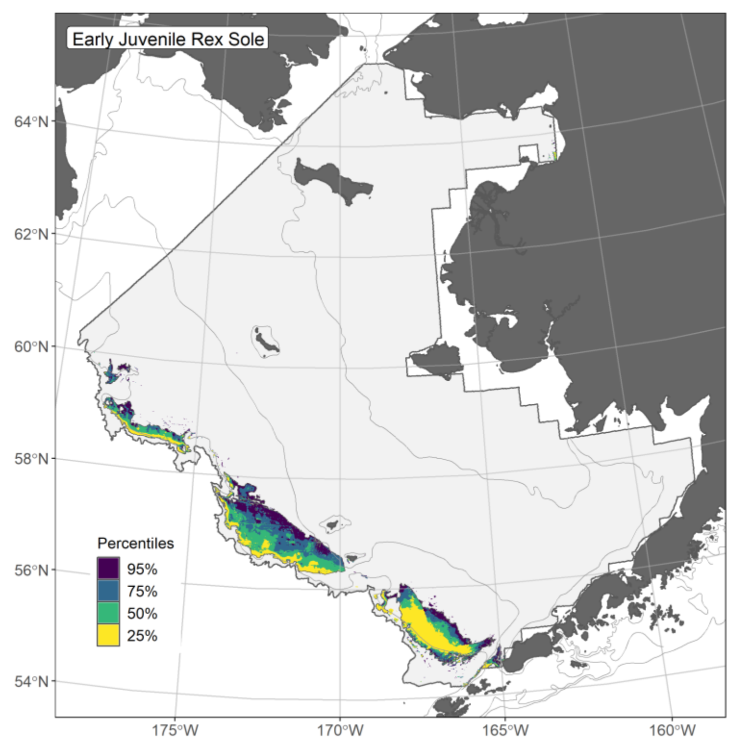

Figure E-116 EFH area of EBS settled early juvenile rex sole, summer

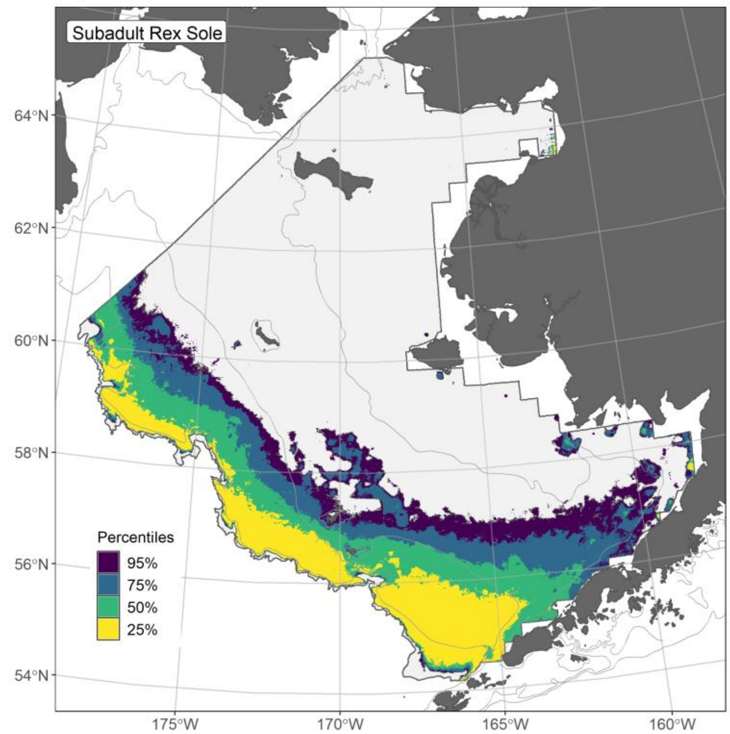

Figure E-117 EFH area of EBS subadult rex sole, summer

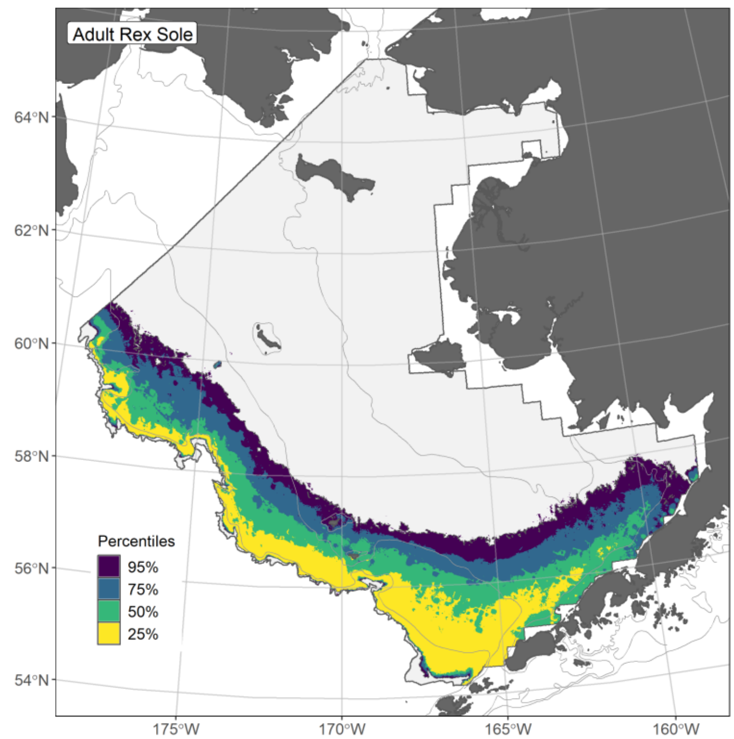

Figure E-118 EFH area of EBS adult rex sole, summer

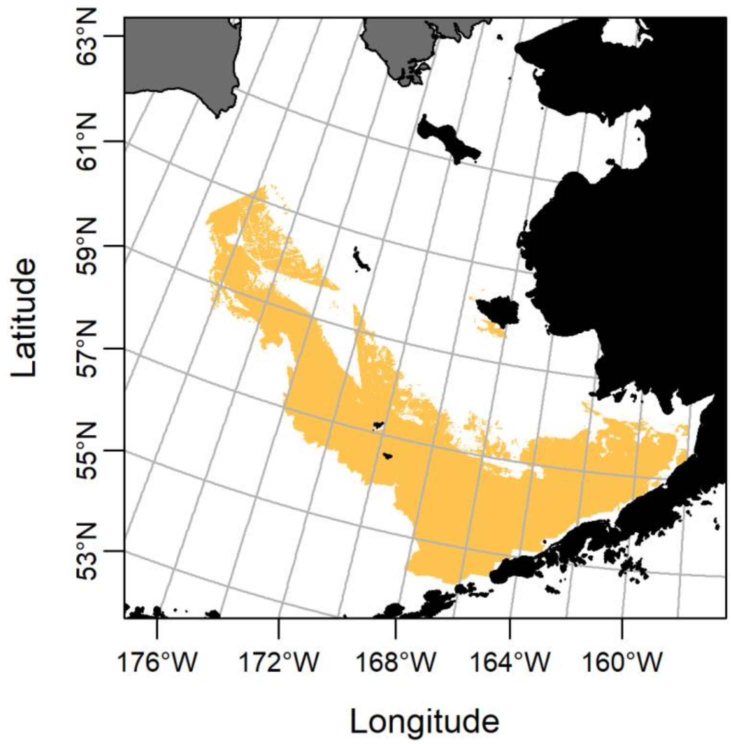

Figure E-119 EFH area of EBS rex sole eggs, summer

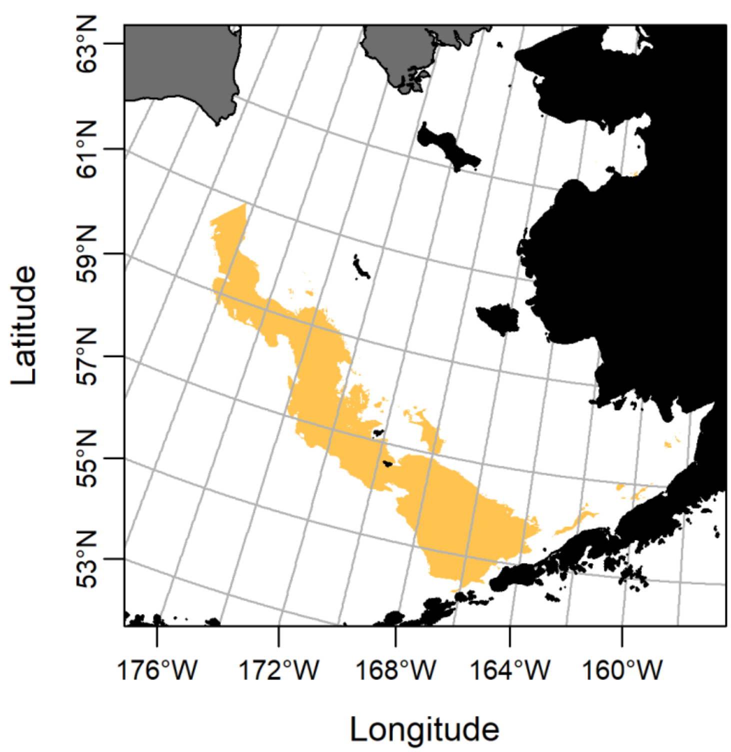

Figure E-120 EFH area of EBS adult rex sole, fall

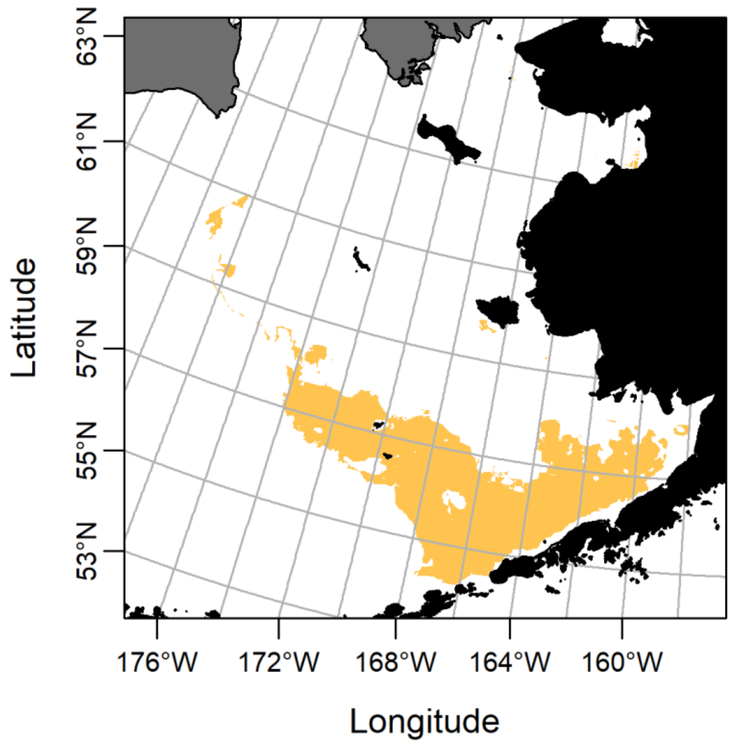

Figure E-121 EFH area of EBS adult rex sole, winter

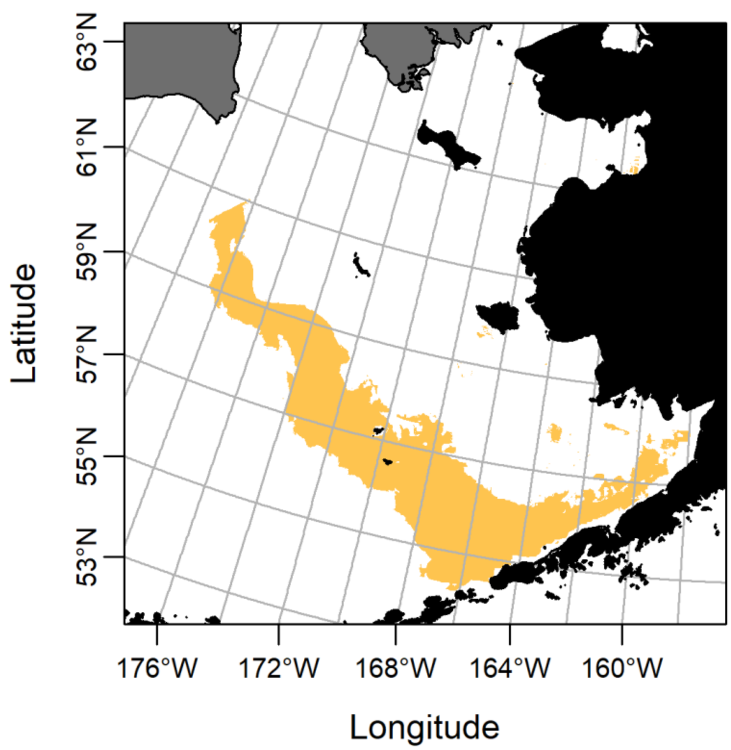

Figure E-122 EFH area of EBS adult rex sole, spring

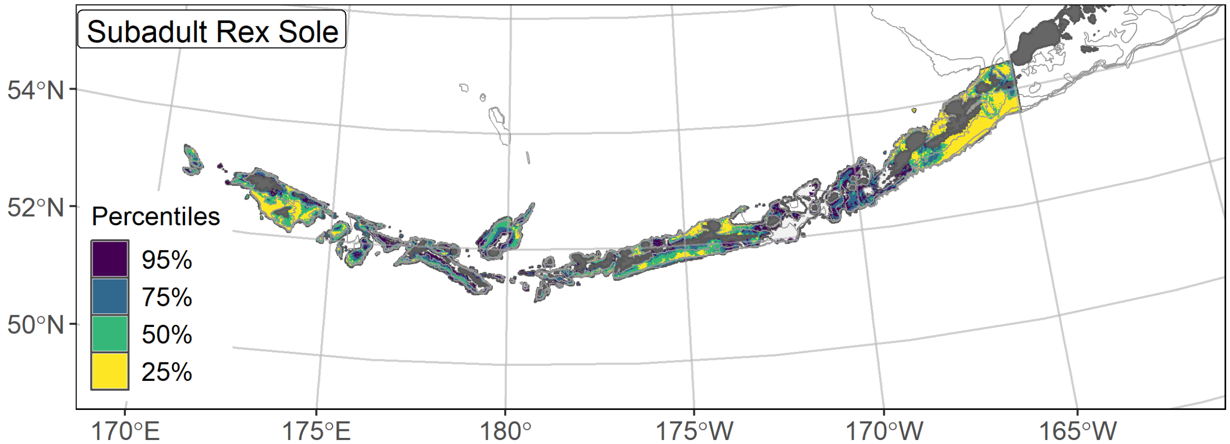

Figure E-123 EFH area of AI subadult rex sole, summer

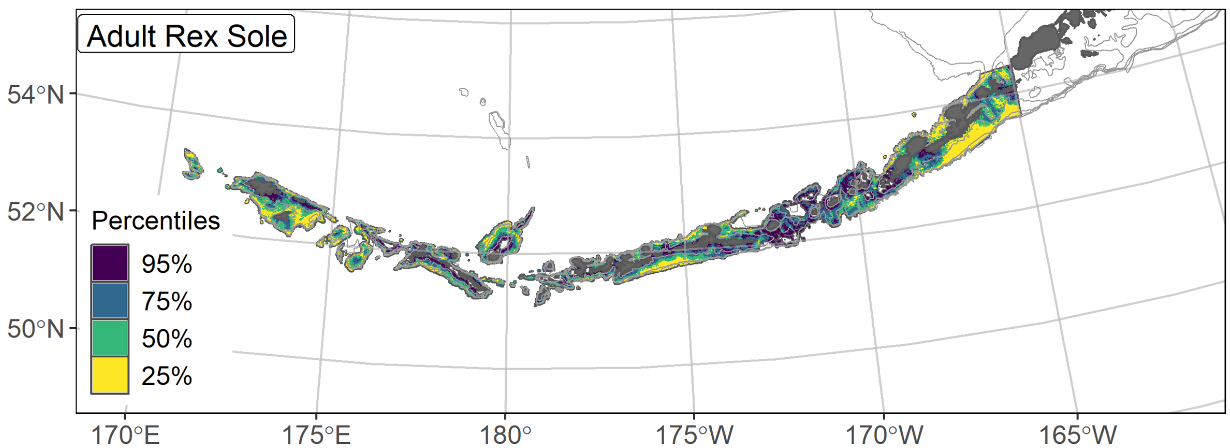

Figure E-124 EFH area of AI adult rex sole, summer

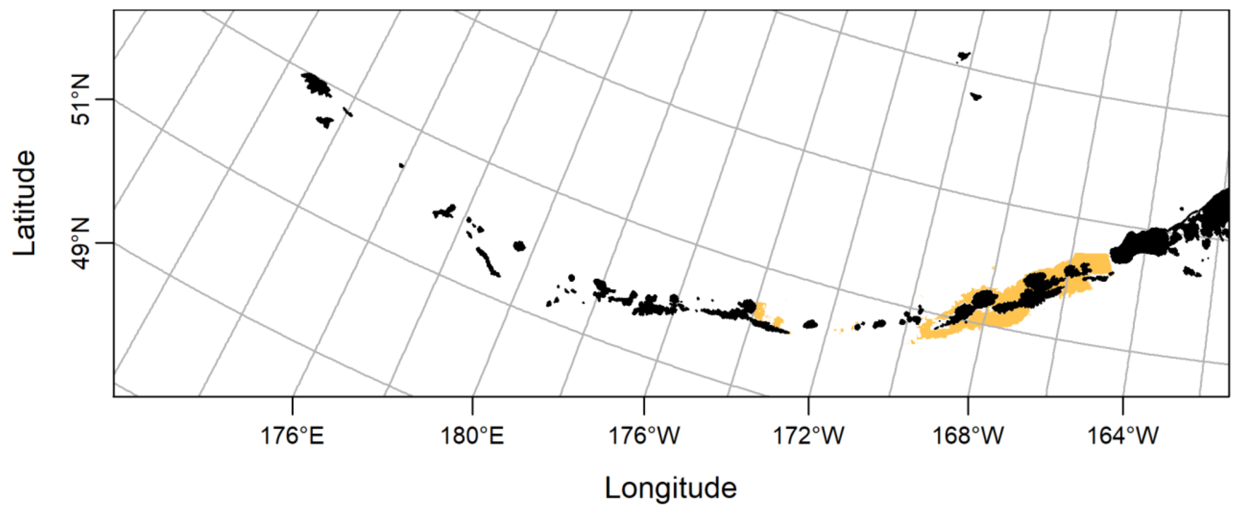

Figure E-125 EFH area of AI rex sole eggs, summer

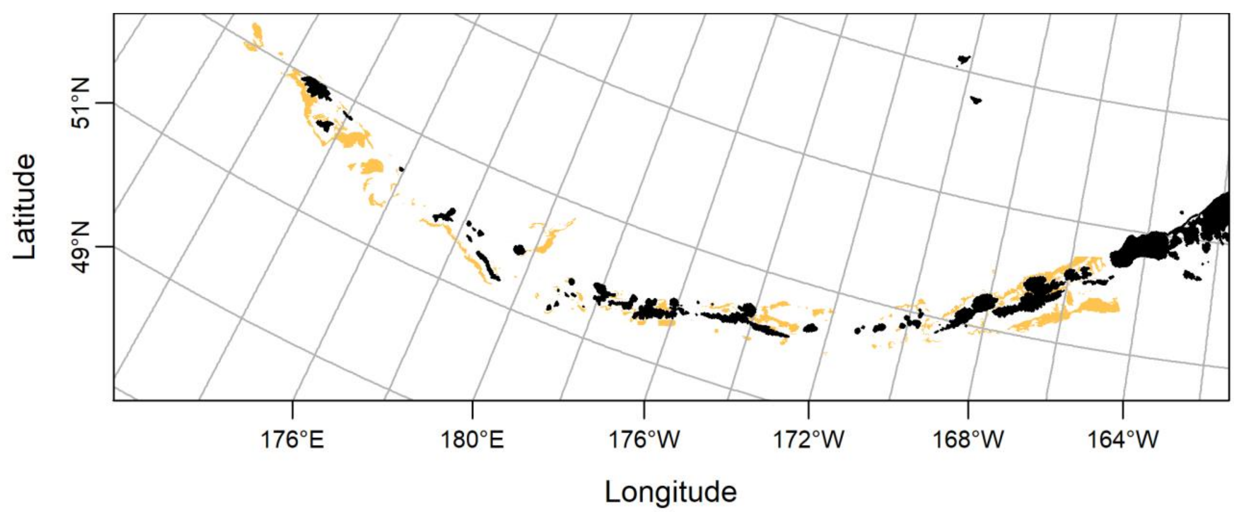

Figure E-126 EFH area of AI adult rex sole, fall

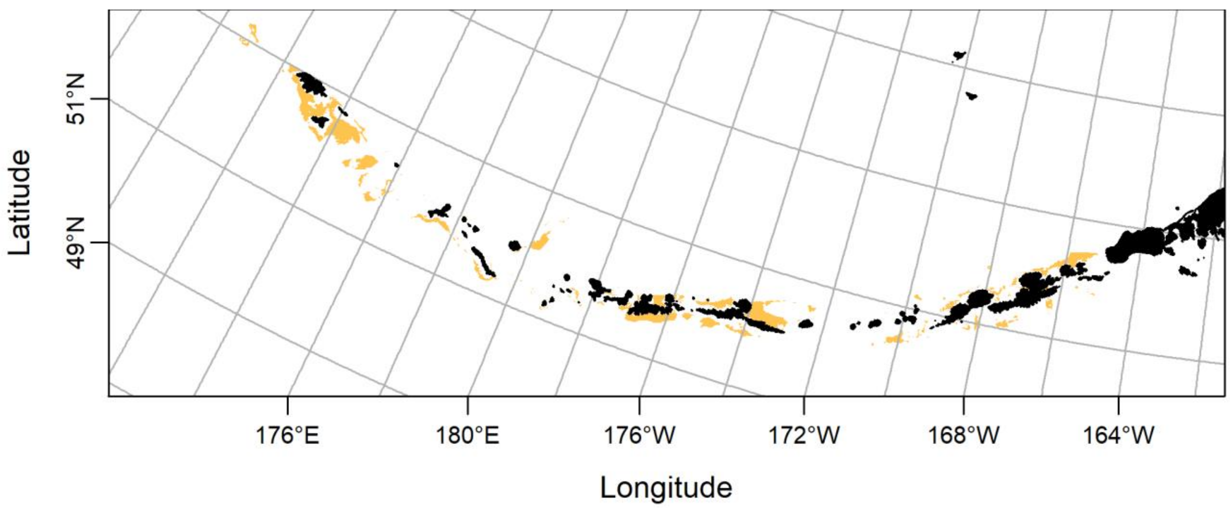

Figure E-127 EFH area of AI adult rex sole, winter

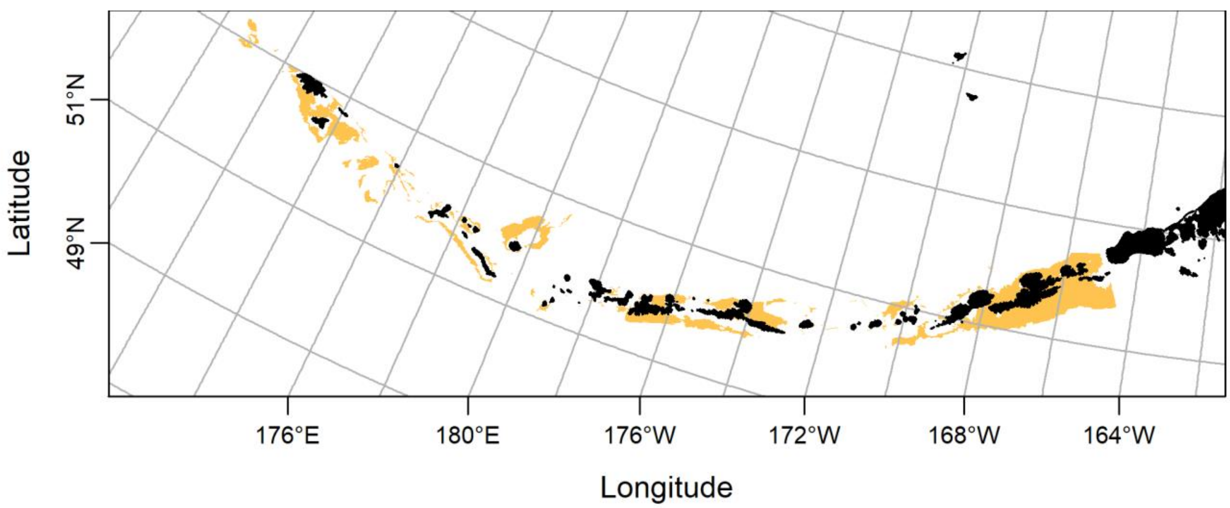

Figure E-128 EFH area of AI adult rex sole, spring

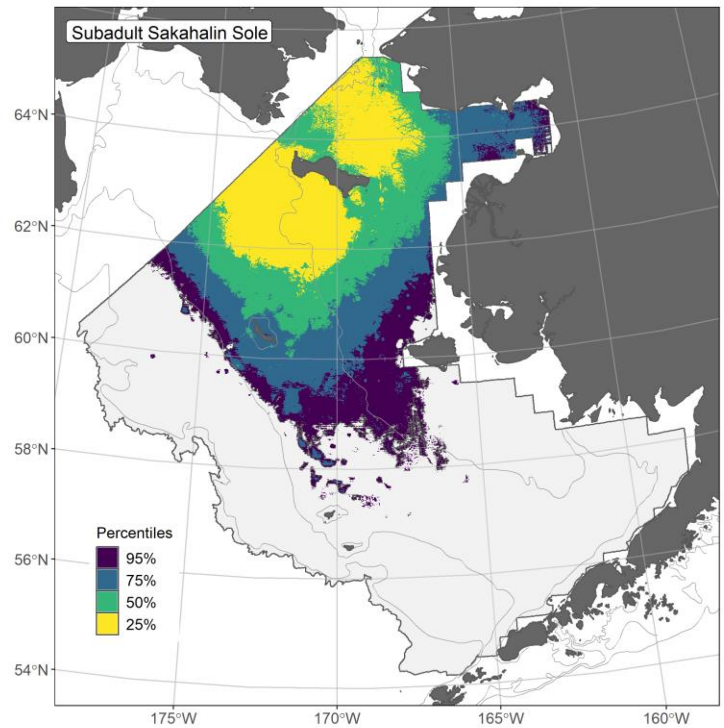

Figure E-129 EFH area of EBS subadult Sakhalin sole, summer

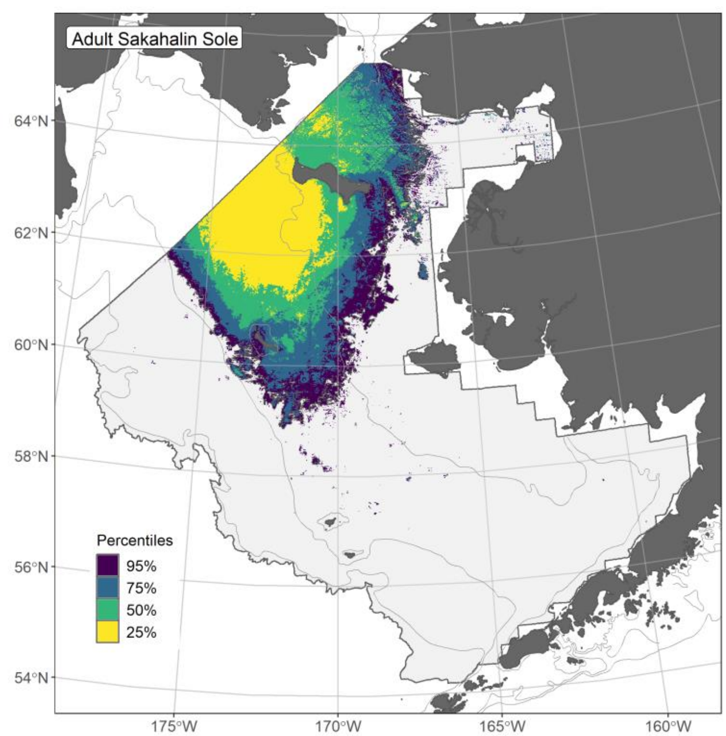

Figure E-130 EFH area of EBS adult Sakhalin sole, summer

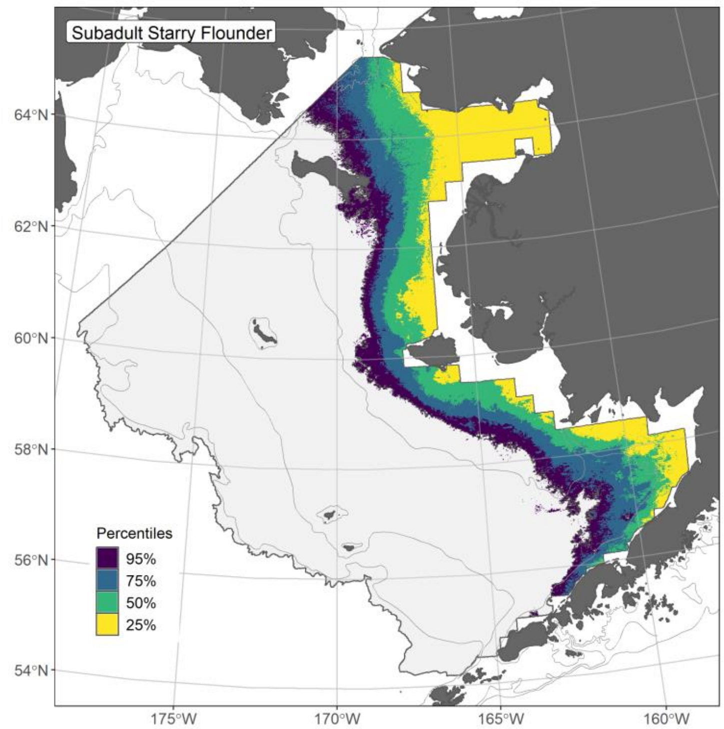

Figure E-131 EFH area of EBS subadult starry flounder, summer

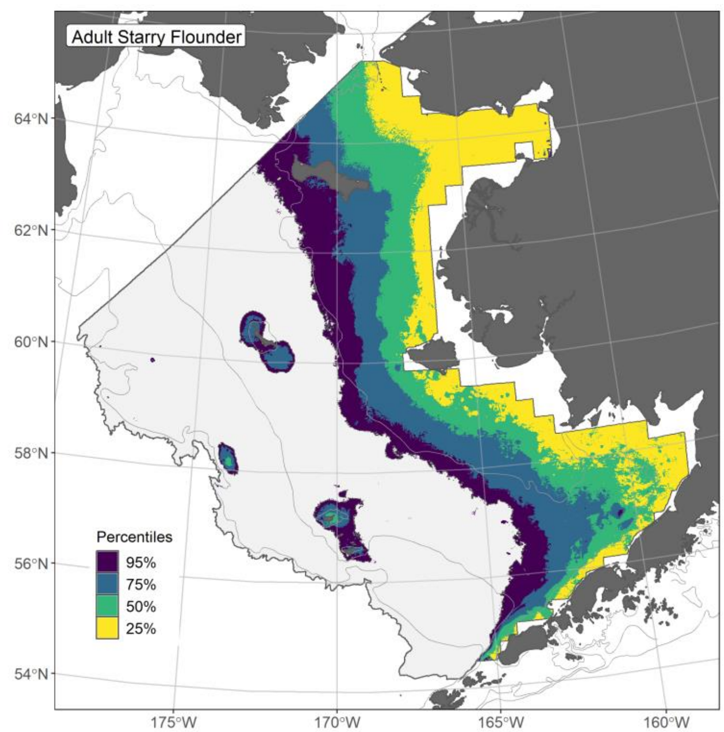

Figure E-132 EFH area of EBS adult starry flounder, summer

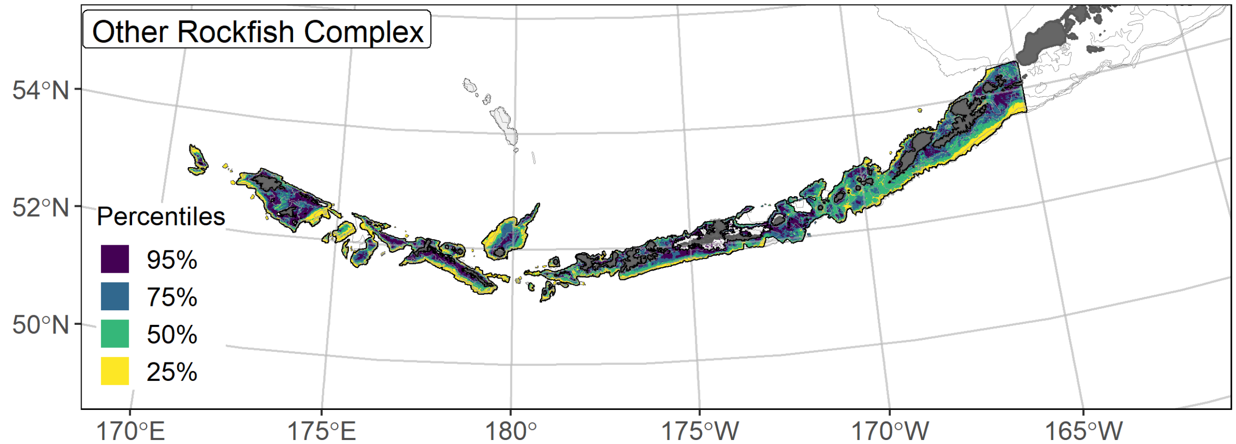

Figure E-133 EFH area of AI subadult/adult other rockfish complex, summer

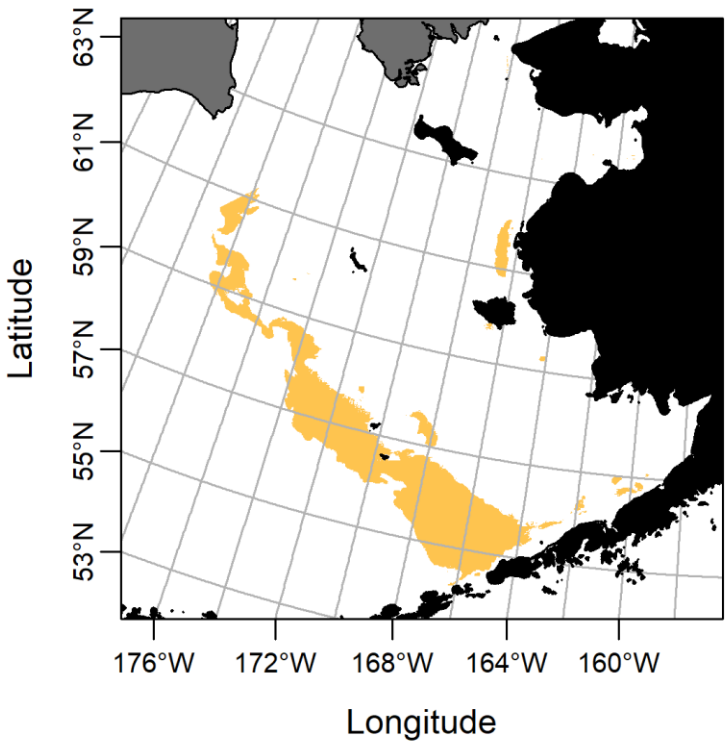

Figure E-134 EFH area of EBS of adult dusky rockfish, summer

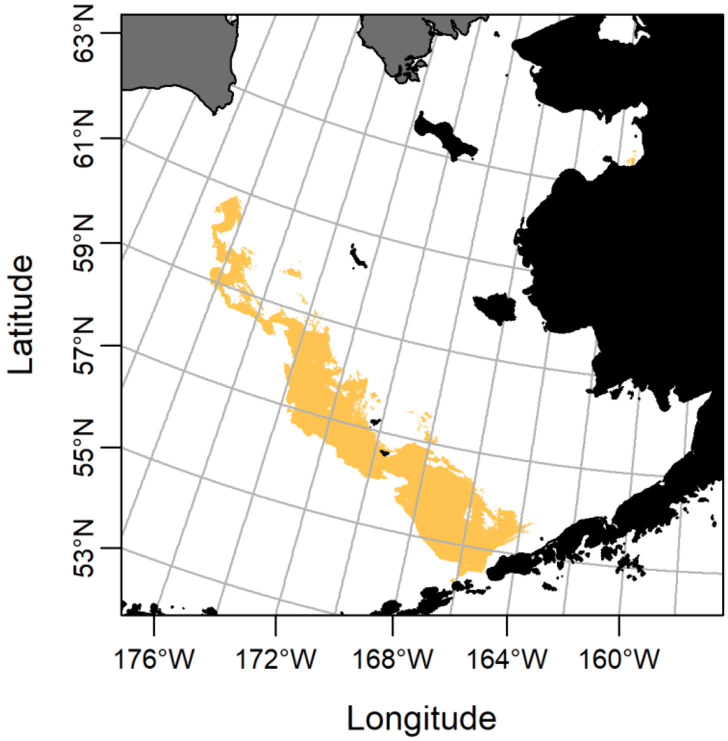

Figure E-135 EFH area of EBS adult dusky rockfish, fall

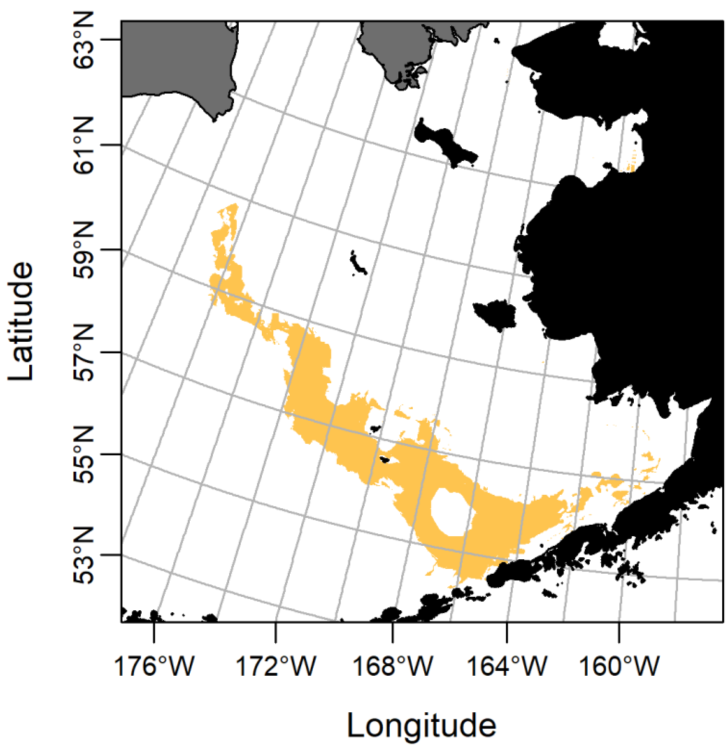

Figure E-136 EFH area of EBS adult dusky rockfish, winter

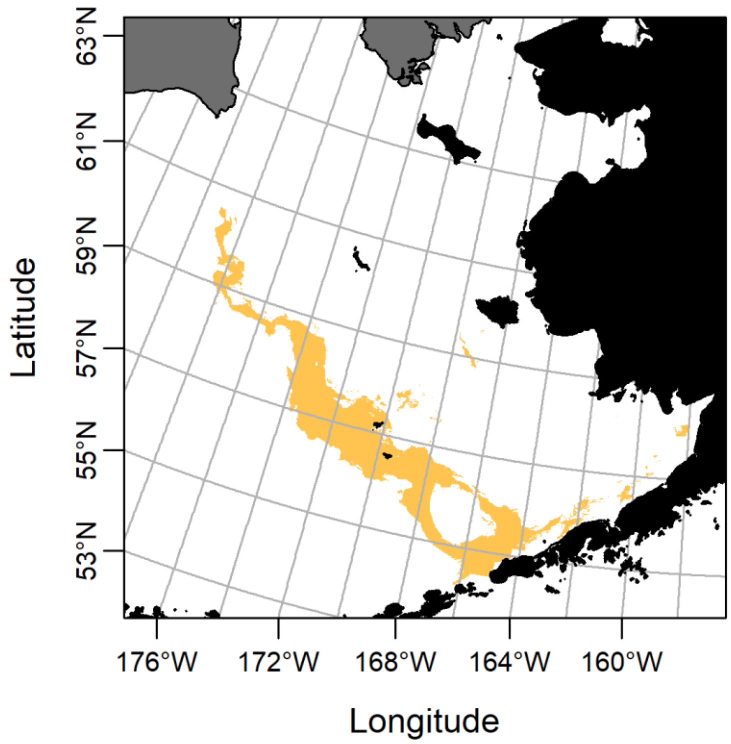

Figure E-137 EFH area of EBS adult dusky rockfish, spring

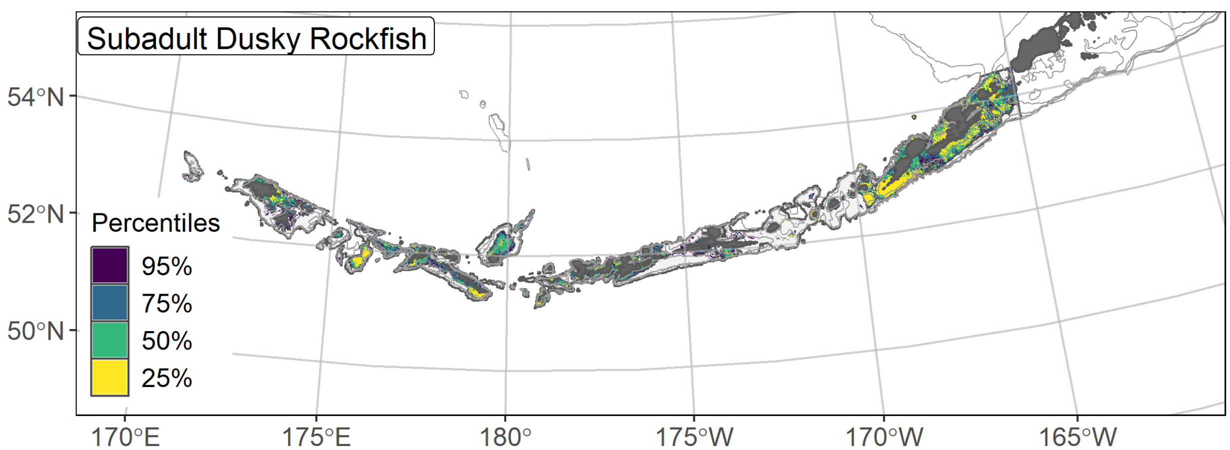

Figure E-138 EFH area of AI subadult dusky rockfish, summer

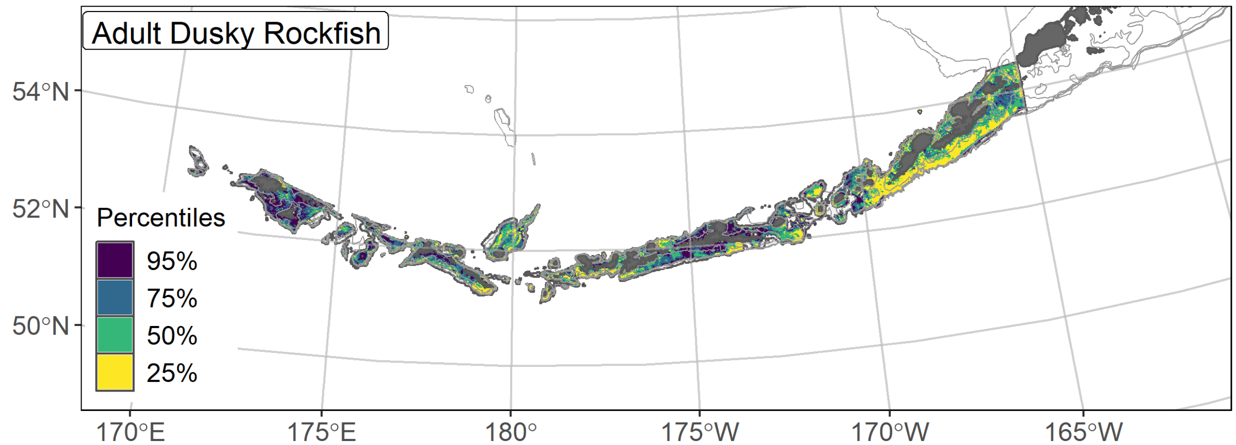

Figure E-139 EFH area of AI adult dusky rockfish, summer

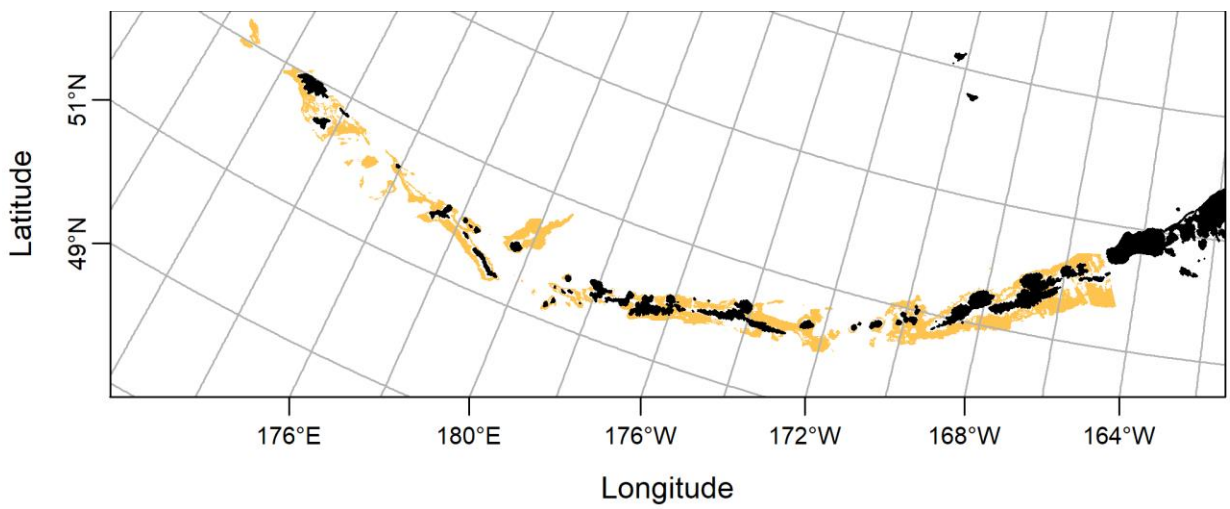

Figure E-140 EFH area of AI adult dusky rockfish, fall

