Appendix B to the Environmental Assessment for Amendment to the Fishery Management Plan for Groundfish of the Gulf of Alaska

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

Make the following changes to 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.4.

1. In Section 4.2.1, replace Figure 4-8 with the updated figure:

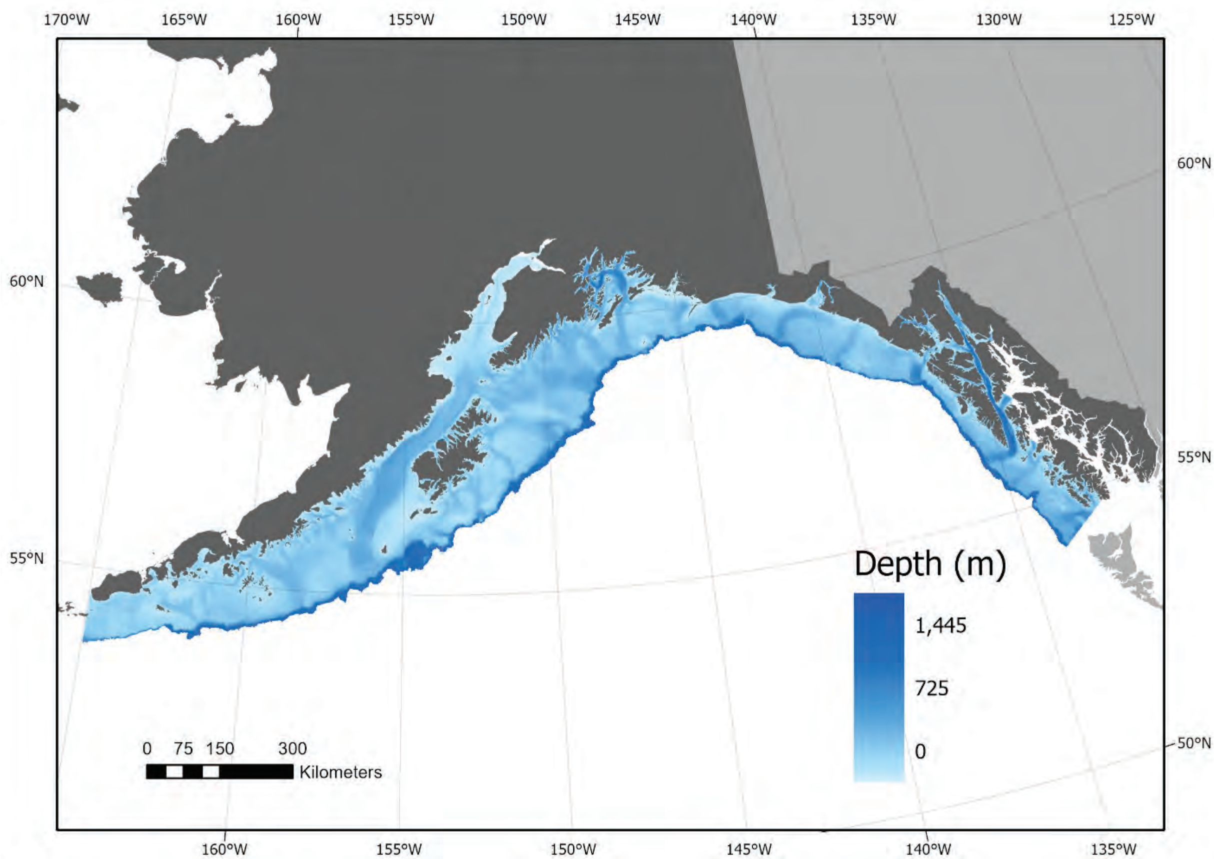

Figure 4-8 Bathymetric map of the Gulf of Alaska.

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. 2023). EFH descriptions include both text (Section 4.2.2.2 and Appendix D) and maps (Section 4.2.2.3 and Appendix E), 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. 2023).

3. ***In Section 4.2.2.1, replace Table 4-13 and the associated text and table caption with the following revised text, table, and caption:***

~~A summary of the habitat information levels for each species is listed in Table 4-13.~~
Table 4-13 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 GOA FMP.

Table 4-13 The levels of EFH information available as a result of the 2023 EFH Review, for species' life stages and species complexes for target species in the GOA FMP.

	Life Stage					
Species/Complex	**Egg**	**Larvae**	**Early Juvenile pelagic**	**Early Juvenile settled**	**Subadult**	**Adult**
Arrowtooth flounder	1	1	1	1	2	2
Atka mackerel	1	0	0	0	2	2
Deepwater flatfish complex	1	1	0	0	0	0
Dover sole	1	1	0	0	2	2

Species/Complex	Life Stage					
	Egg	Larvae	Early Juvenile pelagic	Early Juvenile settled	Subadult	Adult
Dusky rockfish	1	1	1	0	2	2
Flathead sole	1	1	1	1	2	2
Northern rockfish	1	1	1	0	2	2
Octopus	0	0	--	0	0	
Giant octopus	0	0	--	0	2	
Other rockfish complex demersal subgroup	0	1	1	0	2	
Quillback rockfish	0	0	0	0	0	2
Rosethorn rockfish	0	0	0	0	2	2
Yelloweye rockfish	0	0	0	0	2	2
Other rockfish complex slope subgroup	0	1	1	0	2	
Greenstriped rockfish	0	0	0	0	0	2
Harlequin rockfish	0	0	0	0	2	2
Pygmy rockfish	0	0	0	0	2	
Redbanded rockfish	0	0	0	0	2	2
Redstripe rockfish	0	0	0	0	2	2
Sharpchin rockfish	0	0	0	0	2	2
Silvergray rockfish	0	0	0	0	2	2
Pacific cod	3	3	3	3	2	2
Pacific ocean perch	1	1	1	3	2	2
Rex sole	1	1	0	1	2	2
Rougheye/Blackspotted rockfish complex	1	1	1	0	2	2
Sablefish	3	3	3	3	2	2
Shallow water flatfish complex	1	1	1	1	2	
Alaska plaice	1	1	1	0	2	2
Butter sole	0	0	0	0	2	
English sole	0	0	0	1	2	2

Species/Complex	Life Stage					
	Egg	**Larvae**	**Early Juvenile pelagic**	**Early Juvenile settled**	**Subadult**	**Adult**
Northern rock sole	**1**	**1**	**1**	**3**	**2**	**2**
Pacific sanddab	**0**	**0**	**0**	**0**	**2**	
Petrale sole	**0**	**0**	**0**	**0**	**2**	**2**
Sand sole	**0**	**0**	**0**	**0**	**0**	**2**
Slender sole	**0**	**0**	**0**	**0**	**2**	
Southern rock sole	**1**	**1**	**1**	**3**	**2**	**2**
Starry flounder	**0**	**0**	**0**	**1**	**2**	**2**
Yellowfin sole	**1**	**1**	**1**	**3**	**2**	**2**
Shark Complex	**0**	**0**	**--**	**0**	**0**	
Spiny dogfish	**0**	**0**	**--**	**0**	**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**	**2**
Longnose skate	**0**	**0**	**--**	**0**	**2**	**2**
Thornyhead rockfish	**0**	**0**	**1**	**0**	**2**	**2**
Shortspine thornyhead	**0**	**0**	**1**	**0**	**2**	**2**
Walleye pollock	**1**	**1**	**1**	**3**	**2**	**2**

4. In Section 4.2.2.2, replace 4.2.2.2.1 through 4.2.2.2.26 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 Arrowtooth Flounder

Eggs: EFH for arrowtooth flounder eggs is the general distribution area for this life stage, located in demersal habitat at depths mostly greater than 400 m (Doyle et al. 2009) ~~throughout the shelf (0 to 200 m) and upper slope (200 to 500 m)~~.

Larvae: EFH for larval arrowtooth flounder 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 GOA.

Settled Early Juveniles: EFH for settled early juvenile arrowtooth flounder 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 GOA wherever there are softer substrates consisting of sand and mud.

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 depth) throughout the GOA wherever there are softer substrates consisting of gravel, sand, and mud. EFH hot spots for this life stages were prominent in Shelikof Strait and in glacial troughs throughout the GOA (Pirtle et al. 2023).

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) throughout the GOA wherever there are softer substrates consisting of gravel, sand, and mud. EFH hot spots for this life stage were prominent in Shelikof Strait and in glacial troughs throughout the GOA (Pirtle et al. 2023).

4.2.2.2.2 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). Several Nnesting sites in the western GOA have been identified. Historical data from ichthyoplankton tows on the outer shelf and slope off Kodiak Island in the 1970's and 1980's suggest that nesting colonies may have existed at one time in the central GOA. There are general distribution data available; however observations are not complete for the entire GOA, and recent observations are not available.

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

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, Generally, subadult Atka mackerel can be found 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 GOA wherever there are substrates of gravel and rock and in vegetated areas of kelp. However, insufficient information is available. EFH hot spots increase moving west in the GOA (Pirtle et al. 2023).

Adults: EFH for adult 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 GOA wherever there are substrates of gravel and rock and in vegetated areas of kelp. An Atka mackerel population existed in the GOA primarily in the Kodiak, Chirikof, and Shumagin areas, and supported a large foreign fishery through the early 1980s. By the mid-1980s, this fishery, and presumably the population, had all but disappeared. Recently, Atka mackerel have been detected by the summer trawl surveys primarily in the Shumagin (Western) area of the GOA. The fishery also catches Atka mackerel sporadically in low numbers in the western GOA as bycatch. The core EFH area occurred from Kayak Island west (Pirtle et al. 2023).

4.2.2.2.3 Deepwater Flatfish Complex: Dover Sole

Deepwater flatfish complex species:
Deepsea sole
Dover sole (primary, described below)
Greenland turbot

Eggs: EFH for Dover 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 GOA.

Larvae: EFH for larval Dover 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 GOA.

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

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 GOA wherever there are substrates consisting of sand and mud. Subadult distribution is widespread across the central GOA and southeast Alaska, and high abundances are associated with glacial troughs near Yakutat and southeast Alaska (Pirtle et al. 2023).

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 slope (200 to 500 m depth) throughout the GOA wherever there are substrates consisting of sand and mud.

4.2.2.2.4 Dusky Rockfish

Eggs: EFH for dusky rockfish eggs is the general distribution 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).

Larvae: EFH for larval 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 GOA.

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

Subadults: ~~**Late Juveniles:**~~ EFH for subadult ~~late juvenile~~ dusky rockfish is the general distribution area for this life stage, located ~~in the middle and lower portions of the water column along the middle and outer shelfs (100 to 200 m) throughout the GOA~~ wherever there are substrates of cobble, rock, and gravel. It includes the GOA continental shelf and upper slope from southeast Alaska through the western GOA, with hot spots off the Kenai Peninsula and southeast Alaska (Pirtle et al. 2023).

Adults: EFH for adult dusky rockfish is the general distribution 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 GOA wherever there are substrates of cobble, rock, and gravel.

4.2.2.2.5 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 GOA.

Larvae: EFH for larval flathead sole is described the same as for their egg life history stage.~~ the general distribution area for this life stage, located in pelagic waters along the entire shelf (0 to 200 m) and slope (200 to 3,000 m) throughout the GOA.~~

Settled Early Juveniles: EFH for settled early juvenile flathead sole is the general distribution area ~~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 GOA wherever there are softer substrates consisting of sand and mud.

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 GOA wherever there are softer substrates consisting of sand and mud. EFH for subadult flathead sole extends from southeast Alaska to the western GOA with hot spots in Shelikof Strait and over the continental shelf and the coast of the Alaska Peninsula (Pirtle et al. 2023).

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 GOA wherever there are softer substrates consisting of sand and mud.

4.2.2.2.6 Northern Rockfish

Eggs: EFH for northern rockfish eggs is the general distribution 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).

Larvae: EFH for larval northern rockfish 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 GOA.

Settled Early Juveniles: EFH for early juvenile northern rockfish 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 GOA.

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 shelf (100 to 200 m) throughout the GOA, wherever there are substrates of cobble and rock.~~ across the GOA continental shelf west of Kayak Island at depths less than 250 m with rocky substrates (Pirtle et al. 2023).

Adults: EFH for adult northern rockfish is the general distribution ~~habitat-related density~~ area for this life stage, located in the lower portions of the water column along the outer continental shelf (75 to 200 m depth) and upper slope (200 to 300 m depth) in the central and western GOA wherever there are substrates of cobble and rock.

4.2.2.2.7 Octopus: Giant Octopus

Eggs: 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). It is most extensive in the central and western GOA and along the outer continental shelf and upper continental slope (Pirtle et al. 2023).

4.2.2.2.8 Other Rockfish Complex, Demersal Subgroup

This section describes EFH for the demersal subgroup of the Other rockfish complex. This description can be applied as a proxy for species with insufficient information. Three species within the subgroup have individual EFH descriptions: quillback rockfish, rosethorn rockfish, and yelloweye rockfish. The Other rockfish complex, demersal subgroup species include—

Canary rockfish,
China rockfish,
Copper rockfish,
Quillback rockfish,
Rosethorn rockfish,
Tiger rockfish, and
Yelloweye rockfish.

Eggs: EFH for other rockfish eggs is the general distribution area for this life stage, located in the lower portion of the water column along the continental shelf (0 to 200 m depth) and upper slope (200 to 500 m depth).

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

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

Subadults: ~~**Late Juveniles:**~~ EFH for subadult ~~early juvenile~~ other rockfish is the general distribution area for this life stage, based on all rockfish species combined, located in the lower portion of the water column along the middle (50 to 100 m depth) and outer continental shelf (100 to 200 m depth) throughout the GOA.

Adults: EFH for adult other rockfish is the general distribution area for this life stage, located in the lower portion of the water column along the continental shelf (0 to 200 m depth) and upper slope (200 to 500 m depth).

4.2.2.2.8.1 Quillback 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: Quillback rockfish are associated with rocky, high-relief habitats with kelp cover. Adults occur at a higher abundance at shallow depths and mainly on the continental shelf and inshore areas of the southeastern GOA (Pirtle et al. 2023).

4.2.2.2.8.2 Rosethorn 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: Subadult rosethorn rockfish occur along the outer continental shelf of the eastern GOA at around 250 m depth. They are associated with areas of low sponge abundance (Pirtle et al. 2023).

Adults: Rosethorn rockfish are associated with transitional habitat locations between soft, unconsolidated and rocky substrates. The adults occur along the outer continental shelf of the eastern GOA at around 250 m depth (Pirtle et al. 2023).

4.2.2.2.8.3 Yelloweye Rockfish

Eggs: EFH for yelloweye rockfish eggs is the general distribution area for this life stage, located in the lower portion of the water column within bays and island passages and along the inner continental shelf (0 to 50 m depth), outer shelf (100 to 100 m depth), and upper slope (200 to 500 m depth).

Larvae: EFH for larval yelloweye rockfish 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 GOA.

Settled Early Juveniles: EFH for settled early juvenile yelloweye rockfish is the general distribution area for this life stage, located in the lower portion of the water column within bays and island passages and 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 GOA wherever there are substrates of rock and in areas of vertical relief, such as crevices, overhangs, vertical walls, coral, and larger sponges.

Subadults: ~~**Late Juveniles:**~~ EFH for subadult ~~late juvenile~~ yelloweye rockfish is the general distribution area for this life stage, located in the lower portion of the water column within bays and island passages and 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 GOA wherever there are substrates of rock and in areas of vertical relief, such as crevices, overhangs, vertical walls, coral, and larger sponges. They have high abundances around 125 m depth on bathymetric rises in areas of low sponge presence on the GOA continental shelf (Pirtle et al. 2023).

Adults: EFH for adult yelloweye rockfish is the general distribution area for this life stage, located in the lower portion of the water column within bays and island passages and along the inner continental shelf (0 to 50 m depth), middle shelf (50 to 100 m depth), outer shelf (100 to 200 m depth) and upper slope (200 to 500 m depth) throughout the GOA wherever there are substrates of rock and in areas of vertical relief, such as crevices, overhangs, vertical walls, coral, and larger sponges.

4.2.2.2.9 Other Rockfish Complex, Slope Subgroup

This section describes EFH for the slope subgroup of the Other rockfish complex. This description can be applied as a proxy for species with insufficient information. The Other rockfish complex, demersal subgroup species include—
Greenstriped rockfish,
Harlequin rockfish,
Pygmy rockfish,

Redbanded rockfish,
Redstripe rockfish,
Sharpchin rockfish, and
Silvergray 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: The species in this complex are found on the outer continental shelf and upper slope of the eastern GOA, with higher abundances present on the continental shelf south of the Kenai Peninsula (Pirtle et al. 2023).

4.2.2.2.9.1 Greenstriped 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: Adult greenstripe rockfish occur on the eastern GOA continental shelf off southeast Alaska with peaks at depths < 200 m (Pirtle et al. 2023).

4.2.2.2.9.2 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: Subadult harlequin rockfish occur in the central and eastern GOA at shallower depths on the continental shelf (Pirtle et al. 2023).
Adults: Adult harlequin rockfish have a more extensive EFH area than subadults and are found at high abundances around 200 m depth with rocky substrates along the outer continental shelf and upper slope in the eastern and central GOA and west of Kodiak Island (Pirtle et al. 2023).

4.2.2.2.9.3 Pygmy 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 to separate subadult and adult pygmy rockfish based on length at maturity (Pirtle et al. 2023).
Adults: Pygmy rockfish occur at depths < 250 m on the continental shelf of the eastern GOA off southeast Alaska and some areas in the central GOA. They associate more with rocky substrates than with sponge presence (Pirtle et al. 2023).

4.2.2.2.9.4 Redbanded 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: Subadult redbanded rockfish have high abundances in the eastern GOA and off southeast Alaska around 250 m depths (Pirtle et al. 2023).

Adults: Adult redbanded rockfish occur from southeast Alaska to the western GOA around 250 m depth with moderate current exposure in the eastern GOA (Pirtle et al. 2023).

4.2.2.2.9.5 Redstripe 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: Subadult redstripe rockfish occur in high abundances around 200 m depth with rocky substrates on the continental shelf of the southeastern GOA (Pirtle et al. 2023).
Adults: Adult redstripe rockfish also occur in high abundances around 200 m depth with rocky substrates on the continental shelf of the southeastern GOA (Pirtle et al. 2023).

4.2.2.2.9.6 Sharpchin 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: Subadult sharpchin rockfish are found around 200 m depth on the outer continental shelf of the GOA east of Kodiak Island. They associate with rocky substrates and with areas having low sponge abundance (Pirtle et al. 2023).
Adults: Adult sharpchin rockfish have high abundances around 200 m depth on the outer continental shelf of the GOA east of Kodiak Island (Pirtle et al. 2023).

4.2.2.2.9.7 Silvergray 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: Subadult silvergray rockfish abundance was highest around 200 m depth in areas with rocky substrate present in the eastern GOA off southeast Alaska (Pirtle et al. 2023).

Adults: Adult silvergray rockfish occur around 200 m depth in the eastern GOA off southern southeast Alaska (Pirtle et al. 2023).

4.2.2.2.10 Pacific Cod

Eggs: ~~No EFH description determined. Information is insufficient.~~ Pacific cod eggs are demersal that adhere to the bottom (Laurel et al. 2008). They are highly sensitive to temperature with a thermal hatch success range between 3 to 6 °C (Laurel and Rogers 2020).

Larvae: EFH for larval Pacific cod is the general distribution area for this life stage, located in pelagic waters along the inner (0 to 50 m depth) and middle (50 to 100 m depth) continental shelf throughout the GOA~~, as depicted in Figure E-5~~.

Pelagic Early Juveniles: EFH for pelagic early juveniles is the general distribution area for this life stage and overlaps with the EFH for feeding larvae (pre- and postflexion) (Shotwell et al. In preparation). Early life history stages of Pacific cod generally do not disperse far from spawning locations (Hinckley et al. 2019).

Settled Early Juveniles: EFH for early juvenile Pacific cod 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 GOA.

Subadults: ~~**Late Juveniles:**~~ EFH for subadult ~~late juvenile~~ Pacific cod 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 GOA~~, as depicted in Figure E-6~~. Subadult EFH extends from southeast Alaska to the western GOA, with the core area more extensive at shallower depths on the continental shelf (Pirtle et al. 2023).

Adults: EFH for adult Pacific cod 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 GOA~~, as depicted in Figure E-6~~.

4.2.2.2.11 Pacific Ocean Perch

Eggs: EFH for Pacific ocean perch eggs is the general distribution 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).

Larvae: EFH for larval Pacific ocean perch is the general distribution area for this life stage, located in the middle to lower portion of the water column along the inner continental shelf (0 to 50 m depth), middle shelf (50 to 100 m depth), outer shelf (100 to 200 m depth), and upper slope (200 to 500 m depth) throughout the GOA. Additionally, Pacific ocean perch larvae have been found as far as 180 km offshore over depths in excess of 1,000 m.

Settled Early Juveniles: EFH for settled early juvenile Pacific ocean perch is the general distribution area for this life stage, located in the middle to lower portion of the water column along the inner continental shelf (0 to 50 m depth), middle shelf (50 to 100 m depth), outer shelf (100 to 200 m depth), and upper slope (200 to 500 m depth) throughout the GOA wherever there are substrates consisting of cobble, gravel, mud, sandy mud, or muddy sand.

Subadults: ~~**Late Juveniles:**~~ EFH for subadult ~~late juvenile~~ Pacific ocean perch is the general distribution area for this life stage, located in the middle to lower portion of the water column along the inner continental shelf (0 to 50 m depth), middle shelf (50 to 100 m depth), outer shelf (100 to 200 m depth), and upper slope (200 to 500 m depth) throughout the GOA wherever there are substrates consisting of cobble, gravel, mud, sandy mud, or muddy sand. Subadult EFH extends across the GOA with hotspots in the Yakutat and southeast Alaska management areas (Pirtle et al. 2023).

Adults: EFH for adult Pacific ocean perch is the general distribution 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 GOA wherever there are substrates consisting of cobble, gravel, mud, sandy mud, or muddy sand.

4.2.2.2.12 Rex Sole

Eggs: EFH for rex sole eggs is the general distribution area for this life stage, located in pelagic waters along the entire shelf (0 to 200 m) and upper slope (200 to 500 m) throughout the GOA in the spring.

Larvae: EFH for larval rex sole is the general distribution area for this life stage, located in pelagic waters along the entire shelf (0 to 200 m) and upper slope (200 to 500 m) throughout the GOA.

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

Subadults: ~~**Late Juveniles:**~~ EFH for subadult ~~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 GOA wherever there are substrates consisting of gravel, sand, and mud. Subadult EFH extends from southeast Alaska to the western GOA, with hotspots extending from the Kodiak management area into southeast Alaska (Pirtle et al. 2023).

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 GOA wherever there are substrates consisting of gravel, sand, and mud.

4.2.2.2.13 Rougheye/Blackspotted Rockfish Complex

Eggs: EFH for rougheye and blackspotted ~~blackspotted/rougheye~~ rockfish eggs is the general distribution 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).

Larvae: EFH for larval rougheye and blackspotted ~~blackspotted/rougheye~~ rockfish 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 GOA.

Settled Early Juveniles: EFH for early juvenile rougheye and blackspotted ~~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).

Subadults: ~~**Late Juveniles:**~~ EFH for subadult ~~juvenile~~ rougheye and blackspotted rockfish 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 continental shelf (100 to 200 m depth), and upper slope (200 to 500 m depth). Subadult EFH is extensive throughout the GOA with hot spots in the glacial troughs on the continental shelf and along the upper slope (Pirtle et al. 2023).

Adults: EFH for adult rougheye and blackspotted rockfish is the general distribution 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 GOA wherever there are substrates consisting of mud, sand, sandy mud, muddy sand, rock, cobble, and gravel.

4.2.2.2.14 Sablefish

Eggs: Sablefish spawn along the continental slope (Shotwell et al. In preparation). Sablefish also use seamounts in the GOA as spawning grounds (Gibson et al. 2023).

Larvae: EFH for larval sablefish is the general distribution area for this life stage. Larvae are located in epipelagic waters along the middle continental shelf (50 to 100 m depth), outer shelf (100 to 200 m depth), and slope (200 to 3,000 m depth) throughout the GOA, as depicted in Figure E-8.

Pelagic Early Juveniles: EFH for pelagic early juvenile sablefish is the general distribution area for this life stage and extends throughout the GOA from the outer coast of southeast Alaska to the western GOA around Kodiak Island and into Shelikof Strait (Shotwell et al. In preparation).

Settled Early Juveniles: EFH for settled early juvenile sablefish is the general distribution area for this life stage. Early juveniles have been observed in inshore water, bays, and passes, and on shallow continental shelf pelagic and demersal habitat.

Subadults: Late Juveniles: EFH for subadult late juvenile sablefish is the general distribution habitat-related density 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 (400 to 800 m depth200 to 1,000 m) throughout the GOA, as depicted in Figure E-9. Subadult EFH is throughout the GOA from southeast Alaska to the western GOA, with hot spots at deeper depths on the continental shelf and slope (Pirtle et al. 2023).

Adults: EFH for adult sablefish is the general distribution habitat-related density area for this life stage, located in deep shelf gulleys along the continental slope (200 to 1,000 m400 to 800 m) throughout the GOA, as depicted in Figure E-9.

4.2.2.2.15 Shallow Water Flatfish Complex

This section describes EFH for the Shallow water flatfish complex. This description can be applied as a proxy for species with insufficient information. The Shallow water flatfish complex species include—
Alaska plaice,
Butter sole,
English sole,
Northern rock sole,
Pacific sanddab,
Petrale sole,
Sand sole,
Slender sole,
Southern rock sole,
Starry flounder, and
Yellowfin sole.

Eggs: No EFH description determined. Representative descriptions can be found with Alaska plaice, northern rock sole, southern rock sole, and yellowfin sole.

Larvae: No EFH description determined. Representative descriptions can be found with Alaska plaice, northern rock sole, southern rock sole, and yellowfin sole.

Settled Early Juveniles: No EFH description determined. Representative descriptions can be found with Alaska plaice, northern rock sole, southern rock sole, and yellowfin sole.

Subadults: No EFH description determined. Representative descriptions can be found with Alaska plaice, northern rock sole, southern rock sole, and yellowfin sole.

Adults: EFH of this stock complex extends from southeast Alaska in the eastern GOA through the western GOA. Core EFH areas are found on bathymetric rises and inshore areas of the GOA continental shelf (Pirtle et al. 2023).

4.2.2.2.15.1 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 GOA in the spring.

Larvae: EFH for larval Alaska plaice 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 GOA.

Settled Early Juveniles: EFH for settled early juvenile Alaska plaice 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 GOA wherever there are softer substrates consisting of sand and mud.

Subadults: ~~**Late Juveniles:**~~ EFH for subadult ~~late juvenile~~ Alaska plaice 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 GOA wherever there are softer substrates consisting of sand and mud. Subadult EFH is from the Kenai Peninsula to nearshore areas in Kachemak Bay and lower Cook Inlet, and along the Alaska Peninsula and west of Kodiak Island (Pirtle et al. 2023).

Adults: EFH for adult Alaska plaice 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 GOA wherever there are softer substrates consisting of sand and mud.

4.2.2.2.15.2 Butter Sole

Eggs: No EFH description determined. Representative descriptions can be found with Alaska plaice, northern rock sole, southern rock sole, and yellowfin sole.

Larvae: No EFH description determined. Representative descriptions can be found with Alaska plaice, northern rock sole, southern rock sole, and yellowfin sole.

Settled Early Juveniles: No EFH description determined. Representative descriptions can be found with Alaska plaice, northern rock sole, southern rock sole, and yellowfin sole.

Subadults: No EFH description determined. Representative descriptions can be found with Alaska plaice, northern rock sole, southern rock sole, and yellowfin sole.

Adults: Butter sole EFH is on the continental shelf of the GOA from southeast Alaska to the extent of the study area west, with EFH hotspots at shallower depths (less than 200 m) (Pirtle et al. 2023).

4.2.2.2.15.3 English Sole

Eggs: No EFH description determined. Representative descriptions can be found with Alaska plaice, northern rock sole, southern rock sole, and yellowfin sole.

Larvae: No EFH description determined. Representative descriptions can be found with Alaska plaice, northern rock sole, southern rock sole, and yellowfin sole.

Settled Early Juveniles: Settled early juvenile English sole are found in nearshore areas of the GOA at depths less than 100 m (Pirtle et al. 2023).

Subadults: Subadult English sole are found inshore of the continental shelf of the GOA (Pirtle et al. 2023).

Adults: Adult English sole distribution covers the GOA continental shelf from southeast Alaska to the western GOA at relatively shallow depths (Pirtle et al. 2023).

4.2.2.2.15.4 Northern Rock Sole

Eggs: EFH for northern rock sole eggs is the general distribution area for this life stage, located in demersal waters along the entire continental shelf (0 to 200 m depth) throughout the GOA.

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 GOA.

Settled Early Juveniles: EFH for settled early juvenile northern rock 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 continental shelf (0 to 50 m depth).

Subadults: ~~**Late Juveniles:**~~ EFH for subadult ~~late juvenile~~ northern rock 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 GOA wherever there are ~~softer~~ substrates consisting of sand, gravel, and cobble. Subadult EFH occurs at bathymetric rises throughout the GOA continental shelf, with core EFH area and EFH hot spots most concentrated west of the Kenai Peninsula (Pirtle et al. 2023).

Adults: EFH for adult rock 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 GOA wherever there are ~~softer~~ substrates consisting of sand, gravel, and cobble.

4.2.2.2.15.5 Pacific Sanddab

Eggs: No EFH description determined. Representative descriptions can be found with Alaska plaice, northern rock sole, southern rock sole, and yellowfin sole.

Larvae: No EFH description determined. Representative descriptions can be found with Alaska plaice, northern rock sole, southern rock sole, and yellowfin sole.

Settled Early Juveniles: No EFH description determined. Representative descriptions can be found with Alaska plaice, northern rock sole, southern rock sole, and yellowfin sole.

Subadults: No EFH description determined. Representative descriptions can be found with Alaska plaice, northern rock sole, southern rock sole, and yellowfin sole.

Adults: Pacific sanddab EFH is found in the shallower depths of the continental shelf in the eastern GOA off southeast Alaska (Pirtle et al. 2023).

4.2.2.2.15.6 Petrale Sole

Eggs: No EFH description determined. Representative descriptions can be found with Alaska plaice, northern rock sole, southern rock sole, and yellowfin sole.

Larvae: No EFH description determined. Representative descriptions can be found with Alaska plaice, northern rock sole, southern rock sole, and yellowfin sole.

Settled Early Juveniles: No EFH description determined. Representative descriptions can be found with Alaska plaice, northern rock sole, southern rock sole, and yellowfin sole.

Subadults: Subadult petrale sole EFH is in the eastern GOA with hot spots off of southeast Alaska. They have high abundances predicted at depths less than 100 m (Pirtle et al. 2023).

Adults: Adult petrale sole EFH extends from the eastern GOA continental shelf to the central GOA, and high abundances are predicted at depths less than 125 m (Pirtle et al. 2023).

4.2.2.2.15.7 Slender Sole

Eggs: No EFH description determined. Representative descriptions can be found with Alaska plaice, northern rock sole, southern rock sole, and yellowfin sole.

Larvae: No EFH description determined. Representative descriptions can be found with Alaska plaice, northern rock sole, southern rock sole, and yellowfin sole.

Settled Early Juveniles: No EFH description determined. Representative descriptions can be found with Alaska plaice, northern rock sole, southern rock sole, and yellowfin sole.

Subadults: No EFH description determined. Representative descriptions can be found with Alaska plaice, northern rock sole, southern rock sole, and yellowfin sole.

Adults: Slender sole EFH is primarily in the eastern GOA, though also extends through the central and western GOA. Abundance is high around 250 m depth on the outer continental shelf and glacial troughs of the eastern GOA (Pirtle et al. 2023).

4.2.2.2.15.8 Southern Rock Sole

Eggs: EFH for southern rock sole eggs is the general distribution area for this life stage, located in demersal habitat throughout the continental shelf (0 to 200 m depth).

Larvae: EFH for larval southern 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 GOA.

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 along the inner continental shelf (0 to 50 m depth).

Subadults: ~~**Late Juveniles:**~~ EFH for subadult ~~late juvenile~~ southern rock 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 GOA wherever there are ~~softer~~ substrates consisting of sand, gravel, and cobble. Subadult EFH areas occur on bathymetric rises on the continental shelf of the GOA, with hot spots west of the Kenai Peninsula south of Kodiak Island, the Shumagin Islands, along inshore areas of the Alaska Peninsula, and southeast Alaska (Pirtle et al. 2023).

Adults: EFH for adult southern rock 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 GOA wherever there are ~~softer~~ substrates consisting of sand, gravel, and cobble. Adults had similar EFH hotspots to those identified for subadults (Pirtle et al. 2023).

4.2.2.2.15.9 Starry Flounder

Eggs: No EFH description determined. Representative descriptions can be found with Alaska plaice, northern rock sole, southern rock sole, and yellowfin sole.

Larvae: No EFH description determined. Representative descriptions can be found with Alaska plaice, northern rock sole, southern rock sole, and yellowfin sole.

Settled Early Juveniles: Settled early juvenile starry flounder are found in nearshore areas of the GOA in locations less than 100 m depth (Pirtle et al. 2023).

Subadults: EFH for subadult starry flounder is nearshore areas at shallow depths of the GOA continental shelf (Pirtle et al. 2023).

Adults: Adult starry flounder EFH is shallow, nearshore areas of the GOA continental shelf (Pirtle et al. 2023).

4.2.2.2.15.10 Yellowfin Sole

Eggs: EFH for yellowfin 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 upper (200 to 500 m depth) slope throughout the GOA, as depicted in Figure E-10.

Larvae: EFH for larval yellowfin sole is the general distribution area for this life stage, located in pelagic waters along the continental shelf (0 to 200 m depth) and upper slope (200 to 500 m depth) throughout the GOA, as depicted in Figure E-11.

Settled Early Juveniles: EFH for settled early juvenile yellowfin 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 continental shelf (0 to 50 m depth).

Subadults: Late Juveniles: EFH for subadult late juvenile yellowfin sole is the general distribution habitat-related density 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 GOA wherever there are soft substrates consisting mainly of sand, as depicted in Figure E-12. Subadult EFH is concentrated west of the Kenai Peninsula and inshore in the eastern GOA (Pirtle et al. 2023).

Adults: EFH for adult yellowfin sole is the general distribution habitat-related density 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 GOA wherever there are soft substrates consisting mainly of sand, as depicted in Figure E-12.

4.2.2.2.16 Sharks

The species representatives for sharks are:
Lamnidae: Salmon shark (*Lamna ditropis*)
Squalidae: Sleeper shark (*Somniosus pacificus*)
Spiny dogfish (*Squalus suckleyi*)

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

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

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

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

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

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

Adults: EFH for spiny dogfish (representing a combination of subadults and adults) spans most of the GOA with the core extending from Kodiak Island to southeast Alaska (Pirtle et al. 2023). No EFH description determined. Insufficient information is available.

4.2.2.2.17 Shortraker Rockfish

Eggs: EFH for shortraker rockfish eggs is the general distribution 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).

Larvae: EFH for larval shortraker rockfish 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 GOA.

Settled Early Juveniles: EFH for 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).

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 GOA wherever there are substrates consisting of mud, sand, sandy mud, muddy sand, rock, cobble, and gravel. Subadult EFH is predicted around 375 m depth, occurring in the outer extent of glacial troughs on the continental shelf and areas along the continental slope of the GOA (Pirtle et al. 2023).

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 upper continental slope (200 to 500 m depth) regions throughout the GOA wherever there are substrates consisting of mud, sand, sandy mud, muddy sand, rock, cobble, and gravel. Adults are especially found on steep slopes with frequent boulders.

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, and
Longnose skate.

Eggs: EFH for skate egg cases is the general distribution area for this life stage, located on the seafloor below the continental shelf-slope interface, in depths from 140 to 360 m.

Larvae: Not applicable, skates emerge from egg fully formed. ~~No EFH description determined. Insufficient information is available.~~

Settled Early Juveniles: EFH for benthic 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) wherever there are of substrates of mud, sand, gravel, and rock.

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) wherever there are of substrates of mud, sand, gravel, and rock. Subadult EFH includes most of the GOA from southeast Alaska to Unimak Pass (Pirtle et al. 2023).

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), upper slope (200 to 500 m depth), and lower slope (500 to 1000 m depth) throughout the GOA wherever there are substrates of mud, sand, gravel, and rock.

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: No EFH description determined. Insufficient information is available.
Subadults: EFH for subadult Alaska skates is at depths around 250 m in the central GOA, particularly in Shelikof Strait and the western end of the Alaska Peninsula (Pirtle et al. 2023).
Adults: EFH for adult Alaska skates was similar to subadults and primarily in the Shelikof Strait, along the southwestern coast of Kodiak Island, and near Unimak Pass (Pirtle et al. 2023).

4.2.2.2.18.1 Aleutian 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 Aleutian skates is in depths around 300 m across the GOA continental shelf (Pirtle et al. 2023).
Adults: EFH for adult Aleutian skates is in depths around 250 m and concentrated in Shelikof Strait and the Chirikof region (Pirtle et al. 2023).

4.2.2.2.18.1 Bering 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 Bering skates is in the Chirikof and Kodiak regions of the GOA associated with glacial troughs and at depths around 300 m (Pirtle et al. 2023).
Adults: EFH for adult Bering skates is similar to subadults in the Chirikof and Kodiak regions with high abundances around 250 m depths (Pirtle et al. 2023).

4.2.2.2.18.1 Big 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 big skates is generally at shallower depths on the continental shelf and in coastal areas of the GOA (Pirtle et al. 2023).
Adults: EFH for adult big skates is similar to subadults and is at shallower depths on the continental shelf and in coastal areas of the GOA (Pirtle et al. 2023).

4.2.2.2.18.1 Longnose 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 longnose skates is from the Shumagin Islands to southeast Alaska at around 250 m depths (Pirtle et al. 2023).

Adults: EFH for adult longnose skates is also from the Shumagin Islands to southeast Alaska at depths around 250 m and can be associated with glacial troughs (Pirtle et al. 2023).

4.2.2.2.19 Thornyhead Complex: Shortspine Thornyhead Rockfish

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

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

Settled Early Juveniles: EFH for early juvenile thornyhead rockfish is the general distribution ~~habitat-related density~~ 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 GOA.

Subadult: ~~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 GOA wherever there are substrates of mud, sand, rock, sandy mud, muddy sand, cobble, and gravel. Subadult EFH occurs within glacial troughs on the continental shelf and along the outer shelf and continental slope of the GOA, with abundances peaking around 375 m depth (Pirtle et al. 2023).

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 GOA wherever there are substrates of mud, sand, rock, sandy mud, muddy sand, cobble, and gravel.

4.2.2.2.20 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 GOA~~, as depicted in Figure E-1.~~

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 GOA~~, as depicted in Figure E-2.~~

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 GOA. 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).

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 GOA. Substrate preferences, if they exist, are unknown. Subadult EFH is in shallow areas of the GOA from southeast Alaska to the western GOA (Pirtle et al. 2023).

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 (approximately 10 to 200 m depth) and slope (200 to 1,000 m depth) throughout the GOA. Substrate preferences, if they exist, are unknown.

5. In Section 4.2.2.3, replace the sentence on figures with the following:

Figures E-1 through E-192 in Appendix E show EFH distribution for the GOA groundfish species.

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. 2023). 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 should note that the Salmon FMP is being 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.

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

6.3 Literature Cited

Doyle, M.J., Picquelle, S.J., Mier, K.L., Spillane, M.C., and Bond, N.A. 2009. Larval fish abundance and physical forcing in the Gulf of Alaska, 1981-2003. Progress in Oceanography 80(3-4): 163-187.

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.

Gibson, G. A., W. T. Stockhausen, S. K. Shotwell, A. L. Deary, J. L. Pirtle, K. O. Coyle, and A. J. Hermann. 2023. Can seamounts in the Gulf of Alaska be a spawning ground for sablefish settling in coastal nursery grounds? Fisheries Research. 261: 106625. https://doi.org/10.1016/j.fishres.2023.106625

Harrington, G.A., J.L. Pirtle, M. Zaleski, C. Felkley, S. Rheinsmith, and J. Thorson. 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

Hinckley, S., W. Stockhausen, K. Coyle, B. Laurel, G. Gibson, C. Parada, A. Hermann, M. Doyle, and T. Hurst. 2019. Connectivity between spawning and nursery areas for Pacific cod (Gadus macrocephalus) in the Gulf of Alaska. Deep Sea Res. Pt. II. 165: 113–126. https://doi.org/10.1016/j.dsr2.2019.05.007

Laurel, B. J., and Rogers, L. A. 2020. Loss of spawning habitat and prerecruits of Pacific cod during a Gulf of Alaska heatwave. Canadian Journal of Fisheries and Aquatic Sciences 77(4): 644-650.

Laurel B.J., Hurst T.P., Copeman L.A., and Davis M.W. 2008. The role of temperature on the growth and survival of early and late hatching Pacific cod larvae (*Gadus macrocephalus*). Journal of Plankton Research 30(9): 1051–1060.

Pirtle, J. L., E. A. Laman, J. Harris, M. C. Siple, C. N. Rooper, T. P. Hurst, C. L. Conrath, and G. A. Gibson. 2023. Advancing model-based essential fish habitat descriptions for North Pacific species in the Gulf of Alaska. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-468, 541 p. https://doi.org/10.25923/ygdf-5f65

Shotwell, S. K., G. A.Gibson, W. T. Stockhausen, J. L. Pirtle, C. N. Rooper, A. L. Deary, K. O. Coyle, and A. J. Hermann, A.J. In preparation. Developing a novel approach to estimate habitat-related survival rates for early life history stages using individual-based models.

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

Amendment XXX, implemented on _____ *(insert effective date)*_____, revised Amendment 105:

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.

Appendix D 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 groundfish of the GOA.

GOA Groundfish Species	LIFE STAGE	Nearshore				Shelf			Slope						Stratum Reference							Location							Physical Oceanography					Substrate													Structure										Community Associations													Oceanographic Properties			LIFE STAGE
						Inner	Middle	Outer	Upper		Intermediate		Lower	Basin													Pelagic																																															
		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	Seamount	Reefs	Vertical Walls	Man-made	Algal Cover	Anemones	Enchinoderms	Soft Coral	Hard Coral	Mollusca	Drift Algae/Kelp	Kelp	Polychaetes	Sea Grasses	Sponges	Sea Onions	Tunicates	Temperature (Celsius)	Salinity (ppt)	Oxygen Conc (ppm)	
Arrowtooth Flounder	A					x	x	x	x	x	x														x											x	x	x			x																																		A
	S					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																																												L
	E					x	x	x	x	x																x																																																				E
Atka Mackerel	A					x	x	x	x								x								x	x	x				x			x	x			x	x								x	x								x									x			x						3-5	>17		A
	S																						x	x																																																			3-12			S
	L																						x	x																																																			2-12			L
	E					x	x	x									x										x													x								x	x																			x						3-10			E
Deepwater Flatfish Complex (Dover Sole)	A					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	x																	x											x	x			x																																					SEJ
	L					x	x	x	x	x																	x						x																																												L
	E					x	x	x	x	x																	x																																																			E
Dusky Rockfish	A							x	x									x		x	x				x												x								x	x																												A
	S						x	x										x		x					x																																					x													S
	SEJ																																																																								SEJ
	L																																																																								L
Flathead Sole	A					x	x	x	x																x											x	x	x			x		x																																	A
	S					x	x	x																	x											x	x	x			x		x																																	S
	SEJ					x	x																	x											x	x																																									SEJ
	L					x	x	x																		x						x										x																																		L
	E					x	x	x																		x																																																			E
Northern Rockfish	A						x	x									x							x																				x	x																												A
	S						x	x									x	x						x																																																				S
	SEJ																										x																																																SEJ
	L																																																																								L
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 Rockfish Complex	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	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							SEJ
	L					x	x																	x	x	x				x																x					x	x		x	x																			L
	E																																																																								E

Table D.1 (cont) Summary of habitat associations for groundfish of the GOA.

GOA Groundfish Species	LIFE STAGE	Nearshore				Shelf			Slope						Stratum Reference						
		Freshwater	Estuarine	Intertidal	Subtidal	Inner 1-50m	Middle 51-100m	Outer 101-200m	Upper 201-300m	Upper 301-500m	Intermediate 501-700m	Intermediate 701-1000m	Lower 1001-3000m	Basin >3000m	Shallows	Island Pass	Bay/Fjord	Bank	Flat	Edge	Gully
Other Rockfish Complex, Demersal Subgroup	A					x	x	x	x	x						x	x				
	S					x	x	x								x	x				
	SEJ					x	x	x								x	x				
	L					x	x														
	E																				
Other Rockfish Complex, Slope Subgroup	A					x	x	x	x	x	x					x	x				
	S					x	x	x								x	x				
	SEJ					x	x	x								x	x				
	L					x	x														
	E																				
Pacific Cod	A					x	x	x	x	x					x	x	x	x	x	x	
	S					x	x								x	x	x	x	x	x	
	SEJ				x	x									x		x				
	L					x	x	x													
	E					x	x	x													
Pacific Ocean Perch	A							x	x	x								x	x	x	x
	S					x	x	x	x												
	SEJ					x	x	x													
	L																				
Rex Sole	A					x	x	x	x	x											
	S					x	x	x	x												
	SEJ					x	x														
	L					x	x	x	x												
	E					x	x	x	x												
Rougheye/ Blackspotted Rockfish	A								x	x								x	x	x	x
	S							x	x								x		x		
	SEJ												x	x							
	L																				
Sablefish	A								x	x	x	x	x				x				x
	S							x	x	x	x						x				x
	SEJ					x	x	x							x		x				
	L						x	x	x	x	x	x	x	x							
	E								x	x	x	x	x	x							
Shallow Water Flatfish Complex	A					x	x	x													
	S					x	x	x													
	SEJ					x	x														
	L					x	x	x													
	E					x	x	x													

GOA Groundfish Species	LIFE STAGE	Location				Pelagic			Physical Oceanography					Substrate												
		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
Other Rockfish Complex, Demersal Subgroup	A				x				x							x									x	x
	S				x				x																	x
	SEJ				x				x																	x
	L			x	x	x			x																	x
	E																									
Other Rockfish Complex, Slope Subgroup	A				x				x							x									x	x
	S				x				x																	x
	SEJ				x				x																	x
	L			x	x	x			x																	x
	E																									
Pacific Cod	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	x	x	x	x	x	x		
	L					x																				
	E				x										x	x	x	x	x	x	x	x	x	x	x	x
Pacific Ocean Perch	A			x	x	x			x					x	x	x	x	x	x	x	x	x	x	x	x	x
	S								x																x	x
	SEJ			x	x	x	x	x	x								x								x	x
	L		x	x		x	x		x																	
Rex Sole	A				x										x	x				x						
	S				x										x	x				x						
	SEJ				x										x	x				x						
	L					x									x	x										
	E					x																				
Rougheye/ Blackspotted Rockfish	A				x										x	x	x	x	x	x	x	x	x	x	x	x
	S																								x	x
	SEJ		x	x		x																				
	L		x			x																				
Sablefish	A				x				x						x	x	x								x	x
	S				x				x						x	x	x								x	x
	SEJ		x	x	x	x	x		x																	
	L	x	x						x																	
	E					x	x		x																	
Shallow Water Flatfish Complex	A				x										x	x				x						
	S				x										x	x				x						
	SEJ				x										x	x				x						
	L					x					x															
	E				x	x																				

GOA Groundfish Species	LIFE STAGE	Structure										Community Associations													Oceanographic Properties			LIFE STAGE
		Bars	Sinks	Slumps/Rockfalls/Debris	Channels	Ledges	Pinnacles	Seamount	Reefs	Vertical Walls	Man-made	Algal Cover	Anemones	Enchinoderms	Soft Coral	Hard Coral	Mollusca	Drift Algae/Kelp	Kelp	Polychaetes	Sea Grasses	Sponges	Sea Onions	Tunicates	Temperature (Celsius)	Salinity (ppt)	Oxygen Conc (ppm)	
Other Rockfish Complex, Demersal Subgroup	A					x	x			x			x		x													A
	S					x	x			x			x		x													S
	SEJ					x	x			x			x		x													SEJ
	L					x	x			x																		L
	E																											E
Other Rockfish Complex, Slope Subgroup	A					x	x		x	x			x		x							x						A
	S					x	x		x	x			x		x							x						S
	SEJ					x	x		x	x			x		x							x						SEJ
	L					x	x		x	x																		L
	E																											E
Pacific Cod	A				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									SEJ
	L																											L
	E																								3-6	13-23	2-3	E
Pacific Ocean Perch	A														x													A
	S																											S
	SEJ																											SEJ
	L																											L
Rex Sole	A																											A
	S																											S
	SEJ																											SEJ
	L																											L
	E																											E
Rougheye/ Blackspotted Rockfish	A							x								x												A
	S																											S
	SEJ																											SEJ
	L																											L
Sablefish	A							x																				A
	S																											S
	SEJ																											SEJ
	L																											L
	E																											E
Shallow Water Flatfish Complex	A																											A
	S																											S
	SEJ																											SEJ
	L																											L
	E																											E

Table D.1 (cont) Summary of habitat associations for groundfish of the GOA.

GOA Groundfish Species	LIFE STAGE	Nearshore				Shelf			Slope						Stratum Reference							Location							Physical Oceanography					Substrate													Structure										Community Associations													Oceanographic Properties			LIFE STAGE
						Inner	Middle	Outer	Upper		Intermediate		Lower	Basin												Pelagic																																																
		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	Suratce	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	Seamount	Reefs	Vertical Walls	Man-made	Algal Cover	Anemones	Enchinoderms	Soft Coral	Hard Coral	Mollusca	Drift Algae/Kelp	Kelp	Polychaetes	Sea Grasses	Sponges	Sea Onions	Tunicates	Temperature (Celsius)	Salinity (ppt)	Oxygen Conc (ppm)	
Shark Complex (Spiny Dogfish)	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																																														A
	S																																																																									S
	SEJ																																																																									SEJ
	E																																																																								E
Shortraker Rockfish	A								x	x										x					x								x		x	x	x	x	x	x	x	x	x	x	x	x							x								x												A
	S																								x																																																S
	SEJ												x	x									x																																																			SEJ
	L																									x																																															L
Skate Complex	A			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
Thornyhead Rockfish Complex (Shortspine Thornyhead)	A								x	x	x	x	x												x										x		x								x	x							x																					A
	S						x	x	x																x										x		x									x																												S
	SEJ																									x																																															SEJ
	L																									x																																															L
	E																									x																																															E
Walleye Pollock	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																										2-10			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	x	x	x																										2-10			S
	L						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																													L
	E						x	x	x	x	x	x	x	x		x	x	x	x	x	x		x	x		x			x	x	x	x																																											E

Table D.2 Summary of reproductive traits for GOA groundfish.

GOA Groundfish Species	Life Stage	Reproductive Traits																															
		Age at Maturity (unless otherwise noted)				Fertilization/ Egg Development						Spawning Behavior						Spawning Season											
		Female		Male																									
		50%	100%	50%	100%	External	Internal	Oviparous	Ovoviviparous	Aplacental viviparous	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
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		
Deepwater Flatfish: Dover Sole	A	6.7	11			x						x							x	x	x	x							
Dusky Rockfish	A	11					x				x	x																	
Flathead Sole	A	8.7				x						x								x	x	x	x						
Northern Rockfish	A	13					x				x	x								x	x	x							
Octopus	A						x					x			x	x													
Other Rockfish	A						x		x	x							x												
Other Rockfish, Demersal Subgroup	A	22		18			x		x												x	x	x	x					
Other Rockfish, Slope Subgroup	A						x		x	x							x												
Pacific Cod	A	5		5		x							x					x	x	x	x	x							
Pacific Ocean Perch	A	10.5	20.0				x				x	x														x	x	x	x
Rex Sole	A	352 mm		352 mm		x													x	x	x	x	x	x					
Rougheye/ Blackspotted Rockfish	A	19+					x				x	x						x	x	x	x								x
Sablefish	A	585 mm		585 mm		x							x					x	x	x									
Shallow Water Flatfish	A	6-10.5				x						x						x	x	x	x	x	x	x					x
Sharks: Spiny Dogfish	A	35		21			x	x	x	x	x						x	x	x	x						x	x	x	x
Shortraker Rockfish	A	20+					x				x	x							x	x	x	x	x	x	x				
Skates	A						x	x						x															
Thornyhead Rockfish	A	215 mm		215 mm					x			x									x	x	x	x					
Walleye Pollock	A	4-5		4-5		x							x						x	x	x	x							

Table D.3 Summary of predator and prey associations for GOA groundfish.

Predator to

GOA 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	Sand lance	Osmerid (eulachon)	Herring	Myctophid (lantern fishe	Cottidae (sculpins)	Arrowtooth	Rockfish	Salmon	Pacific cod	Pollock	Halibut
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																														
Deepwater Flatfish Complex (Dover Sole)	A												x						x												
	S												x						x												
	SEJ																														
	L	x		x																											
	E																														
Dusky Rockfish	A							x		x	x							x		x	x										
	S							x		x	x							x		x	x										
	SEJ																														
	L																														
Flathead Sole	A							x					x			x		x	x	x											
	S							x					x					x	x	x											
	SEJ				x			x					x					x	x	x											
	L	x		x																											
	E																														
Northern Rockfish	A				x			x			x																				
	S																														
	SEJ																														
	L																														
	E																														
Octopus	A															x	x	x	x	x	x				x		x		x		x
	S																														
	SEJ																														
	L																														
	E																														
Other Rockfish Complex	A																	x		x	x	x	x	x			x				
	S																														
	SEJ										x																				
	L																														
	E																														

Prey of

GOA 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	Northern Fur Seal	Harbor Seal	Steller sea lion	Dalls Porpoise	Beluga whale	Killer Whale	Minke whale	Sperm whale	Eagles	Murres	Puffin	Kittiwake	Gull	Terrestrial Mammals
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																														
Deepwater Flatfish Complex (Dover Sole)	A							x								x															
	S							x								x															
	SEJ																														
	L																														
	E																														
Dusky Rockfish	A								x	x	x				x	x															
	S								x	x	x				x	x															
	SEJ																														
	L																														
Flathead Sole	A							x	x						x	x				x											
	S							x							x																
	SEJ							x	x						x																
	L																														
	E																														
Northern Rockfish	A																														
	S																														
	SEJ																														
	L																														
	E																														
Octopus	A							x	x	x	x					x	x	x	x	x		x									
	S																														
	SEJ																														
	L																														
	E																														
Other Rockfish Complex	A						x			x	x					x	x														
	S						x			x	x					x	x														
	SEJ																														
	L																														
	E																														

Table D.3 (cont) Summary of predator and prey associations for GOA groundfish.

Predator to

GOA 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	Sand lance	Osmerid (eulachon)	Herring	Myctophid (lantern fishe	Cottidae (sculpins)	Arrowtooth	Rockfish	Salmon	Pacific cod	Pollock	Halibut
Other Rockfish Complex, Demersal Subgroup	A																	x		x	x		x				x				
	S																														
	SEJ										x																				
	L																														
	E																														
Other Rockfish Complex, Slope Subgroup	A																	x		x	x	x	x	x			x				
	S																														
	SEJ										x																				
	L																														
	E																														
Pacific Cod	A							x		x			x							x										x	
	S							x		x			x							x										x	
	SEJ							x		x			x							x											
	L			x	x						x																				
	E																														
Pacifc Ocean Perch	A							x		x	x									x											
	S							x		x	x									x											
	SEJ																														
	L			x	x																										
Rex Sole	A							x		x			x					x													
	S							x		x			x					x													
	SEJ																														
	L	x		x																											
	E																														
Rougheye/ Blackspotted Rockfish	A							x			x			x				x		x				x							
	S									x										x											
	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																														
Shallow Water Flatfish Complex	A							x		x			x			x	x	x		x					x					x	
	S							x		x			x			x	x	x		x					x						
	SEJ				x																										
	L	x		x																											
	E																														

Prey of

GOA 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	Northern Fur Seal	Harbor Seal	Steller sea lion	Dalls Porpoise	Beluga whale	Killer Whale	Minke whale	Sperm whale	Eagles	Murres	Puffin	Kittiwake	Gull	Terrestrial Mammals
Other Rockfish Complex, Demersal Subgroup	A						x			x	x					x															
	S						x			x	x					x															
	SEJ																														
	L																														
	E																														
Other Rockfish Complex, Slope Subgroup	A						x			x	x					x	x														
	S						x			x	x					x	x														
	SEJ																														
	L																														
	E																														
Pacific Cod	A															x	x	x		x		x	x	x							
	S															x	x	x		x		x	x	x							
	SEJ															x	x	x				x	x	x				x			
	L																														
	E																														
Pacifc Ocean Perch	A									x						x															
	S									x						x															
	SEJ						x			x	x					x															
	L																														
Rex Sole	A														x																
	S														x																
	SEJ																														
	L																														
	E																														
Rougheye/ Blackspotted Rockfish	A								x							x															
	S								x						x	x															
	SEJ																														
	L																														
Sablefish	A																														
	S						x									x									x						
	SEJ																														
	L																														
	E																														
Shallow Water Flatfish Complex	A																														
	S							x	x					x		x															
	SEJ								x							x															
	L																														
	E																														

Table D.3 (cont) Summary of predator and prey associations for GOA groundfish.

Predator to

GOA 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	Sand lance	Osmerid (eulachon)	Herring	Myctophid (lantern fishe	Cottidae (sculpins)	Arrowtooth	Rockfish	Salmon	Pacific cod	Pollock	Halibut
Shark Complex (Spiny Dogfish)	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
	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
	SEJ						x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x						
	E																														
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	x	x	x	x	x	x	x
	S																														
	SEJ																														
	E																														
Thornyhead Rockfish Complex (Shortspine Thornyhead)	A				x					x								x		x											
	S				x					x								x		x											
	SEJ																														
	L																														
	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																														

Prey of

GOA 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	Northern Fur Seal	Harbor Seal	Steller sea lion	Dalls Porpoise	Beluga whale	Killer Whale	Minke whale	Sperm whale	Eagles	Murres	Puffin	Kittiwake	Gull	Terrestrial Mammals
Shark Complex (Spiny Dogfish)	A																x	x		x			x		x						
	S																x	x		x			x		x						
	SEJ									x					x	x	x	x		x			x		x						
	E																														
Shortraker Rockfish	A																														
	S																														
	SEJ																														
	L																														
Skate Complex	A																		x												
	S																														
	SEJ																														
	E																														
Thornyhead Rockfish Complex (Shortspine Thornyhead)	A														x																
	S														x																
	SEJ																														
	L																														
	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																														

D.1 Arrowtooth flounder (*Atheresthes stomias*)

D.1.1 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 inner 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). Little is known of the fecundity of arrowtooth flounder. Larvae have been found from ichthyoplankton sampling over a widespread area of the eastern Bering Sea shelf in April and May and also on the continental shelf east of Kodiak Island during winter and spring (Waldron and Vinter 1978, Kendall and Dunn 1985). Nearshore sampling in the Kodiak Island area indicates that newly settled larvae are in the 40 to 60 mm size range (Norcross et al. 1996). 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 approximate upper size limit of juvenile fish is 270 mm in males and 460 mm in females. The estimated length at maturity is 460 mm, though length at age varies (Stark 2012, Spies et al. 2019). The natural mortality rate used in stock assessments differs by sex with females estimated at 0.2 and male natural mortality estimated at 0.35 (Turnock et al. 2009, Wilderbuer et al. 2009).

D.1.2 Relevant Trophic Information

Arrowtooth flounder are very important as a large, aggressive and abundant predator of other groundfish species. They feed maily on walleye pollock and other fish species when they reach lengths greater than 300 mm. Groundfish predators include Pacific cod and pollock, mostly on small fish.

D.1.3 Habitat and Biological Associations

Larvae: Larvae are planktonic for at least 2 to 3 months until metamorphosis occurs.

Settled Early Juveniles: Juveniles usually inhabit shallow areas and coastal bays up to two years old once settled. The covariates contributing the most to the final SDM EFH map for this life stage were tidal maximum current, terrain aspect, bottom depth, and bathymetric position index (BPI) (Pirtle et al. 2023). Suitable habitat is broadly distributed across the continental shelf in the Yakutat and southeastern Alaska management areas in 150 m depths with tidal current speeds around 25 cm/s over relatively flat seafloor terrain.

Subadults: The covariates contributing the most to the final SDM EFH map for the subadult life stage were bottom depth, geographic location, and bottom temperature (Pirtle et al. 2023). Their highest abundances were predicted in the Shelikof Strait and over the continental shelf to the west at depths around 200 m and in cooler bottom temperatures.

Adults: The covariates contributing the most to the final SDM EFH map for the adult life stage were bottom depth, geographic location, bottom temperature, slope, and rockiness (Pirtle et al. 2023). Adult ATF distribution and abundance were related to depths around 200 m with cooler bottom temperatures in sloping and non-rocky terrain. They migrate in the winter to deeper waters of the shelf margin and upper continental slope to avoid extreme cold water temperatures and for spawning.

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, OCS	P			
Larvae	2 to 3 months?	U phyto/ zooplankton?	spring, summer?	BAY, ICS, OCS	P			
Juveniles	up to 7 years	euphausiids, crustaceans, amphipods, pollock	all year	ICS, OCS, USP	D	G,M,S		
Adults	7+ years[a]	pollock, Gadidae sp., misc. fish, euphausiids	spawning Jan-April, non-spawning April–Oct	ICS, OCS, USP, BAY	D	G,M,S		

[a] Age at 50% maturity based on a logistic curve from the stock assessment model (Shotwell et al. 2021).

D.1.4 Literature

Auster, P.J., Malatesta, R.J., Langton, R.W., L. Watling, P.C. Valentine, C.S. Donaldson, E.W. Langton, A.N. Shepard, and I G. Babb. 1996. The impacts of mobile fishing gear on seafloor habitats in the Gulf of Maine (Northwest Atlantic): Implications for conservation of fish populations. Rev. in Fish. Sci. 4(2): 185-202.

Hart, J.L. 1973. Pacific fishes of Canada. Fish. Res. Board Can. Bull. 180, 740 p.

Hosie, M.J. 1976. The arrowtooth flounder. Oregon Dep. Fish. Wildl. Info. Rep. 76-3, 4 p.

Kendall, A.W., Jr., and J.R. Dunn. 1985. Ichthyoplankton of the continental shelf near Kodiak Island, Alaska. NOAA Tech. Rep. NMFS 20, U.S. Dep. Commer, NOAA, Natl. Mar. Fish. Serv.

Livingston, P.A., and Y. DeReynier. 1996. Groundfish food habits and predation on commercially important prey species in the EBS from 1990 to 1992. AFSC processed Rep. 96-04, 51 p. Alaska Fish. Sci. Cent., Natl. Mar. Fish. Serv., NOAA, 7600 Sand Point Way NE., Seattle, WA 98115.

Martin, M.H., and D.M. Clausen. 1995. Data report: 1993 GOA Bottom Trawl Survey. U.S. Dept. Commer., NOAA, Natl. Mar. Fish. Serv., NOAA Tech. Mem. NMFS-AFSC-59, 217 p.

Norcross, B.L., B.A. Holladay, S.C. Dressel, and M. Frandsen. 1996. Recruitment of juvenile flatfishes in Alaska: habitat preference near Kodiak Island. U. Alaska Coastal Marine Institute, OCS Study MMS 96-0003, Vol. 1.

Pirtle, J. L., Laman, E. A., Harris, J., Siple, M. C., Rooper, C. N., Hurst, T. P., Conrath, C. L., and Gibson, G. A. 2023. Advancing model-based essential fish habitat descriptions for North Pacific species in the Gulf of Alaska. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-468, 541 p. https://doi.org/10.25923/ygdf-5f65

Rickey, M.H. 1994. Maturity, spawning, and seasonal movement of arrowtooth flounder, *Atheresthes stomias*, off Washington. Fish. Bull. 93:127-138 (1995).

Shotwell, S.K., I. Spies, J.N., Ianelli, K. Aydin, D.H. Hanselman, W. Palsson, K. Siwicke, J. Sullivan, and E. Yasumiishi. 2021. Assessment of the arrowtooth flounder stock in the Gulf of Alaska. North Pacific Fishery Management Council, P. O. Box 103136, Anchorage, AK 99510.

Spies, I., K. Aydin, J. N. Ianelli, and W. Palsson. 2019. Assessment of the arrowtooth flounder stock in the Gulf of Alaska. In Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Gulf of Alaska. North Pacific Fishery Management Council, 1007 West Third, Suite 400 Anchorage, AK 99501.

Stark, J. W. 2012. Female maturity, reproductive potential, relative distribution, and growth compared between arrowtooth flounder (Atheresthes stomias) and Kamchatka flounder (A. evermanni) indicating concerns for management. J. Appl. Ichthyol. 28: 226–230.

Turnock, B.J., T.K. Wilderbuer, and E.S. Brown. 2009. Arrowtooth flounder. *In* Appendix B Stock Assessment and Fishery Evaluation Report for the groundfish resources of the GOA. Council, 605 W. 4th Ave., Suite 306, Anchorage, AK 99501.

Waldron, K.D., and B.M. Vinter. 1978. Ichthyoplankton of the EBS. U.S. Dep. Commer., Natl. Oceanic Atmos. Admin., Natl. Mar. Fish. Serv. Seattle, WA, Processed rep., 88 p.

Wilderbuer, T.K., D.G. Nichol, and K. Aydin. 2009. Arrowtooth flounder. *In* Stock Assessment and Fishery Evaluation Report for the groundfish resources of the BSAI. Council, 605 W. 4th Ave., Suite 306, Anchorage, AK 99501.

Zimmerman, M. 1997. Maturity and fecundity of arrowtooth flounder, *Atheresthes stomias*, from the GOA. Fish. Bull. 95:598-611 (1997).

D.2 Atka mackerel (*Pleurogrammus monopterygius*)

D.2.1 Life History and General Distribution

Atka mackerel are distributed from the GOA to the Kamchatka Peninsula, and 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. Spawning is demersal in moderately shallow waters of the western GOA (down to bottom depths of 144 m) and peaks in June through September, but may occur intermittently throughout the year. Female Atka mackerel deposit eggs in nests built and guarded by males on rocky substrates or on kelp in shallow water. Eggs develop and hatch at depth in 40 to 45 days, releasing planktonic larvae that have been found up to 800 km from shore. Little is known of the distribution of young Atka mackerel before their appearance in trawl surveys and the fishery at about age 2 to 3 years. R-traits are as follows: 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 14 years, respectively). K-selected traits indicate low fecundity (only about 30,000 eggs/female/year, large egg diameters [1 to 2 mm] and male nest-guarding behavior). The average length at 50% maturity for Atka mackerel is 344 mm, though that was observed in the Aleutian Islands (McDermott and Lowe 1997).

D.2.2 Relevant Trophic Information

Atka mackerel are important food for Steller sea lions in the Aleutian Islands, particularly during summer, and for other marine mammals (minke whales, Dall's porpoise, and northern fur seals). Juveniles are eaten by thick billed murres, tufted puffins, and short-tailed shearwaters. The main groundfish predators are Pacific halibut, arrowtooth flounder, and Pacific cod. 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.2.3 Habitat and Biological Associations

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

Larvae: Planktonic larvae have been found up to 800 km from shore, usually in the upper water column (neuston).

Settled Early Juveniles: Little is known of the distribution of Atka mackerel until they are about 2 years old and start to appear in the fishery and surveys.

Subadults: The covariates contributing the most to the final SDM EFH map for this life stage were bottom depth, geographic location, and sponge presence (Pirtle et al. 2023). In general, higher subadult abundance was at shallower depths with low presence of sponges.

Adults: Adults occur in localized aggregations usually at depths less than 250 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 Atka mackerel, albeit in the Aleutian Islands region. 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. The covariates contributing the most to the final SDM EFH map for this life stage were geographic location and bottom depth (Pirtle et al. 2023).

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 to 45 days	NA	summer	IP, ICS	D	GR, R, K	U	develop 3–20 °C; optimum 9–13 °C
Larvae	up to 6 mos	U copepods?	fall–winter	U	U N?	U	U	2–12 °C; optimum 5–7 °C
Settled Early Juveniles /Subadults	½ to 2 years of age	U copepods & euphausiids?	all year	U	U	U	U	3–5 °C
Adults	3+ years of age	Copepods, euphausiids, meso-pelagic fish (myctophids)	spawning (May–Oct) non-spawning (Nov–Apr) tidal/diurnal, year-round?	ICS and MCS, IP MCS and OCS, IP ICS,MCS, OCS, I	P, D (males) semidemersal (females) semidemersal / D (all sexes): D when currents high/day, semidemersal slack tides/night	GR, R, K	F,E	3–5 °C all stages >17 ppt only

D.2.4 Literature

Bailey, K.M., J.F. Piatt, T.C. Royer, S.A. Macklin, R.K. Reed, M. Shima, R.C. Francis, A.B. Hollowed, D.A. Somerton, R.D. Brodeur, W.J. Ingraham, P.J. Anderson, and W.S. Wooster. 1995. ENSO events in the northern Gulf of Alaska, and effects on selected marine fisheries. Calif. Coop. Oceanic Fish. Invest. Rep. 36:78-96.

Boldt, J.L. (Ed). 2005. Ecosystem indicators for the North Pacific and their implications for stock assessment: Proceedings of first annual meeting of NOAA's Ecological Indicators research program. AFSC Processed Rep.2005-04, Alaska Fish. Sci. Cent., Natl. Mar. Fish. Serv., NOAA, 7600 Sand Point Way N.E., Seattle, WA 98115.

Canino, M.F., I.B. Spies, S.A. Lowe, and W.S. Grant. 2010. Highly discordant nuclear and mitochondrial DNA diversities in Atka mackerel. Marine and Coastal Fisheries: Dynamics, Management, and Ecosystem Science. 2:375-387.

Cooper, D. W., S.F. McDermott, and J.N. Ianelli. 2010. Spatial and temporal variability in Atka mackerel female maturity at length and age. Marine and Coastal Fisheries, 2:329-338.

Coyle, K. O., and A. I. Pinchuk. 2006. Gulf of Alaska zooplankton. In J.L. Boldt (Ed.) Ecosystem Considerations for 2007. Appendix C of the BSAI\GOA Stock Assessment and Fishery Evaluation Reports. North Pacific Fishery Management Council, 605 W. 4th Ave., Suite 306, Anchorage, AK 99501.

Dragoo, D.E., G.V. Byrd, and D.B. Irons. 2006. Breeding status, population trends and diets of seabirds in Alaska, 2003. U.S. Fish and Wildl. Serv. Report AMNWR 06/13. Homer, Alaska.

Francis, R.C., and S.R. Hare. 1994. Decadal scale regime shifts in the large marine ecosystems of the northeast Pacific: A case for historical science. Fish. Oceanogr. 3(1):279-291.

Fritz, L.W. 1993. Trawl locations of walleye pollock and Atka mackerel fisheries in the BS, AI, and GOA from 1977-1992. AFSC Processed Report 93-08, NMFS, 7600 Sand Point Way, NE, Seattle, WA 98115. 162 pp.

Fritz, L.W., and S.A. Lowe. 1998. Seasonal distributions of Atka mackerel (*Pleurogrammus monopterygius*) in commercially-fished areas of the Aleutian Islands and Gulf of Alaska. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-92, 29 p.

Gorbunova, N.N. 1962. Razmnozhenie I razvite ryb semeistva terpugovykh (Hexagrammidae) (Spawning and development of greenlings (family Hexagrammidae). Tr. Inst. Okeanol., Akad. Nauk SSSR 59:118-182. In Russian. (Trans. by Isr. Program Sci. Trans., 1970, p. 121-185 in T.S. Rass (editor), Greenlings: taxonomy, biology, interoceanic transplantation; available from the U.S. Dep. Commer., Natl. Tech. Inf. Serv., Springfield, VA., as TT 69-55097).

Guthridge, J.L., and N. Hillgruber. 2008. Embryonic development of Atka mackerel (Pleurogrammus monopterygius) and the effect of temperature. Pages 43-65 in S. F. McDermott, M. Canino, N. Hillgruber, D. W. Cooper, I. Spies, J. Guthridge, J. N. Ianelli, P. Woods. 2008. Atka mackerel Pleurogrammus monopterygius reproductive ecology in Alaska. North Pacific Research Board Final report, 163p.

Hare, S.R., and N.J. Mantua. 2000. Empirical evidence for North Pacific regime shifts in 1977 and 1989. Prog. Oceanogr. 47:103-145.

Hollowed, A.B., S.R. Hare, and W.S. Wooster. 2001. Pacific Basin climate variability and patterns of Northeast Pacific marine fish production. Prog. Oceanogr. 49:257-282.

Kajimura, H. 1984. Opportunistic feeding of the northern fur seal *Callorhinus ursinus*, in the eastern north Pacific Ocean and eastern Bering Sea. NOAA Tech. Rept. NMFS SSRF-779. USDOC, NOAA, NMFS, 49 pp.

Lauth, R. R., J. Guthridge, D. Nichol, S. W. Mcentire, and N. Hillgruber. 2007a. Timing and duration of mating and brooding periods of Atka mackerel (Pleurogrammus monopterygius) in the North Pacific Ocean. Fish. Bull., U.S. 105:560-570.

Lauth, R. R., S. W. Mcentire, and H. H. Zenger, Jr. 2007b. Geographic distribution, depth range, and description of Atka mackerel Pleurogrammus monopterygius nesting habitat in Alaska. Alaska Fish. Res. Bull. 12:165-186.

Lee, J.U. 1985. Studies on the fishery biology of the Atka mackerel *Pleurogrammus monopterygius* (Pallas) in the north Pacific Ocean. Bull. Fish. Res. Dev. Agency, 34, pp.65-125.

Levada, T.P. 1979. Comparative morphological study of Atka mackerel. Pac. Sci. Res. Inst. Fish. Oceanogr. (TINRO), Vladivostok, U.S.S.R., Unpublished manuscript.

Lowe, S.A., and L.W. Fritz. 1996. Atka mackerel. *In* Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the BSAI Regions as Projected for 1997. Council, 605 West 4th Avenue, Suite 306, Anchorage, AK 99501.

Malecha, P.W., R.P. Stone, and J. Heifetz. 2005. Living substrate in Alaska: Distribution, abundance, and species associations. Pages 289-299 *in* P.W. Barnes and J.P. Thomas, editors. Benthic habitats and the effects of fishing. American Fisheries Society, Symposium 41, Bethesda, Maryland.

Martin, M. 2005. Gulf of Alaska Survey Bottom Temperature Analysis. In J.L. Boldt (Ed.) Ecosystem Considerations for 2006. Appendix C of the BSAI\GOA Stock Assessment and Fishery Evaluation Reports. North Pacific Fishery Management Council, 605 W. 4th Ave., Suite 306, Anchorage, AK 99501.

McDermott, S.F., and S.A. Lowe. 1997. The reproductive cycle and sexual maturity of Atka mackerel (*Pleurogrammus monopterygius*) in Alaskan waters. Fishery Bulletin 95: 321-333.

McDermott, S.F., K.E. Pearson and D.R. Gunderson. 2007. Annual fecundity, batch fecundity, and oocyte atresia of Atka mackerel (Pleurogrammus monopterygius) in Alaskan waters. Fish Bull. 105:19-29.

Merrick, R.L., M.K. Chumbley, and G.V. Byrd. 1997. Diet diversity of Steller sea lions (*Eumetopias jubatus*) and their population decline in Alaska: a potential relationship. Can. J. Fish. Aquat. Sci. 54:1342-1348.

Nichol, D.G., and D.A. Somerton. 2002. Diurnal vertical migration of the Atka mackerel *Pleurogrammus monopterygius* as shown by archival tags. Mar Ecol Prog Ser 239: 193-207.

NMFS. 1995. Status review of the Unites States Steller sea lion (*Eumetopias jubatus*) population. National Marine Mammal Laboratory, Alaska Fishery Science Center, NMFS, 7600 Sand Point Way, NE, Seattle, WA 98115.

Ortiz, I. 2007. Ecosystem Dynamics of the Aleutian Islands. Ph.D. Thesis. University of Washington, Seattle.

Pirtle, J. L., Laman, E. A., Harris, J., Siple, M. C., Rooper, C. N., Hurst, T. P., Conrath, C. L., and Gibson, G. A. 2023. Advancing model-based essential fish habitat descriptions for North Pacific species in the Gulf of Alaska. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-468, 541 p. https://doi.org/10.25923/ygdf-5f65

Rutenberg, E.P. 1962. Survey of the fishes family Hexagrammidae. Trudy Instituta Okeanologii Akademiya Nauk SSSR 59:3-100. In Russian. (Translated by the Israel Program for Scientific Translations, 1970. Pages 1-103 in T.S. Rass (editor), Greenlings: taxonomy, biology, interoceanic transplantation; available from the U.S. Department of Commerce, National Technical Information Services, Springfield, Virginia, as TT 69-55097).

Sinclair E.H., and T.K. Zeppelin. 2002. Seasonal and spatial differences in diet in the western stock of Steller sea lions (*Eumetopias jubatus*). Journal of Mammalogy 83(4).

Sinclair, E., J.W. Testa, and L. Fritz. 2006. Marine Mammals. In J.L. Boldt (Ed.) Ecosystem Considerations for 2007. Appendix C of the BSAI\GOA Stock Assessment and Fishery Evaluation Reports. North Pacific Fishery Management Council, 605 W. 4th Ave., Suite 306, Anchorage, AK 99501.

Sinclair, E.H., D.S. Johnson, T.K. Zeppelin, and T.S. Gelatt. 2013. Decadal variation in the diet of western stock Steller sea lions (Eumetopias jubatus). U.S. Dep. Commer., NOAA Tech. Memo., NMFS-AFSC-248, 67 p.

Springer, A.M., J.F. Piatt, V.P. Shuntov, G.B. Van Vliet, V.L. Vladimirov, A.E. Kuzin, and A.S. Perlov. 1999. Marine birds and mammals of the Pacific subarctic gyres. Prog. Oceanogr. 43:443-487.

Yang, M. S. 1993. Food habits of the commercially important groundfishes in the Gulf of Alaska in 1990. NOAA Technical Memorandum, NMFS-AFSC-22, U.S. Department of Commerce, NOAA. p. 150.

Yang, M-S. 1996. Diets of the important groundfishes in the Aleutian Islands in summer 1991. NOAA Technical Memorandum, NMFS-AFSC-60, U.S. Department of Commerce, NOAA. p. 105.

Yang, M-S. 1999. The trophic role of Atka mackerel, *Pleurogrammus monopterygius*, in the Aleutian Islands area. Fishery Bulletin 97(4):1047-1057.

Yang, M-S. 2003. Food habits of the important groundfishes in the Aleutian Islands in 1994 and 1997. AFSC Processed Rep.2003-07, Alaska Fish. Sci. Cent., Natl. Mar. Fish. Serv., NOAA, 7600 Sand Point Way N.E., Seattle, WA 98115. p. 233.

Yang, M-S., K. Dodd, R. Hibpshman, and A. Whitehouse. 2006. Food habits of groundfishes in the Gulf of Alaska in 1999 and 2001. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-164, 199 p.

Yang, M-S., and M.W. Nelson. 2000. Food habits of the commercially important groundfishes in the Gulf of Alaska in 1990, 1993, and 1996. NOAA Technical Memorandum, NMFS-AFSC-112, U.S. Department of Commerce, NOAA. p. 174.

Zolotov, O.G. 1993. Notes on the reproductive biology of *Pleurogrammus monopterygius* in Kamchatkan waters. J. of Ichthy. 33(4), pp. 25-37.

D.3 Deepwater Flatfish complex: Dover sole (*Microstomus pacificus*)

Deepwater flatfish complex species:
Deepsea sole
Dover sole (primary, described below)
Greenland turbot

D.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). They exhibit a widespread distribution throughout the GOA. Adults are demersal and are mostly found in water deeper than 300 m in the winter but occur in highest biomass in the 100- to 200-m depth range during summer in the GOA (Turnock et al. 2002). The spawning period off Oregon is reported to range from January through May (Hunter et al. 1992). Off California, Dover sole spawn in deep water, and the larvae eventually settle in the shallower water of the continental shelf. They gradually move down the slope into deeper water as they grow and reach sexual maturity (Jacobson and Hunter 1993, Vetter et al. 1994, Hunter et al. 1990). For mature adults, most of the biomass may inhabit the oxygen minimum zone in deep waters. Spawning in the GOA has been observed from January through August, with a peak period in May (Hirschberger and Smith 1983), although a more recent study found spawning limited to February through May (Abookire and Macewicz 2003). 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 2 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. A comparison of maturity studies from Oregon and the GOA indicates that females mature at similar age in both areas (6 to 7 years), but GOA females are much larger (440 mm) than their southern counterparts (330 mm) at 50 percent maturity (Abookire and Macewicz 2003). 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 0.085 yr^{-1} based on a maximum observed age in the GOA of 54 years (Stockhausen et al. 2007).

D.3.2 Relevant Trophic Information

Dover sole commonly feed on brittle stars, polychaetes, and other miscellaneous worms (Aydin et al. 2007; Buckley et al. 1999). Important predators include walleye pollock and Pacific halibut (Aydin et al. 2007).

D.3.3 Habitat and Biological Associations

Larvae: Dover sole are planktonic larvae for up to 2 years until metamorphosis occurs.