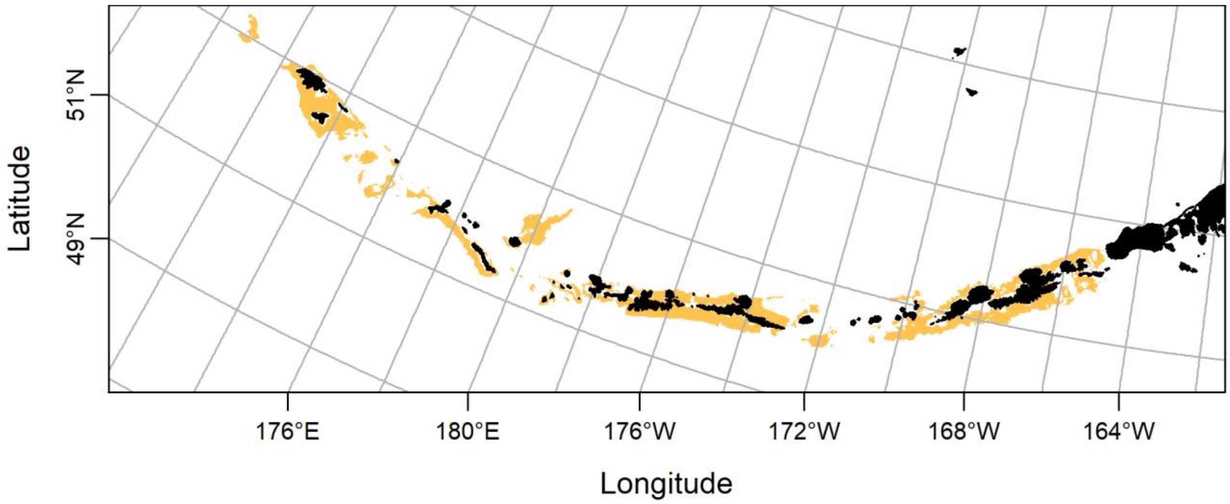

Figure E-141 EFH area of AI adult dusky rockfish, winter

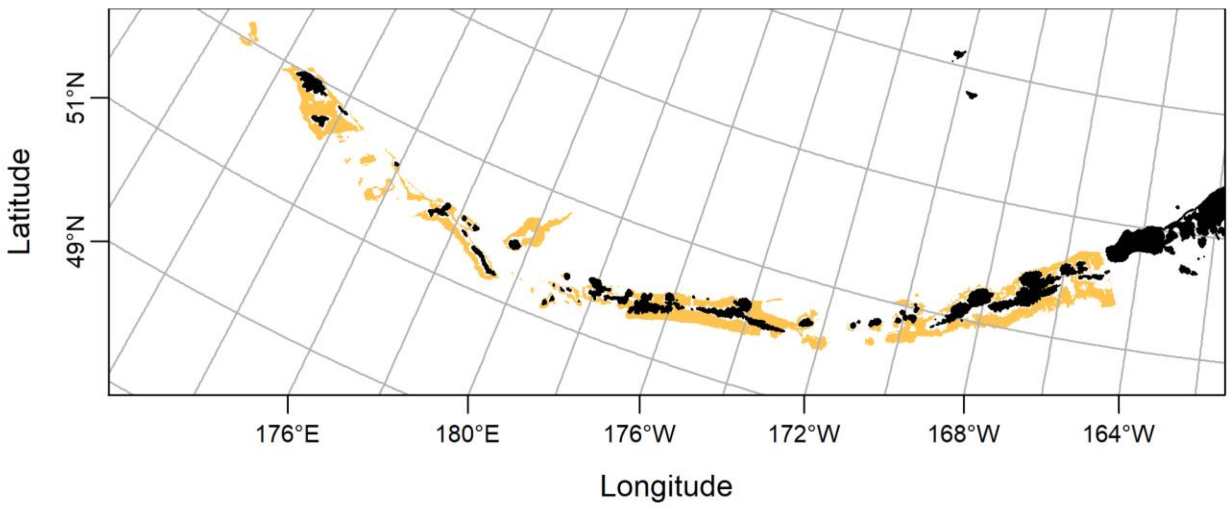

Figure E-142 EFH area of AI adult dusky rockfish, spring

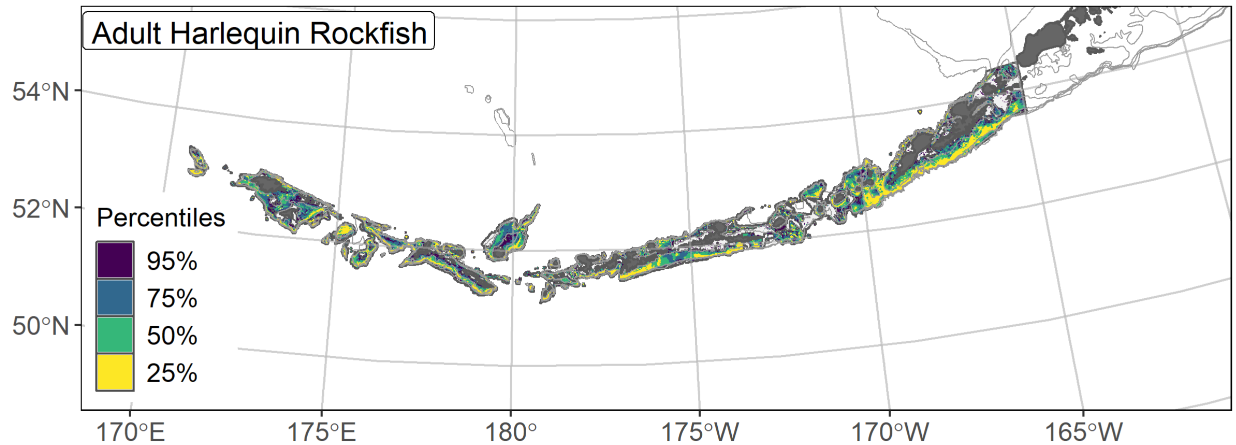

Figure E-143 EFH area of AI adult harlequin rockfish, summer

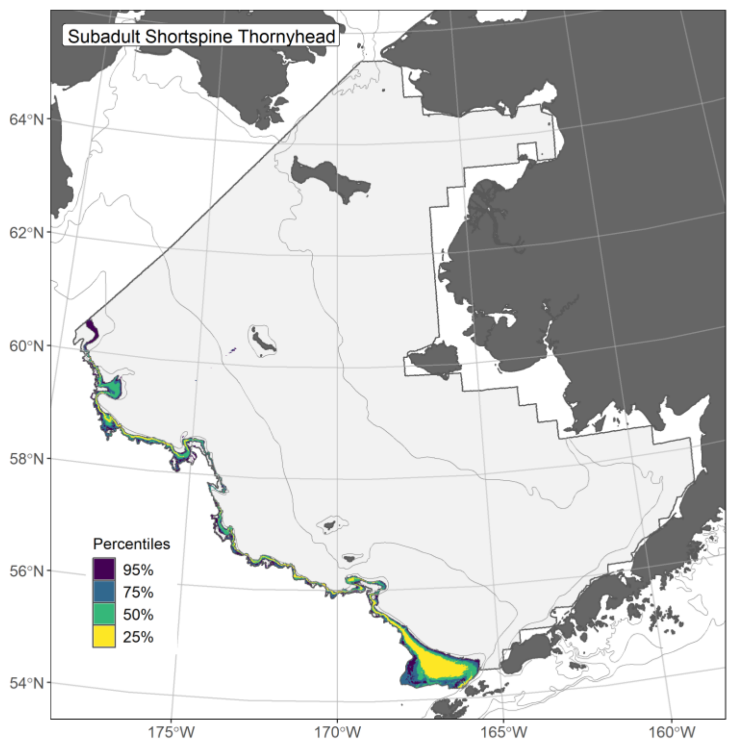

Figure E-144 EFH area of EBS subadult shortspine thornyhead rockfish, summer

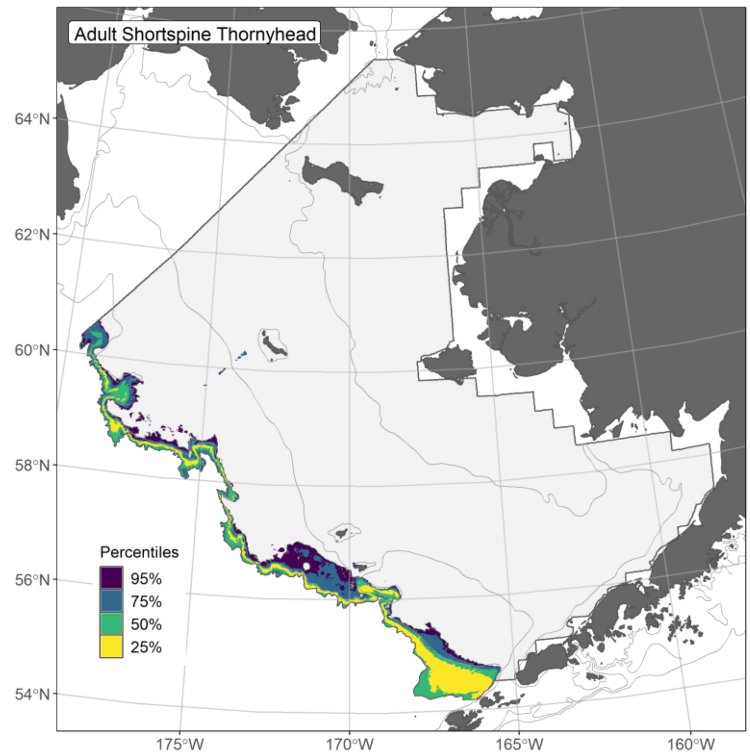

Figure E-145 EFH area of EBS adult shortspine thornyhead rockfish, summer

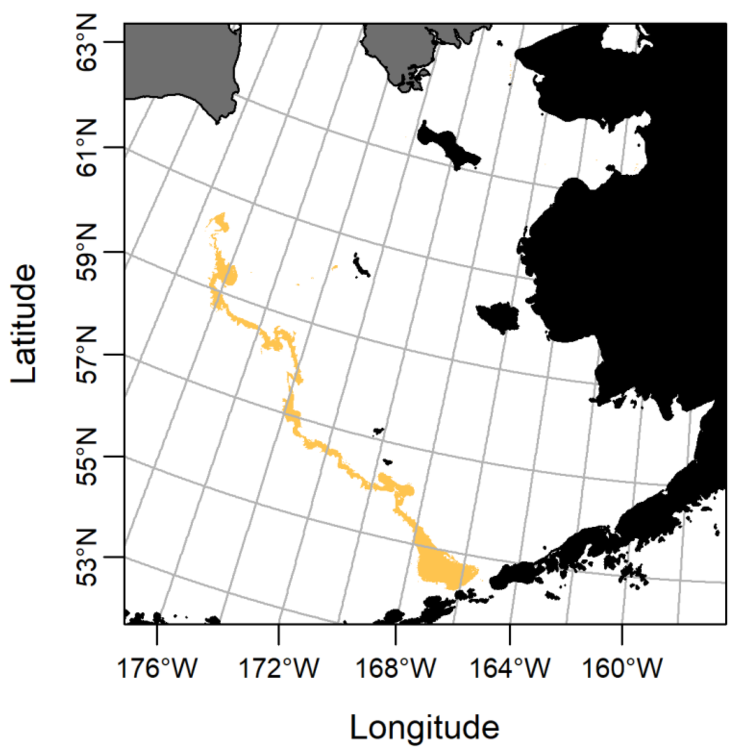

Figure E-146 EFH area of EBS adult shortspine thornyhead rockfish, fall

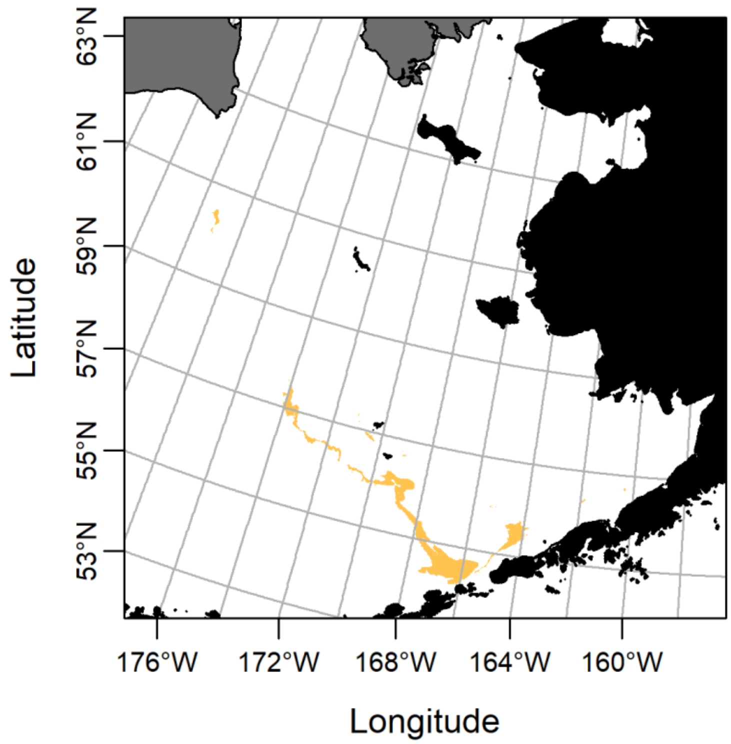

Figure E-147 EFH area of EBS adult shortspine thornyhead rockfish, winter

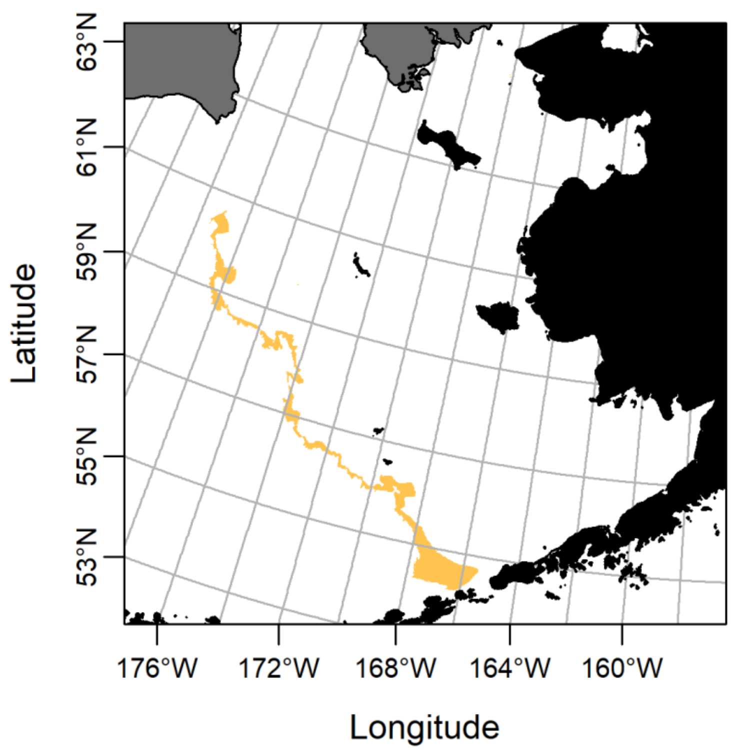

Figure E-148 EFH area of EBS adult shortspine thornyhead rockfish, spring

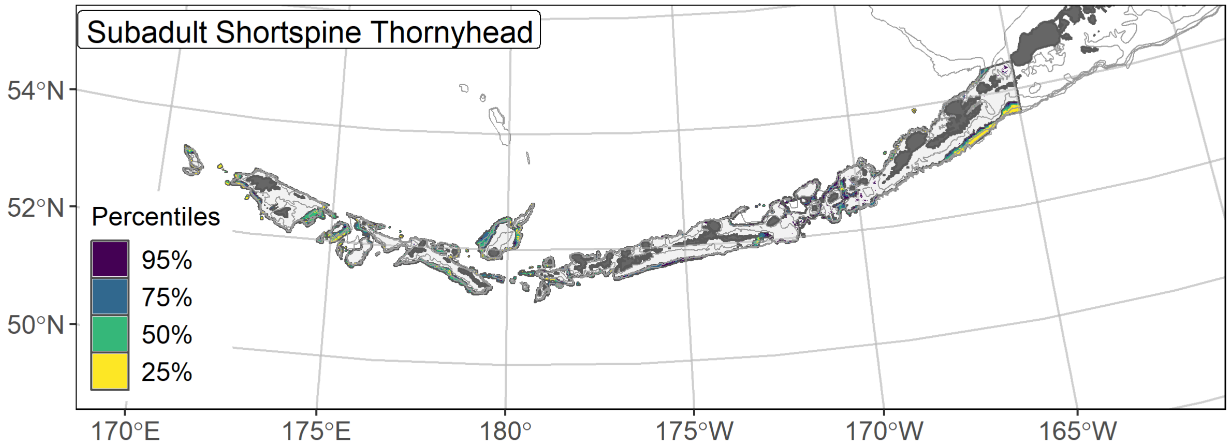

Figure E-149 EFH area of AI subadult shortspine thornyhead rockfish, summer

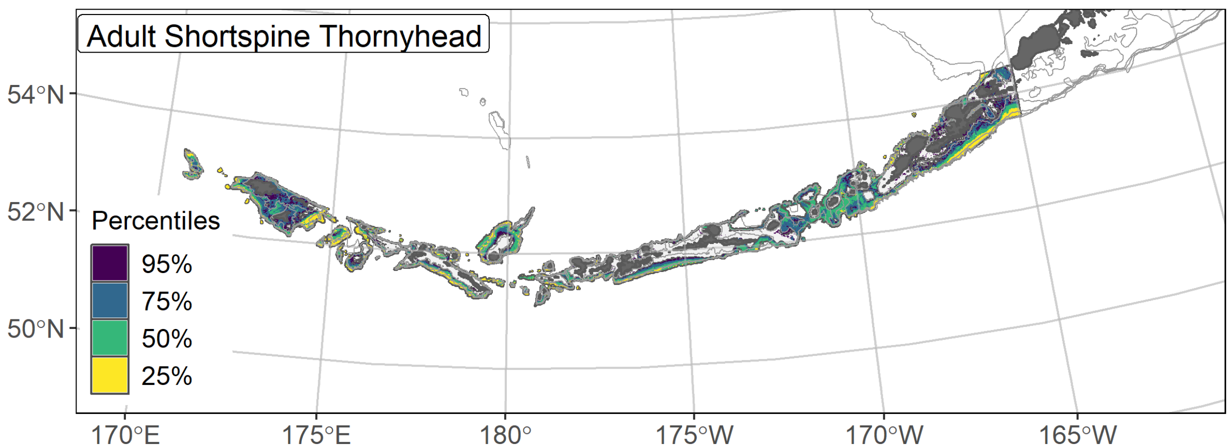

Figure E-150 EFH area of AI adult shortspine thornyhead rockfish, summer

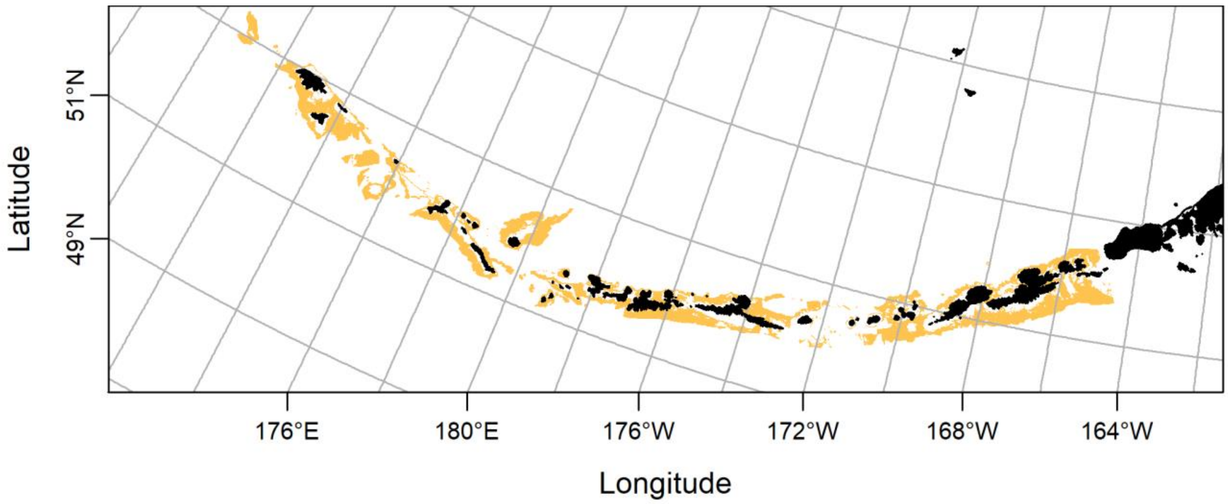

Figure E-151 EFH area of AI adult shortspine thornyhead rockfish, fall

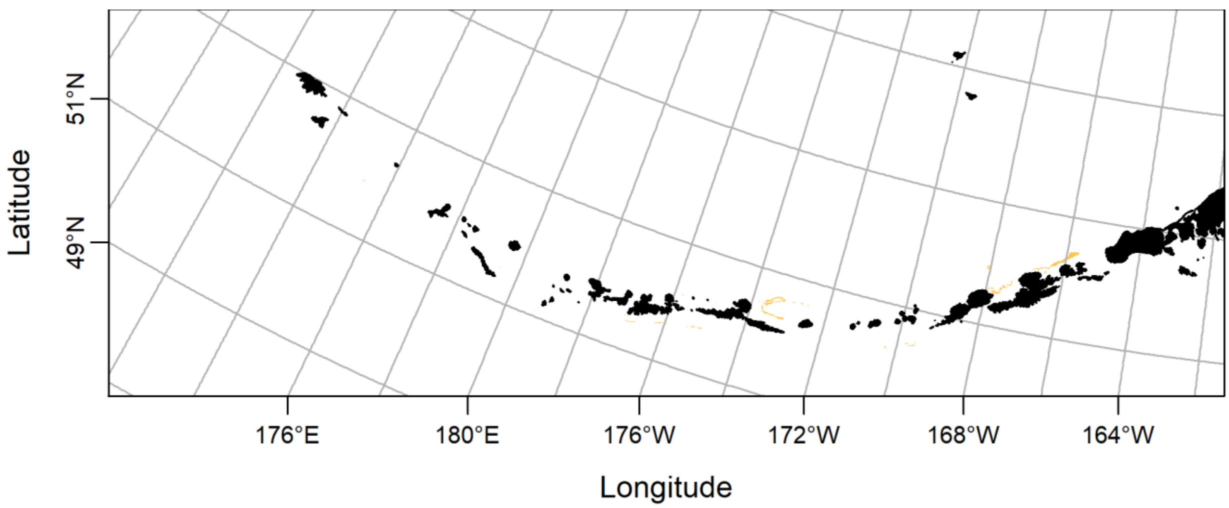

Figure E-152 EFH area of AI adult shortspine thornyhead rockfish, winter

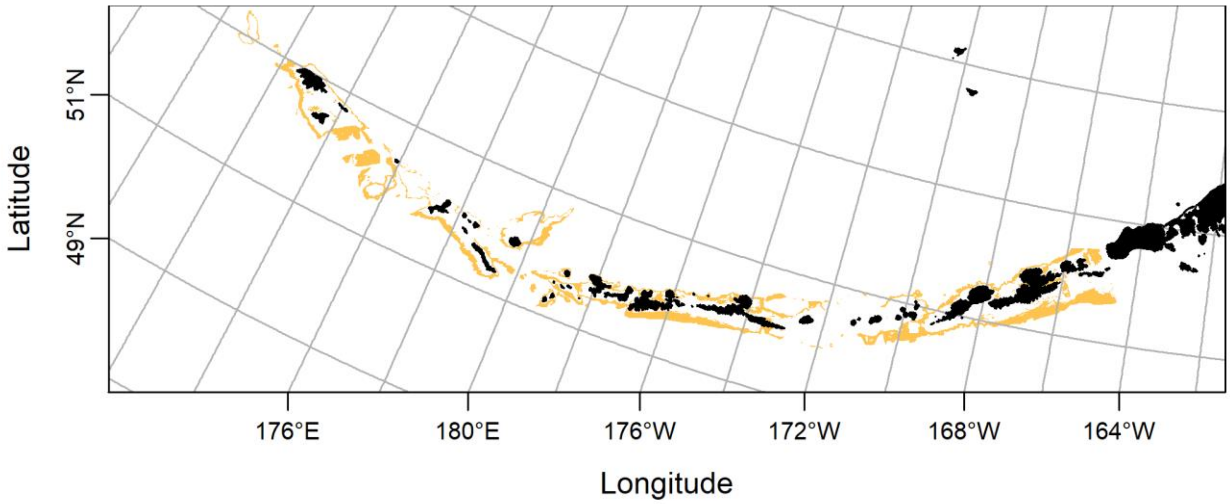

Figure E-153 EFH area of AI adult shortspine thornyhead rockfish, spring

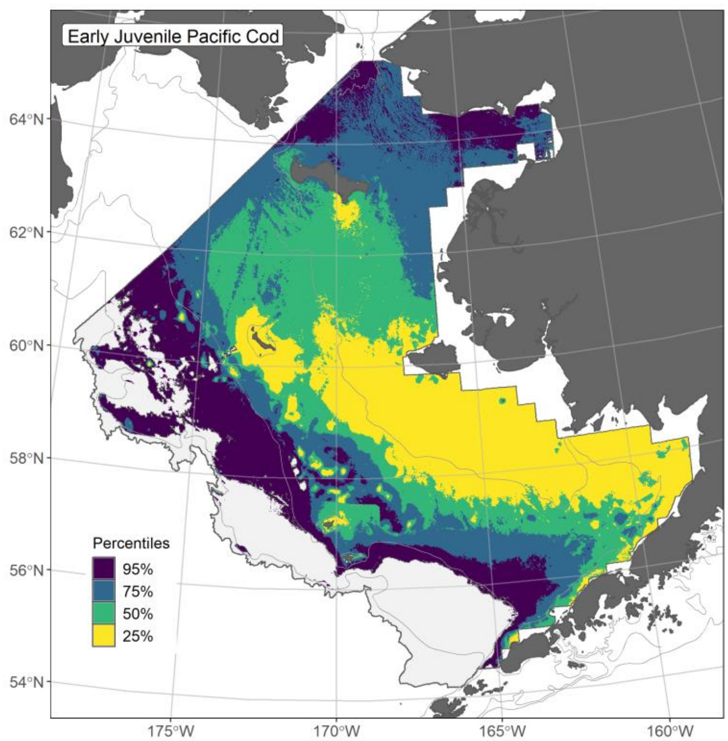

Figure E-154 EFH area of EBS settled early juvenile Pacific cod, summer

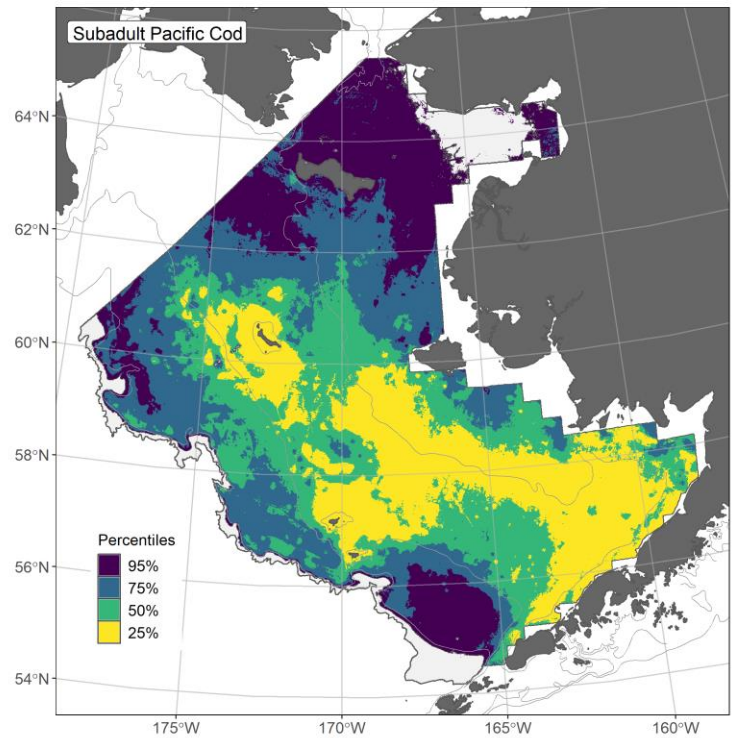

Figure E-155 EFH area of EBS subadult Pacific cod, summer

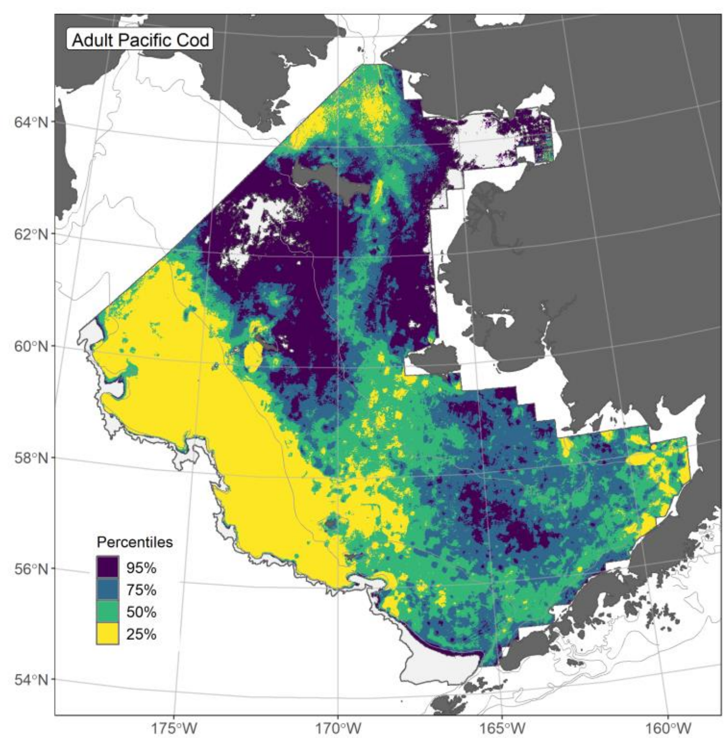

Figure E-156 EFH area of EBS adult Pacific cod, summer

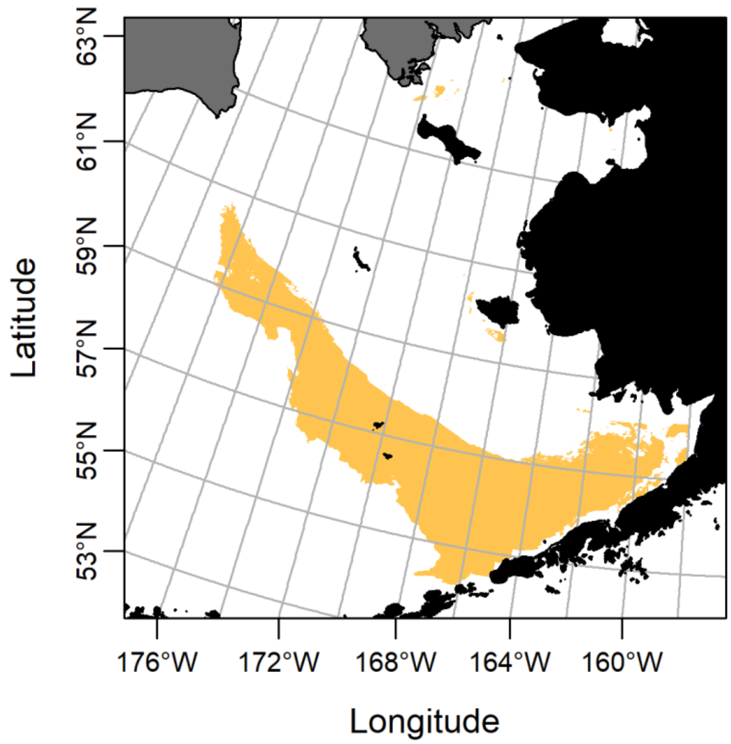

Figure E-157 EFH area of EBS Pacific cod larvae, summer

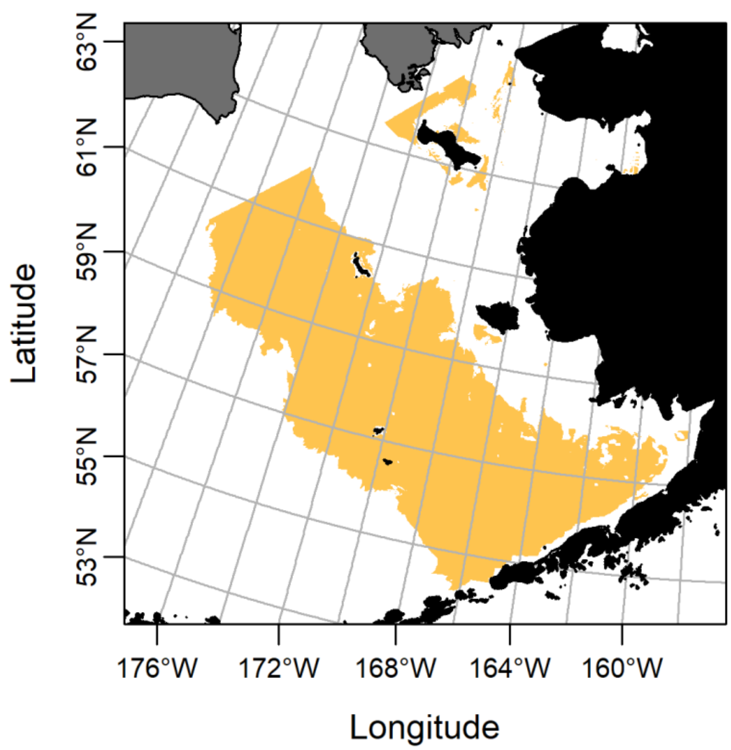

Figure E-158 EFH area of EBS adult Pacific cod, fall

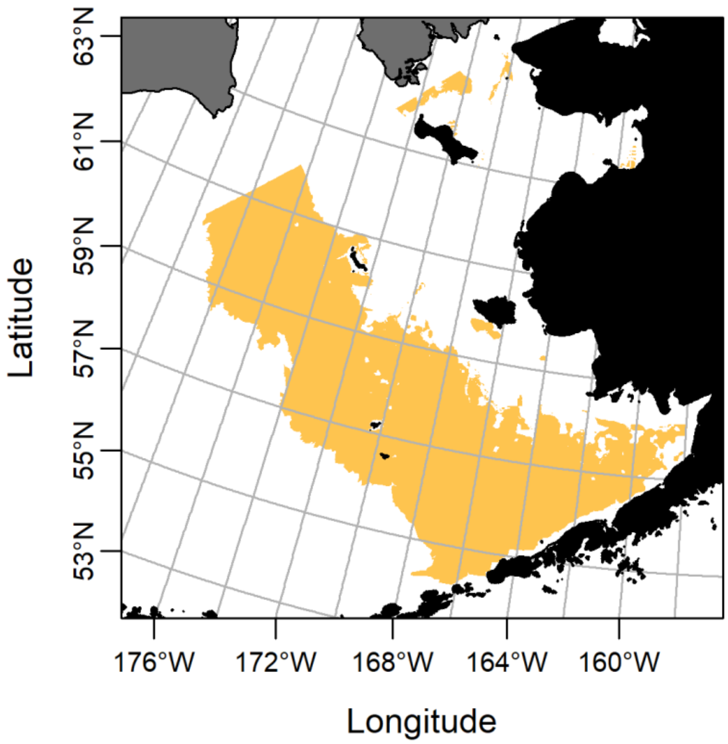

Figure E-159 EFH area of EBS adult Pacific cod, winter

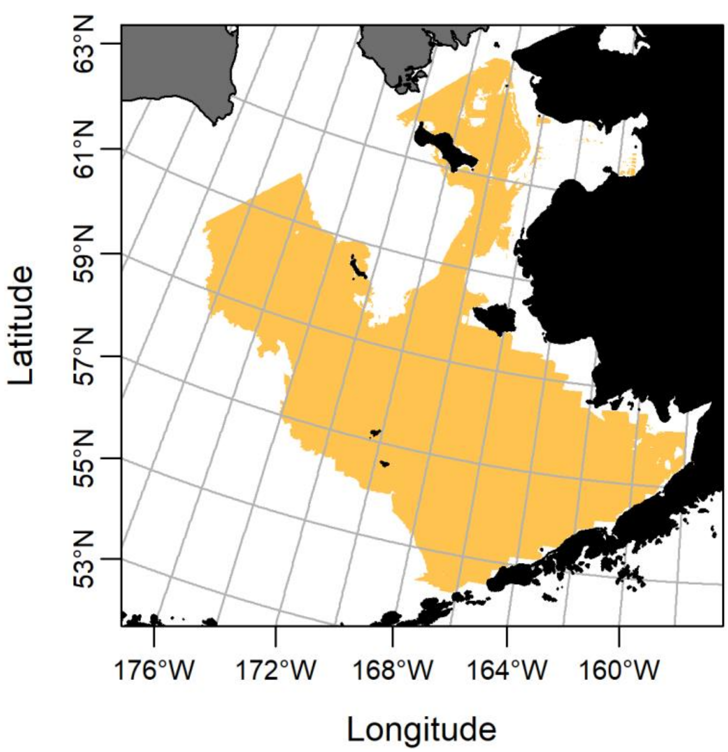

Figure E-160 EFH area of EBS adult Pacific cod, spring

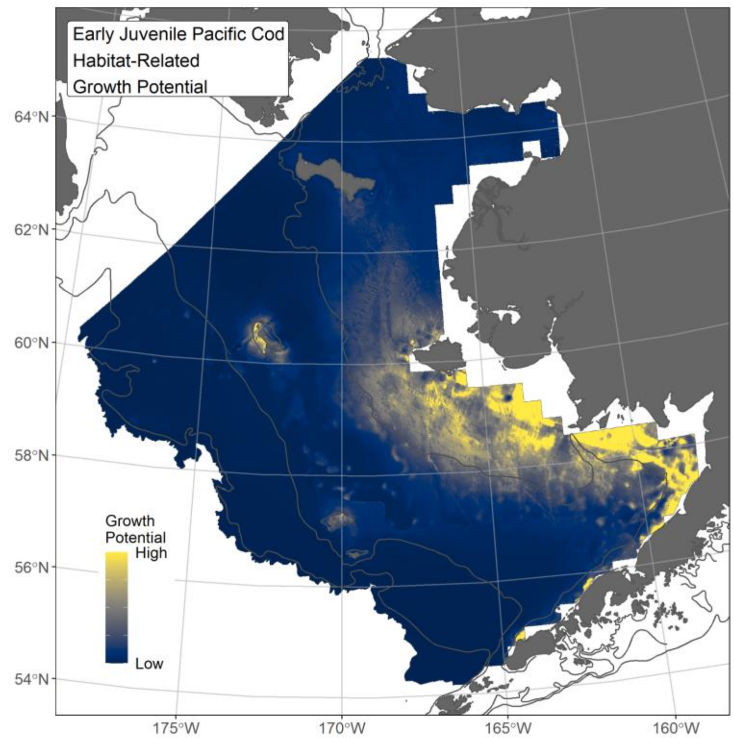

Figure E-161 EFH area of EBS settled early juvenile Pacific cod, habitat-related growth potential, summer

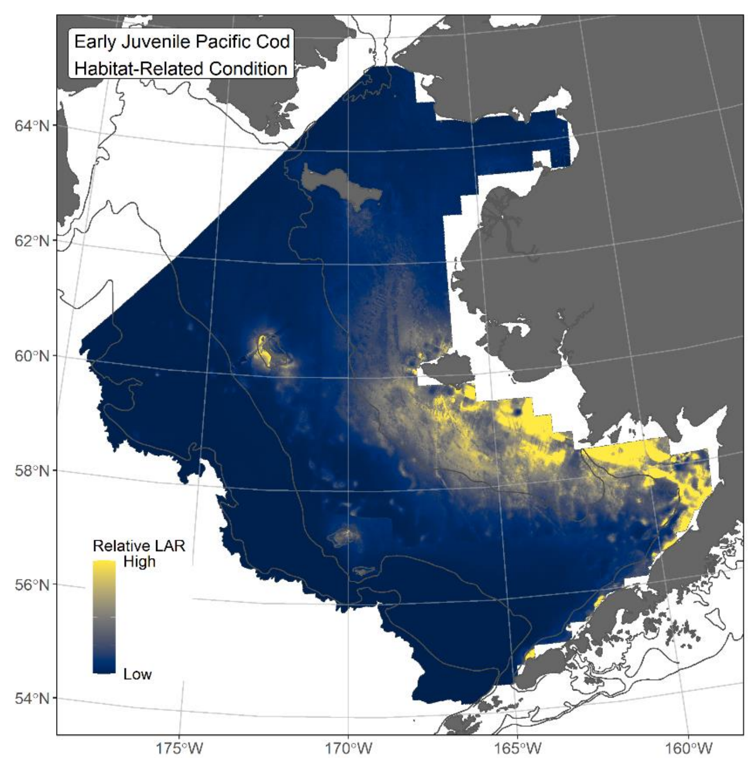

Figure E-162 EFH area of EBS settled early juvenile Pacific cod, habitat-related condition, summer