Settled Early Juveniles: Settled early juvenile distribution is unknown.

Subadults: The covariates contributing the most to the final SDM EFH map for this life stage were geographic location and bottom depth (Pirtle et al. 2023). The highest abundances of subadult Dover sole occurred in the glacial troughs of the Yakutat and southeastern Alaska management areas of the GOA.

Adults: Dover sole are winter and spring spawners, and summer feeding occurs on soft substrates (combination of sand and mud) of the continental shelf and upper slope. Shallower summer distribution occurs mainly on the middle to outer portion of the shelf and upper slope. The covariates contributing the most to the final SDM EFH map for this life stage were bottom depth and geographic location (Pirtle et al. 2023). Adult Dover sole abundance was highest from the Kodiak management area into southeastern Alaska in the glacial troughs extending down the slope at depths around 400 m.

Habitat and Biological Associations: Dover sole

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

D.3.4 Literature

Abookire, A. A. and B. J. Macewicz. 2003. Latitudinal variation in reproductive biology and growth of female Dover sole (Microstomus pacificus) in the North Pacific, with emphasis on the Gulf of Alaska stock. J. Sea Res. 50: 187-197.

Auster, P.J., Malatesta, R.J., Langton, R.W., L. Watling, P.C. Valentine, C.S. Donaldson, E.W. Langton, A.N. Shepard, and I.G. Babb. 1996. The impacts of mobile fishing gear on seafloor habitats in the Gulf of Maine (Northwest Atlantic): Implications for conservation of fish populations. Rev. in Fish. Sci. 4(2): 185-202.

Aydin, K., S. Gaichas, I. Ortiz, D. Kinzey, and N. Friday. 2007. A comparison of the Bering Sea, Gulf of Alaska, and Aleutian Islands large marine ecosystems through food web modeling. NOAA NMFS Tech Memo, NMFS-AFSC-178. 298 p.

Buckley, T.W., G.E. Tyler, D.M. Smith and P.A. Livingston. 1999. Food habits of some commercially important groundfish off the costs of California, Oregon, Washington, and British Columbia. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-102, 173 p.

Hart, J.L. 1973. Pacific fishes of Canada. Fish. Res. Board Canada, Bull. No. 180. 740 p.

Hunter, J.R., J.L. Butler, C.A. Kimbrell, and E.A. Lynn. 1990. Bathymetric patterns in size, age, sexual maturity, water content, caloric density of Dover sole, *Microstomus pacificus*. CALCOFI Rep., Vol. 31, 1990.

Hunter, J.R., B.J. Macewicz, N.C. Lo, and C.A. Kimbrell. 1992. Fecundity, spawning, and maturity of female Dove sole *Microstomus pacificus*, with an evaluation of assumptions and precision. Fish. Bull. 90:101-128(1992).

Hirschberger, W.A., and G.B. Smith. 1983. Spawning of twelve groundfish species in the Alaska and Pacific coast regions. 50 p. NOAA Tech. Mem. NMFS F/NWC-44. U.S. Dep. Commer., NOAA, Natl. Mar. Fish. Serv.

Jacobson, L.D., and J.R. Hunter. 1993. Bathymetric Demography and Management of Dover Sole. NAJFM 13:405-420. 1993.

Kendall, A.W. Jr., and J.R. Dunn. 1985. Ichthyoplankton of the continental shelf near Kodiak Island, Alaska. NOAA Tech. Rep. NMFS 20, U.S. Dep. Commer, NOAA, Natl. Mar. Fish. Serv.

Livingston, P.A., and B.J. Goiney, Jr. 1983. Food habits literature of North Pacific marine fishes: a review and selected bibliography. NOAA Tech. Mem. NMFS F/NWC-54, U.S. Dep. Commer., NOAA, Natl. Mar. Fish. Serv.

Markle, D.F., Harris, P, and C. Toole. 1992. Metamorphosis and an overview of early-life-history stages in Dover sole *Microstomus pacificus*. Fish. Bull. 90:285-301.

Martin, M.H., and D.M. Clausen. 1995. Data report: 1993 GOA Bottom Trawl Survey. U.S. Dept. Commer., NOAA, Natl. Mar. Fish. Serv., NOAA Tech. Mem. NMFS-AFSC-59, 217 p.

Miller, D.J., and R.N. Lea. 1972. Guide to the coastal marine fishes of California. Calif. Dept. Fish. Game, Fish. Bull. 157, 235 p.

Pirtle, J. L., Laman, E. A., Harris, J., Siple, M. C., Rooper, C. N., Hurst, T. P., Conrath, C. L., and Gibson, G. A. 2023. Advancing model-based essential fish habitat descriptions for North Pacific species in the Gulf of Alaska. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-468, 541 p. https://doi.org/10.25923/ygdf-5f65

Stockhauen, W.T., B.J. Turnock, M.E. Wilkins and M.H. Martin. 2007. 5. Gulf of Alaska Deepwater Flatfish. In: Appendix B Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Gulf of Alaska. p 339-398. North Pacific Fishery Management Council, 605 West 4th Ave., Suite 306, Anchorage, AK 99501.

Turnock, B.J., T.K. Wilderbuer, and E.S. Brown. 2002. Flatfish. In Appendix B Stock assessment and fishery evaluation Report for the groundfish resources of the GOA. p 169-197. North Pacific Fishery Management Council, 605 West 4th Ave., Suite 306, Anchorage, AK 99501.

Vetter, R.D., E.A. Lynn, M. Garza, and A.S. Costa. 1994. Depth zonation and metabolic adaptation in Dover sole, *Microstomus pacificus*, and other deep-living flatfishes: factors that affect the sole. Mar. Biol. (1994) 120:145-159.

D.4 Dusky rockfish (*Sebastes variabilis*)

Previously it was thought that there were two varieties of dusky rockfish, a dark colored variety inhabiting inshore, shallow waters, and a lighter colored variety inhabiting deeper water offshore. In 2004 these two varieties were designated as distinct species, the dark colored variety is now recognized as dark rockfish (*Sebastes ciliatus*) and the lighter colored variety is now recognized as dusky rockfish (*Sebastes variabilis*) (Orr and Blackburn 2004). In 2009 dark rockfish were removed from the GOA FMP to allow for more responsive management by the State of Alaska.

D.4.1 Life History and General Distribution

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 GOA (Reuter 1999). The species is much less abundant in the Aleutian Islands and Bering Sea (Reuter and Spencer 2006). 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 particular 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 GOA 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 51 to 59 years. Estimated age at 50 percent maturity for females is 11.3 years. They become mature around 365 mm, and they can grow as large as 590 mm (Chilton 2010).

D.4.2 Relevant Trophic Information

Although no comprehensive food study of dusky rockfish has been done, one smaller study in the GOA showed euphausiids to be the predominant 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 flounder.

D.4.3 Habitat and Biological Associations

Eggs: No information is known, except that parturition probably occurs in the spring, and may extend into summer.

Larvae: No information is known.

Settled Early Juveniles: No information is 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. A manned submersible study in the eastern Gulf observed juvenile (less than 400 mm) dusky rockfish associated with *Primnoa* spp. coral. The covariates contributing the most to the final SDM EFH map for this life stage were bottom depth, geographic location, tidal current speed, and sponge presence (Pirtle et al. 2023). Higher subadult dusky rockfish abundance was predicted at less than 250 m depth with low occurrence of sponges, including the banks and glacial trough edges on the continental shelf and upper slope of the GOA from Portlock Bank and west.

Adults: Commercial fishery and research survey data indicate that adult dusky rockfish are primarily found on offshore banks of the outer continental shelf at depths of 100 to 200 m. Type of substrate in this habitat has not been documented, but it may be rocky. During submersible dives on the outer shelf (40 to 50 m) in the eastern Gulf, adult dusky rockfish were observed in association with rocky habitats and in areas with extensive sponge beds where the fish were observed resting in large vase sponges (V. O’Connell, ADFG, personal communication). Dusky rockfish are the most highly aggregated of the rockfish species caught in GOA trawl surveys. Outside of these aggregations, the fish are sparsely distributed. Because the fish are generally taken only 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 bottom depth, rockiness, and geographic location (Pirtle et al. 2023). Higher adult dusky rockfish abundance was predicted at < 250 m depth with rocky substrate present, including on the banks along the continental shelf and in areas of the outer continental shelf and upper slope from Portlock Bank and west, with some areas of higher abundance at the Fairweather Grounds in the eastern GOA.

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
Early Juveniles	U	U	all year	U	U	U	U	U
Subadults	Up to 11 years	U	U	ICS, MCS, OCS	D	CB, R, G	U	observed associated with *Primnoa* coral
Adults	11 up to 51–59 years.	euphausiids	U, except that larval release may be in the spring in the GOA	OCS, USP	D	CB, R, G	U	observed associated with large vase-type sponges

D.4.4 Literature

Ackley, D.R., and J. Heifetz. 2001. Fishing practices under maximum retainable bycatch rates in Alaska's groundfish fisheries. Alaska Fish. Res. Bull. 8(1): 22-44.

Allen, M.J., and G.B. Smith. 1988. Atlas and zoogeography of common fishes in the BS and northeastern Pacific. U.S. Dep. Commer., NOAA Tech. Rept. NMFS 66, 151 p.

Chilton, E. A. 2010. Maturity and growth of female dusky rockfish (Sebastes variabilis) in the central Gulf of Alaska. Fish. Bull. 108 (1): 70–78.

Clausen, D.M., C.R. Lunsford, and J. Fujioka. 2002. Pelagic shelf rockfish. In Stock assessment and fishery evaluation report for the groundfish resources of the GOA, p.383-417. Council, 605 W. 4th. Ave., Suite 306, Anchorage, AK 99501-2252.

Hanselman, D., P.D. Spencer, S.K. Shotwell, and R.R. Reuter. 2007b. Localized depletion of three Alaskan rockfish species. Proceedings of the 23rd Lowell Wakefield Fisheries Symposium: Biology, Assessment, and Management of North Pacific Rockfishes.

Kendall, A.W. 1989. Additions to knowledge of Sebastes larvae through recent rearing. NWAFC Proc. Rept. 89-21. 46 p.

Krieger, K.J., and B.L. Wing. 2002. Megafauna associations with deepwater corals (Primnoa spp.) in the GOA. Hydrobiologia 471: 83-90.

Lunsford, C.R., S.K. Shotwell, D.H. Hanselman, and D.M.Clausen. 2008. Gulf of Alaska pelagic shelf rockfish. In Stock assessment and fishery evaluation report for the groundfish resources of the Gulf of Alaska, p. 727-780, Appendix A. North Pacific Fishery Management Council, 605 W 4th Ave, Suite 306, Anchorage AK 99501.

Malecha, P. W., D. H. Hanselman, and J. Heifetz. 2007. Growth and mortality of rockfish (Scorpaenidae) from Alaskan waters. NOAA Tech. Memo. NMFS-AFSC-172. 61 p.

Martin, M.H., and D.M. Clausen. 1995. Data report: 1993 GOA bottom trawl survey. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-59. 217 p.

Matarese, A.C., A.W. Kendall, Jr., D.M. Blood, and B.M. Vinter. 1989. Laboratory guide to early life history stages of northeast Pacific fishes. U.S. Dep. Commer. NOAA Tech. Rept. NMFS 80, 652 p.

Orr, J.W., and J.E. Blackburn. 2004. The dusky rockfishes (Teleostei: Scorpaeniformes) of the North Pacific Ocean: resurrection of *Sebastes variabilis* (Pallas, 1814) and a redescription of *Sebastes ciliatus* (Tilesius, 1813). Fish Bull., U.S. 1002:328-348.

Pirtle, J. L., Laman, E. A., Harris, J., Siple, M. C., Rooper, C. N., Hurst, T. P., Conrath, C. L., and Gibson, G. A. 2023. Advancing model-based essential fish habitat descriptions for North Pacific species in the Gulf of Alaska. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-468, 541 p. https://doi.org/10.25923/ygdf-5f65

Reuter, R.F. 1999. Describing dusky rockfish (*Sebastes ciliatus*) habitat in the GOA using historical data. M.S. Thesis, Calif. State Univ., Hayward CA. 83 p.

Reuter, R.F., and P.D. Spencer. 2006. Chapter 14 Other Rockfish. *in* Stock Assessment and Fishery Evaluation Report for the groundfish resources of the Bering Sea and Aleutian Islands. North Pacific Fishery Management Council, 605 W 4th Ave, Suite 306, Anchorage, AK, 99501. November 2006. pp. 925-948.

Spencer, P., D. Hanselman, and M. Dorn. 2007. The effect of maternal age of spawning on estimation of Fmsy for Alaska Pacific ocean perch. In: Heifetz, J., DiCosimo J., Gharrett, A.J., Love, M.S, O'Connell, V.M, and Stanley, R.D. (eds.). Biology, Assessment, and Management of North Pacific Rockfishes. Alaska Sea Grant, University of Alaska Fairbanks. pp 513 – 533.

Stark, J.W., and D.M. Clausen. 1995. Data report: 1990 GOA bottom trawl survey. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-49. 221 p.

Westrheim, S.J. 1973. Preliminary information on the systematics, distribution, and abundance of the dusky rockfish, Sebastes ciliatus. J. Fish. Res. Bd. Can. 30: 1230-1234.

Westrheim, S.J. 1975. Reproduction, maturation, and identification of larvae of some Sebastes (Scorpaenidae) species in the northeast Pacific Ocean. J. Fish. Res. Board Can. 32: 2399-2411.

D.5 Flathead sole (*Hippoglossoides elassodon*)

D.5.1 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 GOA 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 in the GOA. 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. In the GOA, the spawning period may start as early as March but is known to occur in April through June, 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 and have been found in ichthyoplankton sampling on the western portion of the GOA shelf in April through June (Porter 2004). Porter (2004) found that egg density increased late in development such that mid-stage eggs were found near the surface but eggs about to hatch were found at depth (125 to 200 m). Larvae absorb the yolk sac in 6 to 17 days, but the extent of their distribution is unknown. Nearshore sampling indicates that newly settled larvae are in the 30 to 50 mm size range (Norcross et al. 1996, Abookire et al. 2001). 50 percent of GOA flathead sole females are mature at 8.7 years or 333 mm (Stark 2004). Juveniles less than age 2 have not been found with the adult population and remain in shallow areas. The natural mortality rate used in recent stock assessments is 0.2 for both sexes (Turnock et al. 2017).

D.5.2 Relevant Trophic Information

Based on results from an ecosystem model for the GOA (Aydin et al. 2007), flathead sole in the GOA occupy an intermediate trophic level as both juvenile and adults. Pandalid shrimp and brittle stars were the most important prey for adult flathead sole in the GOA (64 percent by weight in sampled stomachs; Yang and Nelson 2000), while euphausiids and mysids constituted the most important prey items for juvenile flathead sole. Other major prey items included polychaetes, mollusks, bivalves, and hermit crabs for both juveniles and adults. Commercially important species that were consumed included age-0 Tanner crab and age-0 walleye pollock (3 percent and less than 0.5 percent by weight, respectively).

Important predators on flathead sole include arrowtooth flounder, walleye pollock, Pacific cod, and other groundfish (Aydin et al. 2007). Pacific cod and Pacific halibut are the major predators on adults, while arrowtooth flounder, sculpins, walleye pollock, and Pacific cod are the major predators on juveniles.

D.5.3 Habitat and Biological Associations

Larvae: Planktonic larvae for 3 to 5 months until metamorphosis occurs.

Settled Early Juveniles: Usually inhabit shallow areas (less than 100 m depth), preferring muddy habitats. The covariates contributing the most to the final SDM EFH map for this life stage were BPI, bottom depth, tidal current, and seafloor aspect (Pirtle et al. 2023). They were predicted to occur in nearshore areas along the Alaska Peninsula, around Kodiak Island, and along the mainland in the southeastern Alaska management area over relatively flat, non-rocky bottom at shallower depths.

Subadults: The covariates contributing the most to the final SDM EFH map for this life stage were geographic location, bottom depth, tidal current, and BPI (Pirtle et al. 2023). The highest subadult flathead sole abundances were predicted in upper Shelikof Strait, in nearshore waters around Kodiak Island, and along the coast of the western Alaska Peninsula in shallower waters with slower maximum tidal currents over submarine channels or valleys.

Adults: Spring 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. The covariates contributing the most to the final SDM EFH map for this life stage were geographic location, BPI, and bottom depth (Pirtle et al. 2023). Adult flathead sole predicted abundance was highest in Shelikof Strait, in coastal waters around Kodiak Island, and the shallower, nearshore waters of the Alaska Peninsula over submarine channels or valleys with relatively non-rocky seafloor.

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		NA	winter	ICS, MCS, OCS	P			
Larvae	U	U phyto/zooplankton?	spring, summer	ICS, MCS, OCS	P			
Settled Early Juveniles/Subadults	U	polychaetes, bivalves, ophiuroids	all year	MCS, ICS, OCS	D	S, M		
Adults	U	polychaetes, bivalves, ophiuroids, pollock, Tanner crab	spawning Jan–April non-spawning May–December	MCS, OCS, ICS	D	S, M	ice edge	

D.5.4 Literature

Abookire, A.A.., J.F. Piatt and B.L. Norcross. 2001. Juvenile groundfish habitat in Kachemak Bay, Alaska, during late summer. Alaska Research Fishery Bulletin 8: 45-56.

Auster, P.J., Malatesta, R.J., Langton, R.W., L. Watling, P.C. Valentine, C.S. Donaldson, E.W. Langton, A.N. Shepard, and I.G. Babb. 1996. The impacts of mobile fishing gear on sea floor habitats in the Gulf of Maine (Northwest Atlantic): Implications for conservation of fish populations. Rev. in Fish. Sci. 4(2): 185-202.

Aydin, K., S. Gaichas, I. Ortiz, D. Kinzey, and N. Friday. 2007. A comparison of the Bering Sea, Gulf of Alaska, and Aleutian Islands large marine ecosystems through food web modeling. U.S. Dep. Commer., NOAA NMFS Tech Memo. NMFS-AFSC-178. 298 p.

Forrester, C.R., and D.F. Alderdice. 1967. Preliminary observations on embryonic development of the flathead sole (*Hippoglossoides elassodon*). Fish. Res. Board Can. Tech. Rep. 100: 20 p

Hart, J.L. 1973. Pacific fishes of Canada. Fish. Res. Board Canada, Bull. No. 180. 740 p.

Livingston, P.A., and Y. DeReynier. 1996. Groundfish food habits and predation on commercially important prey species in the EBS from 1990 to 1992. AFSC processed Rep. 96-04, 51 p. Alaska Fish. Sci. Cent., Natl. Mar. Fish. Serv., NOAA, 7600 Sand Point Way NE., Seattle, WA 98115.

Matarese, A.C., D.M. Blood, S.J. Piquelle and J. Benson. 2003.Atlas of abundance and distribution patterns of ichthyoplankton form the northeast Pacific Ocean and Bering Sea ecosystems based on research conducted by the Alaska Fisheries Science Center (1972-1996). NOAA Prof. Paper NMFS 1. 281 p.

Miller, B.S. 1969. Life history observations on normal and tumor bearing flathead sole in East Sound, Orcas Island (Washington). Ph.D. Thesis. Univ. Wash. 131 p.

Norcross, B.L., A. Blanchard and B.A. Holladay. 1999. Comparison of models for defining nearshore flatfish nursery areas in Alaskan waters. Fish. Oc. 8: 50-67.

Norcross, B.L., B.A. Holladay, S.C. Dressel, and M. Frandsen. 1996. Recruitment of juvenile flatfishes in Alaska: habitat preference near Kodiak Island. U. Alaska Coastal Marine Institute, OCS Study MMS 96-0003, Vol. 1.

Norcross, B.L., F.J. Muter, B.A. Holladay. 1997. Habitat models for juvenile pleuronectids around Kodiak Island, Alaska. Fish. Bull. 95: 504-520.

Pacunski, R.E. 1990. Food habits of flathead sole (*Hippoglossoides elassodon*) in the EBS. M.S. Thesis. Univ. Wash. 106 p.

Pirtle, J. L., Laman, E. A., Harris, J., Siple, M. C., Rooper, C. N., Hurst, T. P., Conrath, C. L., and Gibson, G. A. 2023. Advancing model-based essential fish habitat descriptions for North Pacific species in the Gulf of Alaska. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-468, 541 p. https://doi.org/10.25923/ygdf-5f65

Porter, S.M. 2004.Temporal and spatial distribution and abundance of flathead sole (*Hippoglossoides elassodon*) eggs ad larvae in the western Gulf of Alaska. Fish. Bull. 103:648-658.

Stark, J.W. 2004. A comparison of the maturation and growth of female flathead sole in the central Gulf of Alaska and south-eastern Bering Sea. J. Fish. Biol. 64: 876-889.

Turnock, B.J., C.R. McGilliard and W. Palsson. 2017. 8. Gulf of Alaska Flathead Sole Stock Assessment. In Appendix B: Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Gulf of Alaska. p 841-912. North Pac. Fish. Mgmt. Council, 605 West 4th Ave., Suite 306, Anchorage, AK 99501.

Waldron, K.D. 1981. Ichthyoplankton. In D.W. Hood and J.A. Calder (Editors), The EBS shelf: Oceanography and resources, Vol. 1, p. 471-493. U.S. Dep. Commer., NOAA, Off. Mar. Poll. Asess., U.S. Gov. Print. Off., Wash., D.C.

Yang, M-S. and M.W. Nelson. 2000. Food habits of the commercially important groundfishes in the Gulf of Alaska in 1990, 1993, and 1996. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-112, 174 p.

D.6 Northern rockfish (*Sebastes polyspinis*)

D.6.1 Life History and General Distribution

Northern rockfish range from northern British Columbia through the GOA and Aleutian Islands to eastern Kamchatka and the Kuril Islands, including the Bering Sea (Mecklenburg et al. 2002). The species is most abundant from about Portlock Bank in the central GOA to the western end of the Aleutian Islands; it is rarely found in the eastern GOA. In the GOA, adult fish appear to be concentrated at discrete, relatively shallow offshore banks of the outer continental shelf (Clausen and Heifetz 2002). Typically, these banks are separated from land by an intervening stretch of deeper water. The preferred depth range is approximately 75 to 150 m in the GOA. Information available at present suggests the fish are mostly demersal, as very few have been caught off-bottom or in pelagic trawls (Clausen and Heifetz 2002). 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. 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 other *Sebastes* appear to be, with internal fertilization and incubation of eggs. Observations during research surveys in the GOA suggest that parturition (larval release) occurs in the spring, and is mostly completed by summer. Pre-extrusion larvae have been described (Kendall 1989), but field-collected larvae cannot be unequivocally identified to species at present, even using genetic techniques (Li et al. 2006). Length of the larval stage is unknown, but the fish apparently metamorphose to a pelagic juvenile stage, which also has been described (Matarese et al. 1989). However, similar to the larvae, smaller-sized post-larval northern rockfish cannot be positively identified at present, even with genetic methods (Kondzela et al. 2007). 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 (Clausen and Heifetz 2002).

Northern rockfish is a slow growing species, with a low rate of natural mortality (estimated at 0.06), a relatively old age at 50 percent maturity (12.8 years for females in the GOA), and an old maximum age of 67 years in the GOA (Heifetz et al. 2007). Size at 50 percent maturity has been estimated to be 310 mm (Chilton 2007).

D.6.2 Relevant Trophic Information

Although no comprehensive food study of northern rockfish in the GOA has been done, one small study indicated euphausiids were by far the predominant food item of adults (Yang 1993). Food studies in the Aleutian Islands have also shown northern rockfish to be planktivorous, with euphausiids and copepods being the main prey items (Yang 1996, 2003). Other foods consumed in the Aleutian Islands included Chaetognaths (arrow worms), amphipods, squid, and polychaetes.

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.6.3 Habitat and Biological Associations

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

Larvae: No information known. Larval studies are not possible at present because larvae have not been positively identified to species, even when genetic techniques have been used.

Settled Early Juveniles: No information known for small juveniles (less than 200 mm), except that post-larval fish apparently undergo a pelagic phase immediately after metamorphosis from the larval stage. How long the pelagic stage lasts, and when juveniles assume a demersal existence, is unknown. Observations from manned submersibles in offshore waters of the GOA (e.g., Krieger 1993; Freese and Wing 2003) have consistently indicated that small juvenile rockfish are associated with benthic living and non-living structure and appear to use this structure as refuge. The living structure includes corals and sponges. Although the juvenile rockfish could not be identified to species in the submersible studies, the studies suggest that small juvenile northern rockfish possibly utilize these habitats.

Subadults: Large juvenile northern rockfish have been taken in bottom trawls at various localities of the continental shelf, usually inshore of the adult fishing grounds (Clausen and Heifetz 2002). Substrate preference of these larger juveniles is unknown. The covariates contributing the most to the final SDM EFH map for this life stage were bottom depth, geographic location, and rockiness (Pirtle et al. 2023). Subadult northern rockfish abundance was generally higher at depths less than 250 m in areas with rocky substrate.

Adults: Commercial fishery and research survey data have consistently indicated that adult northern rockfish in the GOA are primarily found on offshore banks of the outer continental shelf at depths of 75 to 150 m. Preferred substrate in this habitat has not been documented, but observations from trawl surveys suggest that large catches of northern rockfish are often associated with hard or rough bottoms.

For example, some of the largest catches in the trawl surveys have occurred in hauls in which the net hung-up on the bottom or was torn by a rough substrate (Clausen and Heifetz 2002). Generally, the fish appear to be demersal, and most of the population occurs in large aggregations. There is no information on seasonal migrations. Northern rockfish often co-occur with dusky rockfish.

The covariates contributing the most to the final SDM EFH map for this life stage were bottom depth, geographic location, bottom current, and rockiness (Pirtle et al. 2023). Higher adult northern rockfish abundance peaked at 190 m depth on bathymetric rises with rocky substrate and moderate bottom current exposure, including at Portlock Bank and along the outer continental shelf from Kodiak Island through the western GOA.

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	NA	NA	NA	NA	NA	NA
Larvae	U	U	spring–summer	U	P (assumed)	NA	U	U
Settled Early Juveniles	From end of larval stage to ?	U	summer to ?	U	P?	U	U	U
Subadults	to 13 years	U	all year	MCS, OCS	D	U	U	U
Adults	13 to 67 years of age	Euphausiids	U, except that larval release is probably in the spring in the GOA	OCS	D	CB, R	U	often co-occur with dusky rockfish

D.6.4 Literature

Ackley, D.R., and J. Heifetz. 2001. Fishing practices under maximum retainable bycatch rates in Alaska's groundfish fisheries. Alaska Fish. Res. Bull. 8(1): 22-44.

Chilton, E. 2007. Maturity of female northern rockfish Sebastes polyspinis in the central Gulf of Alaska. Ak. Fish. Res. Bull. 12: 264–269. https://www.adfg.alaska.gov/static/home/library/PDFs/afrb/chilv12n2.pdf.

Clausen, D.M., and J. Heifetz. 2002. The northern rockfish, *Sebastes polyspinis*, in Alaska: commercial fishery, distribution, and biology. Mar. Fish. Rev. 64(4): 1-28.

Freese, J.L., and B.L. Wing. 2003. Juvenile red rockfish, *Sebastes* sp., associations with sponges in the Gulf of Alaska. Mar. Fish. Rev. 65(3): 38-42.

Hanselman, D., P.D. Spencer, S.K. Shotwell, and R.R. Reuter. 2007. Localized depletion of three Alaskan rockfish species. In J. Heifetz, J. DiCosimo, A.J. Gharrett, M.S. Love, V.M. O'Connell, and R.D. Stanley (editors), Biology, assessment, and management of North Pacific rockfishes, p. 493-511. Alaska Sea Grant, Univ. of Alaska Fairbanks.

Heifetz, J., D. Hanselman, D. Courtney, and J. Ianelli. 2007. Gulf of Alaska northern rockfish. In Stock assessment and fishery evaluation report for the groundfish resources of the Gulf of Alaska, p. 623-674. Council, 605 W 4th Ave, Suite 306 Anchorage, AK 99501.

Heifetz, J., D. Hanselman, D. Courtney, S.K. Shotwell, and J.N. Ianelli. 2008. Assessment of northern rockfish in the Gulf of Alaska (executive summary). In Stock assessment and fishery evaluation report for the groundfish resources of the GOA, p. 445-452. Council, 605 W 4th Ave, Suite 306 Anchorage, AK 99501.

Kendall, A.W. 1989. Additions to knowledge of *Sebastes* larvae through recent rearing. NWAFC Proc. Rept. 89-21. 46 p.

Krieger, K.J. 1993. Distribution and abundance of rockfish determined from a submersible and by bottom trawling. Fish. Bull. 91: 87-96.

Kondzela, C.M., A.W. Kendall, Z. Li, D.M. Clausen, and A.J. Gharrett. 2007. Preliminary identification of pelagic juvenile rockfishes collected in the Gulf of Alaska. In J. Heifetz, J. DiCosimo, A.J. Gharrett, M.S. Love, V.M. O'Connell, and R.D. Stanley (editors), Biology, assessment, and management of North Pacific rockfishes, p. 153-166. Alaska Sea Grant, Univ. of Alaska Fairbanks.

Li, Z., A.K. Gray, M.S. Love, A. Goto, T. Asahida, and A.J. Gharrett. 2006. A key to selected rockfishes (*Sebastes* spp.) based on mitochondrial DNA restriction fragment analysis. Fish. Bull. 104: 182-196.

Matarese, A.C., A.W. Kendall, Jr., D.M. Blood, and B.M. Vinter. 1989. Laboratory guide to early life history stages of Northeast Pacific fishes. U.S. Dep. Commer. NOAA Tech. Rept. NMFS 80, 652 p.

Mecklenburg, C.W., T.A. Mecklenburg, and L.K. Thorsteinson. 2002. Fishes of Alaska. Am. Fish. Soc., Bethesda, Maryland. 1,037 p.

Pirtle, J. L., Laman, E. A., Harris, J., Siple, M. C., Rooper, C. N., Hurst, T. P., Conrath, C. L., and Gibson, G. A. 2023. Advancing model-based essential fish habitat descriptions for North Pacific species in the Gulf of Alaska. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-468, 541 p. https://doi.org/10.25923/ygdf-5f65

Yang, M-S. 1993. Food habits of the commercially important groundfishes in the Gulf of Alaska in 1990. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-22, 150 p.

Yang, M-S. 1996. Diets of the important groundfishes in the Aleutian Islands in summer 1991. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-60, 105 p.

Yang, M-S. 2003. Food habits of important groundfishes in the Aleutian Islands in 1994 and 1997. U.S. Dep. Commer., AFSC Proc. Rep. 2003-07, 233 p.

D.7 Octopuses

There are at least seven species of octopuses currently identified from the GOA, including one species of genus *Octopus* that has not been fully described (*Octopus sp. A*, Conners and Jorgensen 2008). The species most abundant at depths less than 200 m 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, *Benthoctopus leioderma* and the cirrate octopus *Opisthoteuthis* cf *californiana. Octopus californicus* is reported from the eastern GOA at depths ranging from 100 to 1,000 m. *Japetella diaphana* and bathypelagic finned species *Vampyroteuthis infernalis* are found in pelagic waters of the GOA. Preliminary evidence (Conners and Jorgensen 2008, Conners et al. 2004) indicates that octopus 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 GOA has changed since the previous essential fish habitat review and is still developing. The state of knowledge of octopuses in the GOA, including the true species composition, is very limited.

D.7.1 Life History and General Distribution

Octopus 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 GOA, octopuses are found from subtidal waters to deep areas near the outer slope. The highest diversity is along the shelf break region of the GOA, although, unlike the Bering Sea, there is a high abundance of octopuses on the shelf. While octopuses were observed throughout the GOA, they are more commonly observed in the Central and Western GOA (statistical areas 610, 620, and 630) than in the Eastern GOA. The greatest number of observations is clustered around the Shumagin Islands and Kodiak Island. These spatial patterns are influenced by the distribution of fishing effort. Alaska Fisheries Science

Center survey data also show the presence of octopus throughout the GOA but also indicate highest biomass in areas 610 and 630. Octopuses were caught at all depths ranging from shallow inshore areas (mostly pot catches) to trawl and longline catches on the continental slope at depths to nearly 1,000 m. The majority of octopus caught with pots in the GOA came from 40 to 60 fathoms (70 to 110 m); catches from longline vessels tended to be in deeper waters of 200 to 400 fathoms (360 to 730 m). The distribution of octopuses 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 is sexually mature after approximately three years. In Japan, females weigh between 10 to 15 kg at maturity while males are 7 to 17 kg (Kanamaru and Yamashita 1967). *E. dofleini* in the Bering Sea may mature at larger sizes given the more productive waters in the Bering Sea. *E. dofleini* in Japan move to deeper waters to mate during July through October and move to shallower waters to spawn during October through January. There is a 2-month lag time between mating and spawning. This time may be necessary for the females to consume extra food to last the seven months required for hatching of the eggs, during which time the female guards and cleans the eggs but does not feed. *E. dofleini* is a terminal spawner, females die after the eggs hatch while males die shortly after mating. While females may have 60,000 to 100,000 eggs in their ovaries, only an average of 50,000 eggs are laid (Kanamaru 1964). Hatchlings are approximately 3.5 mm. Mottet (1975) estimated survival to 6 mm at 4 percent, while survival to 10 mm was estimated to be 1 percent; mortality at the 1 to 2 year stage was 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.

Octopus californicus is a medium-sized octopus, maximum total length of approximately 400 mm. Very little is known about this species of octopus. It is collected between 100 and 1,000 m. It is believed to spawn 100 to 500 eggs. Hatchlings are likely benthic; hatchling size is unknown. The female likely broods the eggs and dies after hatching.

Octopus sp. A is a small-sized species, maximum total length less than 100 mm. This species has only recently been identified in the GOA and its full taxonomy has not been determined. *Octopus sp. A* is likely a terminal spawner with a life-span of 12 to 18 months. The eggs of *Octopus sp. A* are likely much larger than those of *O. rubescens*, as benthic larvae are often bigger; they could take up to six months or more to hatch. Females have 80 to 90 eggs.

Benthoctopus leioderma is a medium-sized species, maximum total length approximately 600 mm. Its life span is unknown. It occurs from 250 to 1,400 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. They are thought to spawn under rock ledges and crevices. The hatchlings are benthic.

Opisthoteuthis californiana is a cirrate octopus. It has fins and cirri (on the arms). It is common in the GOA but would not be confused with *E. dofleini*. It is found from 300 to 1,100 m and likely common over the abyssal plain. Other details of its life history remain unknown.

Japetella diaphana is a small pelagic octopus. Little is known about members of this family. This is not a common octopus in the GOA and would not be confused with *E. dofleini*.

V. infernalis is a relatively small (up to about 400 mm total length) bathypelagic species, living at depths well below the thermocline; they may be most commonly found at 700 to 1,500 m. They are found throughout the world's oceans. Eggs are large (3 to 4 mm in diameter) and are shed singly into the water. Hatched juveniles resemble adults, but with different fin arrangements, which change to the adult form with development. Little is known of their food habits, longevity, or abundance.

D.7.2 Relevant Trophic Information

Octopuses 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, octopuses eat benthic crustaceans (crabs) and molluscs (clams). Large octopus are also able to catch and eat benthic fishes; the Seattle aquarium has documented a giant Pacific octopus preying on a 4-foot dogfish.

D.7.3 Habitat and Biological Associations

Eggs: Spawning occurs on the 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.

Settled Early Juveniles: Early juveniles are semi-demersal and are widely dispersed on shelf, upper slope. Settled early juveniles become demersal and are also widely dispersed on the shelf and upper slope, preferring cobble and rock substrates.

Subadults/Adults: Adult octopus are demersal; are widely dispersed on shelf and upper slope, preferentially among rocks, cobble, but also on sand/mud. The covariates contributing the most to the final SDM EFH map for this life stage were geographic location, sponge presence, and bottom (Pirtle et al. 2023). Giant Pacific octopus abundance was predicted to be higher in the central and western GOA, with peak depths between 300-600 m.

Habitat and Biological Associations: *Enteroctopus dofleini*, *Octopus gilbertianus*

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

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

D.7.4 Literature

Akimushkin, I.I. 1963. Cephalopods of the seas of the U.S.S.R. Academy of Sciences of the U.S.S.R., Institute of Oceanology, Moscow. Translated from Russian by Israel Program for Scientific Translations, Jerusalem 1965. 223 p.

Alaska Department of Fish and Game (2004). Annual management report of the commercial and subsistence shellfish fisheries of the Aleutian Islands, Bering Sea, and the westward region's shellfish observer program, 2003. Regional Information Report No. 4K04-43

Aydin, K., S. Gaichas, I. Ortiz, D. Kinzey, and N. Friday. 2008. A comparison of the Bering Sea, Gulf of Alaska, and Aleutian Islands large marine ecosystems through food web modeling. NOAA Tech Memo.

Caddy, J.F. 1979. Preliminary analysis of mortality, immigration, and emigration on Illex population on the Scotian Shelf. ICNAF Res. Doc. 79/VI/120, Ser. No. 5488.

Caddy, J.F. 1983. The cephalopods: factors relevant to their population dynamics and to the assessment and management of stocks. Pages 416-452 In J.F. Caddy, ed. Advances in assessment of world cephalopod resources. FAO Fisheries Tech. Paper 231.

Caddy, J.F. 2004. Current usage of fisheries indicators and reference points, and their potential application to management of fisheries for marine invertebrates. Can. J Fish. Aquat. Sci. 61:1307-1324.

Caddy, J.F. and P.G. Rodhouse. 1998. Cephalopod and groundfish landings: evidence for ecological change in global fisheries? Rev. Fish Biology and Fisheries 8:431-444.

Charnov e.L. and D. Berrigan. 1991. Evolution of life history parameters in animals with indeterminate growth, particularly fish. Evol. Ecol. 5:63-68.

Conners, M. E., P. Munro, and S. Neidetcher (2004). Pacific cod pot studies 2002-2003. AFSC Processed Report 2004-04. June 2004

Conners, M.E. and E. Jorgensen. 2005. Octopus Complex in the Gulf of Alaska. In: Stock assessment and fishery evaluation report for the groundfish resources of the Gulf of Alaska. North Pac. Fish. Mgmt. Council, Anchorage, AK,

Conners, M.E. and E. Jorgensen. 2006. Octopus Complex in the Gulf of Alaska. In: Stock assessment and fishery evaluation report for the groundfish resources of the Gulf of Alaska. North Pac. Fish. Mgmt. Council, Anchorage, AK,

Conners, M.E. and E. Jorgensen. 2007. Octopus Complex in the Gulf of Alaska. In: Stock assessment and fishery evaluation report for the groundfish resources of the Gulf of Alaska. North Pac. Fish. Mgmt. Council, Anchorage, AK,

Conners, M.E. and E. Jorgensen. 2008. Octopus Complex in the Gulf of Alaska. In: Stock assessment and fishery evaluation report for the groundfish resources of the Gulf of Alaska. North Pac. Fish. Mgmt. Council, Anchorage, AK,

Fritz, L.W. 1996. Other species In Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Bering Sea/Aleutian Islands Regions as Projected for 1997. North Pacific Fishery Management Council, 605 West 4th Avenue, Suite 306, Anchorage, AK 99501.

Fritz, L. 1997. Summary of changes in the Bering Sea Aleutian Islands squid and other species assessment. (in) Stock assessment and fishery evaluation report for the groundfish resources of the Bering Sea/Aleutian Islands regions. N. Pacific Fish. Management Council, Anchorage, AK.

Gaichas, S. 2004. Other Species (in) Stock assessment and fishery evaluation report for the groundfish resources of the Bering Sea / Aleutian Islands regions. N. Pacific Fish. Management Council, Anchorage, AK.

Hatanaka, H. 1979. Studies on the fisheries biology of common octopus off the northwest coast of Africa. Bull Far Seas Reserarch Lab 17:13-94.

Hartwick, B. 1983. *Octopus dofleini*. In Cephalopod Life Cycles Vol. I. P.R. Boyle eds. 277-291.

Hartwick, E.B., R.F. Ambrose, and S.M.C. Robinson. 1984. Dynamics of shallow-water populations of Octopus dofleini. Mar. Biol. 82:65-72.

Hartwick, E.B, and I. Barriga (1997) *Octopus dofleini*: biology and fisheries in Canada (in) Lang, M. A. and F.G. Hochberg (eds.) (1997). Proceedings of the Workshop on the Fishery and market potential of octopus in California. Smithsonian Institutions: Washington. 192 p.

Hoenig, J.N. 1983. Empirical Use of Longevity Data to Estimate Mortality Rates. Fishery Bulletin V. 82 No. 1, pp. 898-903.

Iverson, S.J., K.J. Frost, and S.L.C. Lang. 2002. Fat content and fatty acid composition of forage fish and invertebrates in Prince William Sound, Alaska: factors contributing to among and within species variability. Marine Ecol. Prog. Ser. 241:161-181.

Kanamaru, S. 1964. The octopods off the coast of Rumoi and the biology of mizudako. Hokkaido Marine Research Centre Monthly Report 21(4&5):189-210.

Kanamaru, S. and Y. Yamashita. 1967. The octopus mizudako. Part 1, Ch. 12. Investigations of the marine resources of Hokkaido and developments of the fishing industry, 1961 – 1965.

Livingston, P.L., Aydin, K.Y., J. Boldt., S. Gaichas, J. Ianelli, J. Jurado-Molina, and I. Ortiz. 2003. Ecosystem Assessment of the Bering Sea/Aleutian Islands and Gulf of Alaska Management Regions. In: Stock assessment and fishery evaluation report for the groundfish resources or the Bering Sea/Aleutian Islands regions. North. Pac. Fish. Mgmt. Council, Anchorage, AK.

Merrick, R.L., M.K. Chumbley, and G.V. Byrd, 1997. Diet diversity of Steller sea lions (*Eumetpias jubatus*) and their population decline in Alaska: a potential relationship. Can J. Fish. Aquat. Sci. 54: 1342-1348.

Mottet, M. G. 1975. The fishery biology of *Octopus dofleini*. Washington Department of Fisheries Technical Report No. 16, 39 pp.

National Research Council. 1998. Improving fish stock assessments. National Academy Press, Washington, D.C.

Nesis, K.N. 1987. Cephalopods of the world. TFH Publications, Neptune City, NJ, USA. 351 pp.

Osako, M. and . Murata. 1983. Stock assessment of cephalopod resources in the northwestern Pacific. Pages55-144 In J.F. Caddy, ed. Advances in assessment of world cephalopod resources. FAO Fisheries Tech. Paper 231.

Paust, B.C. 1988. Fishing for octopus, a guide for commercial fishermen. Alaska Sea Grant Report No. 88-3, 48 pp.

Paust, B.C. 1997. *Octopus dofleini*: Commercial fishery in Alaska (in) Lang, M. A. and F.G. Hochberg (eds.) (1997). Proceedings of the Workshop on the Fishery and market potential of octopus in California. Smithsonian Institutions: Washington. 192 p.

Perez, M. 1990. Review of marine mammal population and prey information for Bering Sea ecosystem studies. U.S. Dep. Commerce, NOAA Tech. Memo. NMFS F/NWC-186, 81 p.

Perry, R.I., C.J. Walters, and J.A. Boutillier. 1999. A framework for providing scientific advice for the management of new and developing invertebrate fisheries. Rev. Fish Biology and Fisheries 9:125-150.

Pirtle, J. L., Laman, E. A., Harris, J., Siple, M. C., Rooper, C. N., Hurst, T. P., Conrath, C. L., and Gibson, G. A. 2023. Advancing model-based essential fish habitat descriptions for North Pacific species in the Gulf of Alaska. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-468, 541 p. https://doi.org/10.25923/ygdf-5f65

Punt, A.E. 1995. The performance of a production-model management procedure. Fish. Res. 21:349-374.

Rikhter, V.A. and V.N. Efanov, 1976. On one of the approaches to estimation of natural mortality of fish populations. ICNAF Res.Doc., 79/VI/8, 12p.

Rooper, C.F.E., M.J. Sweeny, and C.E. Nauen. 1984. FAO Species catalogue vol. 3 cephalopods of the world. FAO Fisheries Synopsis No. 125, Vol. 3.

Sato, R. and H. Hatanaka. 1983. A review of assessment of Japanese distant-water fisheries for cephalopods. Pages 145-203 In J.F. Caddy, ed. Advances in assessment of world cephalopod resources. FAO Fisheries Tech. Paper 231.

Scheel, D. 2002. Characteristics of habitats used by *Enteroctopus dofleini* in Prince William Sound and Cook Inlet, Alaska. Marine Ecology 23(3):185-206.

Sigler M.F., L. Hulbert, C. R. Lunsford, N. Thompson, K. Burek, G. Corry-Crowe, and A. Hirons. 2006. Diet of Pacific sleeper shark, a potential Steller sea lion predator, in the north-east Pacific Ocean. Fish Biol. 69:392-405.

Sinclair, E.H. and T.K. Zeppelin. 2002. Seasonal and spatial differences in diet in the western stock of Steller sea lions (*Eumetopias jubatus*). J Mammology 83:973-990.

Wakabayashi, K, R.G. Bakkala, and M. S. Alton. 1985. Methods of the U.S.-Japan demersal trawl surveys (in) R.G. Bakkala and K. Wakabayashi (eds.), Results of cooperative U.S. - Japan groundfish investigations in the Bering Sea during May - August 1979. International North Pacific Fisheries Commission Bulletin 44.

Walters, G. E. Report to the fishing industry on the results of the 2004 Eastern Bering Sea Groundfish Survey. AFSC Process Report 2005-03. Feb 2005.

Wilson, J.R. and A.H. Gorham (1982). Alaska underutilized species Volume II: Octopus. Alaska Sea Grant Report 82-3. May 1982. 64 p.

Yang, M.S. 1993. Food habits of the commercially important groundfishes in the Gulf of Alaska in 1990. U.S. Dep. Commerce, NOAA Tech. Memo. NMFS-AFSC-22, 150 p.

D.8 Other Rockfish complex, demersal subgroup

Species Complex Summary

In the GOA, the Other Rockfish complex includes the demersal subgroup comprised of canary, China, copper, quillback, rosethorn, tiger, and yelloweye rockfishes (Tribuzio et al. 2021). There were enough catches of quillback, rosethorn, and yelloweye rockfishes in the GOA RACE-GAP summer bottom trawl survey (1993-2019) to support individual species life stage SDMs of habitat-related abundance to map EFH. Because of that, the three species have their own sections, and the rest of the species in the complex will be represented by the demersal subgroup information. The demersal subgroup of the Other Rockfish complex has higher abundance on the continental shelf of the eastern GOA. EFH of the demersal subgroup patchy areas in the central GOA south of the Kenai Peninsula, Kodiak Island, and the Shumagin Islands.

Habitat and Biological Associations: Other Rockfishes, Demersal Subgroup. Yelloweye rockfish has a separate table under Section D.8.3.3 for habitat and biological associations.

Species	Range/Depth	Maximum Age	Trophic	Parturition	Known Habitat
Quillback	Kodiak Island to San Miguel Island, CA to 274 m (commonly 12–76 m)	At least 32 size at 50 percent maturity=300 mm	main prey = crustaceans, herring, sandlance	spring (Mar–Jun)	Juveniles have been observed at the margins of kelp beds, adults occur over rock bottom, or over cobble/sand next to reefs.
Copper	Shelikof St to central Baja, CA shallow to 183 m (commonly to 122 m)	At least 31 years size at 50 percent maturity =5 yr	crustaceans octopuses small fishes	Mar–Jul	Juveniles have been observed near eelgrass beds and in kelp, in areas of mixed sand and rock. Adults are in rocky bays and shallow coastal areas, generally less exposed than the other demersal shelf rockfish.
Tiger	Kodiak Is and Prince William Sound to Tanner-Cortes Banks, CA from 33 to 183 m	to 116 years	invertebrates, primarily crustaceans	early spring	Juveniles and adults in rocky areas: most frequently observed in boulder areas, generally under overhangs.
China	Kachemak Bay to San Miguel Island, CA to 128 m	to 72 years	invertebrates, brittle stars are significant component of diet	Apr–Jun	Juveniles have been observed in shallow kelp beds, adults in rocky reefs and boulder fields. Some indications that adults have a homesite.
Rosethorn	Kodiak Is to Guadalupe Is, Baja, CA to 25 m to 549 m	to 87 years mature 7–10 years		Feb–Sept (May)	Observed over rocky habitats and in rock pavement areas with large sponge cover
Canary	Shelikof St to Cape Colnett, Baja, CA To 424 m (commonly to 137 m)	To 75 years size at 50 percent maturity = 9	macroplankton and small fishes		Occur over rocky and sand/cobble bottoms, often hovering in loose schools over soft bottom near rock outcrops. Schools often associate with schools of yellowtail and silvergrey.

Literature

Tribuzio, C. A., K. B. Echave, and K. Omori. 2021. Assessment of the Other Rockfish stock complex in the Gulf of Alaska. *In* Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Gulf of Alaska. North Pacific Fishery Management Council, 1007 West Third, Suite 400 Anchorage, AK 99501.

D.8.1 Quillback rockfish (*Sebastes mailger*)

D.8.1.1 Life History and General Distribution

These species are distributed from Anacapa Passage in southern California to the central GOA, and are most common from southeast Alaska to northern California (Love et al. 2002). Life history data for this species is based on studies from waters off Alaska and British Columbia, where quillback are reported mature at 290 mm length and 11 years age and live to a maximum of 95 years (Munk 2001, Love et al. 2002, Rooper 2008). Quillback rockfish are associated with the seafloor and prefer rocky, high-relief habitats with kelp cover, where they form a home site association (Love et al. 2002).

D.8.1.2 Relevant Trophic Information

The main prey of quillback rockfish are crustaceans, herring, and sandlance.

D.8.1.3 Habitat and Biological Associations

Settled Early Juveniles/Subadults: Juvenile and subadult quillback rockfish have been observed at the margins of kelp beds.

Adults: The EFH area mainly occurs on the continental shelf and inshore areas of the southeastern GOA. Otherwise, EFH for adult quillback rockfish is patchy throughout their range in the GOA. The covariates contributing the most to the final SDM EFH map for this life stage were bottom depth, bottom temperature, and bottom current speed (Pirtle et al. 2023). Higher abundance of adult quillback rockfish occurred at shallower depths throughout the survey area.

D.8.1.4 Literature

Love, M. S., M. Yoklavich, and L. Thorsteinson. 2002. The rockfishes of the Northeast Pacific. University of California Press, Berkeley and Los Angeles. 404 pgs.

Munk, K. M. 2001. Maximum ages of groundfishes in waters off Alaska and British Columbia and considerations of age determination. Alaska Fish. Res. Bull. 8: 12–21.

Pirtle, J. L., Laman, E. A., Harris, J., Siple, M. C., Rooper, C. N., Hurst, T. P., Conrath, C. L., and Gibson, G. A. 2023. Advancing model-based essential fish habitat descriptions for North Pacific species in the Gulf of Alaska. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-468, 541 p. https://doi.org/10.25923/ygdf-5f65

Rooper, C. N. 2008. An ecological analysis of rockfish (*Sebastes* spp.) assemblages in the North Pacific Ocean along broad-scale environmental gradients. Fish. Bull. 106: 1–11.

D.8.2 Rosethorn rockfish (*Sebastes helvomaculatus*)

D.8.2.1 Life History and General Distribution

Rosethorn rockfish are distributed from Baja California to near Sitkinak Island in the western GOA (Love et al. 2002). Life history data for this species is based on studies from waters off Alaska and British Columbia, where rosethorn rockfish are reported to mature at 215 mm length, living to a maximum age of 87 years (Munk 2001, Love et al. 2002, Rooper 2008). Rosethorn rockfish associate with seafloor structure, often in transitions between habitats of soft unconsolidated and rocky substrates (Love et al. 2002).

D.8.2.2 Relevant Trophic Information

There is insufficient information on rosethorn rockfish predator or prey relationships at this time.

D.8.2.3 Habitat and Biological Associations

Subadults: The covariates contributing the most to the final SDM EFH map for this life stage were geographic location, bottom depth, bottom temperature, and sponge presence (Pirtle et al. 2023). Higher abundance of subadult rosethorn rockfish occurred along the outer continental shelf of the eastern GOA in depths around 250 m in areas of low sponge presence.

Adults: The covariates contributing the most to the final SDM EFH map for this life stage were geographic location, bottom current, bottom temperature, and sponge presence (Pirtle et al. 2023). Similar to subadults, a higher abundance of adult rosethorn rockfish was predicted along the outer continental shelf of the eastern GOA at depths around 250 m in areas of low sponge presence.

D.8.2.4 Literature

Love, M. S., M. Yoklavich, and L. Thorsteinson. 2002. The rockfishes of the Northeast Pacific. University of California Press, Berkeley and Los Angeles. 404 pgs.

Munk, K. M. 2001. Maximum ages of groundfishes in waters off Alaska and British Columbia and considerations of age determination. Alaska Fish. Res. Bull. 8: 12–21.

Pirtle, J. L., Laman, E. A., Harris, J., Siple, M. C., Rooper, C. N., Hurst, T. P., Conrath, C. L., and Gibson, G. A. 2023. Advancing model-based essential fish habitat descriptions for North Pacific species in the Gulf of Alaska. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-468, 541 p. https://doi.org/10.25923/ygdf-5f65

Rooper, C. N. 2008. An ecological analysis of rockfish (*Sebastes* spp.) assemblages in the North Pacific Ocean along broad-scale environmental gradients. Fish. Bull. 106: 1–11.

D.8.3 Yelloweye rockfish *(Sebastes ruberrimus)*

D.8.3.1 Life History and General Distribution

Yelloweye rockfish are distributed from Ensenada, in northern Baja California, to Umnak Island and Unalaska Island, of the Aleutian Islands, in depths from 60 to 1,800 feet but commonly in 300 to 600 feet in rocky, rugged habitat (Allen and Smith 1988, Eschmeyer et al. 1983). Little is known about the young of the year and settlement. Young juveniles between 25 and 100 mm have been observed in areas of high and steep relief in depths deeper than 15 m. Subadult and adult fish are generally solitary, occurring in rocky areas and high relief with refuge space, particularly overhangs, caves, and crevices (O’Connell and Carlile 1993). Yelloweye are ovoviviparous. Parturition occurs in southeast Alaska between April and July with a peak in May (O’Connell 1987). Fecundity ranges from 1,200,000 to 2,700,000 eggs per season (Hart 1942, O’Connell, ADFG, personal communication). Yelloweye feed on a variety of prey, primarily fishes (including other rockfishes, herring, and sandlance) as well as caridean shrimp and small crabs. Yelloweye are a K-selected species with late maturation, slow growth, extreme longevity, and low natural mortality. They reach a maximum length of about 910 mm and growth slows considerably after age 30 years. Approximately 50 percent of females are mature at 450 mm and 22 years (Tribuzio et al. 2021). Natural mortality is estimated to be 0.02, and maximum age published is 118 years (O’Connell and Fujioka 1991, O’Connell and Funk 1987). However a 121-year-old specimen was harvested in the commercial fishery off Southeast Alaska in 2000.

D.8.3.2 Relevant Trophic Information

Yelloweye rockfish eat a large variety of organisms, primarily fishes including small rockfishes, herring, and sandlance as well as caridean shrimp and small crabs (Rosenthal et al. 1988). They also opportunistically consume lingcod eggs. Young rockfishes are in turn eaten by a variety of predators including lingcod, large rockfish, salmon, and halibut.

D.8.3.3 Habitat and Biological Associations

Settled early juveniles: Young juveniles between 25 (1 inch) and 100 mm (4 inches) have been observed in areas of high relief. This relief can be provided by the geology of an area such as vertical walls, fjord-like areas, and pinnacles, or by large invertebrates such as cloud sponges, *Farrea occa*, *Metridium farcimen*, and *Primnoa* coral. These observations were made in depths deeper than 13 m during the course of submersible research in the Eastern GOA (Southeast Alaska Groundfish Project, Alaska Department of Fish and Game, unpublished data).

Subadults: Subadult fish are generally solitary, occurring in rocky areas and high relief with refuge spaces particularly overhangs, caves and crevices (O'Connell and Carlile 1993), and can co-occur with gorgonian corals (Krieger and Wing 2002). The covariates contributing the most to the final SDM EFH map for this life stage were bottom depth, sponge presence, geographic position, and BPI (Pirtle et al. 2023). Higher abundance of subadult yelloweye was predicted around 125 m depth on bathymetric rises (BPI highs) in areas of low sponge presence on the GOA continental shelf.

Adults: Adults are similarly solitary and associate with habitat components listed for subadults. An adult yelloweye rockfish will cohabitate a cave or refuge space with a tiger rockfish. Habitat specific density data shows an increasing density with increasing habitat complexity: deep water boulder fields consisting of very large boulders have significantly higher densities than other rock habitats (O'Connell and Carlile 1993, O'Connell et al. 2007). Although yelloweye do occur over cobble and sand bottoms, generally this is when foraging and often these areas directly interface with a rock wall or outcrop. The covariates contributing the most to the final SDM EFH map for this life stage were bottom depth, geographic location, and seafloor rockiness (Pirtle et al. 2023). Higher abundance of adult yelloweye rockfish in the GOA was predicted around 125 m depth on bathymetric rises (BPI highs) with rocky substrate present.

Habitat and Biological Associations: Yelloweye 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	NA
Larvae	<6 mo	copepod	spring/ summer	U	N?	U	U	
Settled Early Juveniles	to 10 years	U		ICS, MCS, OCS, BAY, IP	D	R, C	U	
Subadults	10 to 18 years	U		ICS, MCS, OCS, BAY, IP	D	R, C	U	
Adults	at least 118 years	fish, shrimp, crab	parturition: Apr–Jul	ICS, MCS, OCS, USP, BAY, IP	D	R, C, CB	U	

D.8.3.4 Literature

Allen, M.J., and G.B. Smith. 1988. Atlas and zoogeography of common fishes in the Bering Sea and Northeast pacific. NOAA Tech. Rep. NMFS 66. Seattle.

Eschmeyer, W.N., E.S. Herald, and H. Hammann. 1983. A field guide to Pacific fishes of North America from the Gulf of Alaska to Baja California. Boston: Houghton Mifflin.

Hart, J.L. 1942. New Item. Red snapper fecundity. Fish. Res. Board. Can. Pac. Progr. Rep. 52: 18.

Krieger, K.J. and B.L. Wing. 2002. Megafauna associations with deepwater corals (*Primnoa* spp.) in the Gulf of Alaska. Hydrobiologia. Vol. 471 (1-3): 83-90.

O'Connell, V.M. 1987. Reproductive seasons for some Sebastes species in southeast Alaska. Alaska Department of Fish and Game Information Leaflet No. 263. Juneau, AK.

O'Connell, V.M., and D.C Carlile. 1993. Habitat-specific density of adult yelloweye rockfish Sebastes ruberrimus in the eastern GOA. Fishery Bull. 91:304-309.

O'Connell, V.M., and J.T. Fujioka. 1991. Demersal Shelf Rockfishes. In Loh-Lee Low (ed.), Status of living marine resources off Alaska as assessed in 1991, p. 46-47. NOAA Tech. Memo. NMFS F/NWC-211, Northwest Fish. Sci. Cent., Auke Bay AK 95 P.

O'Connell, V.M., and F.C. Funk. 1987. Age and growth of yelloweye rockfish (*Sebastes ruberrimus*) landed in southeast Alaska. In B.R. Melteff (ed.), Proceedings of the International Rockfish Symposium. p 171-185. Alaska Sea Grant Report No. 87-2.

O'Connell, V.M., C.K. Brylinsky, and H.G. Greene. 2007. The use of geophysical survey data in fisheries management: a case history from Southeast Alaska. In Mapping the Seafloor for Habitat Characterization. p 319-328. Geological Association of Canada Special paper 47.

Pirtle, J. L., Laman, E. A., Harris, J., Siple, M. C., Rooper, C. N., Hurst, T. P., Conrath, C. L., and Gibson, G. A. 2023. Advancing model-based essential fish habitat descriptions for North Pacific species in the Gulf of Alaska. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-468, 541 p. https://doi.org/10.25923/ygdf-5f65

Rosenthal, R.J., V. Moran-O'Connell, and M.C. Murphy. 1988. Feeding ecology of ten species of rockfishes (Scorpaenidae) from the GOA. Calif. Fish and Game 74(1):16-37.

Tribuzio, C. A., K. B. Echave, and K. Omori. 2021. Assessment of the Other Rockfish stock complex in the Gulf of Alaska. *In* Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Gulf of Alaska. North Pacific Fishery Management Council, 1007 West Third, Suite 400 Anchorage, AK 99501.

D.9 Other Rockfish complex, slope subgroup

Species Complex Summary

The slope subgroup of the GOA Other Rockfish (OR) stock complex includes the following species: aurora, blackgill, darkblotched, greenstriped, harlequin, northern, pygmy, redbanded, redstripe, sharpchin, shortbelly, silvergray, splitnose, stripetail, vermilion, widow, yellowmouth, yellowtail rockfishes, boccacio, and chilipepper (Tribuzio et al 2021). Northern rockfish are only included in this complex in the eastern GOA, and their EFH is described and mapped separately from the GOA OR complex. Greenstriped, harlequin, pygmy, redbanded, redstripe, sharpchin, and silvergray rockfishes were common enough (N > 50) in GOA RACE-GAP summer bottom trawl survey catches (1993–2019) to support individual species life stage SDMs of habitat-related abundance to map EFH and are included here in the complex. Adult Other Rockfish complex species have high abundances on the outer continental shelf and upper slope of the eastern GOA. EFH hot spots were along the eastern and central GOA continental shelf and extended on the outer continental shelf and upper slope westward.

Literature

Tribuzio, C. A., K. B. Echave, and K. Omori. 2021. Assessment of the Other Rockfish stock complex in the Gulf of Alaska. *In* Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Gulf of Alaska. North Pacific Fishery Management Council, 1007 West Third, Suite 400 Anchorage, AK 99501.

D.9.1 Greenstriped rockfish (*Sebastes elongatus*)

D.9.1.1 Life History and General Distribution

Greenstriped rockfish (*Sebastes elongatus*) are distributed from southern California to Chirikof Island in the western GOA (Love et al. 2002). This species was not caught by the GOA RACE-GAP summer bottom trawl survey west of Kayak Island. Based on data from Washington and Oregon, greenstriped rockfish reach maturity at 220 mm length andlive up to 54 years (Love et al. 2002). They have an ontogenetic shift to deeper habitats where they are observed solitary and resting near a variety of benthic habitats (Love et al. 2002). Their adult distribution is concentrated in the eastern GOA off southeast Alaska.

D.9.1.2 Relevant Trophic Information

There is insufficient information on greenstriped rockfish predator or prey relationships at this time.

D.9.1.3 Habitat and Biological Associations

Adults: The covariates contributing the most to the final SDM EFH map for this life stage were geographic location, bottom depth, and bottom temperature (Pirtle et al. 2023). Higher abundance of adult greenstriped rockfish occurred on the eastern GOA continental shelf off southeast Alaska with peak at depths < 200m.

D.9.1.4 Literature

Love, M. S., M. Yoklavich, and L. Thorsteinson. 2002. The rockfishes of the Northeast Pacific. University of California Press, Berkeley and Los Angeles. 404 pgs.

Pirtle, J. L., Laman, E. A., Harris, J., Siple, M. C., Rooper, C. N., Hurst, T. P., Conrath, C. L., and Gibson, G. A. 2023. Advancing model-based essential fish habitat descriptions for North Pacific species in the Gulf of Alaska. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-468, 541 p. https://doi.org/10.25923/ygdf-5f65

D.9.2 Harlequin rockfish (*Sebastes variegatus*)

D.9.2.1 Life History and General Distribution

Harlequin rockfish (*Sebastes variegatus*) are found from the Oregon coast to the western Aleutian Islands (Love et al. 2002). They one of the six most common Other Rockfish complex species by survey catch or biomass, although uncommon in the BSAI (Tribuzio et al. 2021, Sullivan et al. 2022). Life history data collected in waters off Alaska describes harlequin rockfish as a relatively small species in the complex, becoming mature at a length of 188 mm and age of 4.5 years, but they can live as long as 72 years (Tribuzio et al. 2021, Tenbrink and Helser 2021). Harlequin rockfish associate with the seafloor in both trawlable and untrawlable habitats, and they have a associate with rocky and rugged habitats (Rooper et al. 2012a, Jones et al. 2021).

Subadult harlequin rockfish are distributed in the eastern and central GOA with some found on the outer continental shelf south of Kodiak Island through the western GOA. Adults are distributed along the outer continental shelf and upper slope.

D.9.2.2 Relevant Trophic Information

There is insufficient information on harlequin rockfish predator or prey relationships at this time.

D.9.2.3 Habitat and Biological Associations

Subadults: The covariates contributing the most to the final SDM EFH map for this life stage were geographic location, bottom depth, and sponge presence (Pirtle et al. 2023). Subadult harlequin rockfish abundance was higher in the central and eastern GOA at shallower depths on the continental shelf.

Adults: The covariates contributing the most to the final SDM EFH map for this life stage were bottom depth, geographic location, and seafloor rockiness (Pirtle et al. 2023). Adult harlequin rockfish abundance was higher around 200 m depth along the outer continental shelf and upper slope in the eastern and central GOA and west of Kodiak Island. They associate with rocky substrates.

D.9.2.4 Literature

Jones, D., C. N. Rooper, C. D. Wilson, P. D. Spencer, D. H. Hanselman, and R. E. Wilborn. 2021. Estimates of availability and catchability for select rockfish species based on acoustic-optic surveys in the Gulf of Alaska. Fish. Res. 236.

Love, M. S., M. Yoklavich, and L. Thorsteinson. 2002. The rockfishes of the Northeast Pacific. University of California Press, Berkeley and Los Angeles. 404 pgs.

Pirtle, J. L., Laman, E. A., Harris, J., Siple, M. C., Rooper, C. N., Hurst, T. P., Conrath, C. L., and Gibson, G. A. 2023. Advancing model-based essential fish habitat descriptions for North Pacific species in the Gulf of Alaska. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-468, 541 p. https://doi.org/10.25923/ygdf-5f65

Rooper, C. N., M. H. Martin, J. L. Butler, D. T. Jones, and M. Zimmerman. 2012a. Estimating species and size composition of rockfishes to verify targets in acoustic surveys of untrawlable areas. Fishery Bulletin 110 (3): 317–331.

Sullivan, J., M. Callahan, A. Kingham, T. Tenbrink, I. Ortiz, E. Siddon, and P. Spencer. 2022. Assessment of the Other Rockfish stock complex in the Bering Sea/Aleutian Islands. ***In*** Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Bering Sea/Aleutian Islands Regions. North Pacific Fishery Management Council, 1007 West Third, Suite 400 Anchorage, AK 99501.

Tenbrink, T. T., and T. E. Helser. 2021. Reproductive biology, size, and age structure of harlequin rockfish: spatial analysis of life history traits. Mar. Coast. Fish. 13 (5): 463–477. https://doi.org/10.1002/mcf2.10172

Tribuzio, C. A., K. B. Echave, and K. Omori. 2021. Assessment of the Other Rockfish stock complex in the Gulf of Alaska. *In* Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Gulf of Alaska. North Pacific Fishery Management Council, 1007 West Third, Suite 400 Anchorage, AK 99501.

D.9.3 Pygmy rockfish (*Sebastes wilsoni*)

D.9.3.1 Life History and General Distribution

Pygmy rockfish (*Sebastes wilsoni*) are distributed from southern California to the central GOA (Love et al. 2002). Life history data is limited, but observations note a maximum observed size of 260 mm and a maximum age of 26 years based on studies south of Alaska (Love et al. 2002). Pygmy rockfish are thought to be most closely related to harlequin and Puget Sound rockfishes, with lengths at maturity of 190 mm and 130 mm, respectively. This species is often observed in large schools over rocky habitat and closely associated with structural invertebrate cover such as crinoids, sponges, and soft corals (Love et al. 2002, Pirtle 2005). Their distribution is primarily east of Kodiak Island. Hot spots of their distribution are on the continental shelf south of the Kenai Peninsula, Portlock bank, the Fairweather grounds and off southeast Alaska (Pirtle et al. 2023).

D.9.3.2 Relevant Trophic Information

There is insufficient information on pygmy rockfish predator or prey relationships at this time.

D.9.3.3 Habitat and Biological Associations

Subadults: Because length at maturity information for pygmy rockfish is insufficient, all subadults and adults were combined in SDMs of habitat-related abundance to map EFH. The model results are reported with the adult pygmy rockfish, below.

Adults: The covariates contributing the most to the final SDM EFH map for the combined life stages of subadult and adult pygmy rockfish were seafloor rockiness and geographic location (Pirtle et al. 2023).

Pygmy rockfish abundance was higher at depths < 250 m with rocky substrate present on the continental shelf of the eastern GOA off southeast Alaska and some higher abundance areas in the central GOA..

D.9.3.4 Literature

Love, M. S., M. Yoklavich, and L. Thorsteinson. 2002. The rockfishes of the Northeast Pacific. University of California Press, Berkeley and Los Angeles. 404 pgs.

Pirtle, J. L. 2005. Habitat-based assessment of structure-forming megafaunal invertebrates and fishes on Cordell Bank, California. 6-10. M.S. thesis, Washington State University. Available at: https://www.benthicecology.org/s/Pirtle-2005-MS_Thesis.pdf.

Pirtle, J. L., Laman, E. A., Harris, J., Siple, M. C., Rooper, C. N., Hurst, T. P., Conrath, C. L., and Gibson, G. A. 2023. Advancing model-based essential fish habitat descriptions for North Pacific species in the Gulf of Alaska. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-468, 541 p. https://doi.org/10.25923/ygdf-5f65

D.9.4 Redbanded rockfish (*Sebastes babcocki*)

D.9.4.1 Life History and General Distribution

Redbanded rockfish (*Sebastes babcocki*) are distributed from southern California to the Aleutian Islands and Bering Sea canyons (Love et al. 2002). Redbanded rockfish mature at a length of 420 mm and 19 years age and can live as long as 106 years (Love et al. 2002, Munk 2001, Tribuzio et al. 2021). This species associates with the seafloor in rocky or mixed substrate type habitats (Love et al. 2002).

D.9.4.2 Relevant Trophic Information

There is insufficient information on redbanded rockfish predator or prey relationships at this time.

D.9.4.3 Habitat and Biological Associations

Subadults: The covariates contributing the most to the final SDM EFH map for this life stage were bottom depth, geographic location, slope, and seafloor rockiness (Pirtle et al. 2023). Subadult redbanded rockfish abundance was higher around 250 m depth in and around glacial troughs, as well as along the outer continental shelf and upper slope of the eastern GOA.

Adults: The covariates contributing the most to the final SDM EFH map for this life stage were bottom depth, geographic position, and bottom temperature (Pirtle et al. 2023). Adult redbanded rockfish abundance was higher around 250 m depth with moderate current exposure in the eastern GOA off southeast Alaska in and around glacial troughs. Abundance was also high on the outer continental shelf and upper slope.

D.9.4.4 Literature

Love, M. S., M. Yoklavich, and L. Thorsteinson. 2002. The rockfishes of the Northeast Pacific. University of California Press, Berkeley and Los Angeles. 404 pgs.

Munk, K. M. 2001. Maximum ages of groundfishes in waters off Alaska and British Columbia and considerations of age determination. Alaska Fish. Res. Bull. 8: 12–21.

Pirtle, J. L., Laman, E. A., Harris, J., Siple, M. C., Rooper, C. N., Hurst, T. P., Conrath, C. L., and Gibson, G. A. 2023. Advancing model-based essential fish habitat descriptions for North Pacific species in the Gulf of Alaska. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-468, 541 p. https://doi.org/10.25923/ygdf-5f65

Tribuzio, C. A., K. B. Echave, and K. Omori. 2021. Assessment of the Other Rockfish stock complex in the Gulf of Alaska. *In* Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Gulf of Alaska. North Pacific Fishery Management Council, 1007 West Third, Suite 400 Anchorage, AK 99501.

D.9.5 Redstriped rockfish (*Sebastes proriger*)

D.9.5.1 Life History and General Distribution

Redstripe rockfish (*Sebastes proriger*) are distributed from southern California to the western Aleutian Islands and to Pribilof Island in the Bering Sea (Love et al. 2002). Representative life history data report juvenile female maximum length as 290 mm (Rooper 2008). The maximum age for redstripe rockfish is 41 years (Tribuzio et al. 2021). Redstripe rockfish usually occur in high-relief and rugged seafloor habitats, where they associate with complex physical and biogenic structure (Love et al. 2002). Subadult and adults distributions as from southeast Alaska to the western GOA, with higher abundances off southeast Alaska. Subadult EFH hotspots were in the eastern GOA while adult EFH hotspots were prevalent on the outer continental shelf of the eastern GOA, central GOA south of the Kenai Peninsula, and some areas in the western GOA (Pirtle et al. 2023).

D.9.5.2 Relevant Trophic Information

There is insufficient information on redstriped rockfish predator or prey relationships at this time.

D.9.5.3 Habitat and Biological Associations

Subadults: The covariates contributing the most to the final SDM EFH map for this life stage were geographic position, bottom depth, and rockiness (Pirtle et al. 2023). Subadult redstripe rockfish abundance was higher around 200 m depth with rocky substrate present on the continental shelf of the southeastern GOA. The central GOA south of the Kenai Peninsula and areas on the outer continental shelf further west also contain patchy areas of high subadult abundance.

Adults: The covariates contributing the most to the final SDM EFH map for this life stage were geographic location, bottom depth, and rockiness (Pirtle et al. 2023). Adult redstripe rockfish abundance was higher around 200 m depth with rocky substrate present on the continental shelf of the southeastern GOA (Fig. 234). However, patchy areas of high abundance occurred in the central GOA south of the Kenai Peninsula and areas on the outer continental shelf of the western GOA.

D.9.5.4 Literature

Love, M. S., M. Yoklavich, and L. Thorsteinson. 2002. The rockfishes of the Northeast Pacific. University of California Press, Berkeley and Los Angeles. 404 pgs.

Pirtle, J. L., Laman, E. A., Harris, J., Siple, M. C., Rooper, C. N., Hurst, T. P., Conrath, C. L., and Gibson, G. A. 2023. Advancing model-based essential fish habitat descriptions for North Pacific species in the Gulf of Alaska. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-468, 541 p. https://doi.org/10.25923/ygdf-5f65

Rooper, C. N. 2008. An ecological analysis of rockfish (*Sebastes* spp.) assemblages in the North Pacific Ocean along broad-scale environmental gradients. Fish. Bull. 106: 1–11.

Tribuzio, C. A., K. B. Echave, and K. Omori. 2021. Assessment of the Other Rockfish stock complex in the Gulf of Alaska. *In* Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Gulf of Alaska. North Pacific Fishery Management Council, 1007 West Third, Suite 400 Anchorage, AK 99501.

D.9.6 Sharpchin rockfish (*Sebastes zacentrus*)

D.9.6.1 Life History and General Distribution

Sharpchin rockfish (*Sebastes zacentrus*) are distributed from southern California to the western Aleutian Islands and to Pribilof Island in the Bering Sea (Love et al. 2002). Representative life history data describes sharpchin rockfish maturing at 265 mm and 10 years of age, and living as long as 58 years (Malecha et al. 2007, Tribuzio et al. 2021). Sharpchin rockfish are often observed in groups within sponge-covered boulder fields and habitats of scattered cobbles and boulders with sponges (Love et al.

2002, Pirtle 2005). Both subadults and adults are primarily distributed in the eastern and central GOA (Pirtle et al. 2023).

D.9.6.2 Relevant Trophic Information

There is insufficient information on sharpchin rockfish predator or prey relationships at this time.

D.9.6.3 Habitat and Biological Associations

Subadults: The covariates contributing the most to the final SDM EFH map for this life stage were geographic location, bottom depth, sponge presence, and rockiness (Pirtle et al. 2023). Subadult sharpchin rockfish abundance was higher around 200 m depth with rocky substrate and low presence of sponges on the outer continental shelf of the GOA east of Kodiak Island.

Adults: The covariates contributing the most to the final SDM EFH map for this life stage were bottom depth, geographic location, and rockiness (Pirtle et al. 2023). Adult sharpchin rockfish abundance was highest at around 200 m depth on the outer continental shelf of the GOA east of Kodiak Island.

D.9.6.4 Literature

Love, M. S., M. Yoklavich, and L. Thorsteinson. 2002. The rockfishes of the Northeast Pacific. University of California Press, Berkeley and Los Angeles. 404 pgs.

Malecha, P.W., D.H. Hanselman, and J. Heifetz. 2007. Growth and mortality of rockfish (Scorpaenidae) from Alaska waters. U.S. Dept. Commer., NOAA Tech. Memo. NMFS F/AFSC-172. 61 p.

Pirtle, J. L. 2005. Habitat-based assessment of structure-forming megafaunal invertebrates and fishes on Cordell Bank, California. 6-10. M.S. thesis, Washington State University. Available at: https://www.benthicecology.org/s/Pirtle-2005-MS_Thesis.pdf.

Pirtle, J. L., Laman, E. A., Harris, J., Siple, M. C., Rooper, C. N., Hurst, T. P., Conrath, C. L., and Gibson, G. A. 2023. Advancing model-based essential fish habitat descriptions for North Pacific species in the Gulf of Alaska. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-468, 541 p. https://doi.org/10.25923/ygdf-5f65

Tribuzio, C. A., K. B. Echave, and K. Omori. 2021. Assessment of the Other Rockfish stock complex in the Gulf of Alaska. *In* Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Gulf of Alaska. North Pacific Fishery Management Council, 1007 West Third, Suite 400 Anchorage, AK 99501.

D.9.7 Silvergray rockfish (*Sebastes brevispinis*)

D.9.7.1 Life History and General Distribution

Silvergray rockfish (*Sebastes brevispinis*) are found from Baja California to around Sanak Island in the western GOA (Love et al. 2002). Silvergray rockfish were recorded with an average maximum juvenile length of 405 mm and a maximum age of 75 years (Rooper 2008, Tribuzio et al. 2021). Silvergray rockfish associate with various high-relief and rugged rocky habitats generally off the seafloor and are often observed with species that have similar behavior, such as canary, dusky, widow, and yellowtail rockfishes (Love et al. 2002, Bosley et al. 2004, Jones et al. 2012). Subadults occur from southeast Alaska west to the Shumagin Islands; adult silvergray rockfish have a similar distribution and their highest abundance catches are off southeast Alaska (Pirtle et al. 2023).

D.9.7.2 Relevant Trophic Information

There is insufficient information on silvergray rockfish predator or prey relationships at this time.

D.9.7.3 Habitat and Biological Associations

Subadults: The covariates contributing the most to the final SDM EFH map for this life stage were geographic location, bottom depth, and rockiness (Pirtle et al. 2023). Subadult silvergray rockfish abundance was highest around 200 m depth in areas with rocky substrate present in the eastern GOA off southeast Alaska.

Adults: The covariates contributing the most to the final SDM EFH map for this life stage were geographic location, bottom depth, and bottom current variability (Pirtle et al. 2023). Higher adult silvergray rockfish abundance occurred around 200 m depth in the eastern GOA off southern southeast Alaska.

D.9.7.4 Literature

Bosley, K. L., J. W. Lavelle, R. D. Brodeur, W. W. Wakefield, R. L. Emmett, E. T. Baker, and K. M. Rehmke. 2004. Biological and physical processes in and around Astoria submarine Canyon, Oregon, USA. Journal of Marine Systems. 50: 21–37.

Jones, D., C. N. Rooper, C. D. Wilson, P. D. Spencer, D. H. Hanselman, and R. E. Wilborn. 2021. Estimates of availability and catchability for select rockfish species based on acoustic-optic surveys in the Gulf of Alaska. Fish. Res. 236.

Love, M. S., M. Yoklavich, and L. Thorsteinson. 2002. The rockfishes of the Northeast Pacific. University of California Press, Berkeley and Los Angeles. 404 pgs.

Pirtle, J. L., Laman, E. A., Harris, J., Siple, M. C., Rooper, C. N., Hurst, T. P., Conrath, C. L., and Gibson, G. A. 2023. Advancing model-based essential fish habitat descriptions for North Pacific species in the Gulf of Alaska. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-468, 541 p. https://doi.org/10.25923/ygdf-5f65

Rooper, C. N. 2008. An ecological analysis of rockfish (*Sebastes* spp.) assemblages in the North Pacific Ocean along broad-scale environmental gradients. Fish. Bull. 106: 1–11.

Tribuzio, C. A., K. B. Echave, and K. Omori. 2021. Assessment of the Other Rockfish stock complex in the Gulf of Alaska. *In* Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Gulf of Alaska. North Pacific Fishery Management Council, 1007 West Third, Suite 400 Anchorage, AK 99501.

D.10 Pacific cod (*Gadus macrocephalus*)

D.10.1 Life History and General Distribution

Pacific cod is a transoceanic species, occurring at depths from shoreline to 500 m. The southern limit of the species' distribution is about latitude 34° N. with a northern limit of about latitude 63° N. Adults are largely demersal and form aggregations during the peak spawning season, which extends approximately from January through May. Pacific cod eggs are demersal and adhesive. Eggs hatch in about 15 to 20 days. Little is known about the distribution of Pacific cod larvae, which 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 1 m in length, with weights in excess of 10 kilogram (kg). Natural mortality is currently estimated to be 0.47 in the GOA, as opposed to 0.34 in the BSAI. Approximately 50 percent of Pacific cod are mature by age 4 in the GOA, compared to age 5 in the BSAI. The maximum recorded age of a Pacific cod in the GOA is 14 years. Subadults and adults are delineated at 503 mm length (Stark 2007).

D.10.2 Relevant Trophic Information

Pacific cod are omnivorous. In terms of percent occurrence, the most important items in the diet of Pacific cod in the GOA are polychaetes, crangonid shrimp, and pandalid shrimp. In terms of numbers of individual organisms consumed, the most important dietary items are euphausiids, cumacea shrimp, and walleye pollock. In terms of weight of organisms consumed, the most important dietary items are walleye pollock, Tanner crabs, and pandalid shrimp. Small Pacific cod feed mostly on invertebrates, while large Pacific cod are mainly piscivorous. Predators of Pacific cod include halibut, salmon shark, northern fur seals, sea lions, harbor porpoises, various whale species, and tufted puffin.

D.10.3 Habitat and Biological Associations

Egg/Spawning: Spawning takes place in the sublittoral-bathyal zone (40 to 290 m) near the bottom. 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 parts per thousand (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. The covariate contributing the most to the final SDM EFH map for this life stage was bottom depth (Pirtle et al. 2023). The highest probabilities of suitable habitat for early juvenile Pacific cod in the GOA were predicted to occur in nearshore areas and around islands throughout the GOA. Habitat-related growth potential for this life stage is greater at inshore and coastal areas as well as on banks and bathymetric rises on the GOA continental shelf.

Subadults: The covariates contributing the most to the final SDM EFH map for this life stage were bottom depth, geographic location, and tidal currents (Pirtle et al. 2023). The highest subadult Pacific cod abundances were predicted west of the Kenai Peninsula on bathymetric rises in the central and western GOA, with hot spots on the banks south of Kodiak and the Shumagin islands.

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, however mature fish are not limited to a specific depth range and their distribution is thought to change seasonally. Preferred substrate is soft sediment, from mud and clay to sand. The covariates contributing the most to the final SDM EFH map for this life stage were bottom depth, geographic location, and bottom temperature (Pirtle et al. 2023). Adult Pacific cod abundance predicted from the ensemble was highest at depths less than 175 m on bathymetric rises west of the Kenai Peninsula.

Habitat and Biological Associations: Pacific cod

Stage - EFH Level	Duration or Age	Diet/Prey	Season/ Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs	15 to 20 days	NA	winter–spring	ICS, MCS, OCS	D	M, SM, MS, S	U	optimum 3–6 °C optimum salinity 13–23 ppt
Larvae	U	copepods?	winter–spring	U	P?, N?	U	U	
Early Juveniles Pelagic	to 2 years	small invertebrates (euphausiids, mysids, shrimp)	all year	ICS, MCS	D	M, SM, MS, S	U	
Early Juveniles Settled/Subadults	to 5 years	crab, shrimp, euphausiids	all year	ICS, MCS, OCS	D	M, SM, MS, S	U	
Adults	5+ yr	pollock, crab, pandalid shrimp, and other fish	spawning (Jan–May) non-spawning (Jun–Dec)	ICS, MCS, OCS ICS, MCS, OCS	D	M, SM, MS, S,G	U	

D.10.4 Literature

Abookire, A.A., J.T. Duffy-Anderson, and C.M. Jump. 2007. Habitat associations and diet of young-of-the-year Pacific cod (*Gadus macrocephalus*) near Kodiak, Alaska. Marine Biology 150:713-726.

Albers, W.D., and P.J. Anderson. 1985. Diet of Pacific cod, *Gadus macrocephalus*, and predation on the northern pink shrimp, *Pandalus borealis*, in Pavlof Bay, Alaska. Fish. Bull., U.S. 83:601-610.

Alderdice, D.F., and C.R. Forrester. 1971. Effects of salinity, temperature, and dissolved oxygen on early development of the Pacific cod (*Gadus macrocephalus*). J. Fish. Res. Board Can. 28:883-902.

Bakkala, R.G. 1984. Pacific cod of the EBS. Int. N. Pac. Fish. Comm. Bull. 42:157-179.

Brodeur, R.D., and W. C. Rugen. 1994. Diel vertical distribution of ichthyoplankton in the northern Gulf of Alaska. Fish. Bull., U.S. 92:223-235.

Dunn, J.R., and A.C. Matarese. 1987. A review of the early life history of northeast Pacific gadoid fishes. Fish. Res. 5:163-184.

Forrester, C.R., and D.F. Alderdice. 1966. Effects of salinity and temperature on embryonic development of Pacific cod (*Gadus macrocephalus*). J. Fish. Res. Board Can. 23:319-340.

Hirschberger, W.A., and G.B. Smith. 1983. Spawning of twelve groundfish species in Alaska and Pacific Coast regions, 1975-81. U.S. Dept. Commerce, NOAA Tech. Memo. NMFS F/NWC-44. 50 p.

Hurst, T.P., D.W. Cooper, J.S. Scheingross, E.M. Seale, B.J. Laurel, and M.L. Spencer. 2009. Effects of ontogeny, temperature, and light on vertical movements of larval Pacific cod (*Gadus macrocephalus).* Fisheries Oceanography 18:301-311.

Ketchen, K.S. 1961. Observations on the ecology of the Pacific cod (*Gadus macrocephalus*) in Canadian waters. J. Fish. Res. Board Can. 18:513-558.

Laurel, B.J., T.P. Hurst, L.A. Copeman, and M. W. Davis. 2008. The role of temperature on the growth and survival of early and late hatching Pacific cod larvae (*Gadus macrocephalus*). Journal of Plankton Research 30:1051-1060.

Laurel, B.J., C.H. Ryer, B. Knoth, and A.W. Stoner. 2009. Temporal and ontogenetic shifts in habitat use of juvenile Pacific cod (*Gadus macrocephalus*). Journal of Experimental Marine Biology and Ecology 377:28-35.

Laurel, B.J., A.W. Stoner, C.H. Ryer, T.P. Hurst, and A.A. Abookire. 2007. Comparative habitat associations in juvenile Pacific cod and other gadids using seines, baited cameras and laboratory techniques. 2007. Journal of Experimental Marine Biology and Ecology 351:42-55.

Livingston, P.A. 1989. Interannual trends in Pacific cod, *Gadus macrocephalus*, predation on three commercially important crab species in the EBS. Fish. Bull., U.S. 87:807-827.

Livingston, P.A. 1991. Pacific cod. *In* P.A. Livingston (editor), Groundfish food habits and predation on commercially important prey species in the EBS from 1984 to 1986, p. 31-88. U.S. Dept. Commer., NOAA Tech. Memo. NMFS F/NWC-207.

Matarese, A.C., A.W. Kendall Jr., D.M. Blood, and B.M. Vinter. 1989. Laboratory guide to early life history stages of northeast Pacific fishes. U.S. Dept. Commerce, NOAA Tech. Rep. NMFS 80. 652 p.

Moiseev, P.A. 1953. Cod and flounders of far eastern waters. Izv. Tikhookean. Nauchno-issled. Inst. Rybn. Khoz. Okeanogr. 40. 287 p. (Transl. from Russian: Fish. Res. Board Can. Transl. Ser. 119.)

NOAA. 1987. Bering, Chukchi, and Beaufort Seas--Coastal and ocean zones strategic assessment: Data Atlas. U.S. Dept. Commerce, NOAA, National Ocean Service.

NOAA. 1990. West coast of North America--Coastal and ocean zones strategic assessment: Data Atlas. U.S. Dept. Commerce, NOAA, National Ocean Service and NMFS.

Phillips, A.C., and J.C. Mason. 1986. A towed, self-adjusting sld sampler for demersal fish eggs and larvae. Fish. Res. 4:235-242.

Pirtle, J. L., Laman, E. A., Harris, J., Siple, M. C., Rooper, C. N., Hurst, T. P., Conrath, C. L., and Gibson, G. A. 2023. Advancing model-based essential fish habitat descriptions for North Pacific species in the Gulf of Alaska. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-468, 541 p. https://doi.org/10.25923/ygdf-5f65

Poltev, Yu.N. 2007. Specific features of spatial distribution of Pacific cod Gadus macrocephalus in waters off the eastern coast of the northern Kuril Islands and the southern extremity of Kamchatka. Journal of Ichthyology 47:726-738.

Rugen, W.C., and A.C. Matarese. 1988. Spatial and temporal distribution and relative abundance of Pacific cod (*Gadus macrocephalus*) larvae in the western GOA. NWAFC Proc. Rep. 88-18. Available from Alaska Fish. Sci. Center, 7600 Sand Point Way NE., Seattle, WA 98115-0070.

Savin, A.B. 2008. Seasonal distribution and migrations of Pacific cod *Gadus macrocephalus* (Gadidae) in Anadyr Bay and adjacent waters. Journal of Ichthyology 48:610-621.

Shi, Y., D. R. Gunderson, P. Munro, and J. D. Urban. 2007. Estimating movement rates of Pacific cod (*Gadus macrocephalus*) in the Bering Sea and the Gulf of Alaska using mark-recapture methods. NPRB Project 620 Final Report. North Pacific Research Board, 1007 West 3rd Avenue, Suite 100, Anchorage, AK 99501.

Stark, J. W., 2007. Geographic and seasonal variations in maturation and growth of female Pacific cod (Gadus macrocephalus) in the Gulf of Alaska and Bering Sea. Fish. Bull. 105 (3): 396–407.

Stone, R.P. 2006. Coral habitat in the Aleutian Islands of Alaska: depth distribution, fine-scale species associations, and fisheries interactions. Coral Reefs 25:229-238.

Thompson, G., J. Ianelli, R. Lauth, S. Gaichas, and K. Aydin. 2008. Assessment of the Pacific cod stock in the Eastern Bering Sea and Aleutian Islands Area. *In* Plan Team for the Groundfish Fisheries of the Bering Sea and Aleutian Islands (compiler), *Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Bering Sea/Aleutian Islands Regions,* p. 221-401. North Pacific Fishery Management Council, 605 West 4th Avenue, Suite 306, Anchorage, AK 99501.

Thompson, G., J. Ianelli, and M. Wilkins. 2008. Assessment of the Pacific cod stock in the Gulf of Alaska. *In* Plan Team for the Groundfish Fisheries of the Gulf of Alaska (compiler), *Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Gulf of Alaska*, p. 169-301. North Pacific Fishery Management Council, 605 West 4th Avenue, Suite 306, Anchorage, AK 99501.

Westrheim, S.J. 1996. On the Pacific cod (*Gadus macrocephalus*) in British Columbia waters, and a comparison with Pacific cod elsewhere, and Atlantic cod (*G. morhua*). Can. Tech. Rep. Fish. Aquat. Sci. 2092. 390 p.

Yeung, C., and R.A. McConnaughey. 2008. Using acoustic backscatter from a sidescan sonar to explain fish and invertebrate distributions: a case study in Bristol Bay, Alaska. ICES Journal of Marine Science 65:242-254.

D.11 Pacific ocean perch (*Sebastes alutus*)

D.11.1 Life History and General Distribution

Pacific ocean perch (*Sebastes alutus*) have 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 GOA, and the Aleutian Islands (Allen and Smith 1988). Adults are found primarily offshore on the outer continental shelf and the upper continental slope in depths from 150 to 420 m. Seasonal differences in depth distribution have been noted by many investigators. In the summer, adults inhabit shallower depths, especially those between 150 and 300 m. In the fall, the fish apparently migrate farther offshore to depths from approximately 300 to 420 m. They reside in these deeper depths until about May, when they return to their shallower summer distribution (Love et al. 2002). 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 shelf and slope, most of the population occurs in patchy, localized aggregations (Hanselman et al. 2001). Pacific ocean perch are generally considered to be semi-demersal, but there can be a significant pelagic component to their distribution. Pacific ocean perch often move off-bottom at night to feed, apparently following diel euphausiid migrations. Commercial fishing data in the GOA since 1995 show that pelagic trawls fished off-bottom have accounted for as much as 20 percent of the annual harvest of this species.

There is much uncertainty about the life history of Pacific ocean perch, although generally more is known than for other rockfish species (Kendall and Lenarz 1986). The species appears to be viviparous (the eggs develop internally and receive at least some nourishment from the mother), 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 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. Pacific ocean perch larvae are thought to be pelagic and drift with the current. Oceanic conditions may sometimes cause advection to suboptimal areas (Ainley et al. 1993), resulting in high recruitment variability. However, larval studies of rockfish have been hindered by difficulties in species identification since many larval rockfish species share the same morphological characteristics (Kendall 2000). Genetic techniques using allozymes (Seeb and Kendall 1991) and mitochondrial DNA (Li 2004) are capable of identifying larvae and juveniles to species, but are expensive and time-consuming. Post-larval and early young-of-the-year Pacific ocean perch have been positively identified in offshore, surface waters of the GOA (Gharrett et al. 2002), which suggests this may be the preferred habitat of this life stage. Transformation to a demersal existence may take place within the first year (Carlson and Haight 1976). Small juveniles probably reside inshore in very rocky, high relief areas and begin to migrate to deeper offshore waters of the continental shelf by age 3 (Carlson and Straty 1981). As they grow, they continue to migrate deeper, eventually reaching the continental slope, where they attain adulthood.

Pacific ocean perch is a slow growing species, with a low rate of natural mortality (estimated at 0.06), a relatively old age at 50 percent maturity (10.5 years for females in the GOA), and a very old maximum age of 98 years in Alaska (84 years maximum age in the GOA) (Hanselman et al. 2007a). Age at 50 percent recruitment to the commercial fishery has been estimated to be between 7 and 8 years in the GOA. 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 (Leaman 1991). Adult Pacific ocean perch are estimated at > 250 mm length (Rooper 2008).

D.11.2 Relevant Trophic Information

Pacific ocean perch are mostly planktivorous (Carlson and Haight 1976, Yang 1993, 1996, Yang and Nelson 2000, Yang 2003). In a sample of 600 juvenile perch stomachs, Carlson and Haight (1976) found that juveniles fed on an equal mix of calanoid copepods and euphausiids. Larger juveniles and adults fed primarily on euphausiids and, to a lesser degree, on copepods, amphipods, and mysids (Yang and Nelson 2000). In the Aleutian Islands, myctophids have increasingly comprised a substantial portion of the Pacific ocean perch diet, which also compete for euphausiid prey (Yang 2003). 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 GOA in the 1960s may have allowed walleye pollock stocks to greatly expand in abundance.

Pacific ocean perch predators are likely sablefish, Pacific halibut, and sperm whales (Major and Shippen 1970). Juveniles are consumed by seabirds (Ainley et al. 1993), other rockfish (Hobson et al. 2001), salmon, lingcod, and other large demersal fish.

D.11.3 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 from 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. More recent data from British Columbia indicates that larvae may remain at depths of 175 m for some period of time (perhaps 2 months), after which they slowly migrate upward in the water column.

Pelagic Early Juveniles: A recent, preliminary study has identified Pacific ocean perch in these life stages from samples collected in epipelagic waters far offshore in the GOA (Gharrett et al. 2002). Some of the samples were as much as 180 km from land, beyond the continental slope and over very deep water.

Settled Early Juveniles: It is unknown how long young-of-the-year remain in a pelagic stage before eventually becoming demersal. At ages 1 to 3, the fish probably live in very rocky inshore areas. The covariates contributing the most to the final SDM EFH map for this life stage were bottom depth, bottom temperature, tidal current speed, and BPI (Pirtle et al. 2023). The highest probabilities of suitable habitat for early juvenile Pacific ocean perch in the GOA were predicted in offshore waters at depths around 250 m, with bottom temperatures around 6°C, lower tidal current exposure, on bathymetric highs (BPI). Habitat-related growth potential for this life stage is greater in the eastern GOA and lowest westward of Kodiak.

Subadults: Juvenile Pacific ocean perch move to progressively deeper waters of the continental shelf as they age and grow. Older juveniles are often found together with adults at shallower locations of the continental slope in the summer months. The covariates contributing the most to the final SDM EFH map for this life stage were bottom depth, geographic location, and rockiness (Pirtle et al. 2023). The highest abundances of subadult Pacific ocean perch were predicted to occur at depths around 250 m over increasingly rocky bottom.

Adults: Commercial fishery and research data have consistently indicated that adult Pacific ocean perch are found in aggregations over reasonably smooth, trawlable bottom of the outer continental shelf and upper continental slope (Westrheim 1970; Matthews et al. 1989; Krieger 1993). Generally, they are found in shallower depths (150 to 300 m) in the summer, and deeper (300 to 420 m) in the fall, winter, and early spring. Observations from a manned submersible in Southeast Alaska found adult Pacific ocean perch associated with pebble substrate on flat or low-relief bottom (Krieger 1993). Pacific ocean perch have been observed in association with sea whips in both the GOA (Krieger 1993) and the Bering Sea (Brodeur 2001). The fish can at times also be found off-bottom in the pelagic environment, especially at night when they may move up in the water column to feed. There presently is little evidence to support previous conjectures that adult Pacific ocean perch populations might be denser in rough, untrawlable bottom.

The covariates contributing the most to the final SDM EFH map for this life stage were bottom depth, geographic location, tidal current speed, and BPI (Pirtle et al. 2023). The highest predicted abundances of adult Pacific ocean perch were along the edge of the continental shelf in depths around 250 m over seafloor features of increasing vertical relief.

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–spring	NA	NA	NA	NA	NA
Larvae	U; 2 months?	U; assumed to be micro-zooplankton	spring–summer	ICS, MCS, OCS, USP, LSP, BSN	P	NA	U	U
Pelagic Early Juveniles	U; 2 months to ?	U	summer to ?	LSP, BSN	Epipelagic	NA	U	U
Settled Early Juveniles/ Subadults	<1 year (?) to 10 years	calanoid copepods (young juv.) euphausiids (older juv.)	all year	ICS, MCS, OCS, USP	D	R (<age 3); CB,G, M?, SM?, MS? (>age 3)	U	U
Adults	10 to 84 years of age (98 years in Aleutian Islands)	euphausiids	insemination (fall); fertilization, incubation (winter); larval release (spring); feeding in shallower depths (summer)	OCS, USP	D, SD, P	CB, G, M?, SM?, MS?	U	U

D.11.4 Literature

Ainley, D.G., W.J. Sydeman., R.H. Parrish., and W.H. Lenarz. 1993. Oceanic factors influencing distribution of young rockfish (Sebastes) in central California: A predator's perspective. CalCOFI Report 34: 133-139.

Allen, M.J., and G. B. Smith. 1988. Atlas and zoogeography of common fishes in the BS and northeastern Pacific. U.S. Dep. Commer., NOAA Tech. Rept. NMFS 66, 151 p.

Brodeur, R.D. 2001. Habitat-specific distribution of Pacific ocean perch (*Sebastes alutus*) in Pribilof Canyon, BS. Cont. Shelf Res. 21: 207-224.

Carlson, H.R., and R.E. Haight. 1976. Juvenile life of Pacific ocean perch, *Sebastes alutus*, in coastal fiords of southeast Alaska: their environment, growth, food habits, and schooling behavior. Trans. Am. Fish. Soc. 105:191-201.

Carlson, H.R., and R.R. Straty. 1981. Habitat and nursery grounds of Pacific rockfish, *Sebastes* spp., in rocky coastal areas of Southeast Alaska. Mar. Fish. Rev. 43: 13-19.

Gharrett, A.J., Z. Li, C.M. Kondzela, and A.W. Kendall. 2002. Final report: species of rockfish (*Sebastes* spp.) collected during ABL-OCC cruises in the GOA in 1998-2002. (Unpubl. manuscr. available from the NMFS Auke Bay Laboratory, 11305 Glacier Hwy., Juneau AK 99801.)

Hanselman, D. H., J. Heifetz, J. Fujioka, Shotwell, S.K., and J. N. Ianelli. 2007. Gulf of Alaska Pacific ocean perch. In Stock assessment and fishery evaluation report for the groundfish resources of the Gulf of Alaska as projected for 2008. North Pacific Fishery Management Council, 605 W 4th Ave, Suite 306 Anchorage, AK 99501.

Hanselman, D.H., T.J. Quinn., II, J. Heifetz., D. Clausen., and C. Lunsford. 2001. Spatial inferences from adaptive cluster sampling of GOA rockfish. *In* Spatial Processes and Management of Marine Populations. University of Alaska Sea Grant, PO Box 755040 203 O'Neill Bldg. Fairbanks AK 99775-5040, http //www.uaf.alaska.edu/seagrant/.

Hobson, E.S., J.R. Chess., and D.F. Howard. 2001. Interannual variation in predation on first-year Sebastes spp. by three northern California predators. Fish. Bull. 99: 292-302.

Kendall, A.W., and W.H. Lenarz. 1986. Status of early life history studies of northeast Pacific rockfishes. Proc. Int. Rockfish Symp. Oct. 1986, Anchorage Alaska; p. 99-117.

Kendall, A.W., Jr. 2000. An historical review of Sebastes taxonomy and systematics. Mar. Fish. Rev. 62: 1-16.

Krieger, K.J. 1993. Distribution and abundance of rockfish determined from a submersible and by bottom trawling. Fish. Bull., U.S. 91:87-96.

Leaman, B.M. 1991. Reproductive styles and life history variables relative to exploitation and management of Sebastes stocks. Environmental Biology of Fishes 30: 253-271.

Li, Z. 2004. Phylogenetic relationships and identification of juveniles of the genus Sebastes. University of Alaska-Fairbanks, School of Fisheries and Ocean Sciences. M.S. thesis.

Love, M.S., M. Yoklavich, and L. Thorsteinson. 2002. The rockfishes of the northeast Pacific. U. of Calif. Press, Berkeley. 405 p.

Major, R.L., and H.H. Shippen. 1970. Synopsis of biological data on Pacific ocean perch, *Sebastodes alutus*. FAO Fisheries Synopsis No. 79, NOAA Circular 347, 38 p.

Matthews, K.R., J.R. Candy, L.J. Richards, and C.M. Hand. 1989. Experimental gill net fishing on trawlable and untrawlable areas off northwestern Vancouver Island, from the MV Caledonian, August 15-28, 1989. Can. Manuscr. Rep. Fish. Aquat. Sci. 2046, 78 p.

Pirtle, J. L., Laman, E. A., Harris, J., Siple, M. C., Rooper, C. N., Hurst, T. P., Conrath, C. L., and Gibson, G. A. 2023. Advancing model-based essential fish habitat descriptions for North Pacific species in the Gulf of Alaska. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-468, 541 p. https://doi.org/10.25923/ygdf-5f65

Rooper, C. N. 2008. An ecological analysis of rockfish (Sebastes spp.) assemblages in the North Pacific Ocean along broad-scale environmental gradients. Fish. Bull. 106: 1–11.

Seeb, L.W., and A.W. Kendall, Jr. 1991. Allozyme polymorphisms permit the identification of larval and juvenile rockfishes of the genus *Sebastes*. Environmental Biology of Fishes 30:191-201.

Westrheim, S.J. 1970. Survey of rockfishes, especially Pacific ocean perch, in the northeast Pacific Ocean, 1963-66. J. Fish. Res. Bd. Canada 27: 1781-1809.

Yang, M-S. 1993. Food habits of the commercially important groundfishes in the GOA in 1990. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-22, 150 p.

Yang, M-S. 1996. Diets of the important groundfishes in the AI in summer 1991. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-60, 105 p.

Yang, M-S. 2003. Food habits of the important groundfishes of the AI in 1994 and 1997. National Marine Fisheries Service. AFSC Processed report 2003-07: 233 pp.

Yang, M-S., and M.W. Nelson. 2000. Food habits of the commercially important groundfishes in the GOA in 1990, 1993, and 1996. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-112, 174 p.

D.12 Rex sole (*Glyptocephalus zachirus*)

D.12.1 Life History and General Distribution

Rex sole are distributed from Baja California to the Bering Sea and western Aleutian Islands (Hart 1973, Miller and Lea 1972). They are most abundant at depths between 100 and 200 m and are found fairly uniformly throughout the GOA outside the spawning season. The spawning period off Oregon is reported to range from January through June with a peak in March and April (Hosie and Horton 1977). Using data from research surveys, Hirschberger and Smith (1983) found that spawning in the GOA occurred from February through July, with a peak period in April and May, although they had few, if any, observations from October to February. More recently, Abookire (2006) found evidence for spawning starting in

October and ending in June, based on one year's worth of monthly histological sampling (October through July) that included both research survey and fishery samples. It seems reasonable, then, that the actual spawning season extends from October to July. 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). During the spawning season, adult rex sole concentrate along the continental slope, but also appear on the outer shelf (Abookire and Bailey 2007). Eggs are fertilized near the sea bed, become pelagic, and probably require a few weeks to hatch (Hosie and Horton 1977). Abookire and Bailey (2007) concluded that larval duration is about 9 months in the GOA (rather than 12 months off the coast of Oregon) and that size-at-transformation for rex sole is 49 to 72 mm. Although maturity studies from Oregon indicate that females are 50 percent mature at 240 mm, females in the GOA achieve 50 percent maturity at larger size (352 mm) and grow faster such that they achieve 50 percent maturity at about the same age (5.1 years) as off Oregon (Abookire 2006). Juveniles less than 150 mm are rarely found with the adult population. The natural mortality rate used in recent stock assessments is 0.17 (Stockhausen et al. 2007).

D.12.2 Relevant Trophic Information

Based on results from an ecosystem model for the GOA (Aydin et al. 2007), rex sole in the GOA occupy an intermediate trophic level. Polychaetes, euphausiids, and miscellaneous worms were the most important prey for rex sole. Other major prey items included benthic amphipods, polychaetes, and shrimp (Livingston and Goiney, 1983; Yang, 1993; Yang and Nelson, 2000). Important predators on rex sole include longnose skate and arrowtooth flounder.

D.12.3 Habitat and Biological Associations

Larvae: Rex sole larvae are planktonic for an unknown time until metamorphosis occurs.

Settled Early Juveniles: The covariates contributing the most to the final SDM EFH map for this life stage were tidal current speed, terrain aspect, BPI, and rockiness (Pirtle et al. 2023). The highest predicted probabilities of suitable habitat for early juvenile rex sole in the GOA occurred along the Alaska Peninsula from the western GOA through the Shelikof Strait and into southeast Alaska, including areas of low-lying terrain such as channels and glacial troughs with low occurrence of rocky substrate.

Subadults: The covariates contributing the most to the final SDM EFH map for this life stage were bottom depth, geographic location, tidal current speed, and BPI (Pirtle et al. 2023). Subadult rex sole abundance was highest in the Yakutat and southeastern Alaska management areas at depths around 350 m with reduced tidal current speeds.

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, feeding mainly on polychaetes, euphausiids, and miscellaneous worms. The covariates contributing the most to the final SDM EFH map for this life stage were bottom depth, geographic location, and tidal current speed (Pirtle et al. 2023). Adult rex sole abundance was highest in glacial troughs south and west of the outlet to Shelikof Strait and south and east of Kodiak 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	several weeks	NA	Oct –July	ICS?, MCS, OCS	P			
Larvae	9 months	U phyto/zooplankton?	spring summer	ICS?, MCS, OCS	P			
Settled Early Juveniles/ Subadults	ages 1–5 years	polychaetes, euphausiids, misc. worms	all year	MCS, ICS, OCS	D	G, S, M		
Adults	ages 5–33 years	polychaetes, amphipods, euphausiids, misc. worms	spawning Oct–July non-spawning July–Sep	MCS, OCS, USP	D	G, S, M		

D.12.4 Literature

Abookire, A.A. 2006. Reproductive biology, spawning season, and growth of female rex sole (*Glyptocephalus zachirus*) in the Gulf of Alaska. Fish. Bull. 104: 350-359.

Abookire, A.A. and K.M. Bailey. 2007. The distribution of life cycle stages of two deep-water pleuronectids, Dover sole (*Microstomus pacificus*) and rex sole (*Glyptocephalus zachirus*), at the northern extent of their range in the Gulf of Alaska. J. Sea Res. 57:198-208.

Auster, P.J., Malatesta, R.J., Langton, R.W., L. Watling, P.C. Valentine, C.S. Donaldson, E.W. Langton, A.N. Shepard, and I.G. Babb. 1996. The impacts of mobile fishing gear on seafloor habitats in the Gulf of Maine (Northwest Atlantic): Implications for conservation of fish populations. Rev. in Fish. Sci. 4(2): 185-202.

Aydin, K., S. Gaichas, I. Ortiz, D. Kinzey, and N. Friday. 2007. A comparison of the Bering Sea, Gulf of Alaska, and Aleutian Islands large marine ecosystems through food web modeling. U.S. Dep. Commer., NOAA NMFS Tech Memo. NMFS-AFSC-178. 298 p.

Hart, J.L. 1973. Pacific fishes of Canada. Fish. Res. Board Canada, Bull. No. 180. 740 p.

Hosie, M.J., and H.F. Horton. 1977. Biology of the rex sole, *Glyptocephalus zachirus*, in waters off Oregon. Fish. Bull. Vol. 75, No. 1, 1977, p. 51-60.

Hirschberger, W.A., and G.B. Smith. 1983. Spawning of twelve groundfish species in the Alaska and Pacific coast regions. 50 p. NOAA Tech. Mem. NMFS F/NWC-44. U.S. Dep. Commer., NOAA, Natl. Mar. Fish. Serv.

Kendall, A.W., Jr., and J.R. Dunn. 1985. Ichthyoplankton of the continental shelf near Kodiak Island, Alaska. NOAA Tech. Rep. NMFS 20, U.S. Dep. Commer, NOAA, Natl. Mar. Fish. Serv.

Livingston, P.A., and B.J. Goiney, Jr. 1983. Food habits literature of North Pacific marine fishes: a review and selected bibliography. NOAA Tech. Mem. NMFS F/NWC-54, U.S. Dep. Commer., NOAA, Natl. Mar. Fish. Serv.

Matarese, A.C., D.M. Blood, S.J. Piquelle and J. Benson. 2003.Atlas of abundance and distribution patterns of ichthyoplankton form the northeast Pacific Ocean and Bering Sea ecosystems based on research conducted by the Alaska Fisheries Science Center (1972-1996). NOAA Prof. Paper NMFS 1. 281 p.

Miller, D.J., and R.N. Lea. 1972. Guide to the coastal marine fishes of California. Calif. Dep. Fish. Game, Fish. Bull. 157, 235 p.

Pirtle, J. L., Laman, E. A., Harris, J., Siple, M. C., Rooper, C. N., Hurst, T. P., Conrath, C. L., and Gibson, G. A. 2023. Advancing model-based essential fish habitat descriptions for North Pacific species in the Gulf of Alaska. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-468, 541 p. https://doi.org/10.25923/ygdf-5f65

Stockhausen, W.T., B. Matta, B.J. Turnock, M.E. Wilkins and M.H. Martin. 2007. 6. Gulf of Alaska Rex Sole Stock Assessment. *In* Appendix B: Stock Assessment and Fishery Evaluation Report for the Groundfish

Resources of the Gulf of Alaska. p 399-450. North Pac. Fish. Mgmt. Council, 605 West 4th Ave., Suite 306, Anchorage, AK 99501.

Yang, M. S. 1993. Food habits of the commercially important groundfishes in the Gulf of Alaska in 1990. U.S. Dept. Commer., NOAA Tech. Memo. NMFS-AFSC-22, 150 p.

Yang, M.-S. and M.W. Nelson. 2000. Food habits of the commercially important groundfishes in the Gulf of Alaska in 1990, 1993, and 1996. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-112, 174 p.

D.13 Rougheye rockfish (*Sebastes aleutianus*) and Blackspotted rockfish (*Sebastes melanostictus*)

D.13.1 Life History and General Distribution

Orr and Hawkins (2008) formally verified the presence of two species, rougheye rockfish (*Sebastes aleutianus*) and blackspotted rockfish (*S. melanostictus*), in what was once considered a single variable species with light and dark color morphs. They used combined genetic analyses of 339 specimens from Oregon to Alaska to identify the two species and formulated general distribution and morphological characteristics for each. Rougheye rockfish is typically pale with spots absent from the dorsal fin and possible mottling on the body. Blackspotted rockfish is darker with spotting almost always present on the dorsal fin and body. The two species occur in sympatric distribution with rougheye extending farther south along the Pacific Rim and blackspotted extending into the western Aleutian Islands. The overlap is quite extensive (Gharrett et al. 2005, 2006). At present there is difficulty in field identification between the two species. Scientists and observers are currently evaluating new techniques to determine whether rapid and accurate field identification can occur. Ongoing research in this area may distinguish particular habitat preference that might be useful for separating the species and determine whether the two species have significantly different life history traits (i.e., age of maturity and growth). Until such information is available, it will be difficult to undertake distinct population assessments. In the stock assessment, rougheye and blackspotted rockfish are referred together as the rougheye rockfish complex.

Rougheye and blackspotted rockfish inhabit the outer continental shelf and upper continental slope of the northeastern Pacific. Their distribution extends around the arc of the North Pacific from Japan to Point Conception, California, and includes the Bering Sea (Kramer and O’Connell 1988). The center of abundance appears to be Alaskan waters, particularly the eastern GOA. Adults in the GOA inhabit a narrow band along the upper continental slope at depths of 984 to 1,640 feet (300 to 500 m); outside of this depth interval, abundance decreases considerably (Ito 1999). This species often co-occurs with shortraker rockfish (*Sebastes borealis*) in trawl or longline hauls.

Though relatively little is known about their biology and life history, rougheye and blackspotted rockfish appear to be K-selected with late maturation, slow growth, extreme longevity, and low natural mortality. Recent work in the GOA has informed length at 50% maturity for both species: 450 mm for rougheye and 453 mm for blackspotted rockfish (Conrath 2017). Rougheye is considered the oldest of the *Sebastes* spp. with a maximum age of 205 years (Chilton and Beamish 1982, Munk 2001). It is also considered one of the larger rockfish attaining sizes of up to 38 inches (980 mm) (Mecklenburg et al. 2002). Natural mortality is low, estimated to be on the order of 0.004 to 0.07 (Archibald et al. 1981, McDermott 1994, Nelson and Quinn 1987, Clausen et al. 2003, Shotwell et al. 2007).

D.13.2 Relevant Trophic Information

Rougheye rockfish in Alaska feed primarily on shrimps (especially pandalids), and various fish species such as myctophids are also consumed (Yang and Nelson 2000; Yang 2003). However, smaller juvenile rougheye rockfish (less than 12 inches [300 mm] fork length) in the GOA also consume a substantial amount of smaller invertebrates such as amphipods, mysids, and isopods (Yang and Nelson 2000). Recent food studies show the most common prey of rougheye as pandalid shrimp, euphausiids, and tanner crab

(*Chionoecetes bairdi*). Other prey include octopuses and copepods (Yang et al. 2006). Predators of rougheye rockfish likely include halibut (*Hippoglossus stenolepis*), Pacific cod (*Gadus macrocephalus*), and sablefish (*Anoplopoma fimbria*).

D.13.3 Habitat and Biological Associations

Eggs: As with other *Sebastes* species, rougheye and blackspotted rockfish are presumed to be viviparous, where fertilization and incubation of eggs is internal and embryos receive at least some maternal nourishment. There have been no studies on fecundity of rougheye in Alaska. One study on their reproductive biology indicated that rougheye had protracted reproductive periods, and that parturition (larval release) may take place in December through April (McDermott 1994). There is no information as to when males inseminate females or if migrations for spawning/breeding occur.

Larvae: Information on larval rougheye and blackspotted rockfish is very limited. The larval stage is pelagic, but larval studies are hindered because the larvae at present can only be positively identified by genetic analysis, which is both expensive and labor-intensive.

Pelagic Early Juveniles: The post-larvae and early young-of-the-year stages also appear to be pelagic (Matarese et al. 1989, Kondzela et al. 2007). Genetic techniques have been used recently to identify a few post-larval rougheye rockfish from samples collected in epipelagic waters far offshore in the GOA (Kondzela et al. 2007), which is the only documentation of habitat preference for this life stage.

Settled Early Juveniles: There is no information on when juvenile fish become demersal. Juvenile rougheye rockfish 6 to 16 inches (150 to 400 mm) fork length have been frequently taken in GOA bottom trawl surveys, implying the use of low relief, trawlable bottom substrates (Clausen et al. 2003). They are generally found at shallower, more inshore areas than adults and have been taken in a variety of locations, ranging from inshore fiords to offshore waters of the continental shelf. Studies using manned submersibles have found that large numbers of small, juvenile rockfish are frequently associated with rocky habitat on both the shallow and deep shelf of the GOA (Carlson and Straty 1981). Another submersible study on the GOA shelf observed juvenile red rockfish closely associated with sponges that were growing on boulders (Freese and Wing 2004). Although these studies did not specifically identify rougheye rockfish, it is reasonable to suspect that juvenile rougheye rockfish may be among the species that utilize this habitat as refuge during their juvenile stage.

Subadults: The covariates contributing the most to the final SDM EFH map for this life stage were bottom depth, geographic location, and seafloor slope (Pirtle et al. 2023). Higher subadult abundance peaked around 300 m depth, including the glacial troughs on the continental shelf and a narrow depth range along the slope.

Adults: Adult rougheye and blackspotted rockfish are demersal and known to inhabit particularly steep, rocky areas of the continental slope, with highest catch rates generally at depths of 984 to 1,312 feet (300 to 400 m) in longline surveys (Zenger and Sigler 1992) and at depths of 984 to 1,640 feet (300 to 500 m) in bottom trawl surveys and in the commercial trawl fishery (Ito 1999). Observations from a manned submersible in this habitat indicate that the fish prefer steep slopes and are often associated with boulders and sometimes with *Primnoa* spp. coral (Krieger and Ito 1999, Krieger and Wing 2002). Within this habitat, rougheye rockfish tend to have a relatively even distribution when compared with the highly aggregated and patchy distribution of other rockfish such as Pacific ocean perch (*Sebastes alutus*) (Clausen and Fujioka 2007).

The covariates contributing the most to the final SDM EFH map for this life stage were bottom depth, seafloor slope, and geographic location (Pirtle et al. 2023). Higher adult abundance for these species was predicted to peak around 375 m depth and within a relatively small depth range that included the glacial troughs on the continental shelf and areas along the outer continental shelf and slope of the GOA.

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	U	NA	NA	NA	NA	NA	NA	
Larvae	U	U	parturition: Dec–Apr	U	Pelagic	NA	U	
Pelagic Early Juveniles	U	U	summer to ?	LSP, BSN	Epipelagic	NA	U	
Settled Early Juveniles/ Subadults	up to 20 years of age	shrimp, mysids, amphipods, isopods	U	OCS, USP	D	U	U	
Adults	20 to >100 years of age	shrimp, euphausiids, myctophids, tanner crab	year-round?	USP	D	M, S, R, SM, CB, MS, G, C steep slopes and boulders	U	observed associated with *Primnoa* coral

D.13.4 Literature

Archibald, C.P., W. Shaw, and B.M. Leaman. 1981. Growth and mortality estimates of rockfishes (Scorpaenidae) from B.C. coastal waters, 1977-79. Can. Tech. Rep. Fish. Aquat. Sci. 1048, 57 p.

Carlson, H.R. and R.R. Straty. 1981. Habitat and nursery grounds of Pacific rockfish, Sebastes spp., in rocky coastal areas of southeastern Alaska. Marine Fisheries Review 43(7):13-19.

Chilton, D.E., and R.J. Beamish. 1982. Age determination methods for fishes studied by the Groundfish Program at the Pacific Biological Station. Can. Spec. Publ. Fish. Aquat. Sci. 60, 102 p.

Clausen, D. M., and J. T. Fujioka. 2007. Variability in trawl survey catches of Pacific ocean perch, shortraker rockfish, and rougheye rockfish in the Gulf of Alaska. In J. Heifetz, J. Dicosimo, A. J. Gharrett, M. S. Love, V. M. O’Connell, and R. D. Stanley (editors), Biology, assessment, and management of North Pacific rockfishes, p. 411-428. Alaska Sea Grant, Univ. of Alaska Fairbanks.

Clausen, D.M., J.T. Fujioka, and J. Heifetz. 2003. Shortraker/rougheye and other slope rockfish. *In* Stock assessment and fishery evaluation report for the groundfish resources of the GOA, p. 531-572. Council, 605 W 4th Ave, Suite 306 Anchorage, AK 99501.

Conrath, C. L. 2017. Maturity, spawning omission, and reproductive complexity of deepwater rockfish. Trans. Am. Fish. Soc. 146: 495–507.

de Bruin, J., R. Gosden, C. Finch, and B. Leaman. 2004. Ovarian aging in two species of long-lived rockfish, *Sebastes aleutianus* and *S. alutus*. Biol. Reprod. 71: 1036-1042.

Freese, J.F., B.L. Wing. 2004. Juvenile red rockfish, Sebastes spp., associations with sponges in the Gulf of Alaska. Mar. Fish. Rev. 65(3):38-42.

Gharrett, A.J., A.P. Matala, E.L. Peterson, A.K. Gray, Z. Li, and J. Heifetz. 2005. Two genetically distinct forms of rougheye rockfish are different species. Trans. Am. Fish. Soc. 132:242-260.

Gharrett, A.J., C.W. Mecklenburg, L.W. Seeb, L. Li, A.P. Matala, A.K. Gray, and J. Heifetz. 2006. Do genetically distinct rougheye rockfish sibling species differ phenotypically? Trans. Am. Fish. Soc. 135:792-800.

Kondzela, C.M., A.W. Kendall, Z. Li, D.M. Clausen, and A.J. Gharrett. 2007. Preliminary identification of pelagic juvenile rockfishes collected in the Gulf of Alaska. In J. Heifetz, J. DiCosimo, A.J. Gharrett, M.S. Love, V.M. O’Connell, and R.D. Stanley (editors), Biology, assessment, and management of North Pacific rockfishes, p. 153-166. Alaska Sea Grant, Univ. of Alaska Fairbanks.

Kramer, D.E., and V.M. O'Connell. 1988. A Guide to Northeast Pacific Rockfishes: Genera Sebastes and Sebastolobus. In: Alaska Sea Grant Advisory Bulletin, 25. In National Marine Fisheries Service 2001(a).

Krieger, K.J., and D.H. Ito. 1999. Distribution and abundance of shortraker rockfish, *Sebastes borealis*, and rougheye rockfish, *Sebastes aleutianus*, determined from a manned submersible. Fish. Bull. 97: 264-272.

Krieger, K.J., and B.L. Wing. 2002. Megafauna associations with deepwater corals (*Primnoa* spp.) in the GOA. Hydrobiologia 471: 83-90.

Ito, D.H. 1999. Assessing shortraker and rougheye rockfishes in the GOA: addressing a problem of habitat specificity and sampling capability. PhD. Dissertation. Univ. Washington, Seattle. 205 p.

Malecha, P. W., D. H. Hanselman, and J. Heifetz. 2007. Growth and mortality of rockfish (Scorpaenidae) from Alaskan waters. NOAA Tech. Memo. NMFS-AFSC-172. 61 p.

Maloney, N. E. 2004. Sablefish, *Anoplopoma fimbria*, populations on Gulf of Alaska seamounts. Mar. Fish. Rev. 66(3): 1-12.

Matarese, A.C., A.W. Kendall, Jr., D.M. Blood, and B.M. Vinter. 1989. Laboratory guide to early life history stages of northeast Pacific fishes. NOAA Tech. Rep. NMFS 80, 652 p.

McDermott, S.F. 1994. Reproductive biology of rougheye and shortraker rockfish, *Sebastes aleutianus* and *Sebastes borealis*. Masters Thesis. Univ. Washington, Seattle.76 p.

Mecklenburg, C.W., T.A. Mecklenburg, and L.K. Thorsteinson. 2002. Fishes of Alaska. Am. Fish. Soc., Bethesda, Maryland. 1,037 p.

Munk, K.M. 2001. Maximum ages of groundfishes off Alaska and British Columbia and considerations of age determination. Alaska Fish. Res. Bull. 8(1): 12-21.

Nelson, B.D., and T.J. Quinn. 1987. Population parameters of rougheye rockfish (*Sebastes aleutianus*). In Proc. Int. Rockfish Symp. pp. 209-228. Univ. Alaska Sea Grant Report No. 87-2. Anchorage, AK.

Orr, J.W. and S. Hawkins. 2008. Species of the rougheye rockfish complex: resurrection of *Sebastes melanostictus* (Matsubara, 1934) and a redescription of *Sebastes aleutianus* (Jordan and Evermann, 1898) (Teleostei: Scorpaeniformes). Fisheries Bulletin. 106: 111-134.

Pirtle, J. L., Laman, E. A., Harris, J., Siple, M. C., Rooper, C. N., Hurst, T. P., Conrath, C. L., and Gibson, G. A. 2023. Advancing model-based essential fish habitat descriptions for North Pacific species in the Gulf of Alaska. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-468, 541 p. https://doi.org/10.25923/ygdf-5f65

Shotwell, S.K., D. Hanselman, and D. Clausen. 2007. Gulf of Alaska rougheye rockfish. *In* Stock assessment and fishery evaluation report for the groundfish fisheries of the Gulf of Alaska. North Pacific Fishery Management Council, 605 W 4th Avenue, Suite 306, Anchorage, AK 99510.

Yang, M-S., and M.W. Nelson. 2000. Food habits of the commercially important groundfishes in the GOA in 1990, 1993, and 1996. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-112, 174 p.

Yang, M-S. 2003. Food habits of the important groundfishes in the AI in 1994 and 1999. AFSC Proc. Rep 2003-07. 233 p. (Available from NMFS, Alaska Fisheries Science Center, 7600 Sand Point Way NE, Seattle, WA 98115).

Yang, M-S., K. Dodd, R. Hibpshman, and A. Whitehouse. 2006. Food habits of groundfishes in the Gulf of Alaska in 1999 and 2001. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-164, 199 p.

Zenger, H.H., Jr. and M.F. Sigler. 1992. Relative abundance of GOA sablefish and other groundfish based on National Marine Fisheries Service longline surveys, 1988-90. U.S. Dep. Commer., NOAA Tech. Memo. NMFS F/NWC-216, 103 pp.

D.14 Sablefish (*Anoplopoma fimbria*)

D.14.1 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 (10 to 15 cm) 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 30 to 40 cm long during their second summer, after which they apparently leave the nearshore bays. One or two years later, they begin appearing on the continental shelf and move to their adult distribution as they mature (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 GOA 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.14.2 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).

In their demersal stage, juvenile sablefish less than 60 cm feed primarily on euphausiids, shrimp, and cephalopods (Yang and Nelson 2000, Yang et al. 2006) while sablefish greater than 60 cm 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 diet (Laidig et al. 1997). Off the southwest coast of Vancouver Island, euphausiids dominated sablefish diets (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 sablefish with the opportunity to feed on salmon fry and smolts during the summer months, while young-of-the-year sablefish are commonly found in the stomachs of salmon taken in the Southeast Alaska troll fishery during the late summer.

D.14.3 Habitat and Biological Associations

Settled Early Juveniles: The covariates contributing the most to the final SDM EFH map for this life stage were tidal current speed, terrain aspect, bottom temperature, and terrain curvature (Pirtle et al. 2023). Suitable habitat for settled early juvenile sablefish was predicted in nearshore areas (< 125 m depth) and extensively on the continental shelf of the eastern GOA. Habitat-related growth potential for this life stage is greater at the shallowest depths, inshore and along the coast.

Subadults: The covariate contributing the most to the final SDM EFH map for this life stage was bottom depth alone (Pirtle et al. 2023). The highest subadult sablefish abundances were predicted to occur at > 250 m depth in the glacial troughs on the continental shelf, in particular from Shelikof Strait through the eastern GOA, and along the GOA shelf break and slope.

Adults: The covariates contributing the most to the final SDM EFH map for this life stage were bottom depth, geographic location, and bottom current speed (Pirtle et al. 2023). The highest adult sablefish abundances occurred at depths > 250 m in areas with relatively low bottom current exposure along the outer continental shelf and slope, with higher abundances also intruding into the seaward entrances of the glacial troughs.

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 to 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	
Early Juveniles	up to 3 years	small prey fish, sandlance, salmon, herring		OCS, MCS, ICS, during first summer, then observed in BAY and IP, until end of 2nd summer; not observed until 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 to 5 years	opportunistic: other fish, shellfish,	all year	continental slope, and deep	Presumably D	varies	U	

		worms, jellyfish, fishery discards		shelf gullies and fjords.				
Adults	5 to 35+ years	opportunistic: other fish, shellfish, worms, jellyfish, fishery discards	apparently year around, spawning movements (if any) are undescribed	continental slope, and deep shelf gullies and fjords.	Presumably D	varies	U	

D.14.4 Literature

Allen, M.J., and G.B. Smith. 1988. Atlas and Zoogeography of common fishes in the BS and northeastern Pacific. U.S. Dep. Commer., NOAAS Tech. Rept. NMFS 66, 151 p.

Boehlert, G.W., and M.M. Yoklavich. 1985. Larval and juvenile growth of sablefish, *Anoplopoma fimbria*, as determined from otolith increments. Fish. Bull. 83:475-481.

Fredin, R. A. 1987. History of regulation of Alaska groundfish fisheries. NWAFC Processed Report 87-07.

Grover, J.J., and B.L. Olla. 1986. Morphological evidence for starvation and prey size selection of sea-caught larval sablefish, *Anoplopoma fimbria*. Fish. Bull. 84:484-489.

Grover, J.J., and B.L. Olla. 1987. Effects of and El Niño event on the food habits of larval sablefish, *Anoplopoma fimbria*, off Oregon and Washington. Fish. Bull. 85: 71-79.

Grover, J.J., and B.L. Olla. 1990. Food habits of larval sablefish, *Anoplopoma fimbria* from the BS. Fish Bull. 88:811-814.

Hanselman, D.H., C. Lunsford, and C. Rodgveller. 2015. Assessment of the sablefish stock in Alaska. In Stock assessment and fishery evaluation report for the groundfish resources of the GOA and BS/AI. North Pacific Fishery Management Council, 605 W 4th Ave, Suite 306 Anchorage, AK 99501.

Hunter, J.R., B.J. Macewiccz, and C.A. Kimbrell. 1989. Fecundity and other aspects of the reproduction of Sablefish, *Anoplopoma fimbria*, in Central California Waters. Calif. Coop. Fish. Invst. Rep. 30: 61-72.

Kendall, A.W., Jr., and A.C. Matarese. 1984. Biology of eggs, larvae, and epipelagic juveniles of sablefish, *Anoplopoma fimbria*, in relation to their potential use in management. Mar. Fish. Rev. 49(1):1-13.

Laidig, T. E., P. B. Adams, and W. M. Samiere. 1997. Feeding habits of sablefish, Anoplopoma fimbria, off the coast of Oregon and California. In M. Saunders and M. Wilkins (eds.). Proceedings of the International Symposium on the Biology and Management of Sablefish. pp 65-80. NOAA Tech. Rep. 130.

Mason, J.C., R.J. Beamish, and G.A. McFralen. 1983. Sexual maturity, fecundity, spawning, and early life history of sablefish (*Anoplopoma fimbria*) off the Pacific coast of Canada. Can. J. Fish. Aquat. Sci. 40:2121-2134.

McFarlane, G.A., and R.J. Beamish. 1992. Climatic influence linking copepod production with strong year-classes in sablefish, *Anoplopoma fimbria*. Can J. Fish. Aquat. Sci. 49:743-753.

Moser, H.G., R.L. Charter, P.E. Smith, N.C.H. Lo., D.A. Ambrose, C.A. Meyer, E.M. Sanknop, and W. Watson. 1994. Early life history of sablefish, *Anoplopoma fimbria*, off Washington, Oregon, and California with application to biomass estimation. Calif. Coop. Oceanic Fish. Invest. Rep. 35:144-159.

NOAA. 1990. Sablefish, *Anoplopoma fimbria*. Pl 3.2.22. IN: West Coast of North America Coastal and Ocean Zones Strategic Assessment Data Atlas. Invertebrate and Fish Volume. U.S. Dep. Commer. NOAA. OMA/NOS, Ocean Assessment Division, Strategic Assessment Branch.

Pirtle, J. L., S. K. Shotwell, M. Zimmermann, J. A. Reid, and N. Golden. 2019. Habitat suitability models for groundfish in the Gulf of Alaska. Deep-Sea Res. Pt. II. https://doi:10.1016/j.dsr2.2017.12.005.

Pirtle, J. L., Laman, E. A., Harris, J., Siple, M. C., Rooper, C. N., Hurst, T. P., Conrath, C. L., and Gibson, G. A. 2023. Advancing model-based essential fish habitat descriptions for North Pacific species in the Gulf of Alaska. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-468, 541 p. https://doi.org/10.25923/ygdf-5f65

Rodgveller, C. J., J. W. Stark, K. B. Echave, and P-J. F. Hulson. 2016. Age at maturity, skipped spawning, and fecundity of female sablefish (Anoplopoma fimbria) during the spawning season. Fish. Bull. 114 (1): 89–102.

Rutecki, T.L., and E.R. Varosi. 1993. Distribution, age, and growth of juvenile sablefish in Southeast Alaska. Paper presented at International Symposium on the Biology and Management of Sablefish. Seattle, Wash. April 1993.

Rutecki, T.L., and E.R. Varosi. 1993. Migrations of Juvenile Sablefish in Southeast Alaska. Paper presented at International Symposium on the Biology and Management of Sablefish. Seattle, Wash. April 1993.

Sasaki, T. 1985. Studies on the sablefish resources in the North Pacific Ocean. Bulletin 22, (1-108), Far Seas Fishery Laboratory. Shimizu, 424, Japan.

Shotwell, S. K., D. H. Hanselman, and I. M. Belkin. 2014. Toward biophysical synergy: Investigating advection along the Polar Front to identify factors influencing Alaska sablefish recruitment. Deep-Sea Res. II, 107: 40-53. http://dx.doi.org/10.1016/j.dsr2.2012.08.024.

Shotwell, S. K., D. Goethel, A. Deary, K. Echave, B. Fissel, D. Hanselman, C. Lunsford, K. Siwicke, J. Sullivan, M. Szymkowiak, A. Tyrell, B. Williams, and S. Zador. 2021. Ecosystem and Socioeconomic Profile of the Sablefish stock in Alaska - Report Card. *In*: Stock assessment and fishery evaluation report for the groundfish resources of the GOA and BS/AI. North Pacific Fishery Management Council, 605 W 4th Ave, Suite 306 Anchorage, AK 99501.

Sigler, M.F., E.R. Varosi, and T.R. Rutecki. 1993. Recruitment curve for sablefish in Alaska based on recoveries of fish tagged as juveniles. Paper presented at International Symposium on the Biology and Management of Sablefish. Seattle, Wash. April 1993.

Sigler, M. F., T. L. Rutecki, D. L. Courtney, J. F. Karinen, and M.-S.Yang. 2001. Young-of-the-year sablefish abundance, growth, and diet. Alaska Fisheries Research Bulletin 8(1): 57-70.

Smith, G.B., G.E. Walters, P.A. Raymore, Jr., and W.A, Hischberger. 1984. Studies of the distribution and abundance of juvenile groundfish in the northwestern GOA, 1980-82: Part I, Three-year comparisons. NOAA Tech. Memo. NMFS F/NWC-59. 100p.

Tanasichuk, R. W. 1997. Diet of sablefish, Anoplopoma fimbria, from the southwest coast of Vancouver Island. In M. Saunders and M. Wilkins (eds.). Proceedings of the International Symposium on the Biology and Management of Sablefish. pp 93-98. NOAA Tech. Rep. 130.

Umeda, Y., T. Sample, and R. G. Bakkala. 1983. Recruitment processes of sablefish in the EBS. In Proceedings of the International Sablefish Symposium March 1983, Anchorage, Alaska. Alaska Sea Grant Report 83-8.Walters, G.E., G.B. Smith, P.A. Raymore, and W.A. Hirschberger. 1985. Studies of the distribution and abundance of juvenile groundfish in the northwestern GOA, 1980-82: Part II, Biological characteristics in the extended region. NOAA Tech. Memo. NMFS F/NWC-77. 95 p.

Wing, B.L. 1985. Salmon Stomach contents from the Alaska Troll Logbook Program, 1977-84. U.S. Dep. Commer., NOAA Tech. Memo. NMFS F/NWC-91, 41 p.

Wing, B.L. 1997. Distribution of sablefish, *Anoplopoma fimbria*, larvae in the eastern GOA: Neuston-net tows versus oblique tows. *In*: M. Wilkins and M. Saunders (editors), Proc. Int. Sablefish Symp., April 3-4, 1993, p. 13-25. U.S. Dep. Commer., NOAA Tech. Rep. 130.

Wing, B.L., and D.J. Kamikawa. 1995. Distribution of neustonic sablefish larvae and associated ichthyoplankton in the eastern GOA, May 1990. U.S. Dept. Commer., NOAA Tech. Memo. NMFS-AFSC-53, 48 p.

Wing, B.L., C. Derrah, and V. O'Connell. 1997. Ichthyoplankton in the eastern GOA, May 1990. U.S. Dept. Commer., NOAA Tech. Memo. NMFS-AFSC-376, 42 p.

Wing, B.L. and D.J. Kamikawa. 1995. Distribution of neustonic sablefish larvae and associated ichthyoplankton in the eastern GOA, May 1990. NOAA Tech. Memo. NMFS-AFSC-53.

Witherell, D 1997. A brief history of bycatch management measures for EBS groundfish fisheries. Marine Fisheries Review. Wolotera, R.J., Jr., T.M. Sample, S.F. Noel, and C.R. Iten. 1993. Geographic and bathymetric distributions for many commercially important fishes and shellfishes off the west coast of North America, based on research survey and commercial catch data, 1912-1984. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-6, 184 p.

Yang, M-S. 1993. Food habits of the commercially important groundfishes in the GOA in 1990. NOAA Tech. Memo. NMFS-AFSC-22. 150 p.

Yang, M-S. and M.W. Nelson. 2000. Food habits of the commercially important groundfishes in the GOA in 1990, 1993, and 1996. NOAA Technical Memorandum NMFS-AFSC-112.

Yang, M-S., K. Dodd, R. Hibpshman, and A. Whitehouse. 2006. Food habits of groundfishes in the Gulf of Alaska in 1999 and 2001. NOAA Technical Memorandum NMFS-AFSC-164.

D.15 Shallow Water Flatfish complex

Species Complex Summary

In the GOA, the shallow water flatfish stock complex is comprised of Alaska plaice, butter sole, English sole, northern and southern rock soles, sand sole, starry flounder, and yellowfin sole (Turncock et al. 2017). Additional "other flatfish" species with relatively low biomass are also included in this group; Pacific sanddab, petrale sole, and slender sole. In GOA RACE-GAP summer bottom trawl survey catches (1993–2019) and mixed gear-type summer surveys (1989–2019), all member species except sand sole were common enough (N > 50) to support SDMs of probability of suitable habitat or habitat-related abundance to map EFH. Of all the species, there were higher abundance catches on the continental shelf of the GOA, and the probability of encountering shallow water flatfish was low along the slope and deep glacial troughs (Pirtle et al. 2023).

Literature

Pirtle, J. L., Laman, E. A., Harris, J., Siple, M. C., Rooper, C. N., Hurst, T. P., Conrath, C. L., and Gibson, G. A. 2023. Advancing model-based essential fish habitat descriptions for North Pacific species in the Gulf of Alaska. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-468, 541 p. https://doi.org/10.25923/ygdf-5f65

Turncock, B. J., M. Bryan, and T. K. Wilderbuer. 2017. Assessment of the shallow-water Flatfish Stock Complex in the Gulf of Alaska. In Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Gulf of Alaska. North Pacific Fishery Management Council, 1007 West Third, Suite 400 Anchorage, AK 99501.

D.15.1 Alaska plaice (*Pleuronectes quadrituberculatus*)

D.15.1.1 Life History and General Distribution

Alaska plaice inhabit continental shelf waters of the North Pacific ranging from the GOA 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). Alaska plaice are caught in near shore areas along the Alaska Peninsula and Kodiak Island in summer resource assessment surveys. 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, although it is unknown if this behavior is also consistent with the GOA. 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, particularly in the Shelikof Strait area (Waldron and Favorite 1977).

Fecundity estimates (Fadeev 1965) indicate female fish produce an average of 56,000 eggs at lengths of 280 to 300 mm and 313,000 eggs at lengths of 480 to 500 mm. Subadults have a size range of 141 – 319 mm and adults are > 319 mm (Tenbrink and Wilderbuer 2015). The approximate upper size limit of settled early juvenile fish is 140 mm. Natural mortality rate estimates range from 0.19 to 0.22 (Wilderbuer and Zhang 1999).

D.15.1.2 Relevant Trophic Information

Groundfish predators include Pacific halibut (Novikov 1964) yellowfin sole, beluga whales, and fur seals (Salveson 1976). Adult Alaska plaice feed on sandy substrates during the summer and target polychaetes, amphipods, and echiurids (Livingston and DeReynier 1996

D.15.1.3 Habitat and Biological Associations

Larvae: Larvae are planktonic for at least 2 to 3 months until metamorphosis occurs.

Pelagic Early Juveniles: After metamorphosis, juveniles usually inhabit shallow areas.

Subadults: The covariates contributing the most to the final SDM EFH map for this life stage were geographic location, bottom depth, tidal maximum, and BPI (Pirtle et al. 2023). Higher subadult Alaska plaice abundance occurred in nearshore areas in Kachemak Bay and along the Alaska Peninsula and western Kodiak Island.

Adults: EFH for adult Alaska plaice shifts seasonally, with adults feeding on sandy substrates in the summer and migrating to deeper waters of the shelf margin in winter to avoid extreme cold water temperatures. The covariates contributing the most to the final SDM EFH map for this life stage were geographic location, bottom depth, and current metrics (Pirtle et al. 2023). Similar to subadults, higher adult Alaska plaice abundance was predicted to occur in nearshore areas in Kachemak Bay and along the Alaska Peninsula and western Kodiak Island

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/zooplankton?	spring and summer	ICS, MCS	P			
Juveniles	up to 7 years	polychaete, amphipods, echiurids	all year	ICS, MCS	D	S, M		
Adults	7+ years	polychaete, amphipods, echiurids	spawning March–May non-spawning and feeding June–February	ICS, MCS ICS, MCS	D	S, M	ice edge	

D.15.1.4 Literature

Auster, P.J., Malatesta, R.J., Langton, R.W., L. Watling, P.C. Valentine, C.S. Donaldson, E.W. Langton, A.N. Shepard, and I.G. Babb. 1996. The impacts of mobile fishing gear on seafloor habitats in the Gulf of Maine (Northwest Atlantic): Implications for conservation of fish populations. Rev. in Fish. Sci. 4(2): 185-202.

Fadeev, N.W. 1965. Comparative outline of the biology of fishes in the southeastern part of the Bering Sea and condition of their resources. [In Russ.] Tr. Vses. Nauchno-issled. Inst.Morsk. Rybn. Khoz. Okeanogr. 58 (Izv. Tikhookean. Nauchno-issled Inst. Morsk. Rybn. Khoz. Okeanogr. 53):121-138. (Trans. By Isr. Prog. Sci. Transl., 1968), p 112-129. In P.A. Moiseev (Editor), Soviet Fisheries Investigations in the northeastern Pacific, Pt. IV. Avail. Natl. Tech. Inf. Serv., Springfield, Va. As TT 67-51206.

Livingston, P.A. and Y. DeReynier. 1996. Groundfish food habits and predation on commercially important prey species in the eastern Bering Sea from 1990 to 1992. AFSC processed Rep. 96-04, 51 p. Alaska Fish. Sci. Cent., Natl. Mar. Fish. Serv., NOAA, 7600 Sand Point Way NE., Seattle, WA 98115.

Novikov, N.P. 1964. Basic elements of the biology of the Pacific Halibut (*Hippoglossus stenolepis* Schmidt) in the Bering Sea. Tr. Vses. Nauchno-issled. Inst. Morsk. Rybn. Khoz. Okeanogr. 49 (Izv. Tikhookean. Nauchno-isslled. Inst. Morsk. Rybn. Khoz. Okeanogr. 51):167-204. (Transl. In Soviet Fisheries Investigations in the

Northeast Pacific, Part II, p.175-219, by Israel Program Sci. Transl., 1968, avail. Natl. Tech. Inf. Serv. Springfield, VA, as TT67-51204.)

Pertseva-Ostroumova, T.A. 1961. The reproduction and development of far eastern flounders. (Transl. By Fish. Res. Bd. Can. 1967. Transl. Ser. 856, 1003 p.).

Pirtle, J. L., Laman, E. A., Harris, J., Siple, M. C., Rooper, C. N., Hurst, T. P., Conrath, C. L., and Gibson, G. A. 2023. Advancing model-based essential fish habitat descriptions for North Pacific species in the Gulf of Alaska. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-468, 541 p. https://doi.org/10.25923/ygdf-5f65

Quast, J.C. and E.L. Hall. 1972. List of fishes of Alaska and adjacent waters with a guide to some of their literature. U.S. Dep. Commer. NOAA, Tech. Rep. NMFS SSRF-658, 48p.

Salveson, S.J. 1976. Alaska plaice. In Demersal fish and shellfish resources of the eastern Bering Sea in the baseline year 1975 (eds. W.T. Pereyra, J.E. Reeves, and R.G. Bakkala). Processed Rep., 619 p. NWAFC, NMFS, NOAA, 2725 Montlake Blvd. E., Seattle, WA 98112.

Tenbrink, T. T., and T. K. Wilderbuer. 2015. Updated maturity estimates for flatfishes (Pleuronectidae) in the eastern Bering Sea, with implications for fishery management. Mar. Coast. Fish. 7: 474–482. https://doi.org/10.1080/19425120.2015.1091411.

Waldron, K.D. and F. Favorite. 1977. Ichthyoplankton of the eastern Bering Sea. In Environmental assessment of the Alaskan continental shelf, Annual reports of principal investigators for the year ending March 1977, Vol. IX. Receptors-Fish, littoral, benthos, p. 628-682. U.S. Dep. Comm., NOAA, and U.S. Dep. Int., Bur. Land. Manage.

Wilderbuer, T.K. and C.I. Zhang. 1999. Evaluation of the population dynamics and yield characteristics of Alaska plaice (Pleuronectes quadrituberculatus) in the eastern Bering Sea Fisheries Research 41 (1999) 183-200.

Wilderbuer, T.K., D.G. Nichol, and P.D. Spencer. 2010. Alaska Plaice. *In* Stock Assessment and Fishery Evaluation Report for Groundfish Resources of the Bering Sea/Aleutian Islands Regions. North Pacific Fishery Management Council, 605 W 4th Ave, Suite 306, Anchorage, Alaska 99501. Pp. 969-1020.

Zhang, C.I. 1987. Biology and Population Dynamics of Alaska plaice, *Pleuronectes quadrituberculatus*, in the Eastern Bering Sea. PhD. dissertation, University of Washington: p.1-225.

D.15.2 Butter sole (*Isopsetta isolepis*)

D.15.2.1 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). Although butter sole are one of five species that account for most of the current biomass of the Shallow Water Flatfish complex, little is known about their life history. Doyle et al. (2019) reported a maximum observed transformation length from pelagic larvae to early juveniles of 15–20 mm TL in the GOA, and settled individuals as small as 11 mm FL were captured in summer beach seine surveys, yet not in sufficient numbers to model (N < 50).

D.15.2.2 Relevant Trophic Information

There is insufficient information on butter sole predator or prey relationships at this time

D.15.2.3 Habitat and Biological Associations

Subadults/Adults: Length-based information was not available so subadult and adult butter sole were modeled in composite to map EFH. The covariates contributing the most to the final SDM EFH map for this life stage were bottom depth and rockiness (Pirtle et al. 2023). Higher butter sole abundance was predicted in nearshore areas at less than 200 m depth with low presence of rocky substrate and at bathymetric rises on the GOA continental shelf.

D.15.2.4 Literature

Doyle, M. J., S. L. Stromb, K. O. Coyle, A. J. Hermann, C. Ladd, A. C. Matarese, S. K. Shotwell, and R. R. Hopcroft. 2019. Early life history phenology among Gulf of Alaska fish species: Strategies, synchronies, and sensitivities. Deep-Sea Res. II 165: 41–73.

Mecklenburg, C. W., T. A. Mecklenburg, and L. K. Thorsteinson. 2002. Fishes of Alaska. American Fisheries Society, Bethesda, MD.

Pirtle, J. L., Laman, E. A., Harris, J., Siple, M. C., Rooper, C. N., Hurst, T. P., Conrath, C. L., and Gibson, G. A. 2023. Advancing model-based essential fish habitat descriptions for North Pacific species in the Gulf of Alaska. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-468, 541 p. https://doi.org/10.25923/ygdf-5f65

D.15.3 English sole (*Parophrys vetulus*)

D.15.3.1 Life History and General Distribution

Little is known about English sole life history in the GOA. The smallest settled early juvenile English sole caught by beach seine gear in summer surveys in the GOA was 17 mm FL (mean 31 mm FL; Nearshore Fish Atlas of Alaska). Subadults and adults are distinguished by a length break using L50 = 230 mm FL (Sampson and Al-Jufaily 1999). For mapping, these length breaks were used to separate English sole demersal life stages, including settled early juveniles (20–140 mm), subadults (141–230 mm), and adults (> 230 mm) (Pirtle et al. 2023). Settled early juvenile EFH is in nearshore areas and at shallow depths in the GOA. Subadult EFH occurred inshore in the GOA and adult English sole EFH was extensive across the GOA continental shelf (Pirtle et al. 2023). English sole may demonstrate ontogenetic migrations to deeper depths with increasing size or age.

D.15.3.2 Relevant Trophic Information

There is insufficient information on English sole predator or prey relationships at this time

D.15.3.3 Habitat and Biological Associations

Settled Early Juveniles: The covariate contributing the most to the final SDM EFH map for this life stage was bottom depth (Pirtle et al. 2023). The highest predicted probabilities of suitable habitat for settled early juvenile English sole occurred at locations less than 100 m depth.

Subadults: The covariates contributing the most to the final SDM EFH map for this life stage were bottom depth, tidal maximum speed, and geographic location (Pirtle et al. 2023). The highest abundances were predicted in inshore areas east of 148°W and in western Cook Inlet.

Adults: The covariates contributing the most to the final SDM EFH map for this life stage were bottom depth and geographic location (Pirtle et al. 2023). The highest abundances were in inshore areas east of 148°W and off southeast Alaska.

D.15.3.4 Literature

Pirtle, J. L., Laman, E. A., Harris, J., Siple, M. C., Rooper, C. N., Hurst, T. P., Conrath, C. L., and Gibson, G. A. 2023. Advancing model-based essential fish habitat descriptions for North Pacific species in the Gulf of Alaska. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-468, 541 p. https://doi.org/10.25923/ygdf-5f65

Sampson, D. B., and S. M. Al-Jufaily. 1999. Geographic variation in the maturity and growth schedules of English sole along the U.S. West Coast. J. Fish Biol. 54: 1–17. https://doi.org/10.1111/j.1095-8649.1999.tb00608.x.

D.15.4 Northern rock sole (*Lepidopsetta polyxystra*)

The shallow water flatfish management complex in the GOA consists of eight species: northern rock sole (*Lepidopsetta polyxystra)*, southern rock sole (*Lepidopsetta bilineata*), yellowfin sole (*Limanda aspera*), starry flounder (*Platichthys stellatus*), butter sole (*Isopsetta isolepis*), English sole (*Parophrys vetulus*), Alaska plaice (*Pleuronectes quadrituberculatus*), and sand sole (*Psettichthys melanostictus*). The two rock sole species in the GOA have distinct characteristics and overlapping distributions. These two species of rock sole and yellowfin sole are the most abundant and commercially important species of this management complex in the GOA, and the description of their habitat and life history best represents the shallow water complex species.

D.15.4.1 Life History and General Distribution

Northern rock sole are distributed from Puget Sound through the BSAI to the Kuril Islands, overlapping with southern rock sole in the GOA (Orr and Matarese 2000). Centers of abundance occur off the Kamchatka Peninsula (Shubnikov and Lisovenko 1964), British Columbia (Forrester and Thompson 1969), the central GOA, and in the southeastern Bering Sea (Alton and Sample 1976). 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 through 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' and 55°0' N. and approximately 165°2' W. (Shubnikov and Lisovenko 1964). Northern rock sole spawning in the GOA has been found to occur at depths of 43 to 61 m (Stark and Somerton 2002). Spawning females deposit a mass of eggs that 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 ºC to about 25 days at 2.9 ºC (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, Orr and Matarese 2000). Forrester and Thompson (1969) report that by age 1, they are found with adults on the continental shelf during summer.

In the springtime, after spawning, northern rock sole begin actively feeding and exhibit a widespread distribution throughout 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 and in the GOA. 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, northern rock sole begin the return migration to the deeper wintering grounds. Fecundity varies with size and was reported to be 450,000 eggs for fish 420 mm long. Larvae are pelagic, but their occurrence in plankton surveys in the eastern Bering Sea is rare (Musienko 1963). Juveniles are separate from the adult population, remaining in shallow areas until they reach age 1 (Forrester 1964). The estimated age of 50 percent maturity is 7 years for northern rock sole females (approximately 330 mm). The length-based life stage break used for modeling EFH was > 328 mm for adult northern rock sole (Stark 2012, Pirtle et al. 2023). The natural mortality rate is believed to range from 0.18 to 0.20 (Turnock et al. 2002).

D.15.4.2 Relevant Trophic Information

Groundfish predators to rock sole include Pacific cod, walleye pollock, skates, Pacific halibut, and yellowfin sole, mostly on fish ranging from 50 to 150 mm standard length. Adult northern rock sole feed on bivalves, polychaetes, amphipods, and miscellaneous crustaceans.

D.15.4.3 Habitat and Biological Associations

Larvae: Larval northern rock sole are planktonic for at least 2 to 3 months until metamorphosis occurs.

Pelagic Early Juveniles: Juveniles inhabit shallow areas at least until age 1.

Settled Early Juveniles: The covariate contributing the most to the final SDM EFH map for this life stage, which was modeled combining both northern and southern rock sole, was bottom depth (Pirtle et al. 2023). The highest predicted probabilities of suitable habitat for settled early juvenile rock sole were nearshore or less than 125 m depth on the GOA continental shelf, including Cook Inlet and the bathymetric rises south and west of Kodiak Island. Habitat-related growth potential for this life stage is greater at shallower, inshore depths and on banks and bathymetric rises on the GOA continental shelf.

Subadults: The covariates contributing the most to the final SDM EFH map for this life stage were bottom depth and geographic location (Pirtle et al. 2023). Bathymetric rises less than 125 m depth and shallow nearshore locations on the continental shelf had high predicted abundances or high probability of encountering northern rock sole, particularly west of the Kenai Peninsula.

Adults: The covariate contributing the most to the final SDM EFH map for this life stage was bottom depth (Pirtle et al. 2023). The highest abundances of adult northern rock sole were predicted at less than 125 m depth on bathymetric rises, such as the banks south of Kodiak Island. Abundance increases westward in the GOA around the Shumagin Islands and the Alaska Peninsula.

Habitat and Biological Associations: Northern 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 to 3 months	U phyto/ zooplankton?	winter/spring	OCS, MCS, ICS	P			
Early Juveniles	to 3.5 years	polychaetes, bivalves, amphipods, misc. crustaceans	all year	BAY, ICS, OCS, MCS	D	S, G		
Subadults	up to 9 years	polychaetes, bivalves, amphipods, misc. crustaceans	all year	BAY, ICS, OCS, MCS	D	S, G		
Adults	9+ years	polychaetes, bivalves, amphipods, misc. crustacean	feeding May–September spawning Dec–April	MCS, ICS MCS, OCS	D	S, G	ice edge	

D.15.4.4 Literature

Alton, M.S., and T.M. Sample. 1976. Rock sole (Family Pleuronectidae) p. 461-474. *In*: Demersal fish and shellfish resources in the BS in the baseline year 1975. Principal investigators Walter T. Pereyra, Jerry E. Reeves, and Richard Bakkala. U.S. Dep. Comm., Natl. Oceanic Atmos. Admin., Natl. Mar. Serv., Northwest and Alaska Fish Center, Seattle, WA. Processed Rep., 619 p.

Armistead, C.E., and D.G. Nichol. 1993. 1990 Bottom Trawl Survey of the EBS Continental Shelf. U.S. Dep. Commer., NOAA Tech. Mem. NMFS-AFSC-7, 190 p.

Auster, P.J., R.J. Malatesta., R.W. Langton., L. Watling, P.C. Valentine, C.S. Donaldson, E.W. Langton, A.N. Shepard, and I.G. Babb. 1996. The impacts of mobile fishing gear on seafloor habitats in the Gulf of Maine (Northwest Atlantic): Implications for conservation of fish populations. Rev. in Fish. Sci. 4(2): 185-202.

Forrester, C.R. 1964. Demersal Quality of fertilized eggs of rock sole. J. Fish. Res. Bd. Canada, 21(6), 1964. P. 1531.

Forrester, C.R., and J.A. Thompson. 1969. Population studies on the rock sole, *Lepidopsetta bilineata*, of northern Hecate Strait British Columbia. Fish. Res. Bd. Canada, Tech. Rep. No. 108, 1969. 104 p.

Livingston, P.A., and Y. DeReynier. 1996. Groundfish food habits and predation on commercially important prey species in the EBS from 1990 to 1992. AFSC processed Rep. 96-04, 51 p. Alaska Fish. Sci. Cent., Natl. Mar. Fish. Serv., NOAA, 7600 Sand Point Way NE., Seattle, WA 98115.

Musienko, L.N. 1963. Ichthyoplankton of the BS (data of the BS expedition of 1958-59). Tr. Vses Nauchno-issled. Inst. Morsk. Rybn. Khoz. Okeanogr. 48 (Izv. Tikhookean. Nauchno-issled. Inst. Rybn. Khoz. Okeanogr. 50)239-269. [In Russ.] Transl. By Isr. Prog. Sci. Transl., 1968, p. 251-286. In P. A. Moiseev (Editor), Soviet fisheries investigations in the northeastern Pacific, Part I. Avail. Natl. Tech. Inf. Serv., Springfield, VA., as TT67-51203.

Orr, J. W. and A. C. Matarese. 2000. Revision of the genus *Lepidopsetta* Gill, 1862 (Teleostei: Pleuronectidae) based on larval and adult morphology, with a description of a new species from the North Pacific Ocean and Bering Sea. Fish. Bull. 98:539-582 (2000).

Pirtle, J. L., Laman, E. A., Harris, J., Siple, M. C., Rooper, C. N., Hurst, T. P., Conrath, C. L., and Gibson, G. A. 2023. Advancing model-based essential fish habitat descriptions for North Pacific species in the Gulf of Alaska. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-468, 541 p. https://doi.org/10.25923/ygdf-5f65

Shubnikov, D.A., and L.A. Lisovenko. 1964. Data on the biology of rock sole in the southeastern BS. Tr. Vses. Nauchno-issled. Inst. Morsk. Rybn. Khoz. Okeanogr. 49 (Izv. Tikookean. Nauchno-issled. Inst. Morsk. Rybn. Khoz. Okeanogr. 51) : 209-214. (Transl. In Soviet Fisheries Investigations in the Northeast Pacific, Part II, p. 220-226, by Israel Program Sci. Transl., 1968, available Natl. Tech. Inf. Serv., Springfield, VA, as TT 67-51204).

Shvetsov, F.G. 1978. Distribution and migrations of the rock sole, *Lepidopsetta bilineata*, in the regions of the Okhotsk Sea coast of Paramushir and Shumshu Islands. J. Ichthol., 18 (1), 56-62, 1978.

Stark, J. W. 2012b. Contrasting maturation and growth of northern rock sole in the Eastern Bering Sea and Gulf of Alaska for the purpose of stock management. N. Amer. J. Fish. Manage. 32:93-99. Turnock, B.J., T.K. Wilderbuer, and E.S. Brown. 2002. Flatfish. In Appendix B Stock Assessment and Fishery Evaluation for Groundfish Resources of the GOA Region. Pages 169-197. Council, 605 West 4th Ave., Suite 306, Anchorage, AK 99501.

Stark, J.W., and D. A. Somerton. 2002. Maturation, spawning and growth of rock soles off Kodiak Island in the GOA. J. Fish. Biology (2002) 61, 417-431.

Waldron, K.D., and B.M. Vinter. 1978. Ichthyoplankton of the EBS. U.S. Dep. Commer., Natl. Oceanic Atmos. Admin., Natl. Mar. Fish. Serv. Seattle, WA, Processed rep., 88 p.

D.15.5 Pacific sanddab (*Citharichthys sordidus*)

D.15.5.1 Life History and General Distribution

Pacific sanddab (*Citharichthys sordidus*) is a shallow-water flatfish species ranging from Baja California to southeast Alaska (Lamb and Edgell 2010). Little is known about Pacific sanddab life history in the GOA, which encompasses the northern part of their range. Their EFH is in shallower depths of the continental shelf in the eastern GOA off southeast Alaska (Pirtle et al. 2023).

D.15.5.2 Relevant Trophic Information

There is insufficient information on Pacific sanddab predator or prey relationships at this time.

D.15.5.3 Habitat and Biological Associations

Adults: The covariates contributing the most to the final SDM EFH map for this life stage were geographic location and bottom temperature (Pirtle et al. 2023). Higher Pacific sanddab abundance was predicted to occur at shallower depths on the continental shelf of the eastern GOA. The SDM used all individual Pacific sanddabs caught by RACE-GAP summer bottom trawl surveys in the GOA because there is no length-based information for this species to distinguish between life history stages (Pirtle et al. 2023).