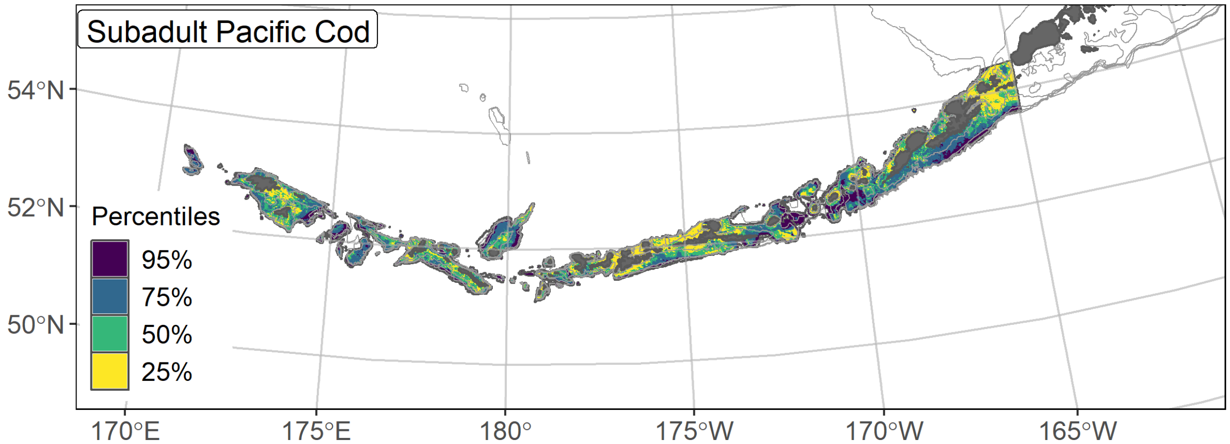

Figure E-163 EFH area of AI subadult Pacific cod, summer

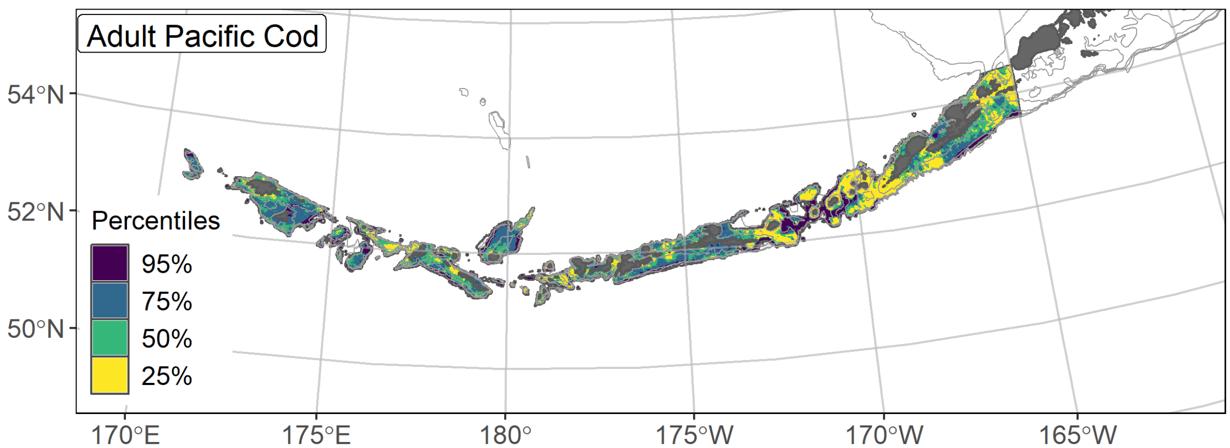

Figure E-164 EFH area of AI adult Pacific cod, summer

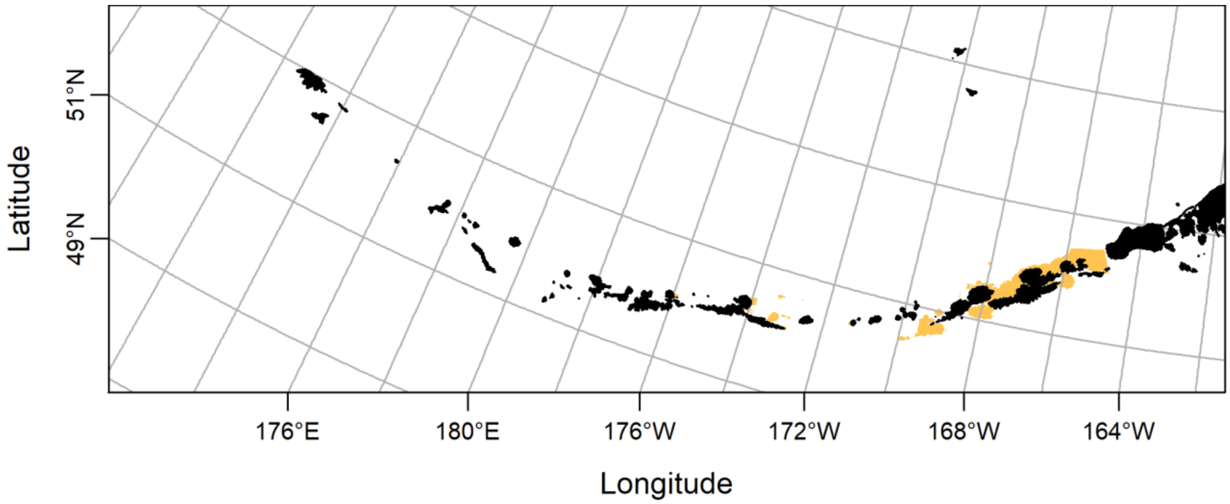

Figure E-165 EFH area of AI larvae Pacific cod, summer

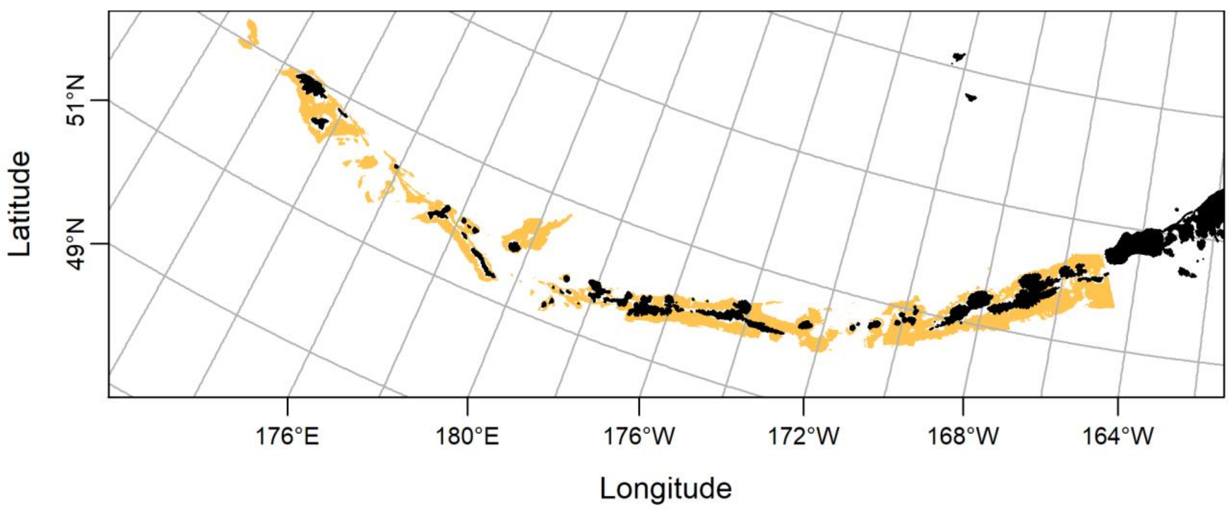

Figure E-166 EFH area of AI adult Pacific cod, fall

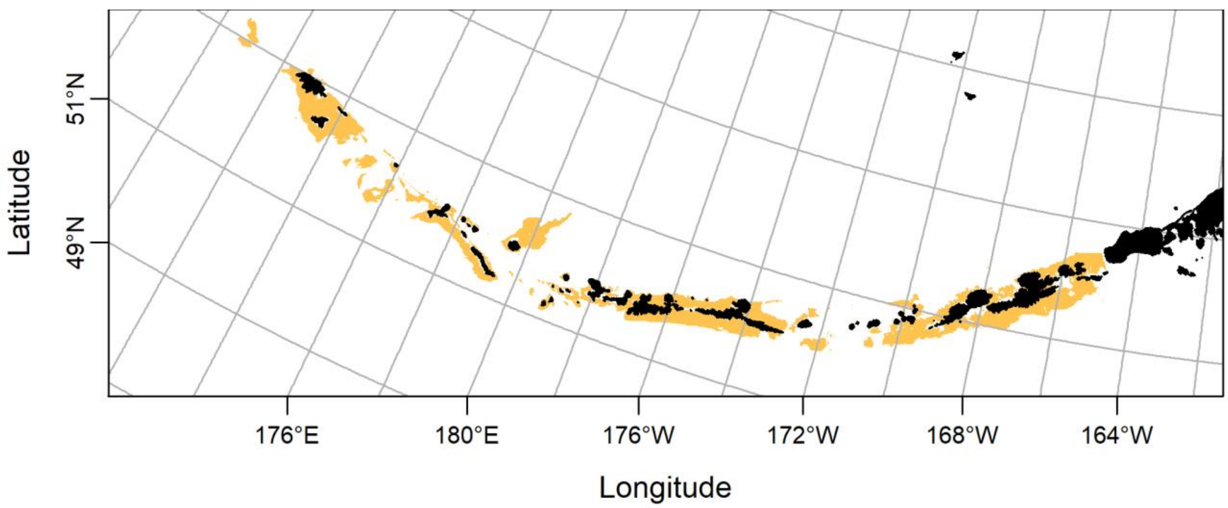

Figure E-167 EFH area of AI adult Pacific cod, winter

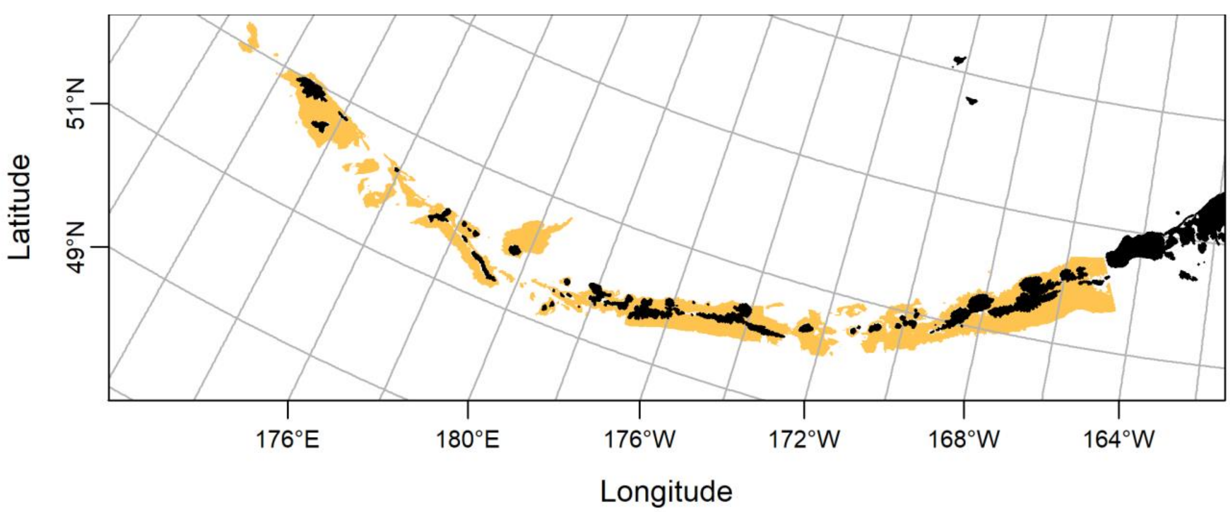

Figure E-168 EFH area of AI adult Pacific cod, spring

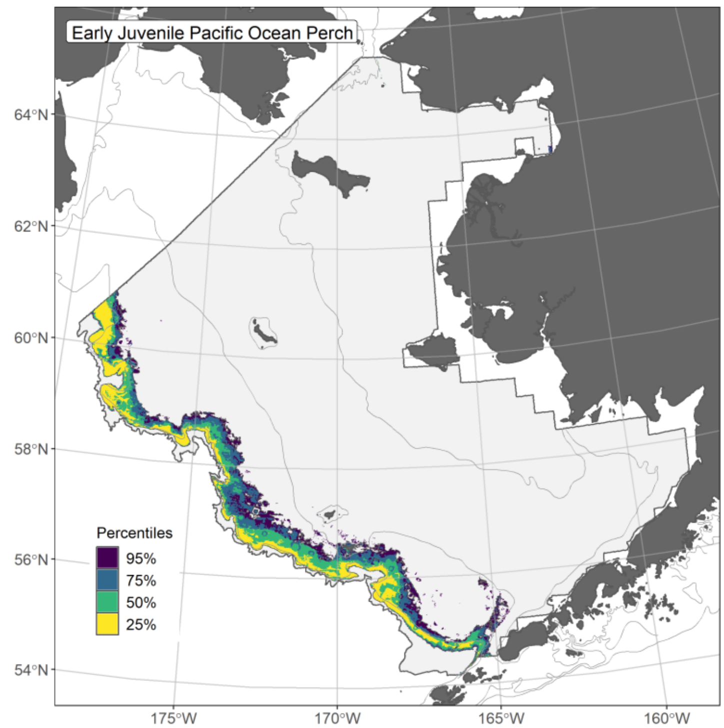

Figure E-169 EFH area of EBS settled early juvenile Pacific ocean perch, summer

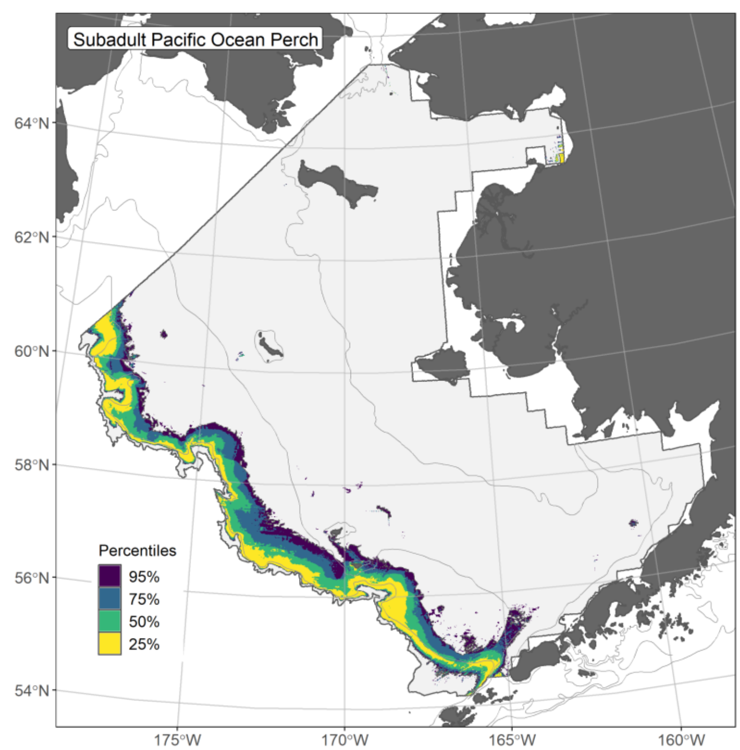

Figure E-170 EFH area of EBS subadult Pacific ocean perch, summer

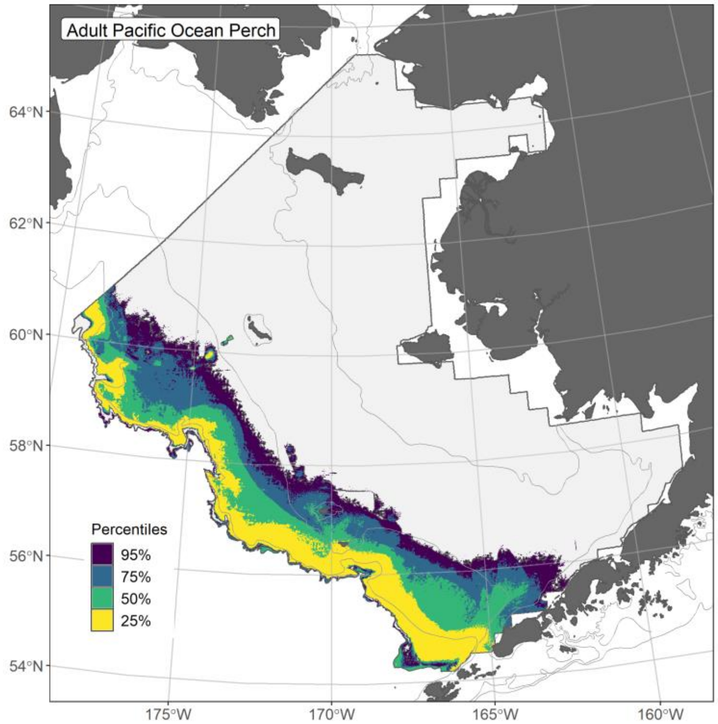

Figure E-171 EFH area of EBS adult Pacific ocean perch, summer

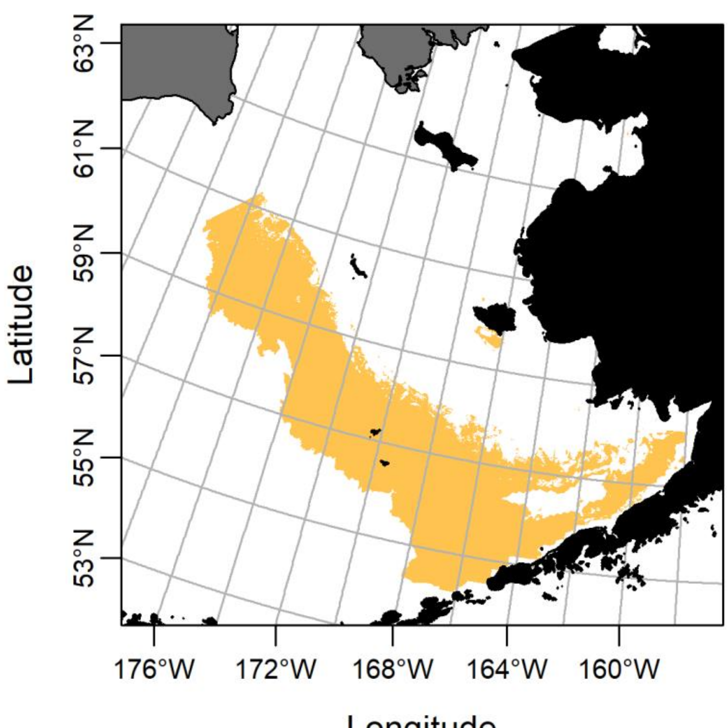

Figure E-172 EFH area of EBS Pacific ocean perch larvae, summer

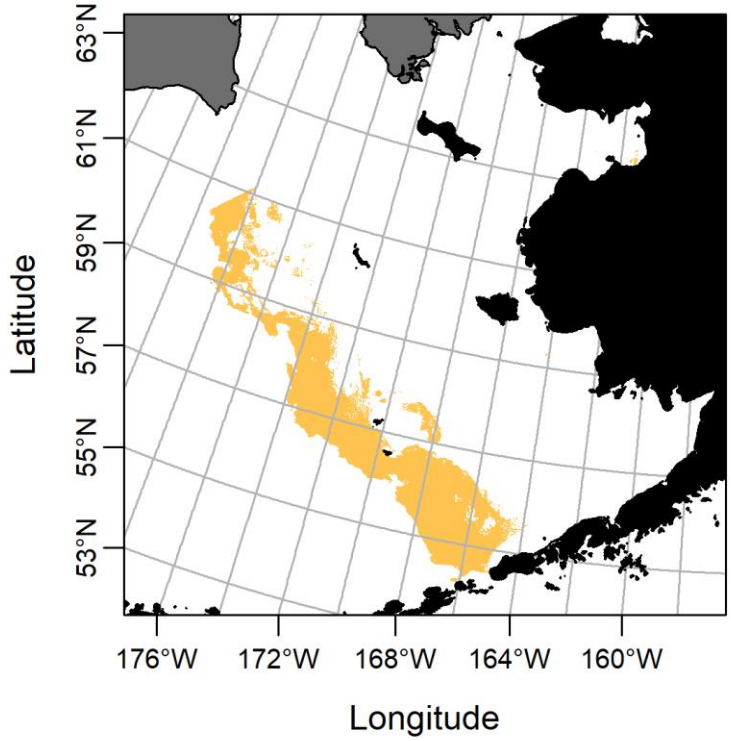

Figure E-173 EFH area of EBS adult Pacific ocean perch, fall

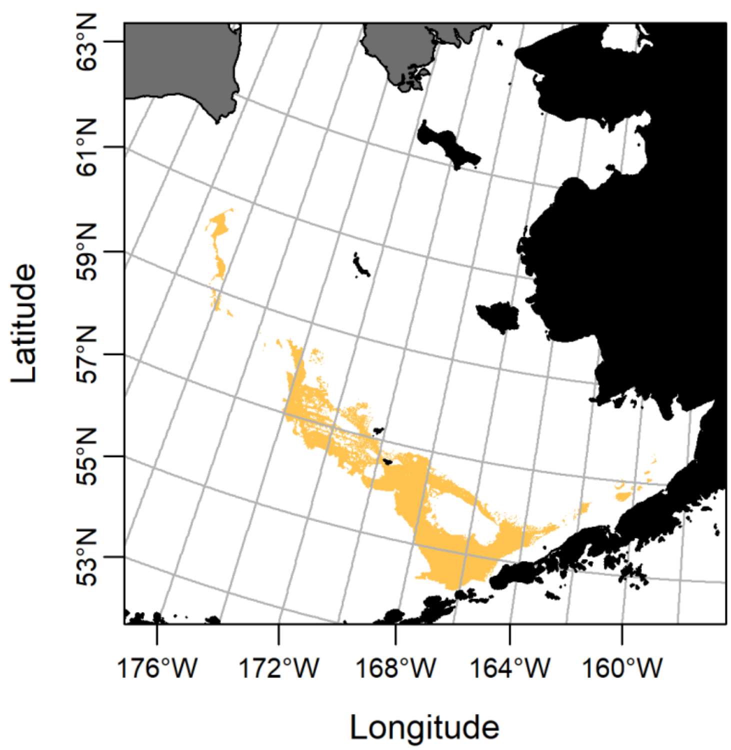

Figure E-174 EFH area of EBS adult Pacific ocean perch, winter

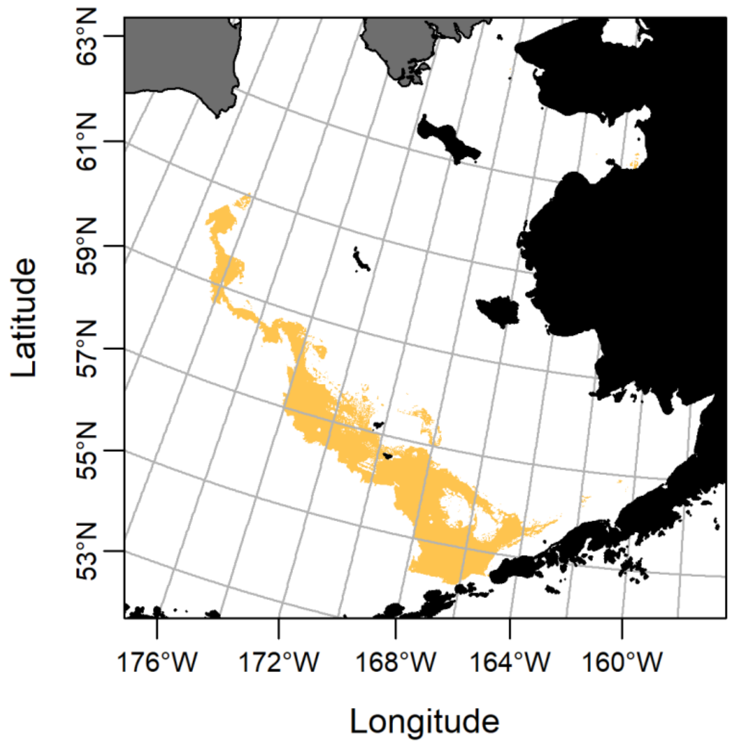

Figure E-175 EFH area of EBS adult Pacific ocean perch, spring

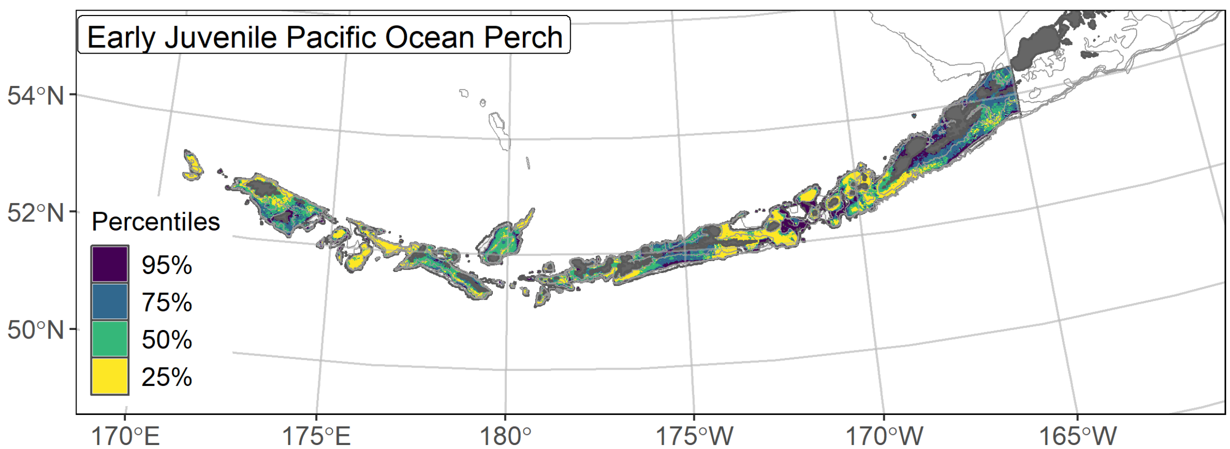

Figure E-176 EFH area of AI settled early juvenile Pacific ocean perch, summer

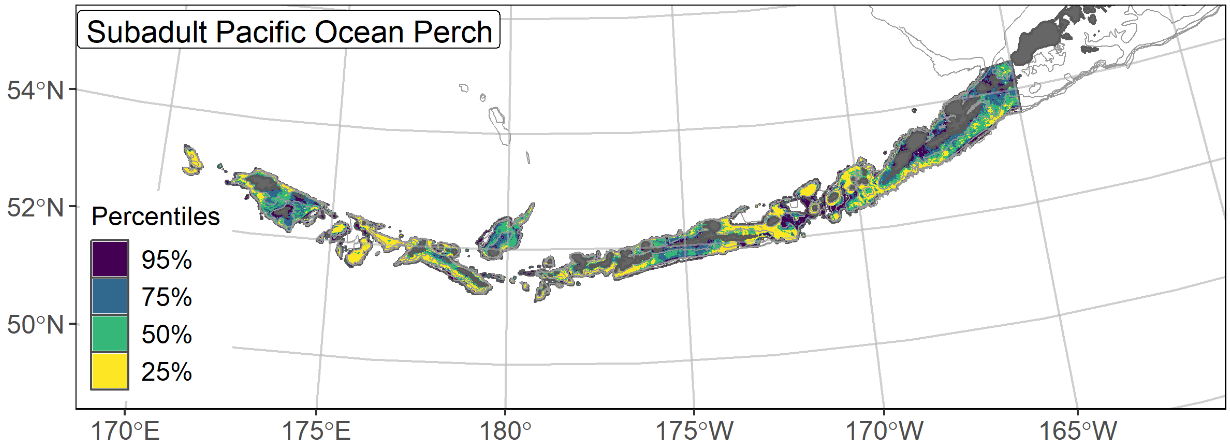

Figure E-177 EFH area of AI subadult Pacific ocean perch, summer

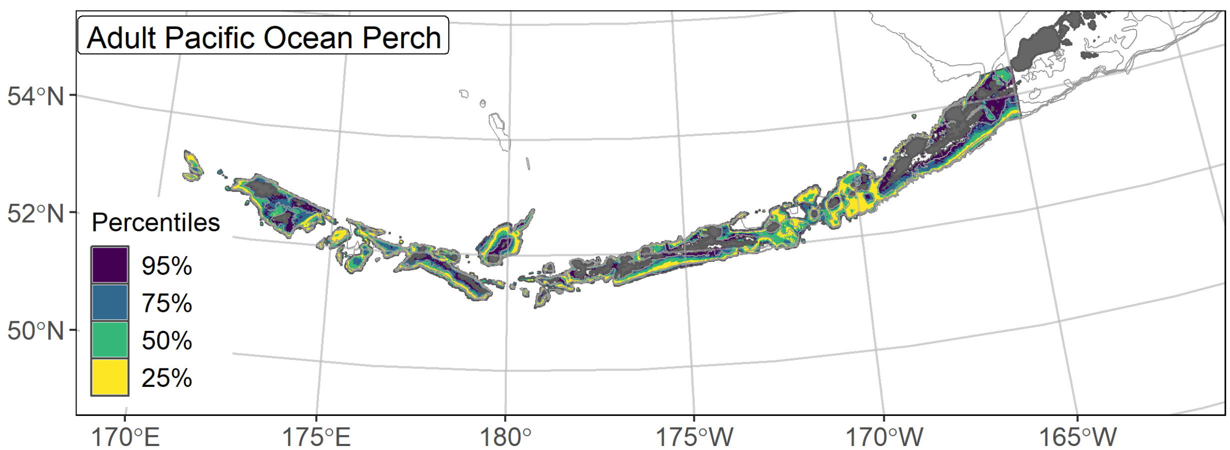

Figure E-178 EFH area of AI adult Pacific ocean perch, summer

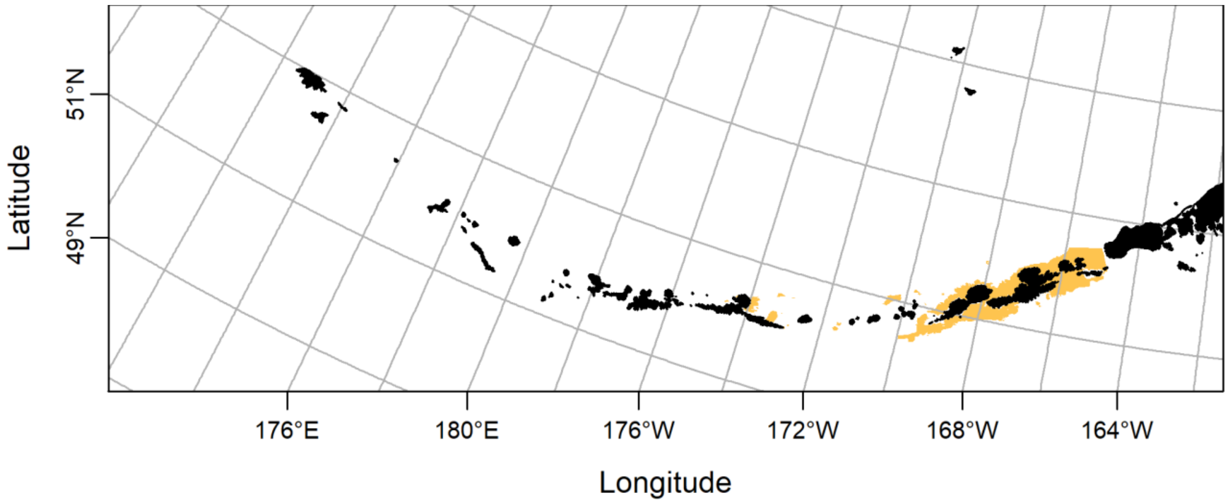

Figure E-179 EFH area of AI Pacific ocean perch larvae, summer

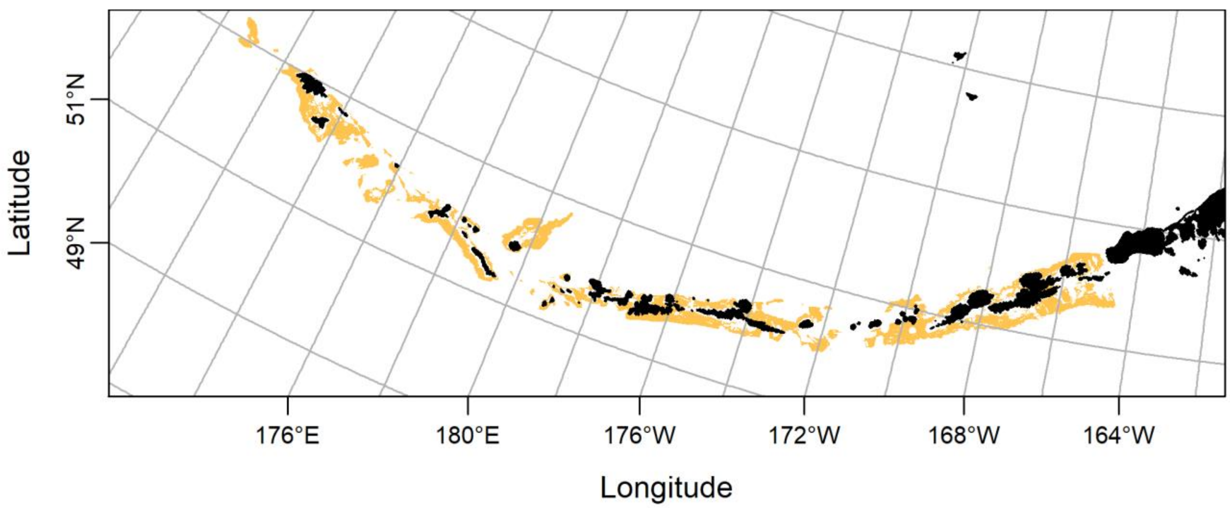

Figure E-180 EFH area of AI adult Pacific ocean perch, fall

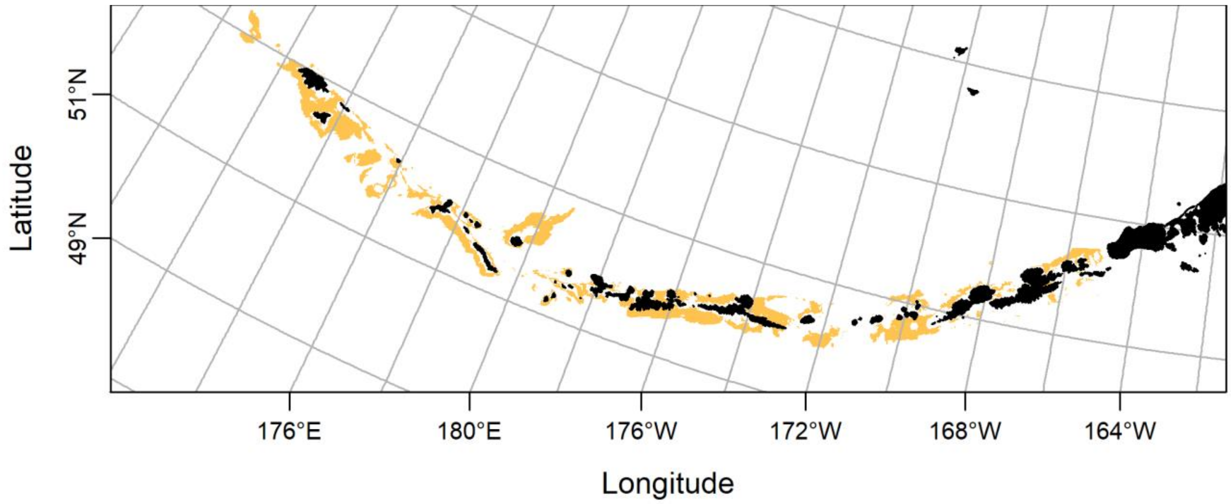

Figure E-181 EFH area of AI adult Pacific ocean perch, winter

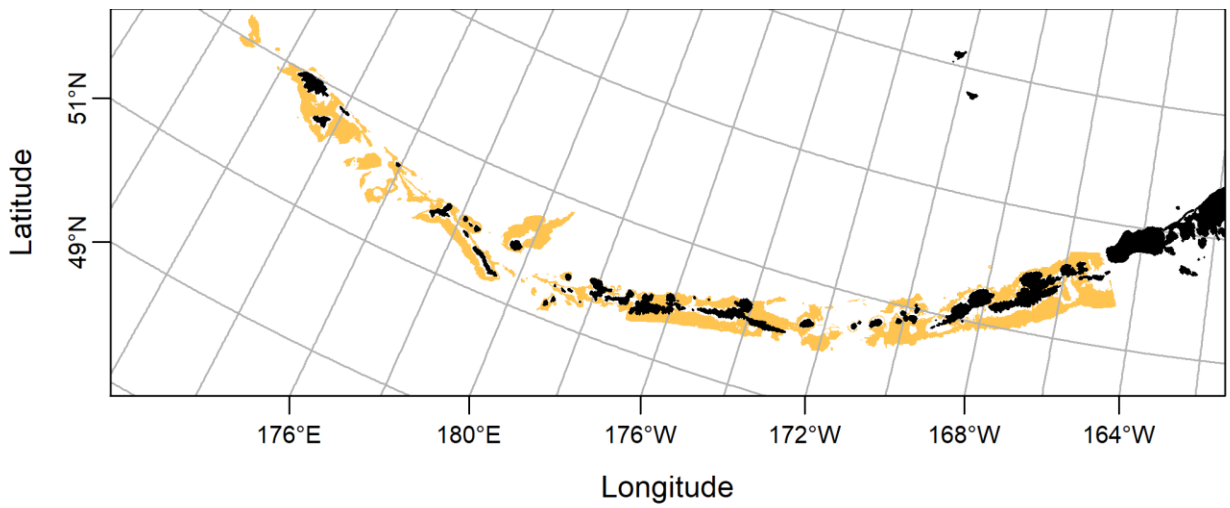

Figure E-182 EFH area of AI adult Pacific ocean perch, spring

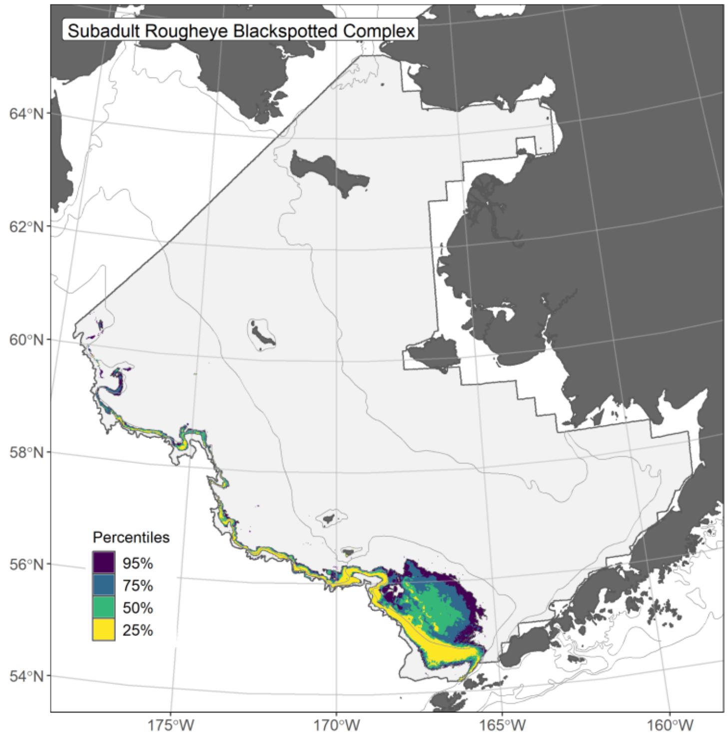

Figure E-183 EFH area of EBS subadult rougheye/blackspotted rockfish, summer

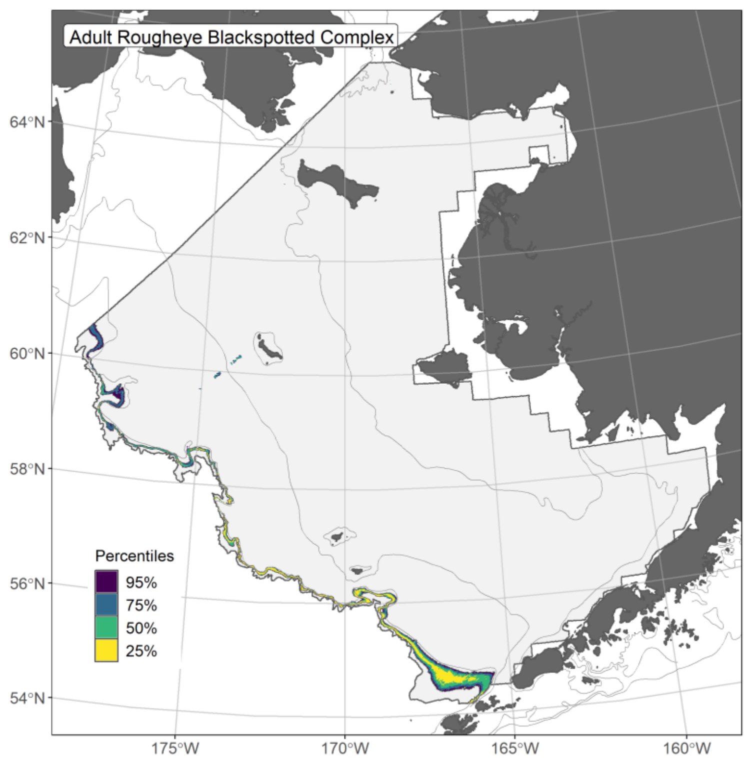

Figure E-184 EFH area of EBS adult rougheye/blackspotted rockfish, summer

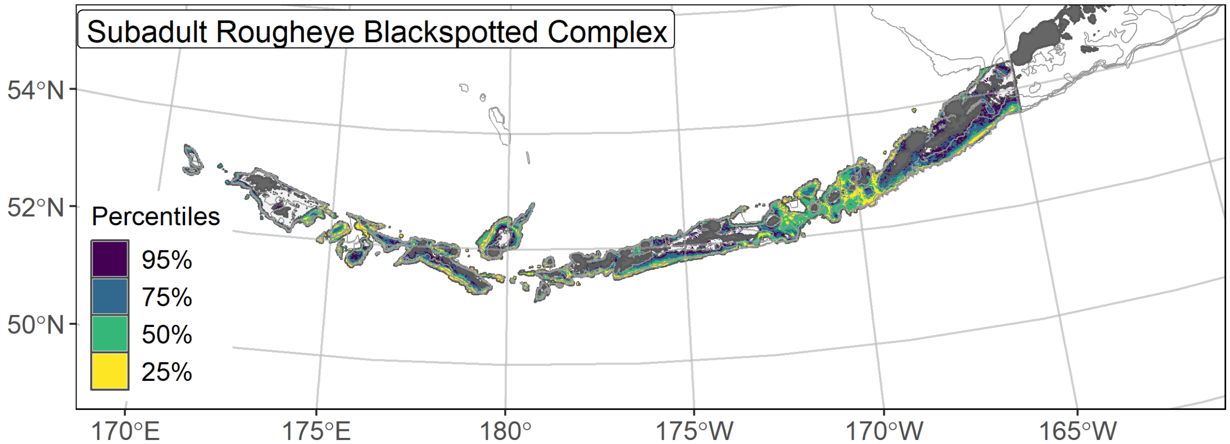

Figure E-185 EFH area of AI subadult rougheye/blackspotted rockfish, summer

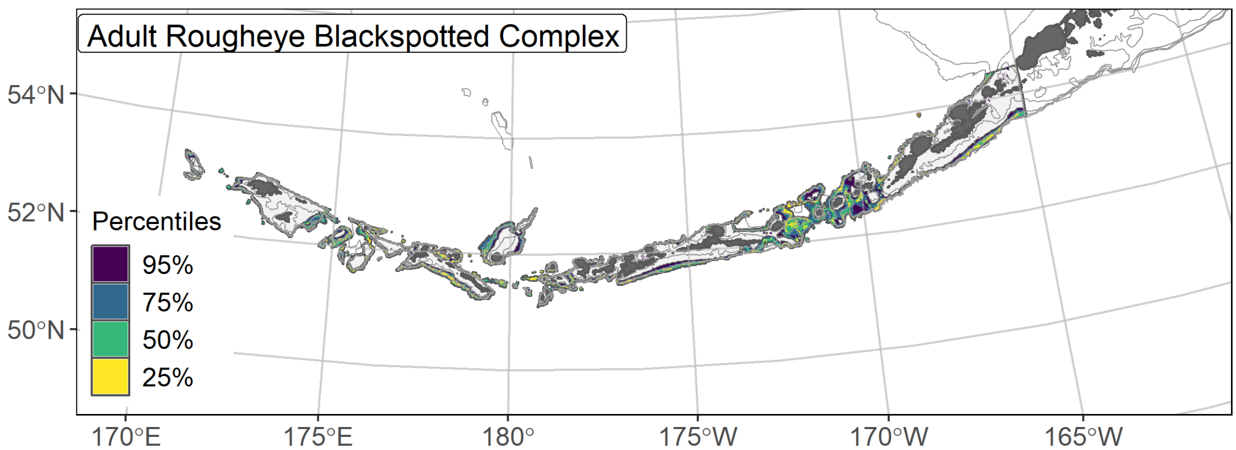

Figure E-186 EFH area of AI adult rougheye/blackspotted rockfish, summer

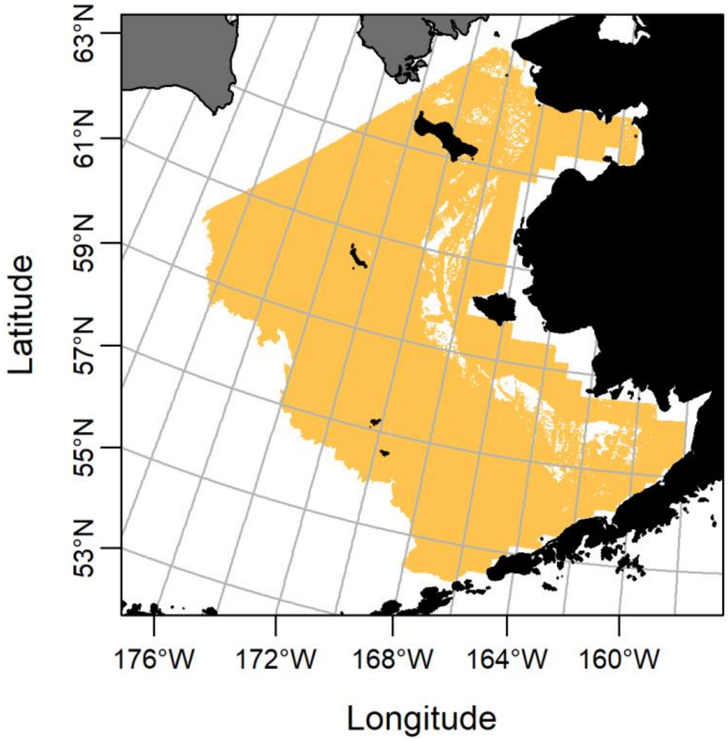

Figure E-187 EFH area of EBS adult rougheye rockfish, fall

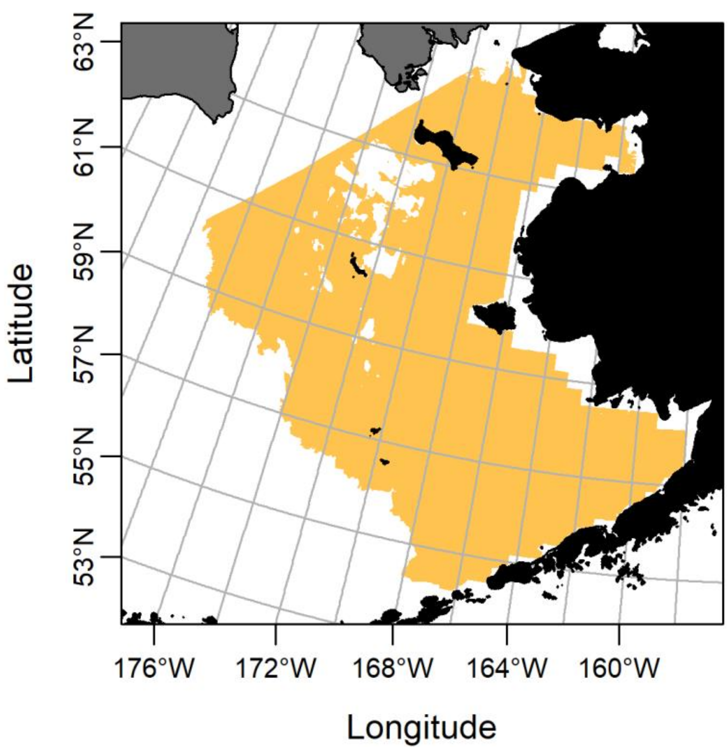

Figure E-188 EFH area of EBS adult rougheye rockfish, winter

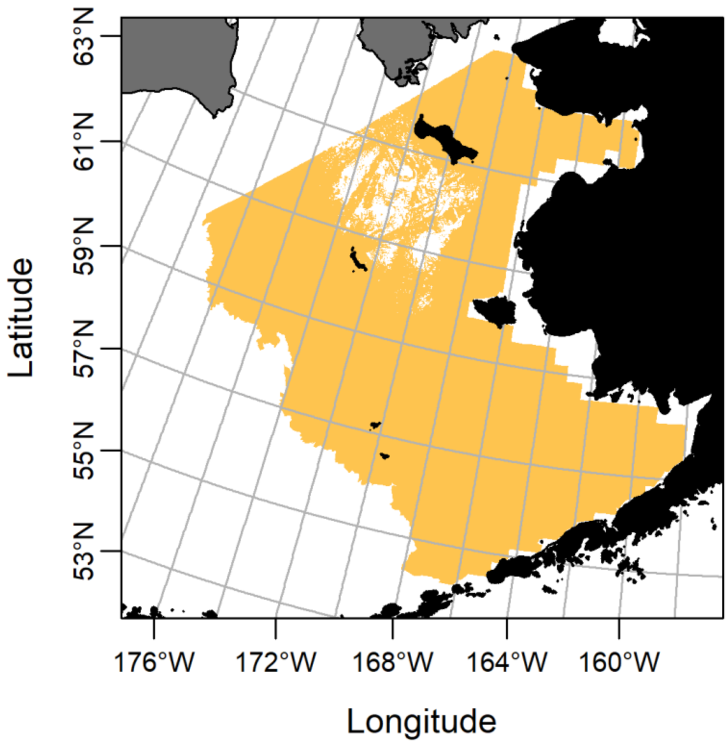

Figure E-189 EFH area of EBS adult rougheye rockfish, spring

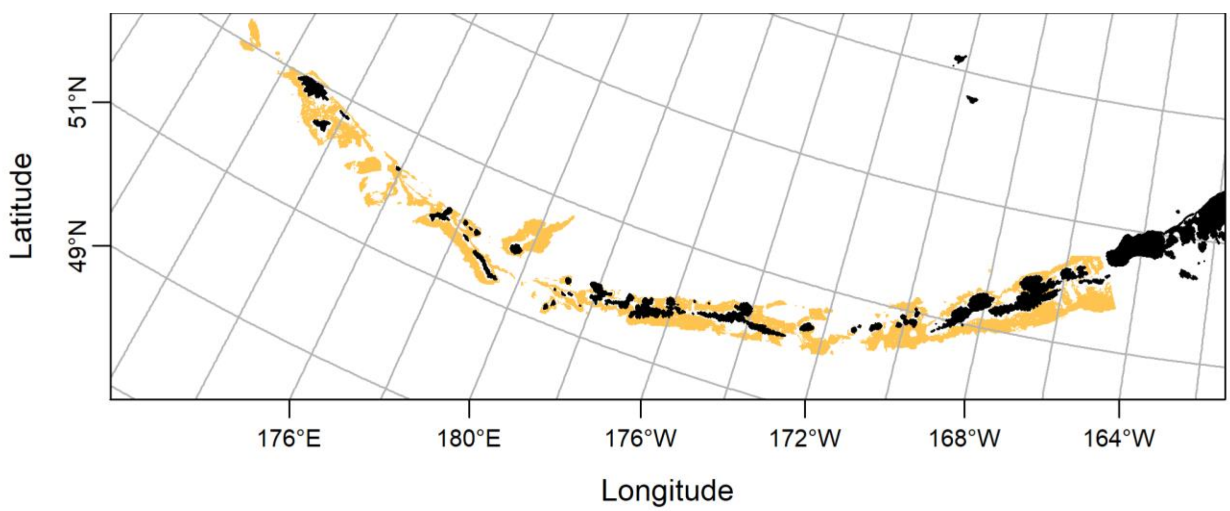