D.15.5.4 Literature

Lamb, A. and P. Edgell. 2010. Coastal fishes of the Pacific northwest. Second edition. Madeira Park, BC, Canada: Harbor Publishing Co. Ltd., 335 p.

Pirtle, J. L., Laman, E. A., Harris, J., Siple, M. C., Rooper, C. N., Hurst, T. P., Conrath, C. L., and Gibson, G. A. 2023. Advancing model-based essential fish habitat descriptions for North Pacific species in the Gulf of Alaska. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-468, 541 p. https://doi.org/10.25923/ygdf-5f65

D.15.6 Petrale sole (*Eopsetta jordani*)

D.15.6.1 Life History and General Distribution

Petrale sole (*Eopsetta jordani*) is a right-eyed flounder ranging from Baja California to the western GOA (Wetzel 2019). Little is known about petrale sole life history in the GOA, which is the northern extent of their range. However, maturity studies of individuals from the US West Coast estimated L50 = 331 mm FL (Hannah et al. 2002), which is used to distinguish the subadult (< 331 mm FL) and adult (> 331 mm FL) life stages. Adults have a larger EFH area than subadults, extending into the central GOA and the eastern GOA continental shelf, while subadults were prevalent off southeast Alaska (Pirtle et al. 2023).

D.15.6.2 Relevant Trophic Information

There is insufficient information on petrale sole predator or prey relationships at this time.

D.15.6.3 Habitat and Biological Associations

Subadults: The covariates contributing the most to the final SDM EFH map for this life stage were geographic location, bottom temperature, and tidal current accounted (Pirtle et al. 2023). The highest abundances were predicted less than 100 m depth in the eastern GOA off southeast Alaska.

Adults: The covariates contributing the most to the final SDM EFH map for this life stage were geographic location, bottom depth, and bottom temperature (Pirtle et al. 2023). The highest abundances were predicted less than 125 m depth in the eastern GOA off southeast Alaska.

D.15.6.4 Literature

Hannah, R., Parker, S., and Fruth, E. 2002. Length and age at maturity of female petrale sole (Eopsetta jordani) determined from samples collected prior to spawning aggregation. U.S. Fish Bulletin 100: 711–719.

Pirtle, J. L., Laman, E. A., Harris, J., Siple, M. C., Rooper, C. N., Hurst, T. P., Conrath, C. L., and Gibson, G. A. 2023. Advancing model-based essential fish habitat descriptions for North Pacific species in the Gulf of Alaska. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-468, 541 p. https://doi.org/10.25923/ygdf-5f65

Wetzel, C.R. 2019. Status of petrale sole (Eopsetta jordani) along the U.S. west coast in 2019. Pacific Fishery Management Council, 7700 Ambassador Place NE, Suite 101, Portland, OR 97220.

D.15.7 Slender sole (*Lyopsetta exilis*)

D.15.7.1 Life History and General Distribution

Slender sole (*Lyopsetta exilis*) range from Baja California to the eastern Bering Sea (Mecklenburg et al. 2002). Little is known about slender sole life history in the GOA. Slender sole were primarily caught on the continental shelf off southeast Alaska in the GOA RACE-GAP summer bottom trawl surveys (1993 - 2019). Their core EFh area is found in glacial troughs and along the outer continental shelf and upper slope (Pirtle et al. 2023).

D.15.7.2 Relevant Trophic Information

There is insufficient information on slender sole predator or prey relationships at this time.

D.15.7.3 Habitat and Biological Associations

Adults: The covariates contributing the most to the final SDM EFH map for this life stage were geographic location and bottom depth (Pirtle et al. 2023). Higher slender sole abundance for their demersal life history stages was around 250 m depth on the outer continental shelf and glacial troughs of the eastern GOA. The SDM used all individual Pacific sanddabs caught by RACE-GAP summer bottom trawl surveys in the GOA because there is no length-based information for this species to distinguish between life history stages (Pirtle et al. 2023).

D.15.7.4 Literature

Mecklenburg, C. W., T. A. Mecklenburg, and L. K. Thorsteinson. 2002. Fishes of Alaska. American Fisheries Society, Bethesda, MD.

Pirtle, J. L., Laman, E. A., Harris, J., Siple, M. C., Rooper, C. N., Hurst, T. P., Conrath, C. L., and Gibson, G. A. 2023. Advancing model-based essential fish habitat descriptions for North Pacific species in the Gulf of Alaska. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-468, 541 p. https://doi.org/10.25923/ygdf-5f65

D.15.8 Southern rock sole (*Lepidopsetta bilineata*)

The shallow water flatfish management complex in the GOA consists of eight species: southern rock sole (*Lepidopsetta bilineata*), northern rock sole (*Lepidopsetta polyxystra*), yellowfin sole (*Limanda aspera*), starry flounder (*Platichthys stellatus*), butter sole (*Isopsetta isolepis*), English sole (*Parophrys vetulus*), Alaska plaice (*Pleuronectes quadrituberculatus*), and sand sole (*Psettichthys melanostictus*). The rock sole resource in the GOA consists of two separate species: a northern and a southern form that have distinct characteristics and overlapping distributions. The two species of rock sole and yellowfin sole are the most abundant and commercially important species of this management complex in the GOA, and the description of their habitat and life history best represents the shallow water complex species.

D.15.8.1 Life History and General Distribution

Southern rock sole are distributed from Baja California waters north into the GOA and the eastern Aleutian Islands. Centers of abundance occur off the Kamchatka Peninsula (Shubnikov and Lisovenko 1964), British Columbia (Forrester and Thompson 1969), the central GOA, and to a lesser extent in the extreme southeastern Bering Sea (Alton and Sample 1976, Orr and Matarese 2000). Adults exhibit a benthic lifestyle and occupy separate winter (spawning) and summertime feeding distributions on the continental shelf. Southern rock sole spawn during the summer in the GOA (Stark and Somerton 2002). Before they were identified as two separate species, Russian 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' and 55°0' N. and approximately 165°2' W. (Shubnikov and Lisovenko 1964). Southern rock sole spawning in the GOA was found to occur at depths of 35 and 120 m. Spawning females deposit a mass of eggs that 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 ºC to about 25 days at 2.9 ºC (Forrester 1964). Newly hatched larvae are pelagic (Waldron and Vinter 1978) and have been captured on all sides of Kodiak Island and along the Alaska Peninsula (Orr and Matarese 2000). Kamchatka larvae are reportedly 20 mm in length when they assume their side-swimming, bottom-dwelling form (Alton and Sample 1976) and have been present in nearshore juvenile sampling catches around Kodiak Island in September and October (Abookire et al. 2007). Forrester and Thompson (1969) report that age 1 fish are found with adults on the continental shelf during summer.

In the springtime southern rock sole begin actively feeding and commence a migration to the shallow waters of the continental shelf to spawn in summer. 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 may be a 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, southern rock sole begin the return migration to the deeper wintering grounds. Fecundity varies with size and was reported to be 450,000 eggs for fish 420 mm long. Larvae are pelagic and settlement occurs in September and October. The age or size at metamorphosis is unknown. Juveniles are separate from the adult population, remaining in shallow areas until they reach age 1 (Forrester 1964). The estimated age of 50 percent maturity is 9 years for southern rock sole females at approximately 347 mm length (Stark and Somerton 2002). The natural mortality rate is believed to range from 0.18 to 0.20 (Turnock et al. 2002).

D.15.8.2 Relevant Trophic Information

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

D.15.8.3 Habitat and Biological Associations

Larvae: Larval southern rock sole are planktonic for at least 2 to 3 months before metamorphosis occurs.

Settled Early Juveniles: The covariate contributing the most to the final SDM EFH map for this life stage, which was modeled combining both northern and southern rock sole, was bottom depth (Pirtle et al. 2023). The highest predicted probabilities of suitable habitat for settled early juvenile rock sole were nearshore or less than 125 m depth on the GOA continental shelf, including Cook Inlet and the bathymetric rises south and west of Kodiak Island. Habitat-related growth potential for this life stage is greater at shallower, inshore depths and on banks and bathymetric rises on the GOA continental shelf.

Subadults: The covariate contributing the most to the final SDM EFH map for this life stage was bottom depth (Pirtle et al. 2023). The highest abundances were predicted at less than 125 m depth on bathymetric rises, such as the banks south of Kodiak Island and west in the GOA. Nearshore areas along the outer coast of southeast Alaska were also areas of predicted high abundance for subadult southern rock sole.

Adults: The covariates contributing the most to the final SDM EFH map for this life stage were bottom depth (Pirtle et al. 2023). The highest abundances were predicted at less than 125 m depth on bathymetric rises, such as the banks south of Kodiak Island, around the Shumagin Islands, and the Alaska Peninsula. Inshore areas along the outer coast of southeast Alaska were also areas of predicted high abundance for adult southern rock sole.

Habitat and Biological Associations: Southern rock sole

Stage - EFH Level	Duration or Age	Diet/Prey	Season/ Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs		NA	summer	OCS	D			
Larvae	2 to 3 months?	U phyto/ zooplankton?	summer	OCS, MCS, ICS	P			
Settled Early Juveniles	to 3.5 years	polychaetes, bivalves, amphipods, misc. crustaceans	all year	BAY, ICS, OCS, MCS	D	S, G		
Subadults	up to 9 years	polychaetes, bivalves, amphipods, misc. crustaceans	all year	BAY, ICS, OCS, MCS	D	S, G		
Adults	9+ years	polychaetes, bivalves, amphipods, misc. crustaceans	feeding May–September spawning June–August	MCS, ICS MCS, OCS	D	S, G	ice edge	

D.15.8.4 Literature

Abookire, A., C. H. Ryer, T.P. Hurst and A. W. Stoner. 2007. A multi-species view of nursery areas: flatfish assemblages in coastal Alaska. Estuarine, Coastal and Shelf Science.

Alton, M.S., and T.M. Sample. 1976. Rock sole (Family Pleuronectidae) p. 461-474. *In*: Demersal fish and shellfish resources in the BS in the baseline year 1975. Principal investigators Walter T. Pereyra, Jerry E. Reeves, and Richard Bakkala. U.S. Dep. Comm., Natl. Oceanic Atmos. Admin., Natl. Mar. Serv., Northwest and Alaska Fish Center, Seattle, WA. Processed Rep., 619 p.

Armistead, C.E., and D.G. Nichol. 1993. 1990 Bottom Trawl Survey of the EBS Continental Shelf. U.S. Dep. Commer., NOAA Tech. Mem. NMFS-AFSC-7, 190 p.

Auster, P.J., R.J. Malatesta., R.W. Langton., L. Watling, P.C. Valentine, C.S. Donaldson, E.W. Langton, A.N. Shepard, and I.G. Babb. 1996. The impacts of mobile fishing gear on seafloor habitats in the Gulf of Maine (Northwest Atlantic): Implications for conservation of fish populations. Rev. in Fish. Sci. 4(2): 185-202.

Forrester, C.R. 1964. Demersal Quality of fertilized eggs of rock sole. J. Fish. Res. Bd. Canada, 21(6), 1964. P. 1531.

Forrester, C.R., and J.A. Thompson. 1969. Population studies on the rock sole, *Lepidopsetta bilineata*, of northern Hecate Strait British Columbia. Fish. Res. Bd. Canada, Tech. Rep. No. 108, 1969. 104 p.

Livingston, P.A., and Y. DeReynier. 1996. Groundfish food habits and predation on commercially important prey species in the EBS from 1990 to 1992. AFSC processed Rep. 96-04, 51 p. Alaska Fish. Sci. Cent., Natl. Mar. Fish. Serv., NOAA, 7600 Sand Point Way NE., Seattle, WA 98115.

Musienko, L.N. 1963. Ichthyoplankton of the BS (data of the BS expedition of 1958-59). Tr. Vses Nauchno-issled. Inst. Morsk. Rybn. Khoz. Okeanogr. 48 (Izv. Tikhookean. Nauchno-issled. Inst. Rybn. Khoz. Okeanogr. 50)239-269. [In Russ.] Transl. By Isr. Prog. Sci. Transl., 1968, p. 251-286. In P. A. Moiseev (Editor), Soviet fisheries investigations in the northeastern Pacific, Part I. Avail. Natl. Tech. Inf. Serv., Springfield, VA., as TT67-51203.

Orr, J. W. and A. C. Matarese. 2000. Revision of the genus *Lepidopsetta* Gill, 1862 (Teleostei: Pleuronectidae) based on larval and adult morphology, with a description of a new species from the North Pacific Ocean and Bering Sea. Fish. Bull. 98:539-582 (2000).

Pirtle, J. L., Laman, E. A., Harris, J., Siple, M. C., Rooper, C. N., Hurst, T. P., Conrath, C. L., and Gibson, G. A. 2023. Advancing model-based essential fish habitat descriptions for North Pacific species in the Gulf of Alaska. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-468, 541 p. https://doi.org/10.25923/ygdf-5f65

Shubnikov, D.A., and L.A. Lisovenko. 1964. Data on the biology of rock sole in the southeastern BS. Tr. Vses. Nauchno-issled. Inst. Morsk. Rybn. Khoz. Okeanogr. 49 (Izv. Tikookean. Nauchno-issled. Inst. Morsk. Rybn. Khoz. Okeanogr. 51) : 209-214. (Transl. In Soviet Fisheries Investigations in the Northeast Pacific, Part II, p. 220-226, by Israel Program Sci. Transl., 1968, available Natl. Tech. Inf. Serv., Springfield, VA, as TT 67-51204).

Shvetsov, F.G. 1978. Distribution and migrations of the rock sole, *Lepidopsetta bilineata*, in the regions of the Okhotsk Sea coast of Paramushir and Shumshu Islands. J. Ichthol., 18 (1), 56-62, 1978.

Stark, J.W., and D. A. Somerton. 2002. Maturation, spawning and growth of rock soles off Kodiak Island in the GOA. J. Fish. Biology (2002) 61, 417-431.

Turnock, B.J., T.K. Wilderbuer, and E.S. Brown. 2002. Flatfish. In Appendix B Stock Assessment and Fishery Evaluation for Groundfish Resources of the GOA Region. Pages 169-197. Council, 605 West 4th Ave., Suite 306, Anchorage, AK 99501.

Waldron, K.D., and B.M. Vinter. 1978. Ichthyoplankton of the EBS. U.S. Dep. Commer., Natl. Oceanic Atmos. Admin., Natl. Mar. Fish. Serv. Seattle, WA, Processed rep., 88 p.

D.15.9 Starry flounder (*Platichthys stellatus*)

D.15.9.1 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). This euryhaline species can tolerate a wide range of salinities and has been collected from marine to essentially freshwater environments (Orcutt 1950, Ralston 2005). The length ranges to separate starry flounder demersal life stages are settled early juveniles (20–150 mm), subadults (151–369 mm), and adults (> 369 mm) (Pirtle et al. 2023). They are distributed on the continental shelf across the GOA from southeast Alaska westward. Settled early juvenile and subadults had EFH hotspots inside Cook Inlet and offshore of the Copper and Bering Rivers (Pirtle et al. 2023).

D.15.9.2 Relevant Trophic Information

There is insufficient information on starry flounder predator or prey relationships at this time.

D.15.9.3 Habitat and Biological Associations

Settled Early Juveniles: The covariate contributing the most to the final SDM EFH map for this life stage was bottom depth (Pirtle et al. 2023). The highest predicted probabilities of suitable habitat for settled early juvenile starry flounder occurred at locations less than 100 m depth in nearshore areas throughout the GOA.

Subadults: The covariates contributing the most to the final SDM EFH map for this life stage were bottom depth and geographic location (Pirtle et al. 2023). Their highest abundances were predicted in nearshore areas and at shallow depths on the GOA continental shelf.

Adults: The covariate contributing the most to the final SDM EFH map for this life stage was bottom depth (Pirtle et al. 2023). The highest abundances were predicted in nearshore areas and at shallow depths on the GOA continental shelf.

D.15.9.4 Literature

Mecklenburg, C. W., T. A. Mecklenburg, and L. K. Thorsteinson. 2002. Fishes of Alaska. American Fisheries Society, Bethesda, MD.

Orcutt, H. G. 1950. The life history of the starry flounder Platichthys stellatus (Pallas). Calif. Dept. Fish and Game Fish Bull. No. 78, 64 p.

Pirtle, J. L., Laman, E. A., Harris, J., Siple, M. C., Rooper, C. N., Hurst, T. P., Conrath, C. L., and Gibson, G. A. 2023. Advancing model-based essential fish habitat descriptions for North Pacific species in the Gulf of Alaska. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-468, 541 p. https://doi.org/10.25923/ygdf-5f65

Ralston, S. 2005. An assessment of starry flounder off California, Oregon, and Washington. NOAA Fisheries, Southwest Fisheries Science Center.

D.15.10 Yellowfin sole (*Limanda aspera*)

D.15.10.1 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 are consistently caught in shallow areas along the Alaska Peninsula and around Kodiak Island during resource assessment surveys in the GOA. 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. Larvae have primarily been captured in shallow shelf areas in the Kodiak Island area and 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 in the Bering Sea. The age or size at metamorphosis is unknown. Juveniles are separate from the subadult and adult population, remaining in shallow areas until they reach approximately 140 mm. The estimated age of 50 percent maturity is 296 mm (Tenbrink and Wilderbuer 2015). Natural mortality rate is believed to range from 0.12 to 0.16.

D.15.10.2 Relevant Trophic Information

Groundfish predators include Pacific cod, skates, and Pacific halibut, mostly on fish ranging from 70 to 250 mm standard length. Adults feed over sandy substrates typically nearshore in shallow shelf areas on bivalves, polychaetes, amphipods and echiurids.

D.15.10.3 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 covariate contributing the most to the final SDM EFH map for this life stage was bottom depth (Pirtle et al. 2023). The highest predicted probabilities of suitable habitat for settled early juvenile yellowfin sole were less than 100 m depth on the GOA continental shelf. Habitat-related growth potential for this life stage is greater at shallower, inshore depths in the GOA.

Subadults: The covariates contributing the most to the final SDM EFH map for this life stage were bottom depth, geographic location, and tidal maximum (Pirtle et al. 2023). The highest abundances of subadult yellowfin sole were predicted in inshore areas of the central and western GOA west of the Kenai Peninsula.

Adults: The covariates contributing the most to the final SDM EFH map for this life stage were geographic location, bottom depth, and tidal maximum (Pirtle et al. 2023). Higher abundances of adult yellowfin sole were predicted in inshore areas of the central and western GOA west of the Kenai Peninsula

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 to 3 months?	U phyto/zooplankton?	summer, autumn?	BAY, BCH,ICS	P			
Early Juveniles	to 5.5 years	polychaetes, bivalves, amphipods, echiurids	all year	BAY, ICS, OCS, MCS	D	S		
Subadults	5.5 to 10 years	polychaetes, bivalves, amphipods, echiurids	all year	BAY, ICS, OCS, MCS, IP	D	S		
Adults	10+ years	polychaetes, bivalves, amphipods, echiurids	spawning/ feeding May–August non-spawning Nov–April	BAY, BCH, ICS, MCS, OCS, IP	D	S	ice edge	

D.15.10.4 Literature

Auster, P.J., Malatesta, R.J., Langton, R.W., L. Watling, P.C. Valentine, C.S. Donaldson, E.W. Langton, A.N. Shepard, and I.G. Babb. 1996. The impacts of mobile fishing gear on seafloor habitats in the Gulf of Maine (Northwest Atlantic): Implications for conservation of fish populations. Rev. in Fish. Sci. 4(2): 185-202.

Bakkala, R.G., V.G. Wespestad, and L.L. Low. 1982. The yellowfin sole (*Limanda aspera*) resource of the EBS--Its current and future potential for commercial fisheries. U.S. Dep. Commer., NOAA Tech. Memo. NMFS F/NWC-33, 43 p.

Fadeev, N.W. 1965. Comparative outline of the biology of fishes in the southeastern part of the BS and condition of their resources. [In Russ.] Tr. Vses. Nauchno-issled. Inst.Morsk. Rybn. Khoz. Okeanogr. 58 (Izv. Tikhookean. Nauchno-issled Inst. Morsk. Rybn. Khoz. Okeanogr. 53):121-138. (Trans. By Isr. Prog. Sci. Transl., 1968), p 112-129. In P.A. Moiseev (Editor), Soviet Fisheries Investigations in the northeastern Pacific, Pt. IV. Avail. Natl. Tech. Inf. Serv., Springfield, VA as TT 67-51206.

Kashkina, A.A. 1965. Reproduction of yellowfin sole (*Limanda aspera*) and changes in its spawning stocks in the EBS. Tr. Vses. Nauchno-issled, Inst. Morsk. Rybn. Khoz. Okeanogr. 58 (Izv. Tikhookean. Nauchno-issled. Inst. Rbn. Khoz. Okeanogr. 53):191-199. [In Russ.] Transl. By Isr. Prog. Sci. Transl., 1968, p. 182-190. In P.A. Moiseev (Editor), Soviet fisheries investigations in the northeastern Pacific, Part IV. Avail. Natl. Tech. Inf. Serv., Springfield, VA., as TT67-51206.

Livingston, P.A. and Y. DeReynier. 1996. Groundfish food habits and predation on commercially important prey species in the EBS from 1990 to 1992. AFSC processed Rep. 96-04, 51 p. Alaska Fish. Sci. Cent., Natl. Mar. Fish. Serv., NOAA, 7600 Sand Point Way NE., Seattle, WA 98115.

Musienko, L.N. 1963. Ichthyoplankton of the BS (data of the BS expedition of 1958-59). Tr. Vses Nauchno-issled. Inst. Morsk. Rybn. Khoz. Okeanogr. 48 (Izv. Tikhookean. Nauchno-issled. Inst. Rybn. Khoz. Okeanogr. 50)239-269. [In Russ.] Transl. By Isr. Prog. Sci. Transl., 1968, p. 251-286. In P.A. Moiseev (Editor), Soviet fisheries investigations in the northeastern Pacific, Part I. Avail. Natl. Tech. Inf. Serv., Springfield, VA, as TT67-51203.

Musienko, L.N. 1970. Reproduction and Development of BS. Tr. Vses Nauchno-issled. Inst. Morsk. Rybn. Khoz. Okeanogr. 70 (Izv. Tikhookean. Nauchno-issled. Inst. Rybn. Khoz. Okeanogr. 72)161-224. [In Russ.] Transl. By Isr. Prog. Sci. Transl., 1972, p. 161-224. In P.A. Moiseev (Editor), Soviet fisheries investigations in the northeastern Pacific, Part V. Avail. Natl. Tech. Inf. Serv., Springfield, VA., as TT71-50127.

Nichol, D.G. 1994. Maturation and Spawning of female yellowfin sole in the EBS. Preceding of the International North Pacific Flatfish Symposium, Oct. 26-28, 1994, Anchorage, AK. Alaska Sea Grant Program.

Pirtle, J. L., Laman, E. A., Harris, J., Siple, M. C., Rooper, C. N., Hurst, T. P., Conrath, C. L., and Gibson, G. A. 2023. Advancing model-based essential fish habitat descriptions for North Pacific species in the Gulf of

Alaska. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-468, 541 p. https://doi.org/10.25923/ygdf-5f65

Tenbrink, T. T., and T. K. Wilderbuer. 2015. Updated maturity estimates for flatfishes (Pleuronectidae) in the eastern Bering Sea, with implications for fishery management. Mar. Coast. Fish. 7: 474–482. https://doi.org/10.1080/19425120.2015.1091411.

Wakabayashi, K. 1986. Interspecific feeding relationships on the continental shelf of the EBS, with special reference to yellowfin sole. Int. N. Pac. Fish. Comm. Bull. 47:3-30.

Waldron, K.D. 1981. Ichthyoplankton. In D.W. Hood and J.A. Calder (Editors), The EBS shelf: Oceanography and resources, Vol. 1, p. 471-493. U.S. Dep. Commer., NOAA, Off. Mar. Poll. Asess., U.S. Gov. Print. Off., Wash., D.C.

Wilderbuer, T.K., G.E. Walters, and R.G. Bakkala. 1992. Yellowfin sole, *Pleuronectes asper*, of the EBS: Biological Characteristics, History of Exploitation, and Management. Mar. Fish. Rev. 54(4) p 1-18.

D.16 Shark complex

The species representatives for sharks are:

Lamnidae:	Salmon shark (*Lamna ditropis*)
Squalidae:	Sleeper shark (*Somniosus pacificus*)
	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 24 to 30 cm 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 97 cm and 36 years old; 50 percent of males are mature at 74 cm 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 GOA groundfish fishery and survey data, salmon sharks occur near the coast to the outer shelf, particularly near Kodiak Island.

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. They occur often 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 GOA groundfish fishery and survey data, Pacific sleeper sharks are found along the coast to the outer shelf, 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 Adults: Spiny dogfish are widely dispersed throughout the water column on shelf in the GOA. They are not common at depths greater than 200 m. The covariates contributing the most to the final SDM EFH map for these combined life stages were geographic location, bottom temperature, and bottom current velocity (Pirtle et al. 2023). Higher abundance of spiny dogfish was predicted to occur in southern Cook Inlet, east of Kodiak Island, and areas of the central and eastern GOA.

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

Pacific sleeper sharks are widely dispersed on shelf/upper slope in the GOA; they are 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
Neonates								
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	
Juveniles and Adults								
Salmon shark	30+ years	fish (salmon, sculpins, and gadids)	all year	ICS, MCS, OCS, USP in GOA	P	NA	U	4-24°C
Pacific sleeper shark	U	flatfish, cephalopods, rockfish, crabs, seals, salmon, pinnipeds	all year	ICS, MCS, OCS, USP in GOA	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	P/D	U	U	4–16°C

D.16.4 Literature

Alverson, Dand M. E. Stansby. 1963. The spiny dogfish (*Squalus acanthias*) in the northeastern Pacific. USFWS Spec Sci Rep-Fisheries. 447:25p.

Beamish, R. J., G. A. McFarlane, K. R. Weir, M. S. Smith, J.Scarsbrook, A. J. Cass and C. C. Wood. 1982. Observations on the biology of Pacific hake, walleye pollock and spiny dogfish in the Strait of Georgia, Juan de Fuca Strait and off the west coast of Vancouver Island and United States, July 13-24, 1976. Can MS Rep Fish Aquat Sci. 1651:150p.

Beamish, R.J., and G.A. McFarlane. 1985. Annulus development on the second dorsal spine of the spiny dogfish (*Squalus acanthias*) and its validity for age determination. JAquat. Sci. 42:1799-1805.

Benz, G. W., R. Hocking, A. Kowunna Sr., S. A. Bullard, J.C. George. 2004. A second species of Arctic shark: Pacific sleeper shark *Somniosus pacificus* from Point Hope, Alaska. Polar Biol. 27:250-252.

Bonham, K. 1954. Food of the dogfish *Squalus acanthias*. Fish Res Paper. 1:25-36.

Bright, D.B. 1959. The occurance and food of the sleeper shark, *Sominus pacificus*, in a central Alaskan Bay. Copeia 1959. 76-77.

Campana, S. E., C. Jones, G. A. McFarlane, and S. Myklevoll. 2006. Bomb dating and age validation using the spines of spiny dogfish (*Squalus acanthias*). Environ Biol Fish. 77:327-336.

Conrath, C.L., C.A. Tribuzio, and K.J. Goldman. 2014. Notes on the reproductive biology of female salmon sharks in the eastern North Pacific Ocean. Transactions of the American Fisheries Society. 143:363-368.

Cortes, E. 1999. Standardized diet compositions and trophic levels of sharks. J Mar Sci. 56:707-717.

Cortes, E. 2007. Chondrichthyan demographic modelling: an essay on its use, abuse and future. *Marine and Freshwater Research* **58**, 4-6.

Courtney, D. L. and R. FoyPacific sleeper shark *Somniosus pacificus* trophic ecology in the eastern North Pacific Ocean inferred from nitrogen and carbon stable-isotope ratios and diet. Journal of Fish Biology. 80:1508-1545.

Ebert, D.A., L.J.V. Compagno, and L.J. Natanson. 1987. Biological notes on the Pacific sleeper shark, *Somniosus pacificus (*Chondrichthyes: Squalidae). Calif. Fish and Game 73(2); 117-123.

Ebert, D.A., T.W. White, K.J. Goldman, L.J.V. Compagno, T.S. Daly-Engel and R.D. WardResurrection and redescriptions of *Squalus suckleyi* (Girard, 1854) from the North Pacfici, with comments on the *Squalus acanthias* subgroup (Squaliformes: Squalidae). Zootaxa. 2612:22-40.

Gilmore, R.G. 1993. Reproductive biology of lamnoid sharks. Env. Fish. 38:95-114.

Girard, C.F. 1854. Characterstics of some cartilaginous fishes of the Pacific coast of North America. Proceedings of the Natural Sciences of Philadephia. 7:196-197.

Goldman, K.J., S.D. Anderson, R.J. Latour and J.A. MusickHomeothermy in adult salmon sharks, *Lamna ditropis*. Env. Biol. Fish. December 2004.

Goldman, K.J. and J.A. Musick. 2006. Growth and maturity of salmon sharks in the eastern and western North Pacific, with comments on back-calculation methods. Fish. Bull 104:278-292.

Gotshall, D. W., and T. Jow. 1965. Sleeper sharks (*Somniosus pacificus*) off Trinidad, California, with life history notes. California Fish and Game 51:294 –298.

Hart, JL. 1973. Pacific fishes of Canada. Fisheries Research Board of Canada (Bull. 180), Ottawa, Canada. 749 pp.

Hulbert, L., A. M. Aires-Da-Silva, V. F. Gallucci, and J. S. Rice. 2005. Seasonal foraging behavior and migratory patterns of female *lamna ditropis* tagged in Prince William Sound, Alaska. J. Fish Biol. 67:490-509.

Hulbert, L., M. Sigler, and C. R. Lunsford. 2006. Depth and movement behavior of the Pacific sleeper shark in the north-east Pacific Ocean. J. of Fish Biol. 69:406-425.

Hulson, P-J.F., C.A. Tribuzio, K. Coutre. In review. The use of satellite tags to inform the stock assessment of a data poor species: Spiny Dogfish in the Gulf of Alaska. Proceedings of the 2015 Lowell Wakefield Symposium.

Ketchen, K. S. 1972. Size at maturity, fecundity, and embryonic growth of the spiny dogfish (*Squalus acanthias*) in British Columbia waters. J Fish Res Bd Canada. 29:1717-1723.

McFarlane. G.A., and J.R. King.Migration patterns of spiny dogfish (*Squalus acanthias*) in the North Pacific Ocean. Fishery Bulletin. 101:358-367.

Nagasawa, K. 1998. Predation by salmon sharks (*Lamna ditropis*) on Pacific salmon (*Oncorhynchus spp.*) in the North Pacific Ocean. Bulletin of the North Pacific Anadromous Fish Commission, No. 1:419-433.

Orlov, A.M. 1999. Capture of especially large sleeper shark *Somniosus pacificus* (Squalidae) with some notes on its ecology in Northwestern Pacific. Jornal of Ichthyology. 39: 548-553.

Orlov, A.M., and S.I. Moiseev. Some biological features of Pacific sleeper shark, *Somniosus pacificus* (Bigelow et Schroeder 1944) (Squalidae) in the Northwestern Pacific Ocean. Oceanological Studies. 28: 3-16.

Pirtle, J. L., Laman, E. A., Harris, J., Siple, M. C., Rooper, C. N., Hurst, T. P., Conrath, C. L., and Gibson, G. A. 2023. Advancing model-based essential fish habitat descriptions for North Pacific species in the Gulf of Alaska. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-468, 541 p. https://doi.org/10.25923/ygdf-5f65

Sano, O.The investigation of salmon sharks as a predator on salmon in the North Pacific, 1960. Bulletin of the Hokkaido Regional Fisheries Research Laboratory, Fisheries Agency 24:148–162 (in Japanese).

Saunders, M.W. and G.A. McFarlane. 1993. Age and length at maturity of the female spiny dogfish (*Squalus acanthias*) in the Strait of Georgia, British Columbia, Canada. Environ Biol Fish 38:49-57.

Schauffler, L. R. Heintz, M. Sigler and L. Hulbert. 2005. Fatty acid composition of sleeper shark (*Somniosus pacificus*) liver and muscle reveals nutritional dependence on planktivores. ICES CM 2005/N:05.

Sigler M.F., L. Hulbert, C. R. Lunsford, N. Thompson, K. Burek, G. Corry-Crowe, and A. Hirons. 2006. Diet of Pacific sleeper shark, a potential Steller sea lion predator, in the north-east Pacific Ocean. J. Fish Biol. 69:392-405.

Tanaka, S. 1980. Biological investigation of *Lamna ditropis* in the north-western waters of the North Pacific. *In* Report of investigation on sharks as a new marine resource (1979). Published by: Japan Marine Fishery Resource Research Center, Tokyo [English abstract, translation by Nakaya].

Taylor, I.G., G.R. Lippert, V.F. Gallucci and G.G. BargmannMovement patterns of spiny dogfish from historical tagging experiments in Washington State. In ' Biology and Management of Dogfish Sharks'. (Eds. V. F. Gallucci, G. A. McFarlane, and G. Bargmann) pp. 67 – 76. (American Fisheries Society: Bethesda, MD)

Tribuzio C. A., and G. H. Kruse. 2011. Demographic and risk analyses of spiny dogfish (Squalus suckleyi) in the Gulf of Alaska using age- and stage-based population models. Marine and Freshwater Research 62, 1395-1406. https://doi.org/10.1071/MF11062

Tribuzio, C.A. and G. H. Kruse. 2012. Life history characteristics of a lightly exploited stock of *Squalus suckleyi*. Journal of Fish Biology. 80:1159-1180.

Tribuzio, C. A., Gallucci, V. F., and Bargmann, G. G. 2009. A survey of demographics and reproductive biology of spiny dogfish (*Squalus acanthias*) in Puget Sound, WA. In ' Biology and Management of Dogfish Sharks'. (Eds. V. F. Gallucci, G. A. McFarlane, and G. Bargmann) pp. 181-194. (American Fisheries Society: Bethesda, MD)

Tribuzio, C.A., G.H. Kruse and J.T. Fujioka. 2010. Age and growth of spiny dogfish (*Squalus acanthias*) in the Gulf of Alaska: Analysis of alternative growth models. Fishery Bulletin. 102:119-135.

Tribuzio C. A., M. E. Matta, C. Gburski, C. Blood, W. Bubley, and G. H. Kruse. 2018. Are Pacific spiny dogfish lying about their age? A comparison of ageing structures for Squalus suckleyi. Marine and Freshwater Research 69, 37-47. https://doi.org/10.1071/MF16329

Tribuzio, C.A., M. E. Matta, K. Echave, C. Rodgveller, G. Dunne, and K. Fuller. 2022. Assessment of the shark stock complex in the Bering Sea/Aleutian Islands and Gulf of Alaska. North Pacific Fishery Management Council, 605 W. 4th Ave., Suite 306, Anchorage, AK 99501. 153 p.

Weng, K.C., A. Landiera, P.C. Castilho, D.B. Holts, R.J. Schallert, J.M. Morrissette, K.J. Goldman, and B.A. Block. 2005. Warm sharks in polar seas: satellite tracking from the dorsal fins of salmon sharks. Science 310:104-106.

White W.T., P.R. Last, J.D. Stevens, G.K. Yearsley, Fahmi and Dharmadi. 2006 Economically important sharks and rays of Indonesia Australian Centre for International Agricultural Research, Canberra, Australia.

Wood, C. C., Ketchen, K. S., and Beamish, R. J. (1979). Population dynamics of spiny dogfish (*Squalus acanthias*) in British Columbia waters. *Journal of the Fisheries Research Board of Canada* 36, 647-656.

Yang, M., and B.N. Page.Diet of Pacific sleeper shark, *Somniosus pacificus*, in the Gulf of Alaska. Fish. Bull. 97: 406-4-9.

Yano, K., J.D. Stevens, and L.J.V. Compagno.Distribution, reproduction and feeding of the Greenland shark *Somniosus (Somniosus) microcephalus*, with notes on two other sleeper sharks, *Somniosus (Somniosus) pacificus* and *Somniosus (Somniosus) antarticus.* J. Fish. Biol. 70: 374-390.

D.17 Shortraker rockfish (*Sebastes borealis*)

D.17.1 Life History and General Distribution

Shortraker rockfish are found around the arc of the north Pacific from southern California to northern Japan, including the Bering Sea and the Sea of Okhotsk (Mecklenburg et al. 2002). They also occur on seamounts in the GOA (Maloney 2004). Except for the adult stage, information on the life history of shortraker rockfish is extremely limited. Similar to other *Sebastes*, the fish appear to be viviparous; fertilization is internal and the developing eggs receive at least some nourishment from the mother. Parturition (release of larvae) may occur from February through August (McDermott 1994). Larvae can be positively identified only by using genetic techniques (Gray et al. 2006), which greatly hinders study of this life stage. Based on genetic identification, a few larval shortraker rockfish have been found in coastal waters of Southeast Alaska (Gray et al. 2006). Post-larvae are also difficult to identify, but genetic identification confirmed the presence of two specimens in epipelagic offshore waters of the GOA over depths greater than 1,000 m (Kondzela et al. 2007). It is unknown whether this very limited sampling of larval and post-larval fish is a good indication of the habitat preference of these life stages; clearly, additional sampling is needed. Similarly, almost nothing is known about juvenile shortraker rockfish in the GOA; only a few specimens less than 350-mm fork length have ever been caught by fishing gear in this region. Juveniles have been caught in somewhat larger numbers in bottom trawl surveys of the Aleutian Islands (e.g., Harrison 1993), but these data have not been analyzed to determine patterns of distribution or habitat preference. As adults, shortraker rockfish are demersal and inhabit depths from 328 to 3,937 feet (100 to 1,200 m) (Mecklenburg et al. 2002). However, survey and commercial fishery data indicate that the fish are most abundant along a narrow band of the continental slope at depths of 984 to 1,640 feet (300 to 500 m) (Ito 1999), where they often co-occur with rougheye and blackspotted rockfish. Within this habitat, shortraker rockfish tend to have a relatively even distribution when compared with the highly aggregated and patchy distribution of many other rockfish such as Pacific ocean perch (Clausen and Fujioka 2007).

Though relatively little is known about its biology and life history, shortraker rockfish appears to be a K-selected species with late maturation, slow growth, extreme longevity, and low natural mortality. Age of 50 percent maturity for female shortraker rockfish has been estimated to be 21.4 years for the GOA, with a maximum age of 116 years (Hutchinson 2004). Both these values are very old relative to other fish species. Another study reported an even older maximum age of 157 years (Munk 2001). Female length of 50 percent maturity has been estimated to be 449 mm (McDermott 1994). There is no information on age or length of maturity for males. Shortraker rockfish attains the largest size of any species in the genus *Sebastes*, with a maximum length of up to 47 inches (1200 mm; Mecklenburg et al. 2002). Estimates of natural mortality for shortraker rockfish range between 0.027 and 0.042 (McDermott 1994), and a mortality of 0.03 has been used in recent stock assessments to determine values of acceptable biological catch and overfishing for the GOA (Clausen 2007).

D.17.2 Relevant Trophic Information

The diet of adult shortraker rockfish in the GOA is not well known, but shrimp, deepwater fish such as myctophids, and squid appear to be the major prey items (Yang and Nelson 2000; Yang et al. 2006), A food study in the Aleutian Islands with a larger sample size of shortraker rockfish also found the diet to be mostly myctophids, squid, and shrimp (Yang 2003). In addition, gammarid amphipods, mysids, and miscellaneous fish were important food items in some years. There is no information on predators of shortraker rockfish. Due to their large size, older shortraker rockfish likely have few potential predators other than very large animals such as sleeper sharks or sperm whales.

D.17.3 Habitat and Biological Associations

Eggs: The timing of reproductive events is apparently protracted. Similar to all *Sebastes*, egg development for shortraker rockfish is completely internal. One study suggested parturition (i.e., larval release) may occur from February to August (McDermott 1994). Another study indicated the peak month of parturition in Southeast Alaska was April (Westrheim 1975). There is no information as to when males inseminate females or if migrations occur for spawning/breeding.

Larvae: Information on larval shortraker rockfish is very limited. Larval shortraker rockfish have been identified in pelagic plankton tows in coastal Southeast Alaska (Gray et al. 2006). Larval studies are hindered because the larvae at present can be positively identified only by genetic analysis, which is both expensive and labor-intensive.

Pelagic Early Juveniles: One study used genetics to identify two specimens of post-larval shortraker rockfish from samples collected in epipelagic waters far offshore in the GOA beyond the continental slope (Kondzela et al. 2007). This limited information is the only documentation of habitat preference for this life stage.

Subadults: Subadult shortraker rockfish were caught in summer bottom trawl surveys from Yakutat Trough to the weather GOA. The covariate contributing the most to the final SDM EFH map for this life stage was bottom depth alone (Pirtle et al. 2023). Higher subadult shortraker rockfish abundance was predicted to peak around 375 m depth, occurring over a relatively narrow depth range that included the outer extent of glacial troughs on the continental shelf and areas along the continental slope of the GOA.

Adults: Adult shortraker rockfish are demersal and in the GOA are concentrated at depths of 300 to 500 m (984 to 1,640 feet) along the continental slope. Much of this area is generally considered by fishermen to be steep and difficult to trawl. Observations from a manned submersible indicated that shortraker rockfish occurred over a wide range of habitats, but soft substrates of sand or mud usually had the highest densities of fish (Krieger 1992). However, this study also showed that habitats with steep slopes and frequent boulders were used at a higher rate than habitats with gradual slopes and few boulders. Another submersible study also found that shortraker and rougheye rockfish occur more frequently on steep slopes with numerous boulders (Krieger and Ito 1999). Although the study could not distinguish between the two species, it is highly probable that many of the fish were shortraker rockfish. Finally, a third submersible study found that “large” rockfish had a strong association with *Primnoa* spp. coral growing on boulders: less than 1 percent of the observed boulders had coral, but 85 percent of the “large” rockfish, which included redbanded rockfish along with shortraker and rougheye, were next to boulders with coral (Krieger and Wing 2002). Again, in this latter study, “large” rockfish were not positively identified, but it is likely based on location and depth that many were shortraker rockfish.

The covariates contributing the most to the final SDM EFH map for adult shortraker rockfish were bottom depth, bottom current speed, and geographic location (Pirtle et al. 2023). Higher adult shortraker rockfish abundance was predicted to peak around 375 m depth along increasingly sloping terrain with relatively moderate bottom current exposure, within a relatively narrow depth range that included the outer extent of glacial troughs on the continental shelf and areas along the continental slope of the GOA.

Habitat and Biological Associations: Shortraker Rockfish

Stage - EFH Level	Duration or Age	Diet/Prey	Season/ Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs	U	NA	NA	NA	NA	NA	NA	
Larvae	U	U	parturition: Feb–Aug	U; BAY	probably P	NA	U	
Pelagic Early Juveniles	U	U	summer to ?	LSP, BSN	probably D	NA	U	
Subadults	Up to 21 years of age	U	U	OCS?, USP?	probably D	U	U	
Adults	21 to >100 years of age	shrimp, squid, myctophids	year-round?	USP	D	M, S, R, SM, CB, MS, G, C; steep slopes and boulders	U	observed associated with *Primnoa* coral

D.17.4 Literature

Clausen, D.M. 2007. Shortraker rockfish and other slope rockfish. In Stock assessment and fishery evaluation report for the groundfish resources of the GOA, p. 735-780. North Pacific Fishery Management Council, 605 W 4th Ave, Suite 306, Anchorage, AK 99501.

Clausen, D.M., and J.T. Fujioka. 2007. Variability in trawl survey catches of Pacific ocean perch, shortraker rockfish, and rougheye rockfish in the Gulf of Alaska. In J. Heifetz, J. DiCosimo, A.J. Gharrett, M.S. Love, V.M. O'Connell, and R.D. Stanley (editors), Biology, assessment, and management of North Pacific rockfishes, p. 411-428. Alaska Sea Grant, Univ. of Alaska Fairbanks.

Gray, A.K., A.W. Kendall, B.L. Wing, M.G. Carls, J. Heifetz, Z. Li, and A.J. Gharrett. 2006. Identification and first documentation of larval rockfishes in Southeast Alaskan waters was possible using mitochondrial markers but not pigmentation patterns. Trans. Am. Fish. Soc. 135: 1-11.

Harrison, R.C. 1993. Data report: 1991 bottom trawl survey of the Aleutian Islands area. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-12, 144 p.

Hutchinson, C.E. 2004. Using radioisotopes in the age determination of shortraker (*Sebastes borealis*) and canary (*Sebastes pinniger*) rockfish. Master's Thesis. Univ. Washington, Seattle. 84 p.

Kondzela, C.M., A.W. Kendall, Z. Li, D.M. Clausen, and A.J. Gharrett. 2007. Preliminary identification of pelagic juvenile rockfishes collected in the Gulf of Alaska. In J. Heifetz, J. DiCosimo, A.J. Gharrett, M.S. Love, V.M. O'Connell, and R.D. Stanley (editors), Biology, assessment, and management of North Pacific rockfishes, p. 153-166. Alaska Sea Grant, Univ. of Alaska Fairbanks.

Krieger, K. 1992. Shortraker rockfish, *Sebastes borealis*, observed from a manned submersible. Mar. Fish. Rev., 54(4): 34-37.

Krieger, K.J., and D.H. Ito. 1999. Distribution and abundance of shortraker rockfish, *Sebastes borealis*, and rougheye rockfish, *Sebastes aleutianus*, determined from a manned submersible. Fish. Bull. 97: 264-272.

Krieger, K.J., and B.L. Wing. 2002. Megafauna associations with deepwater corals (*Primnoa* spp.) in the GOA. Hydrobiologia 471: 83-90.

Ito, D.H. 1999. Assessing shortraker and rougheye rockfishes in the GOA: addressing a problem of habitat specificity and sampling capability. PhD. Dissertation. Univ. Washington, Seattle. 205 p.

Maloney, N. E. 2004. Sablefish, *Anoplopoma fimbria*, populations on Gulf of Alaska seamounts. Mar. Fish. Rev. 66(3): 1-12.

McDermott, S.F. 1994. Reproductive biology of rougheye and shortraker rockfish, *Sebastes aleutianus* and *Sebastes borealis*. Masters Thesis. Univ. Washington, Seattle.76 p.

Mecklenburg, C.W., T.A. Mecklenburg, and L.K. Thorsteinson. 2002. Fishes of Alaska. Am. Fish. Soc., Bethesda, Maryland. 1,037 p.

Munk, K.M. 2001. Maximum ages of groundfishes off Alaska and British Columbia and considerations of age determination. Alaska Fish. Res. Bull. 8(1): 12-21.

Pirtle, J. L., Laman, E. A., Harris, J., Siple, M. C., Rooper, C. N., Hurst, T. P., Conrath, C. L., and Gibson, G. A. 2023. Advancing model-based essential fish habitat descriptions for North Pacific species in the Gulf of Alaska. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-468, 541 p. https://doi.org/10.25923/ygdf-5f65

Westrheim, S.J. 1975. Reproduction, maturation, and identification of larvae of some *Sebastes* (Scorpaenidae) species in the northeast Pacific Ocean. J. Fish. Res. Board Can. 32:2399-2411.

Yang, M-S., and M.W. Nelson. 2000. Food habits of the commercially important groundfishes in the GOA in 1990, 1993, and 1996. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-112, 174 p.

Yang, M-S. 2003. Food habits of the important groundfishes in the AI in 1994 and 1999. AFSC Proc. Rep 2003-07. 233 p. (Available from NMFS, Alaska Fisheries Science Center, 7600 Sand Point Way NE, Seattle, WA 98115).

Yang, M-S., K. Dodd, R. Hibpshman, and A. Whitehouse. 2006. Food habits of groundfishes in the Gulf of Alaska in 1999 and 2001. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-164, 199 p.

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
Longnose skate

Species Complex Summary

Skates (Rajidae) that occur in the BSAI and GOA are grouped into two genera: *Bathyraja* sp., or soft-nosed species (rostral cartilage slender and snout soft and flexible), and *Raja* sp., or hard-nosed species (rostral cartilage is thick making the snout rigid). In the GOA, the Skate stock complex is managed as three units with big skate and longnose skate each having separate harvest specifications, and all remaining skates are managed as an “other skates” group (Ormseth 2019). Skates are oviparous; fertilization is internal, and eggs (one to five or more in each case) are deposited in horny cases for incubation. Big skates (*Raja binoculata*) and longnose skates (*Raja rhina*) are the most abundant skates in the GOA. Most of the biomass for these two species is located in the Central GOA (NMFS statistical areas 620 and 630). Depth distributions from surveys show that big skates are found primarily from 0 to 100 m; longnose skates are found primarily from 100 to 200 m, although they are found at all depths shallower than 300 m. Below 200 m depth, *Bathyraja* sp. skates are dominant. Little is known of their habitat requirements for growth or reproduction, nor of any seasonal movements. BSAI skate biomass estimate more than doubled between 1982 and 1996 from bottom trawl surveys; it may have decreased in the GOA and remained stable in the Aleutian Islands in the 1980

Relevant Trophic Information

Adults and juveniles are demersal and feed on bottom invertebrates (crustaceans, molluscs, and polychaetes) and fish.

Habitat and Biological Associations

Eggs: Skates deposit eggs in horny cases on the shelf and slope.

Juveniles: After hatching, juveniles probably remain in shelf and slope waters, but distribution is unknown.

Adults: Adults found across wide areas of shelf and slope; surveys found most skates at depths less than 500 m in the GOA and eastern Bering Sea, but greater than 500 m in the Aleutian Islands. In the GOA, most skates found between 4 and 7 °C, but data are limited.

Habitat and Biological Associations: Skates

Stage - EFH Level	Duration or Age	Diet/Prey	Season/ Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs	U	NA	U	MCS, OCS, USP	D	U	U	
Larvae	NA	NA	NA	NA	NA	NA	NA	
Juveniles	U	invertebrates, small fish	all year	MCS, OCS, USP	D	U	U	
Adults	U	invertebrates, small fish	all year	MCS,OCS, USP	D	U	U	

Literature

Allen, M.J., and G.B. Smith. 1988. Atlas and zoogeography of common fishes in the BS and Northeastern Pacific. U.S. Dep. Commerce., NOAA Tech. Rept. NMFS 66, 151 p.

Eschmyer, W.N., and E.S. Herald. 1983. A field guide to Pacific coast fishes, North America. Houghton Mifflin Co., Boston. 336 p.

Fritz, L.W. 1996. Other species *In* Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the BSAI Regions as Projected for 1997. Council, 605 West 4th Avenue, Suite 306, Anchorage, AK 99501.

Hart, J.L. 1973. Pacific fishes of Canada. Fisheries Res. Bd. Canada Bull. 180. Ottawa. 740 p.

Ormseth, O.A. and B. Matta. 2009. Gulf of Alaska Skates. In: Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Gulf of Alaska Region. North Pacific Fishery Management Council, 605 W. 4th Ave., Suite 306, Anchorage, AK 99501.

Ormseth, O. A. 2019. Assessment of the skate stock complex in the Gulf of Alaska. In Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Gulf of Alaska. North Pacific Fishery Management Council, 1007 West Third, Suite 400 Anchorage, AK 99501.

Teshima, K., and T.K. Wilderbuer. 1990. Distribution and abundance of skates in the EBS, AI region, and the GOA. Pp. 257-267 *in* H.L. Pratt, Jr., S.H. Gruber, and T. Taniuchi (eds.)., Elasmobranchs as living resources: advances in the biology, ecology, systematics and the status of the fisheries. U.S. Dep. Commerce., NOAA Technical Report 90.

D.18.1 Alaska skate (*Bathyraja parmifera*)

D.18.1.1 Life History and General Distribution

The Alaska skate (*Bathyraja parmifera*) is a large, shallow water skate (Ebert 2005, Stevenson et al. 2007) that ranges from the eastern Bering Sea and Aleutian Islands to the eastern Gulf of Alaska (Mecklenberg et al. 2002). Subadult Alaska skates (≤ 920 mm TL) are distinguished from adults (> 920 mm TL) based on length at 50% maturity (Matta and Gunderson 2007). EFH for both subadult and adult Alaska skates is similar and primarily in Shelikof Strait, off southwestern Kodiak Island, and near Unimak Pass (Pirtle et al. 2023).

D.18.1.2 Relevant Trophic Information

There is insufficient information on Alaska skate predator or prey relationships at this time.

D.18.1.3 Habitat and Biological Associations

Subadults: The covariates contributing the most to the final SDM EFH map for this life stage were geographic location, bottom depth, and BPI (Pirtle et al. 2023). The highest abundances of subadult Alaska skate were predicted in the central GOA in Shelikof Strait and near the western end of the Alaska Peninsula at depths around 250 m.

Adults: The covariates contributing the most to the final SDM EFH map for this life stage were geographic location, bottom depth, and bottom current velocity variability (Pirtle et al. 2023). Their predicted numerical abundance was higher in the western half of GOA.

D.18.1.4 Literature

Ebert, D. A. 2005. Reproductive biology of skates, Bathyraja (Ishiyama), along the eastern Bering Sea continental slope. J. Fish Biol. 66 (3): 618–649.

Matta, M. E., and D. R. Gunderson. 2007. Age, growth, maturity, and mortality of the Alaska skate, Bathyraja parmifera, in the eastern Bering Sea. *In*: Ebert, D.A., Sulikowski, J.A. (eds) Biology of Skates. Developments in Environmental Biology of Fishes 27, vol 27. Springer, Dordrecht. https://doi.org/10.1007/978-1-4020-9703-4_15

Mecklenburg, C. W., T. A. Mecklenburg, and L. K. Thorsteinson. 2002. Fishes of Alaska. American Fisheries Society, Bethesda, MD.

Pirtle, J. L., Laman, E. A., Harris, J., Siple, M. C., Rooper, C. N., Hurst, T. P., Conrath, C. L., and Gibson, G. A. 2023. Advancing model-based essential fish habitat descriptions for North Pacific species in the Gulf of Alaska. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-468, 541 p. https://doi.org/10.25923/ygdf-5f65

Stevenson, D. E., J. W. Orr, G. R. Hoff, and J. D. McEachran. 2007. Sharks, skates and ratfish of Alaska. Fairbanks, AK: Alaska Sea Grant, University of Alaska.

D.18.2 Aleutian skate (*Bathyraja aleutica*)

D.18.2.1 Life History and General Distribution

The Aleutian skate (*Bathyraja aleutica*) is a large species (1,500 mm TL maximum length) that ranges from the Bering Sea and Aleutian Islands into the Gulf of Alaska over a wide range of depths (29–950 m; Stevenson et al. 2007). In RACE-GAP summer bottom trawl surveys of the GOA, they are generally found in the outer domain on the GOA shelf (> 200 m depths) and on the upper continental slope (Hoff 2009). The spatial distribution of subadult (≤ 1,320 mm TL) and adult (> 1,320 mm TL) life stages (Ebert et al. 2007, Haas et al. 2016) overlaps in the GOA.

D.18.2.2 Relevant Trophic Information

There is insufficient information on Alaska skate predator or prey relationships at this time.

D.18.2.3 Habitat and Biological Associations

Subadults: The covariates contributing the most to the final SDM EFH map for this life stage were bottom depth, geographic location, and bottom temperature (Pirtle et al. 2023). Higher subadult Aleutian skate abundance occurred in Shelikof Strait and to the southwest in depths around 300 m.

Adults: The covariates contributing the most to the final SDM EFH map for this life stage were geographic location, bottom depth, and bottom temperature (Pirtle et al. 2023), which predicted adult

Aleutian skate abundance to be highest in the Shelikof Strait and into the Chirikof region in depths around 250 m.

D.18.2.4 Literature

Ebert, D. A., W. D. Smith, D. L. Haas, S. M. Ainsley, and G. M. Cailliet. 2007. Life history and population dynamics of Alaskan skates: providing essential biological information for effective management of bycatch and target species. Final Report to the North Pacific Research Board, Project 510.

Haas, D. L., D. A. Ebert, and G. M. Cailliet. 2016. Comparative age and growth of the Aleutian skate, Bathyraja aleutica, from the eastern Bering Sea and Gulf of Alaska. Env. Biol. Fish. 99: 813–828.

Hoff, G. R. 2009. Embryo developmental events and the egg case of the Aleutian skate Bathyraja aleutica (Gilbert) and the Alaska skate Bathyraja parmifera (Bean). J. Fish. Biol. 74 (3): 438–501.

Pirtle, J. L., Laman, E. A., Harris, J., Siple, M. C., Rooper, C. N., Hurst, T. P., Conrath, C. L., and Gibson, G. A. 2023. Advancing model-based essential fish habitat descriptions for North Pacific species in the Gulf of Alaska. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-468, 541 p. https://doi.org/10.25923/ygdf-5f65

Stevenson, D. E., J. W. Orr, G. R. Hoff, and J. D. McEachran. 2007. Sharks, skates and ratfish of Alaska. Fairbanks, AK: Alaska Sea Grant, University of Alaska.

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; Mecklenberg et al. 2002) and reaches a maximum length of 800 mm TL (Stevenson et al. 2007). Bering skate subadult and adult life stages are separated at 690 mm TL (Ainsley et al. 2011). Subadults are distributed across the GOA continental shelf from Dixon Entrance to Unimak Pass while adult Bering skates are more common between the Yakutat region through to the western GOA (Pirtle et al. 2023).

D.18.3.2 Relevant Trophic Information

There is insufficient information on Alaska skate predator or prey relationships at this time.

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 geographic location, bottom depth, and bottom temperature (Pirte et al. 2023). Higher abundances of subadult Bering skates occurred in Shelikof Strait and to the southwest in depths around 300 m.

Adults: The covariates contributing the most to the final SDM EFH map for this life stage were geographic location, bottom depth, and bottom temperature (Pirtle et al. 2023). Adult Bering skate abundance was highest in Shelikof Strait in depths around 250 m with relatively little bottom current.

D.18.3.4 Literature

Ainsley, S. M., D. A. Ebert, and G. M. Cailliet. 2011. A comparison of reproductive parameters of the Bering skate, Bathyraja interrupta, from two Alaskan large marine ecosystems. Mar. Fresh. Res. 62: 557–566.

Mecklenburg, C. W., T. A. Mecklenburg, and L. K. Thorsteinson. 2002. Fishes of Alaska. American Fisheries Society, Bethesda, MD.

Pirtle, J. L., Laman, E. A., Harris, J., Siple, M. C., Rooper, C. N., Hurst, T. P., Conrath, C. L., and Gibson, G. A. 2023. Advancing model-based essential fish habitat descriptions for North Pacific species in the Gulf of Alaska. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-468, 541 p. https://doi.org/10.25923/ygdf-5f65

Stevenson, D. E., J. W. Orr, G. R. Hoff, and J. D. McEachran. 2007. Sharks, skates and ratfish of Alaska. Fairbanks, AK: Alaska Sea Grant, University of Alaska.

D.18.4 Big skate (*Beringraja binoculata*)

D.18.4.1 Life History and General Distribution

The big skate (*Beringraja binoculata*) is a large skate (maximum reported TL ~ 2.4 m) that ranges from the eastern Bering Sea and Aleutians Islands to Baja California (Mecklenberg et al. 2002). They inhabit a wide depth range (3–800 m) but are more commonly encountered in the GOA in waters shallower than 200 m. Big skate subadult and adult life stages are separated using L50 = 1,486 mm (Ebert et al. 2008). Subadult big skate distribution in the GOA is in shallower waters of the continental shelf from southeast Alaska to Unimak Pass; adult big skates are widely distributed across the GOA with concentrations around Kodiak Island and in Cook Inlet (Pirtle et al. 2023).

D.18.4.2 Relevant Trophic Information

There is insufficient information on Alaska skate predator or prey relationships at this time.

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 bottom depth, BPI, and geographic location (Pirtle et al. 2023). Subadult big skate abundance was highest in shallower depths (< 100 m) over high bathymetric rises in the Yakutat region, Cook Inlet, and around Kodiak Island.

Adults: The covariates contributing the most to the final SDM EFH map for this life stage were bottom depth, geographic location, and bottom temperature (Pirtle et al. 2023). Adult big skate abundance was highest in Cook Inlet and off southwestern Kodiak Island in the Chirikof region at shallower depths and warmer bottom temperature.

D.18.4.4 Literature

Ebert, D. A., W. D. Smith, and G. M. Cailliet. 2008. Reproductive biology of two commercially exploited skates, Raja binoculata and R. rhina, in the western Gulf of Alaska. Fish. Res. 94 (1): 48–57.

Mecklenburg, C. W., T. A. Mecklenburg, and L. K. Thorsteinson. 2002. Fishes of Alaska. American Fisheries Society, Bethesda, MD.

Pirtle, J. L., Laman, E. A., Harris, J., Siple, M. C., Rooper, C. N., Hurst, T. P., Conrath, C. L., and Gibson, G. A. 2023. Advancing model-based essential fish habitat descriptions for North Pacific species in the Gulf of Alaska. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-468, 541 p. https://doi.org/10.25923/ygdf-5f65

D.18.5 Longnose skate (*Raja rhina*)

D.18.5.1 Life History and General Distribution

The longnose skate (*Raja rhina*) is a relatively large skate (maximum reported TL ~ 1.4 m) that ranges from the southeastern Bering Sea through the eastern Pacific Ocean to Baja California at depths of 20 m to more than 600 m (Mecklenberg et al. 2002). Longnose skate subadult and adult life stages are separated using female length at the onset of maturity (1,331 mm TL; Ebert et al. 2008). In the GOA, subadult longnose skates are distributed from the Shumagin region towards southeast Alaska and adult longnose skates are distributed over the continental shelf from southeast Alaska to Unimak Pass (Pirtle et al. 2023).

D.18.5.2 Relevant Trophic Information

There is insufficient information on Alaska skate predator or prey relationships at this time.

D.18.5.3 Habitat and Biological Associations

Subadults: The covariates contributing the most to the final SDM EFH map for this life stage were bottom depth, geographic location, and bottom temperature (Pirtle et al. 2023). Subadult longnose skate abundance was highest in the Kodiak and Yakutat regions in depths around 250 m in the glacial troughs.

Adults: The covariates contributing the most to the final SDM EFH map for this life stage were geographic location, bottom depth, and BPI (Pirtle et al. 2023). Adult longnose skate abundance was highest in the northern portion of Shelikof Strait and the eastern portion of the Kodiak region over depths around 250 m in the glacial troughs.

D.18.5.4 Literature

Ebert, D. A., W. D. Smith, and G. M. Cailliet. 2008. Reproductive biology of two commercially exploited skates, Raja binoculata and R. rhina, in the western Gulf of Alaska. Fish. Res. 94 (1): 48–57.

Mecklenburg, C. W., T. A. Mecklenburg, and L. K. Thorsteinson. 2002. Fishes of Alaska. American Fisheries Society, Bethesda, MD.

Pirtle, J. L., Laman, E. A., Harris, J., Siple, M. C., Rooper, C. N., Hurst, T. P., Conrath, C. L., and Gibson, G. A. 2023. Advancing model-based essential fish habitat descriptions for North Pacific species in the Gulf of Alaska. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-468, 541 p. https://doi.org/10.25923/ygdf-5f65

D.19 Thornyhead Rockfish complex *(Sebastolobus spp.)*

D.19.1 Life History and General Distribution

Thornyhead rockfish of the northeastern Pacific Ocean comprise two species, the shortspine thornyhead (*Sebastolobus alascanus*) and the longspine thornyhead (*S. altivelis*). The longspine thornyhead is not common in the GOA. The shortspine thornyhead is a demersal species which inhabits deep waters from 17 to 1,524 m along the Pacific rim from the Seas of Okhotsk and Japan in the western north Pacific, throughout the Aleutian Islands, Bering Sea slope, and GOA, and south to Baja California. This species is common throughout the GOA, 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. Shortspine thornyhead spawning takes place in the late spring and early summer, between April and July in the GOA Thornyhead rockfish spawn a bi-lobed mass of fertilized eggs which floats in the water column. Juvenile shortspine thornyhead rockfish have an extended pelagic period of about 14 to 15 months and settle out at about 22 to 27 mm into relatively shallow benthic habitats between 100 and 600 m and then migrate deeper as they grow. Fifty percent of female shortspine thornyhead rockfish are sexually mature at about 215 mm.

D.19.2 Relevant Trophic Information

Shortspine thornyhead rockfish prey mainly on epibenthic shrimp and fish. Yang (1993, 1996) showed that shrimp were the top prey item for shortspine thornyhead rockfish in the GOA, 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. Shortspine thornyhead rockfish are consumed by a variety of piscivores, including arrowtooth flounder, sablefish, “toothed whales” (sperm whales), and sharks. Juvenile shortspine thornyhead rockfish are thought to be consumed almost exclusively by adult thornyhead rockfish.

D.19.3 Habitat and Biological Associations

Egg/Spawning: Eggs float in masses of various sizes and shapes. Frequently the masses are bilobed with the lobes 150 mm 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.

Pelagic/Settled Early Juveniles: Juvenile shortspine thornyhead rockfish have an extended pelagic period of about 14 to 15 months and settle out at about 22 to 27 mm into relatively shallow benthic habitats between 100 and 600 m and then migrate deeper as they grow.

Subadults: The covariates contributing the most to the final SDM EFH map for this life stage were bottom depth, geographic location, and sponge presence (Pirtle et al. 2023). Higher subadult shortspine thornyhead abundance was predicted to peak around 375 m depth with a low presence of sponges. Predicted abundance was highest within a relatively small depth range that included the outer extent of glacial troughs on the continental shelf and areas along the continental slope of the GOA.

Adults: Adults are demersal and can be found at depths ranging from about 90 to 1,500 m. Once in benthic habitats thornyhead rockfish associate with muddy substrates, sometimes near rocks or gravel, and distribute themselves evenly across this habitat, appearing to prefer minimal interactions with individuals of the same species. They have very sedentary habits and are most often observed resting on the bottom in small depressions. Groundfish species commonly associated with thornyhead rockfish 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*).

The covariates contributing the most to the final SDM EFH map for this life stage were bottom depth, geographic location, and bottom current (Pirtle et al. 2023). Higher adult shortspine thornyhead abundance was predicted to peak around 300 m depth with relatively low bottom current exposure within a relatively small depth range, including glacial troughs on the continental shelf and areas along the continental slope of the GOA.

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		MCS, OCS, USP, LSP	D	M, S, R, SM, CB, MS, G	year-round?	

D.19.4 Literature

Allen, M.J., and G.B. Smith. 1988. Atlas and zoogeography of common fishes in the BS and Northeastern Pacific. U.S. Dep. Commer., NOAA Tech. Rept. NMFS 66, 151 p.

Aton, M. 1981. GOA bottomfish and shellfish resources. U.S. Dep. Commer. Tech. Memo. NMFS F/NWC-10, 51 p.

Aydin, K., S. Gaichas, I. Ortiz, D. Kinzey, and N. Friday. *In press*. A comparison of the Bering Sea, Gulf of Alaska, and Aleutian Islands large marine ecosystems through food web modeling. NOAA Tech Memo.

Archibald, C.P., W. Shaw, and B.M. Leaman. 1981. Growth and mortality estimates of rockfishes (Scorpaenidae) from B.C. coastal waters, 1977-79. Can. Tech. Rep. Fish. Aquat. Sci. 1048, 57 p.

Cailliet, G.M., A.H. Andrews, E.J. Burton, D.L. Watters, D.E. Kline, and L.A. Ferry-Grahan. 2001. Age determination and validation studies of marine fishes; do deep-dwellers live longer? Experimental Gerontology 36: 739-764Chilton, D.E., and R.J. Beamish. 1982. Age determination methods for fishes studied by the Groundfish Program at the Pacific Biological Station. Can. Spec. Publ. Fish. Aquat. Sci. 60, 102 p.

Cooper, D.W., K.E. Pearson, and D.R. Gunderson. 2005. Fecundity of shortspine thornyhead (*Sebastolobus alascanus*) and longspine thornyhead (*S. altivelis*) (Scorpaenidae) from the northeastern Pacific Ocean, determined by stereological and gravimetric techniques. Fish Bull 103: 15-22.

Gunderson, D.R. 1997. Trade-off between reproductive effort and adult survival in oviparous and viviparous fishes. Canadian Journal of Fisheries and Aquatic Science 54: 990-998.

Heifetz, J., J.N. Ianelli, and D.M. Clausen. 1996. Slope rockfish. In Stock assessment and fishery evaluation report for the groundfish resources of the GOA, p. 230-270. Council, 605 West 4th Avenue, Suite 306, Anchorage, AK 99501.

Ianelli, J.N., D.H. Ito, and M. Martin. 1996. Thornyheads (*Sebastolobus* sp.). In Stock Assessment and fishery evaluation report for the groundfish resources of the GOA, p. 303-330. Council, 605 West 4th Avenue, Suite 306, Anchorage, AK 99501.

Jacobson, L.D. 1993. Thornyheads. In Status of living marine resources off the Pacific coast of the United States for 1993. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-26, 35-37 p.

Kastelle, C.R., D.K. Kimura, and S.R. Jay. 2000. Using 210Pb/226Ra disequilibrium to validate conventional ages in Scorpaenids (genera *Sebastes* and *Sebastolobus*). Fisheries Research 46: 299-312.

Kline, D.E. 1996. Radiochemical age verification for two deep-sea rockfishes *Sebastolobus altivelis* and *S. alascanus*. M.S. Thesis, San Jose State University, San Jose CA, 124 pp.

Kramer, D.E., and V.M. O'Connell. 1986. Guide to northeast Pacific rockfishes, Genera *Sebastes* and *Sebastolobus*. Marine Advisory Bulletin No. 25: 1-78. Alaska Sea Grant College Program, University of Alaska.

Low, L.L. 1994. Thornyheads. In Status of living marine resources off Alaska, 1993. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-27, 56-57 p.

Love, M.S., M. Yoklavich, and L. Thorsteinson. 2002. The rockfishes of the northeast Pacific. University of California Press, Berkeley CA, 405 p.

Love, M.S., C.W. Mecklenberg, T.A. Mecklenberg, and L.K. Thorsteinson. 2005. Resource inventory of marine and estuarine fishes of the West Coast and Alaska: a checklist of north Pacific and Arctic Ocean species from Baja California to the Alaska-Yukon Border. U.S. Department of the Interior, U.S. Geological Survey, Biological Resources Division, Seattle, Washington, 98104, OCS Study MMS 2005-030 and USGS/NBII 2005-001.

Miller, P. P. 1985. Life history study of the shortspine thornyhead, *Sebastolobus alascanus*, at Cape Ommaney, south-eastern Alaska. M.S. Thesis, Univ. Alaska, Fairbanks, AK, 61 p. Sigler, M.F., and H.H. Zenger, Jr. 1994. Relative abundance of GOA sablefish and other groundfish based on the domestic longline survey, 1989. NOAA Tech. Memo. NMFS-AFSC-40.

Pearson, K.E., and D.R. Gunderson, 2003. Reproductive biology and ecology of shortspine thornyhead rockfish (*Sebastolobus alascanus*) and longspine thornyhead rockfish (*S. altivelis*) from the northeastern Pacific Ocean. Environ. Biol. Fishes 67:11-136.Wolotira, R.J., Jr., T.M. Sample, S.F. Noel, and C.R. Iten. 1993. Geographic and bathymetric distributions for many commercially important fishes and shellfishes off the west coast of North America, based on research survey and commercial catch data, 1912-84. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-6, 184 p.

Pirtle, J. L., Laman, E. A., Harris, J., Siple, M. C., Rooper, C. N., Hurst, T. P., Conrath, C. L., and Gibson, G. A. 2023. Advancing model-based essential fish habitat descriptions for North Pacific species in the Gulf of Alaska. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-468, 541 p. https://doi.org/10.25923/ygdf-5f65

Yang, M-S. 1993. Food habits of the commercially important groundfishes in the GOA in 1990. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-22, 150 p.

Yang, M-S. 1996. Diets of the important groundfishes in the AI in summer 1991. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-60, 105 p.

D.20 Walleye pollock (*Gadus chalcogrammus*)

The Gulf of Alaska (GOA) pollock stocks are managed under the Fishery Management Plan for Groundfish of the Gulf of Alaska (FMP), and 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. Pollock occur throughout the area covered by the FMP and straddle into the Canadian and Russian Exclusive Economic Zone (EEZ), the U.S. EEZ, international waters of the central Bering Sea, and into the Chukchi Sea.

D.20.1 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. In the GOA, pollock is the second most abundant groundfish stock comprising 25 to 50 percent of the catch and 20 percent of the biomass.

Four stocks of pollock are recognized for management purposes: GOA, 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 GOA 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.

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 GOA 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 GOA 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 GOA 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.

Peak pollock spawning occurs on the southeastern Bering Sea and eastern Aleutian Islands 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. In the GOA, peak spawning occurs in late March in Shelikof Strait. Peak spawning in the Shumagin area appears to be 2 to 3 weeks earlier than in Shelikof Strait.

Spawning occurs in the pelagic zone and eggs develop throughout the water column (70 to 80 m in the Bering Sea shelf, 150 to 200 m in Shelikof Strait). 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. In the GOA, development takes approximately 2 weeks at ambient temperature (5 °C). 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). In the GOA, larvae are distributed in the upper 40 m of the water column, and their diet is similar to Bering Sea larvae. 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 farther 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 and then 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. Length-based life stage breaks divide pollock subadults and adults at 410 mm (Williams et al. 2016).

D.20.2 Relevant Trophic Information

Juvenile pollock through newly maturing pollock primarily utilize copepods and euphausiids for food. At maturation and older ages pollock become increasingly piscivorous, with pollock (cannibalism) a major food item in the Bering Sea. Most of the pollock consumed by pollock are age 0 and 1 pollock, and recent research suggests that cannibalism can regulate year-class size. Weak year-classes appear to be those located 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.20.3 Habitat and Biological Associations

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

Larvae: Pelagic outer to mid-shelf region in the Bering Sea. Pelagic throughout the continental shelf within the top 40 m in the GOA.

Settled 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. The covariates contributing the most to the final SDM EFH map for this life stage were bathymetric position index (BPI), bottom depth, and terrain aspect covariates (Pirtle et al. 2023). The highest probabilities of suitable habitat for early juvenile pollock in the GOA were predicted to occur < 125 m depth, inshore, and on the continental shelf. Habitat-related growth potential for this life stage is greater at inshore and coastal areas as well as in glacial troughs on the GOA continental shelf, such as Shelikof Strait.

Subadults: The covariates contributing the most to the final SDM EFH map for this life stage were bottom depth, geographic location, and tidal current speed (Pirtle et al. 2023). The highest subadult pollock abundances were predicted relatively inshore in the RACE-GAP GOA survey area.

Adults: Adults occur both pelagically and demersally on the outer and mid-continental shelf of the GOA, 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. The covariates contributing the most to the final SDM EFH map for this life stage were bottom depth, geographic location, and rockiness (Pirtle et al. 2023). Adult pollock abundance was predicted to be highest near 250 m depth in the glacial troughs (BPI lows), including Shelikof Strait.

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 d. at 5 °C	None	Feb–Apr	OCS, UCS	P	NA	G?	
Larvae	60 days	copepod nauplii 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 to 16 years	pelagic crustaceans and fish	spawning Feb–Apr	OCS, BSN	P, SD	U	F, UP	increasingly demersal with age

D.20.4 Literature

A'mar, Z. T., Punt, A. E., and Dorn, M. W. 2009. The evaluation of two management strategies for the Gulf of Alaska walleye pollock fishery under climate change. – ICES Journal of Marine Science, 66.

Bailey, K.M. 2000. Shifting control of recruitment of walleye pollock *Theragra chalcogramma* after a major climatic and ecosystem change. Mar. Ecol. Prog. Ser 198:215-224.

Bailey, K.M., P.J. Stabeno, and D.A. Powers. 1997. The role of larval retention and transport features in mortality and potential gene flow of walleye pollock. J. Fish. Biol. 51(Suppl. A):135-154.

Bailey, K.M., S.J. Picquelle, and S.M. Spring. 1996. Mortality of larval walleye pollock (*Theragra chalcogramma*) in the western Gulf of Alaska, 1988-91. Fish. Oceanogr. 5 (Suppl. 1):124-136.

Bailey, K.M., T.J. Quinn II, P. Bentzen, and W.S. Grant. 1999. Population structure and dynamics of walleye pollock, *Theragra chalcogramma*. Advances in Mar. Biol. 37: 179-255.

Bakkala, R.G., V.G. Wespestad and L.L. Low. 1987. Historical trends in abundance and current condition of walleye pollock in the eastern Bering Sea. Fish. Res., 5:199-215.

Barbeaux, S. J., and M. W. Dorn. 2003. Spatial and temporal analysis of eastern Bering Sea echo integration-trawl survey and catch data of walleye pollock, *Theragra chalcogramma*. NOAA Technical Memorandum NMFS-AFSC-136.

Barbeaux, S. J., and D. Fraser (In Press). Aleutian Islands cooperative acoustic survey study 2006.NMFS AFSC NOAA Technical Memorandum. 90 p. NTIS. NTIS number pending

Bates, R.D. 1987. Ichthyoplankton of the Gulf of Alaska near Kodiak Island, April-May 1984. NWAFC Proc. Rep. 87-11, 53 pp.

Bond, N.A., and J.E. Overland 2005. The importance of episodic weather events to the ecosystem of the Bering Sea shelf. Fisheries Oceanography, Vol. 14, Issue 2, pp. 97-111.

Brodeur, R.D. and M.T. Wilson. 1996. A review of the distribution, ecology and population dynamics of age-0 walleye pollock in the Gulf of Alaska. Fish. Oceanogr. 5 (Suppl. 1):148-166.

Brown, A.L. and K.M. Bailey. 1992. Otolith analysis of juvenile walleye pollock *Theragra chalcogramma* from the western Gulf of Alaska. Mar. Bio. 112:23-30.

Dorn, M., S. Barbeaux, M. Guttormsen, B. Megrey, A. Hollowed, E. Brown, and K. Spalinger. 2002. Assessment of Walleye Pollock in the Gulf of Alaska. In Stock assessment and fishery evaluation report for the groundfish resources of the Gulf of Alaska, 2002. North Pacific Fishery Management Council, Box 103136, Anchorage, AK 99510. 88p.

Grant, W.S. and F.M. Utter. 1980. Biochemical variation in walleye pollock *Theragra chalcogramma*: population structure in the southeastern Bering Sea and Gulf of Alaska. Can. J. Fish. Aquat. Sci. 37:1093-1100.

Guttormsen , M. A., C. D. Wilson, and S. Stienessen. 2001. Echo integration-trawl survey results for walleye pollock in the Gulf of Alaska during 2001. In Stock Assessment and Fishery Evaluation Report for Gulf of Alaska. Prepared by the Gulf of Alaska Groundfish Plan Team, North Pacific Fishery Management Council, P.O. Box 103136, Anchorage, AK 99510. North Pacific Fisheries Management Council, Anchorage, AK.

Hinckley, S. 1987. The reproductive biology of walleye pollock, *Theragra chalcogramma*, in the Bering Sea, with reference to spawning stock structure. Fish. Bull. 85:481-498.

Hollowed, A.B., J.N. Ianelli, P. Livingston. 2000. Including predation mortality in stock assessments: a case study for Gulf of Alaska pollock. ICES J. Mar. Sci. 57:279-293.Hughes, S. E. and G. Hirschhorn. 1979. Biology of walleye pollock, *Theragra chalcogramma*, in Western Gulf of Alaska. Fish. Bull., U.S. 77:263-274.Ianelli, J.N. 2002. Bering Sea walleye pollock stock structure using morphometric methods. Tech. Report Hokkaido National Fisheries Research Inst. No. 5, 53-58.

Ianelli, J.N., S. Barbeaux, T. Honkalehto, G. Walters, and N. Williamson. 2002. Bering Sea-Aleutian Islands Walleye Pollock Assessment for 2003. In Stock assessment and fishery evaluation report for the groundfish resources of the Eastern Bering Sea and Aleutian Island Region, 2002. North Pacific Fishery Management Council, Box 103136, Anchorage, AK 99510. 88p.

Kendall, A.W., Jr. and S.J. Picquelle. 1990. Egg and larval distributions of walleye pollock *Theragra chalcogramma* in Shelikof Strait, Gulf of Alaska. U.S. Fish. Bull. 88(1):133-154.

Kim, S. and A.W. Kendall, Jr. 1989. Distribution and transport of larval walleye pollock (*Theragra chalcogramma*) in Shelikof Strait, Gulf of Alaska, in relation to water movement. Rapp. P.-v. Reun. Cons. int. Explor. Mer 191:127-136.

Kotwicki, S., T.W. Buckley, T. Honkalehto, and G. Walters. 2005. Variation in the distribution of walleye pollock (*Theragra chalcogramma*) with temperature and implications for seasonal migration. U.S. Fish. Bull. 103:574-587.

Kotwicki, S., A. DeRobertis, P von Szalay, and R. Towler. 2009. The effect of light intensity on the availability of walleye pollock (*Theragra chalcogramma*) to bottom trawl and acoustic surveys. Can. J. Fish. Aquat. Sci. 66(6): 983–994

Livingston, P.A. 1991. Groundfish food habits and predation on commercially important prey species in the eastern Bering Sea from 1884-1986. U.S. Dept. Commerce, NOAA Tech Memo. NMFS F/NWC-207.

Meuter, F.J. and B.L. Norcross. 2002. Spatial and temporal patterns in the demersal fish community on the shelf and upper slope regions of the Gulf of Alaska. Fish. Bull. 100:559-581.

Mueter, F.J., C. Ladd, M.C. Palmer, and B.L. Norcross. 2006. Bottom-up and top-down controls of walleye pollock (*Theragra chalcogramma*) on the Eastern Bering Sea shelf. Progress in Oceanography, Volume 68, 2:152-183.

Moss, J.H., E.V. Farley, Jr., and A.M. Feldmann, J.N. Ianelli. 2009. Spatial Distribution, Energetic Status, and Food Habits of Eastern Bering Sea Age-0 Walleye Pollock. Transactions of the American Fisheries Society 138:497–505.

Mulligan, T.J., Chapman, R.W. and B.L. Brown. 1992. Mitochondrial DNA analysis of walleye pollock, *Theragra chalcogramma*, from the eastern Bering Sea and Shelikof Strait, Gulf of Alaska. Can. J. Fish. Aquat. Sci. 49:319-326.

Olsen, J.B., S.E. Merkouris, and J.E. Seeb. 2002. An examination of spatial and temporal genetic variation in walleye pollock (*Theragra chalcogramma*) using allozyme, mitochondrial DNA, and microsatellite data. Fish. Bull. 100:752-764.

Pirtle, J. L., Laman, E. A., Harris, J., Siple, M. C., Rooper, C. N., Hurst, T. P., Conrath, C. L., and Gibson, G. A. 2023. Advancing model-based essential fish habitat descriptions for North Pacific species in the Gulf of Alaska. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-468, 541 p. https://doi.org/10.25923/ygdf-5f65

Rugen, W.C. 1990. Spatial and temporal distribution of larval fish in the western Gulf of Alaska, with emphasis on the period of peak abundance of walleye pollock (*Theragra chalcogramma*) larvae. NWAFC Proc. Rep. 90-01, 162 pp.

Stram, D. L., and J. N. Ianelli. 2009. Eastern Bering Sea pollock trawl fisheries: variation in salmon bycatch over time and space. *In* C. C. Krueger and C. E. Zimmerman, editors. Pacific salmon: ecology and management of western Alaska's populations. American Fisheries Society, Symposium 70, Bethesda, Maryland.

Shima, M. 1996. A study of the interaction between walleye pollock and Steller sea lions in the Gulf of Alaska. Ph.D. dissertation, University of Washington, Seattle, WA 98195.

Stabeno, P.J., J.D. Schumacher, K.M. Bailey, R.D. Brodeur, and E.D. Cokelet. 1996. Observed patches of walleye pollock eggs and larvae in Shelikof Strait, Alaska: their characteristics, formation and persistence. Fish. Oceanogr. 5 (Suppl. 1): 81-91.

Wespestad V.G., and T.J. Quinn, II. 1997. Importance of cannibalism in the population dynamics of walleye pollock. In: Ecology of Juvenile Walleye Pollock, *Theragra chalcogramma*. NOAA Technical Report, NMFS 126.

Wespestad, V.G. 1993. The status of BS pollock and the effect of the “Donut Hole” fishery. Fisheries 18(3)18-25.

Williams B. C., G. H. Kruse, and M. W. Dorn. 2016. Interannual and spatial variability in maturity of walleye pollock Gadus chalcogrammus and implications for spawning stock biomass estimates in the Gulf of Alaska. PLoS ONE 11 (10): e0164797. https://doi:10.1371/journal.pone.0164797.

Wolotira, R.J., Jr., T.M. Sample, S.F. Noel, and C.R. Iten. 1993. Geographic and bathymetric distributions for many commercially important fishes and shellfishes off the west coast of North America, based on research survey and commercial catch data, 1912-84. U.S. Dep. Commerce, NOAA Tech. Memo. NMFS-AFSC-6, 184 pp.

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 (see Pirtle et al. 2023 for mapping methods):

Figures E-1 to E-7	Arrowtooth flounder (larvae, settled early juvenile, subadult, adult) • settled early juvenile summer L1 E-1, subadult summer L2 E-2, adult summer L2 E-3; • larvae summer L1 E-4, adult fall L1 E-5, adult winter L1 E-6, adult spring L1 E-7.
Figures E-8 to E-12	Atka mackerel (subadult, adult) • subadult summer L2 E-8, adult summer L2 E-9; • adult fall L1 E-10, adult winter L1 E-11, adult spring L1 E-12.
Figures E-13 to E-19	Deepwater flatfish complex: Dover sole (egg, larvae, subadult, adult) • subadult summer L2 E-13, adult summer L2 E-14; • egg summer L1 E-15, larvae summer L1 E-16, adult fall L1 E-17, adult winter L1 E-18, adult spring L1 E-19
Figures E-20 to E-24	Dusky rockfish (subadult, adult) • subadult summer L2 E-20, adult summer L2 E-21; • adult fall L1 E-22, adult winter L1 E-23, adult spring L1 E-24.
Figures E-25 to E-32	Flathead sole (egg, larvae, settled early juvenile, subadult, adult) • settled early juvenile summer L1 E-25, subadult summer L2 E-26, adult summer L2 E-27; • egg summer L1 E-28, larvae summer L1 E-29, adult fall L1 E-30, adult winter L1 E-31, adult spring L1 E-32.
Figures E-33 to E-37	Northern rockfish (subadult, adult) • subadult summer L2 E-33, adult summer L2 E-34; • adult fall L1 E-35, adult winter L1 E-36, adult spring L1 E-37.
Figures E-38 to E-41	Octopuses (subadult/adult, adult) • subadult/adult summer L2 E-38; • adult fall L1 E-39, adult winter L1 E-40, adult spring L1 E-41.
Figures E-42 to E-49	Other rockfish complex, demersal subgroup (subadult/adult) • subadult/adult summer L2 E-42.
Figure E-43	Quillback rockfish (adult) • adult summer L2 E-43.
Figures E-44 to E-45	Rosethorn rockfish (subadult, adult)

	• subadult summer L2 E-44, adult summer L2 E-45.
Figures E-46 to E-49	Yelloweye rockfish (subadult, adult) • subadult summer L2 E-46, adult summer L2 E-47; • adult fall L1 E-48, adult spring L1 E-49.
Figures E-50 to E-62	Other rockfish complex, slope subgroup (subadult/adult) • subadult/adult summer L2 E-50.
Figure E-51	Greenstriped rockfish (adult) • adult summer L2 E-51.
Figures E-52 to E-54	Harlequin rockfish (subadult, adult) • subadult summer L2 E-52, adult summer L2 E-53; • adult spring L1 E-54.
Figure E-55	Pygmy rockfish (subadult/adult) • subadult/adult summer L2 E-55.
Figures E-56 to E-58	Redbanded rockfish (subadult, adult) • subadult summer L2 E-56, adult summer L2 E-57; • adult spring L1 E-58.
Figures E-59 to E-60	Redstripe rockfish (subadult, adult) • subadult summer L2 E-59, adult summer L2 E-60
Figures E-61 to E-63	Sharpchin rockfish (subadult, adult) • subadult summer L2 E-61, adult summer L2 E-62; • adult spring L1 E-63.
Figures E-64 to E-65	Silvergray rockfish (subadult, adult) • subadult summer L2 E-64, adult summer L2 E-65.
Figures E-66 to E-83	Pacific cod (egg, larvae yolk sac, larvae feeding preflexion, larvae feeding postflexion, pelagic early juvenile, settled early juvenile, subadult, adult) • egg summer L2 E-66, larvae yolk sac summer L2 E-67, larvae feeding preflexion summer L2 E-68, larvae feeding postflexion summer L2 E-69, early juvenile pelagic summer L2 E-70; settled early juvenile summer L1 E-71, subadult summer L2 E-72, adult summer L2 E-73; • adult fall L1 E-74, adult winter L1 E-75, adult spring L1 E-76; • egg summer L3 growth E-77, larvae yolk sac summer L3 growth E-78, larvae feeding preflexion summer L3 growth E-79, larvae feeding postflexion summer L3 growth E-80, early juvenile pelagic summer L3 growth E-81, settled early juvenile summer L3 growth E-82, settled early juvenile summer L3 condition E-83.
Figures E-84 to E-91	Pacific ocean perch (larvae, settled early juvenile, subadult, adult) • settled early juvenile summer L1 E-84, subadult summer L2 E-85, adult summer L2 E-86;

	• larvae summer L1 E-87, adult fall L1 E-88, adult winter L1 E-89, adult spring L1 E-90; • settled early juvenile summer L3 growth E-91.
Figures E-92 to E-99	Rex sole (egg, larvae, settled early juvenile, subadult, adult) • settled early juvenile summer L1 E-92, subadult summer L2 E-93, adult summer L2 E-94; • egg summer L1 E-95, larvae summer L1 E-96, adult fall L1 E-97, adult winter L1 E-98, adult spring L1 E-99.
Figures E-100 to E-104	Rougheye/blackspotted rockfish (subadult, adult) • subadult summer L2 E-100, adult summer L2 E-101; • adult (rougheye rockfish) fall L1 E-102, adult (rougheye rockfish) winter L1 E-103, adult (rougheye rockfish) spring L1 E-104.
Figures E-105 to E-121	Sablefish (egg, larvae yolk sac, larvae feeding, early juvenile epipelagic, early juvenile pelagic, settled early juvenile, subadult, adult) • egg summer L2 E-105, larvae yolk sac summer L2 E-106, larvae feeding summer L2 E-107, early juvenile epipelagic summer L2 E-108, early juvenile pelagic summer L2 E-109, settled early juvenile summer L1 E-110, subadult summer L2 E-111, adult summer L2 E-112; • adult fall L1 E-113, adult winter L1 E-114, adult spring L1 E-115; • egg summer L3 growth E-116, larvae yolk sac summer L3 growth E-117, larvae feeding summer L3 growth E-118, early juvenile epipelagic summer L3 growth E-119, early juvenile pelagic summer L3 growth E-120, settled early juvenile summer L3 growth E-121.
Figures E-122 to E-154	Shallow water flatfish complex (subadult/adult) • subadult/adult summer L2 E-122.
Figures E-123 to E-126	Alaska plaice (egg, larvae, subadult, adult) • subadult summer L2 E-123, adult summer L2 E-124; • egg summer L1 E-125, larvae summer L1 E-126.
Figure E-127	Butter sole (subadult/adult) • subadult/adult summer L2 E-127.
Figures E-128 to E-130	English sole (settled early juvenile, subadult, adult) • settled early juvenile summer L1 E-128, subadult summer L2 E-129, adult summer L2 E-130.
Figure E-131 to E-138	Northern rock sole (larvae, settled early juvenile, subadult, adult) • settled early juvenile (rock soles) summer L1 E-131, subadult summer L2 E-132, adult summer L2 E-133; • larvae summer L1 E-134, adult fall L1 E-135, adult winter L1 E-136, adult spring L1 E-137; • settled early juvenile (rock soles) summer L3 growth E-138.
Figure E-139	Pacific sanddab (subadult/adult)

	• subadult/adult summer L2 E-139.
Figure E-140 to E-141	Petrale sole (subadult, adult) • subadult summer L2 E-140, adult summer L2 E-141.
Figure E-142	Sand sole (adult) • adult summer L2 E-142.
Figure E-143	Slender sole (subadult/adult) • subadult/adult summer L2 E-143.
Figures E-144 to E-146	Southern rock sole (larvae, subadult, adult) • subadult summer L2 E-144, adult summer L2 E-145; • larvae summer L1 E-146.
Figures E-147 to E-149	Starry flounder (settled early juvenile, subadult, adult) • settled early juvenile summer L1 E-147, subadult summer L2 E-148, adult summer L2 E-149.
Figures E-150 to E-154	Yellowfin sole (egg, settled early juvenile, subadult, adult) • settled early juvenile summer L1 E-150, subadult summer L2 E-151, adult summer L2 E-152; • egg summer L1 E-153; • settled early juvenile summer L3 growth E-154.
Figure E-155	Shark complex: Spiny dogfish (subadult/adult) • subadult/adult summer L2 E-155.
Figures E-156 to E-159	Shortraker rockfish (subadult, adult) • subadult summer L2 E-156, adult summer L2 E-157; • adult fall L1 E-158, adult spring L1 E-159.
Figures E-160 to E-177	Skate complex (subadult, adult) • subadult summer L2 E-160, adult summer L2 E-161.
Figures E-162 to E-166	Alaska skate (subadult, adult) • subadult summer L2 E-162, adult summer L2 E-163; • adult fall L1 E-164, adult winter L1 E-165, adult spring L1 E-166.
Figures E-167 to E-171	Aleutian skate (subadult, adult) • subadult summer L2 E-167, adult summer L2 E-168; • adult fall L1 E-169, adult winter L1 E-170, adult spring L1 E-171.
Figures E-172 to E-173	Bering skate (subadult, adult) • subadult summer L2 E-172, adult summer L2 E-173.
Figures E-174 to E-175	Big skate (subadult, adult) • subadult summer L2 E-174, adult summer L2 E-175.
Figures E-176 to E-177	Longnose skate (subadult, adult)

	• subadult summer L2 E-176, adult summer L2 E-177.
Figures E-178 to E-183	Thornyhead rockfish complex
Figure E-178	Longspine thornyhead rockfish (adult) • adult spring L1 E-178.
Figures E-179 to E-183	Shortspine thornyhead rockfish (subadult, adult) • subadult summer L2 E-179, adult summer L2 E-180; • adult fall L1 E-181, adult winter L1 E-182, adult spring L1 E-183.
Figures E-184 to E-192	Walleye pollock (egg, settled early juvenile, subadult, adult) • settled early juvenile summer L1 E-184, subadult summer L2 E-185, adult summer L2 E-186; • egg summer L1 E-187, adult fall L1 E-188, adult winter L1 E-189, adult spring L1 E-190; • settled early juvenile summer L3 growth E-191, settled early juvenile summer L3 condition E-192.

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 were used to map EFH Level 2 information for the 2023 EFH 5-year Review for subadults and adults in the summer from their distribution and abundance in 1993-2019 (Pirtle et al. 2023). New maps of habitat-related species distribution from SDMs for the settled early juvenile life stage were used to map EFH Level 1 information for the first time in the 2023 EFH 5-year Review from their distribution and abundance in 1989-2019 (Pirtle et al. 2023). 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, and 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 (Pirtle et al. 2023). For settled early juveniles, the cloglog probability of suitable habitat was used in place of encounter probability. 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 EFH 5-year Review by combining spatial projections of temperature dependent growth and lipid accumulation (condition) rates with SDMs (Pirtle et al. 2023).

EFH Level 2 maps of habitat-related density for pelagic early life stages were mapped for the first time in the 2023 EFH 5-year Review by combining biophysical individual-based models (IBMs) and SDMs for Pacific cod and sablefish as case studies (Hinckley et al. 2019, Gibson et al. 2023, Shotwell et al. In preperation). EFH Level 3 maps of habitat-related vital rates were also developed for each pelagic early life stage mapped by the combined IBM and SDM approach.