Figure E-190 EFH area of AI adult rougheye rockfish, fall

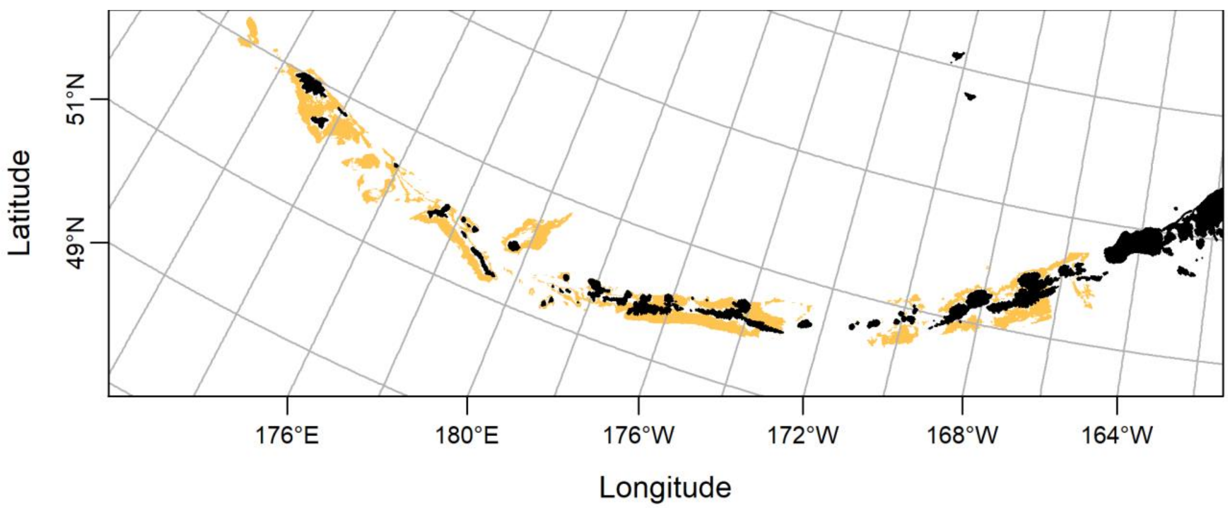

Figure E-191 EFH area of AI adult rougheye rockfish, winter

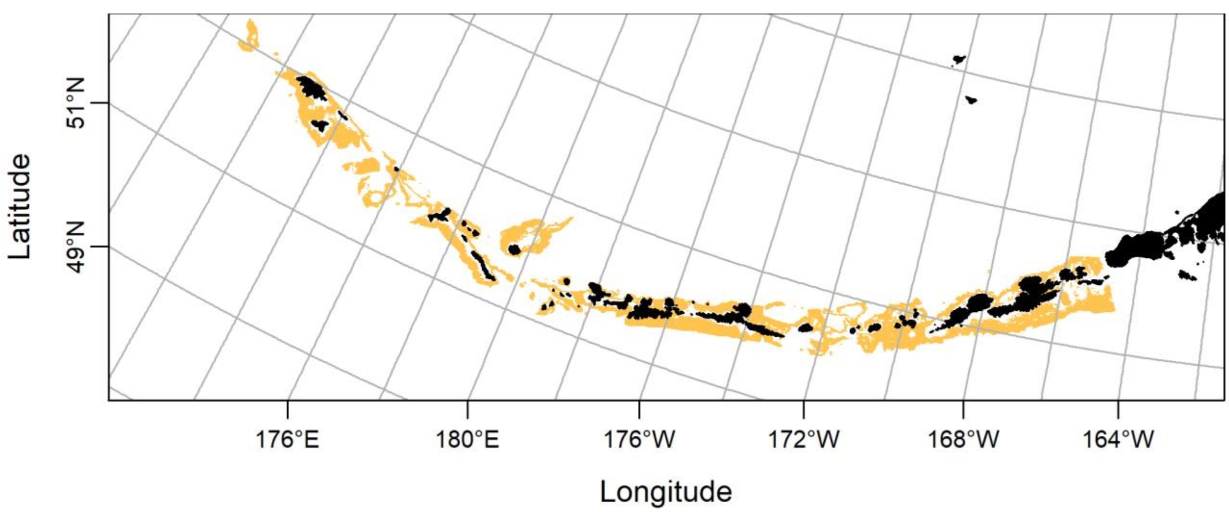

Figure E-192 EFH area of AI adult rougheye rockfish, spring

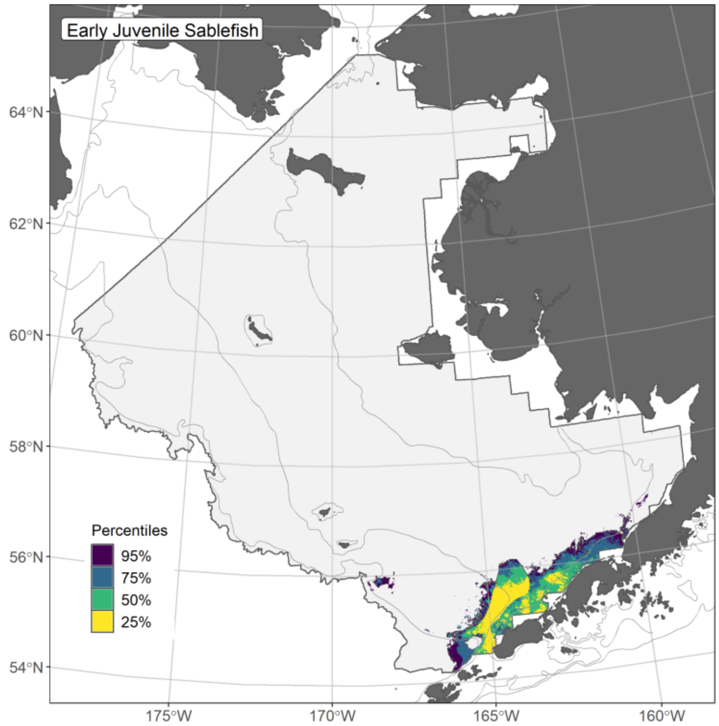

Figure E-193 EFH area of EBS settled early juvenile sablefish, summer

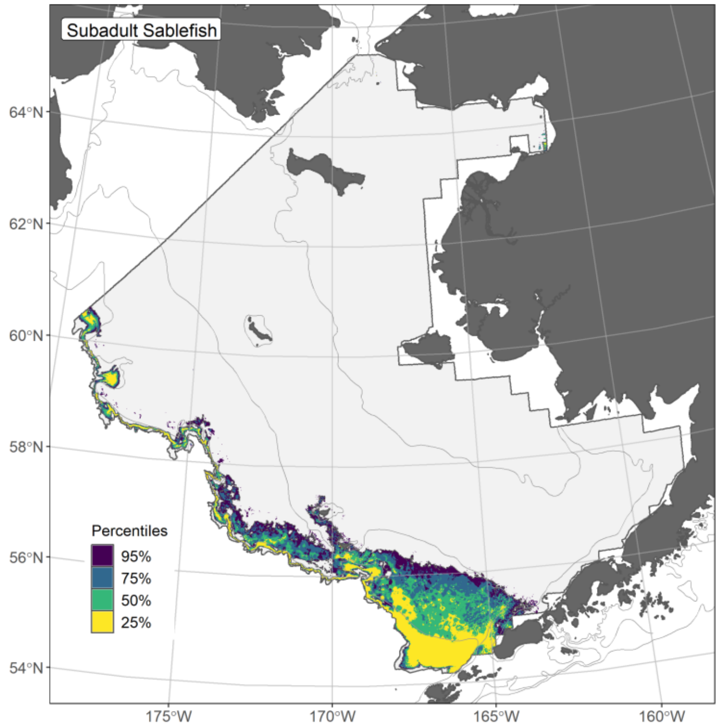

Figure E-194 EFH area of EBS subadult sablefish, summer

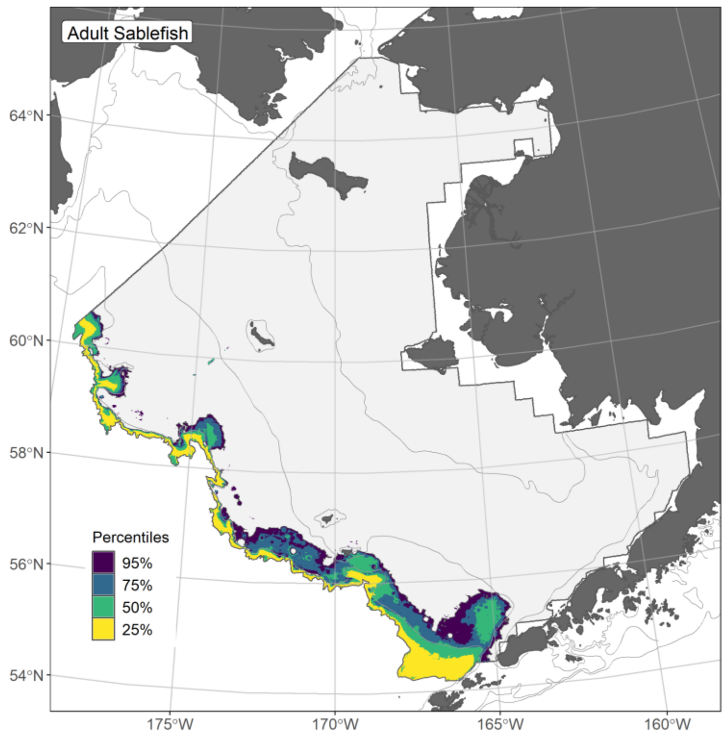

Figure E-195 EFH area of EBS adult sablefish, summer

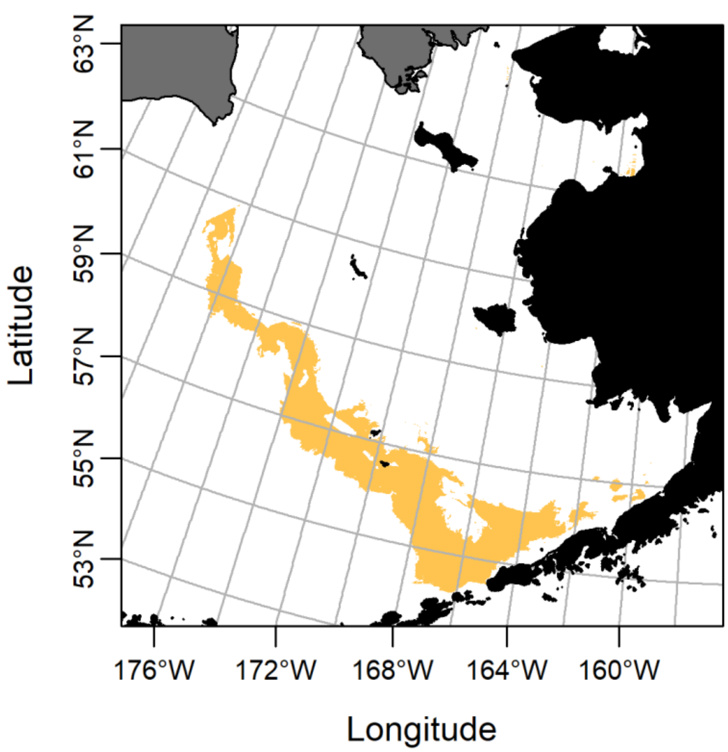

Figure E-196 EFH area of EBS adult sablefish, fall

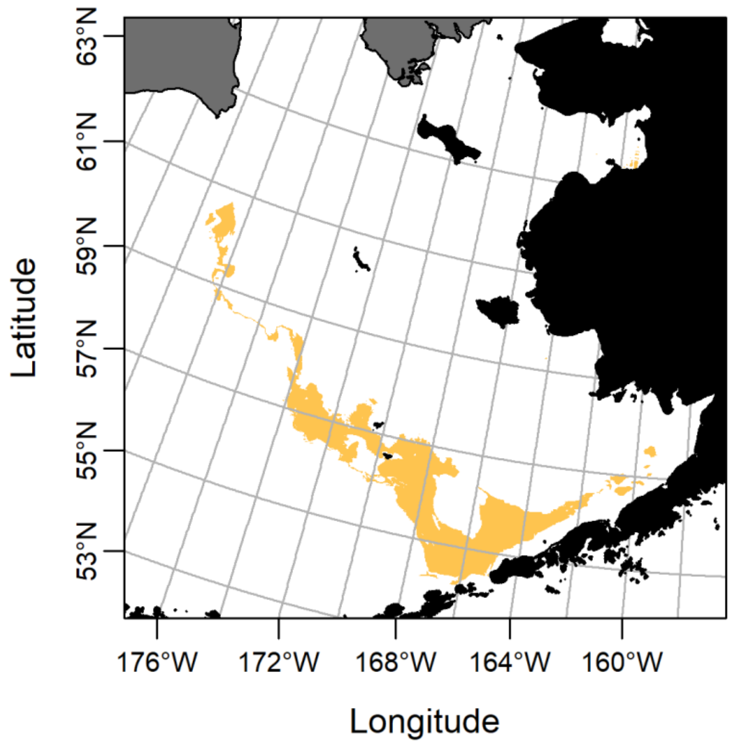

Figure E-197 EFH area of EBS adult sablefish, winter

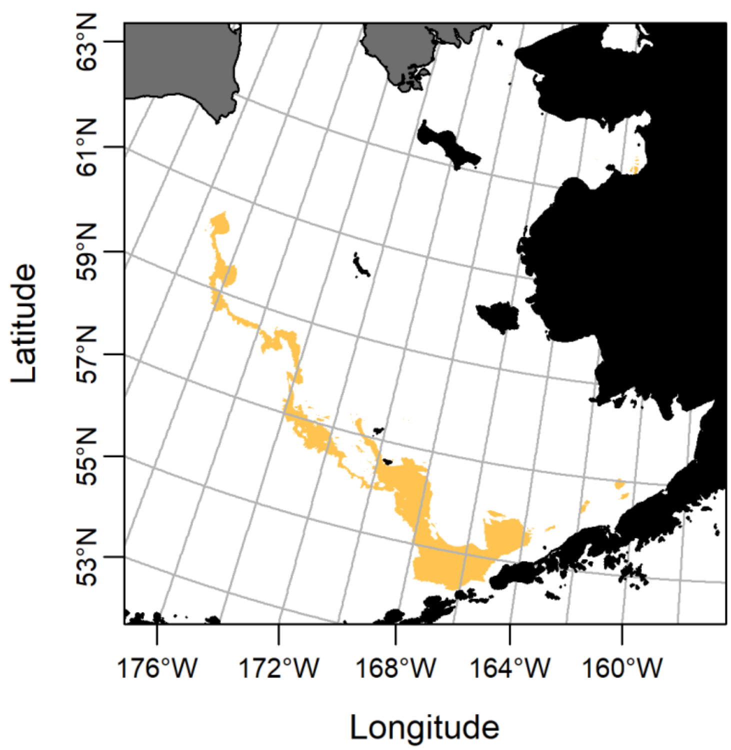

Figure E-198 EFH area of EBS adult sablefish, spring

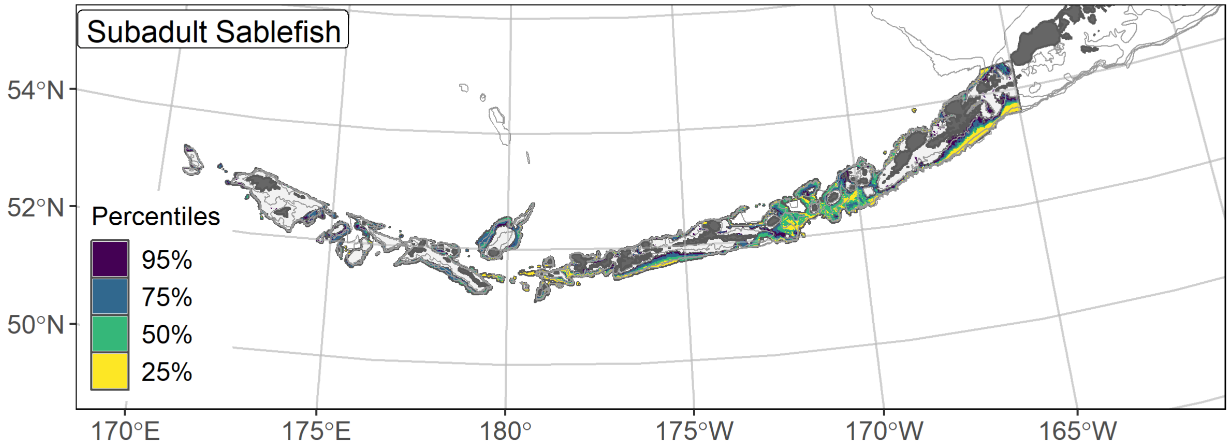

Figure E-199 EFH area of AI subadult sablefish, summer

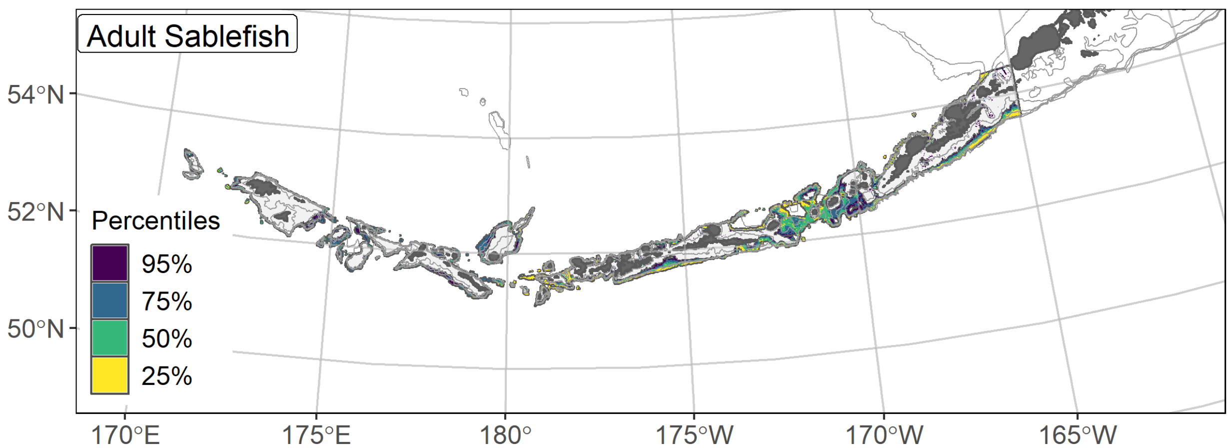

Figure E-200 EFH area of AI adult sablefish, summer

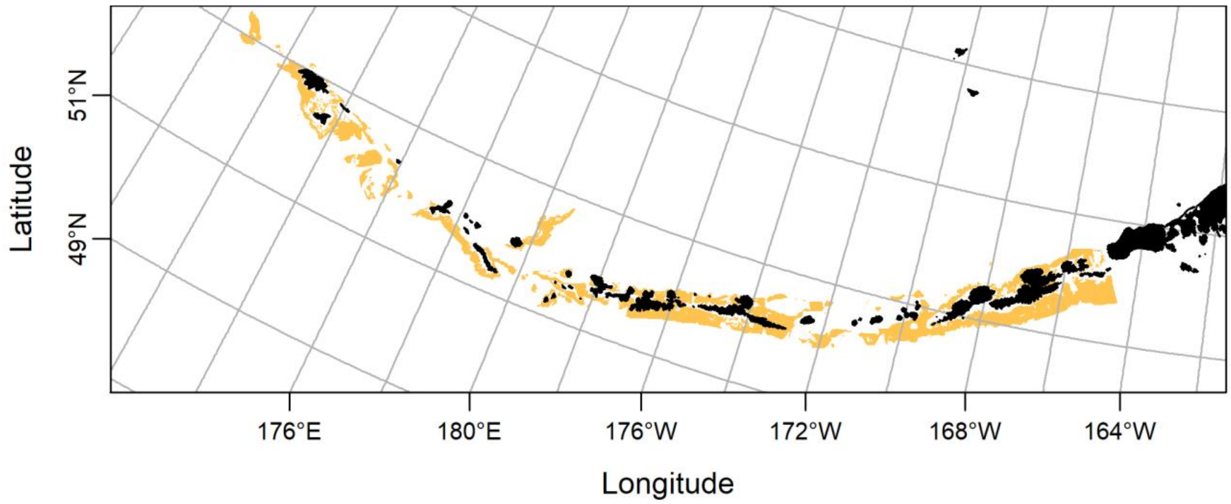

Figure E-201 **EFH area of AI adult sablefish, fall**

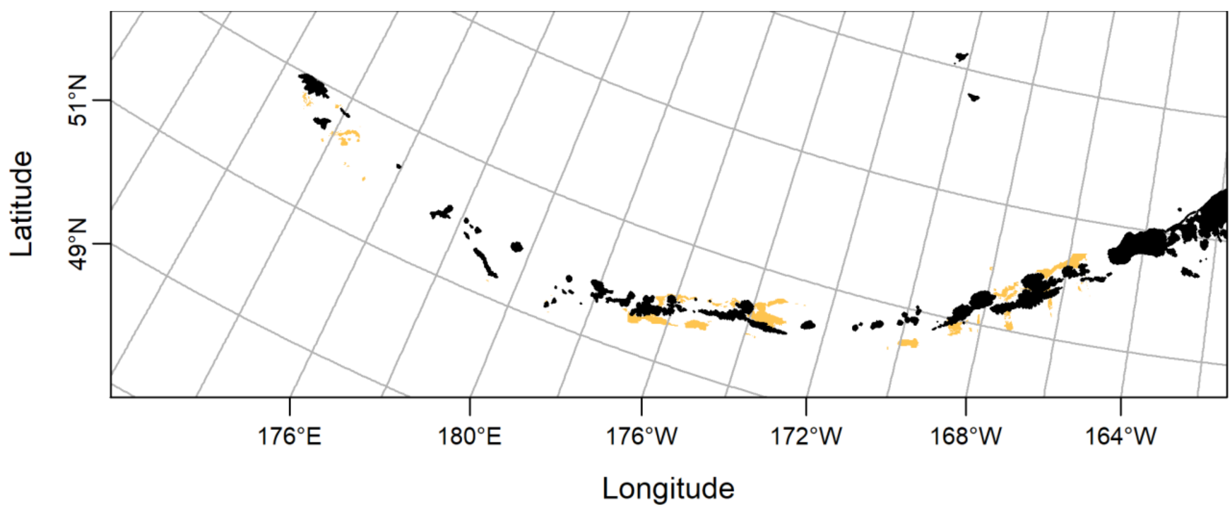

Figure E-202 **EFH area of AI adult sablefish, winter**

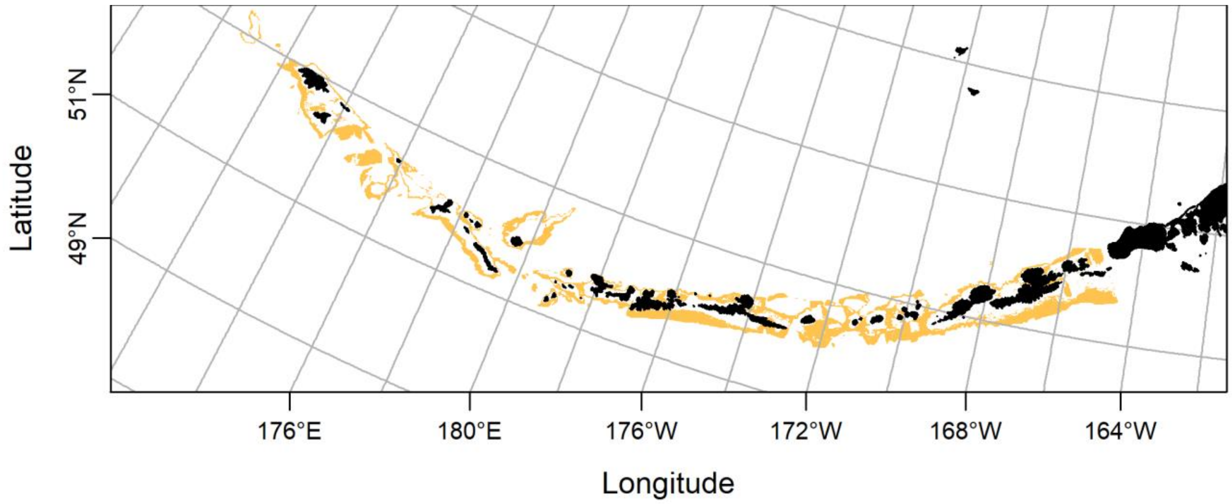

Figure E-203 EFH area of AI adult sablefish, spring

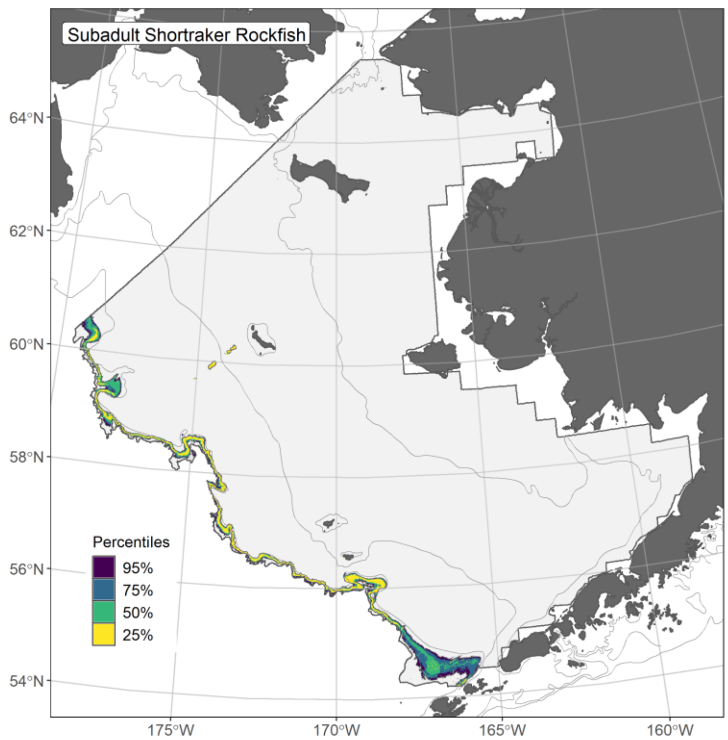

Figure E-204 EFH area of EBS subadult shortraker rockfish, summer

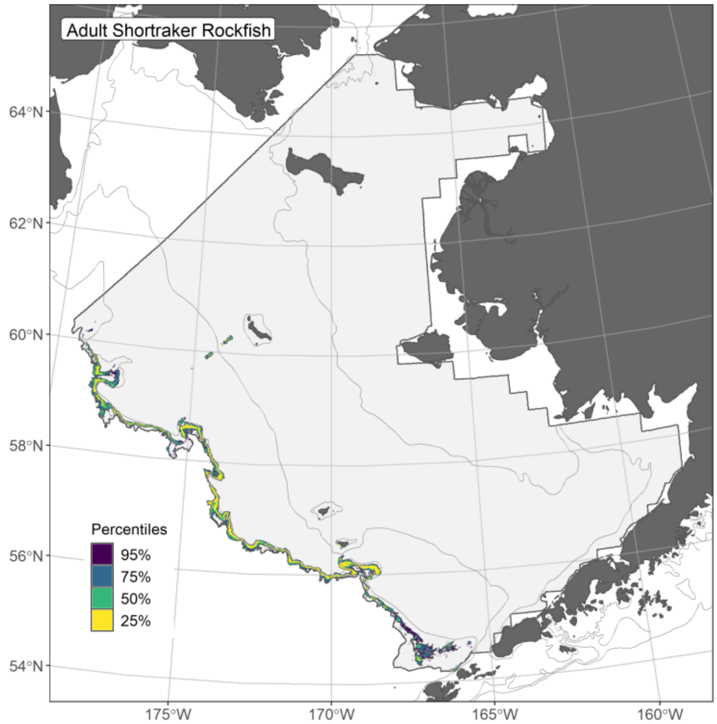

Figure E-205 EFH area of EBS adult shortraker rockfish, summer

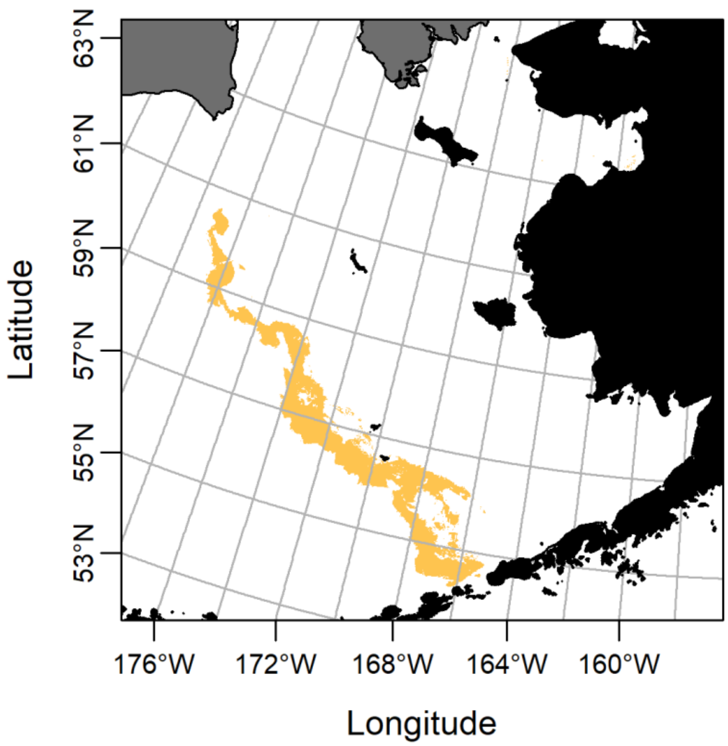

Figure E-206 EFH area of EBS adult shortraker rockfish, fall

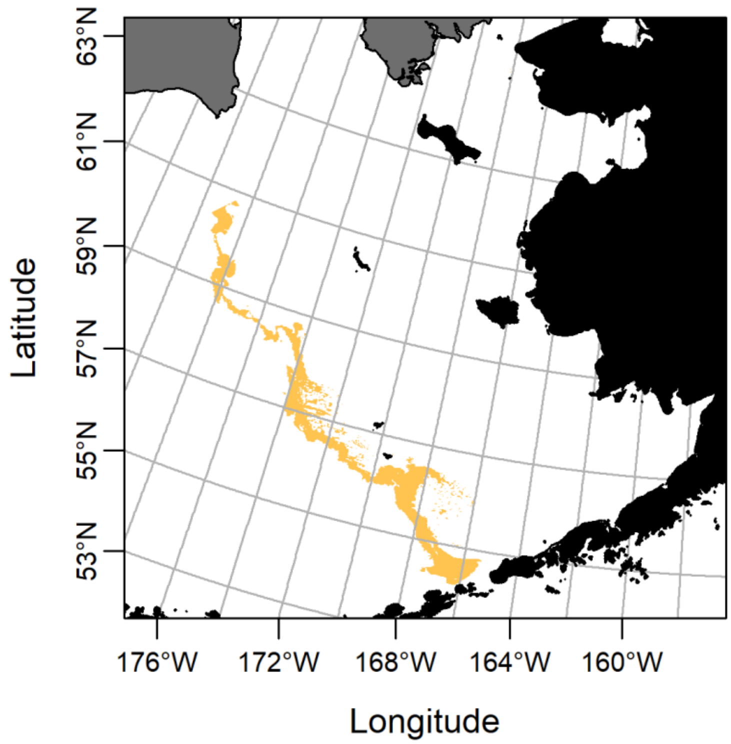

Figure E-207 EFH area of EBS adult shortraker rockfish, winter

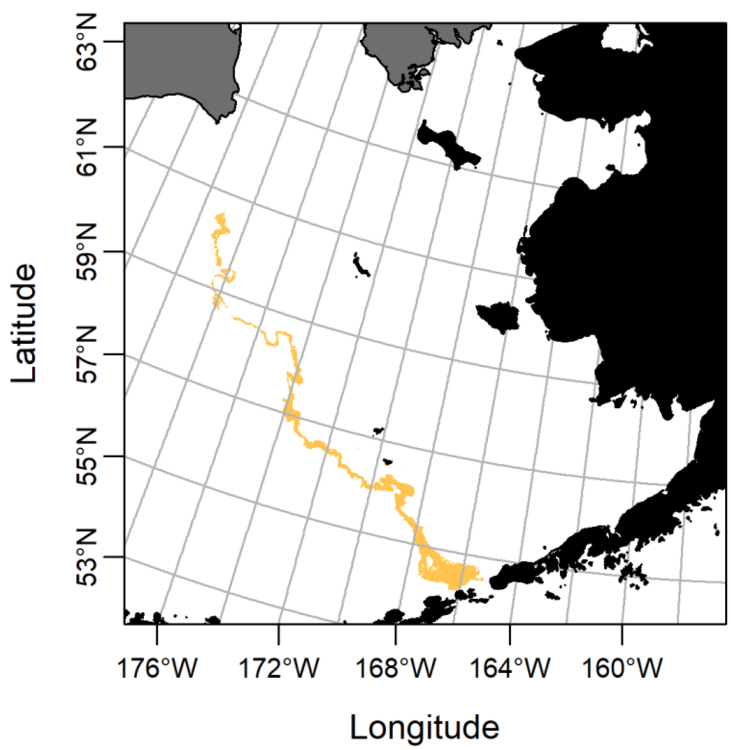

Figure E-208 EFH area of EBS adult shortraker rockfish, spring

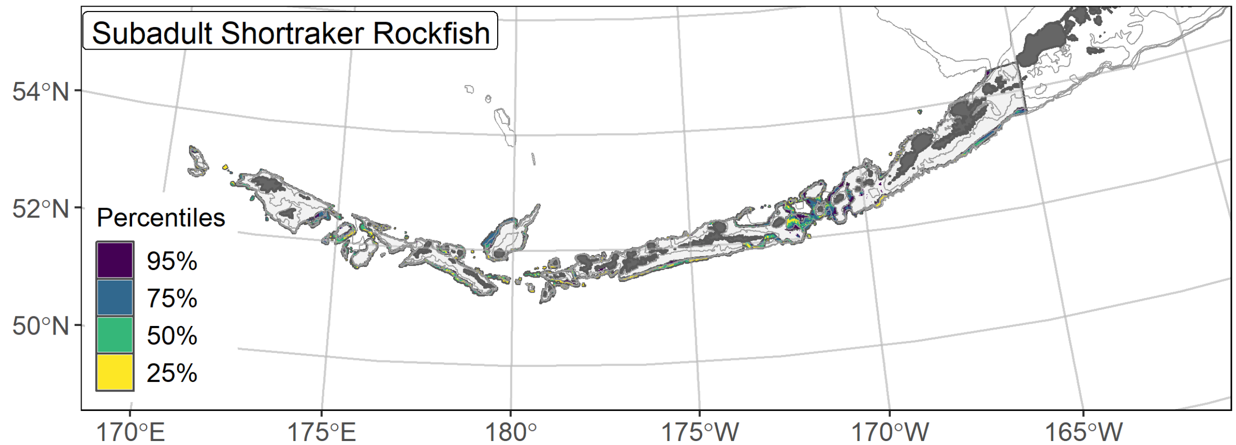

Figure E-209 EFH area of AI subadult shortraker rockfish, summer

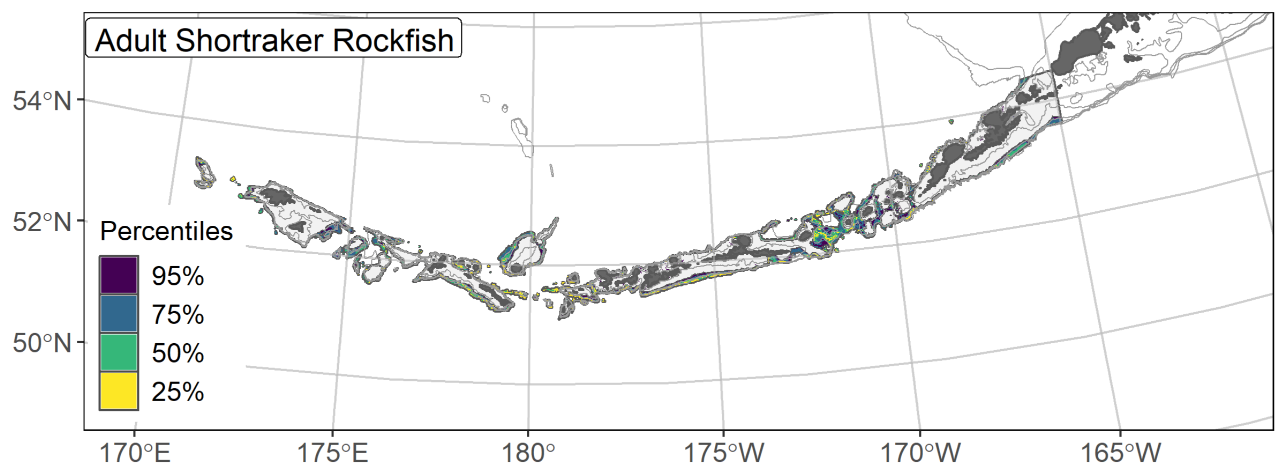

Figure E-210 EFH area of AI adult shortraker rockfish, summer

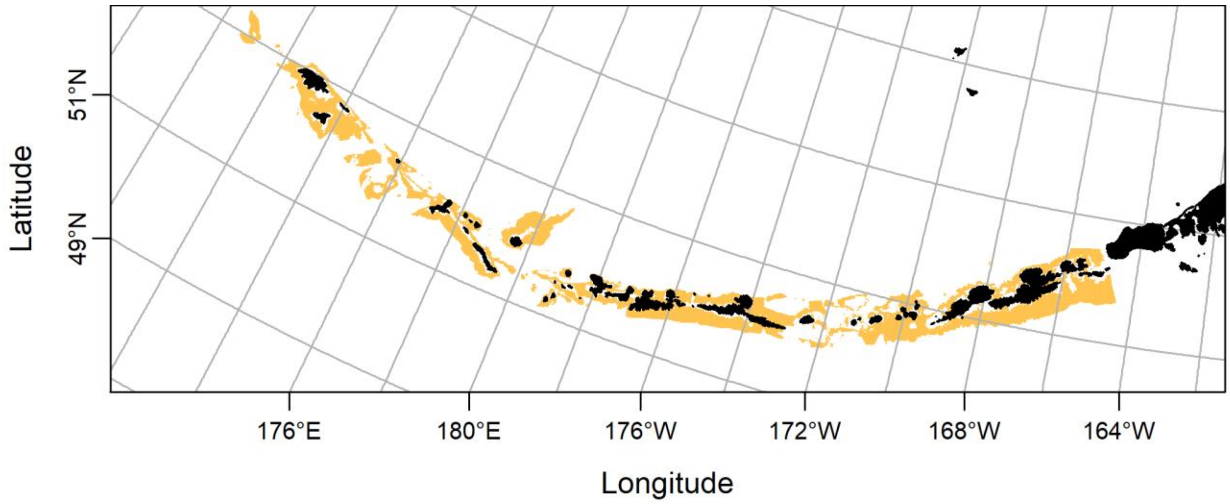

Figure E-211 EFH area of AI adult shortraker rockfish, fall

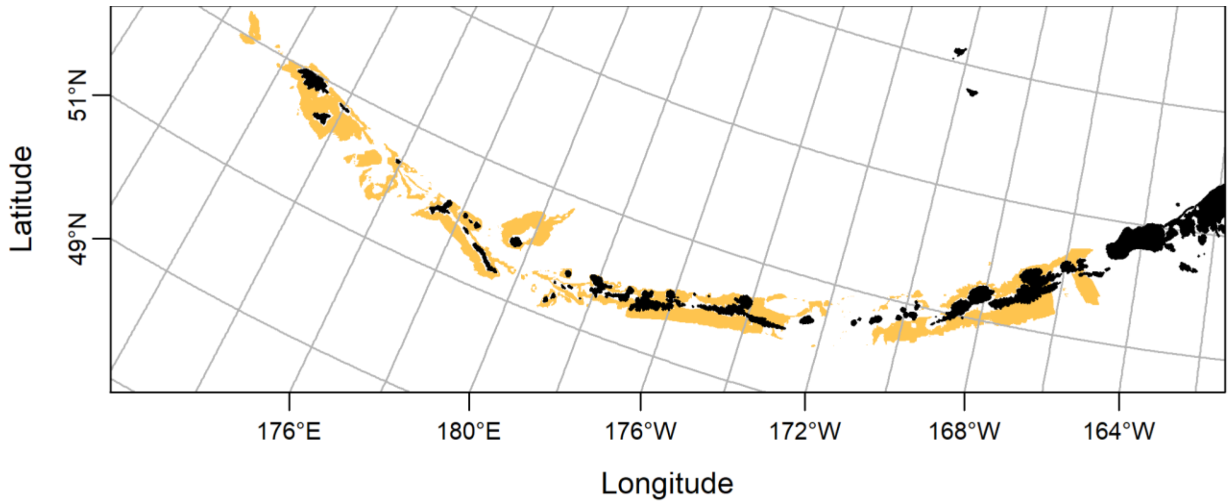

Figure E-212 EFH area of AI adult shortraker rockfish, winter

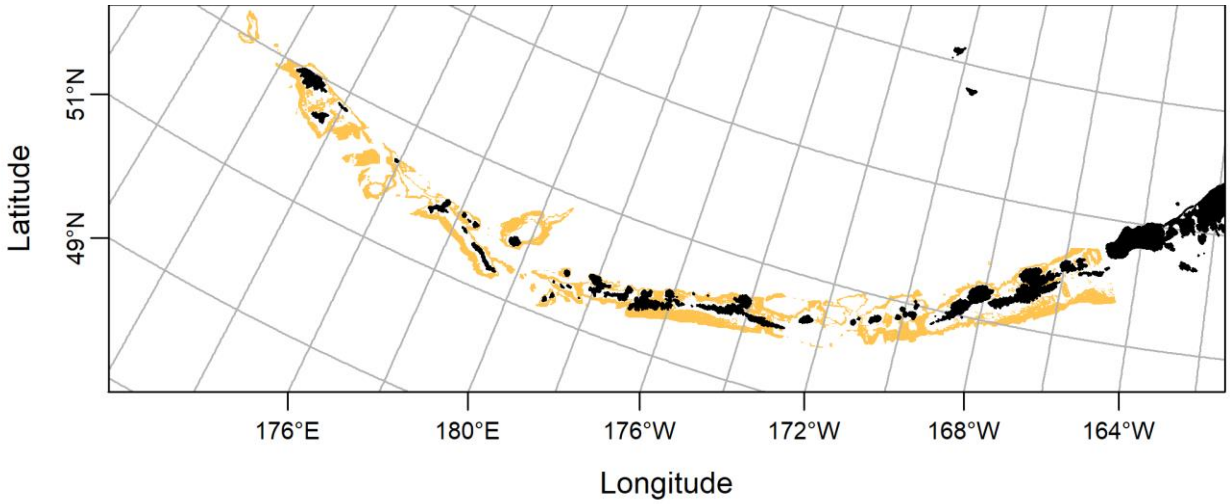

Figure E-213 EFH area of AI adult shortraker rockfish, spring

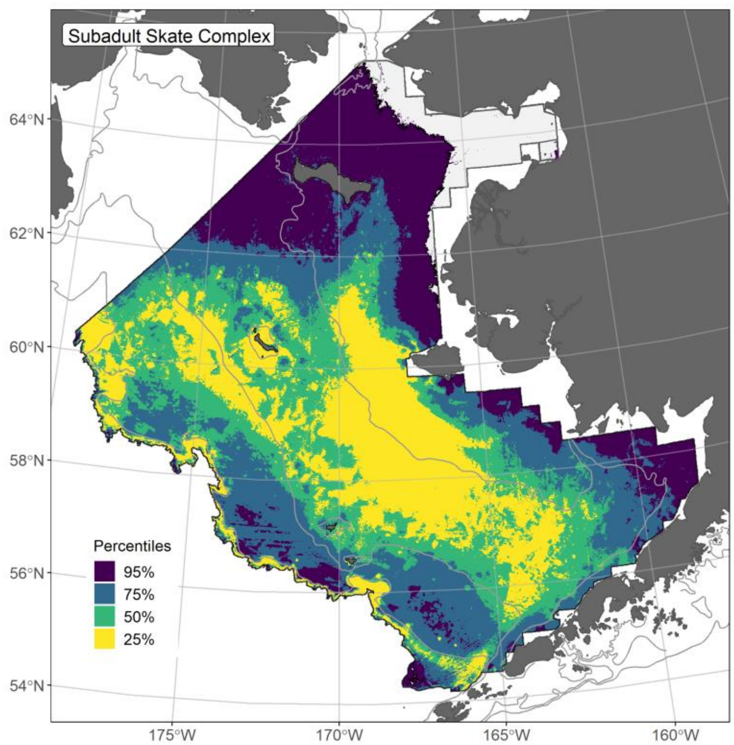

Figure E-214 EFH area of EBS subadult skate complex, summer

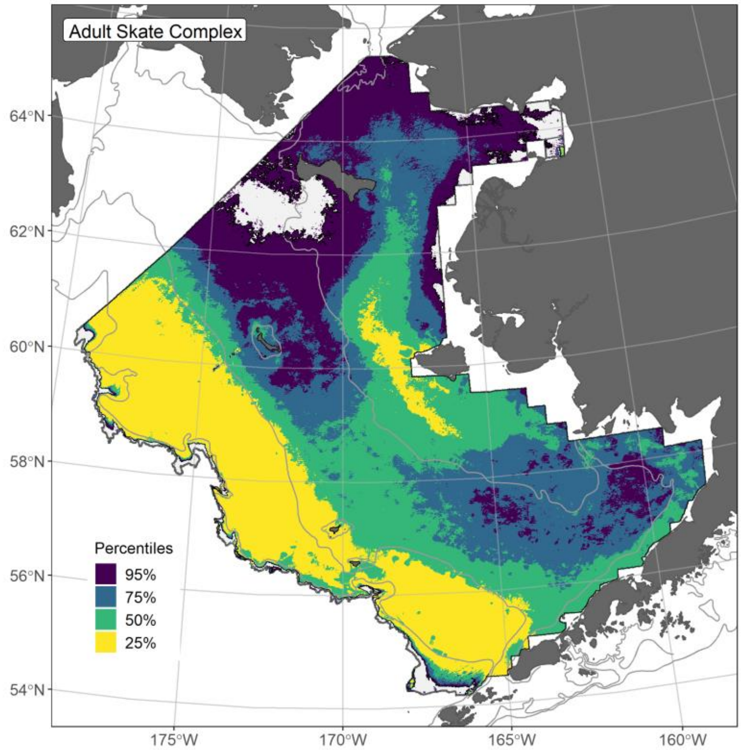

Figure E-215 EFH area of EBS adult skate complex, summer

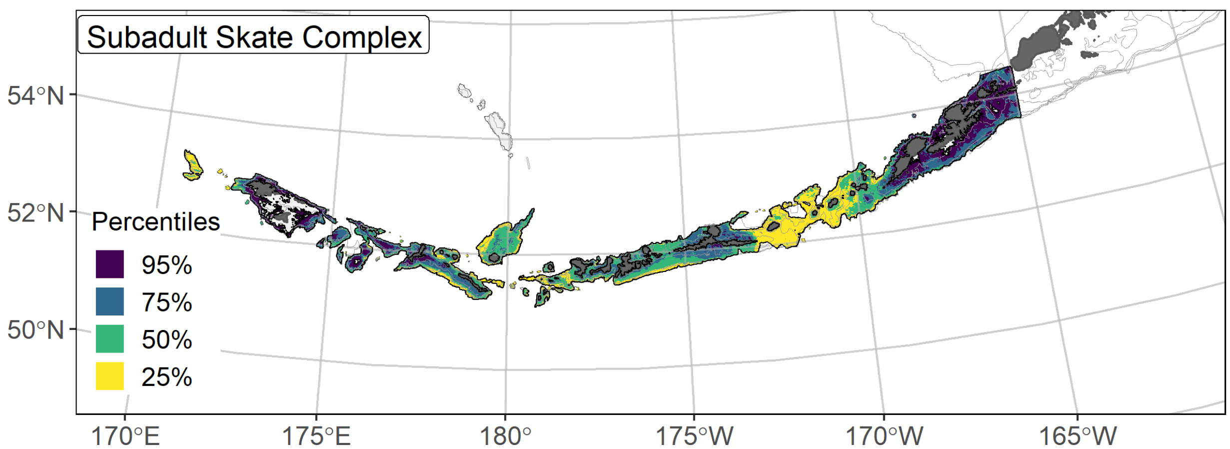

Figure E-216 EFH area of AI subadult skate complex, summer

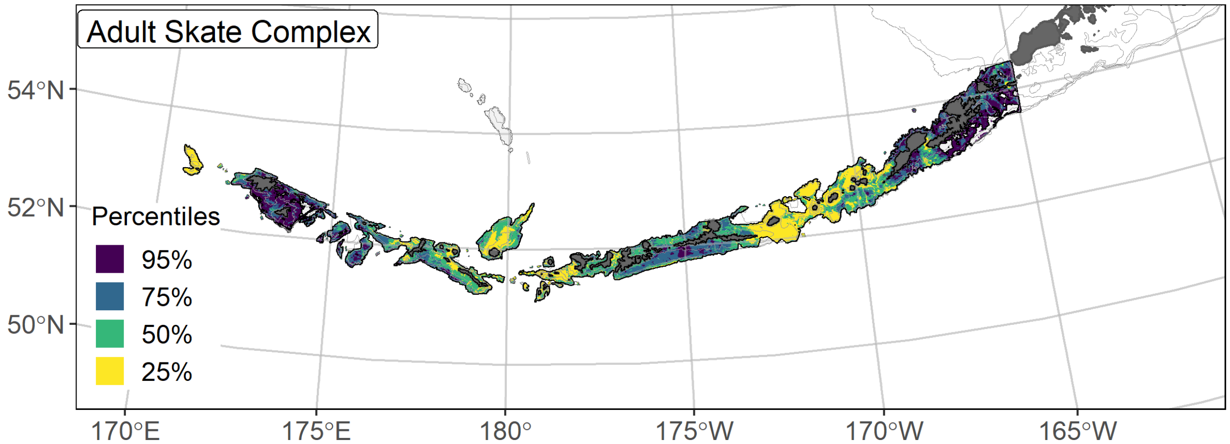

Figure E-217 EFH area of AI adult skate complex, summer

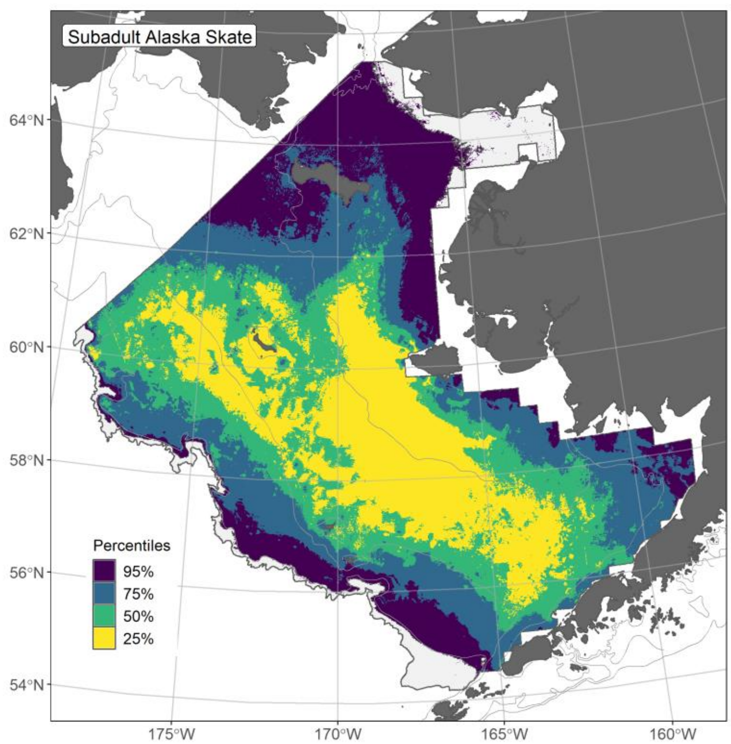

Figure E-218 EFH area of EBS subadult Alaska skate, summer

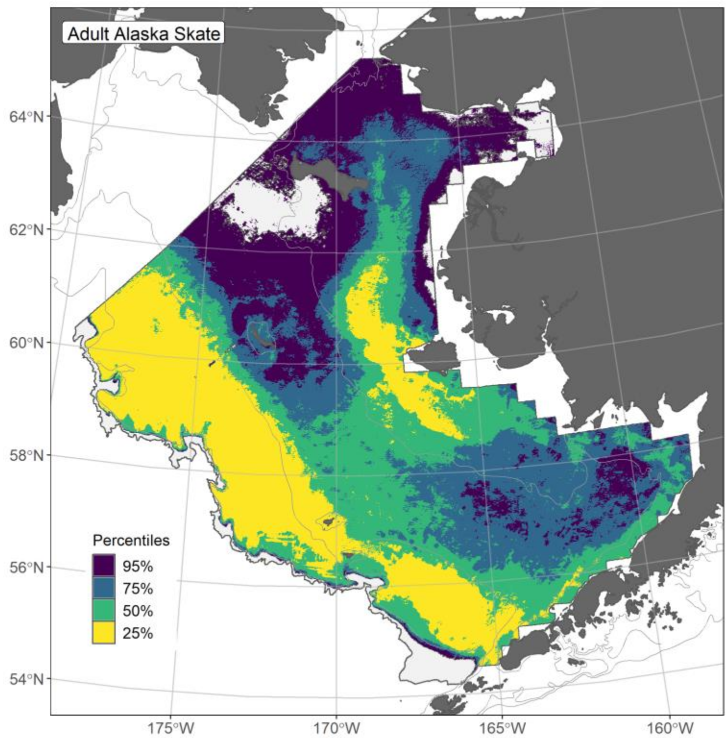