E.3 Figures

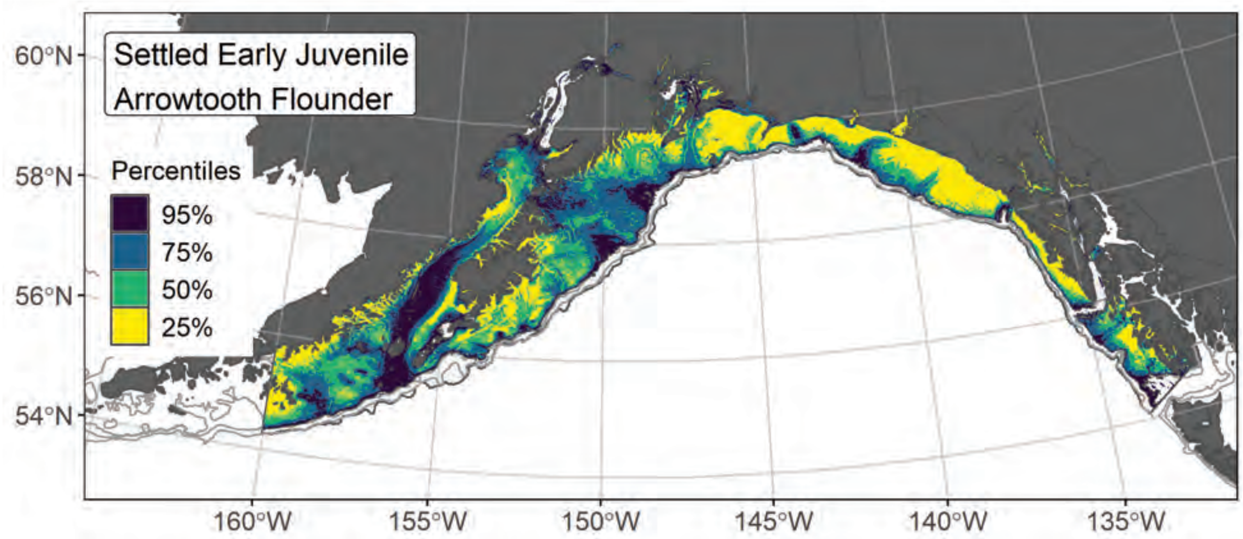

Figure E-1 EFH area of settled early juvenile arrowtooth flounder, summer

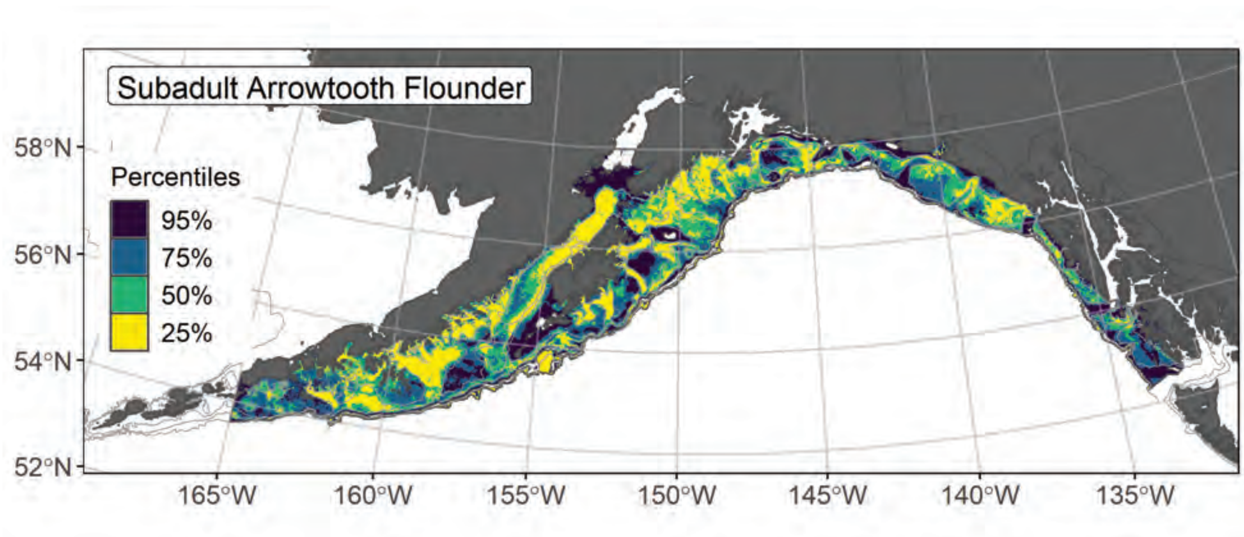

Figure E-2 EFH area of subadult arrowtooth flounder, summer

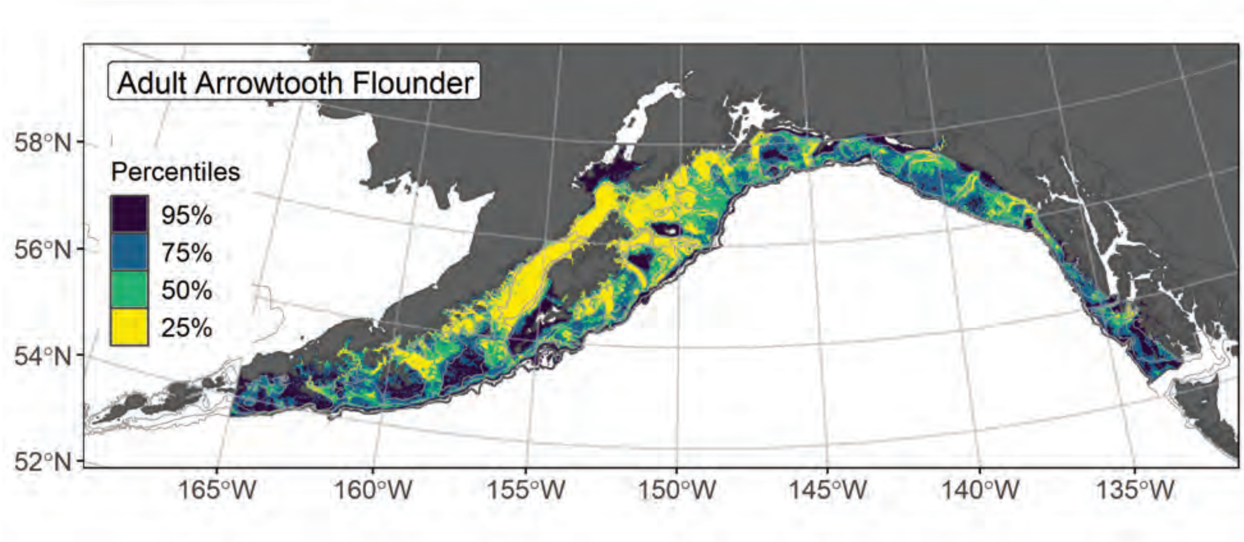

Figure E-3 EFH area of adult arrowtooth flounder, summer

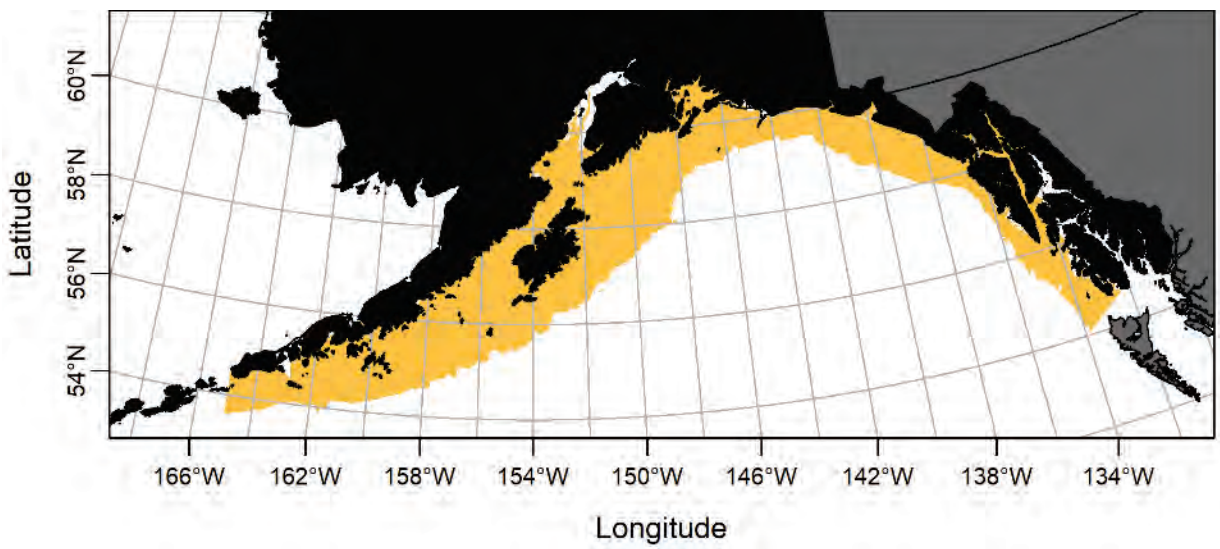

Figure E-4 EFH area of arrowtooth flounder larvae, summer

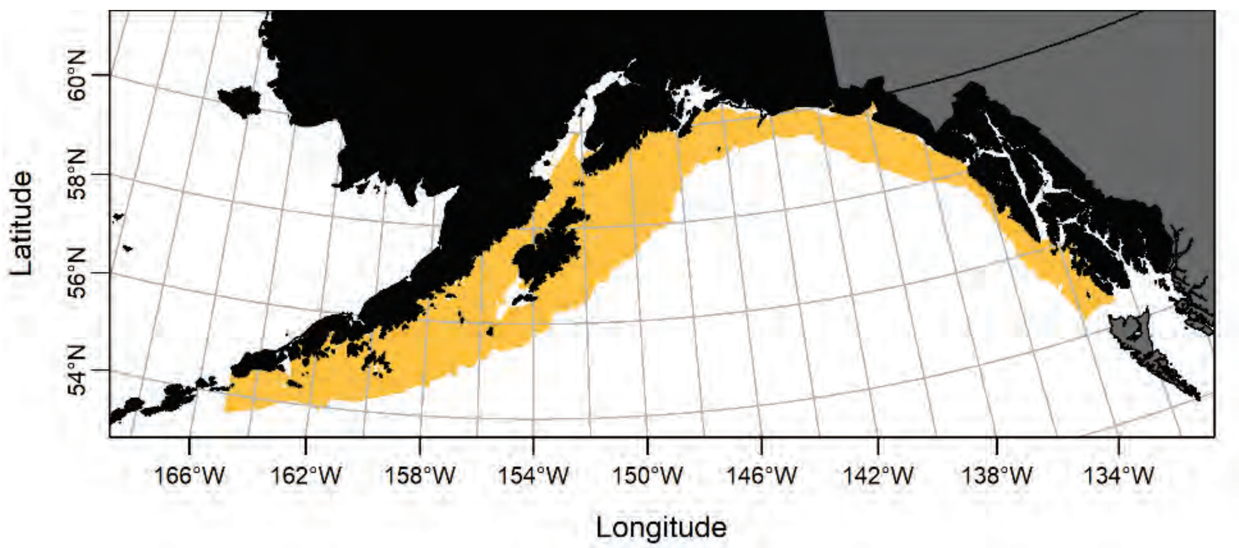

Figure E-5 EFH area of adult arrowtooth flounder, fall

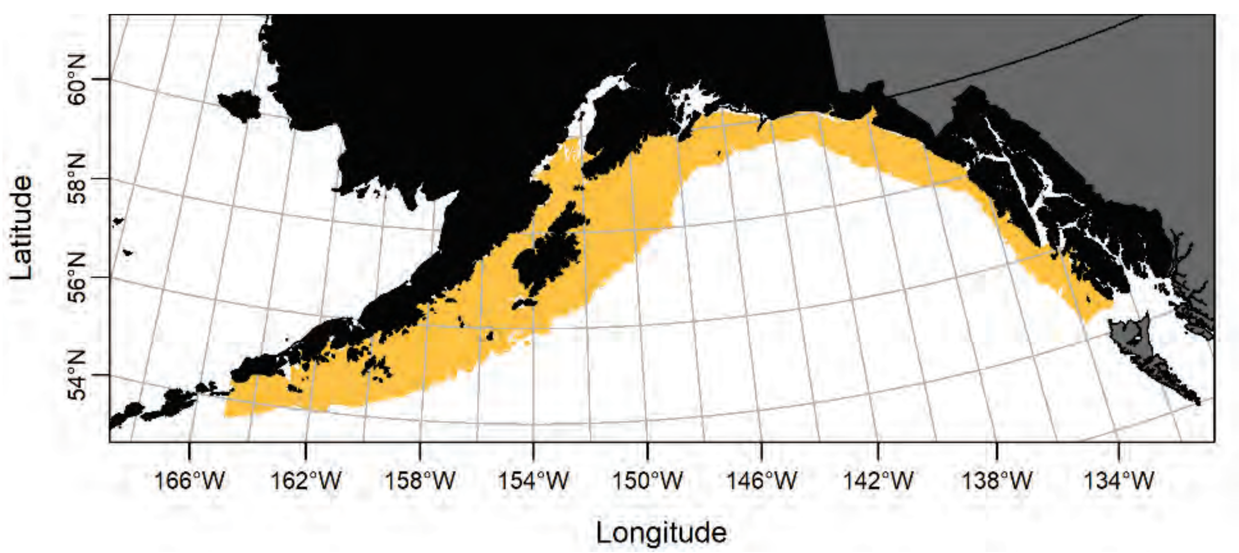

Figure E-6 EFH area of adult arrowtooth flounder, winter

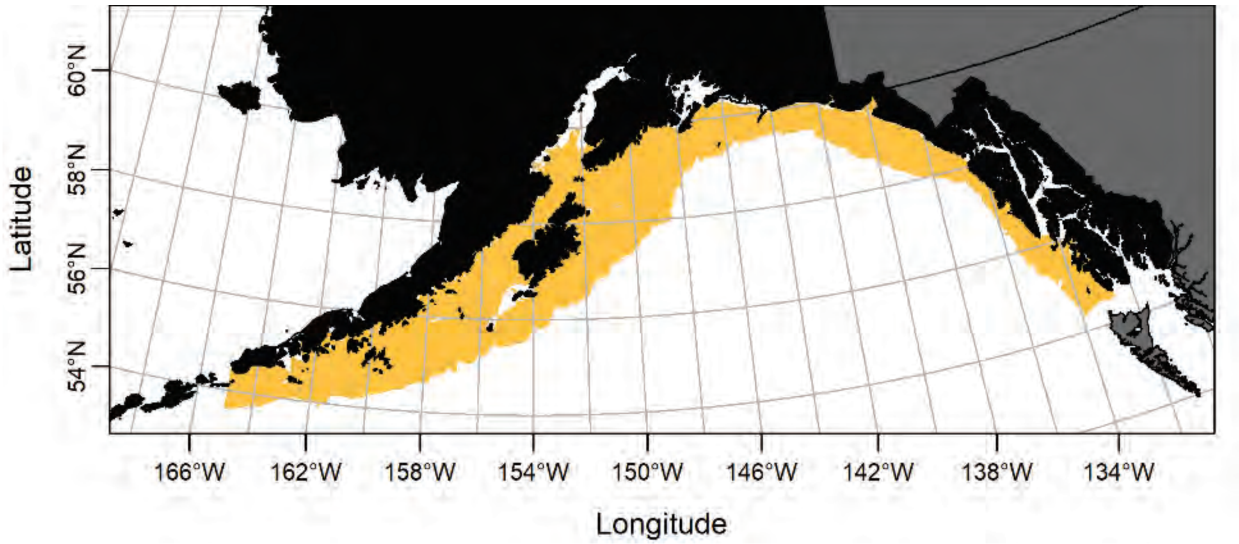

Figure E-7 EFH area of adult arrowtooth flounder, spring

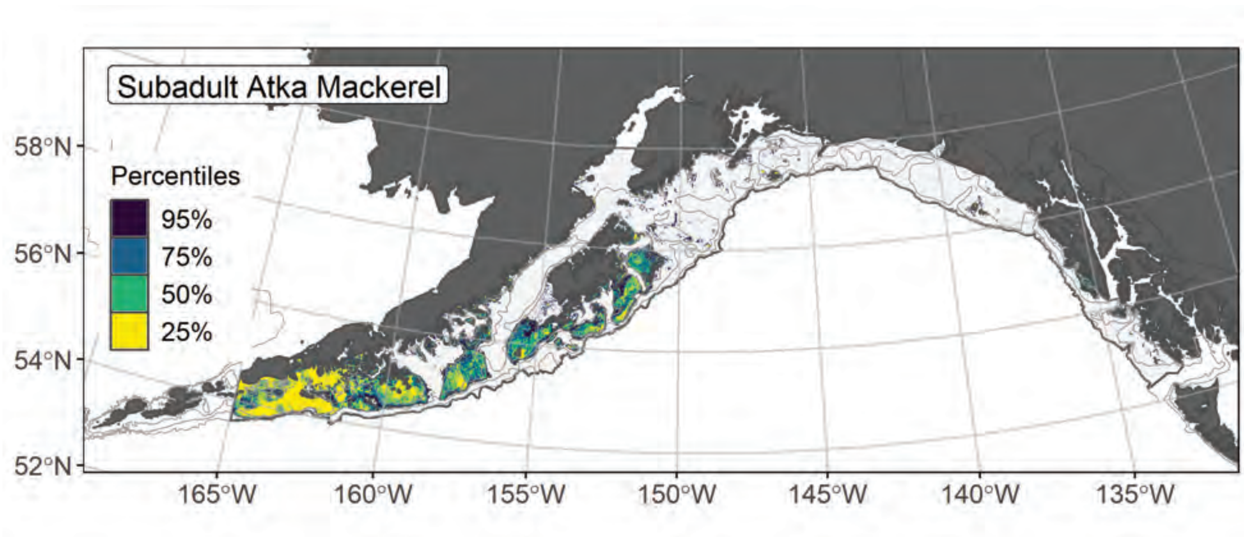

Figure E-8 EFH area of subadult Atka mackerel, summer

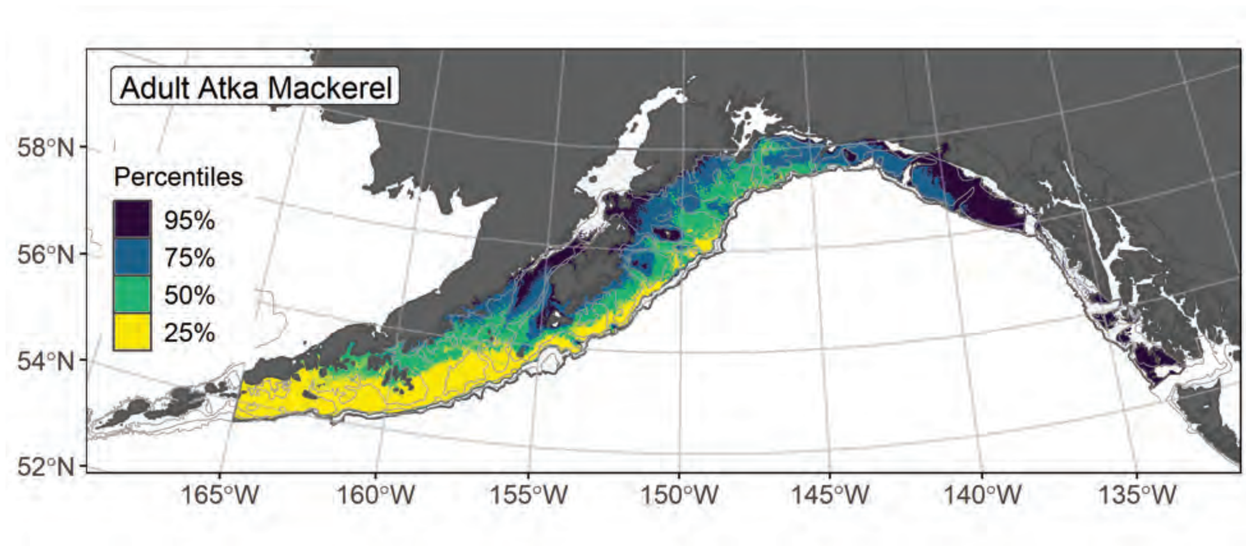

Figure E-9 EFH area of adult Atka mackerel, summer

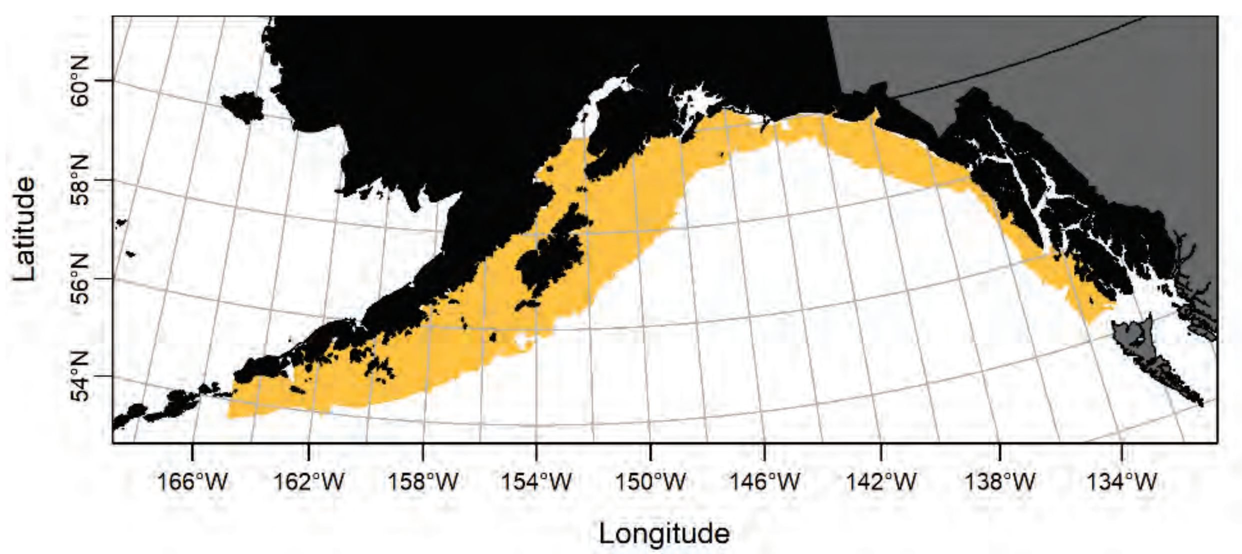

Figure E-10 EFH area of adult Atka mackerel, fall

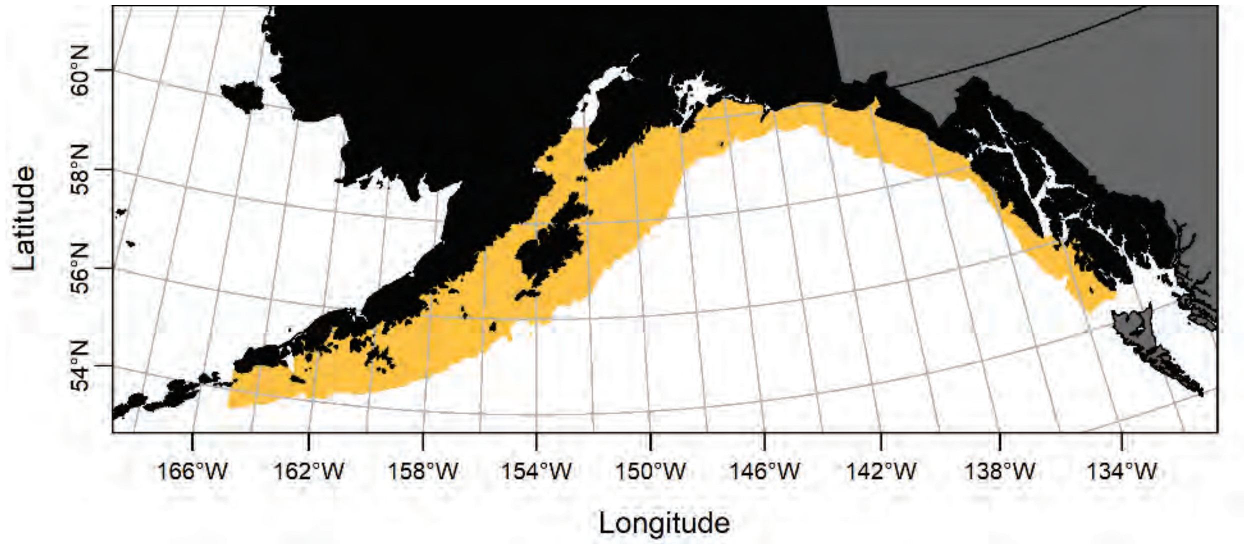

Figure E-11 EFH area of adult Atka mackerel, winter

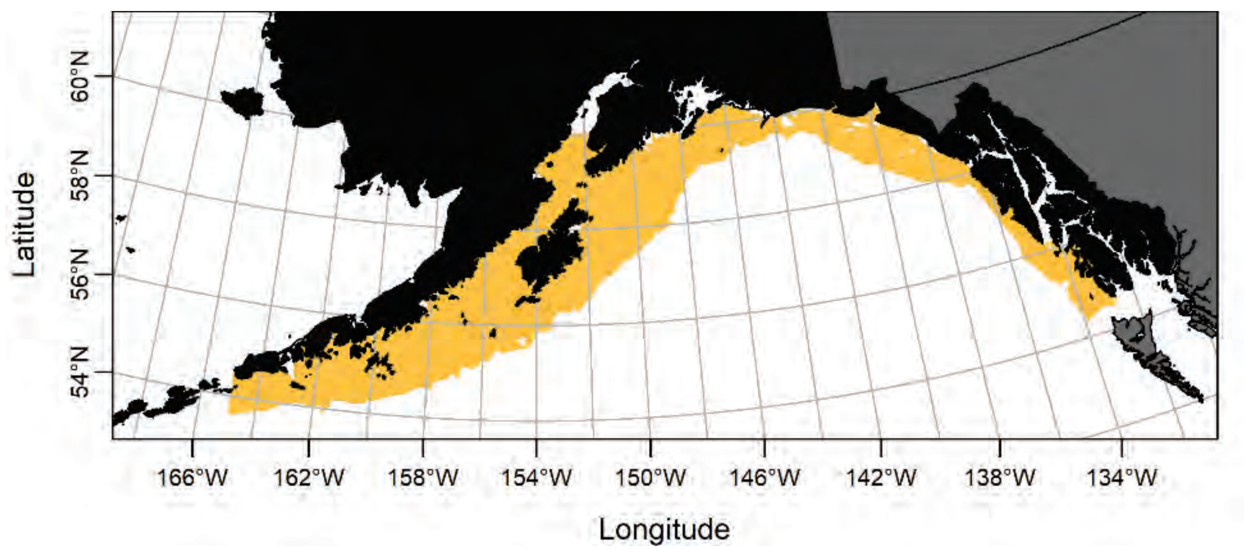

Figure E-12 EFH area of adult Atka mackerel, spring

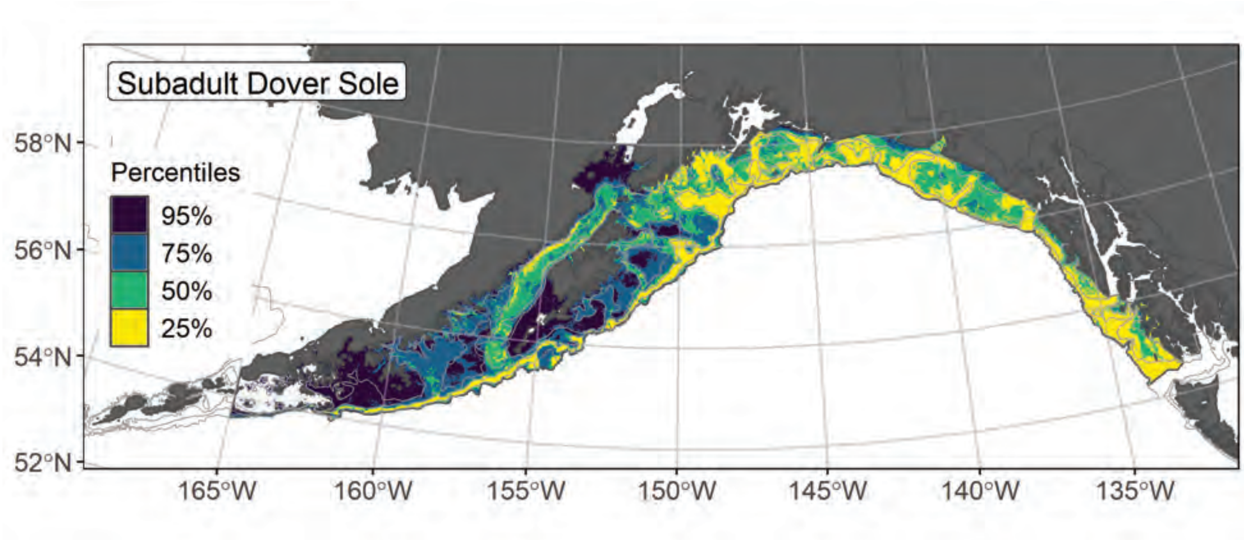

Figure E-13 EFH area of subadult Dover sole, summer

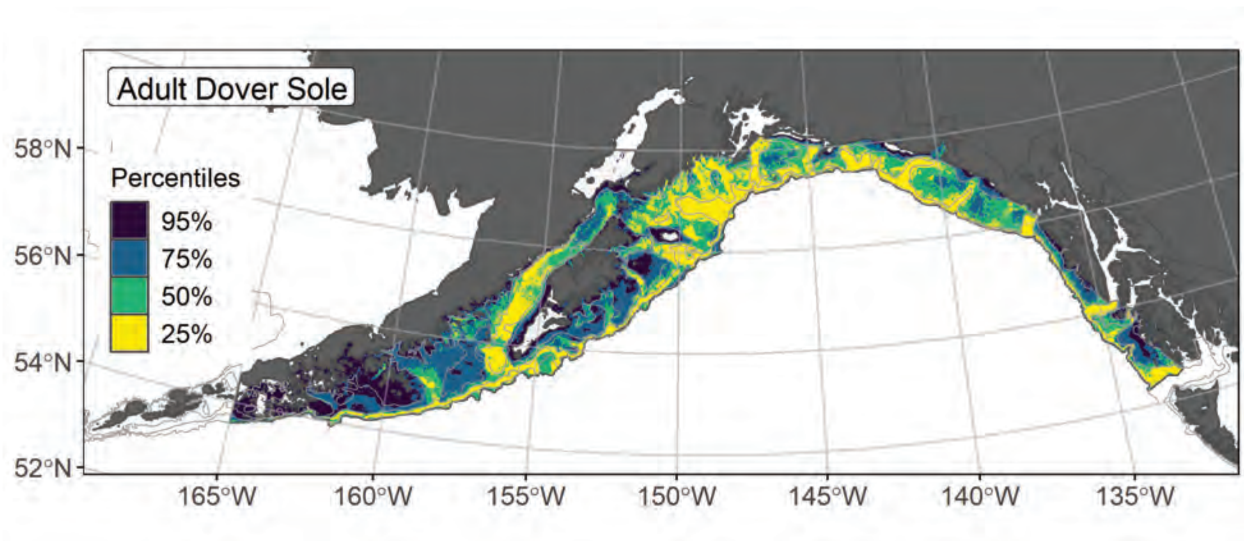

Figure E-14 EFH area of adult Dover sole, summer

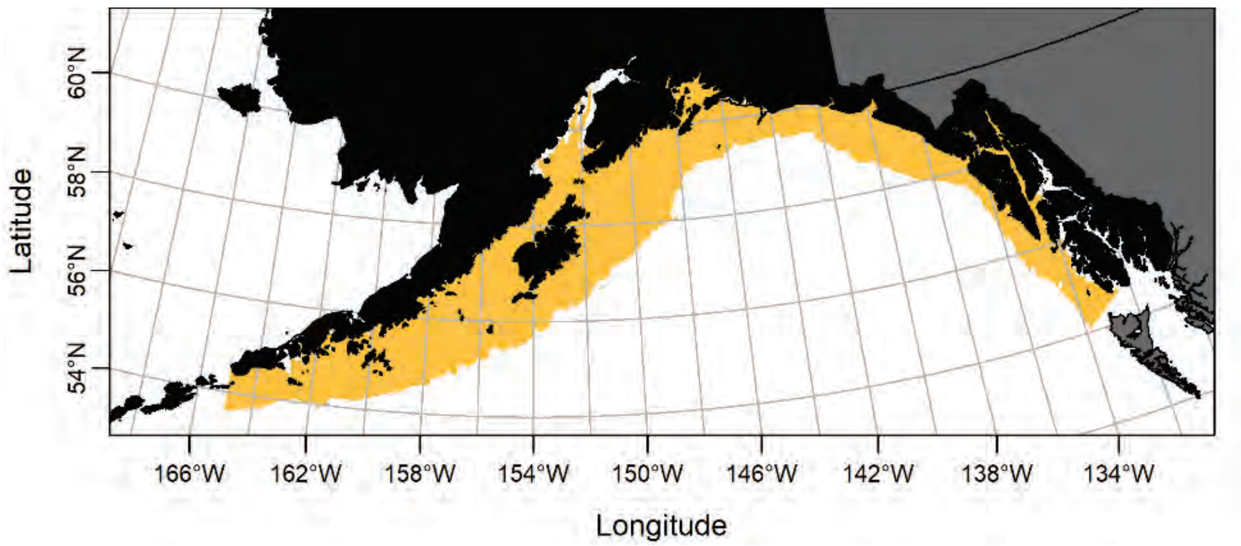

Figure E-15 EFH area of Dover sole eggs, summer

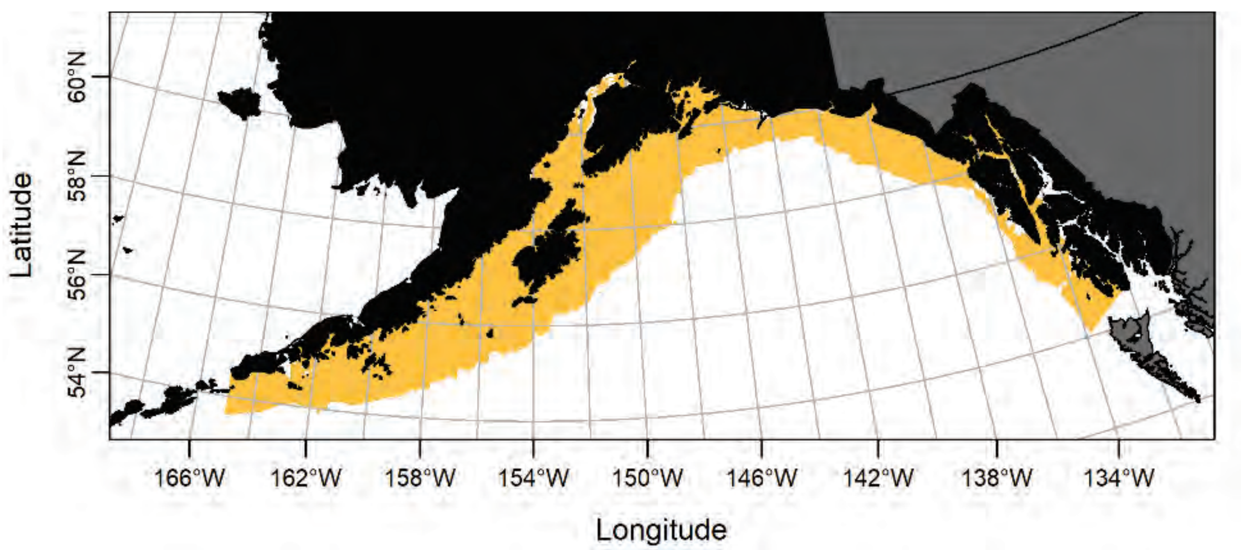

Figure E-16 EFH area of Dover sole larvae, summer

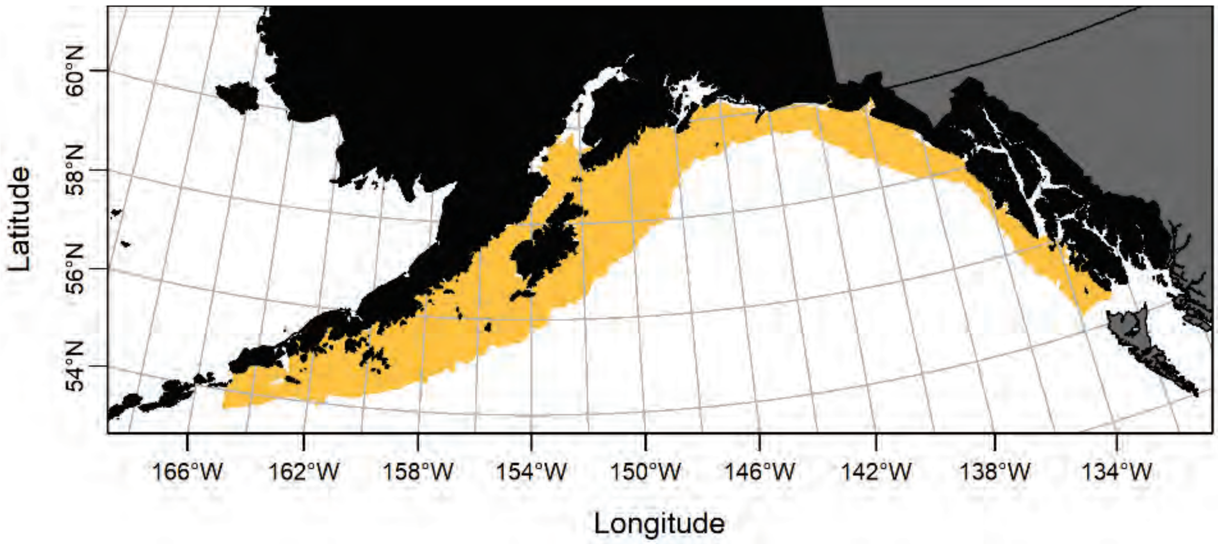

Figure E-17 EFH area of adult Dover sole, fall

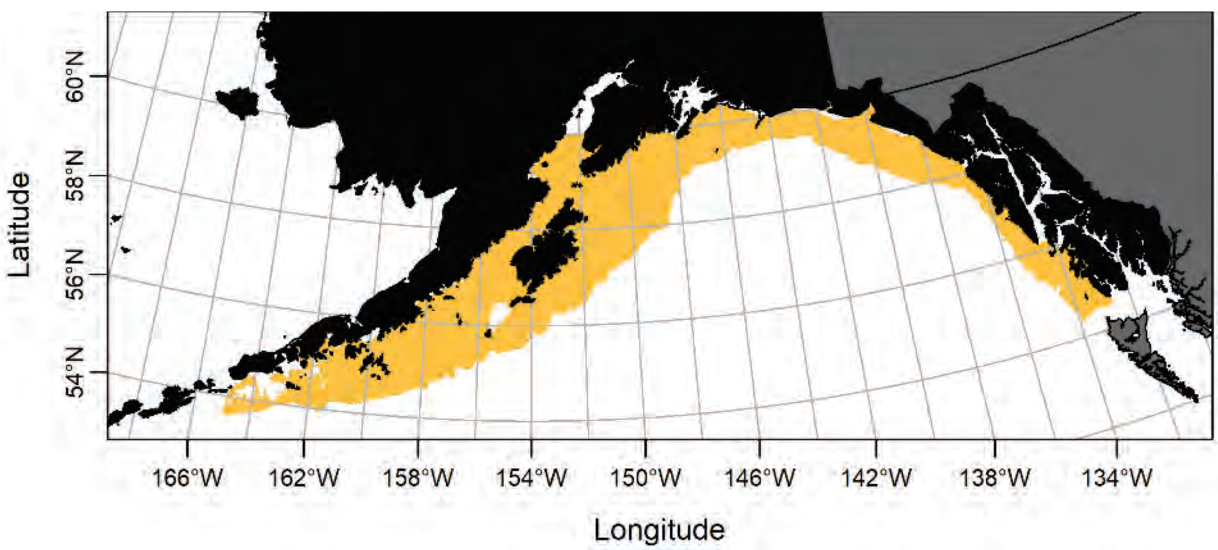

Figure E-18 EFH area of adult Dover sole, winter

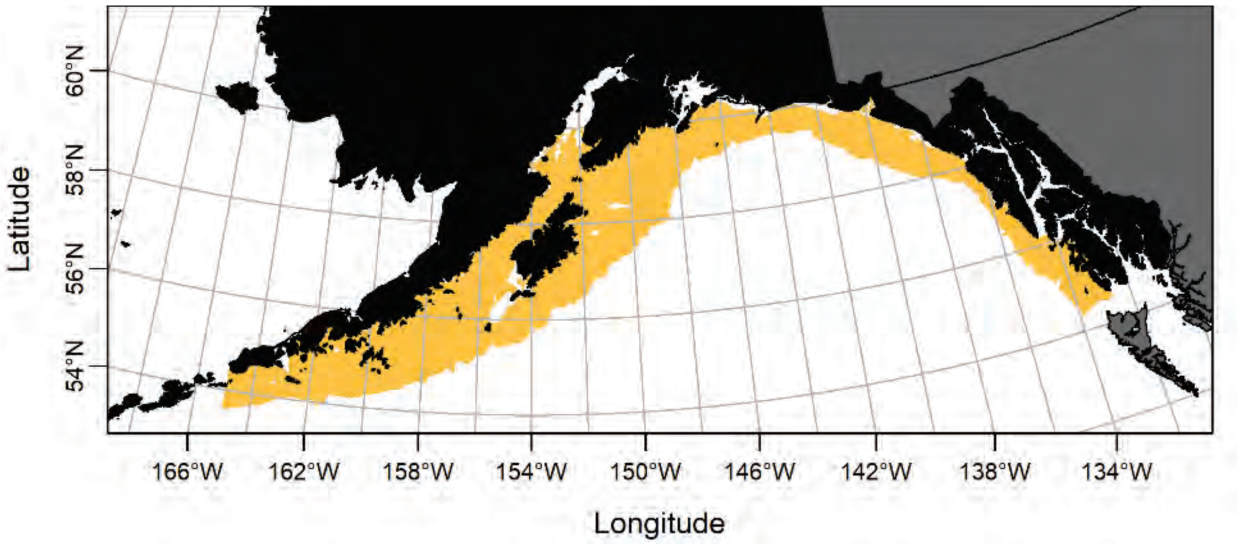

Figure E-19 EFH area of adult Dover sole, spring

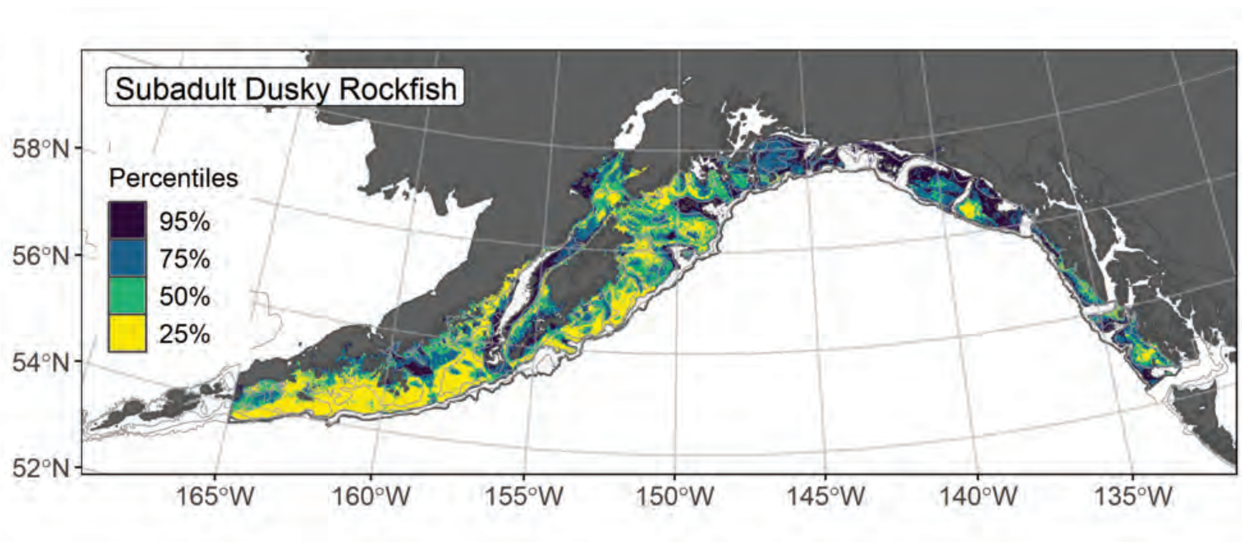

Figure E-20 EFH area of subadult Dusky rockfish, summer

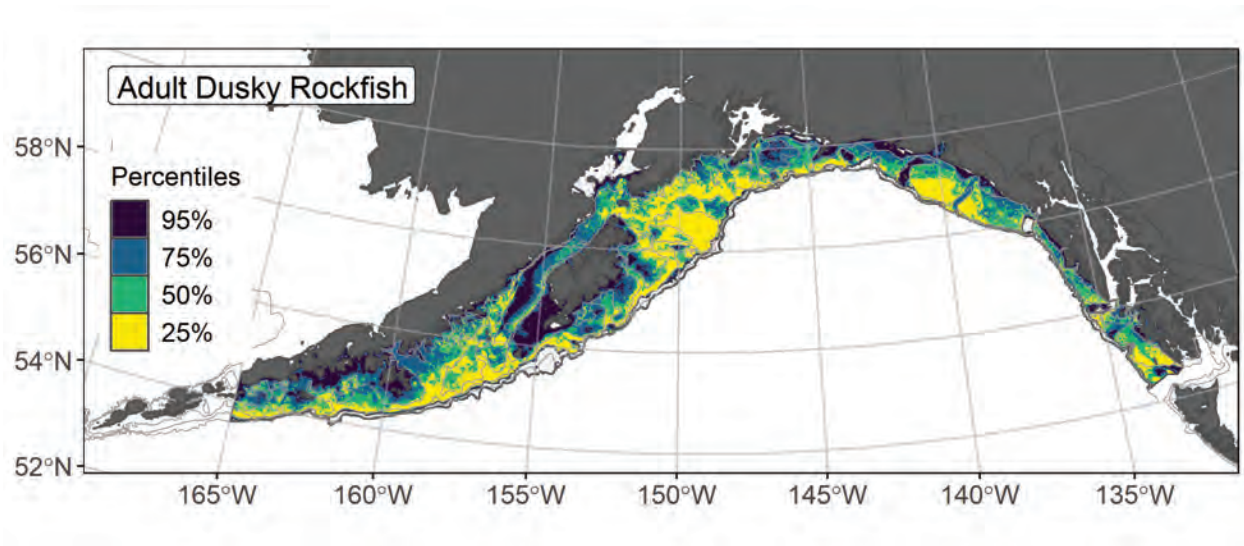

Figure E-21 EFH area of adult Dusky rockfish, summer

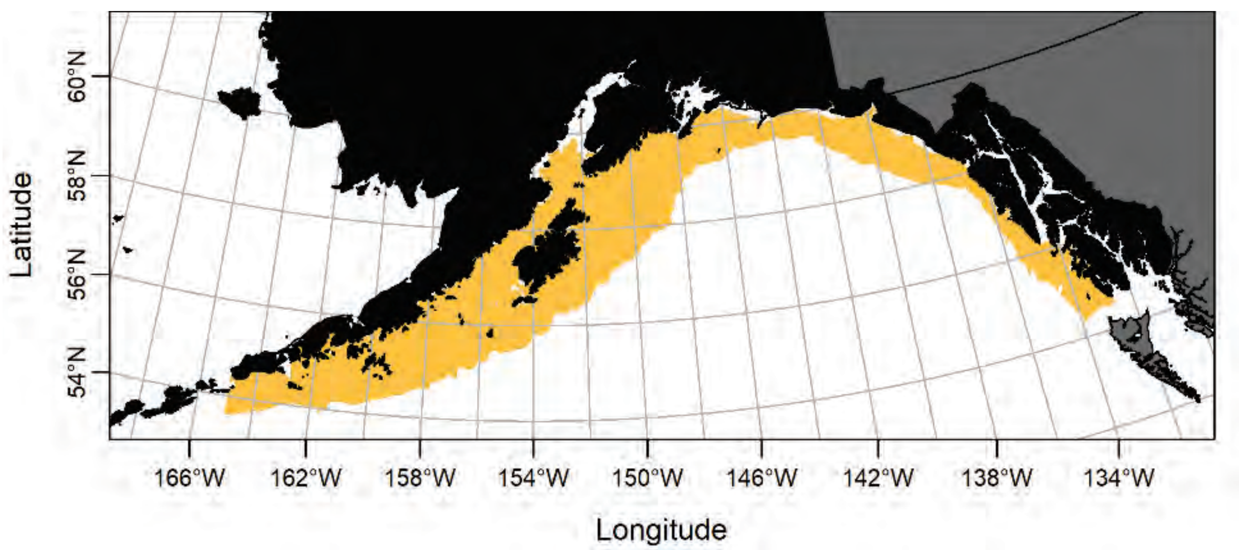

Figure E-22 EFH area of adult Dusky rockfish, fall

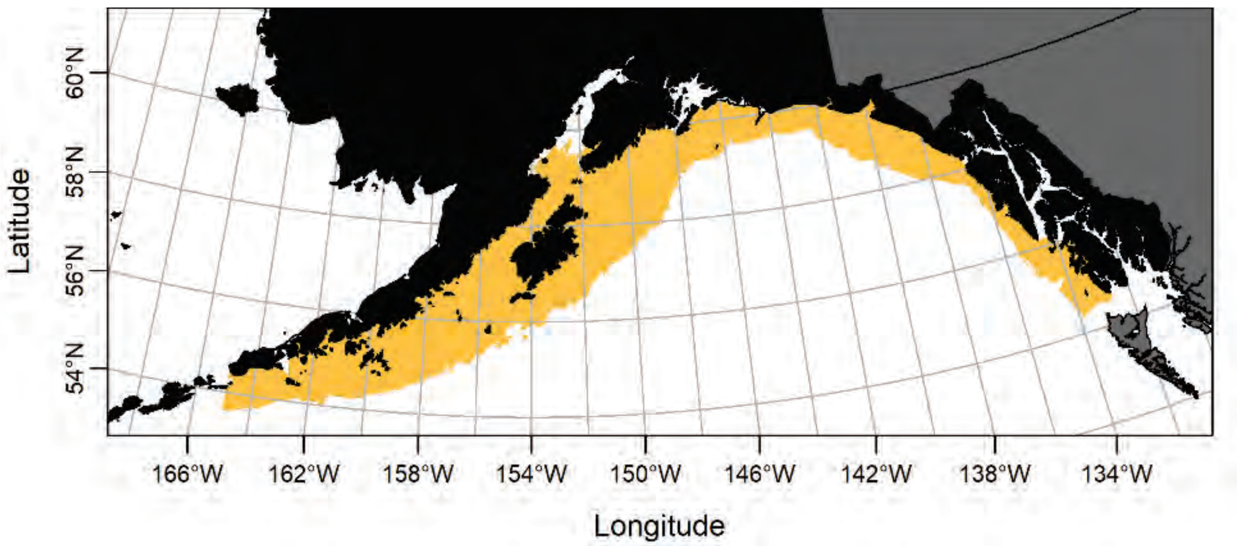

Figure E-23 EFH area of adult Dusky rockfish, winter

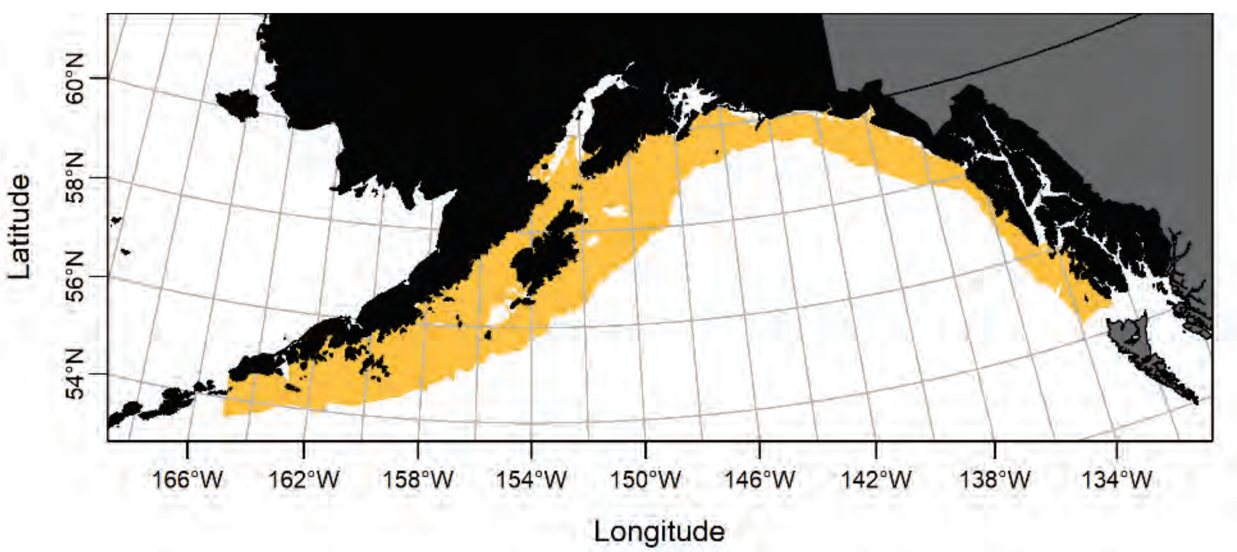

Figure E-24 EFH area of adult Dusky rockfish, spring

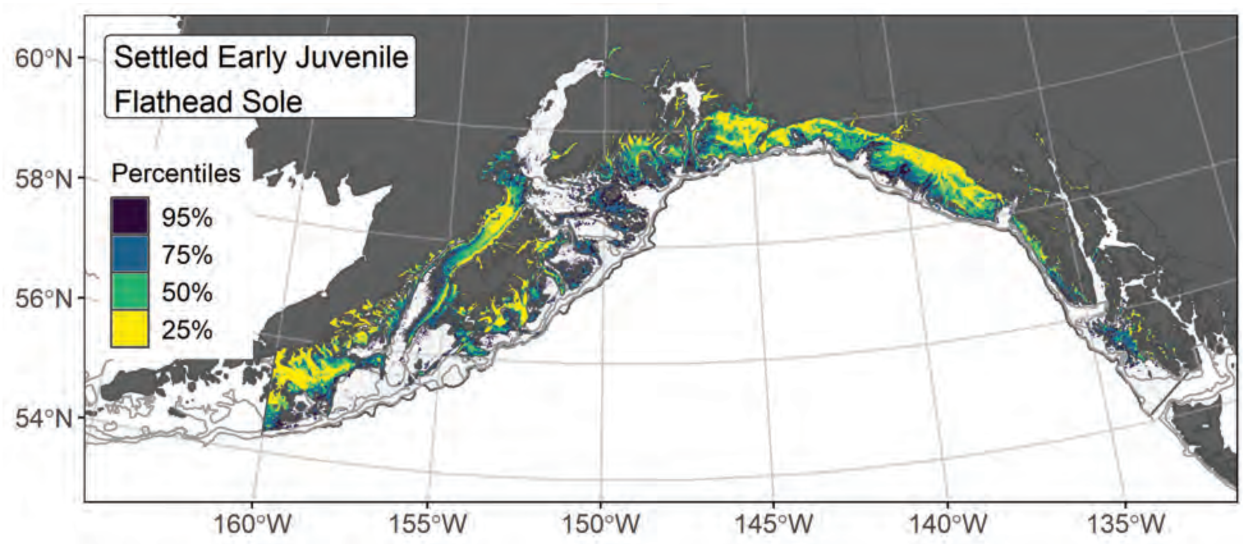

Figure E-25 EFH area of settled early juvenile flathead sole, summer

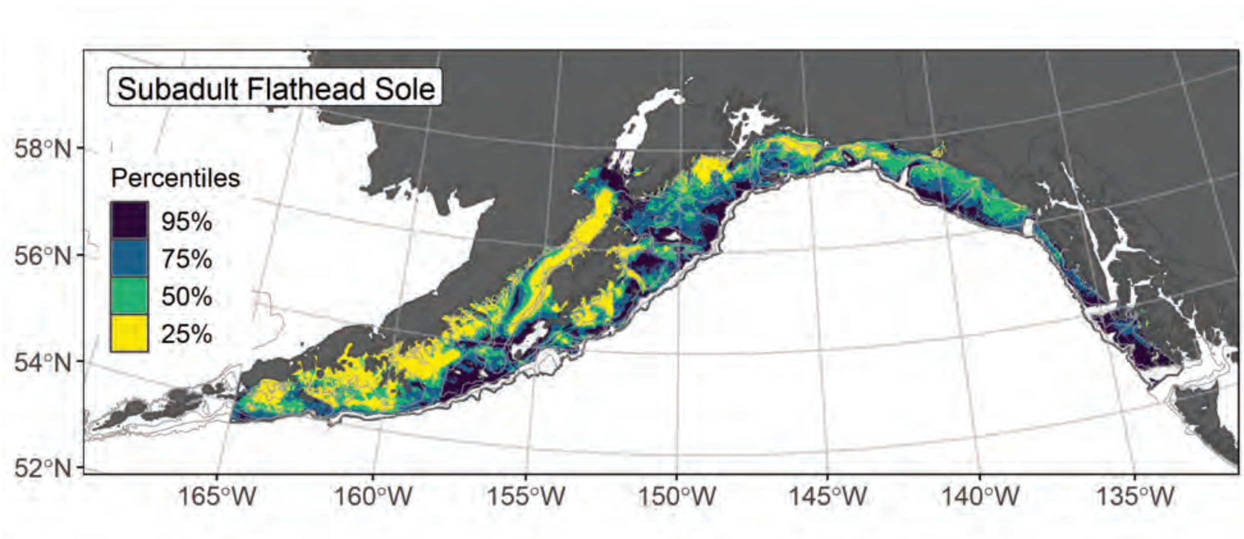

Figure E-26 EFH area of subadult flathead sole, summer

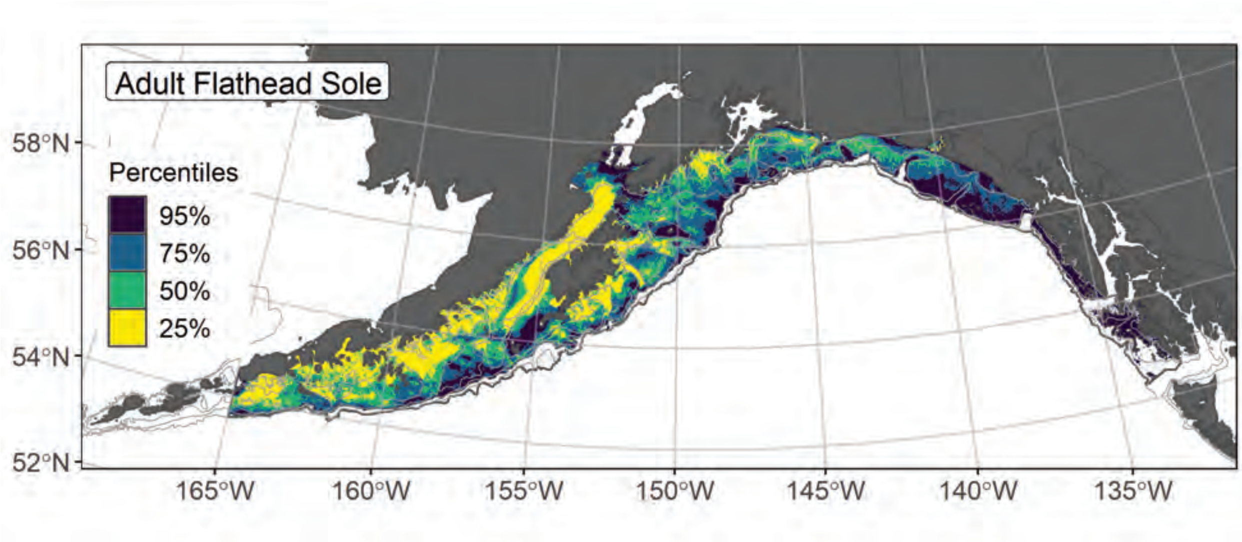

Figure E-27 EFH area of adult flathead sole, summer

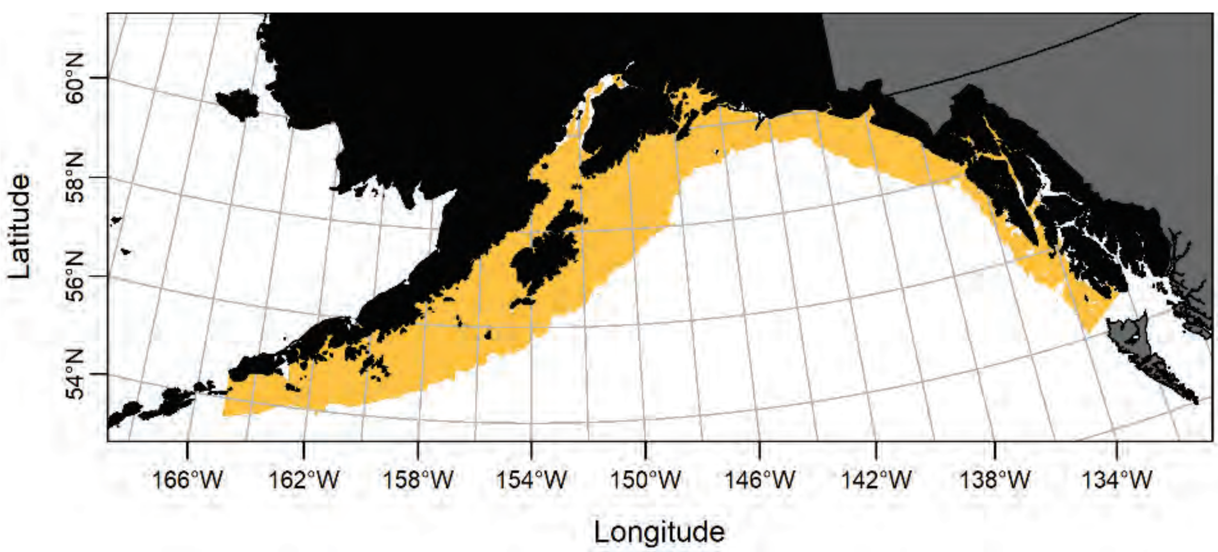

Figure E-28 EFH area of flathead sole eggs, summer

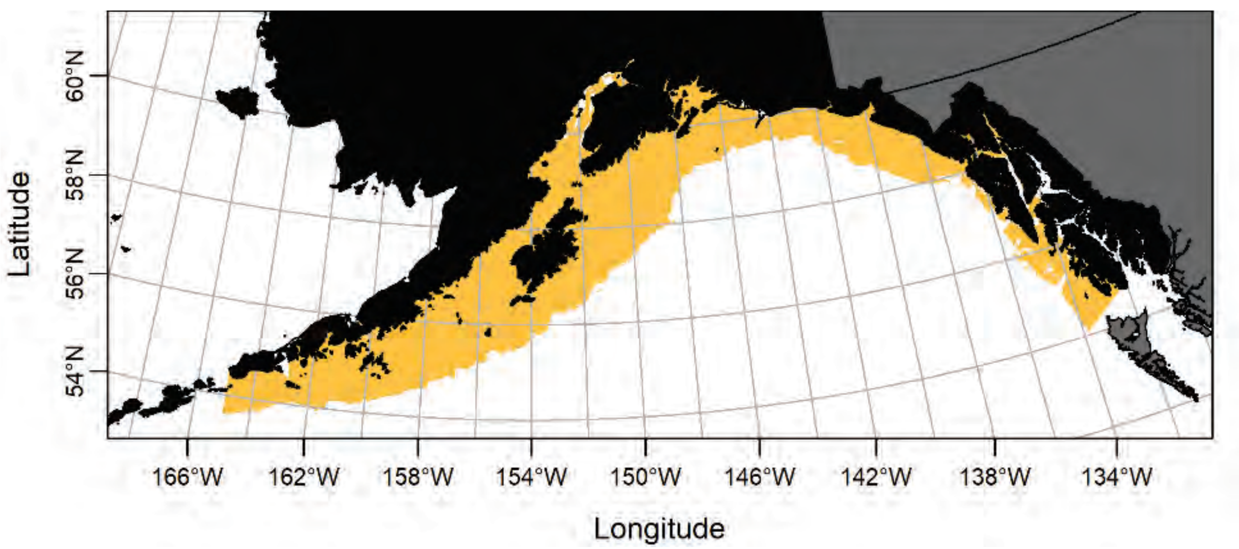

Figure E-29 EFH area of flathead sole larvae, summer

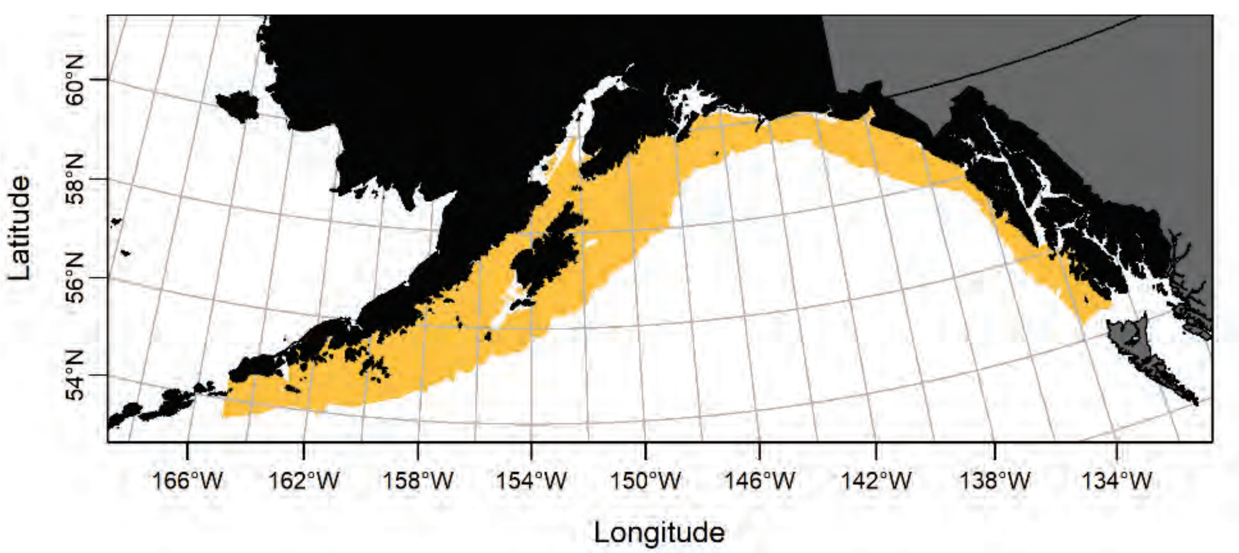

Figure E-30 EFH area of adult flathead sole, fall

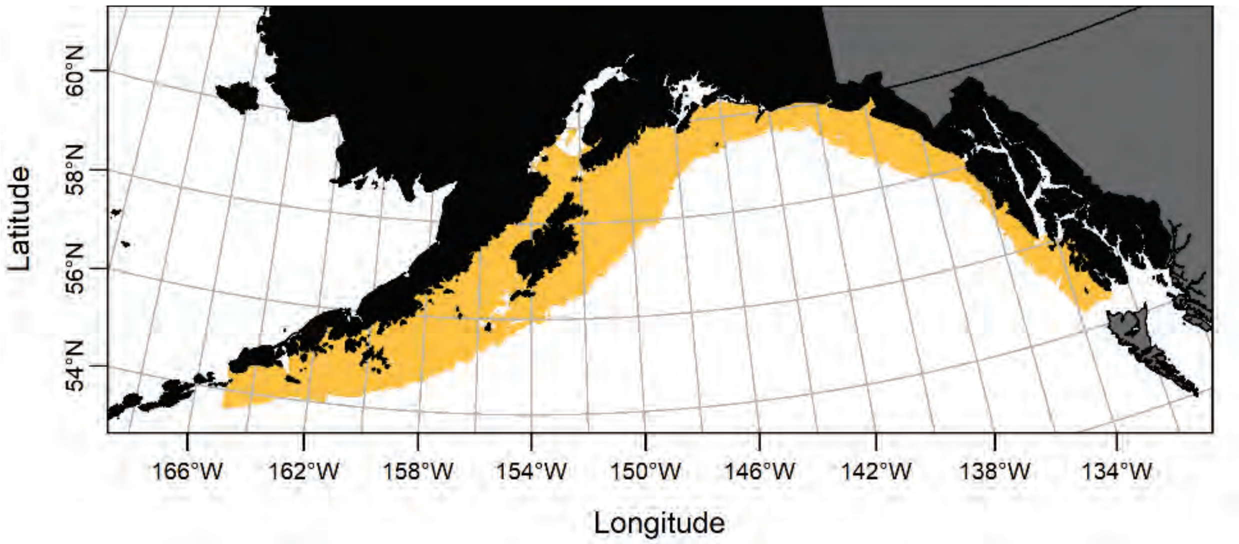

Figure E-31 EFH area of adult flathead sole, winter

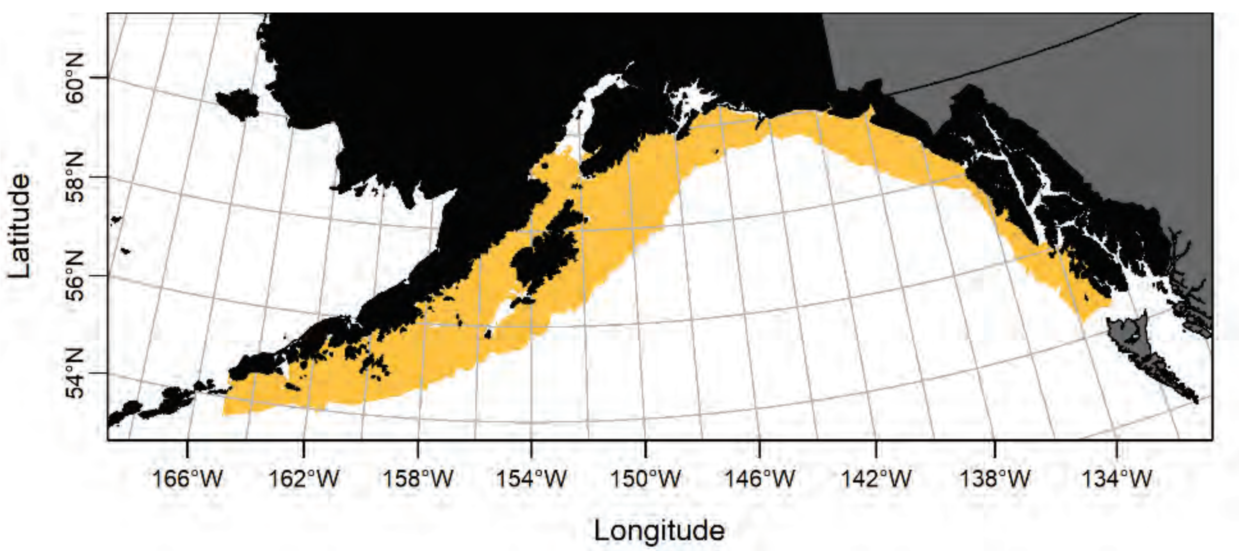

Figure E-32 EFH area of adult flathead sole, spring

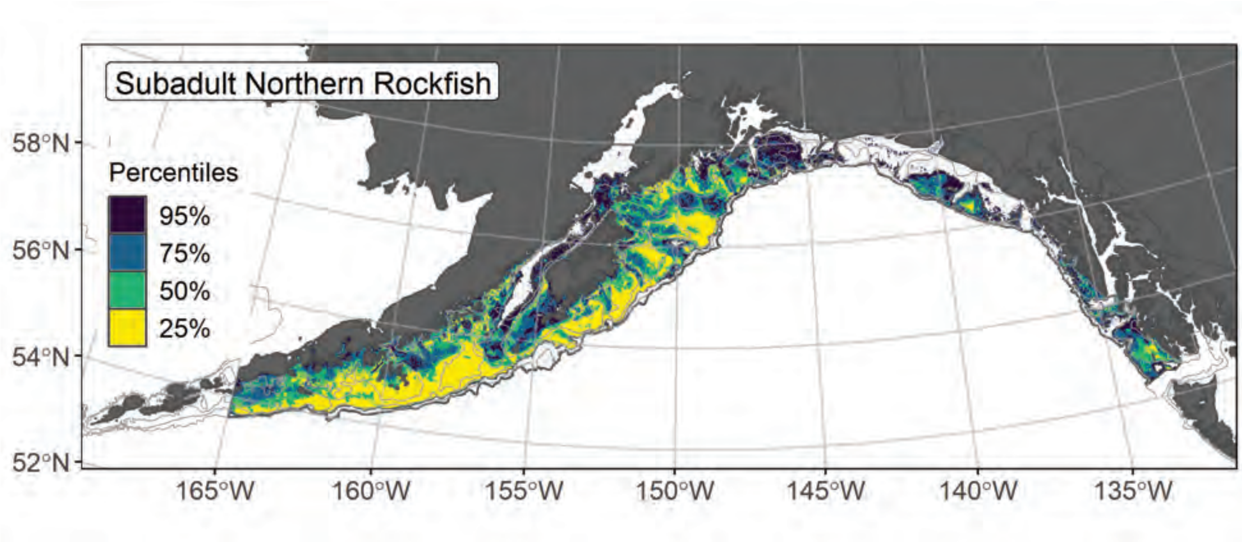

Figure E-33 EFH area of subadult northern rockfish, summer

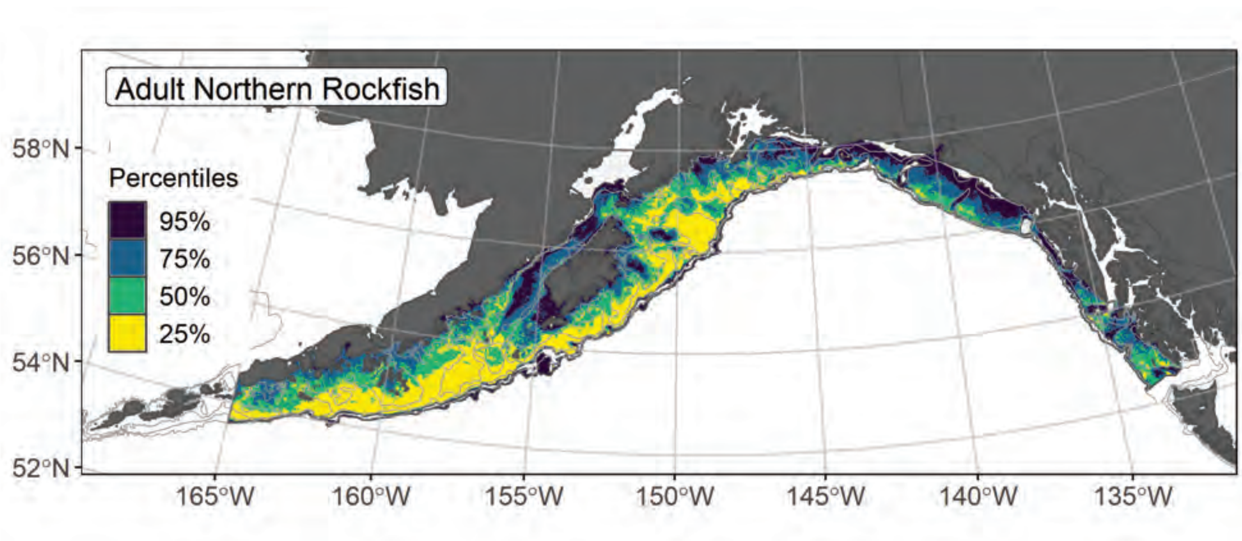

Figure E-34 EFH area of adult northern rockfish, summer

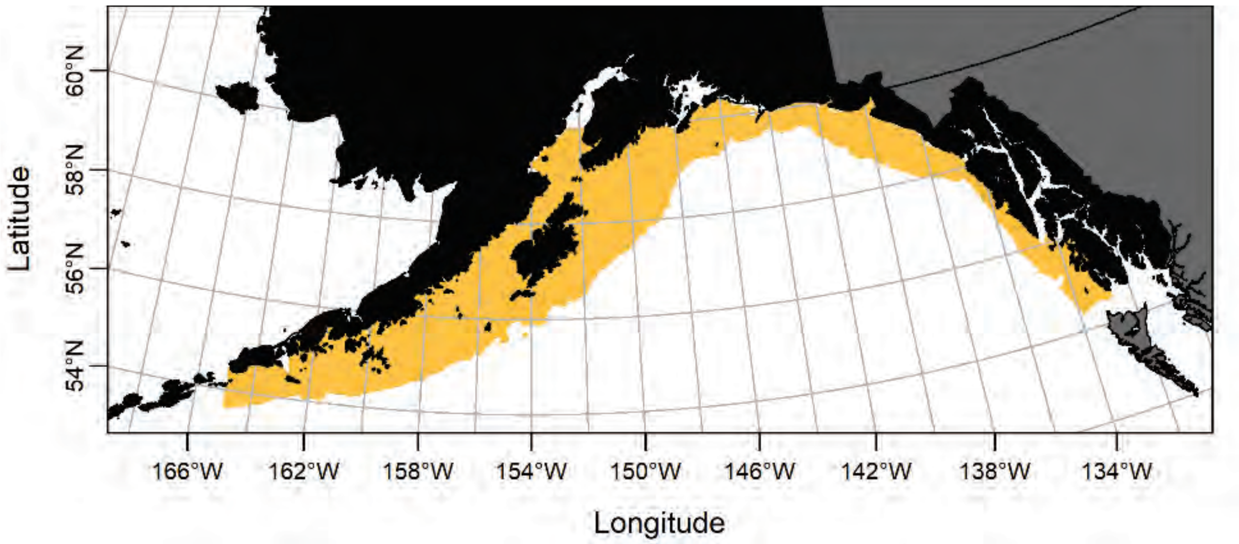

Figure E-35 EFH area of adult northern rockfish, fall

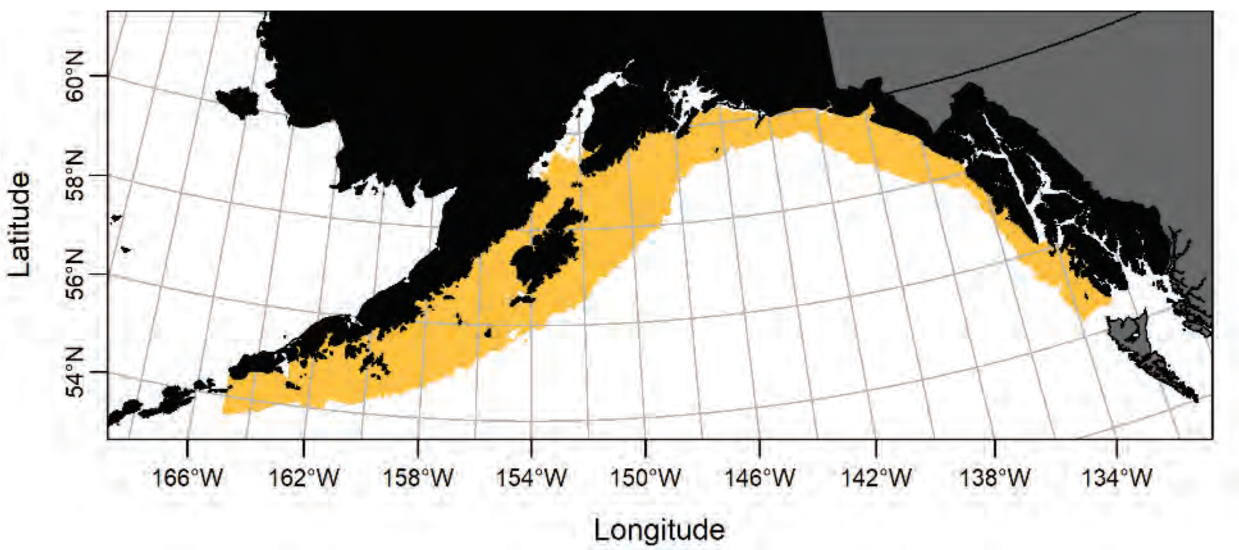

Figure E-36 EFH area of adult northern rockfish, winter

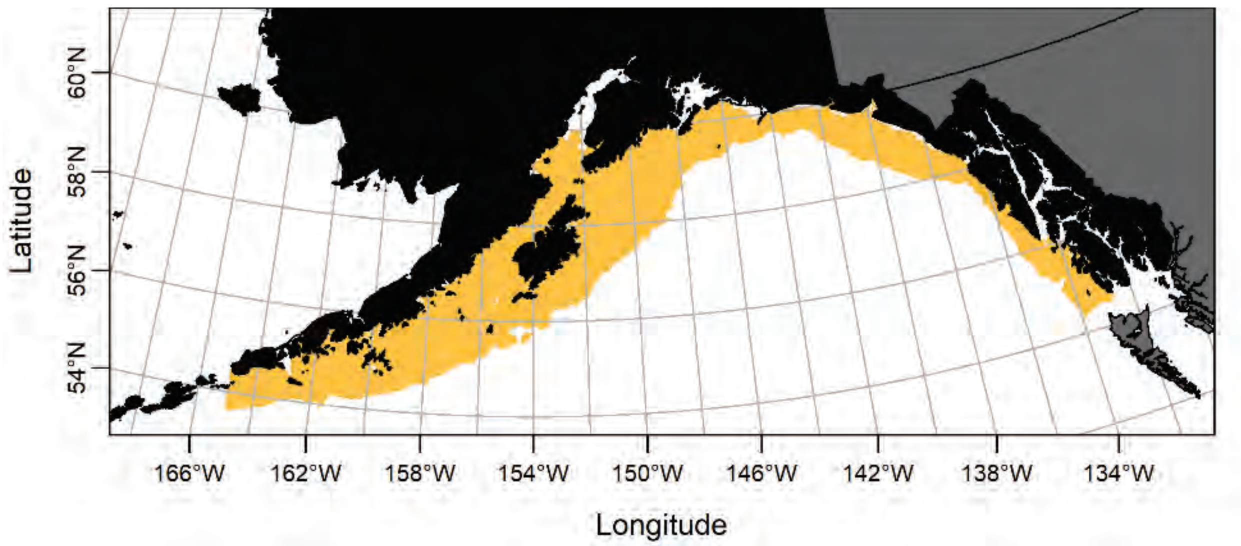

Figure E-37 EFH area of adult northern rockfish, spring

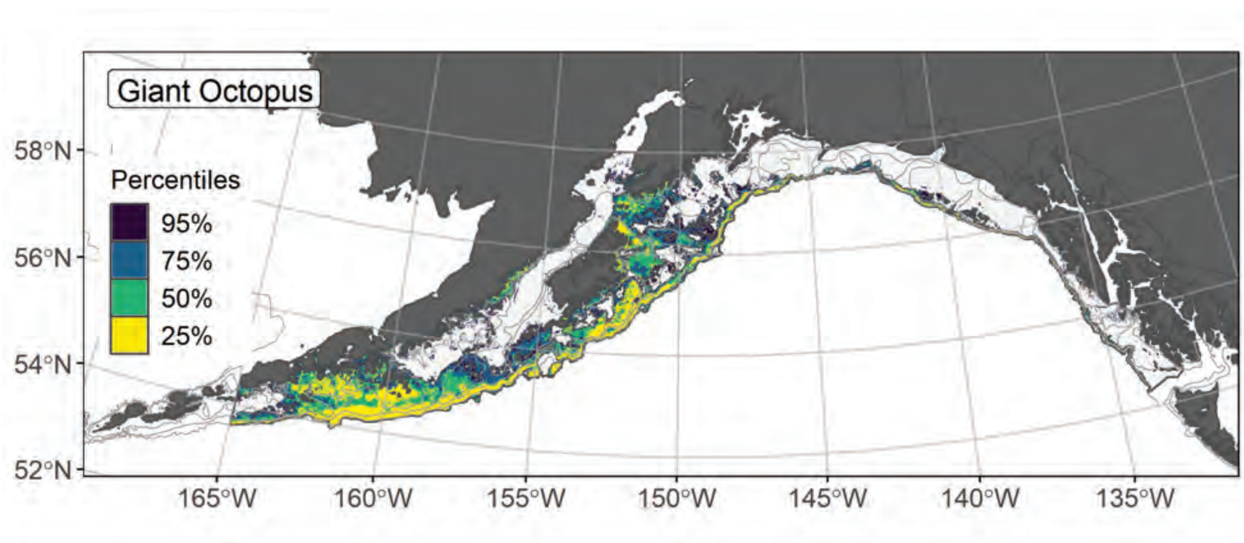

Figure E-38 EFH area of subadult/adult giant octopus, summer

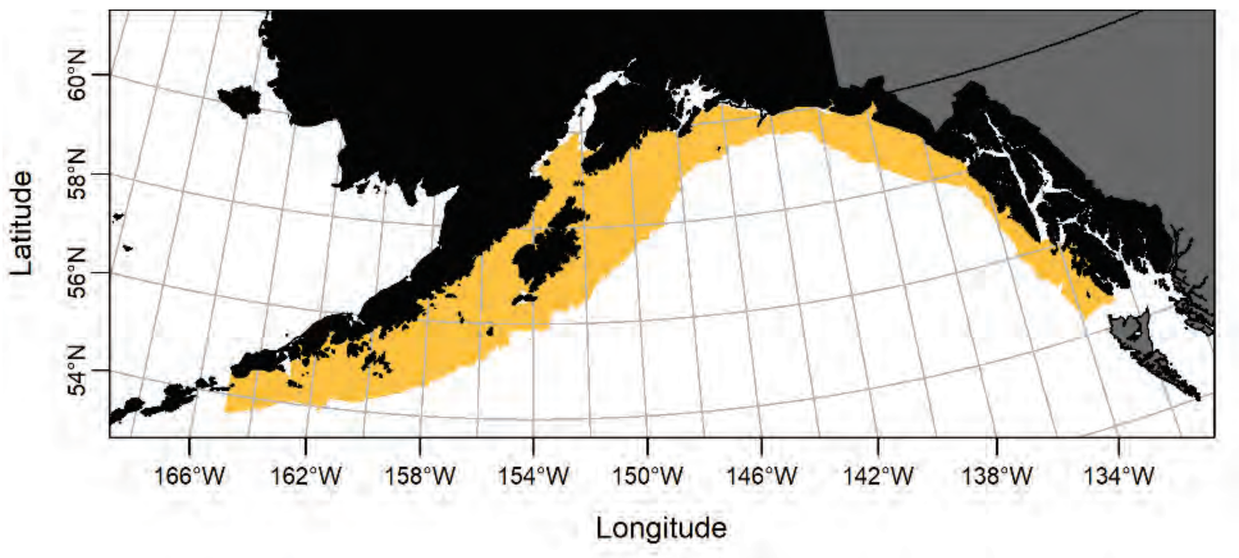

Figure E-39 EFH area of adult octopus, fall

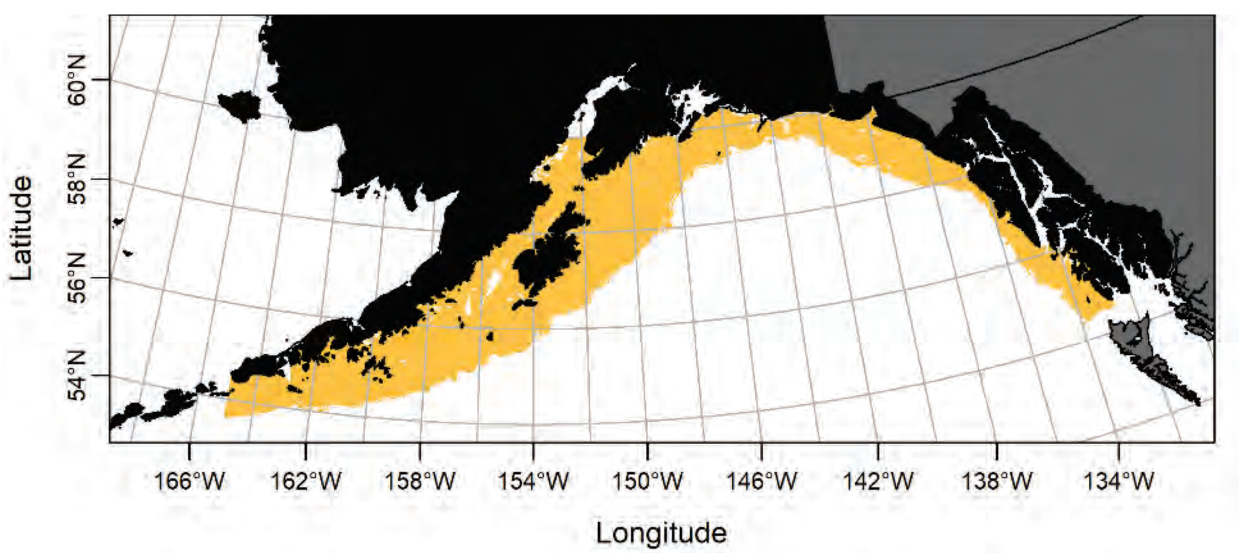

Figure E-40 EFH area of adult octopus, winter

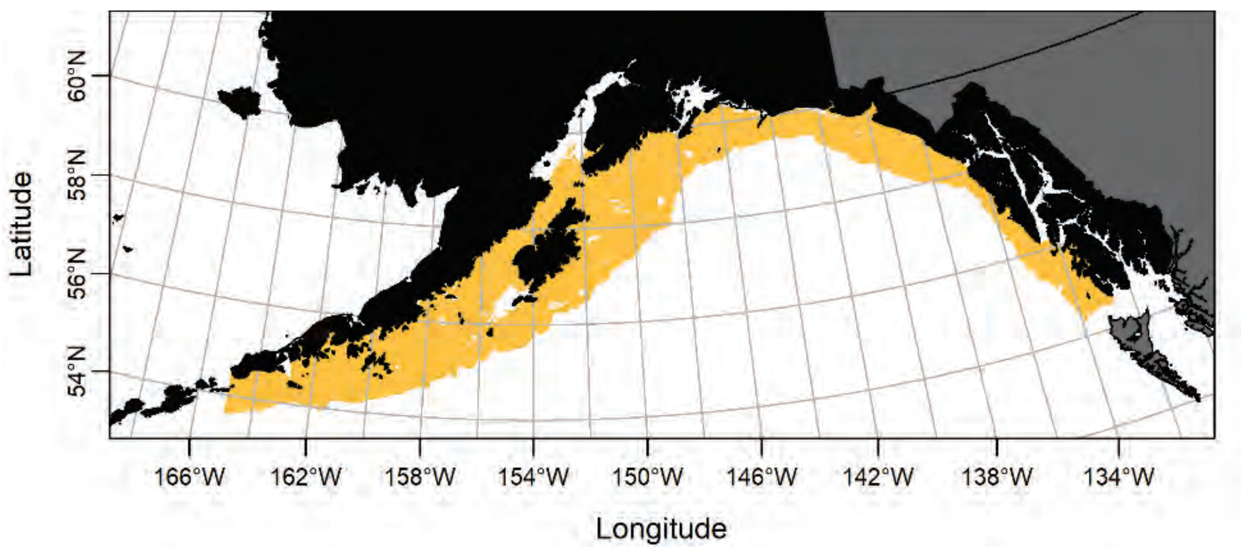

Figure E-41 EFH area of adult octopus, spring

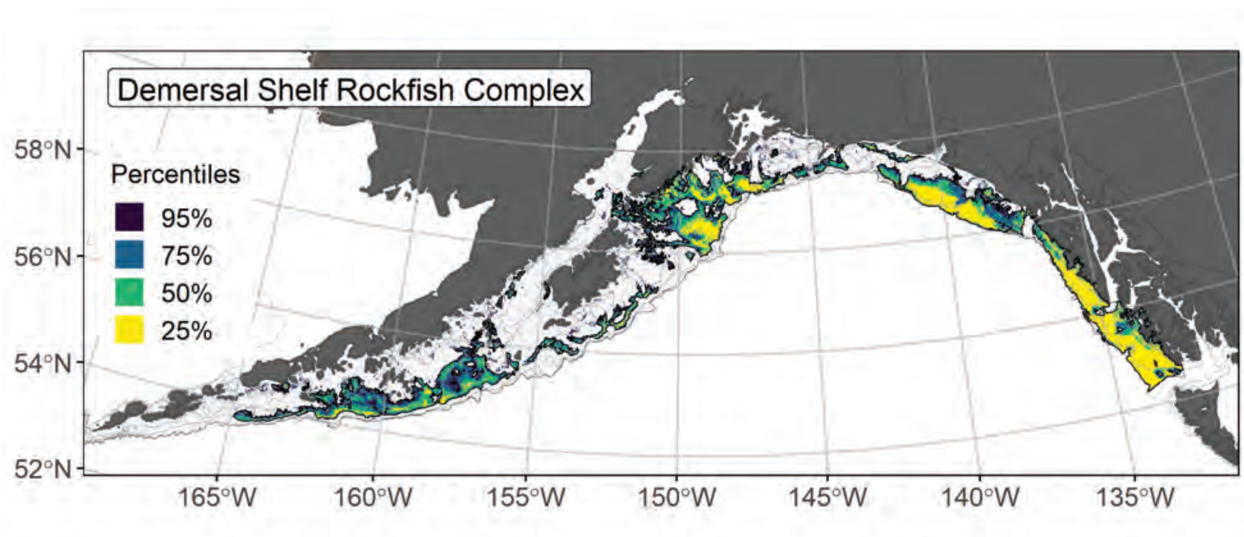

Figure E-42 EFH area of subadult/adult other rockfish complex, demersal subgroup, summer

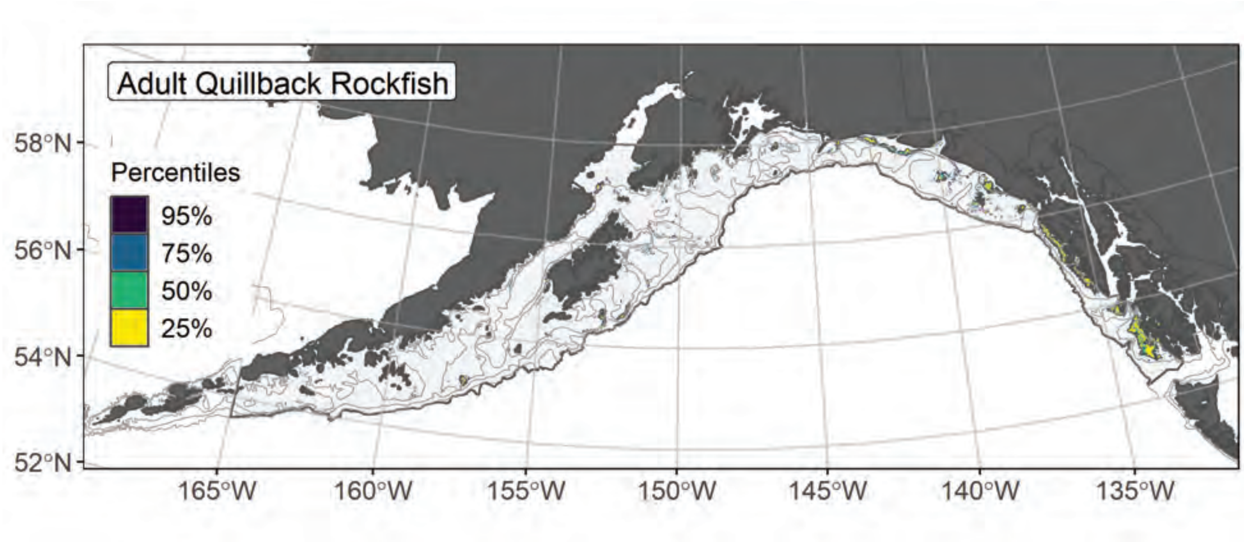

Figure E-43 EFH area of adult quillback rockfish, summer

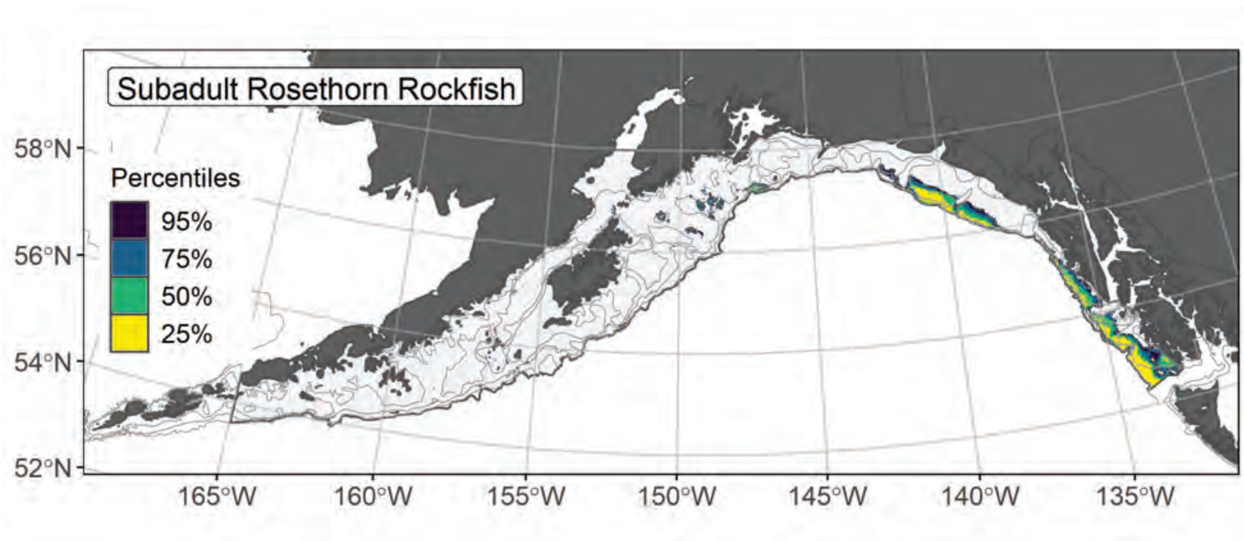

Figure E-44 EFH area of subadult rosethorn rockfish, summer

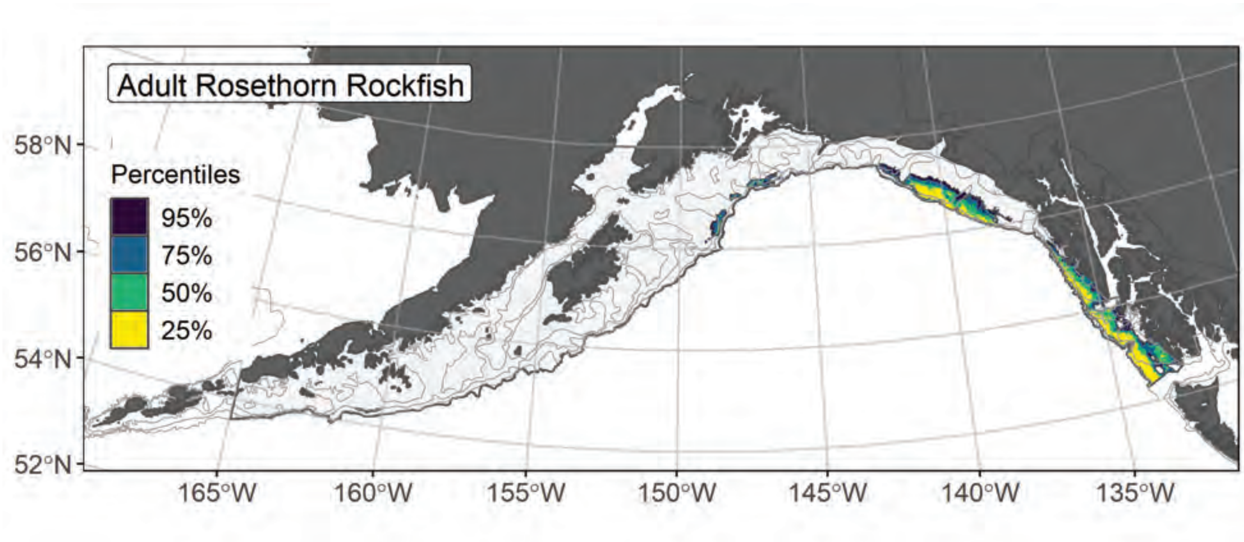

Figure E-45 EFH area of adult rosethorn rockfish, summer

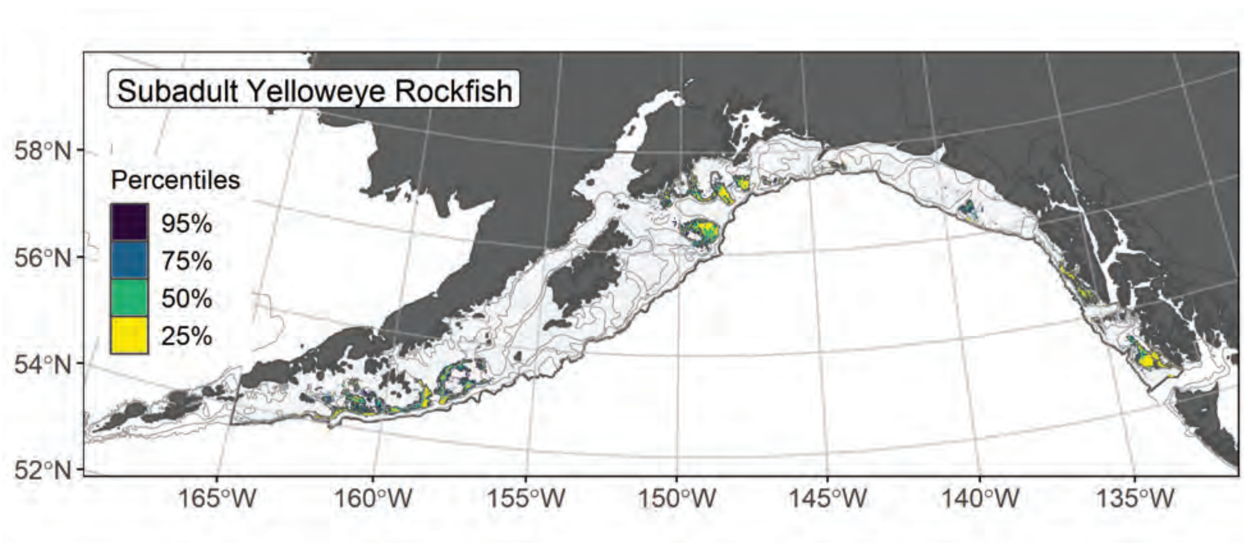

Figure E-46 EFH area of subadult yelloweye rockfish, summer

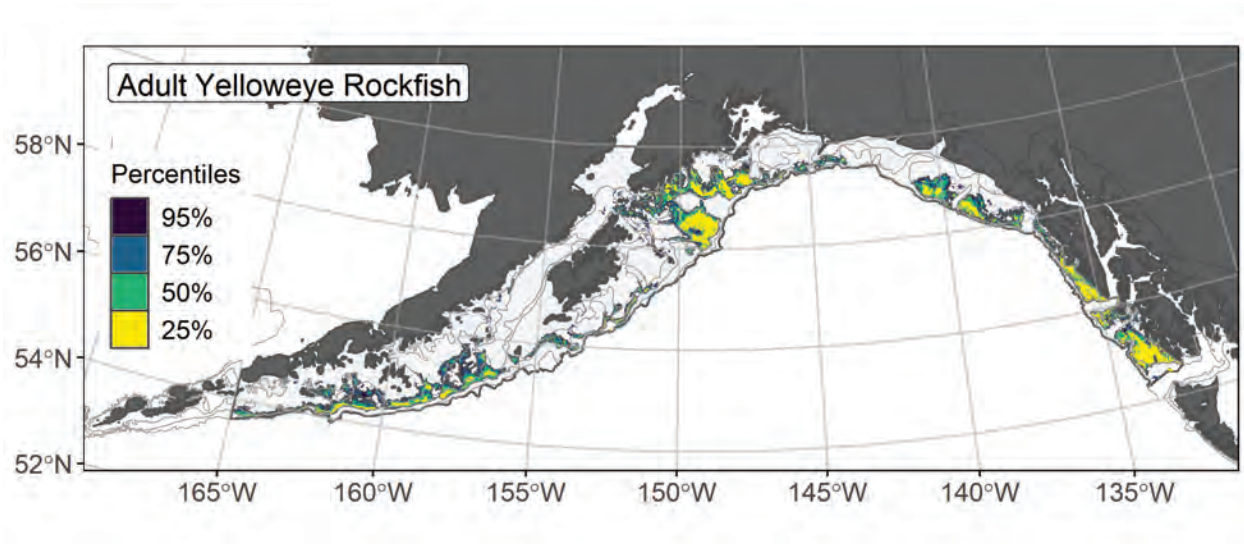

Figure E-47 EFH area of adult yelloweye rockfish, summer

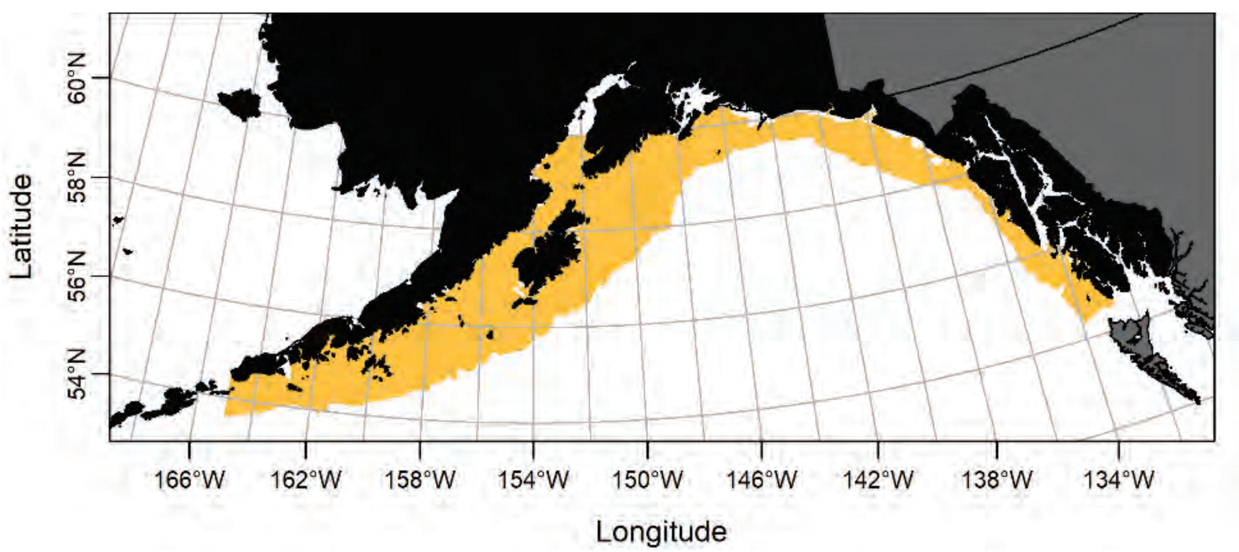

Figure E-48 EFH area of adult yelloweye rockfish, fall

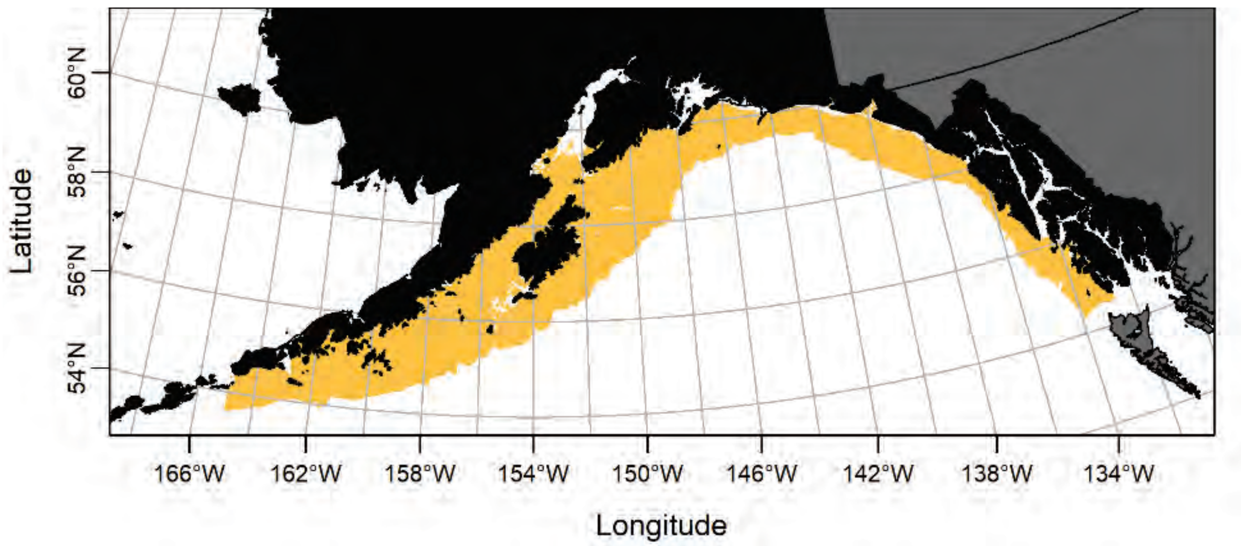

Figure E-49 EFH area of adult yelloweye rockfish, spring

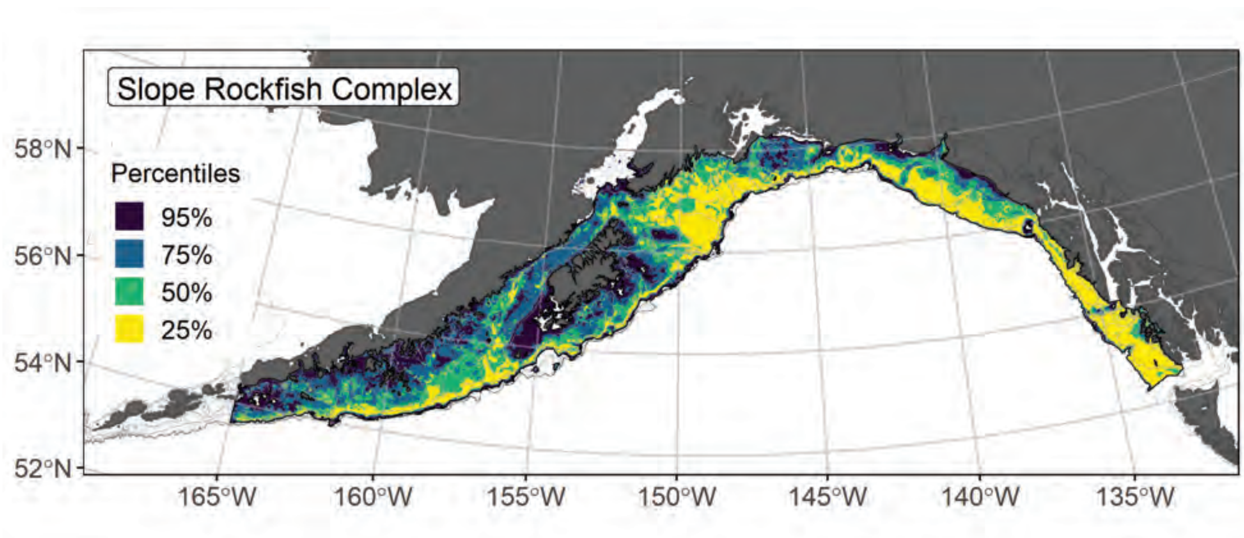

Figure E-50 EFH area of subadult/adult other rockfish complex, slope subgroup, summer

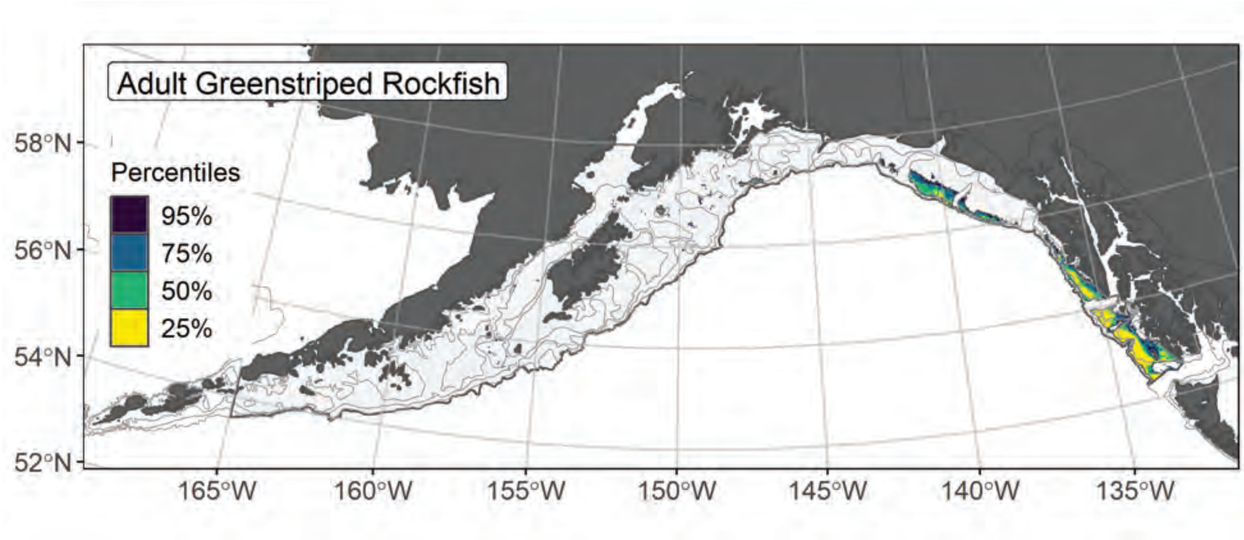

Figure E-51 EFH area of adult greenstriped rockfish, summer

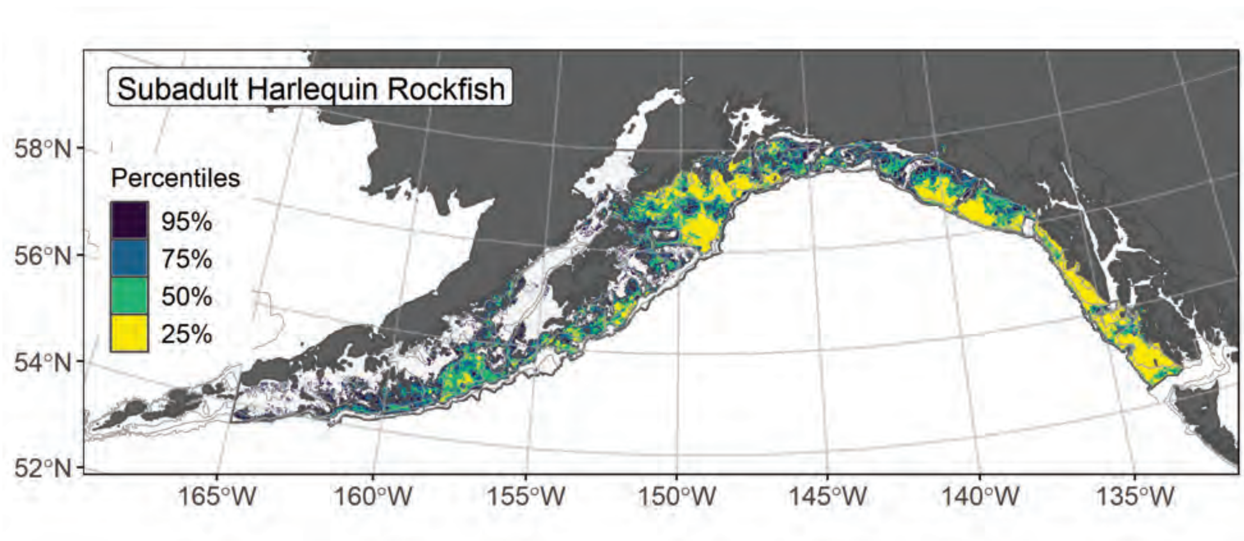

Figure E-52 EFH area of subadult harlequin rockfish, summer

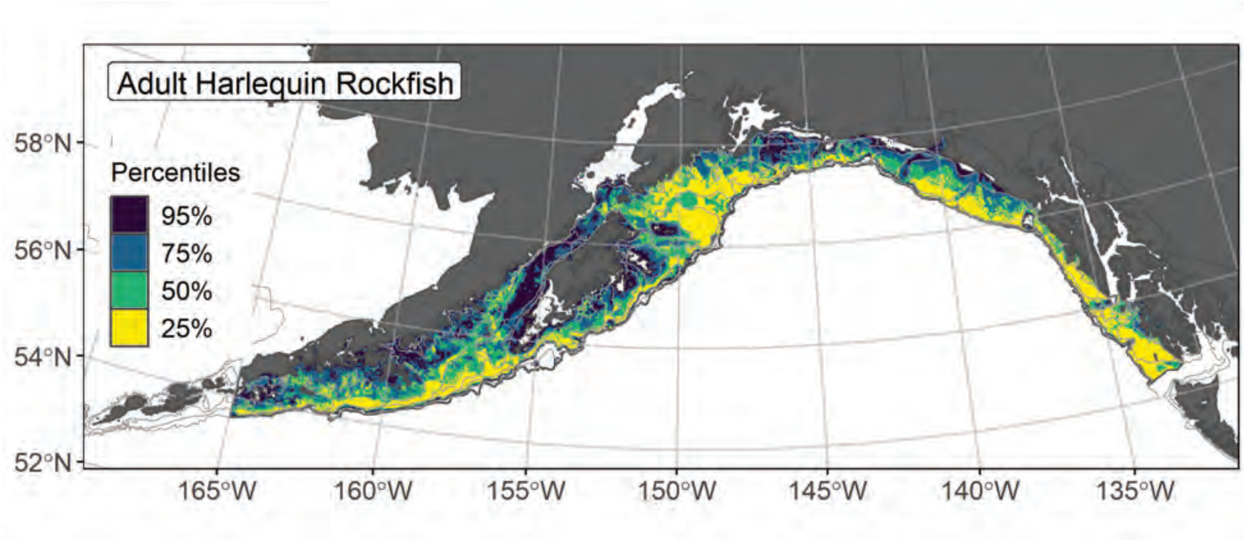

Figure E-53 EFH area of adult harlequin rockfish, summer

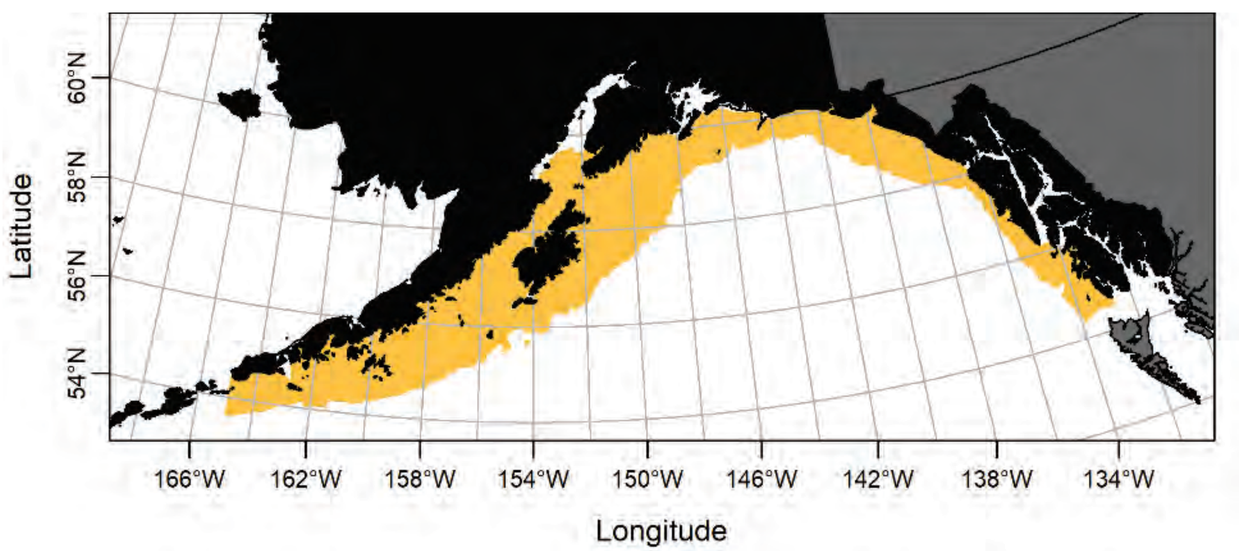

Figure E-54 EFH area of adult harlequin rockfish, spring

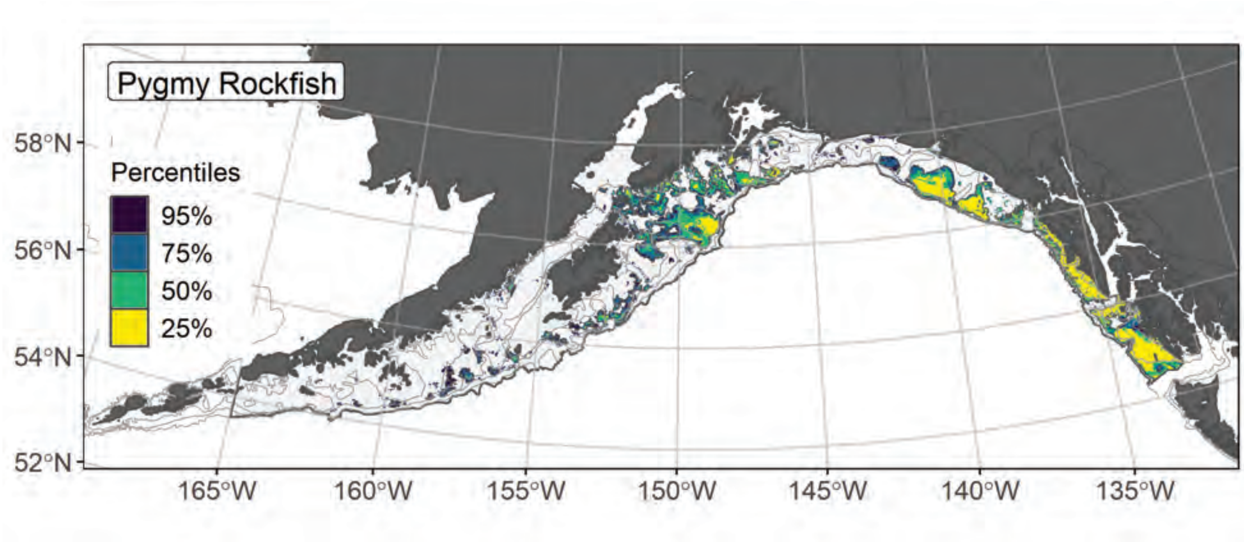

Figure E-55 EFH area of subadult/adult pygmy rockfish, summer

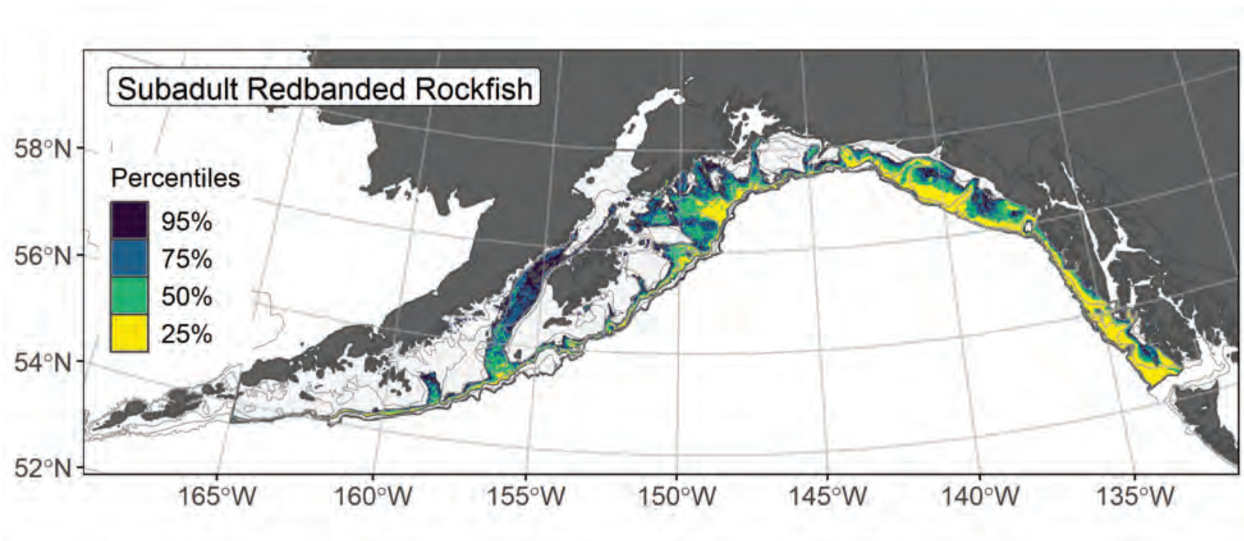

Figure E-56 EFH area of subadult redbanded rockfish, summer

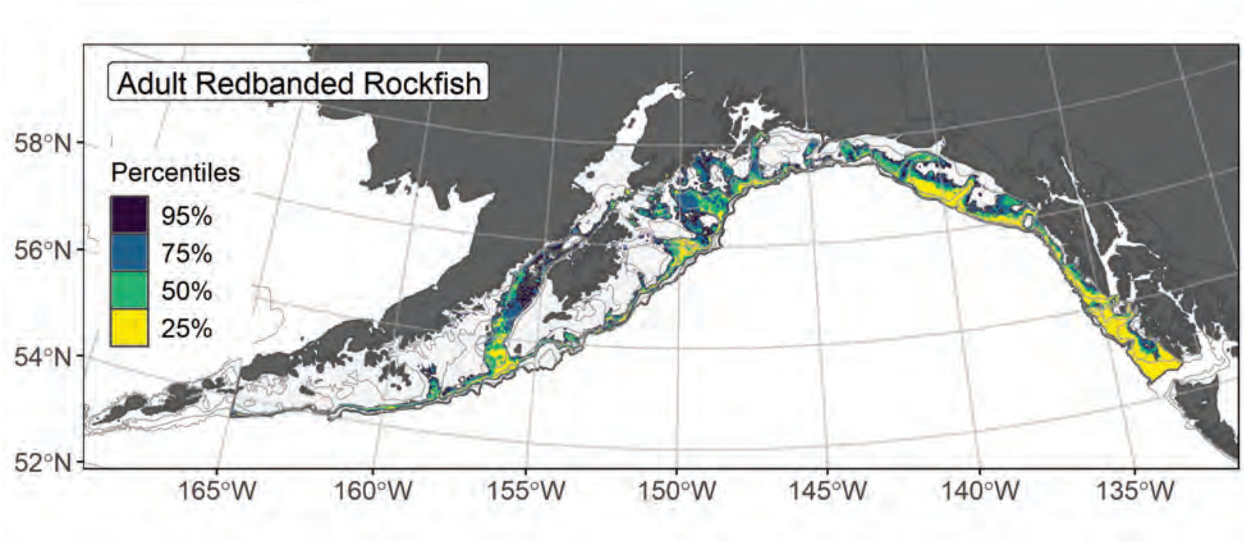

Figure E-57 EFH area of adult redbanded rockfish, summer

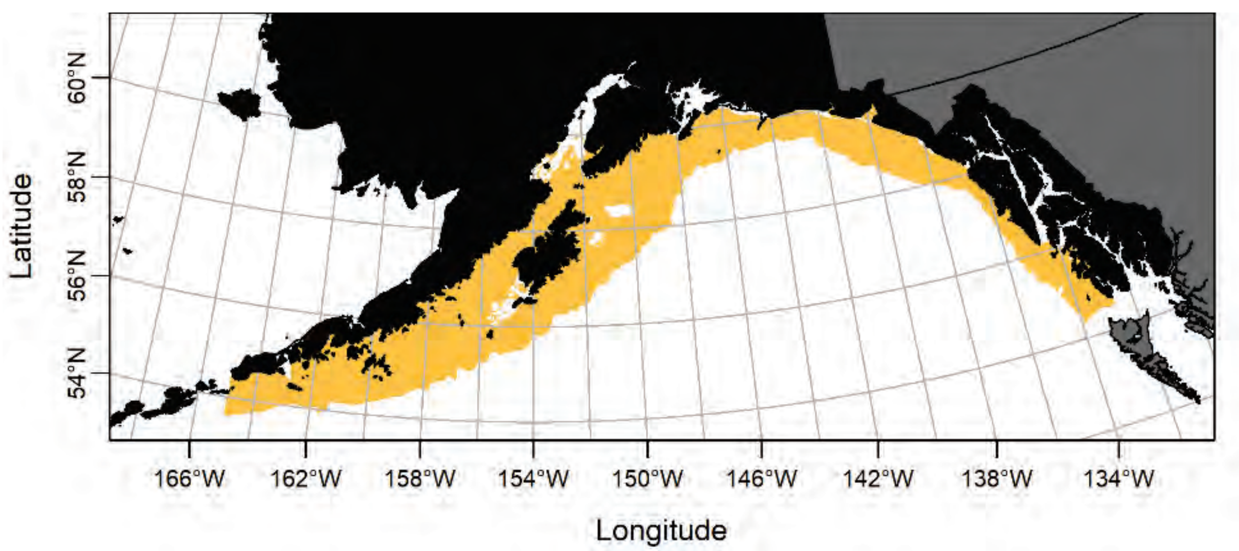

Figure E-58 EFH area of adult redbanded rockfish, spring

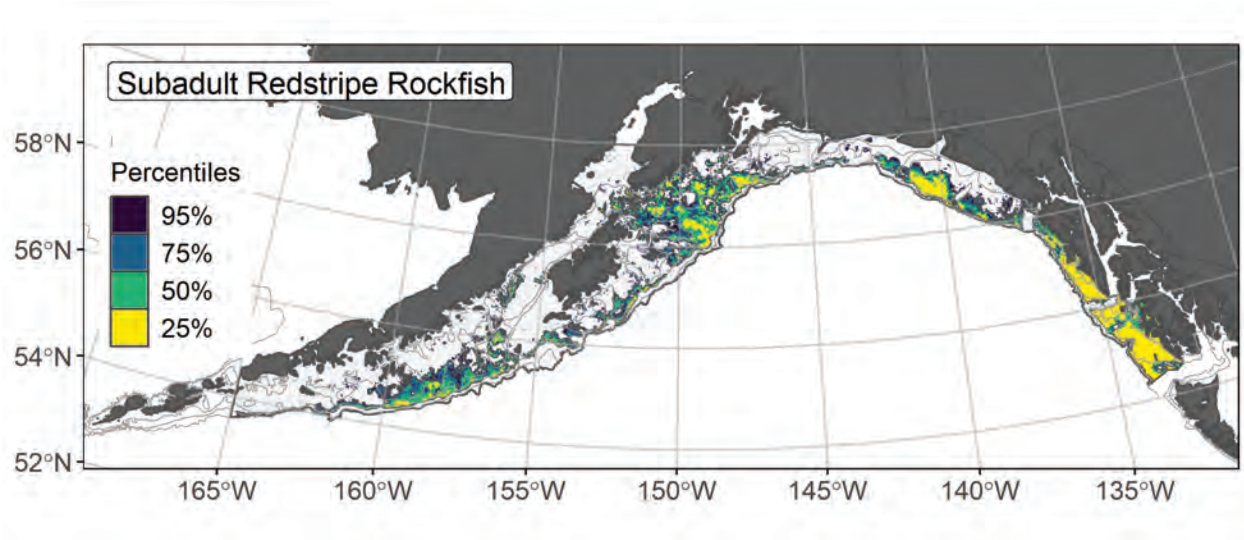

Figure E-59 EFH area of subadult redtripe rockfish, summer

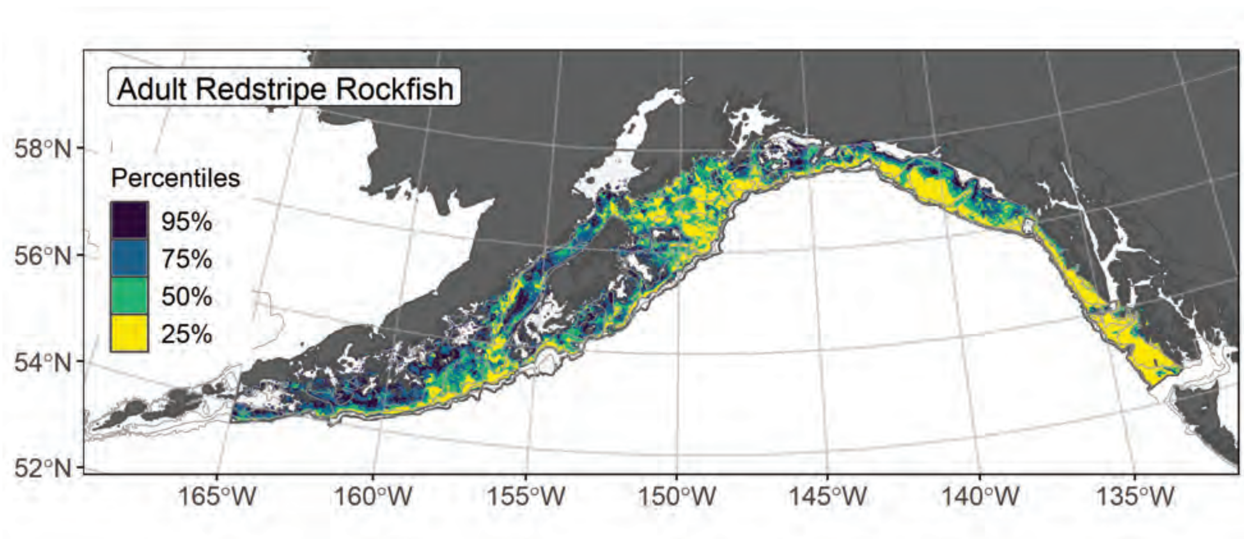

Figure E-60 EFH area of adult redtripe rockfish, summer

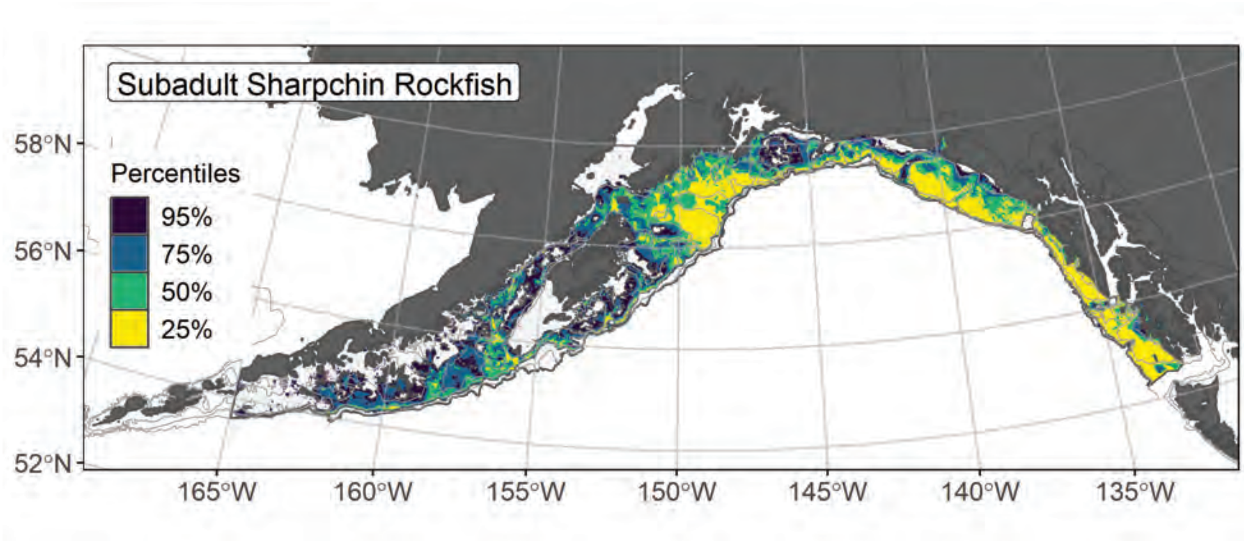

Figure E-61 EFH area of subadult sharpchin rockfish, summer

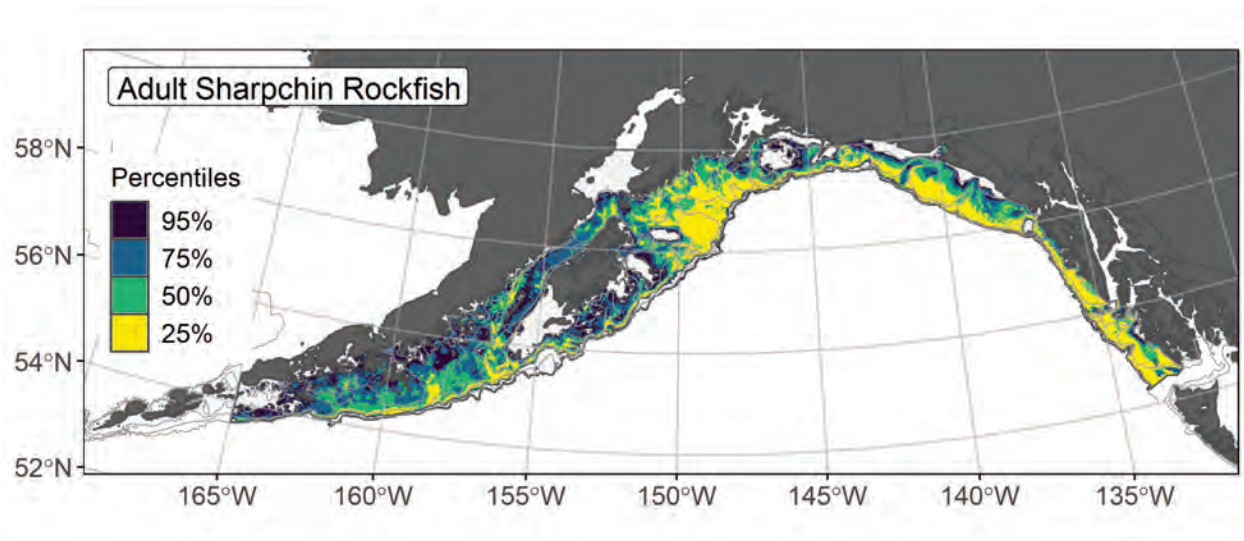

Figure E-62 EFH area of adult sharpchin rockfish, summer

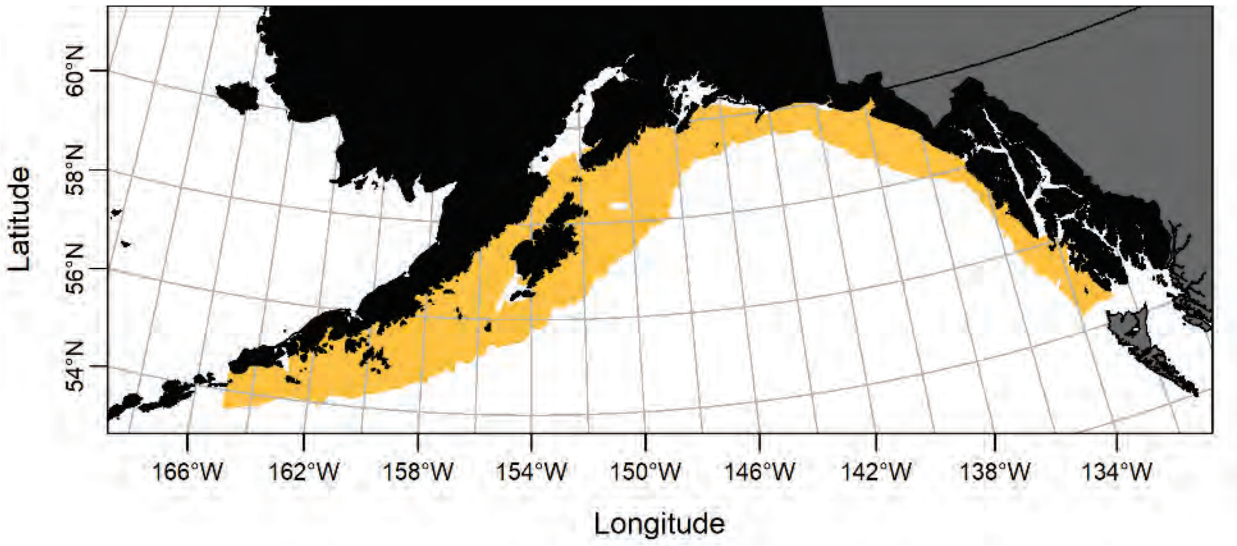

Figure E-63 EFH area of adult sharpchin rockfish, spring

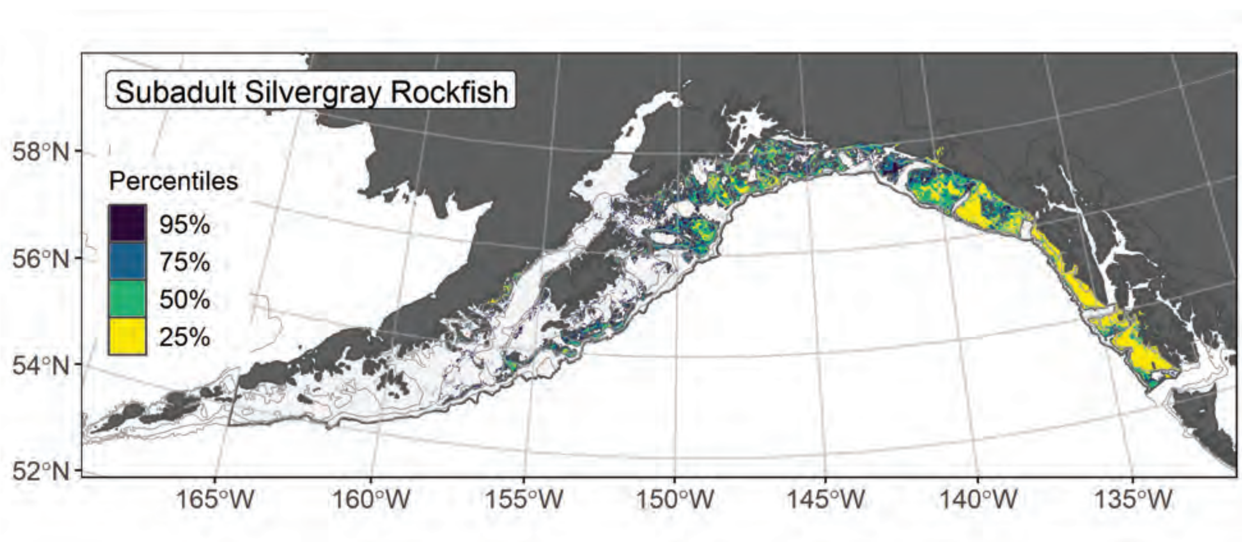

Figure E-64 EFH area of subadult silvergray rockfish, summer

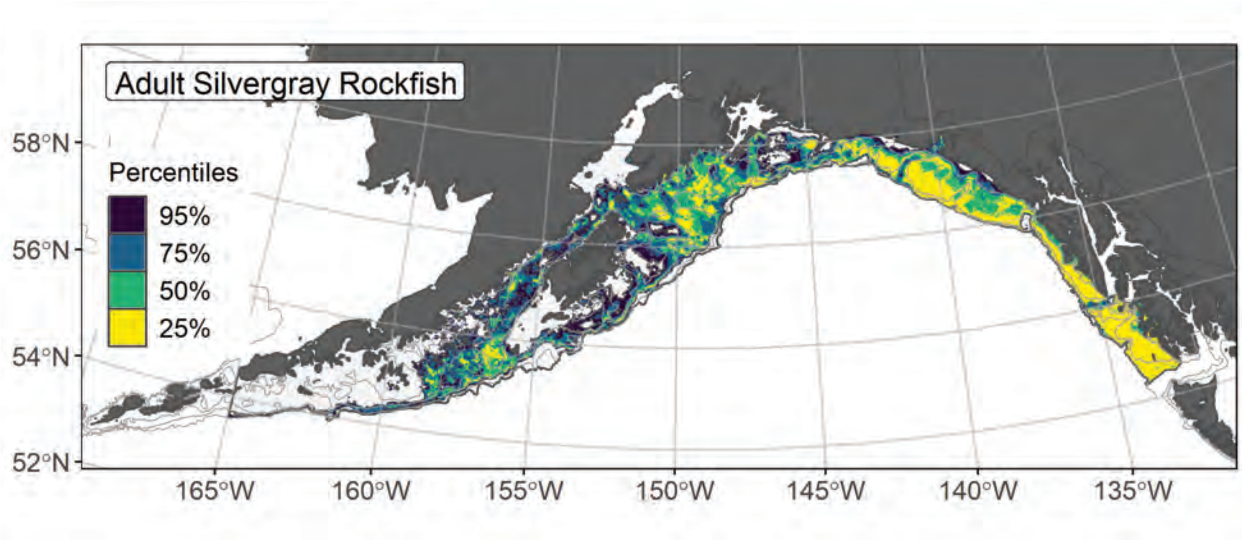

Figure E-65 EFH area of adult silvergray rockfish, summer

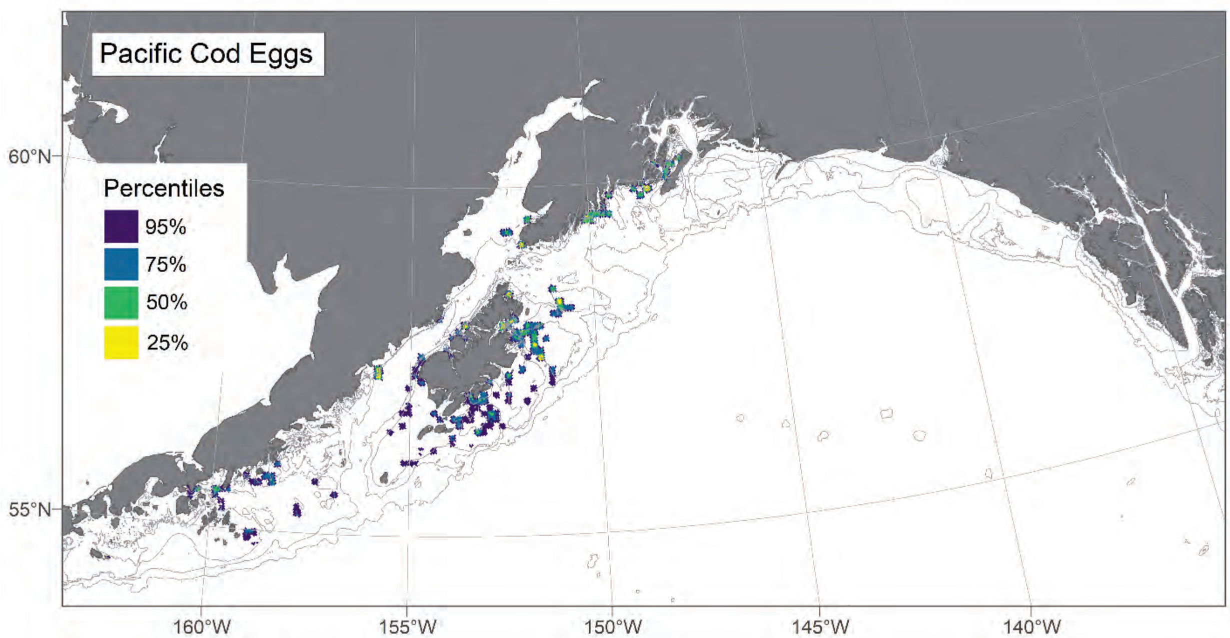

Figure E-66 EFH area of Pacific cod eggs, summer

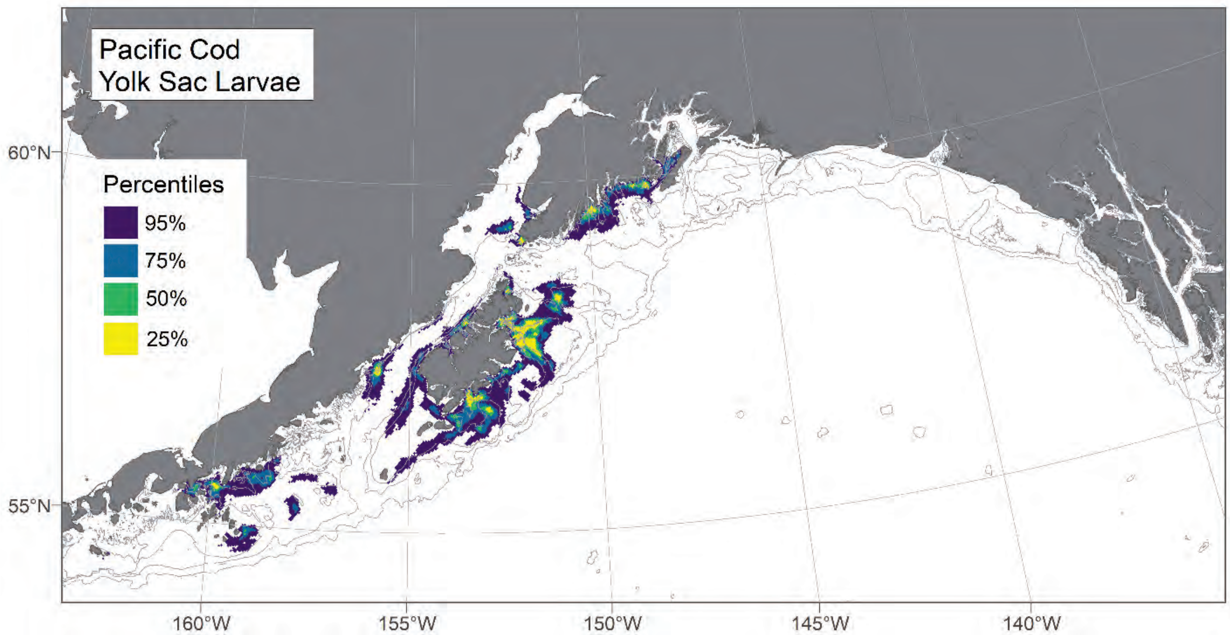

Figure E-67 EFH area of Pacific cod yolk sac larvae, summer

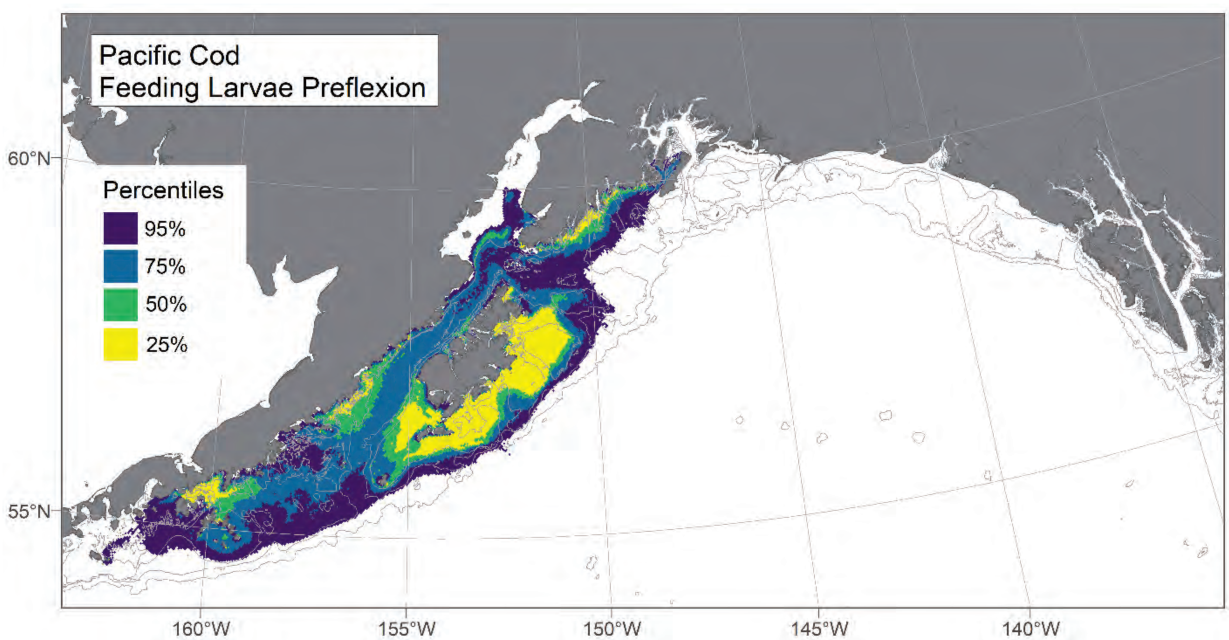

Figure E-68 EFH area of Pacific cod feeding larvae preflexion, summer

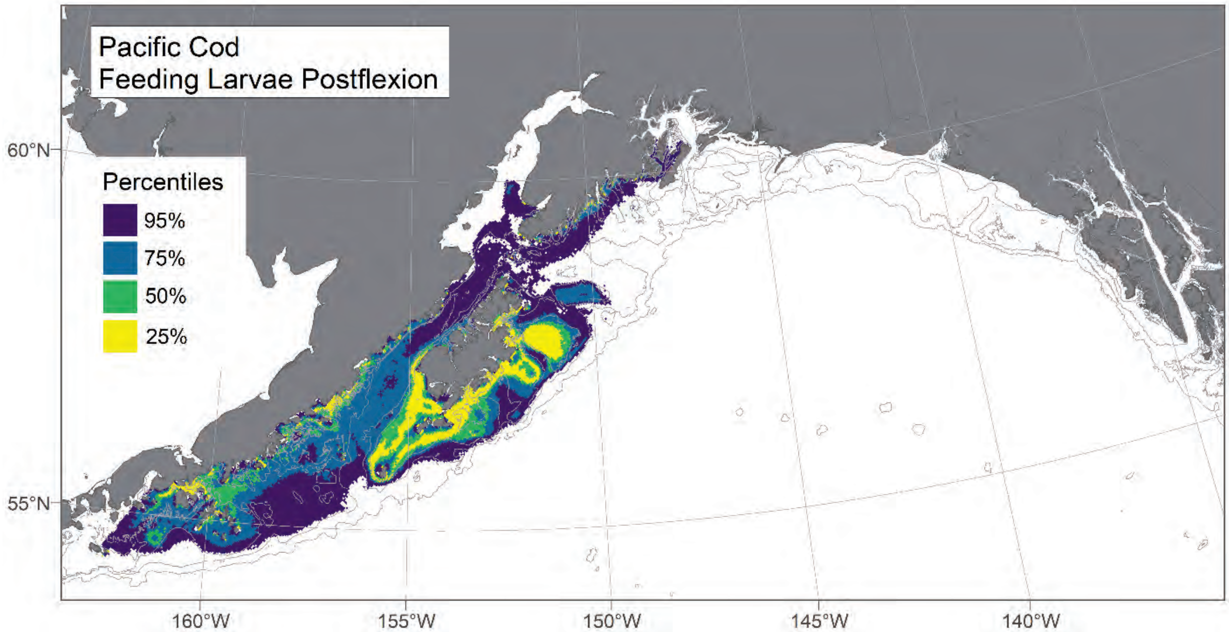

Figure E-69 EFH area of Pacific cod feeding larvae postflexion, summer

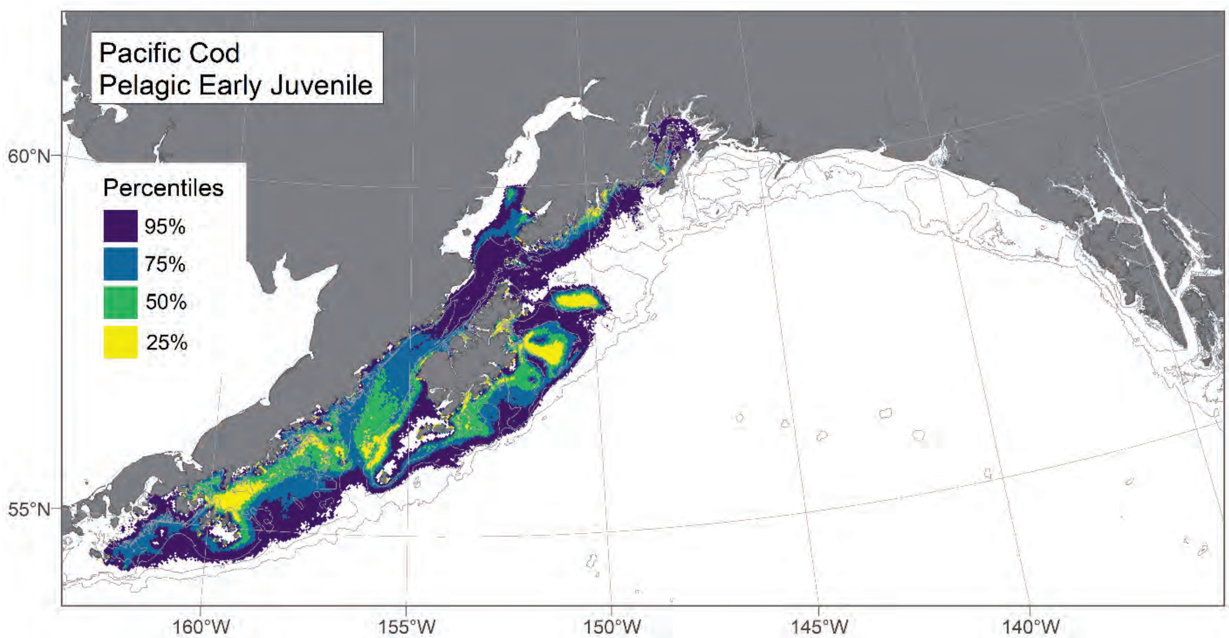

Figure E-70 EFH area of pelagic early juvenile Pacific cod, summer

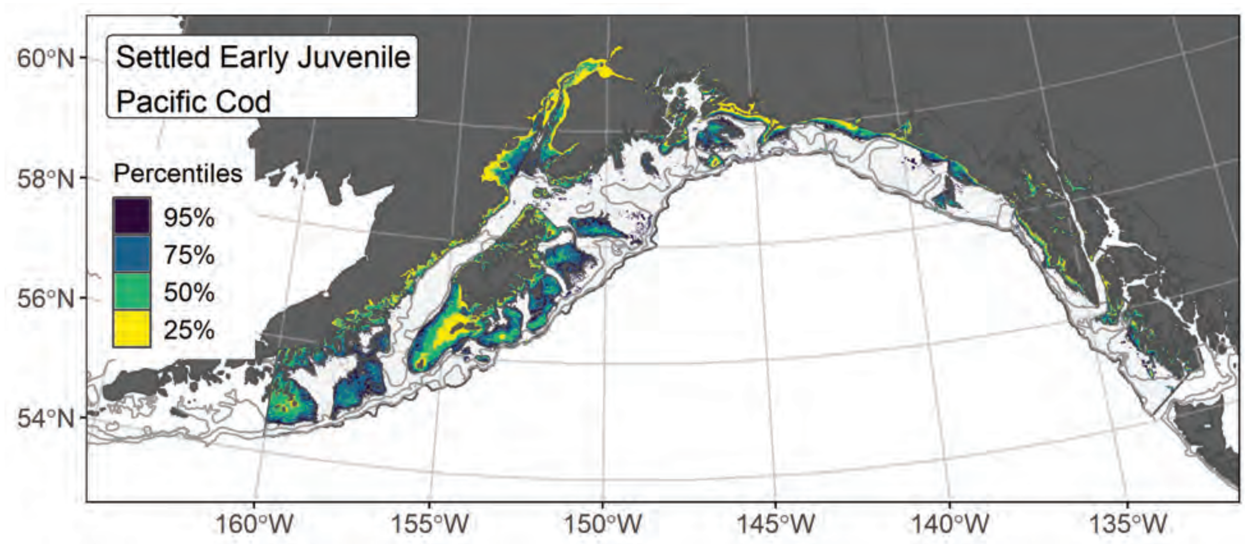

Figure E-71 EFH area of settled early juvenile Pacific cod, summer

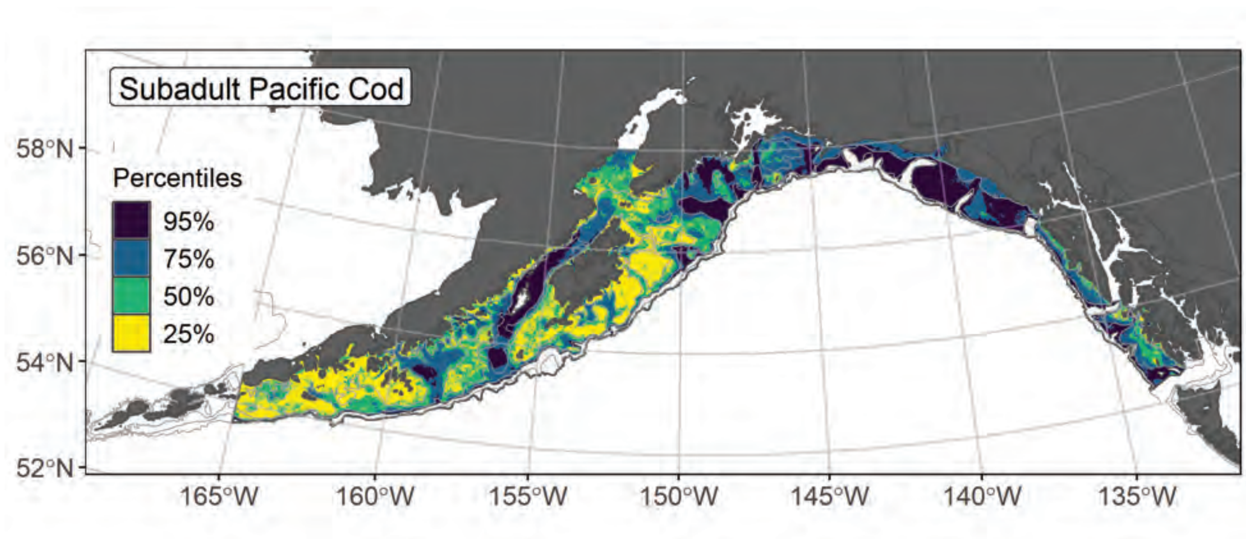

Figure E-72 EFH area of subadult Pacific cod, summer

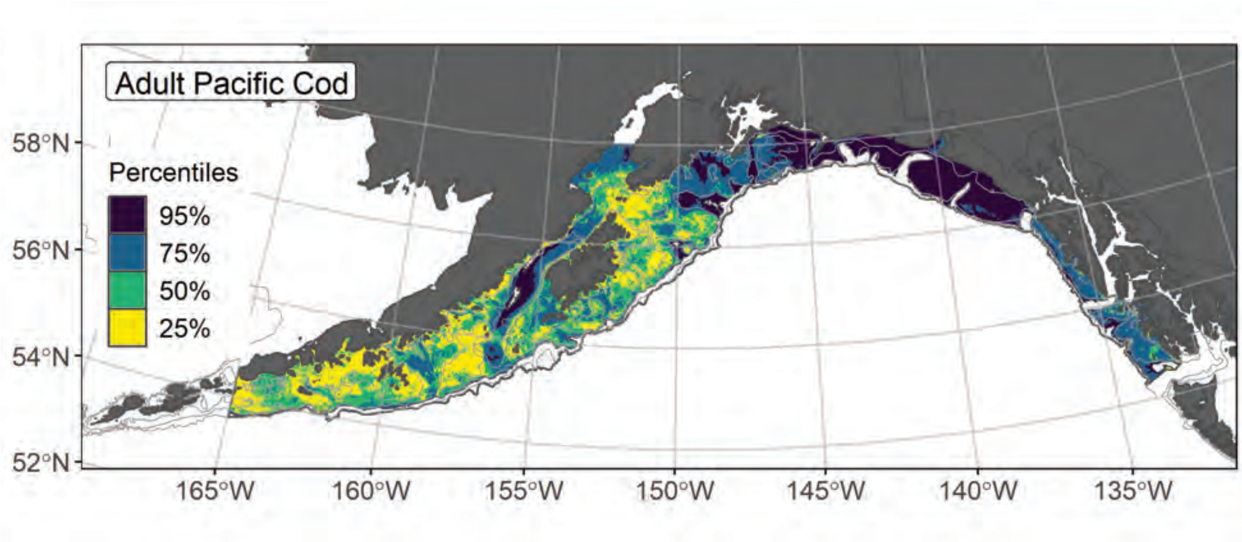

Figure E-73 EFH area of adult Pacific cod, summer

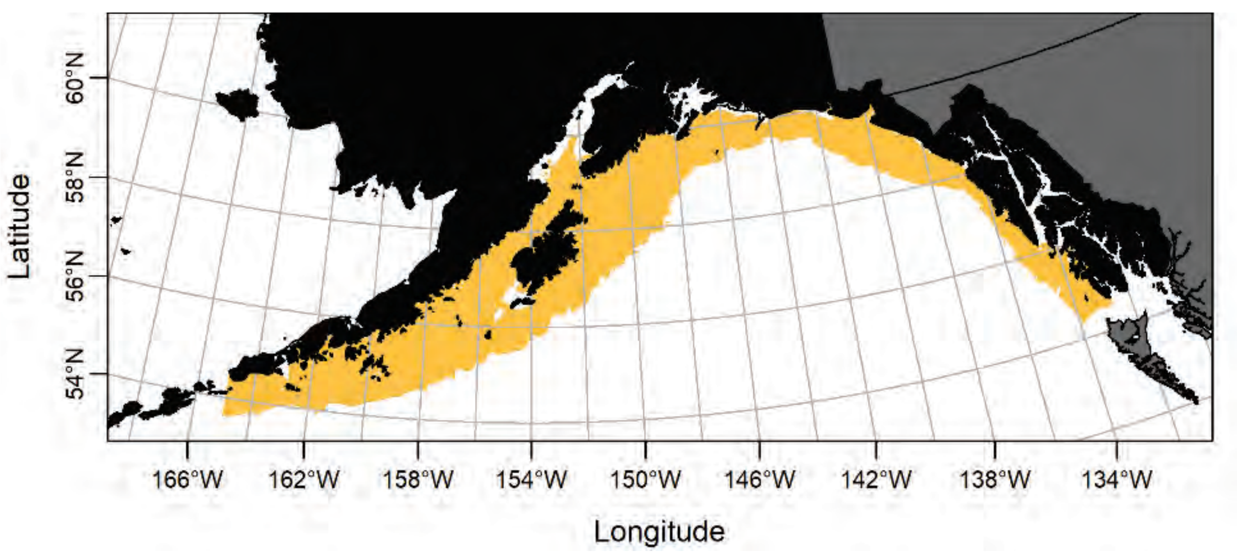

Figure E-74 EFH area of adult Pacific cod, fall

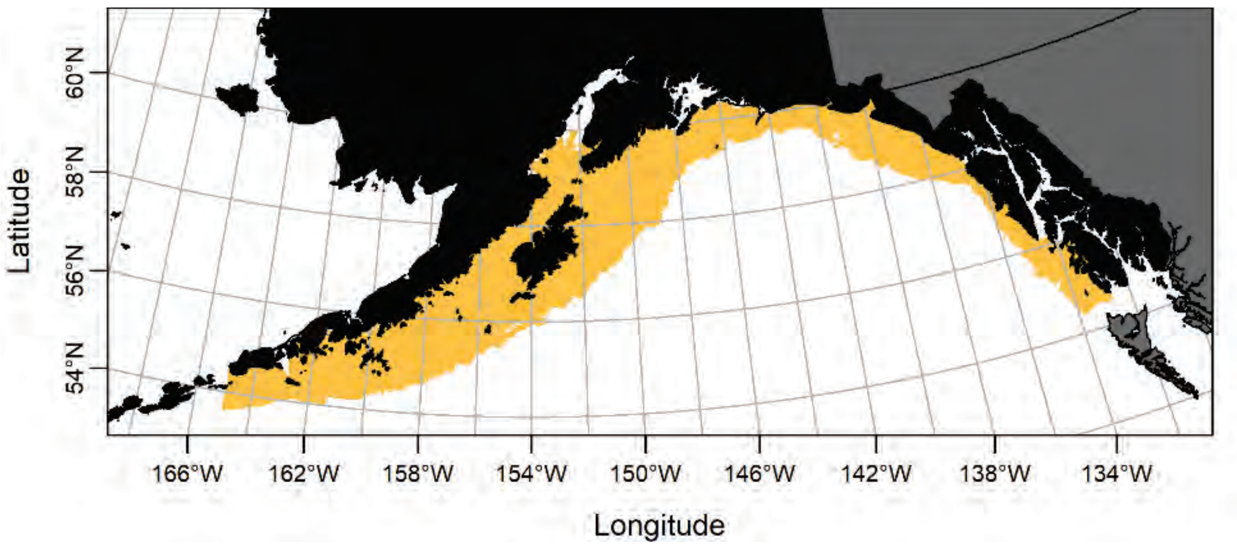

Figure E-75 EFH area of adult Pacific cod, winter

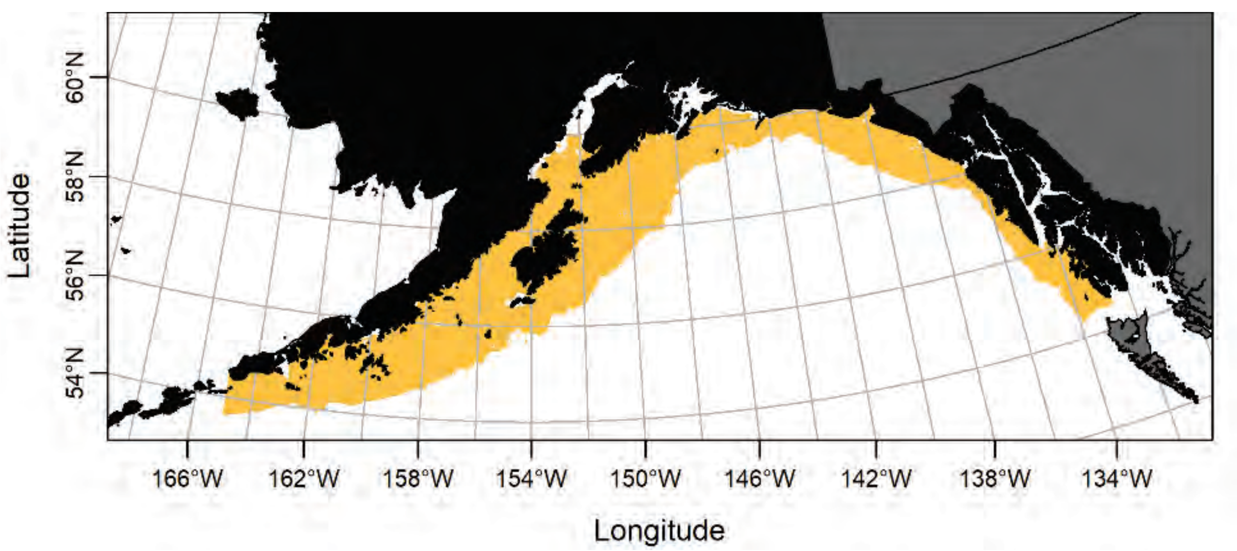

Figure E-76 EFH area of adult Pacific cod, spring

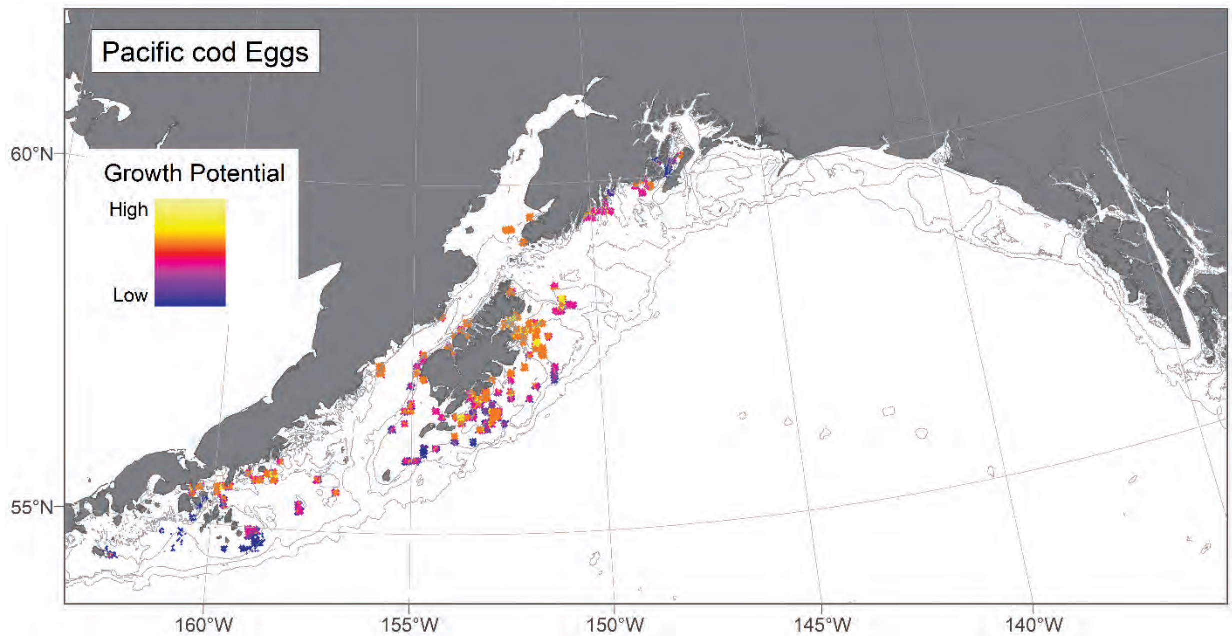

Figure E-77 EFH area of Pacific cod eggs, habitat-related growth potential, summer

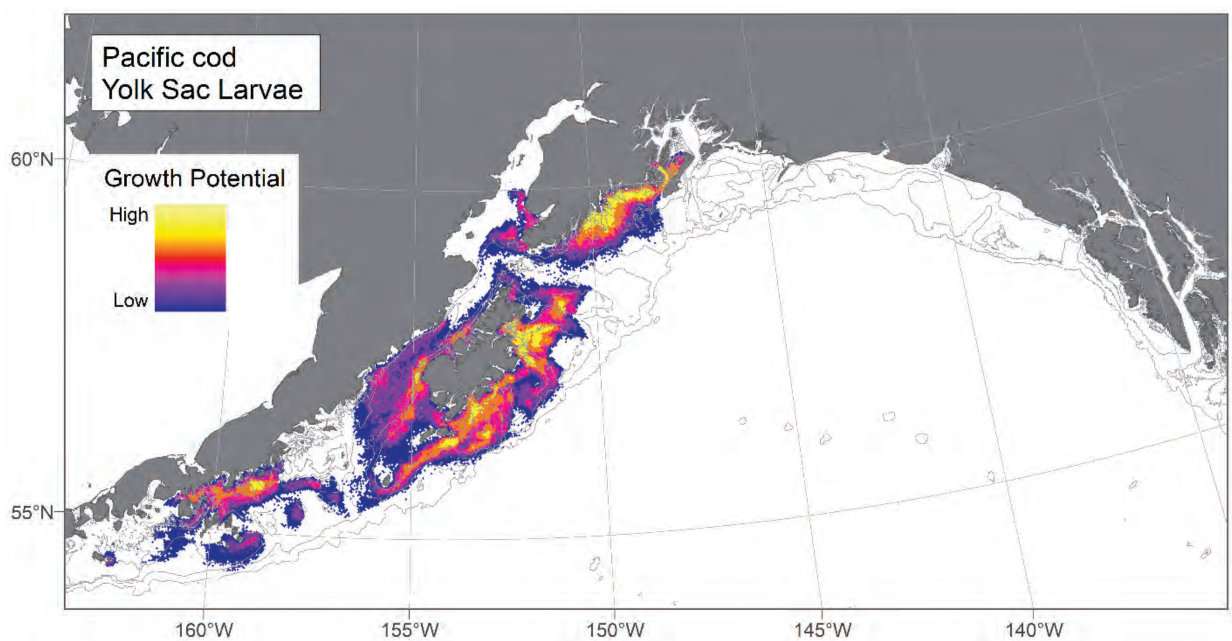

Figure E-78 EFH area of Pacific cod yolk sac larvae, habitat-related growth potential, summer

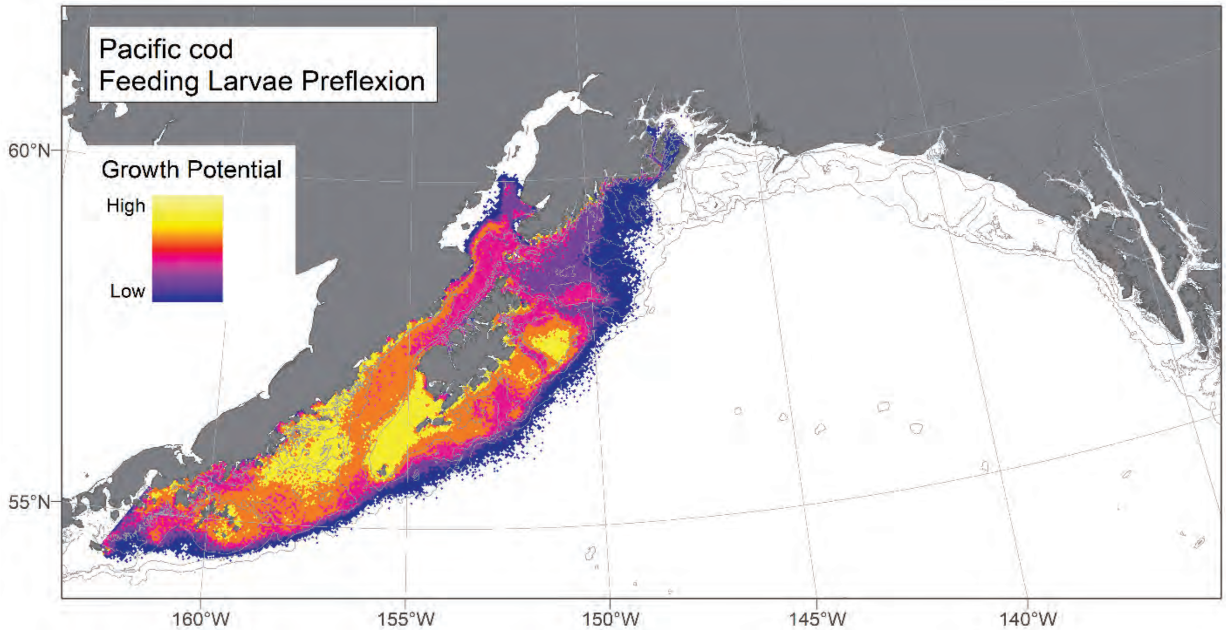

Figure E-79 EFH area of Pacific cod feeding larvae preflexion, habitat-related growth potential, summer

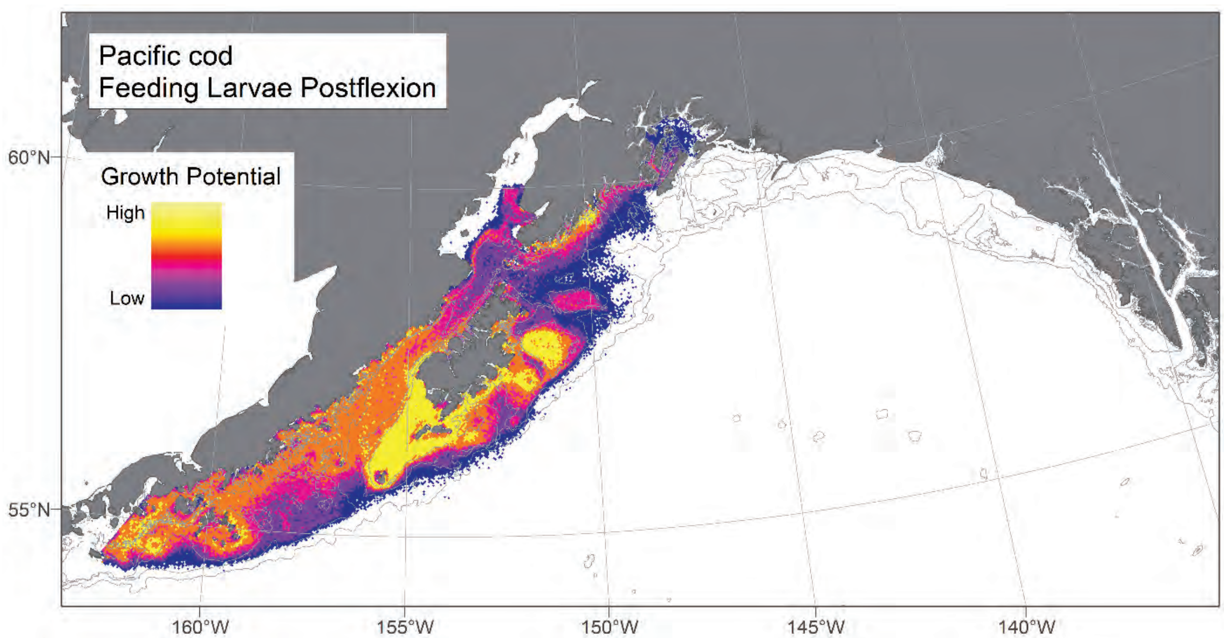

Figure E-80 EFH area of Pacific cod feeding larvae postflexion, habitat-related growth potential, summer

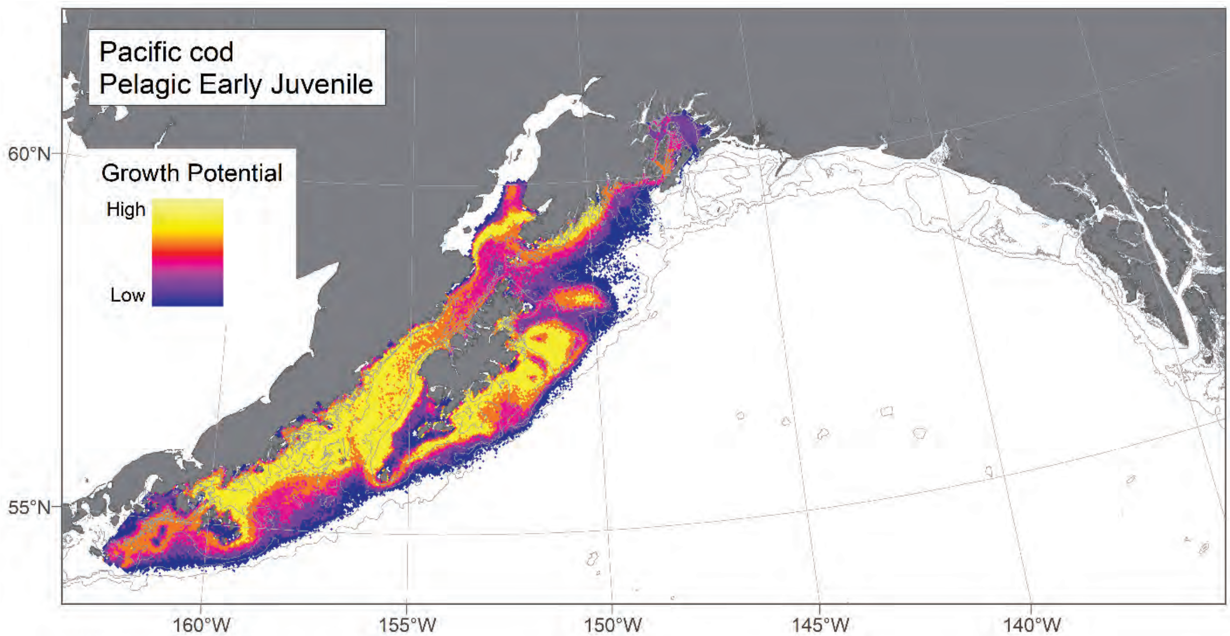

Figure E-81 EFH area of pelagic early juvenile Pacific cod, habitat-related growth potential, summer

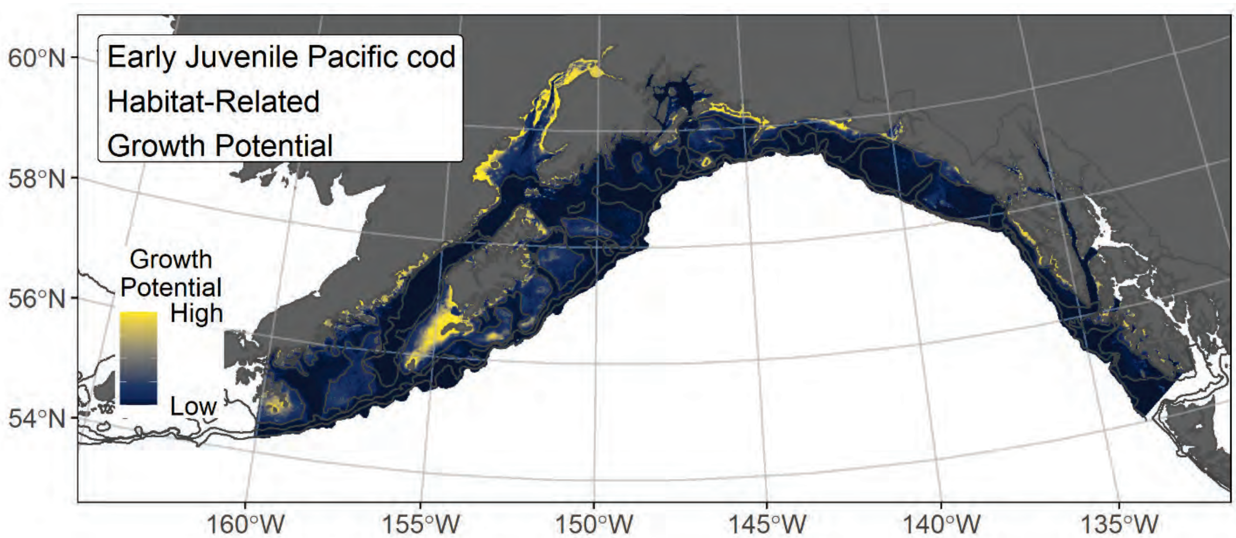

Figure E-82 EFH area of settled early juvenile Pacific cod, habitat-related growth potential, summer

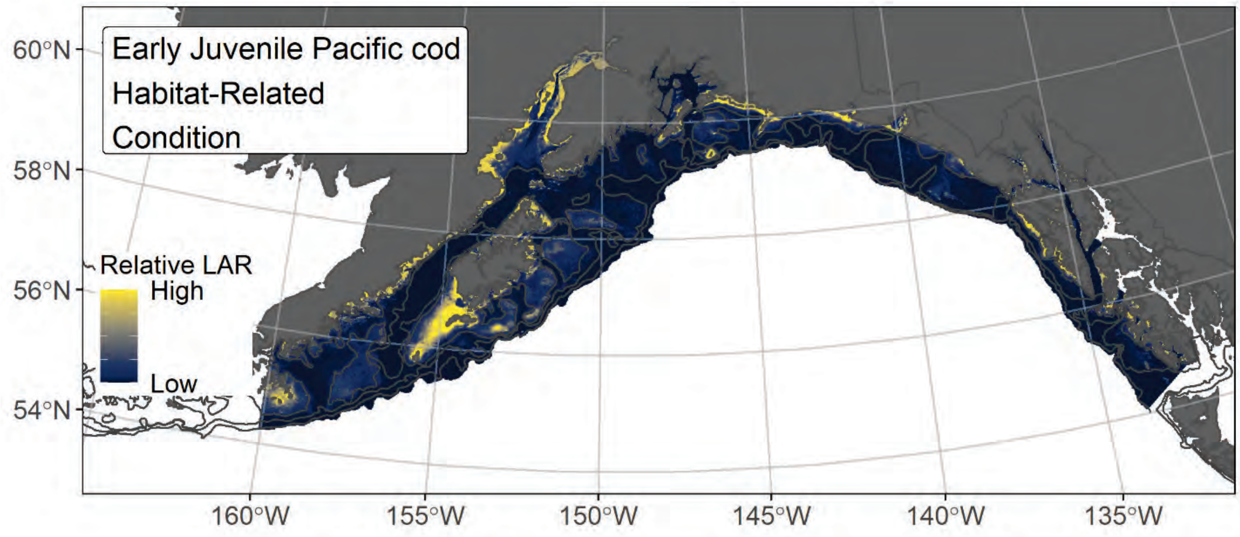

Figure E-83 EFH area of settled early juvenile Pacific cod, habitat-related condition, summer

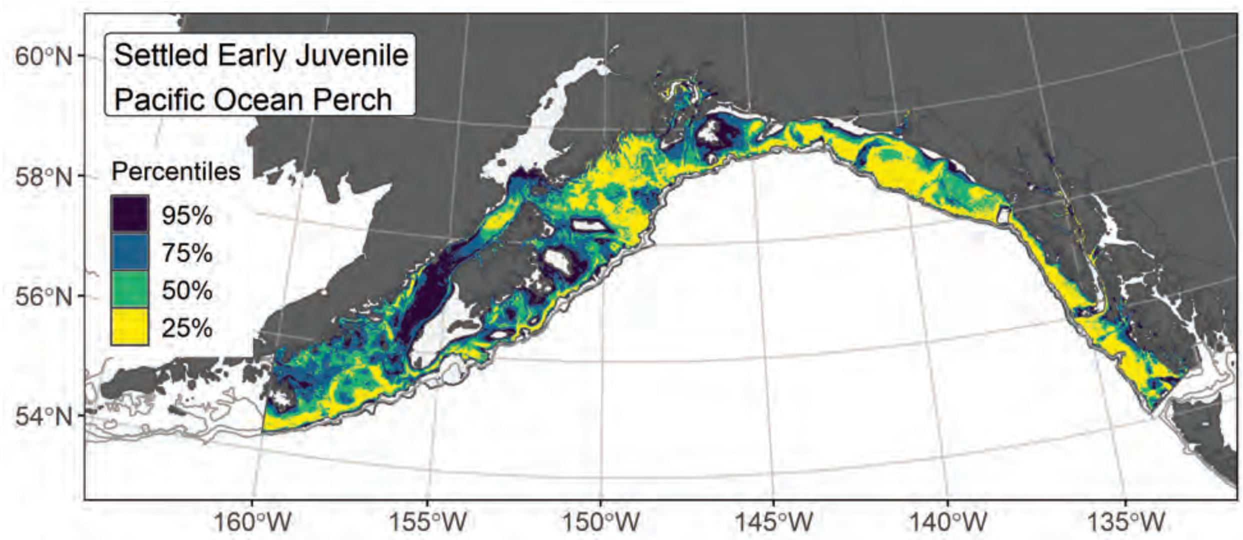

Figure E-84 EFH area of settled early juvenile Pacific ocean perch, summer

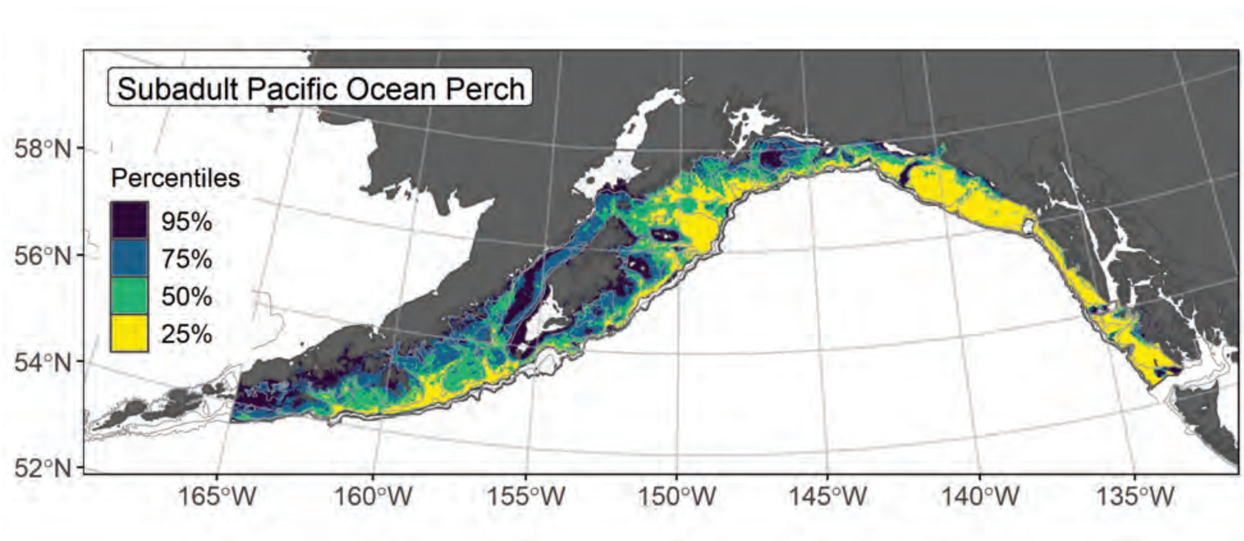

Figure E-85 EFH area of subadult Pacific ocean perch, summer

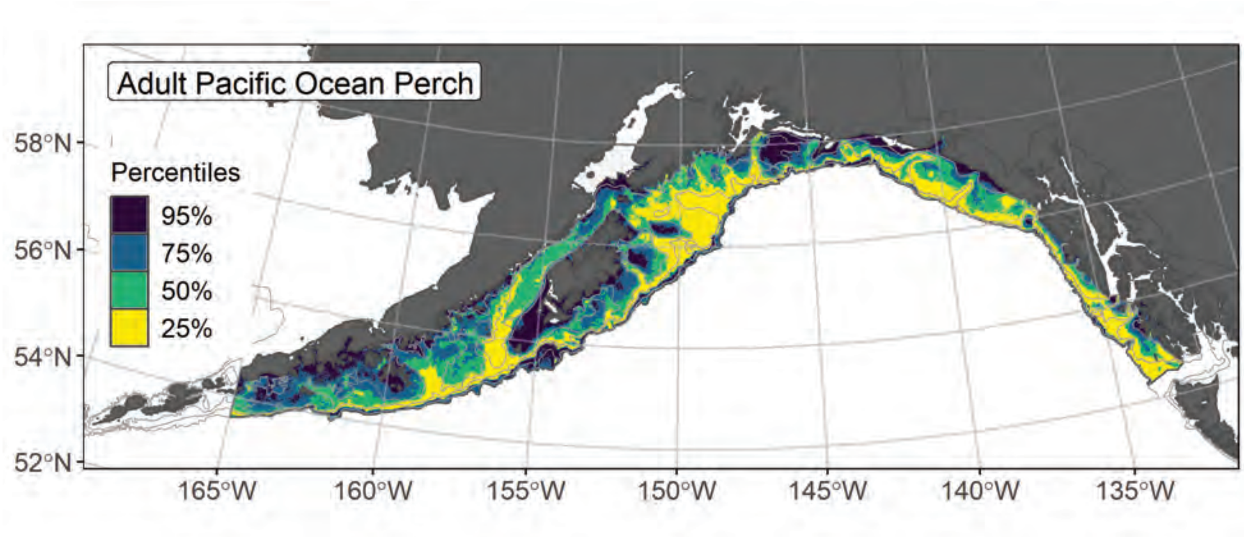

Figure E-86 EFH area of adult Pacific ocean perch, summer

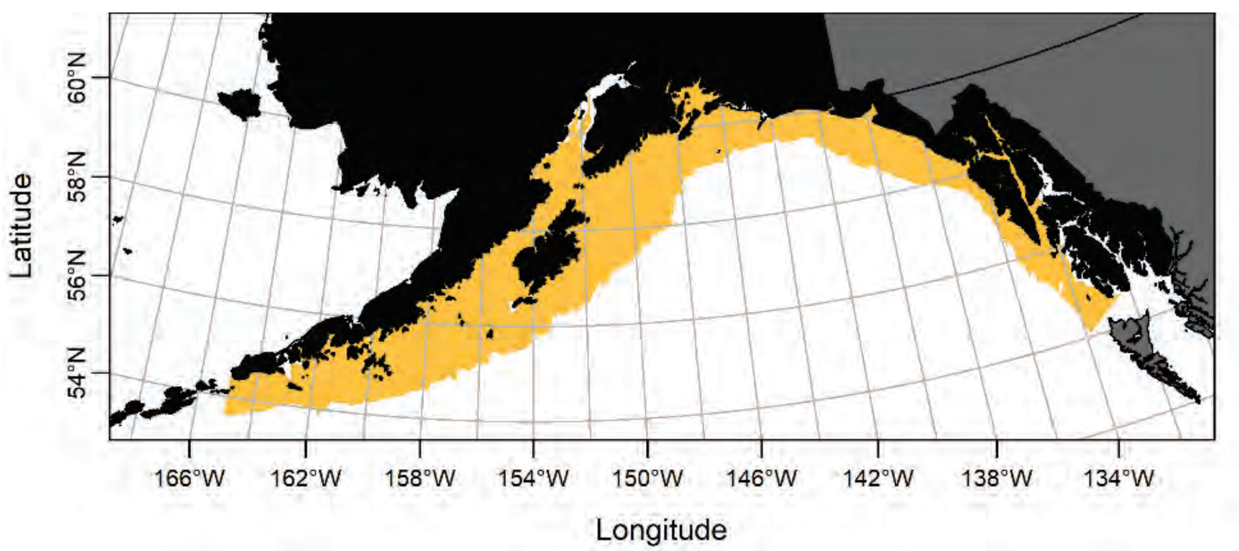

Figure E-87 EFH area of Pacific ocean perch larvae, summer

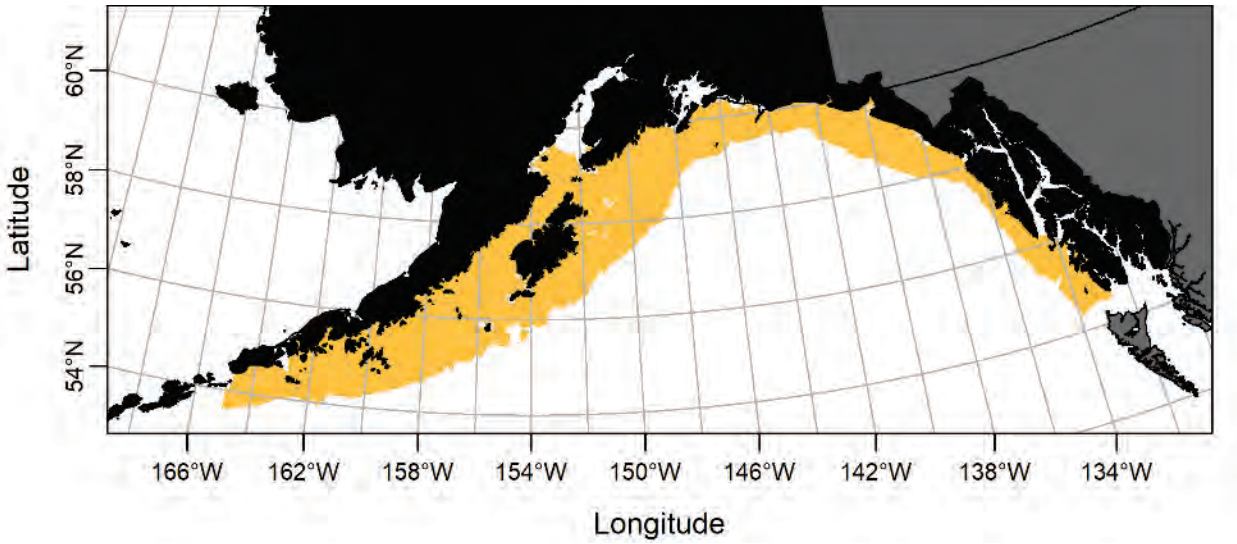

Figure E-88 EFH area of adult Pacific ocean perch, fall

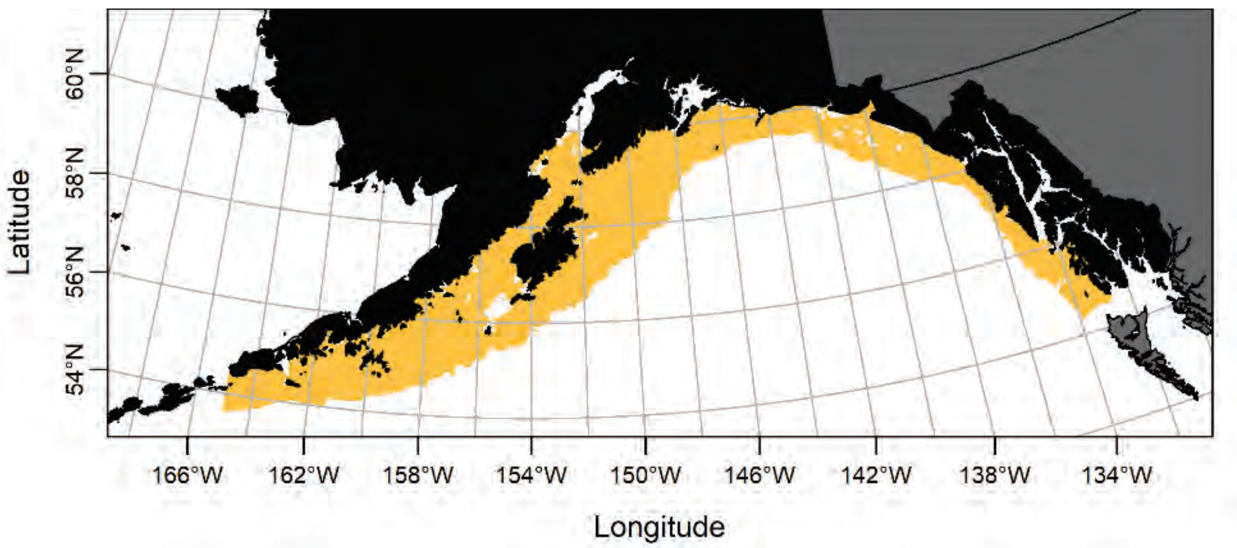

Figure E-89 EFH area of adult Pacific ocean perch, winter

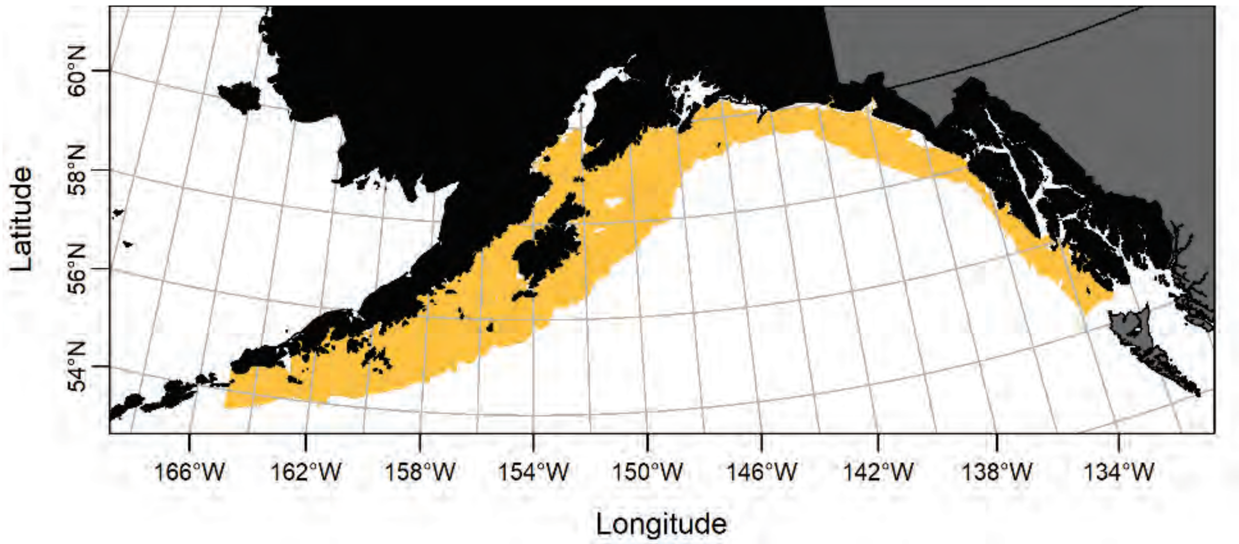

Figure E-90 EFH area of adult Pacific ocean perch, spring

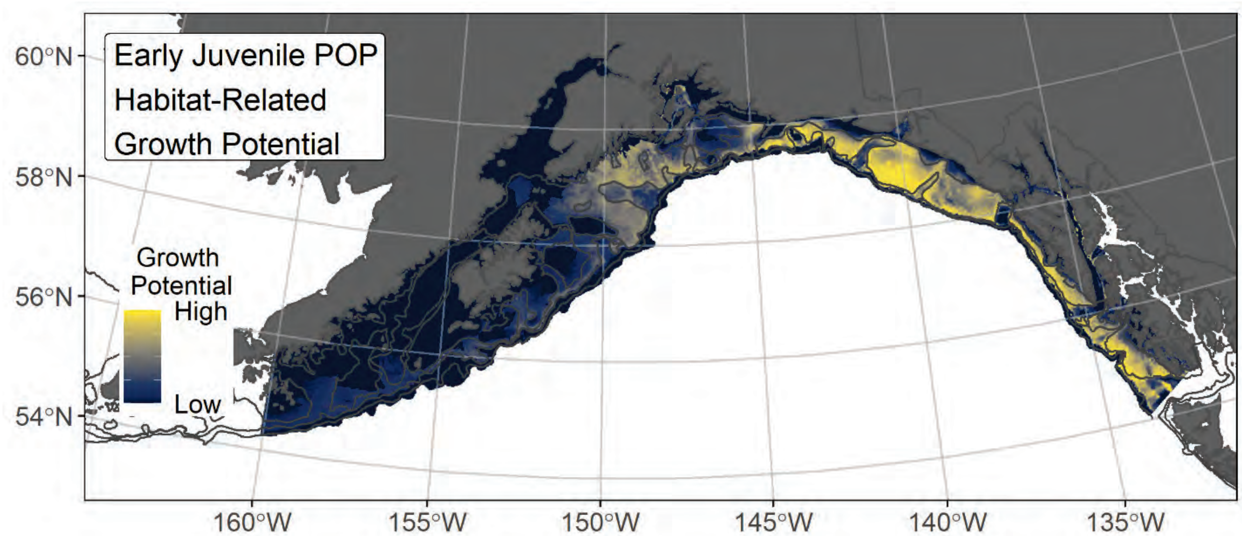

Figure E-91 EFH area of settled early juvenile Pacific ocean perch, habitat-related growth potential, summer