Figure E-219 EFH area of EBS adult Alaska skate, summer

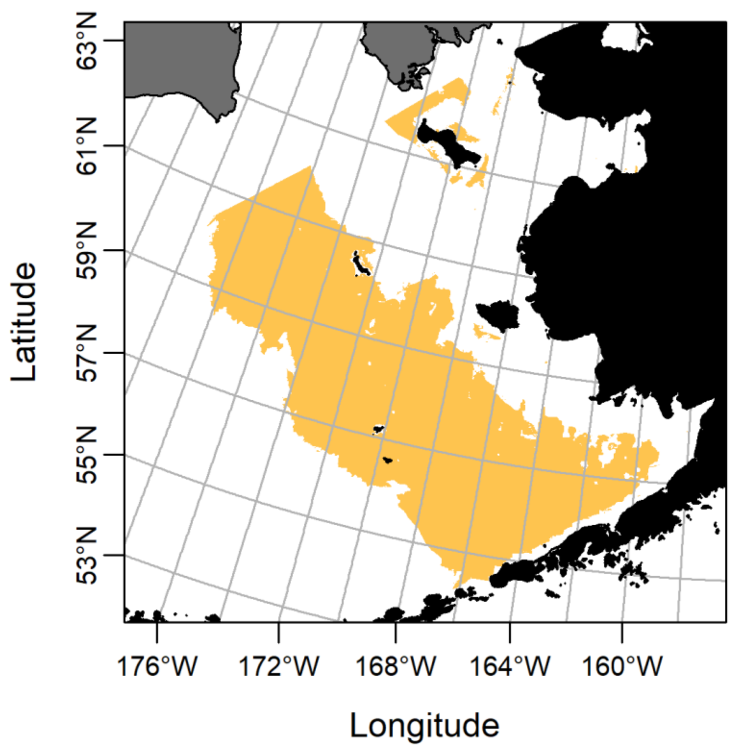

Figure E-220 EFH area of EBS adult Alaska skate, fall

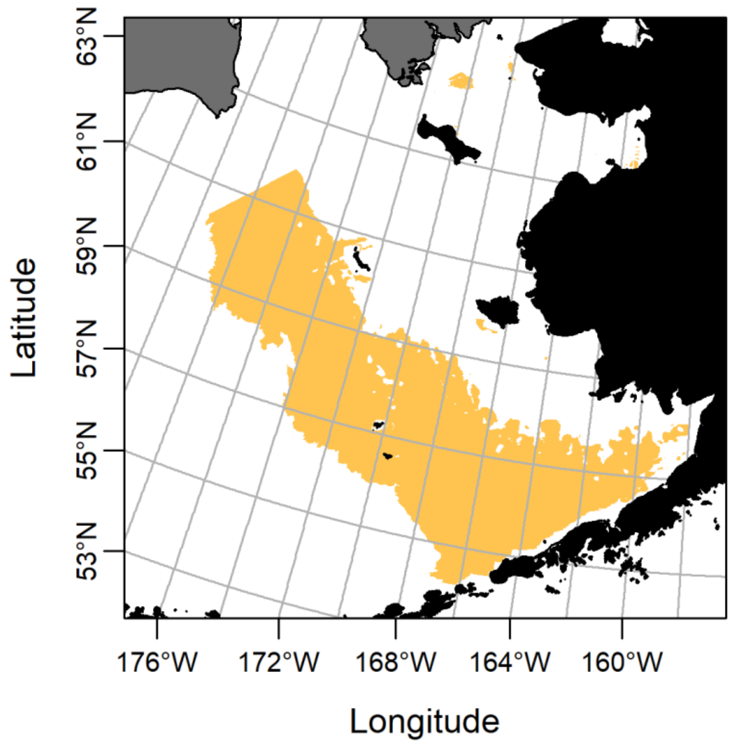

Figure E-221 EFH area of EBS adult Alaska skate, winter

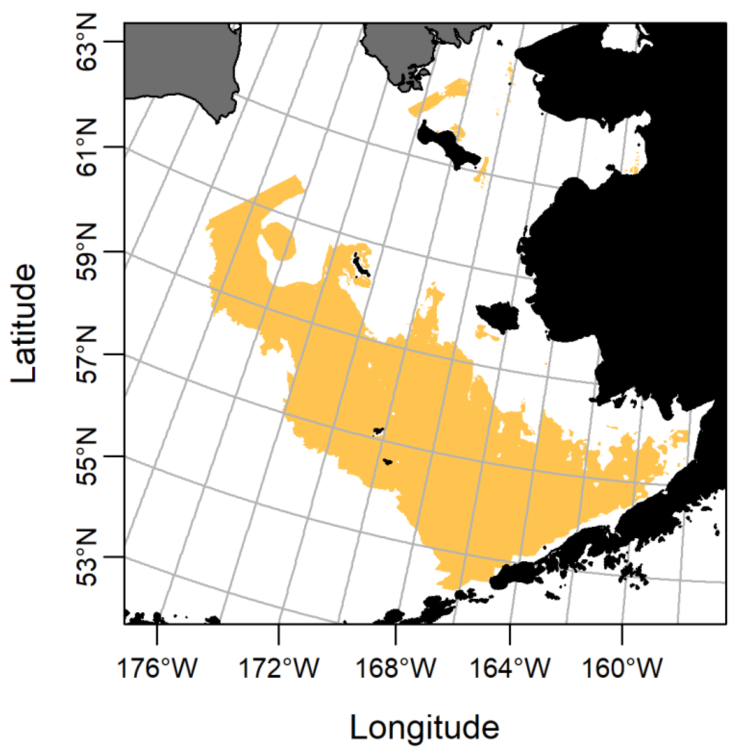

Figure E-222 EFH area of EBS adult Alaska skate, spring

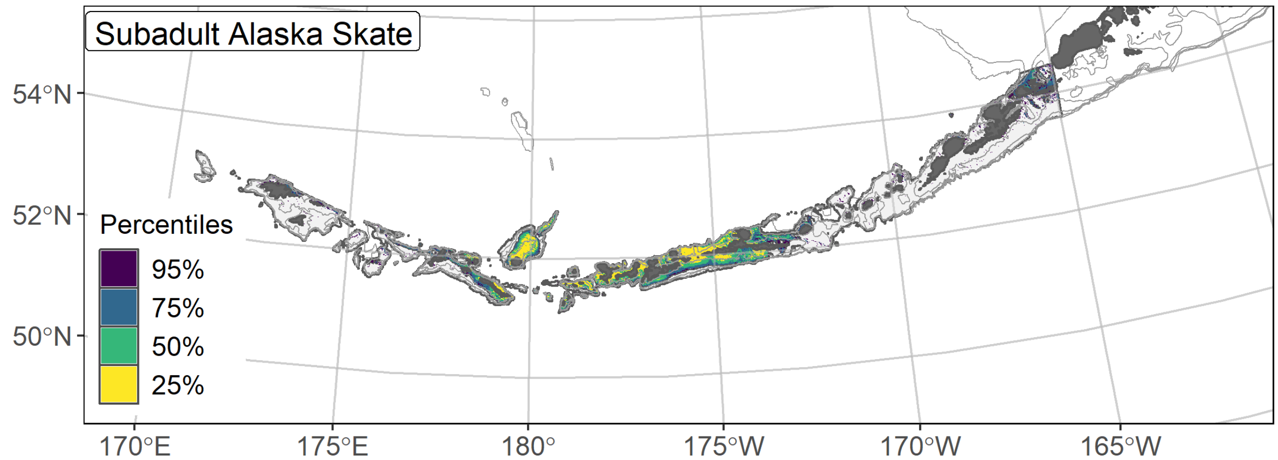

Figure E-223 EFH area of AI subadult Alaska skate, summer

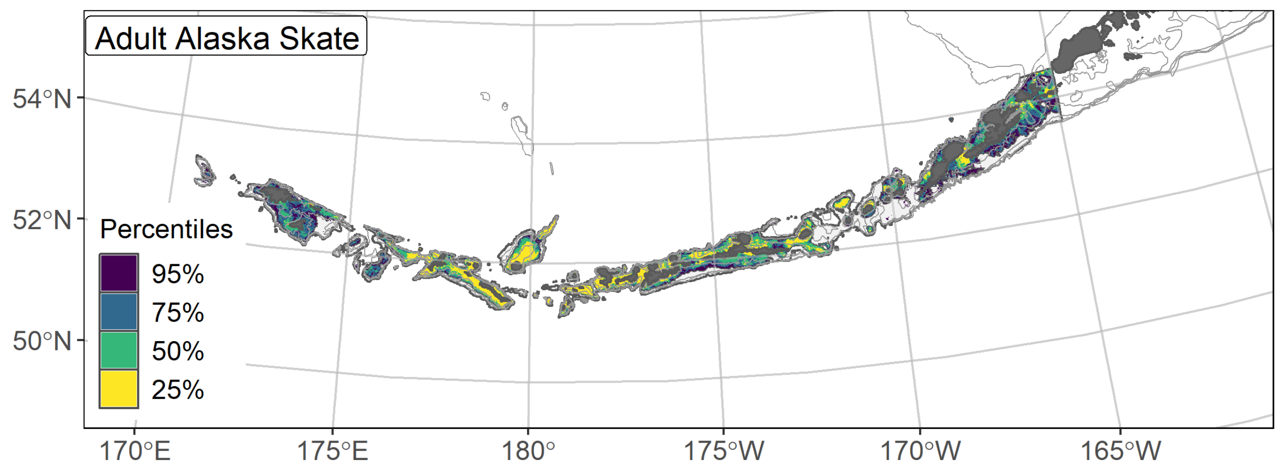

Figure E-224 EFH area of AI adult Alaska skate, summer

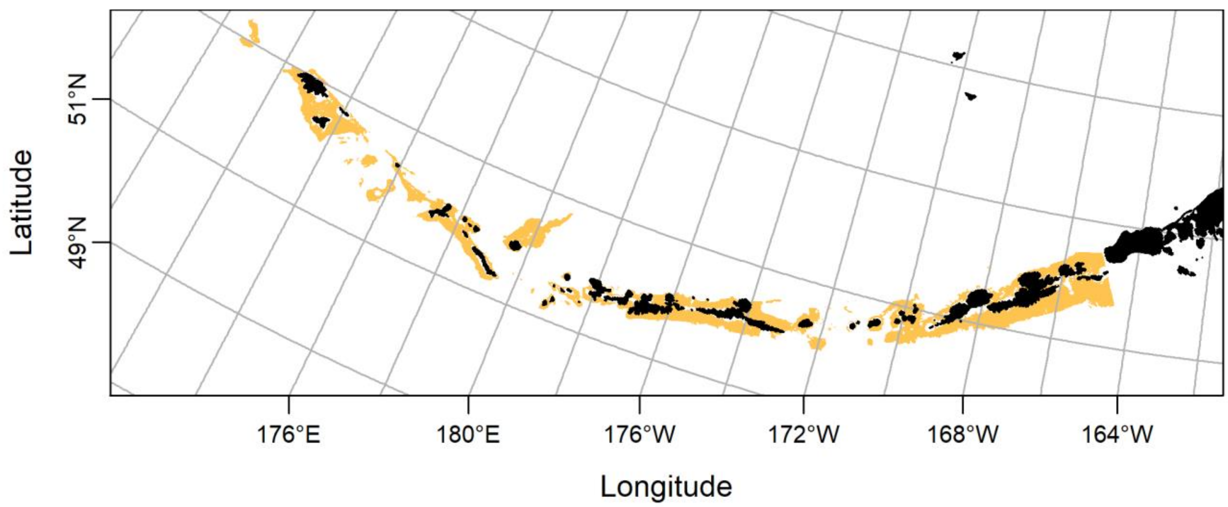

Figure E-225 EFH area of AI adult Alaska skate, fall

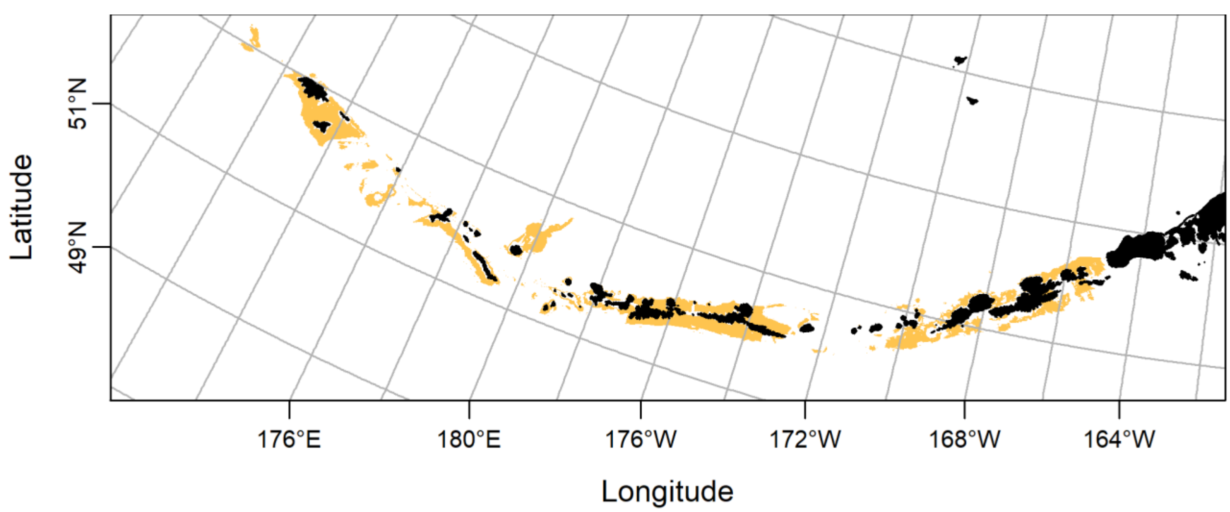

Figure E-226 EFH area of AI adult Alaska skate, winter

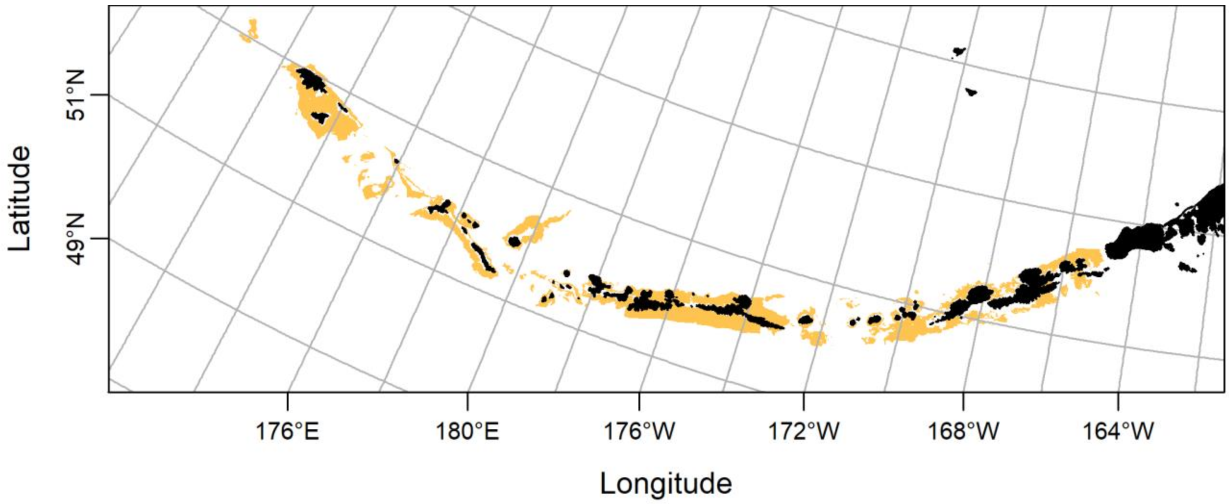

Figure E-227 EFH area of AI adult Alaska skate, spring

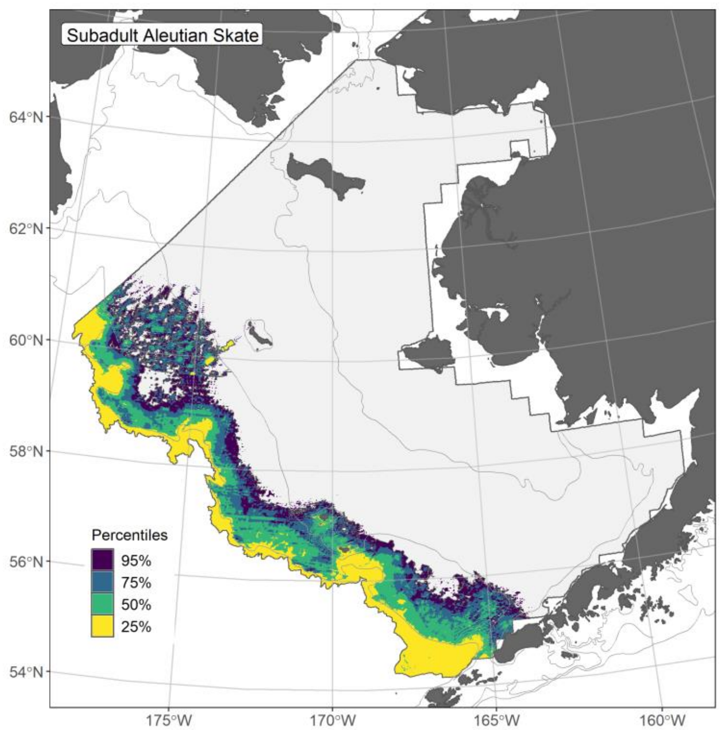

Figure E-228 EFH area of EBS subadult Aleutian skate, summer

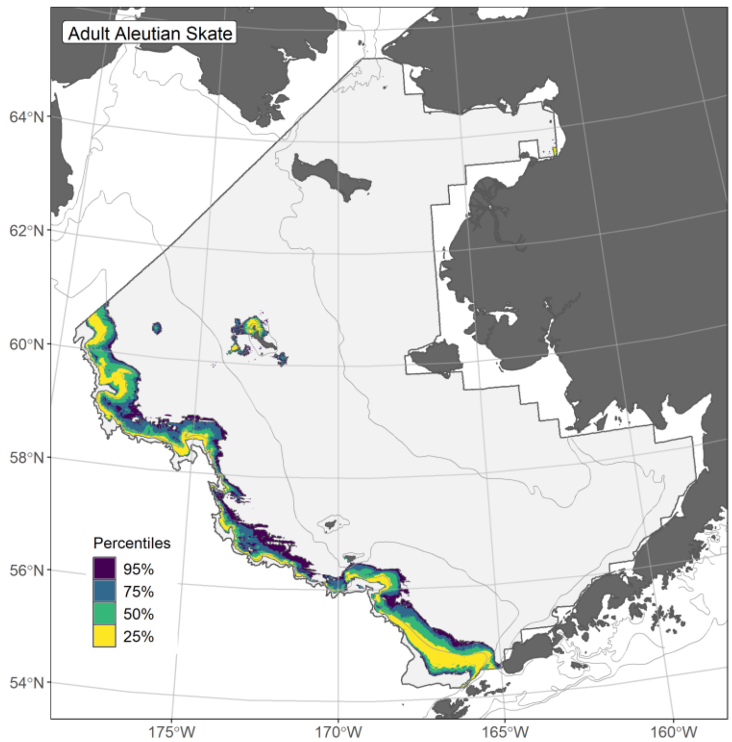

Figure E-229 EFH area of EBS adult Aleutian skate, summer

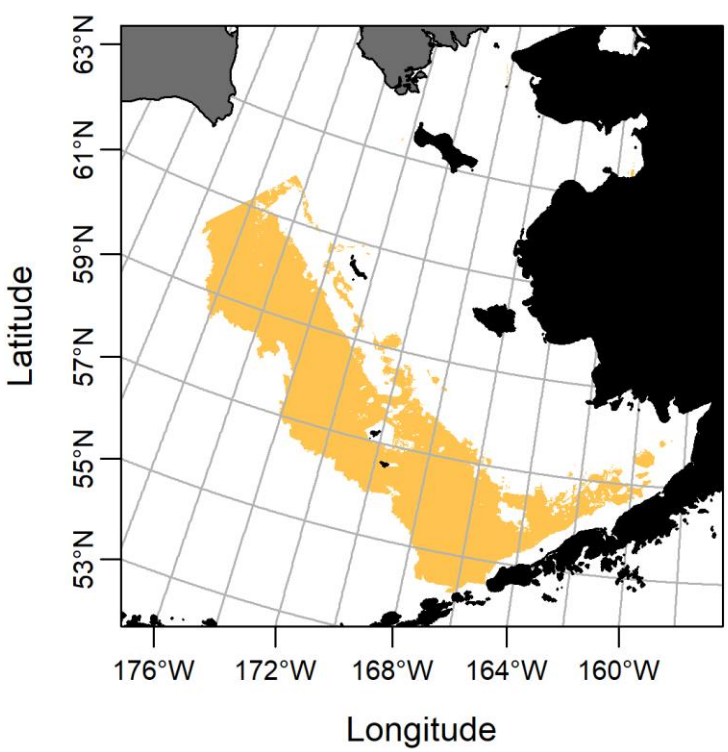

Figure E-230 EFH area of EBS adult Aleutian skate, fall

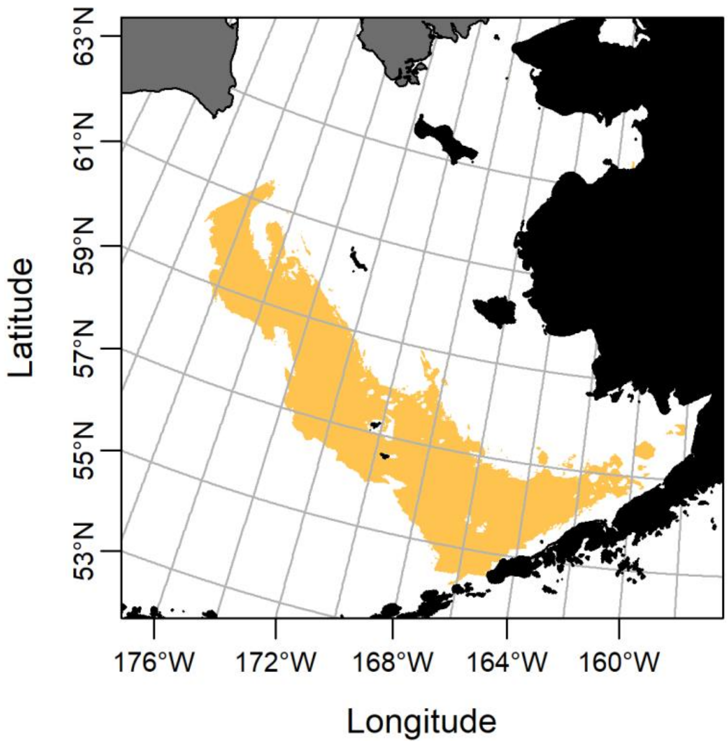

Figure E-231 EFH area of EBS adult Aleutian skate, winter

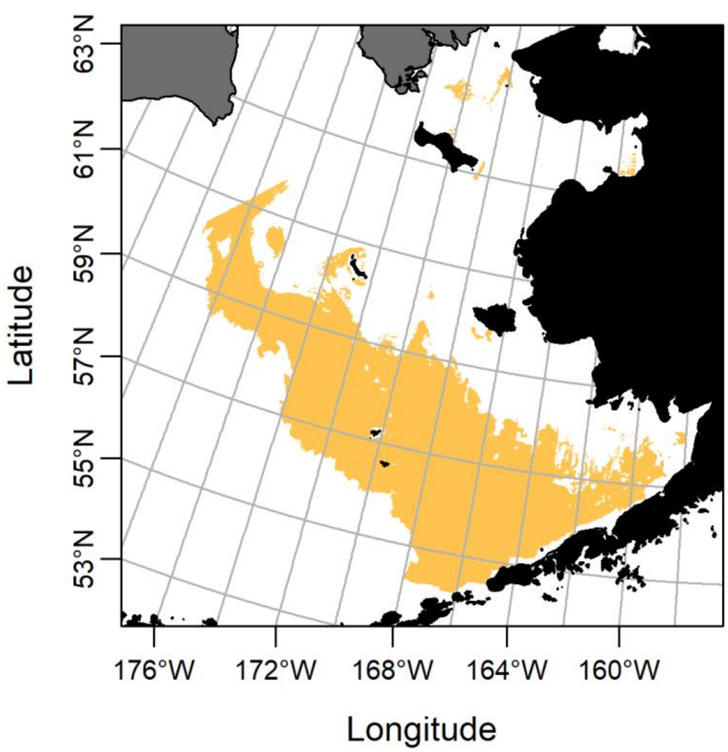

Figure E-232 EFH area of EBS adult Aleutian skate, spring

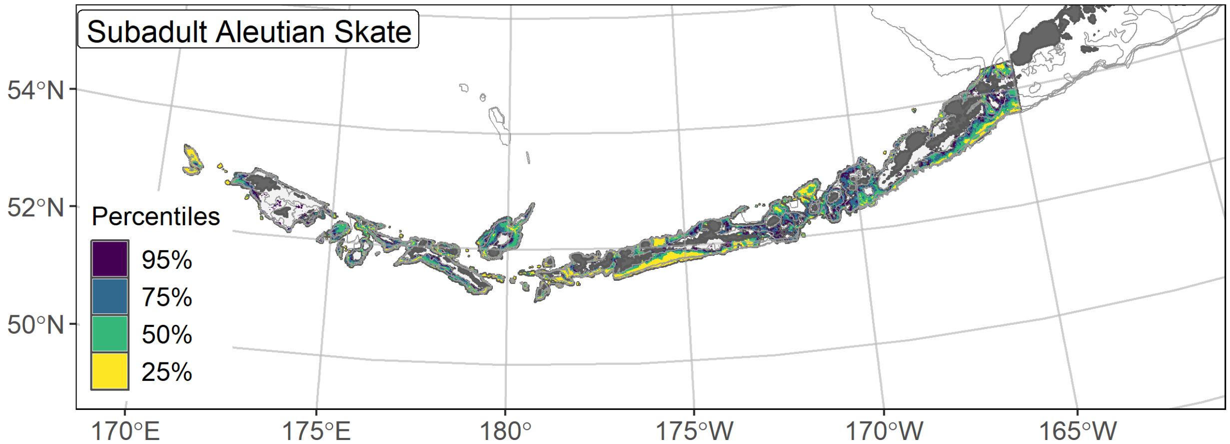

Figure E-233 EFH area of AI subadult Aleutian skate, summer

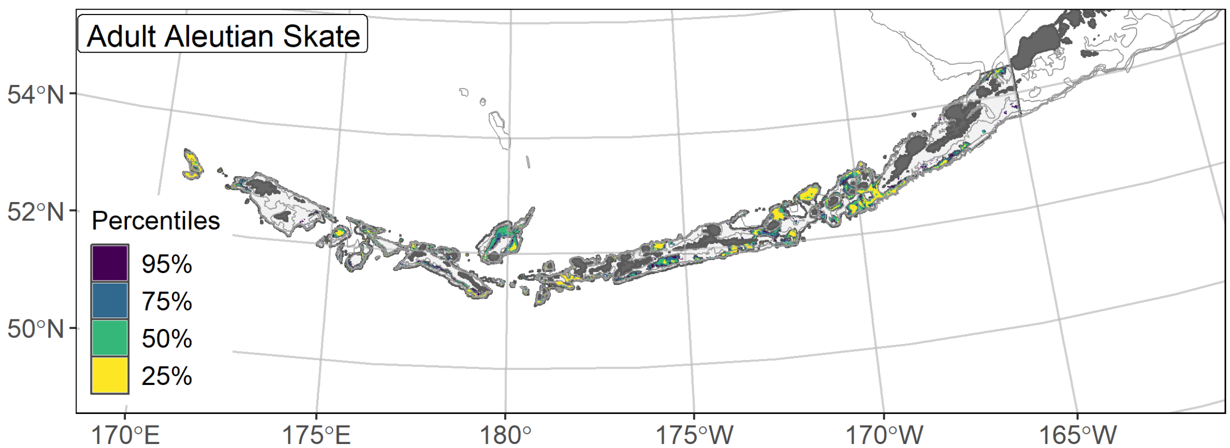

Figure E-234 EFH area of AI adult Aleutian skate, summer

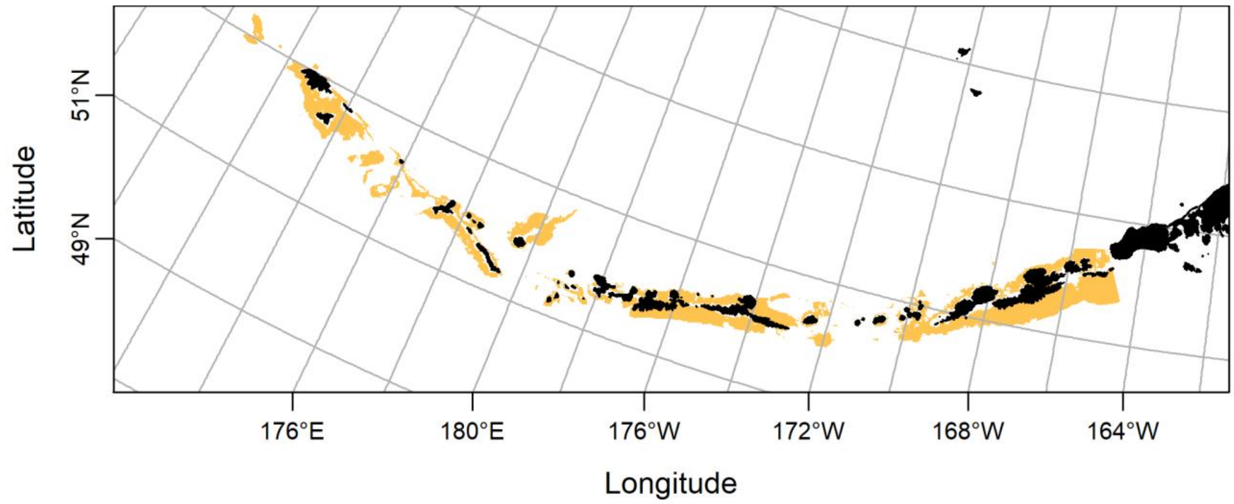

Figure E-235 EFH area of AI adult Aleutian skate, fall

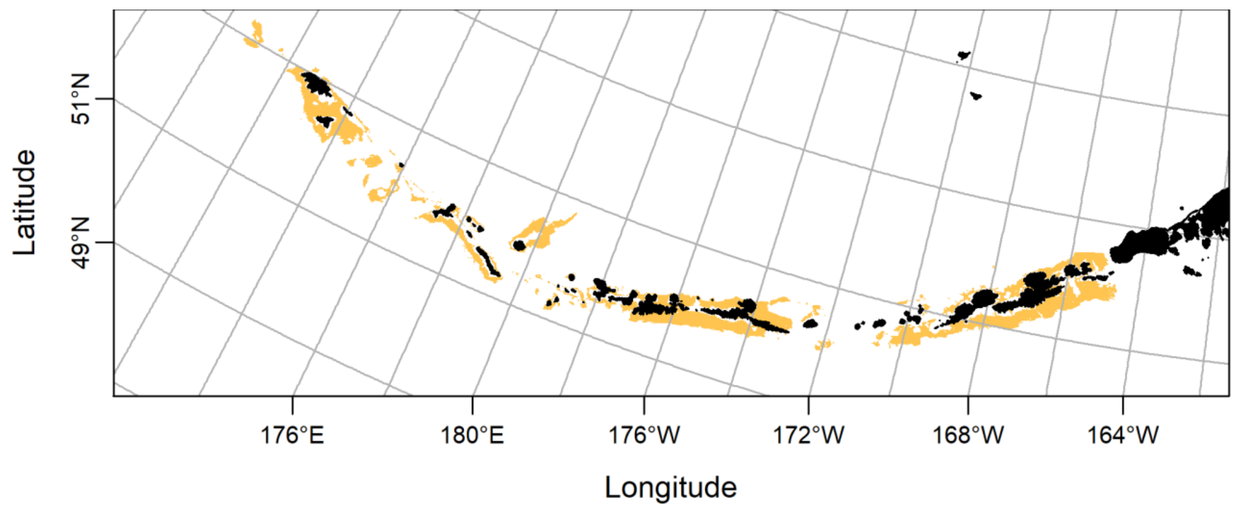

Figure E-236 EFH area of AI adult Aleutian skate, winter

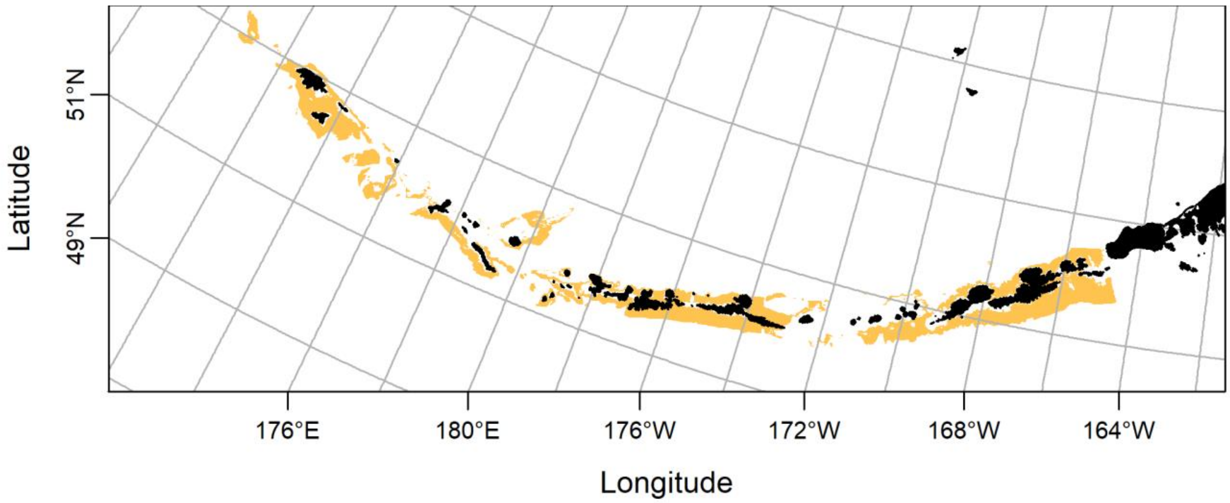

Figure E-237 EFH area of AI adult Aleutian skate, spring

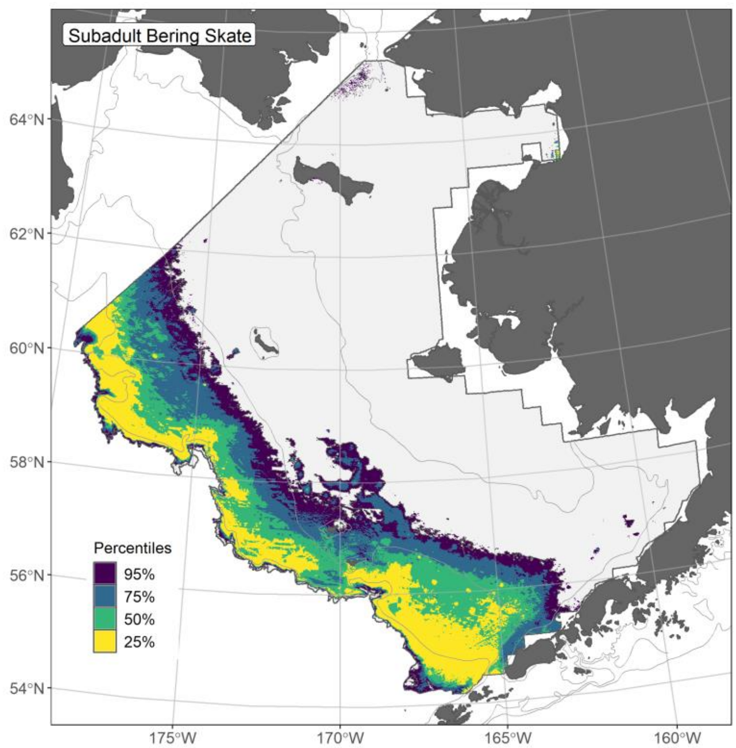

Figure E-238 EFH area of EBS subadult Bering skate, summer

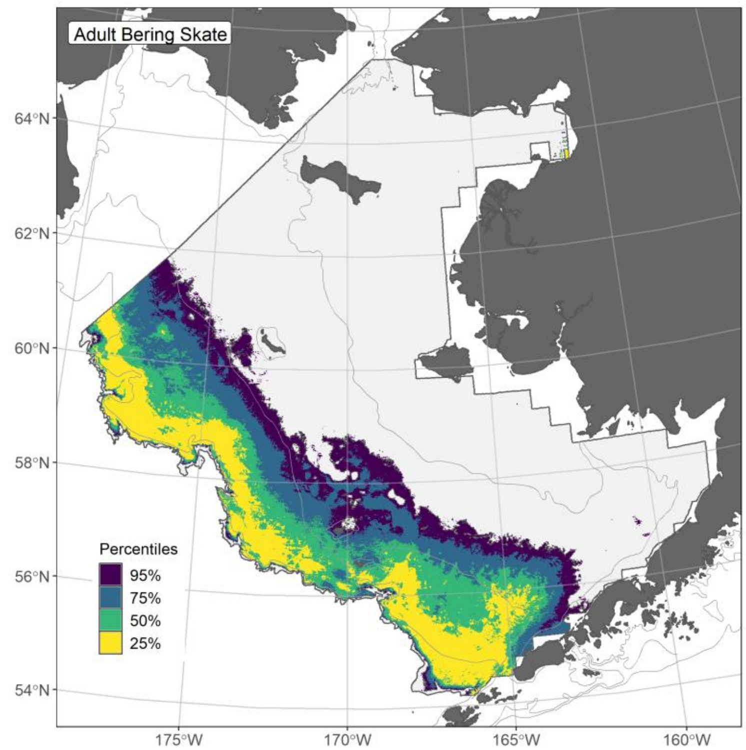

Figure E-239 EFH area of EBS adult Bering skate, summer

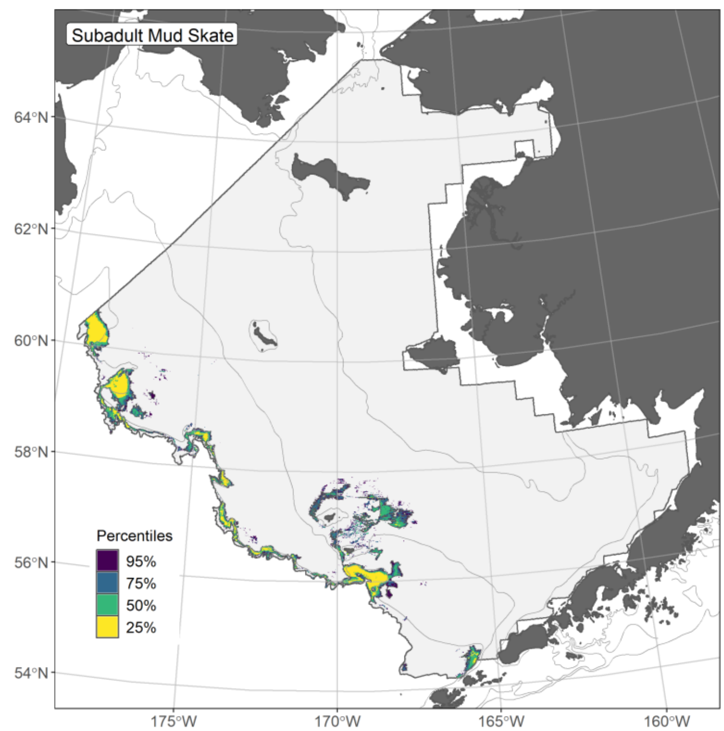

Figure E-240 EFH area of EBS subadult mud skate, summer

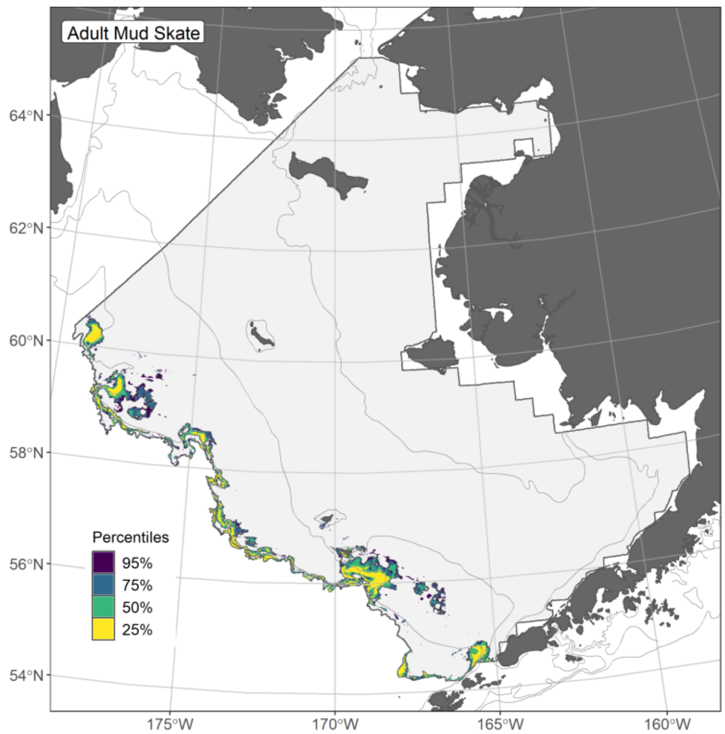

Figure E-241 EFH area of EBS adult mud skate, summer

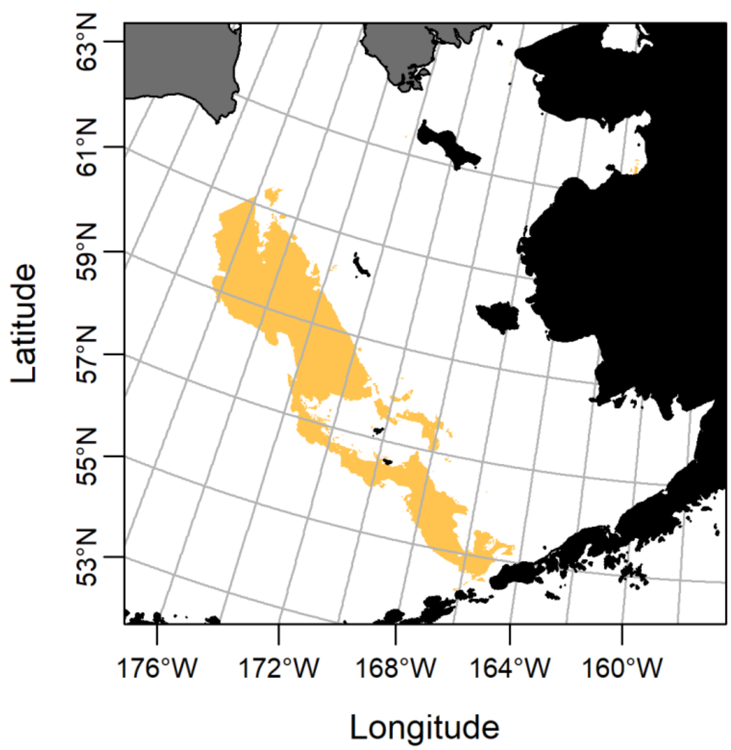

Figure E-242 EFH area of EBS adult mud skate, fall

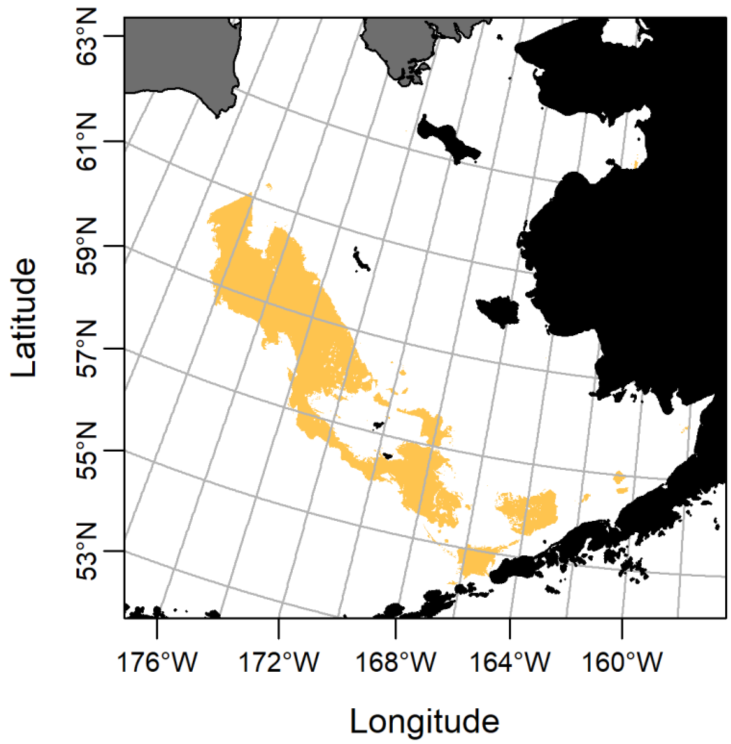

Figure E-243 EFH area of EBS adult mud skate, winter

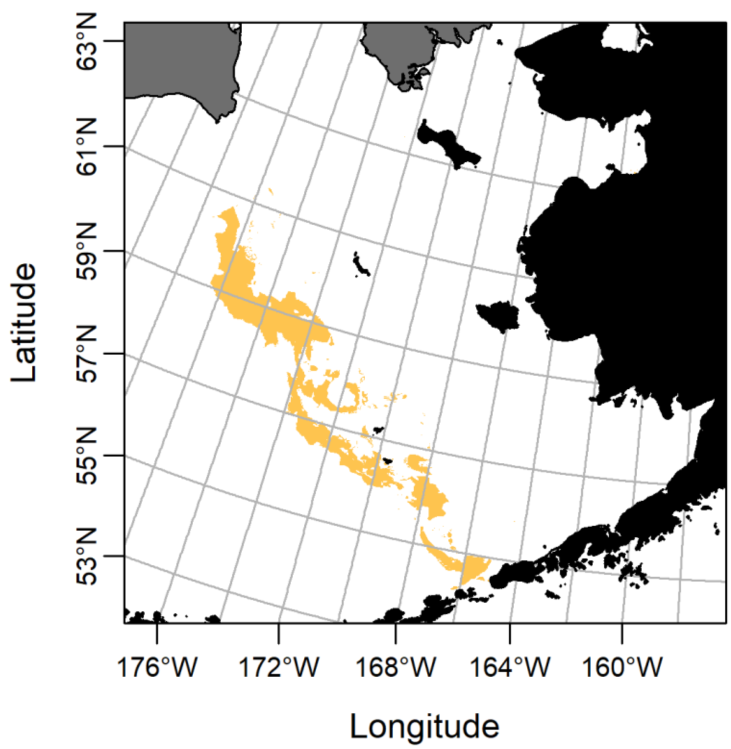

Figure E-244 EFH area of EBS adult mud skate, spring

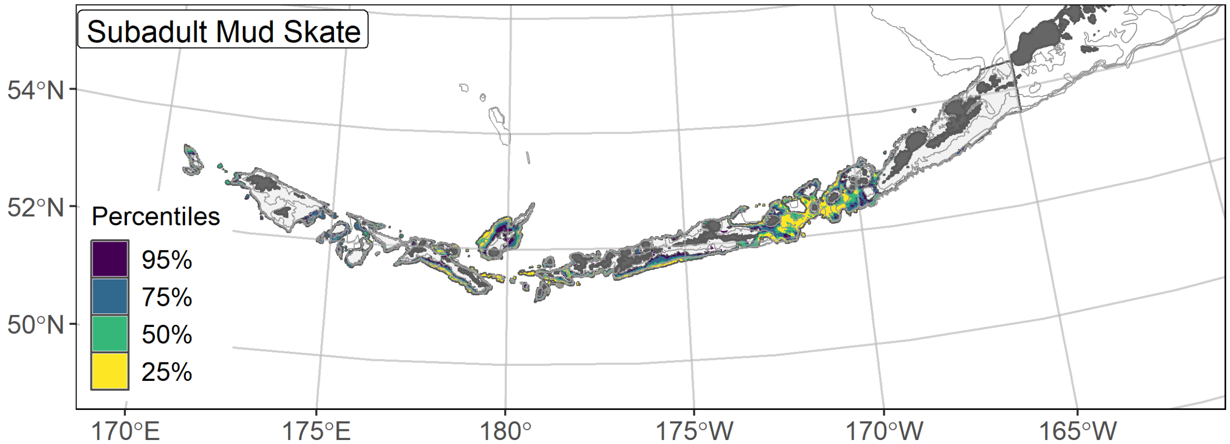

Figure E-245 EFH area of AI subadult mud skate, summer

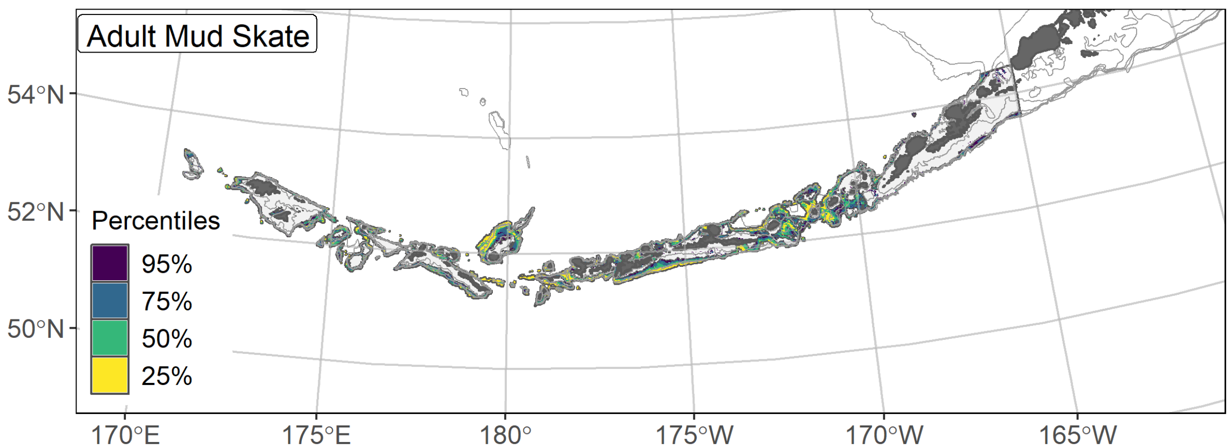

Figure E-246 EFH area of AI adult mud skate, summer

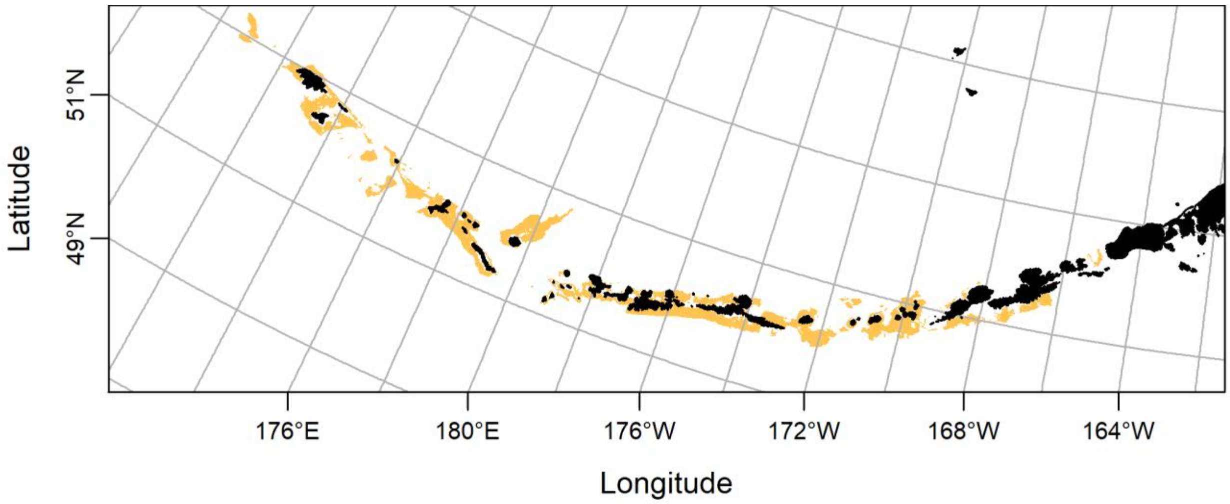

Figure E-247 EFH area of AI adult mud skate, fall

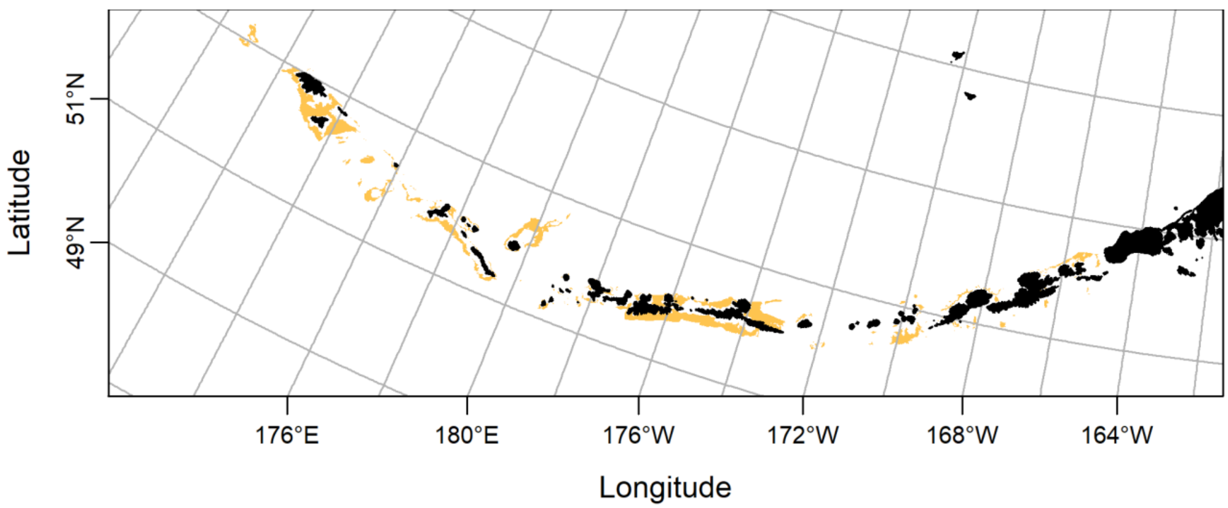

Figure E-248 EFH area of AI adult mud skate, winter

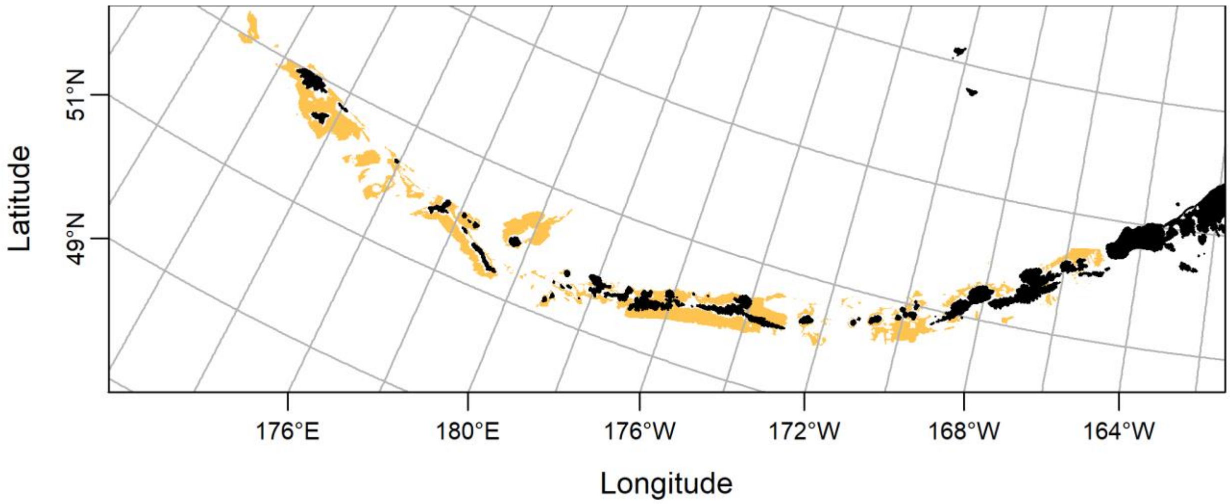

Figure E-249 EFH area of AI adult mud skate, spring

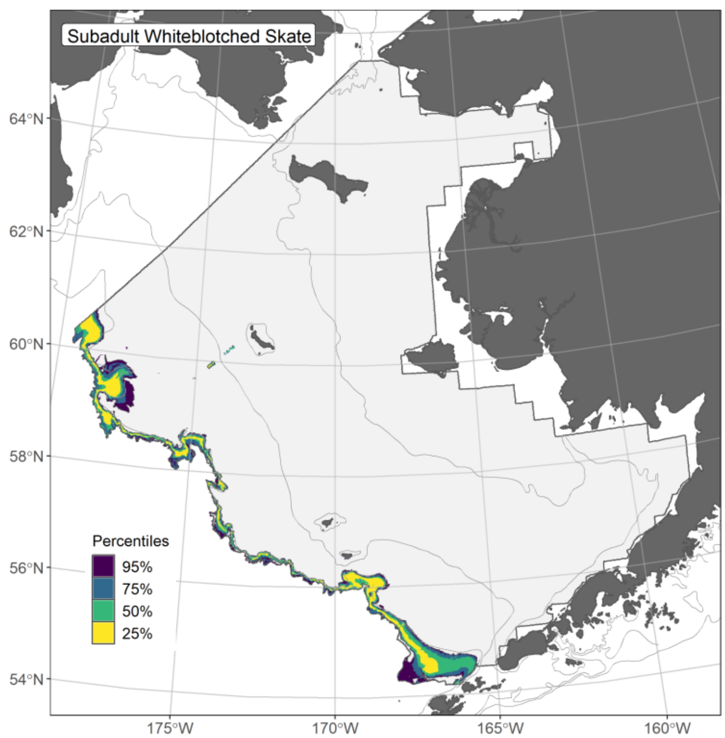

Figure E-250 EFH area of EBS subadult whiteblotched skate, summer

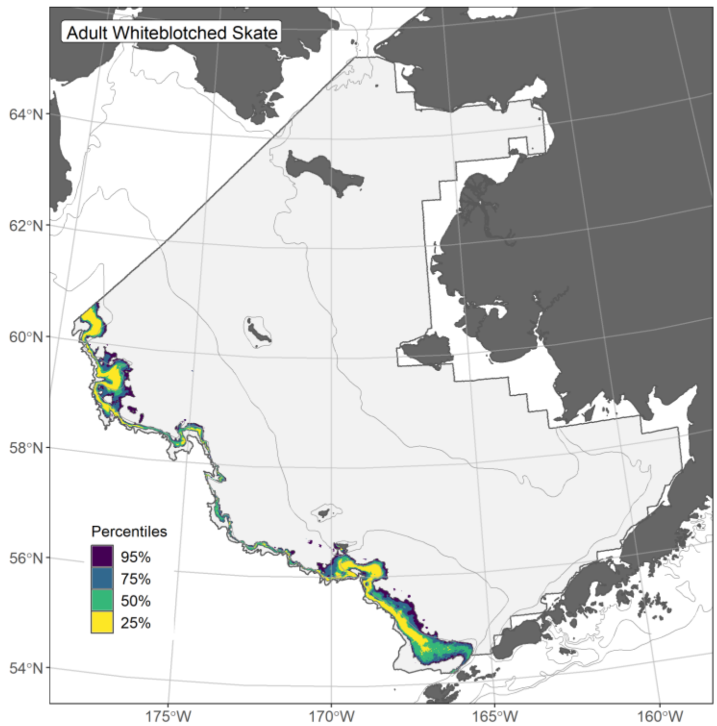

Figure E-251 EFH area of EBS adult whiteblotched skate, summer

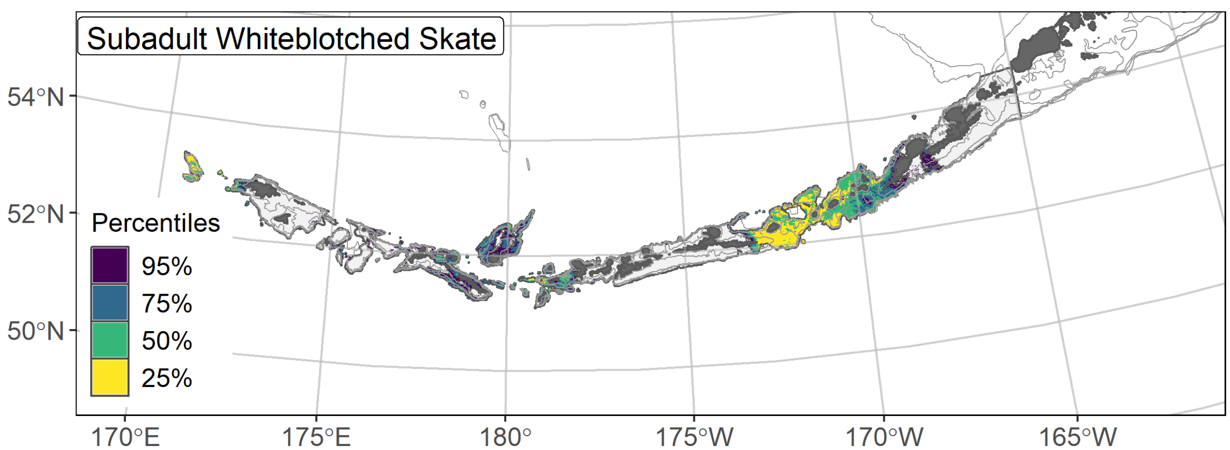

Figure E-252 EFH area of AI subadult whiteblotched skate, summer

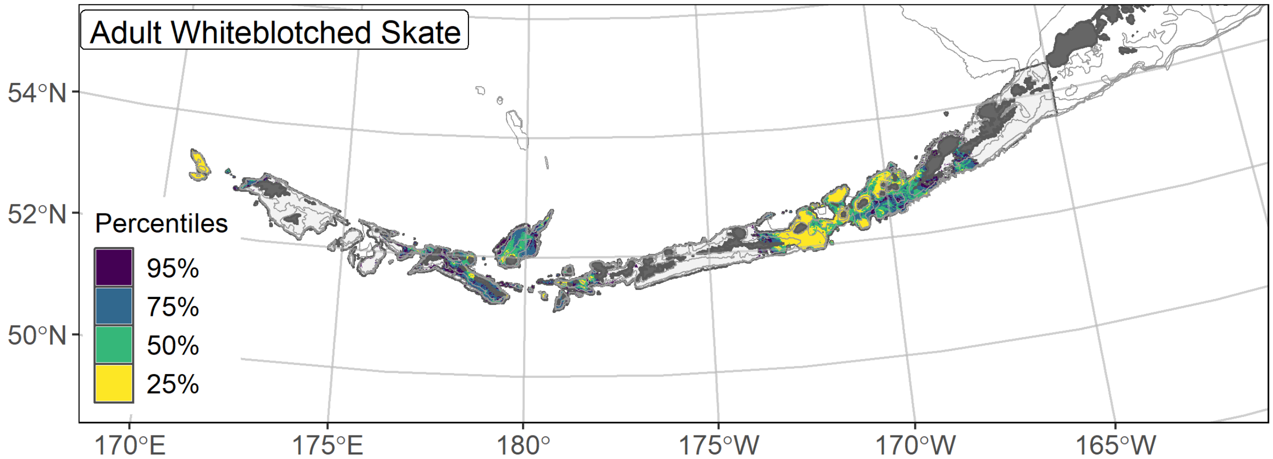

Figure E-253 EFH area of AI adult whiteblotched skate, summer

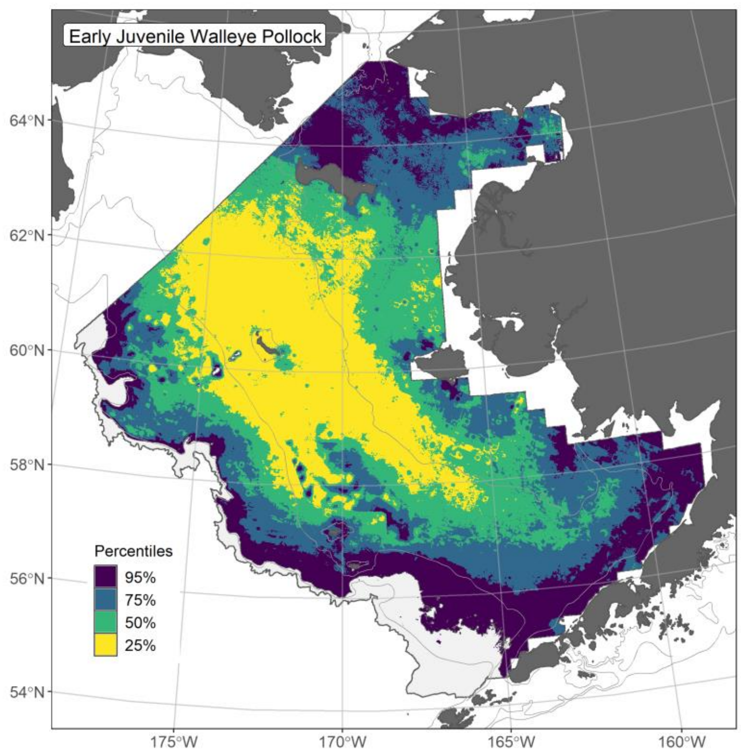

Figure E-254 EFH of EBS settled early juvenile walleye pollock, summer

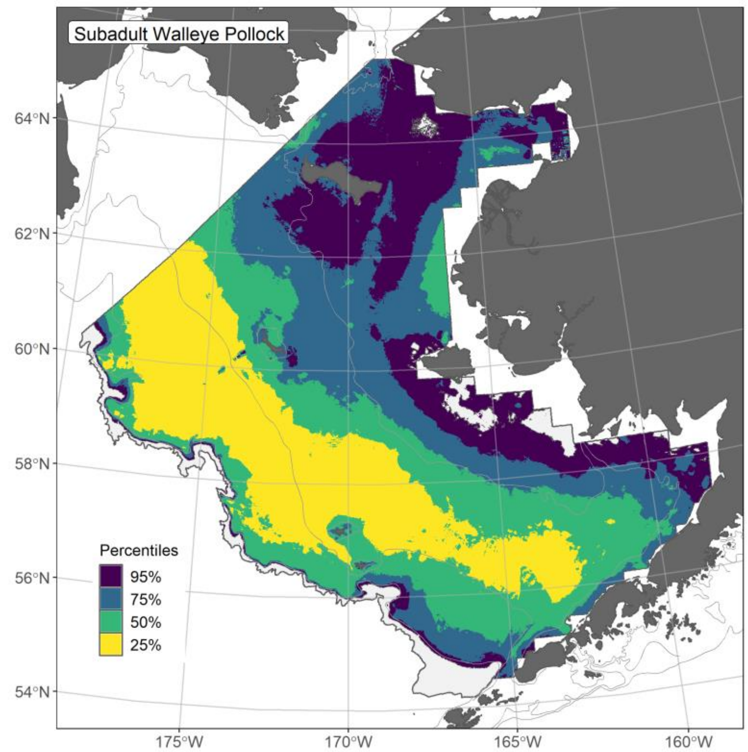

Figure E-255 EFH area of EBS subadult walleye pollock, summer

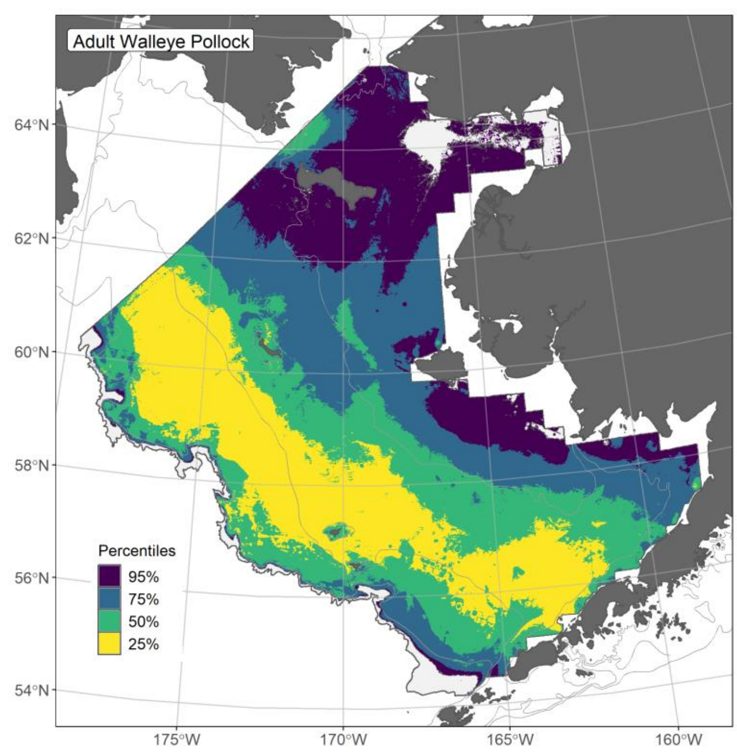

Figure E-256 EFH area of EBS adult walleye pollock, summer

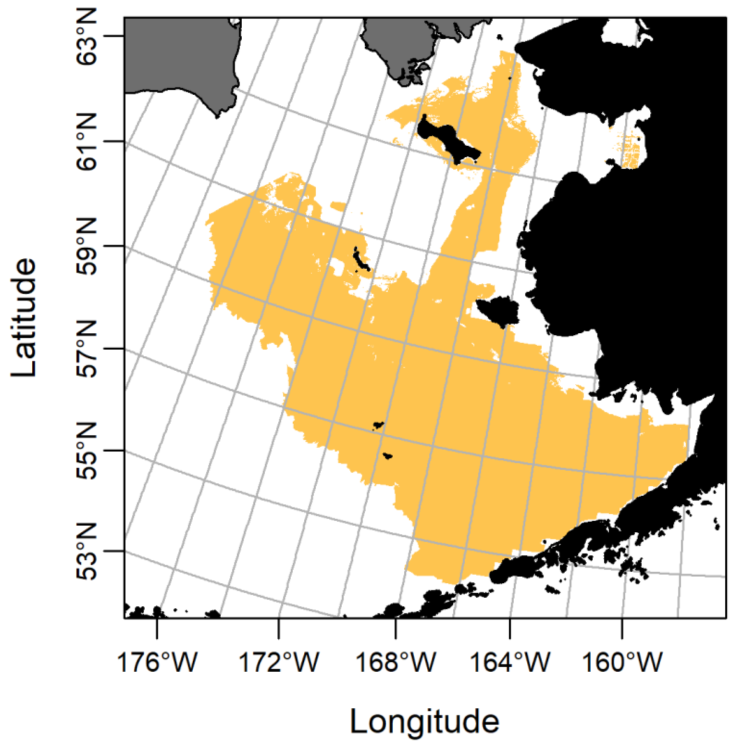

Figure E-257 EFH area of EBS walleye pollock eggs, summer

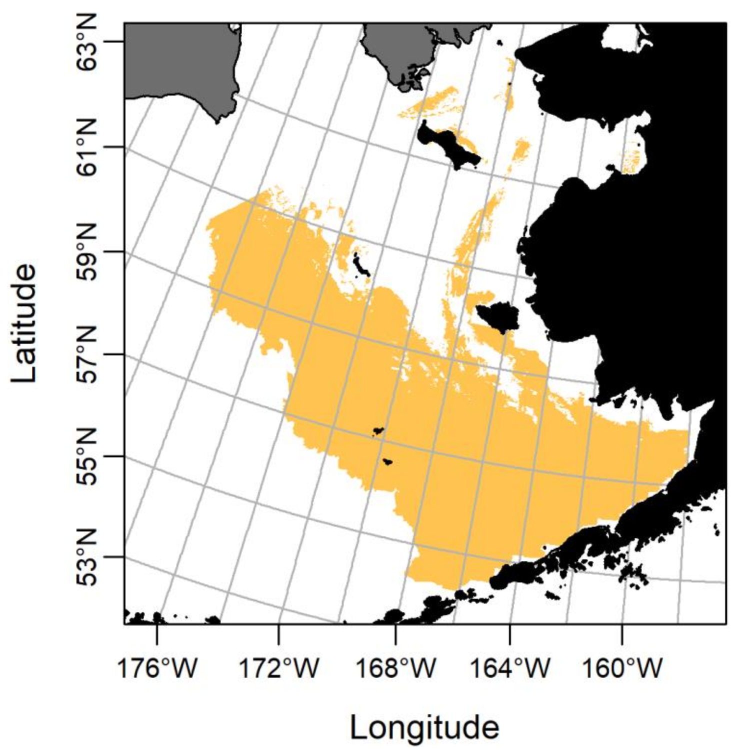

Figure E-258 EFH area of EBS larvae walleye pollock larvae, summer

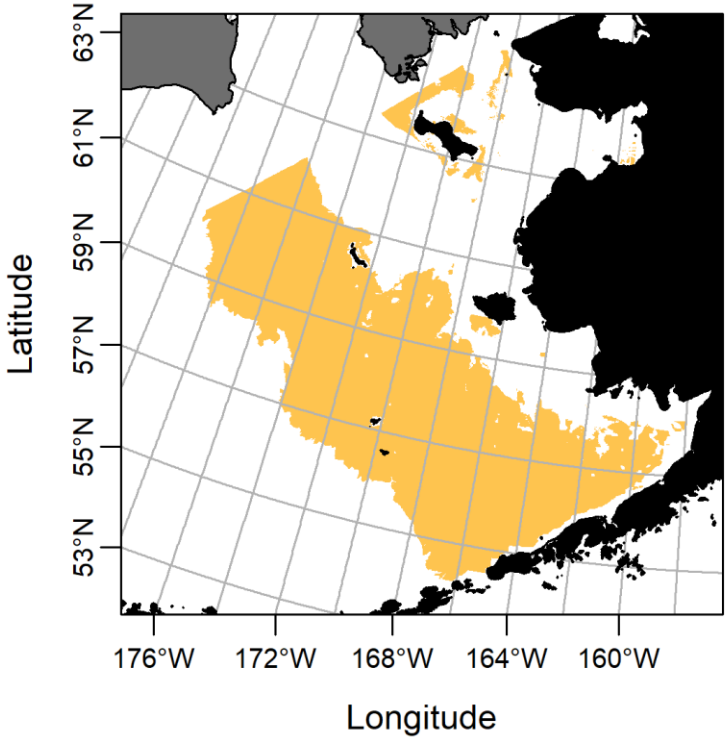

Figure E-259 EFH area of EBS adult walleye pollock, fall

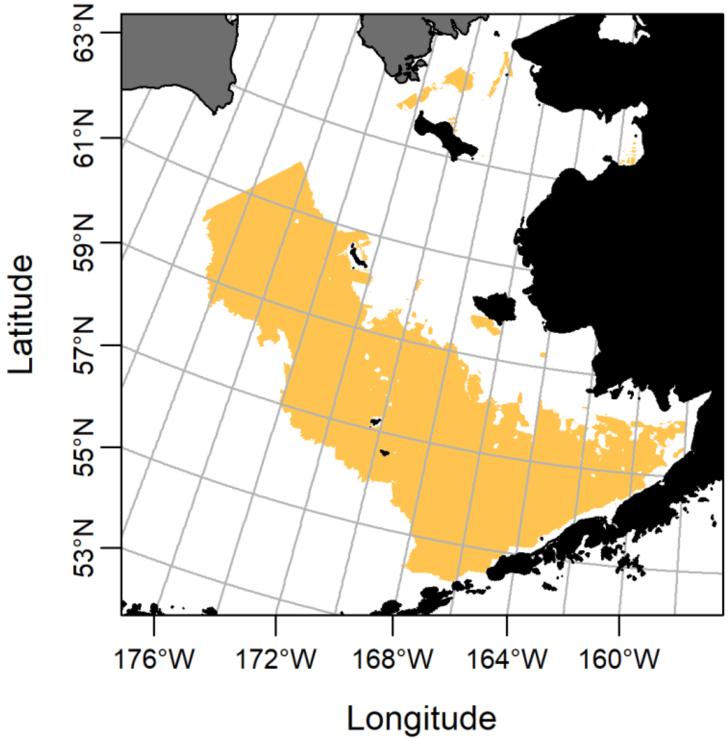

Figure E-260 EFH area of EBS adult walleye pollock, winter

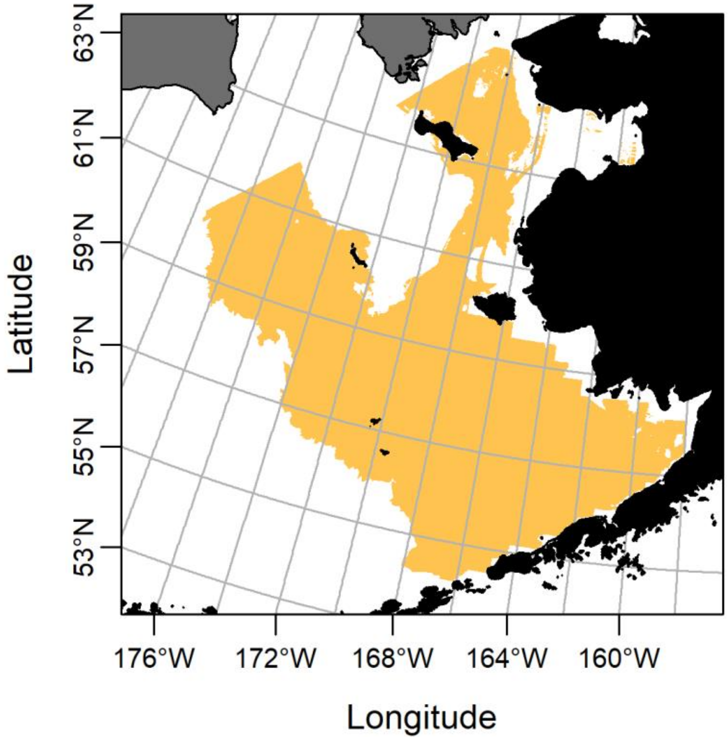

Figure E-261 EFH area of EBS adult walleye pollock, spring

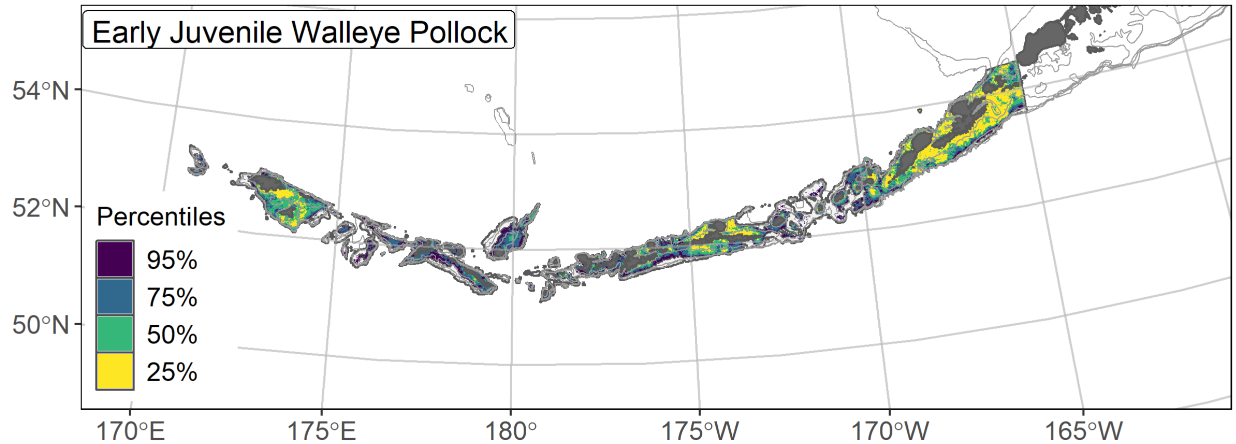

Figure E-262 EFH area of AI settled early juvenile walleye pollock, summer

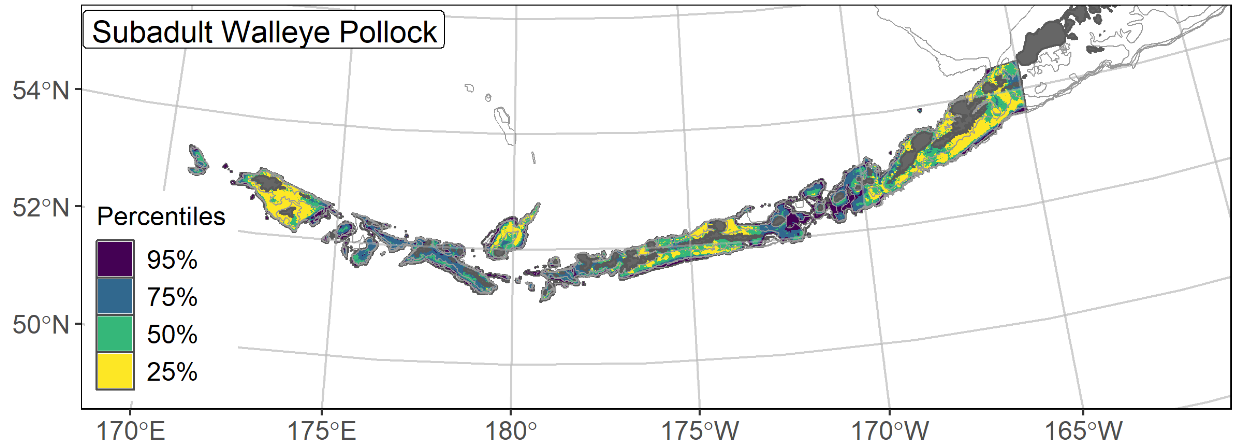

Figure E-263 EFH area of AI subadult walleye pollock, summer

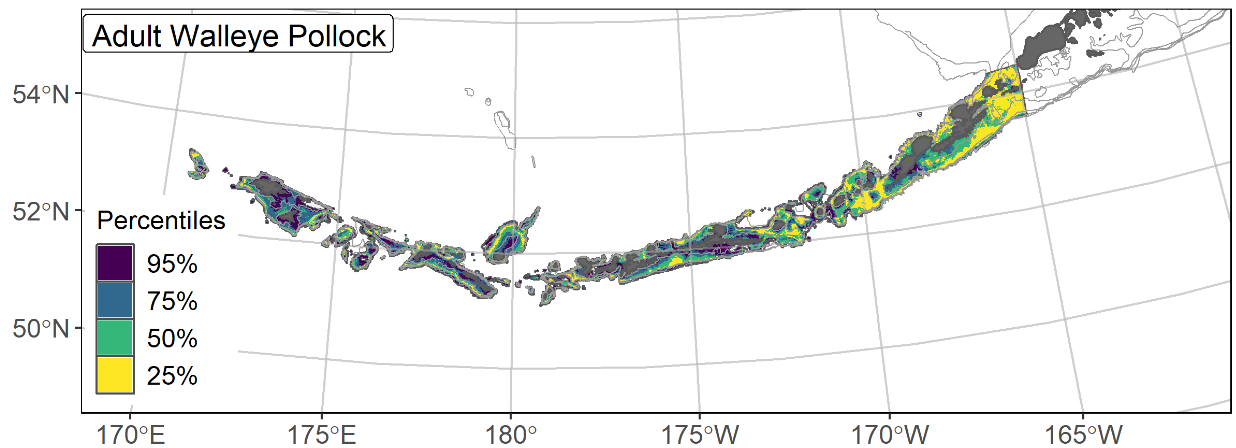

Figure E-264 EFH area of AI adult walleye pollock, summer

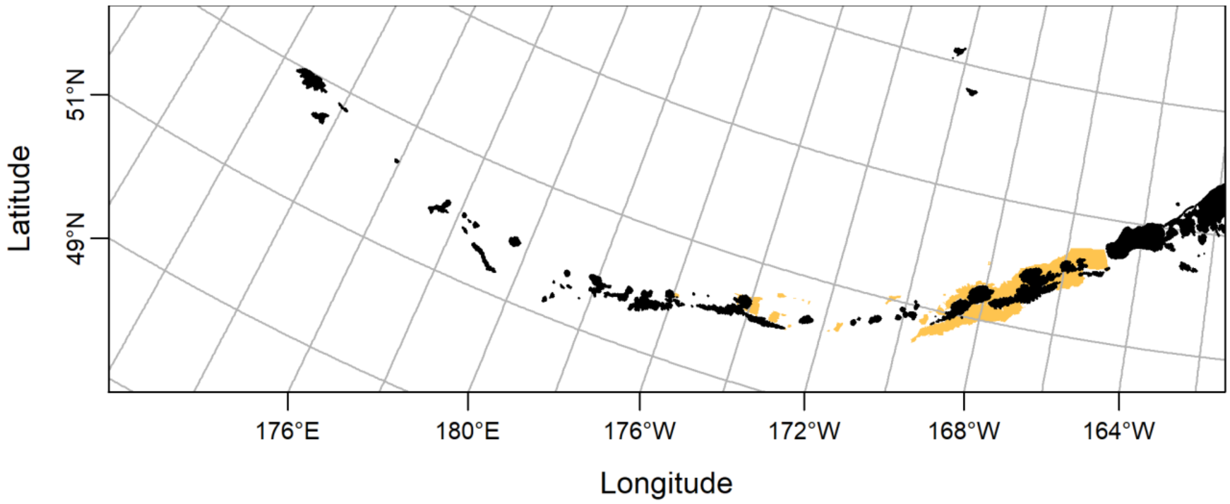

Figure E-265 EFH area of AI walleye pollock eggs, summer

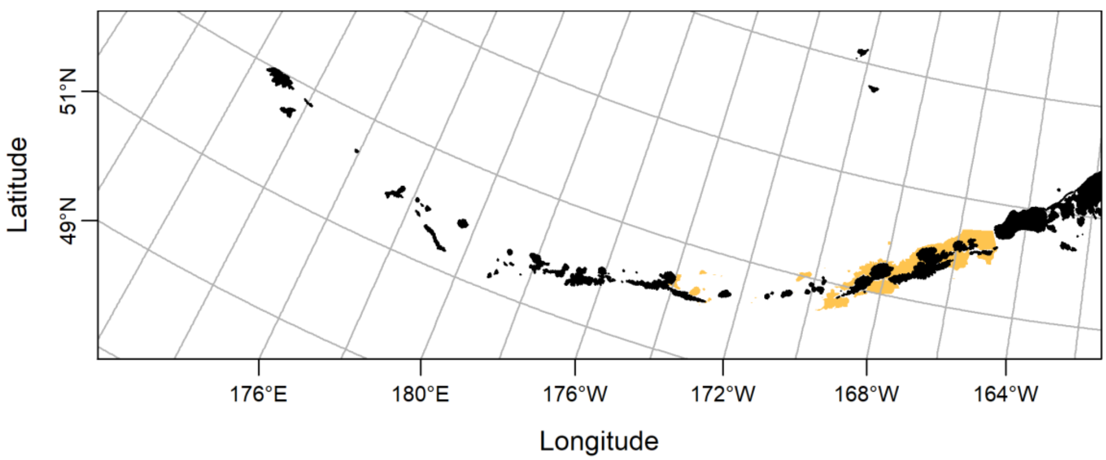

Figure E-266 EFH of AI walleye pollock larvae, summer

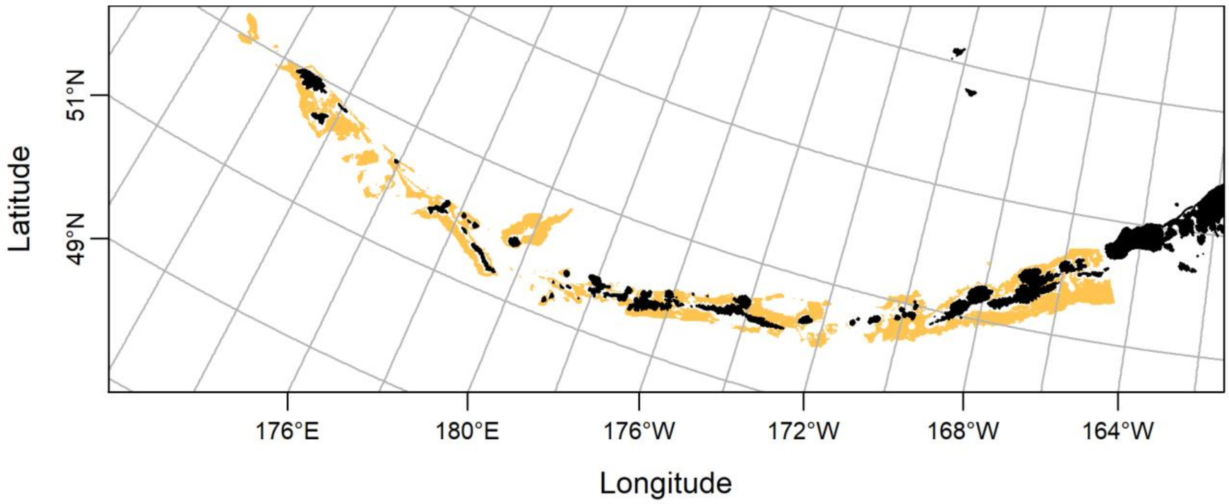

Figure E-267 EFH area of AI adult walleye pollock, fall

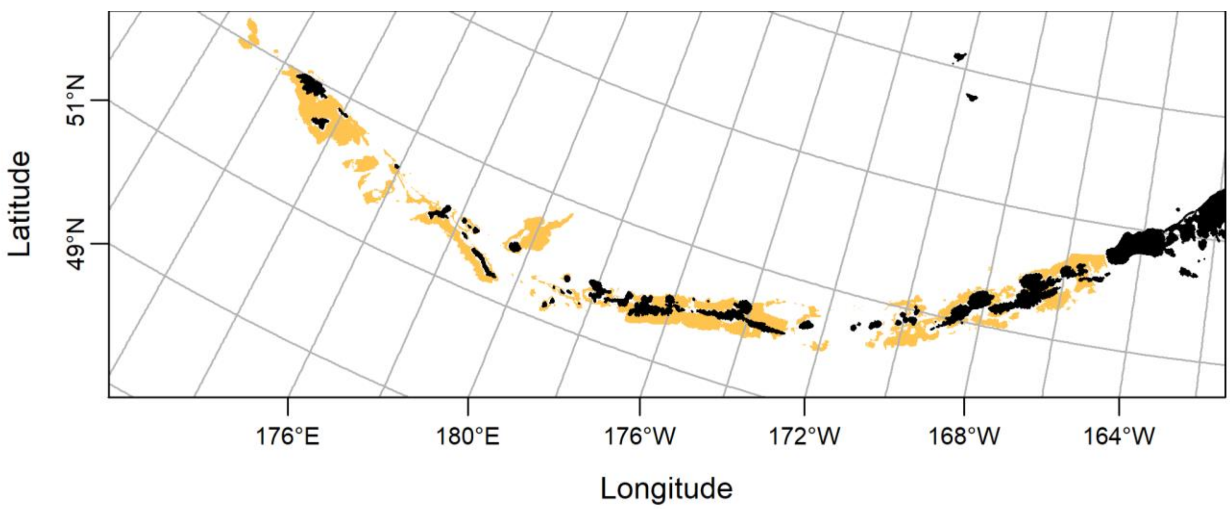

Figure E-268 EFH area of AI adult walleye pollock, winter

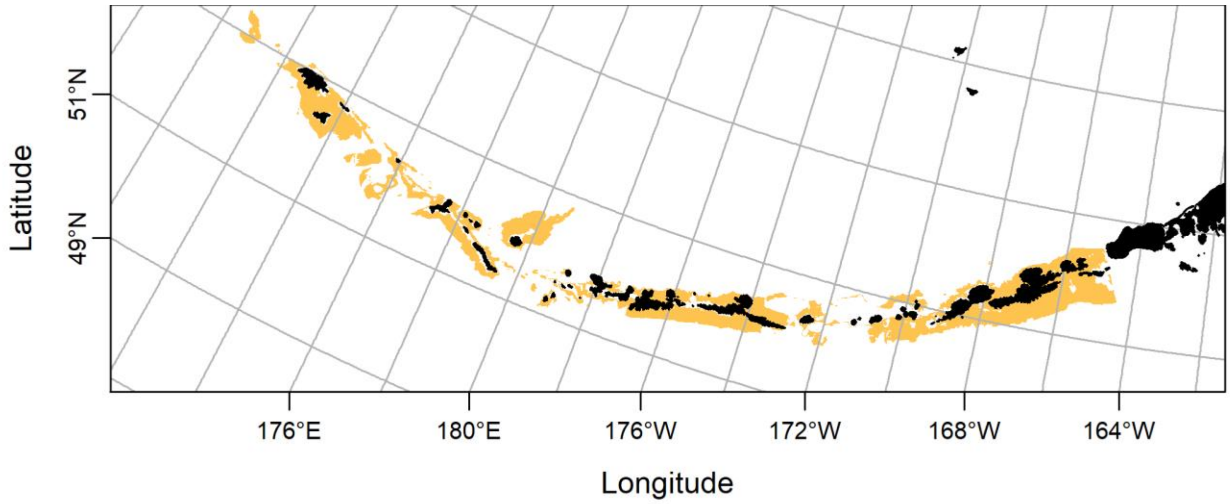

Figure E-269 EFH area of AI adult walleye pollock, spring

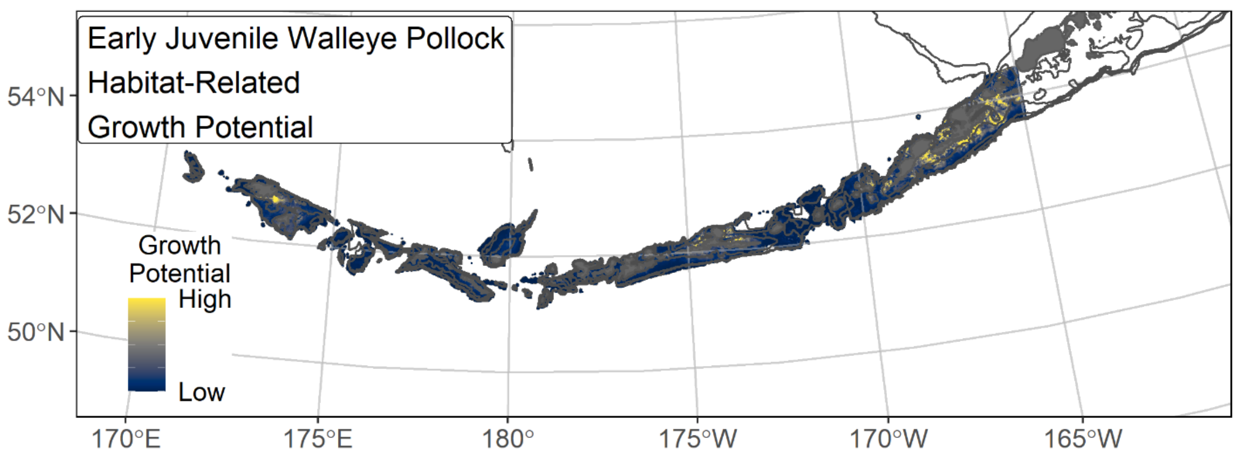

Figure E-270 EFH area of AI settled early juvenile walleye pollock, habitat-related growth potential, summer

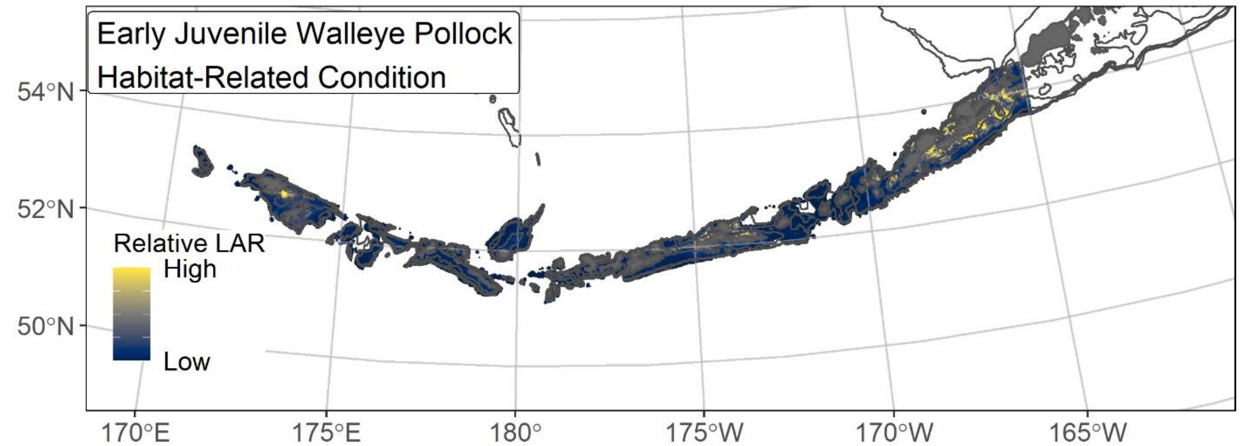

Figure E-271 EFH area of AI settled early juvenile walleye pollock, habitat-related condition, summer

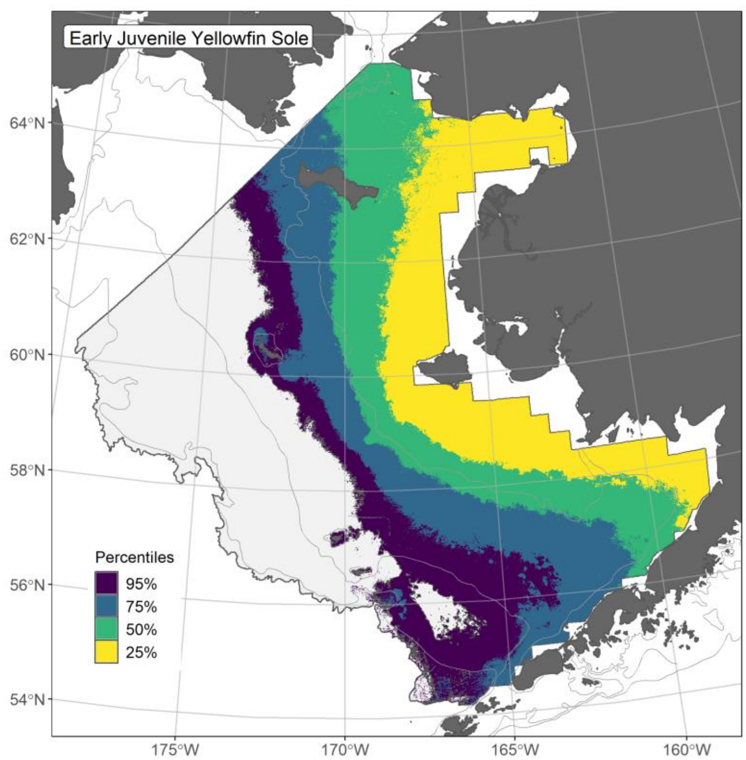

Figure E-272 EFH area of EBS settled early juvenile yellowfin sole, summer

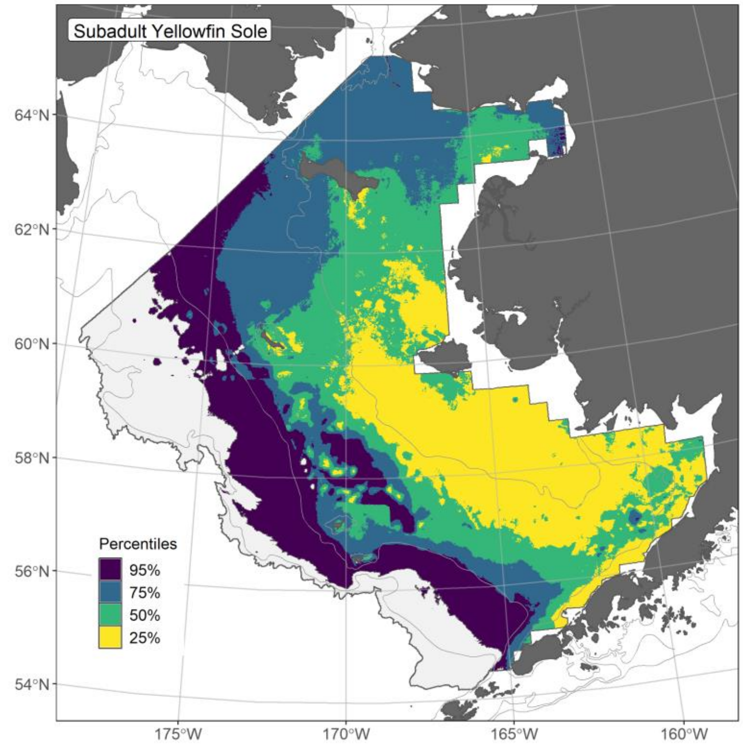

Figure E-273 EFH area of EBS subadult yellowfin sole, summer

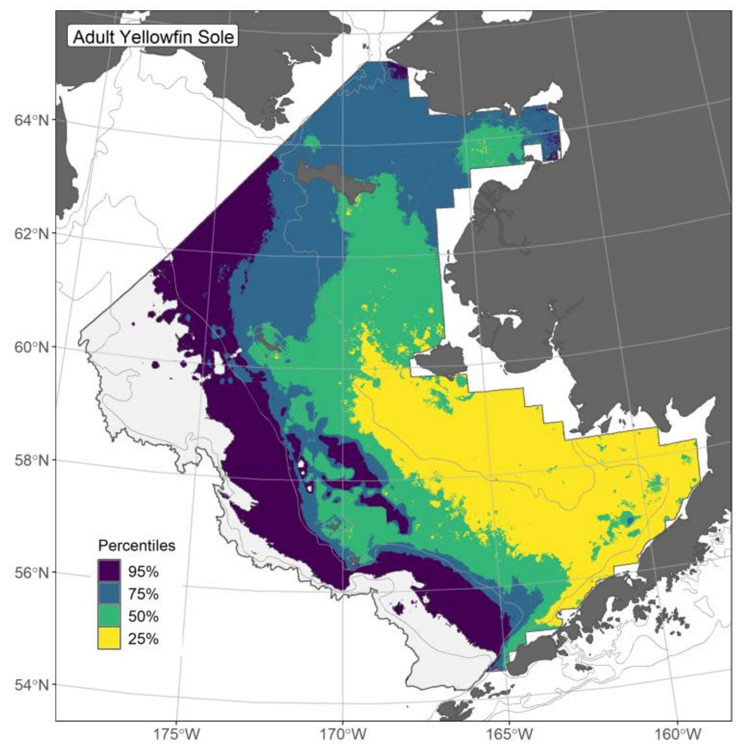

Figure E-274 EFH area of EBS adult yellowfin sole, summer

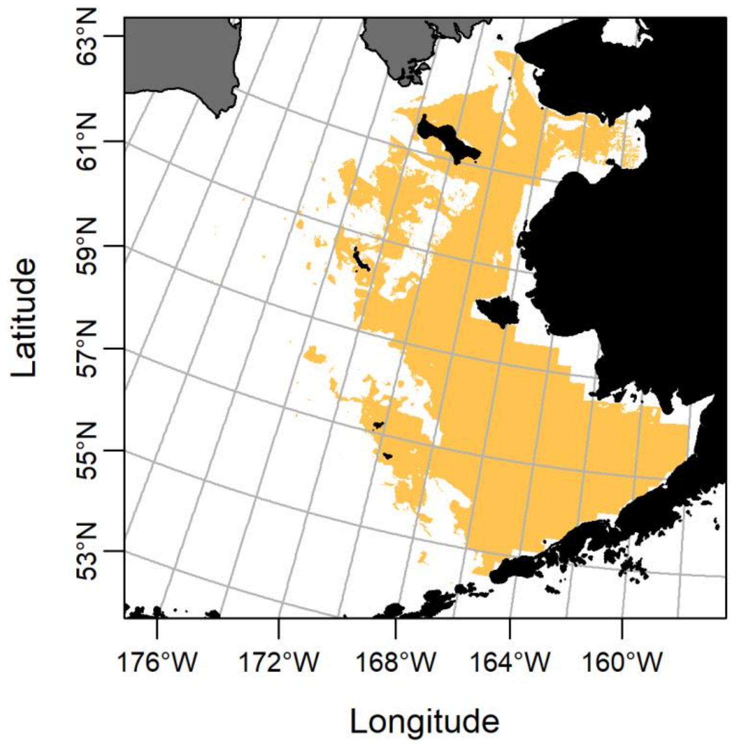

Figure E-275 EFH area of EBS yellowfin sole eggs, summer

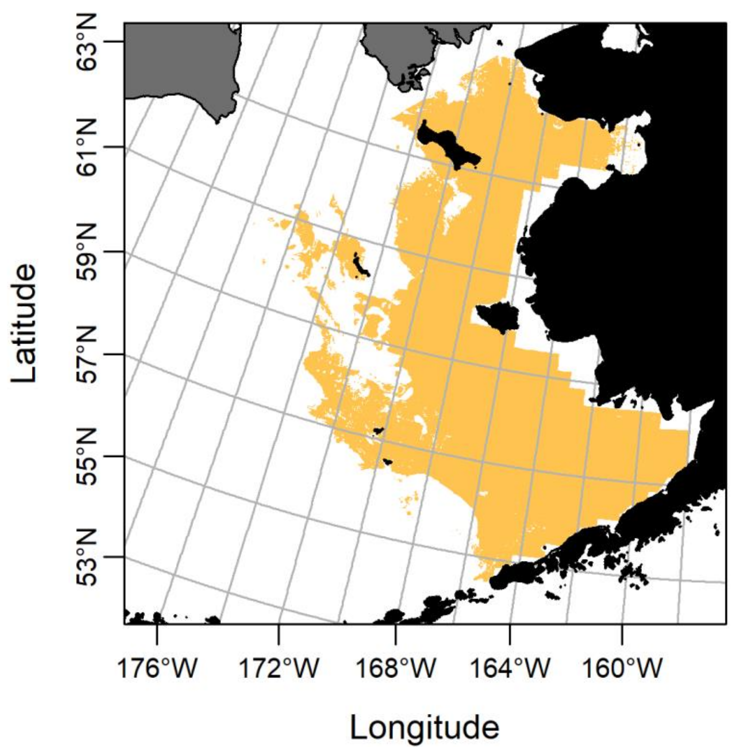

Figure E-276 EFH area of EBS yellowfin sole larvae, summer

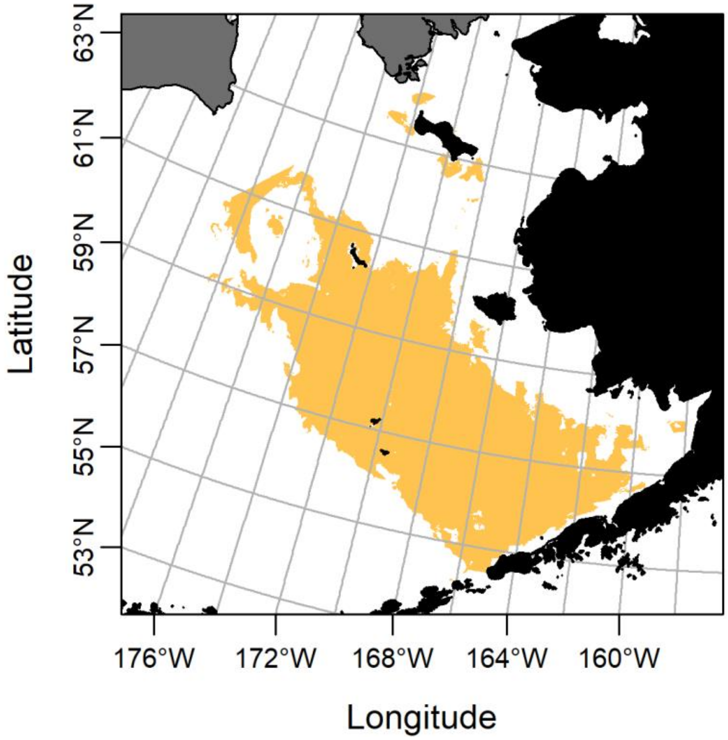

Figure E-277 EFH area of EBS adult yellowfin sole, fall

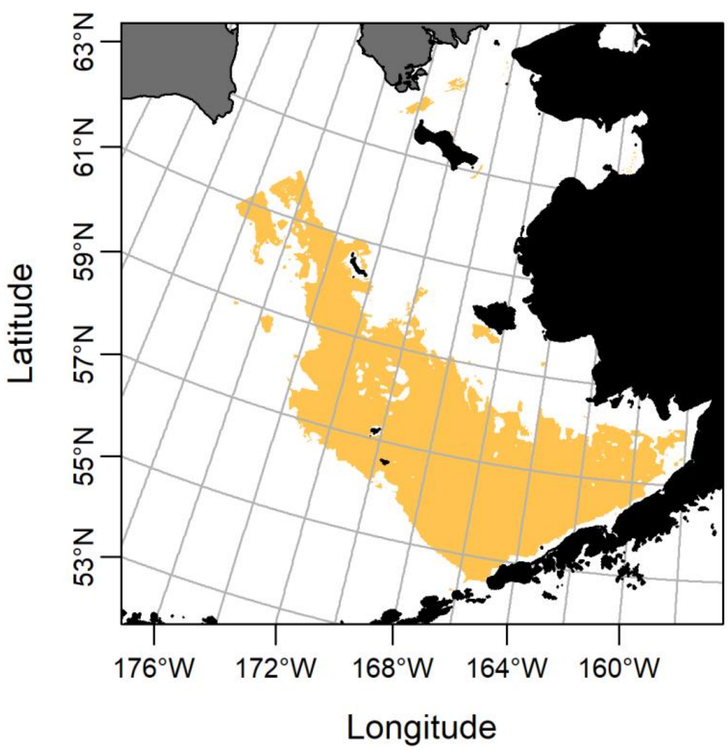

Figure E-278 EFH area of EBS adult yellowfin sole, winter

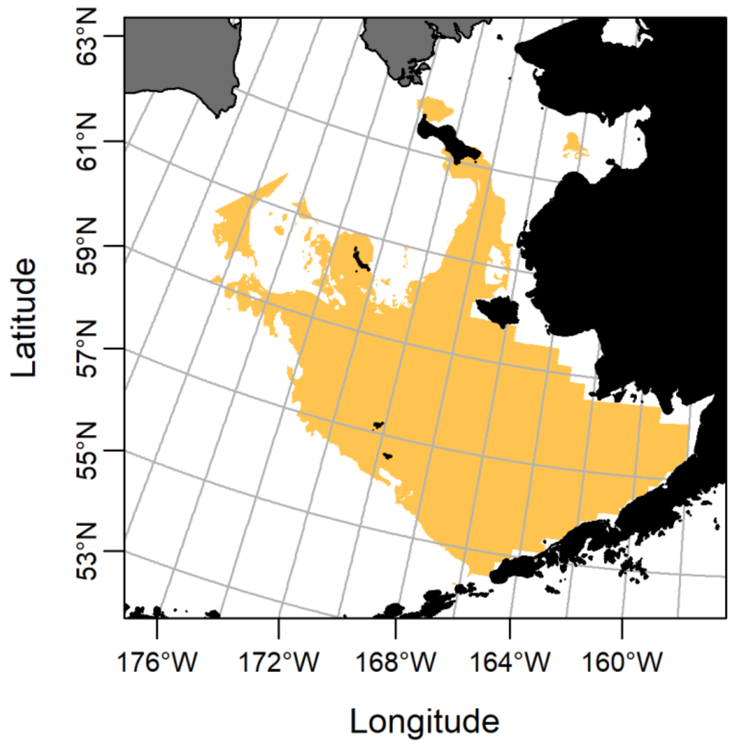

Figure E-279 EFH area of EBS adult yellowfin sole, spring

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Harris, J., E. A. Laman, J. L. Pirtle, M. C. Siple, C. N. Rooper, T. P. Hurst, and C. L. Conrath. 2022. Advancing model-based essential fish habitat descriptions for North Pacific species in the Aleutian Islands. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-458, 406 p. https://doi.org/10.25923/ffnc-cg42

Laman, E. A., J. L. Pirtle, J. Harris, M. C. Siple, C. N. Rooper, T. P. Hurst, and C. L. Conrath. 2022. Advancing model-based essential fish habitat descriptions for North Pacific species in the Bering Sea. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-459, 538 p. https://doi.org/10.25923/y5gc-nk42

Appendix F Adverse Effects on Essential Fish Habitat

F.1 Fishing Effects on Essential Fish Habitat

F.1.2 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).

F.1.3 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. 2024). 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. 2024). 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. The FE Report includes each stock author's evaluations in Appendix 5. For the BSAI groundfish species or species complexes, 15 had estimates of habitat disturbance $\geq$ 10% of their core EFH area. No stock authors concluded that fishing effects were 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.

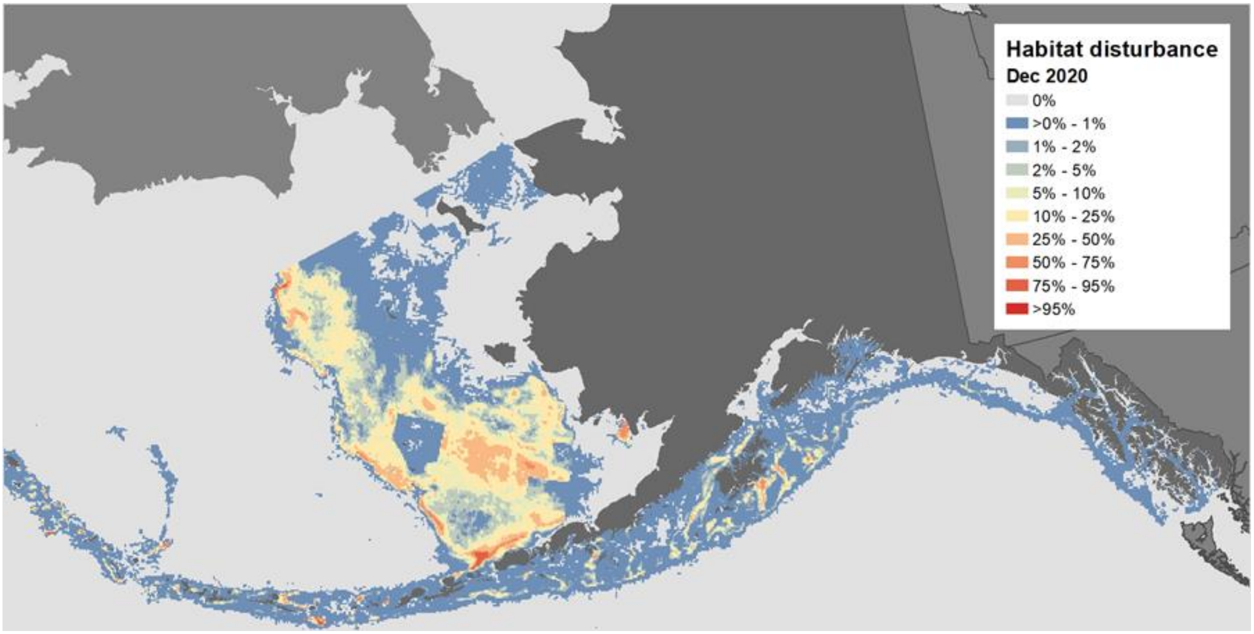

Figure F-1 Eastern Bering Sea cumulative percentage habitat disturbed. All gears combined.

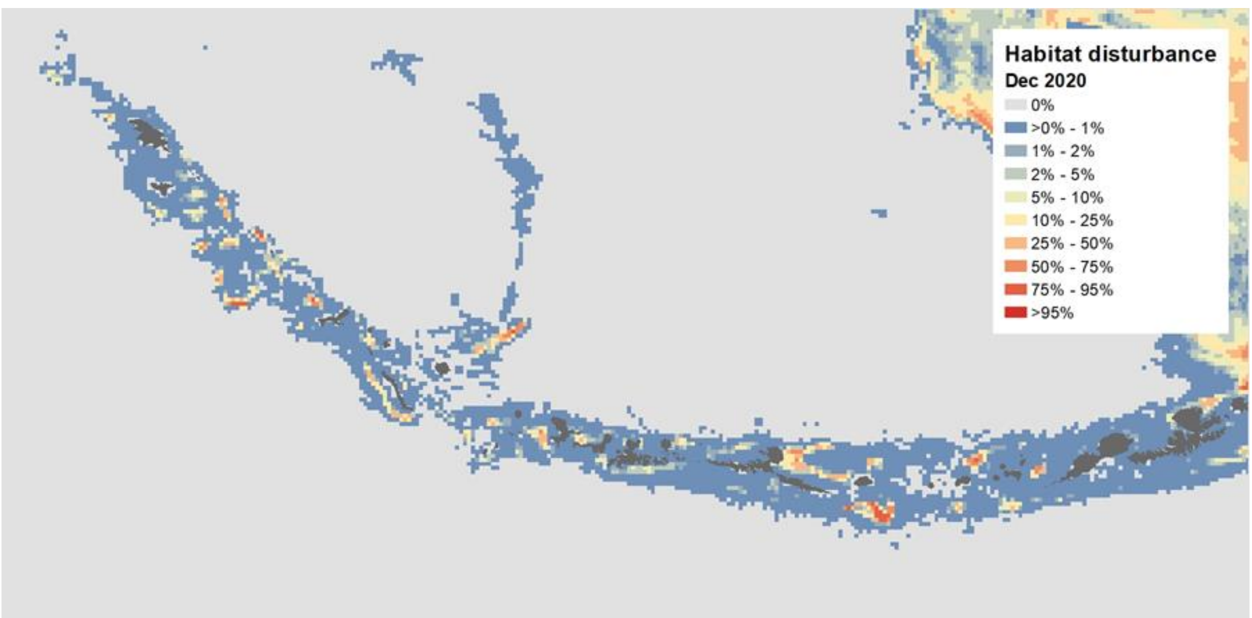

Figure F-2 Aleutian Islands cumulative percentage habitat disturbed. All gears combined.

F.2 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.

F.2.2 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.

F.2.3 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.

F.3 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 and includes 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. 2024).

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.

F.4 Appendix F References

Limpinsel, D., S. McDermott, C. Felkley, E. Ammann, S. Coxe, G.A. Harrington, S. Kelly, J.L. Pirtle, L. Shaw, and M. Zaleski. 2023. Impacts to Essential Fish Habitat from Non-Fishing Activities in Alaska: EFH 5-year review from 2018-2023. National Marine Fisheries Service, Alaska Region, Juneau, Alaska. U.S. Dep. Commerce, NOAA Tech. Memo. NMFS-F/AKR-30, 26 p. https://doi: 10.25923/9z4h-n860

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Appendix H Research Needs

H.4 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.

H.4.1 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. 2024). 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 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 Groundfish FMP.

H.4.2 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. 2024)—

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. 2024). 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 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. 2024).

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

Bering Sea / Aleutian Island Species	**Research Notes from Stock Assessment Authors**
arrowtooth flounder	Incorporate other data sources like longline survey and IPHC survey data to supplement the slope bottom trawl survey. When evaluating FE, referencing habitat specificity variables in the climate vulnerability assessment and the habitat assessment prioritization for Alaska stocks could allow for a more targeted approach.
Atka mackerel	Further stratification of data in time and space may allow for patterns to become apparent at local scales.
flathead sole-Bering flounder complex	Investigate impacts to the habitat/environment on early life history and recruitment distribution.
Greenland turbot	Incorporate AFSC longline survey data in addition to the bottom trawl survey data. They also suggested forming a small team to reevaluate life stage breaks and look at spatially varying growth differences.
Kamchatka flounder	Incorporate AFSC longline survey data in addition to the bottom trawl survey data.
northern rock sole	Northern rock sole have exhibited changes in growth over time, so length-based categories may need to be addressed.
northern rockfish	Continue research on observing and modeling stock densities in untrawlable grounds, particularly in the Aleutian Islands and Bering Sea slope.
other flatfish complex	Group life history stages by age rather than length where possible.
other rockfish complex	Incorporate AFSC longline survey data.
Pacific ocean perch	Continue research on observing and modeling stock densities in untrawlable grounds, particularly in the Aleutian Islands and Bering Sea slope.
rougheye/ blackspotted rockfish complex	Continue research on observing and modeling stock densities in untrawlable grounds, particularly in the Aleutian Islands and Bering Sea slope.
sablefish	Incorporate longline survey data in future EFH analyses. Gather more data on life history patterns and habitat utilization: spawning locations, larval dispersal, juvenile nursery areas, and/or ontogenetic movement patterns. Utilize FE model outputs for areas aside from the regional requirements.
shortraker rockfish	Incorporate other data sources like longline survey and IPHC survey data to supplement the slope bottom trawl survey. When evaluating FE, referencing habitat specificity variables in the climate vulnerability assessment and the habitat assessment prioritization for Alaska stocks could allow for a more targeted approach.

H.4.3 References

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