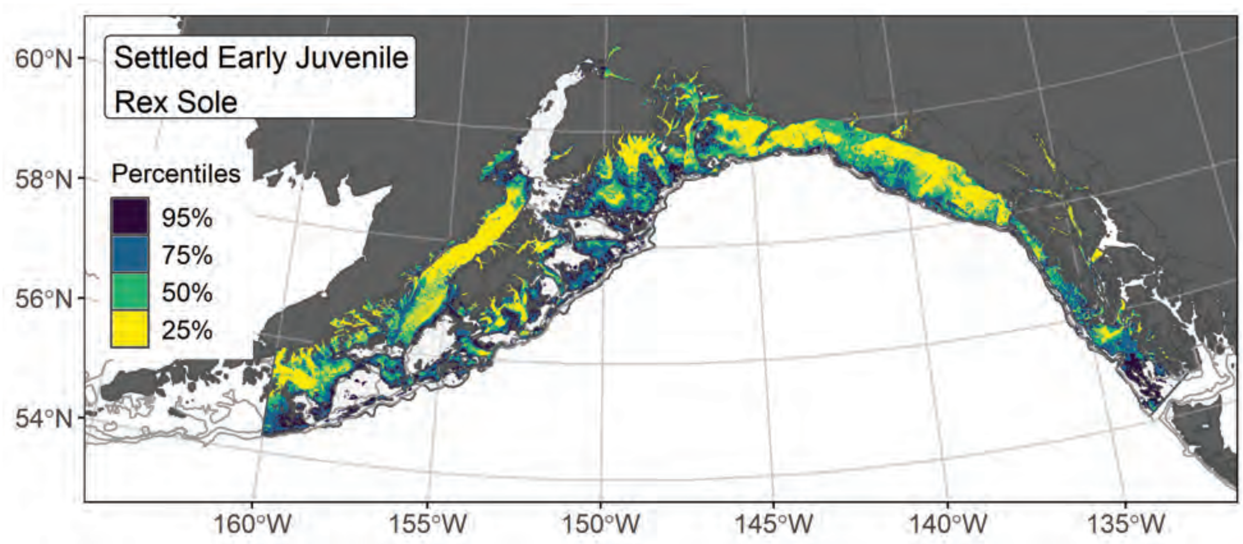

Figure E-92 EFH area of settled early juvenile rex sole, summer

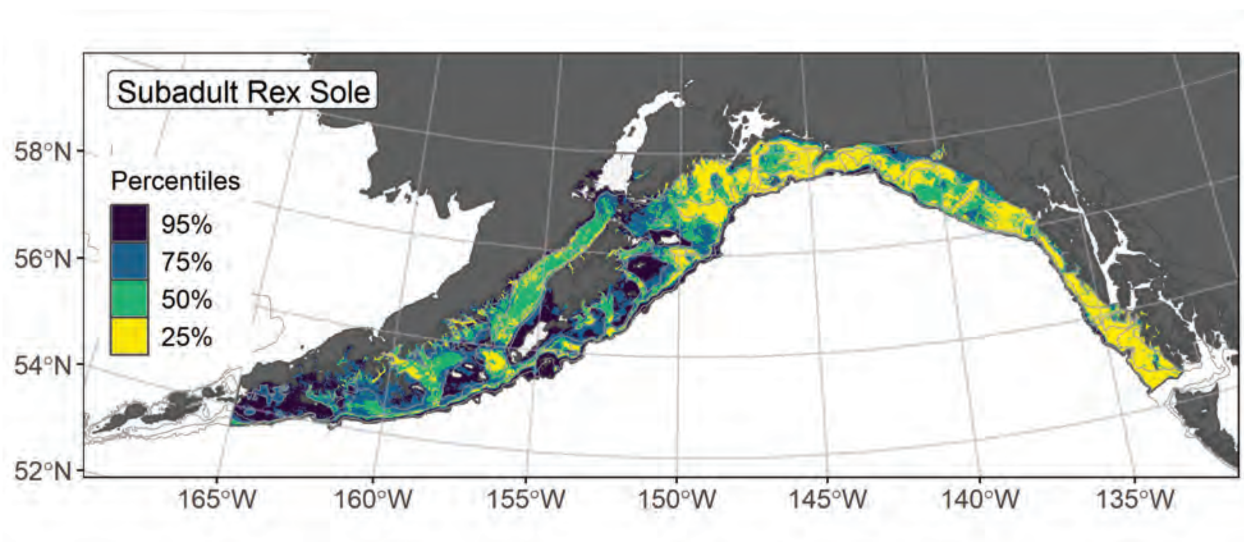

Figure E-93 EFH area of subadult rex sole, summer

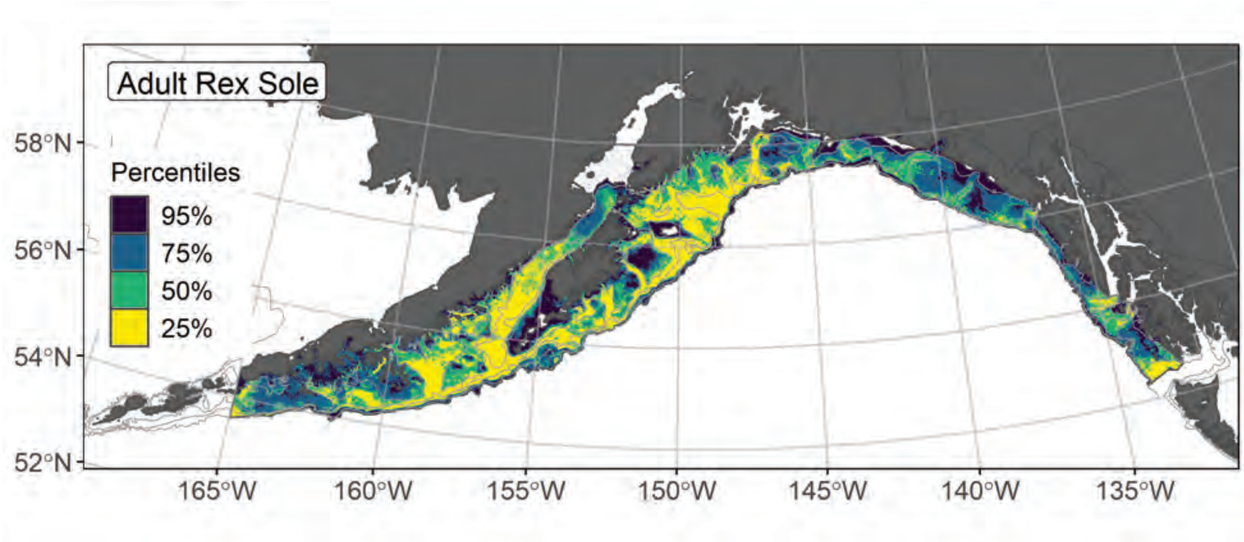

Figure E-94 EFH area of adult rex sole, summer

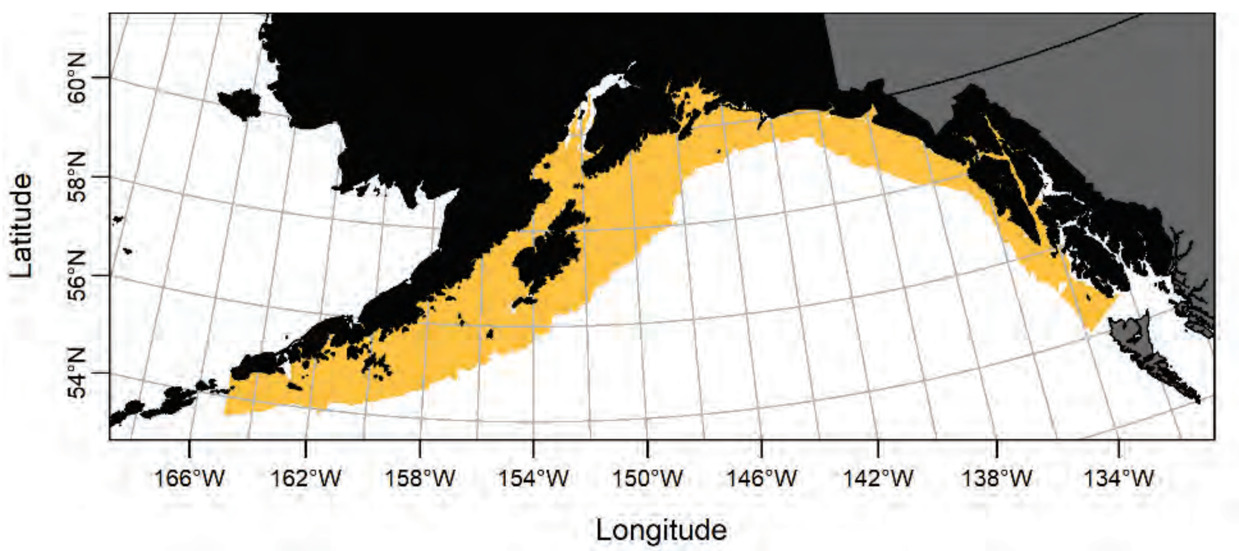

Figure E-95 EFH area of rex sole eggs, summer

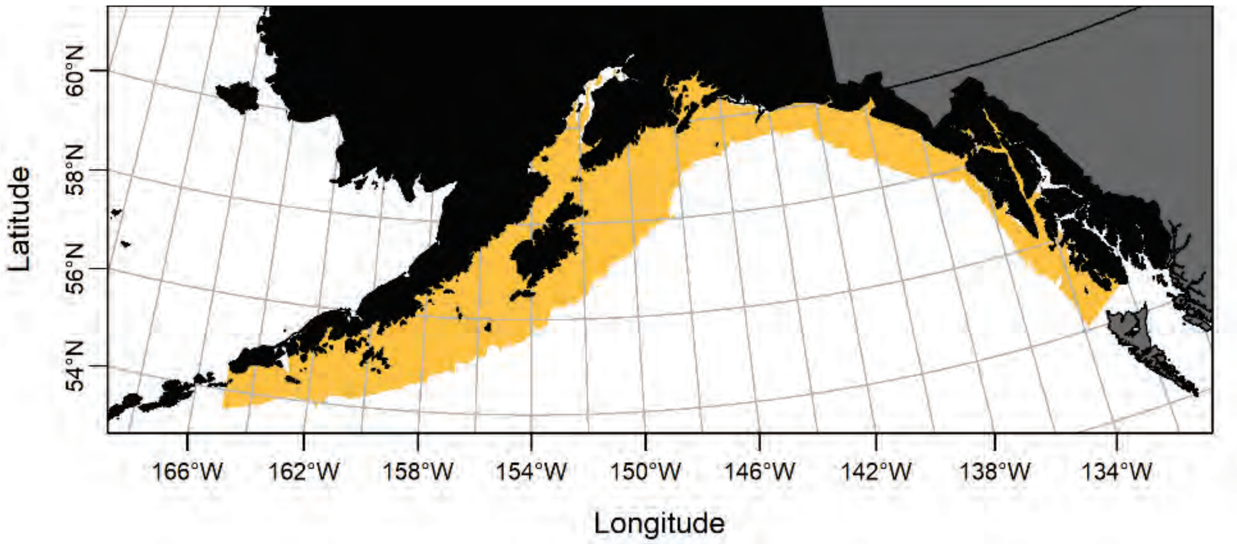

Figure E-96 EFH area of rex sole larvae, summer

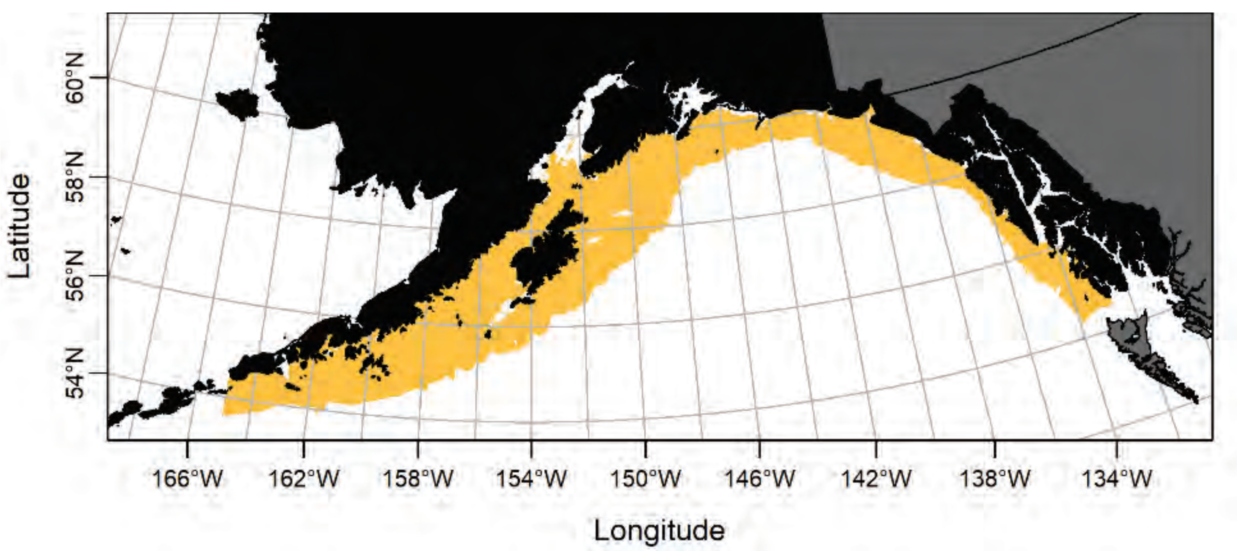

Figure E-97 EFH area of adult rex sole, fall

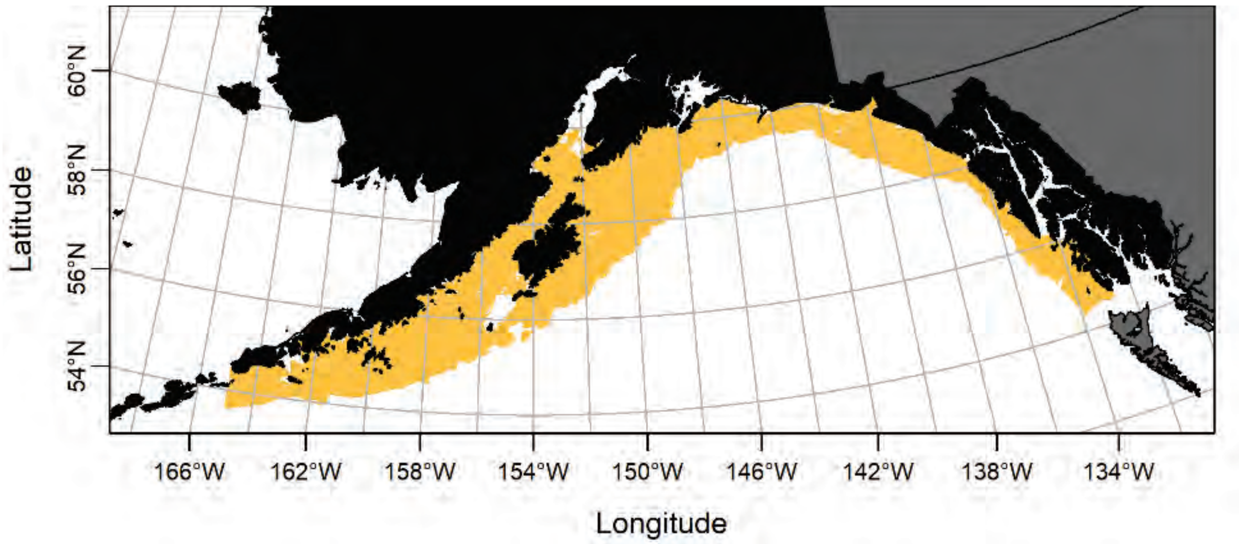

Figure E-98 EFH area of adult rex sole, winter

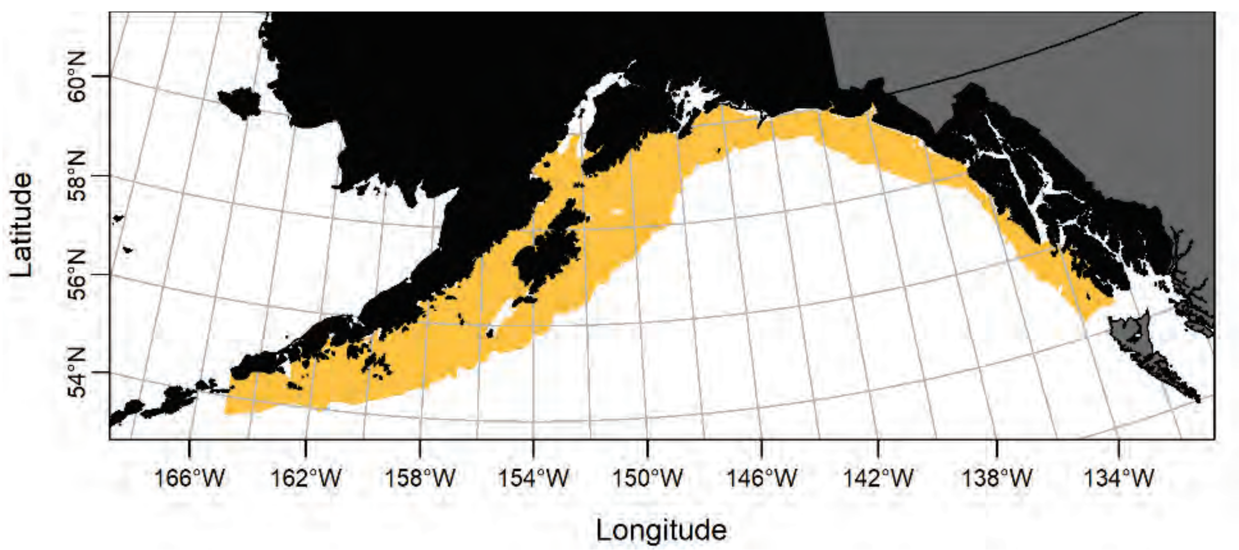

Figure E-99 EFH area of adult rex sole, spring

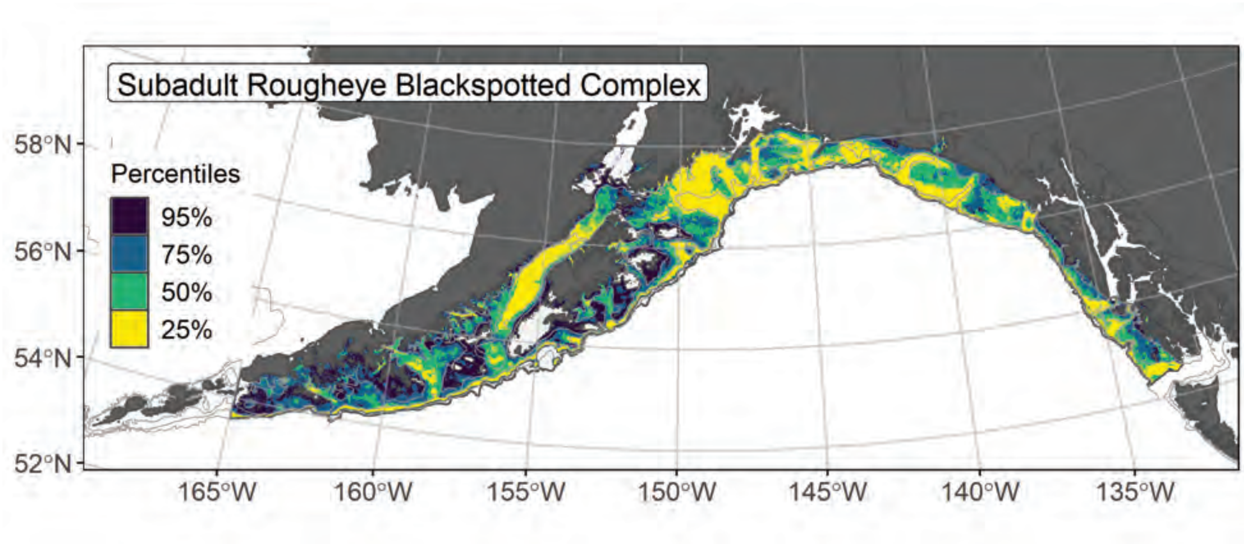

Figure E-100 EFH area of subadult rougheye/blackspotted rockfish, summer

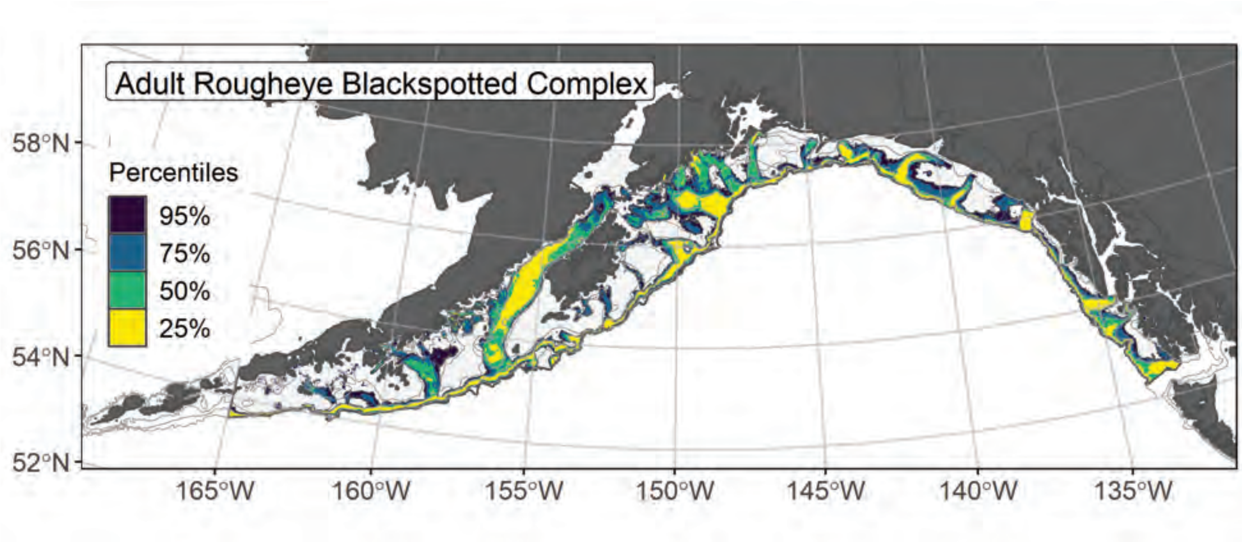

Figure E-101 **EFH area of adult rougheye/blackspotted rockfish, summer**

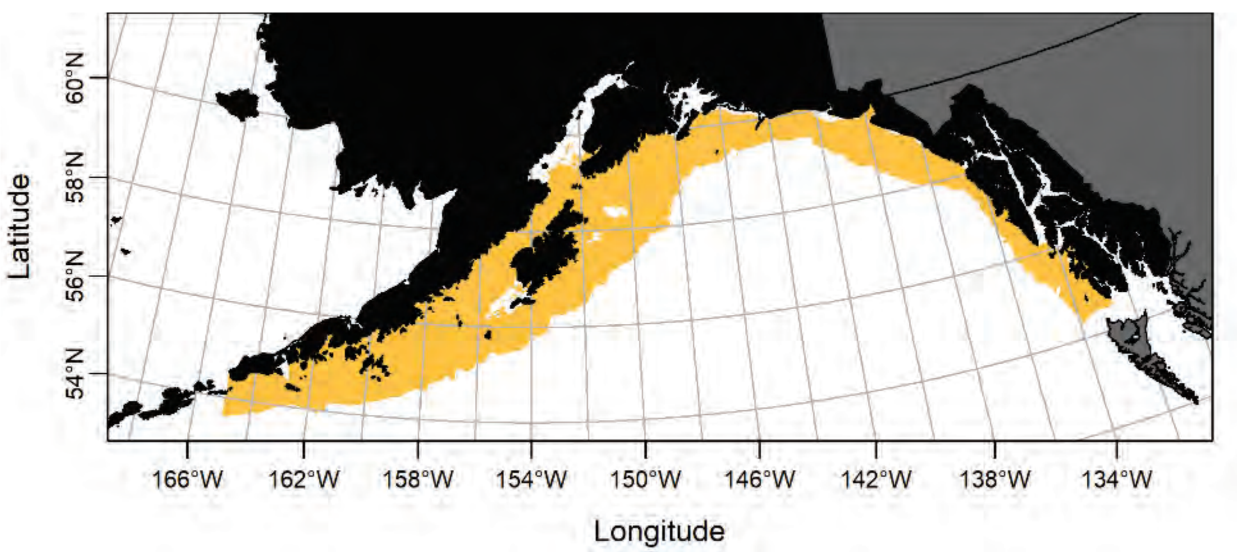

Figure E-102 **EFH area of adult rougheye rockfish, fall**

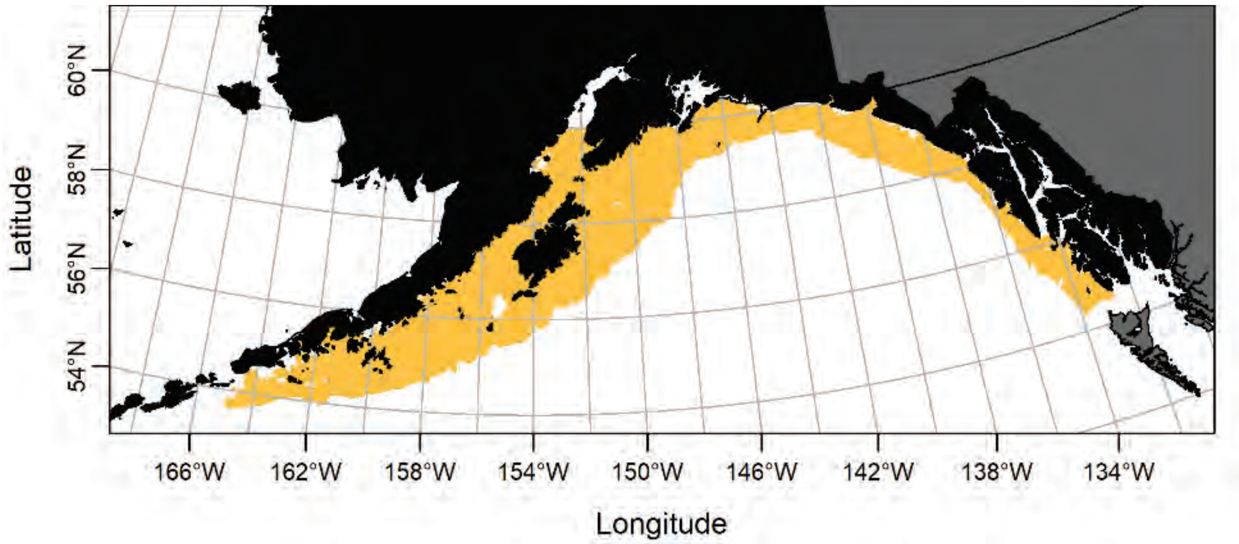

Figure E-103 EFH area of adult rougheye rockfish, winter

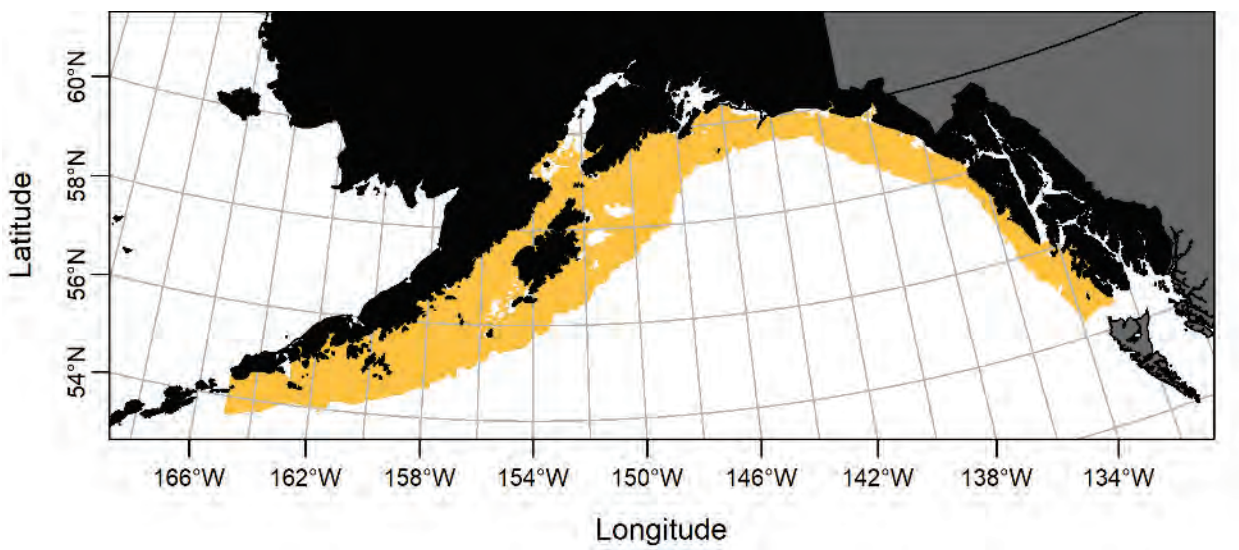

Figure E-104 EFH area of adult rougheye rockfish, spring

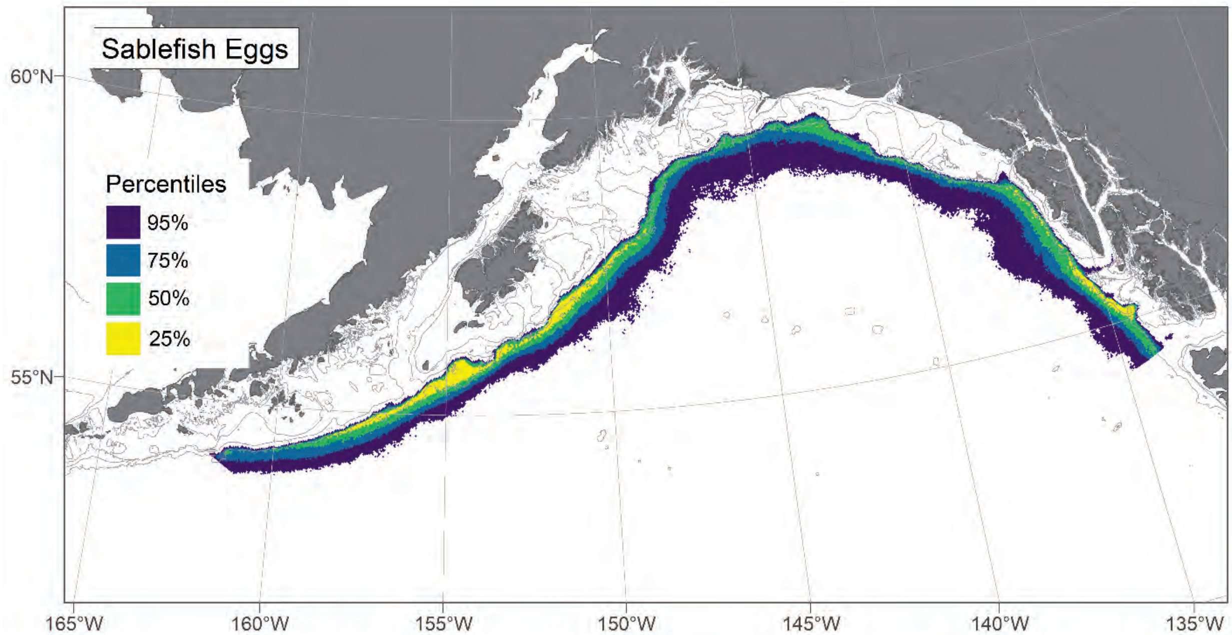

Figure E-105 EFH area of sablefish eggs, summer

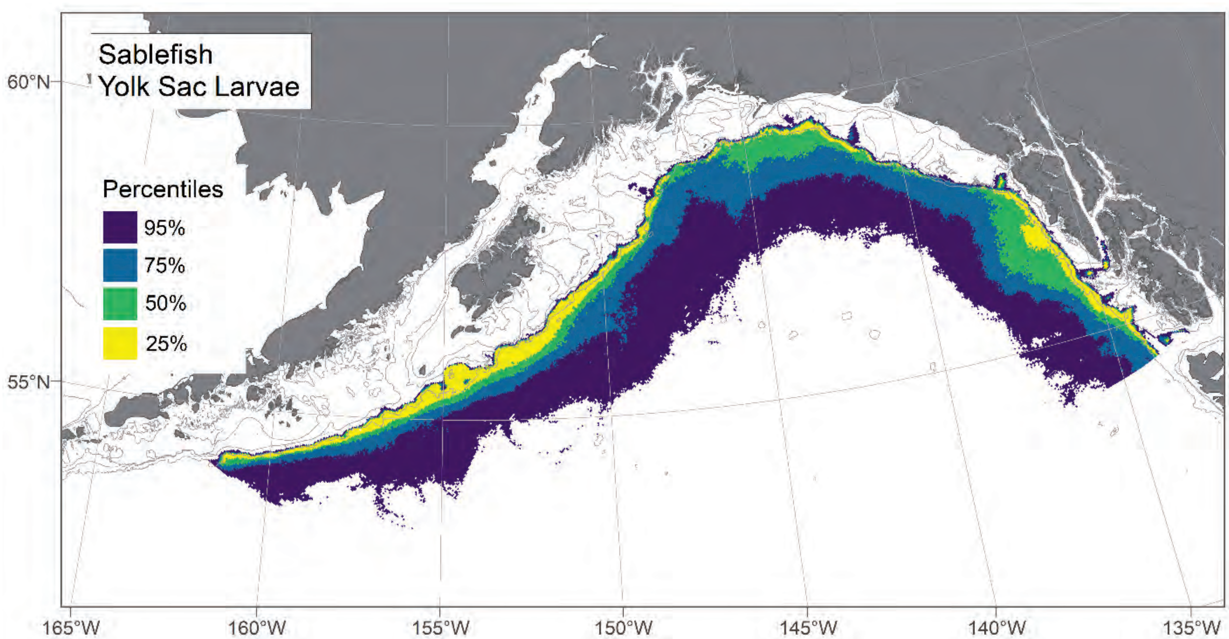

Figure E-106 EFH area of sablefish yolk sac larvae, summer

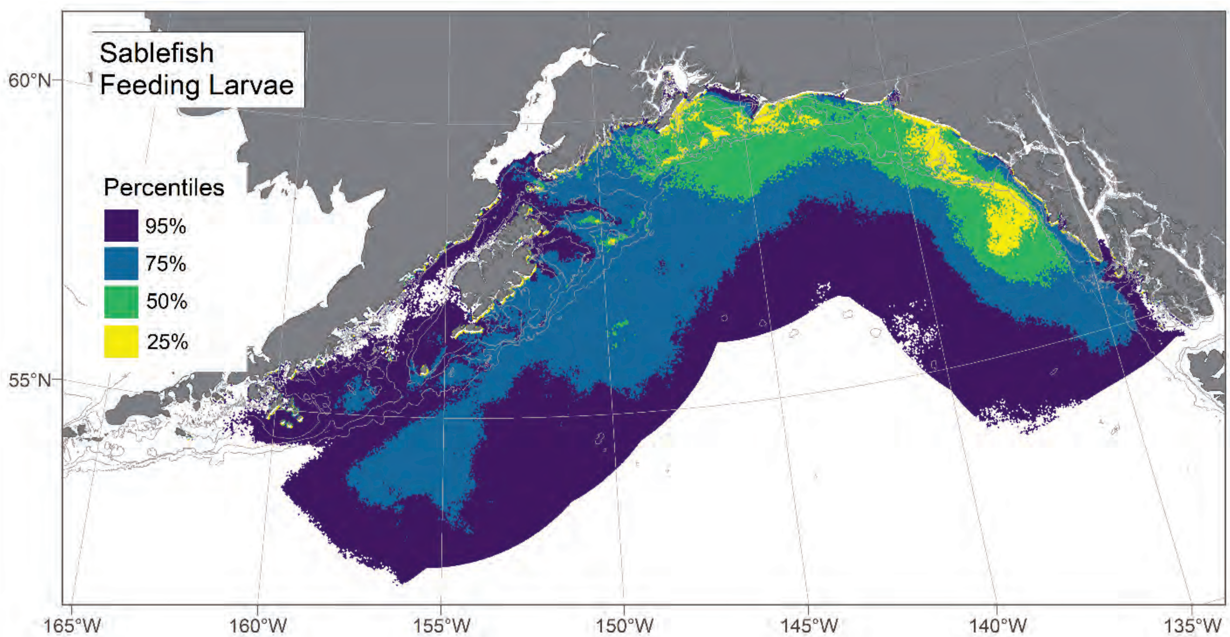

Figure E-107 EFH area of sablefish feeding larvae, summer

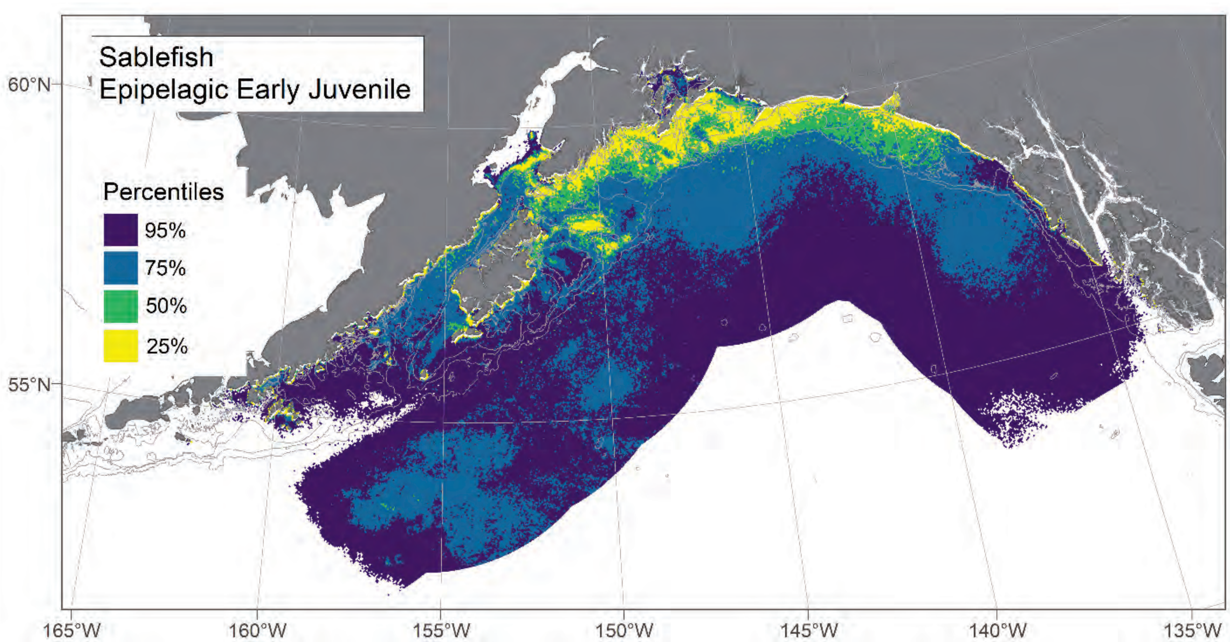

Figure E-108 EFH area of epipelagic early juvenile sablefish, summer

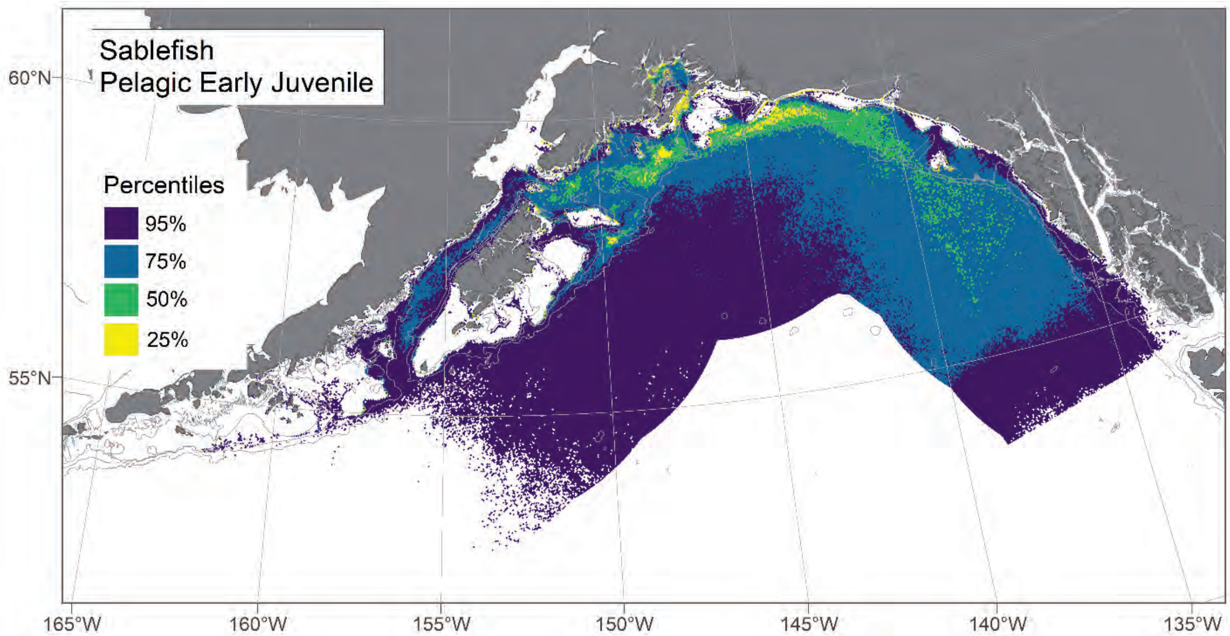

Figure E-109 EFH area of pelagic early juvenile sablefish, summer

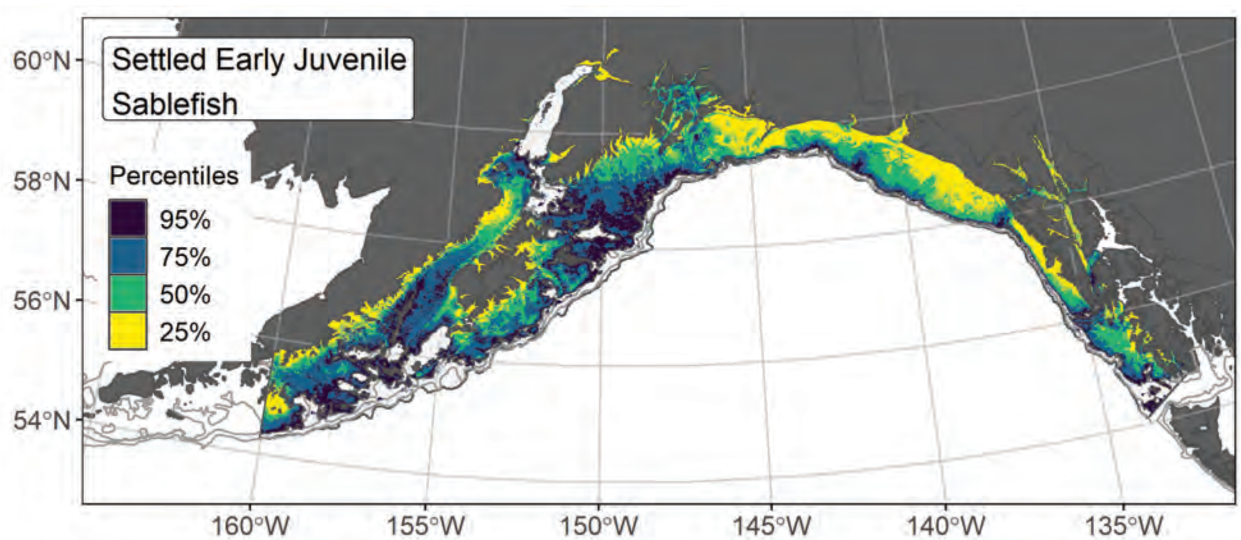

Figure E-110 EFH area of settled early juvenile sablefish, summer

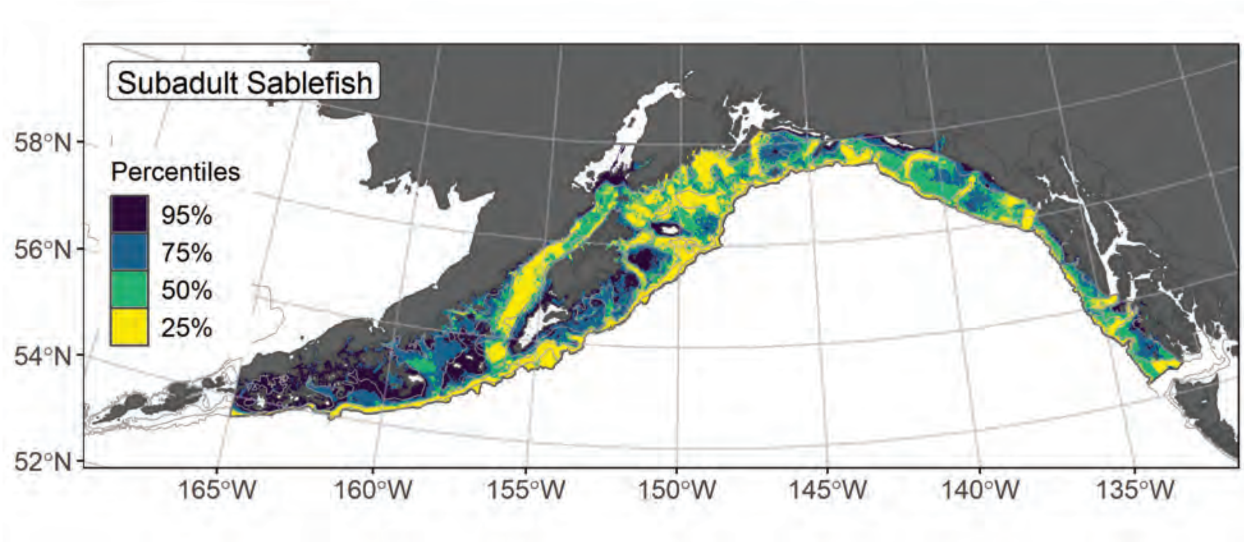

Figure E-111 EFH area of subadult sablefish, summer

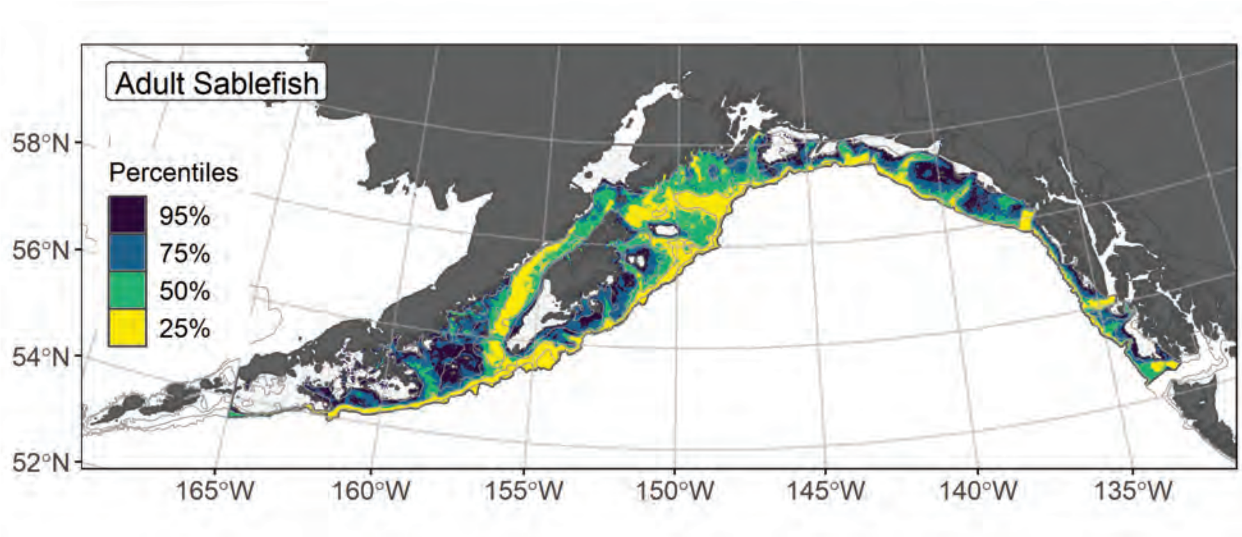

Figure E-112 EFH area of adult sablefish, summer

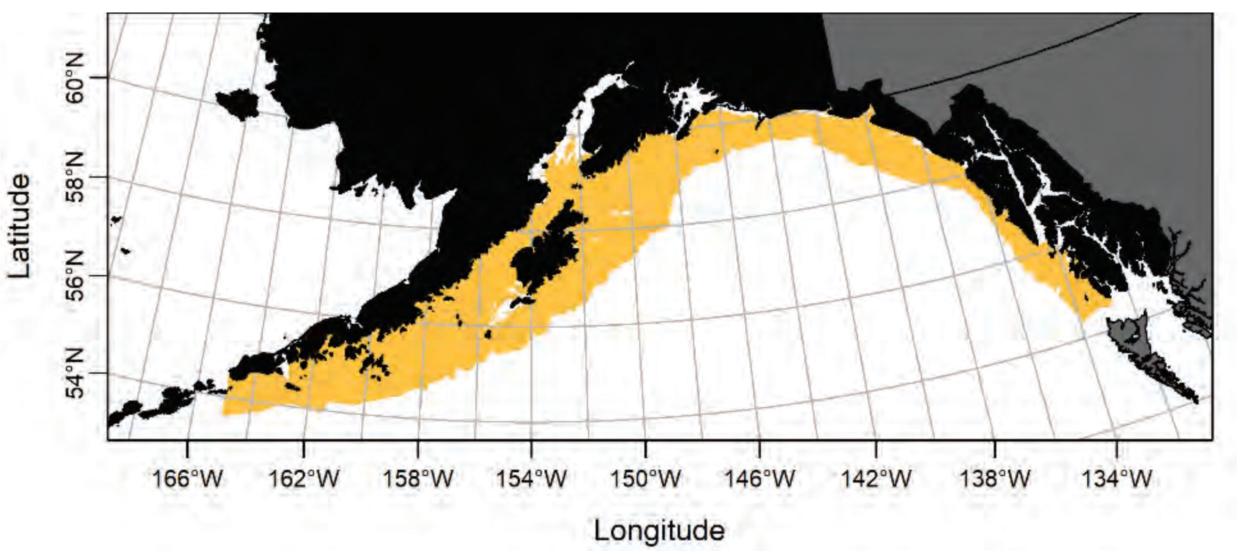

Figure E-113 EFH area of adult sablefish, fall

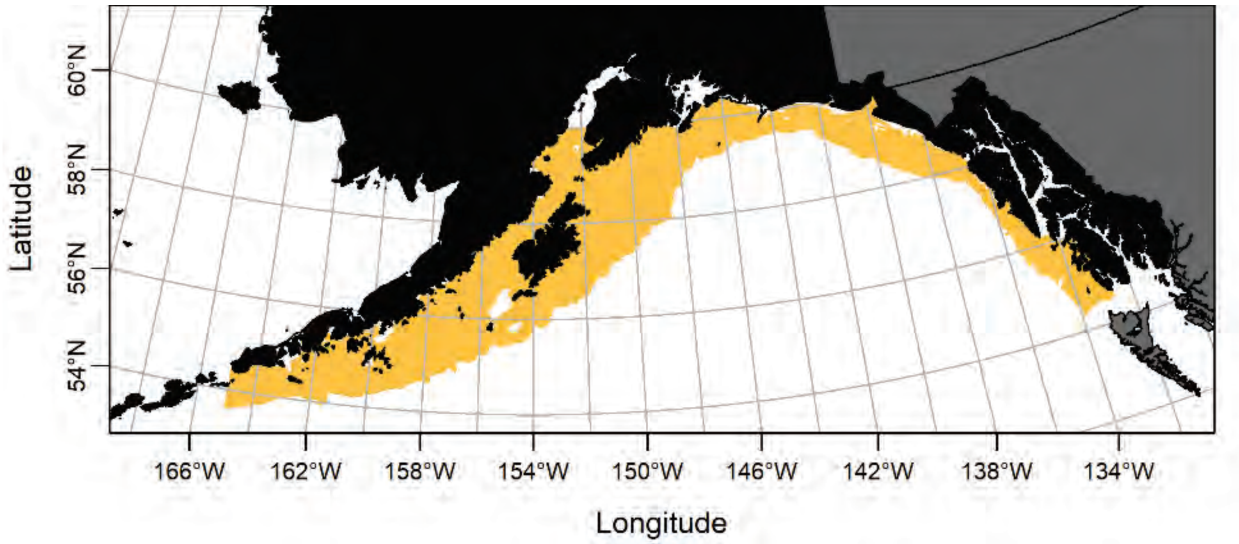

Figure E-114 **EFH area of adult sablefish, winter**

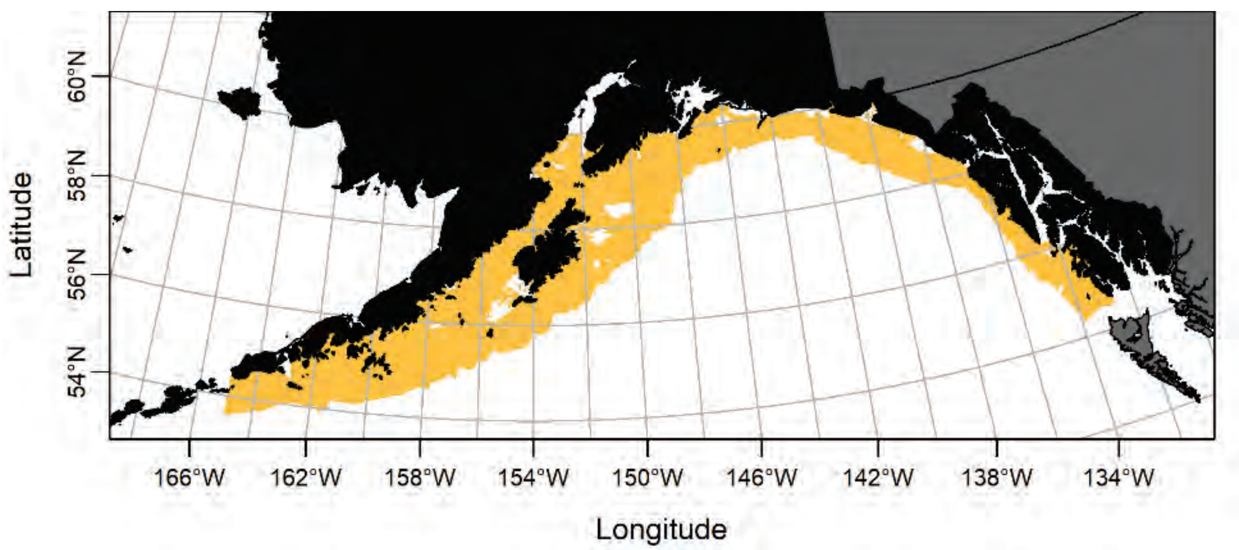

Figure E-115 **EFH area of adult sablefish, spring**

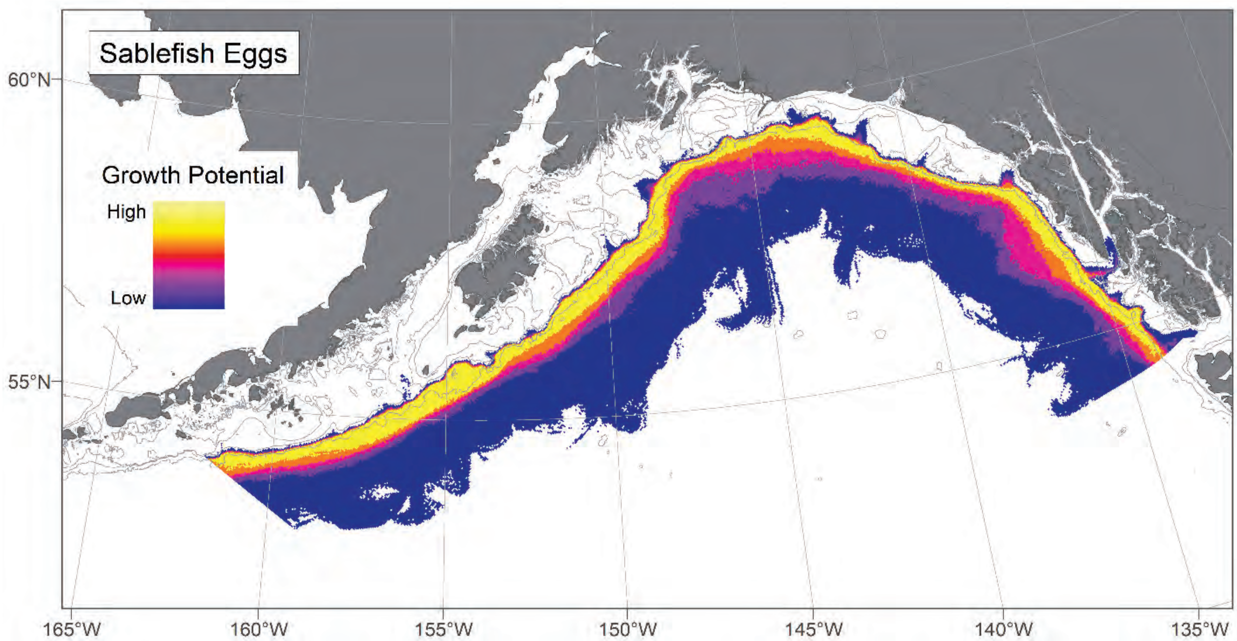

Figure E-116 EFH area of sablefish eggs, habitat-related growth potential, summer

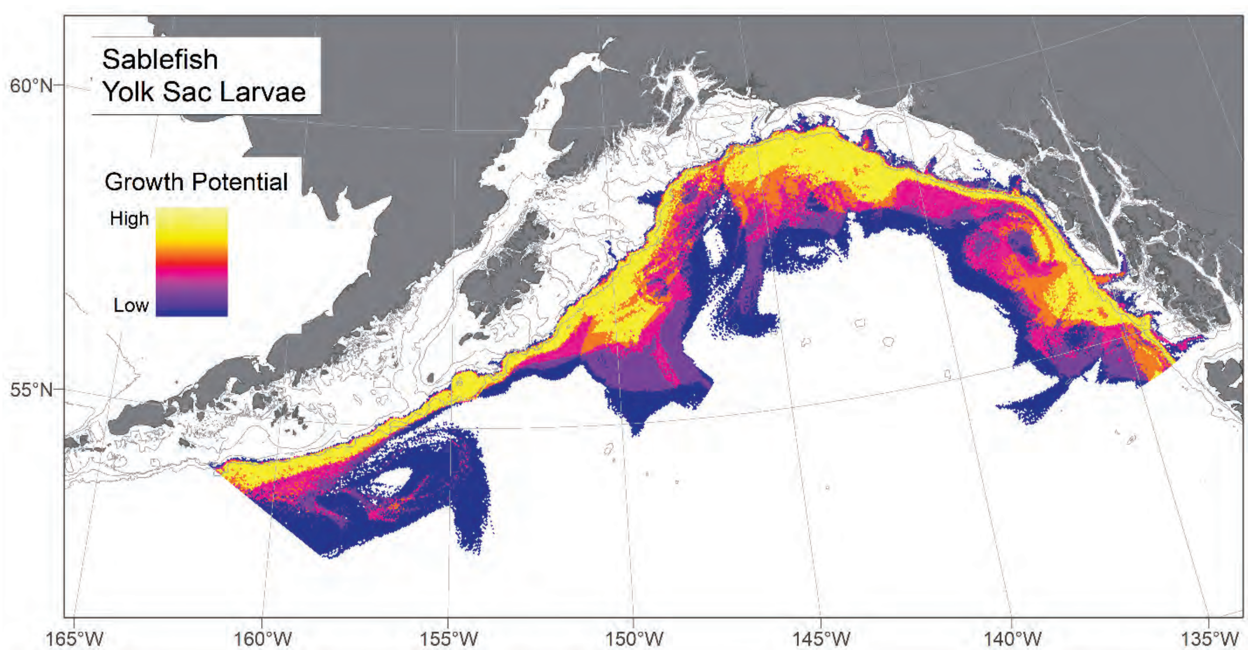

Figure E-117 EFH area of sablefish yolk sac larvae, habitat-related growth potential, summer

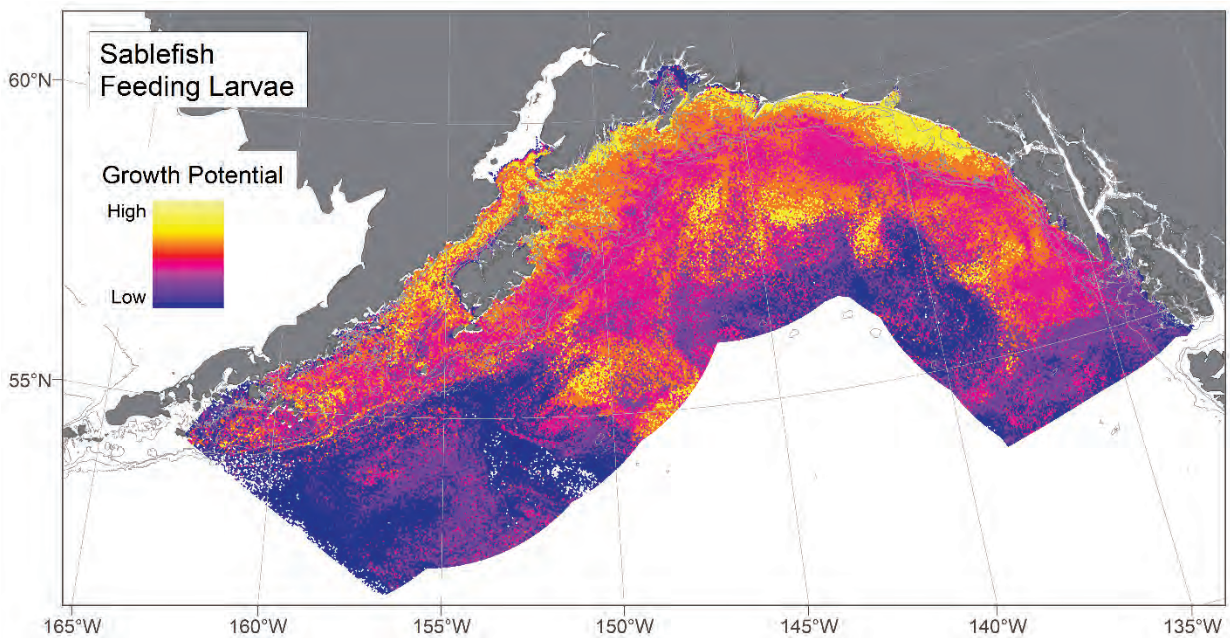

Figure E-118 EFH area of sablefish larvae feeding, habitat-related growth potential, summer

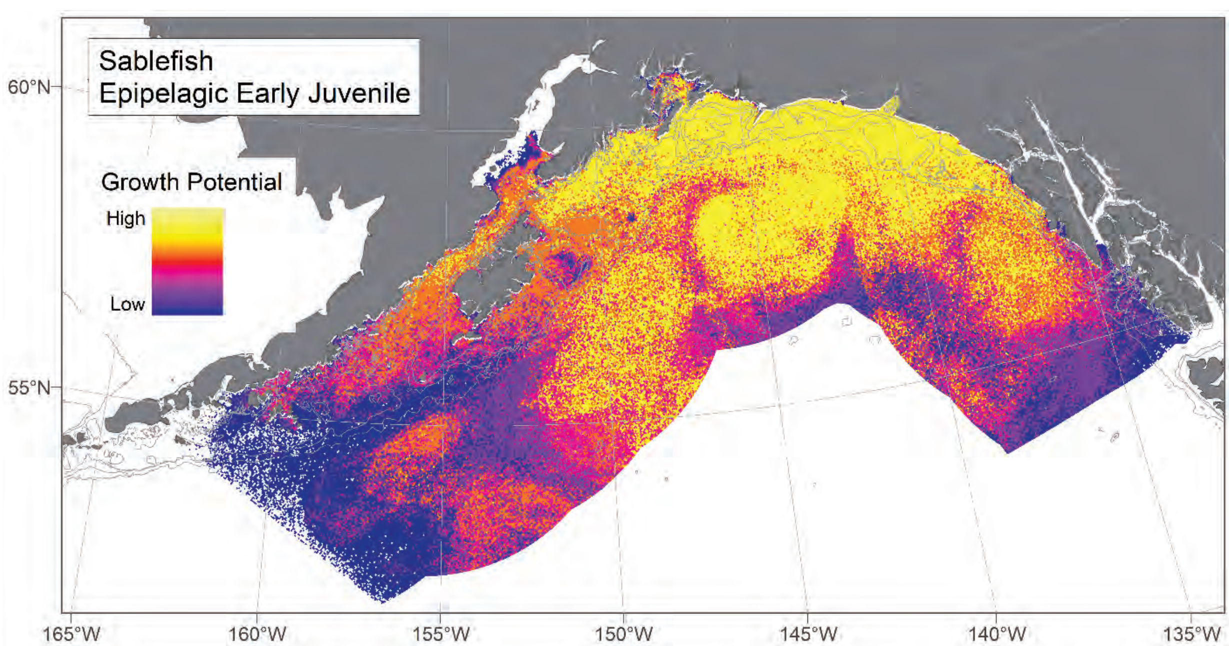

Figure E-119 EFH area of epipelagic early juvenile sablefish, habitat-related growth potential, summer

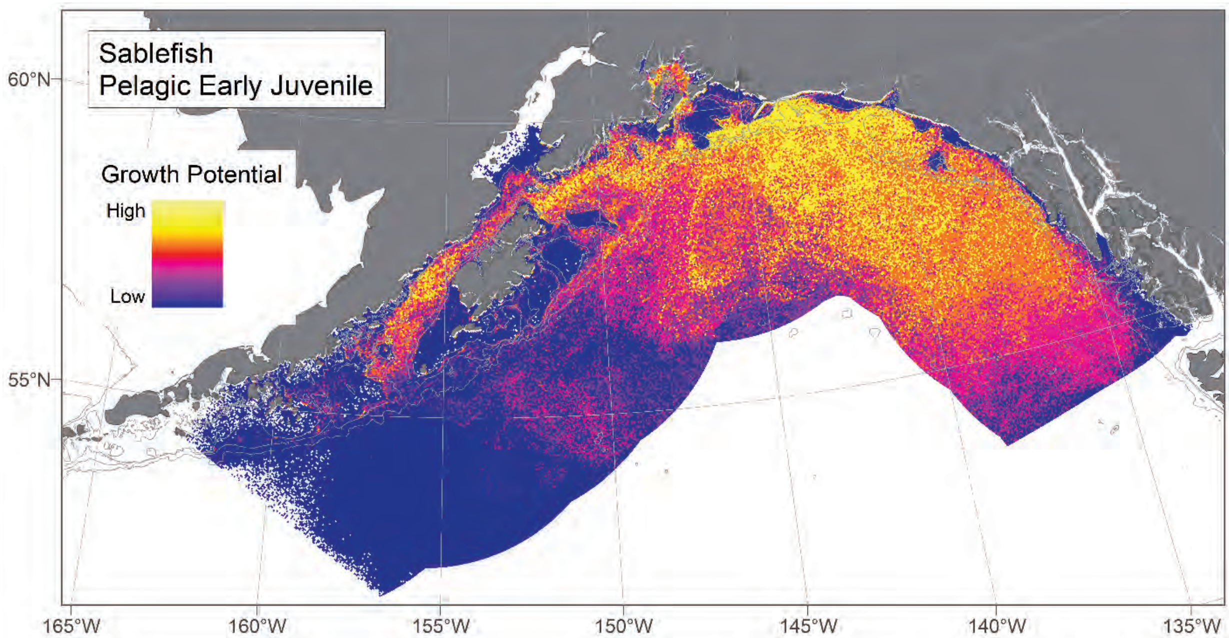

Figure E-120 EFH area of pelagic early juvenile sablefish, habitat-related growth potential, summer

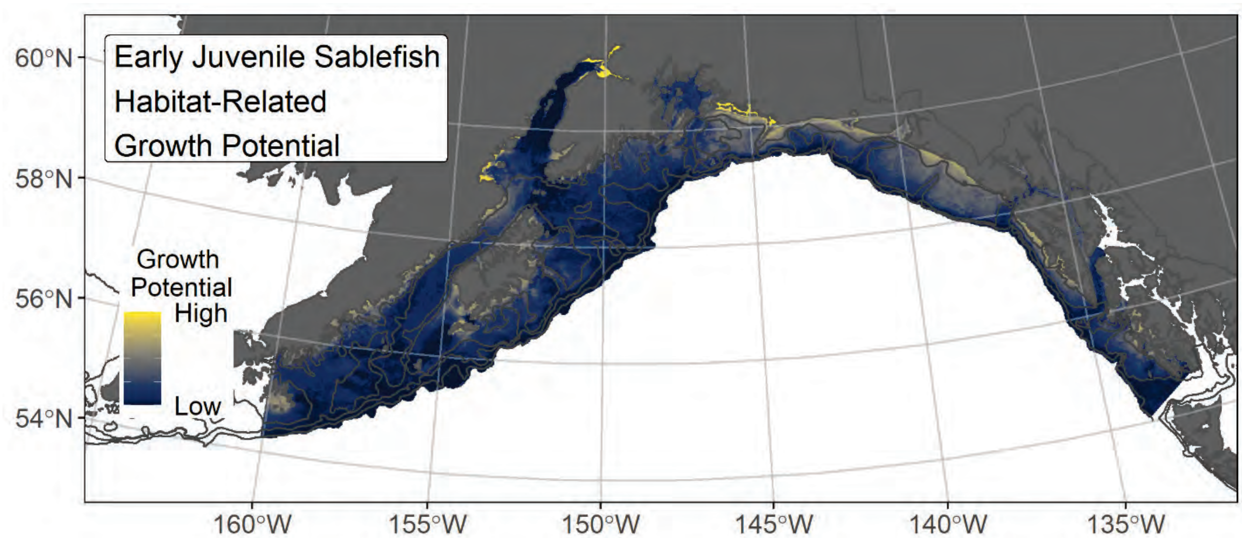

Figure E-121 EFH area of settled early juvenile sablefish, habitat-related growth potential, summer

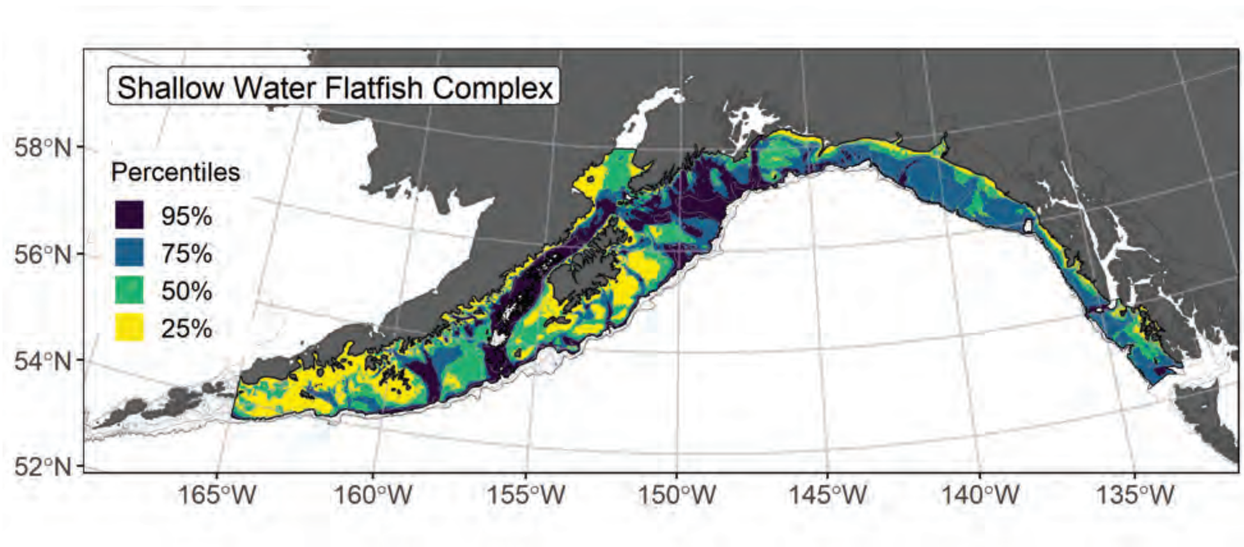

Figure E-122 EFH area of subadult/adult shallow water flatfish complex, summer

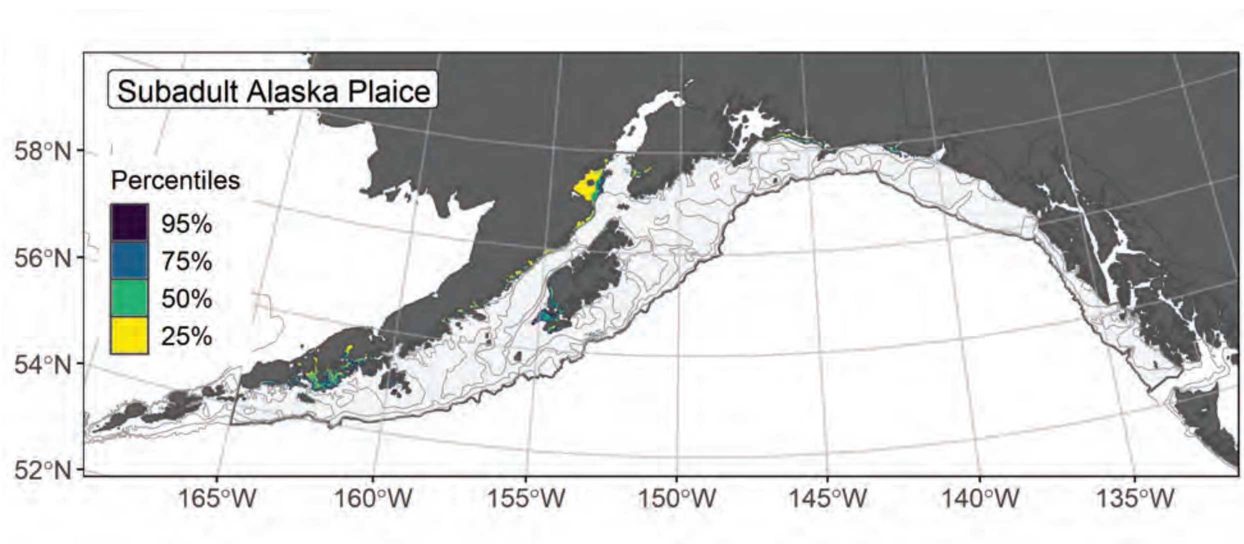

Figure E-123 EFH area of subadult Alaska plaice, summer

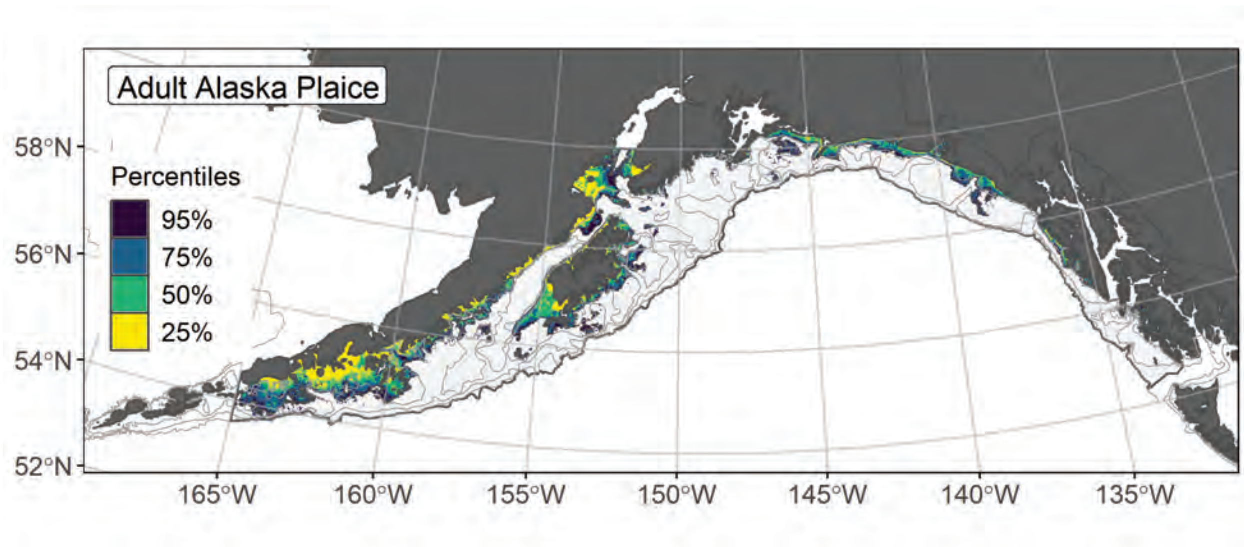

Figure E-124 EFH area of adult Alaska plaice, summer

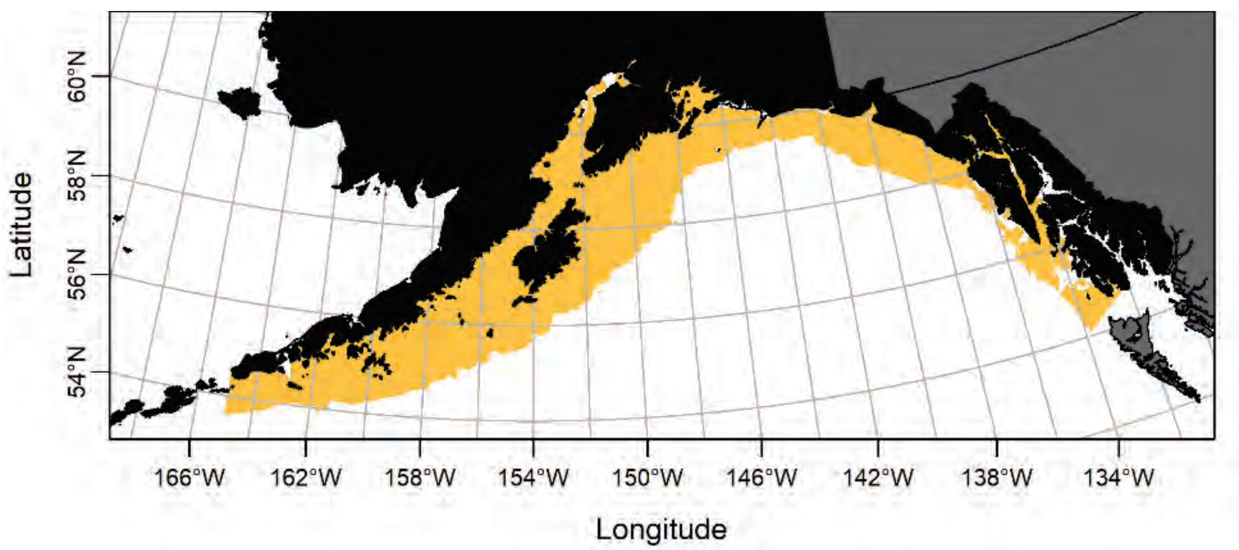

Figure E-125 EFH area of Alaska plaice eggs, summer

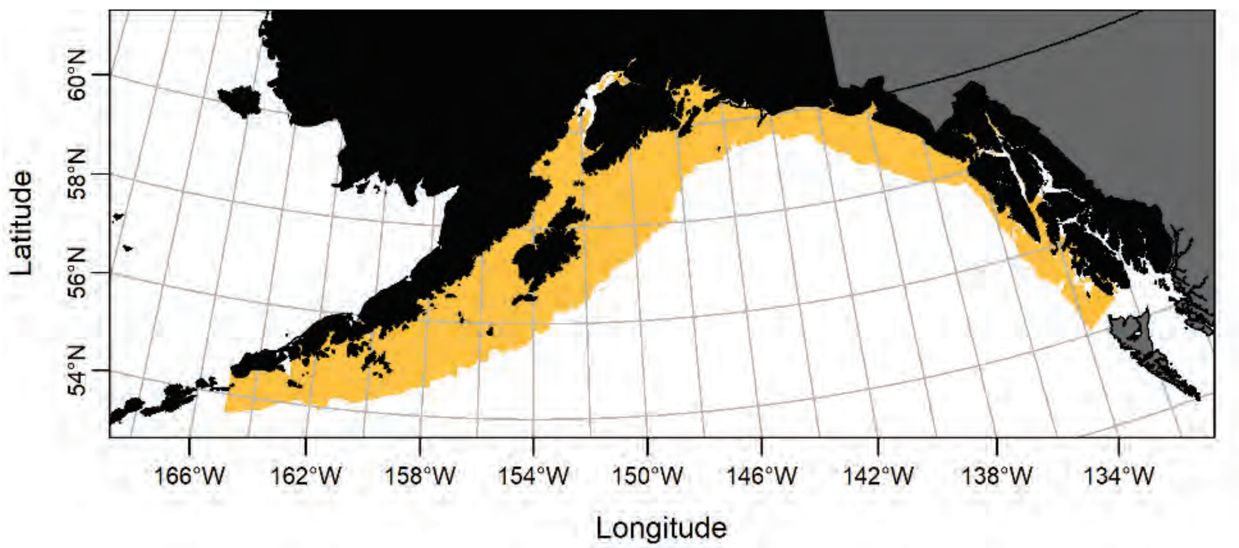

Figure E-126 EFH area of Alaska plaice larvae, summer

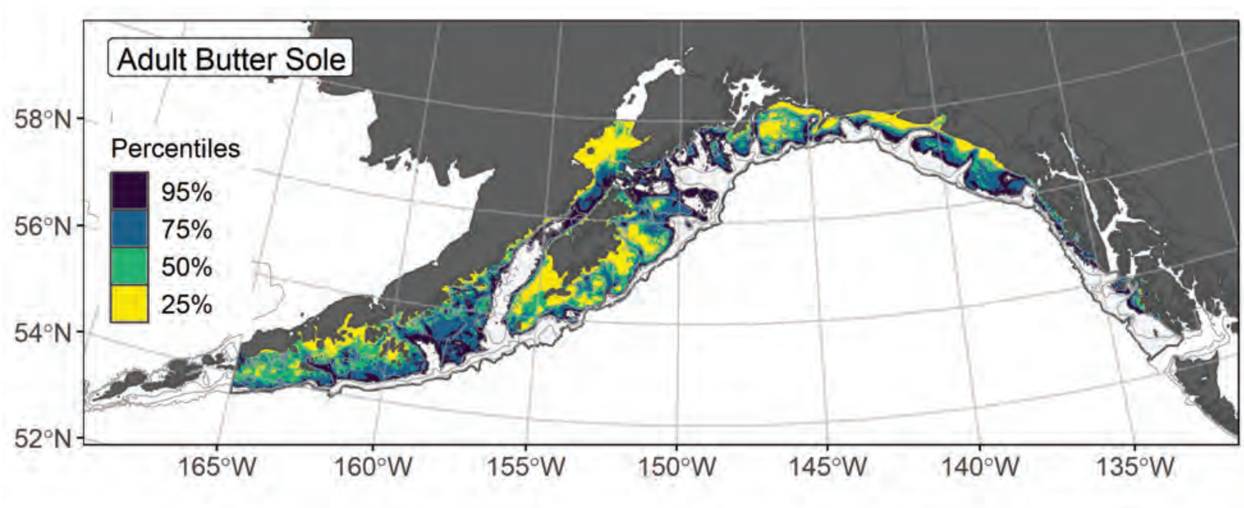

Figure E-127 EFH area of subadult/adult butter sole, summer

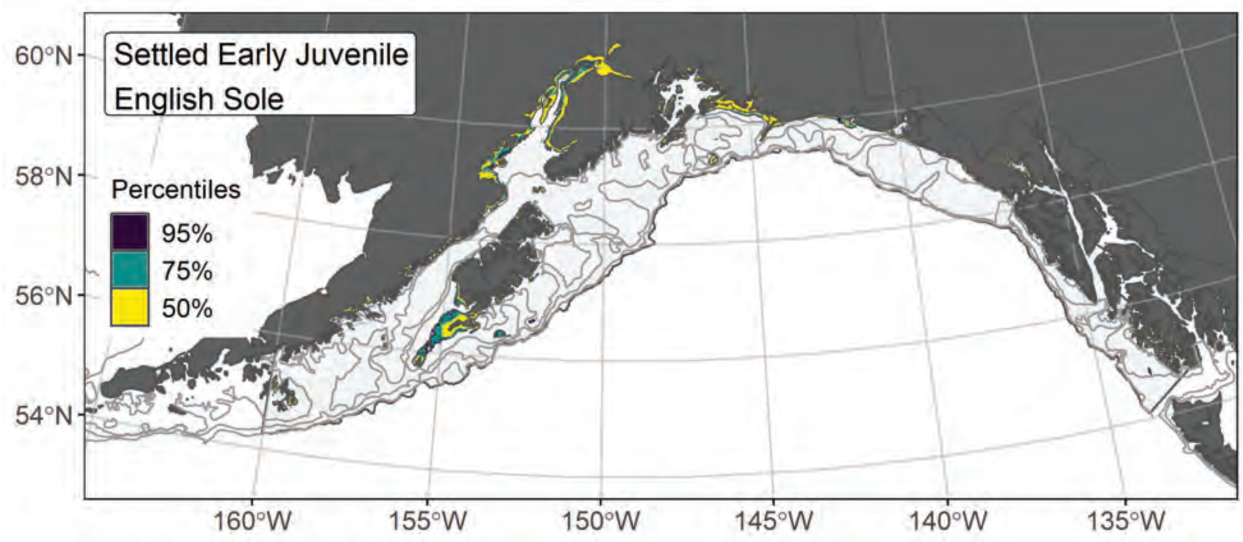

Figure E-128 EFH area of settled early juvenile English sole, summer

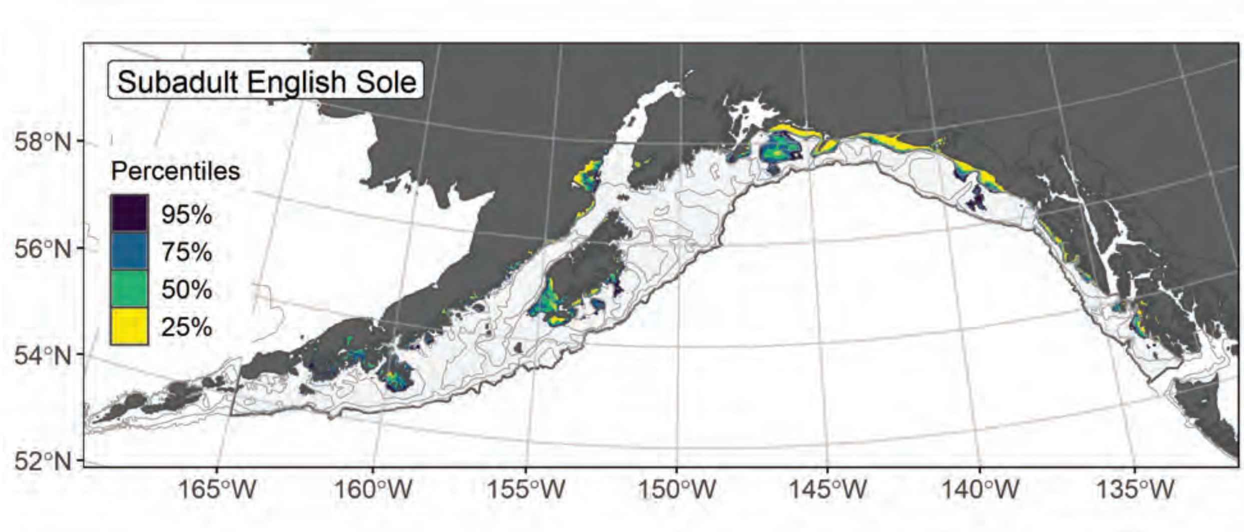

Figure E-129 EFH area of subadult English sole, summer

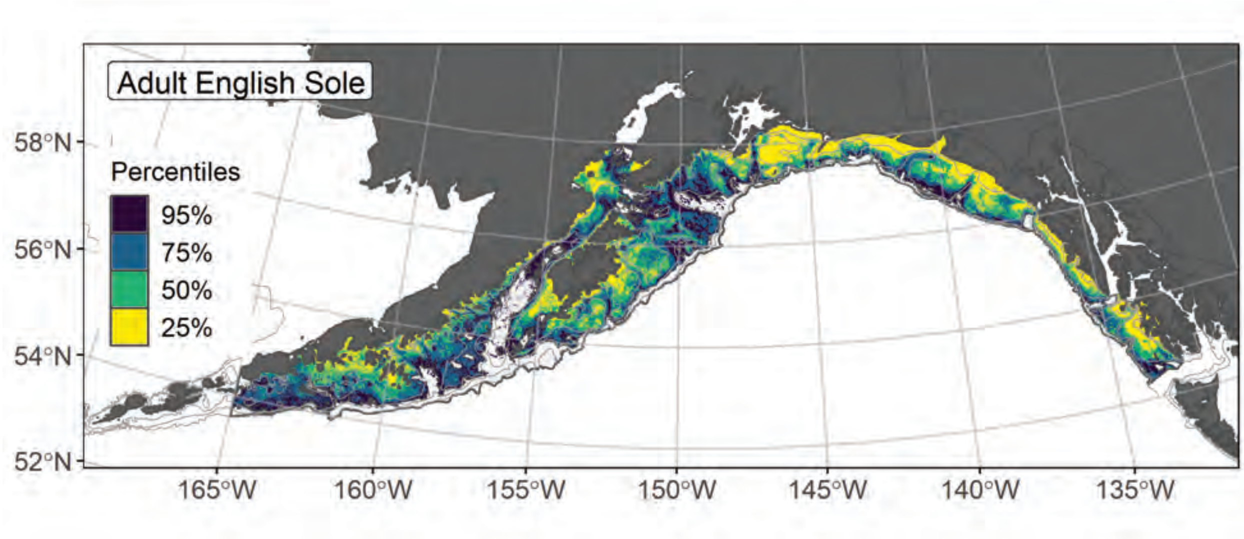

Figure E-130 EFH area of adult English sole, summer

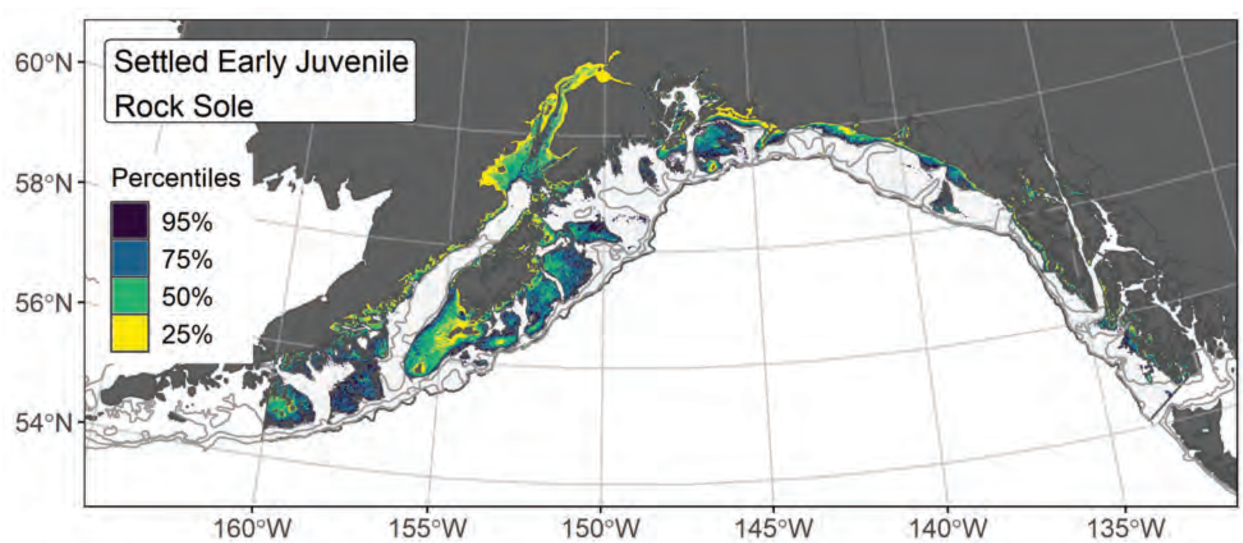

Figure E-131 EFH area of settled early juvenile rock sole, summer

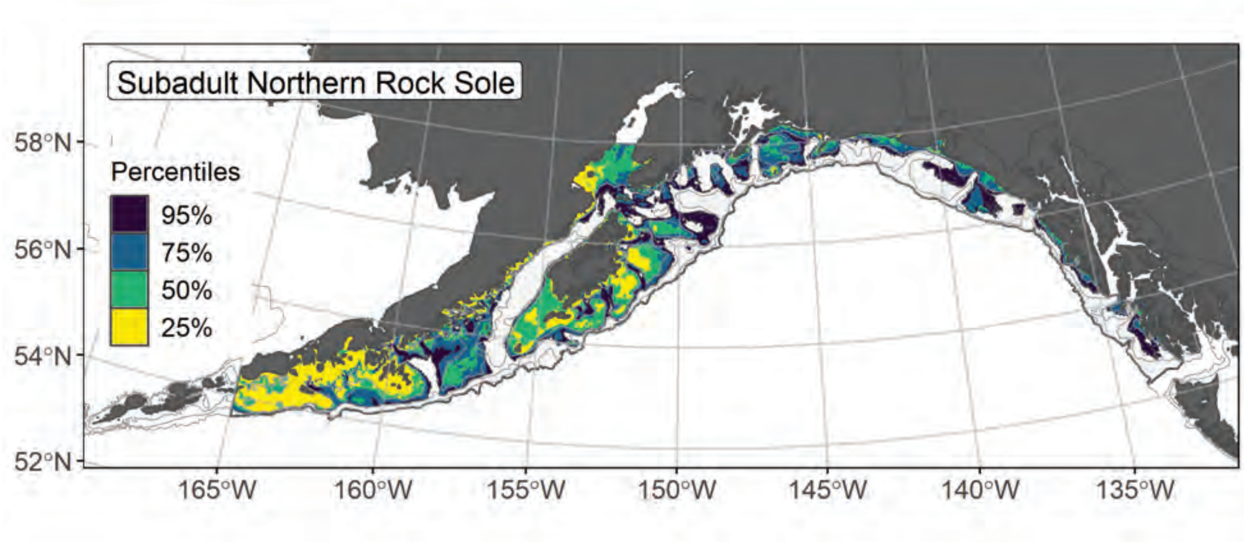

Figure E-132 EFH area of subadult northern rock sole, summer

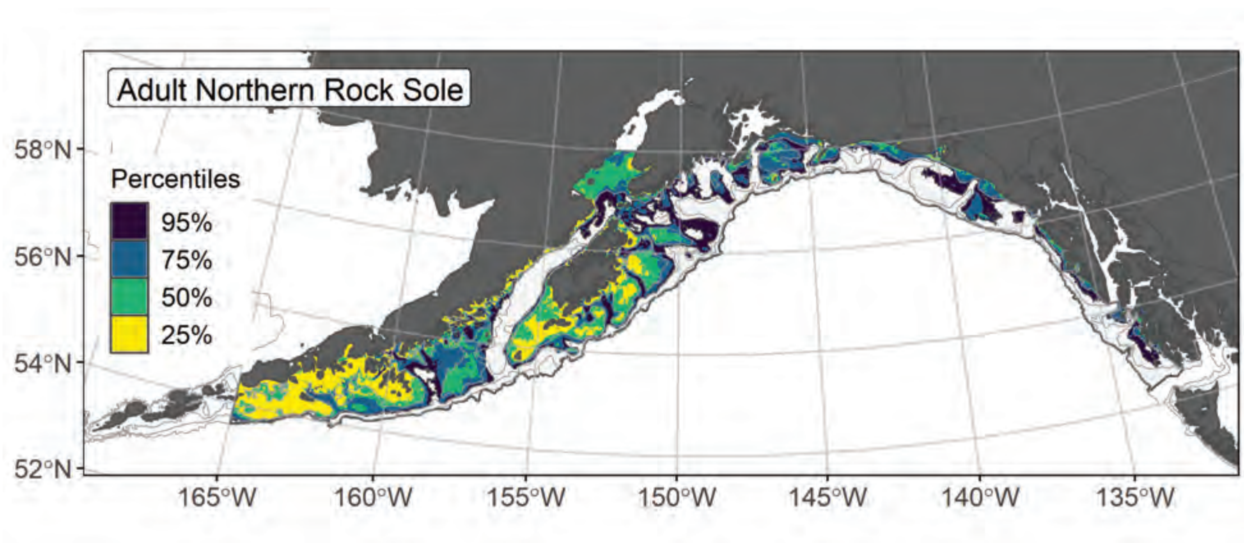

Figure E-133 EFH area of adult northern rock sole, summer

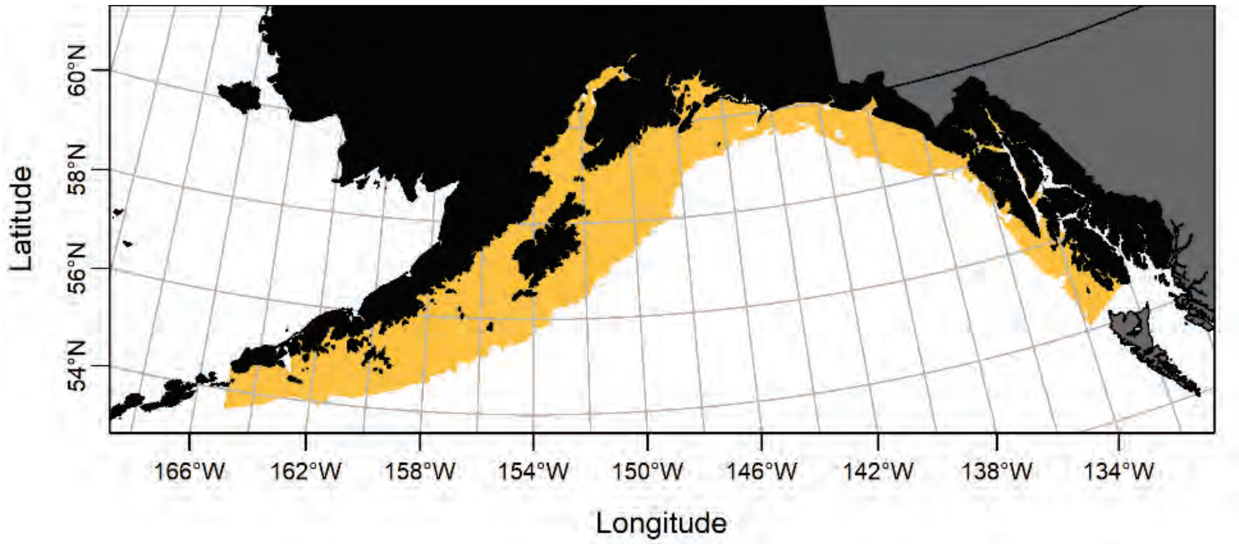

Figure E-134 **EFH area of northern rock sole larvae, summer**

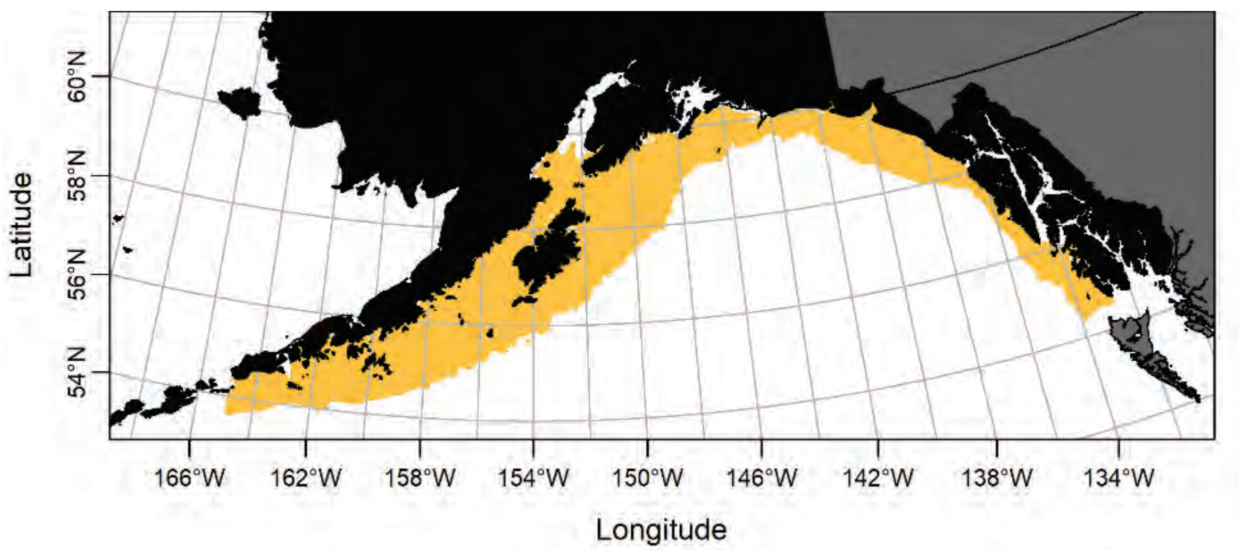

Figure E-135 **EFH area of adult northern rock sole, fall**

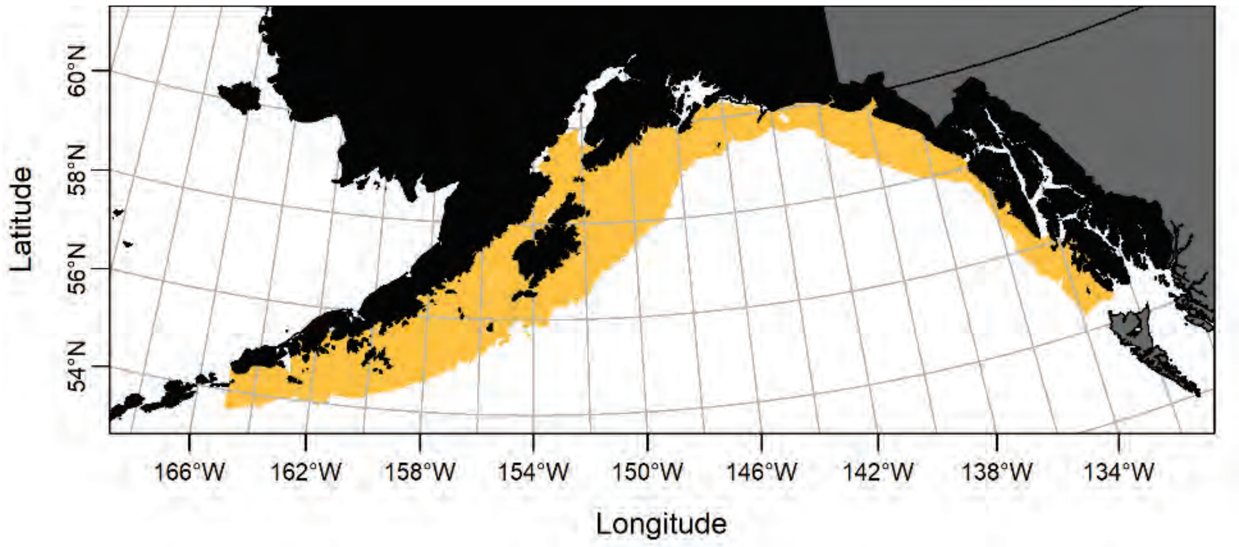

Figure E-136 EFH area of adult northern rock sole, winter

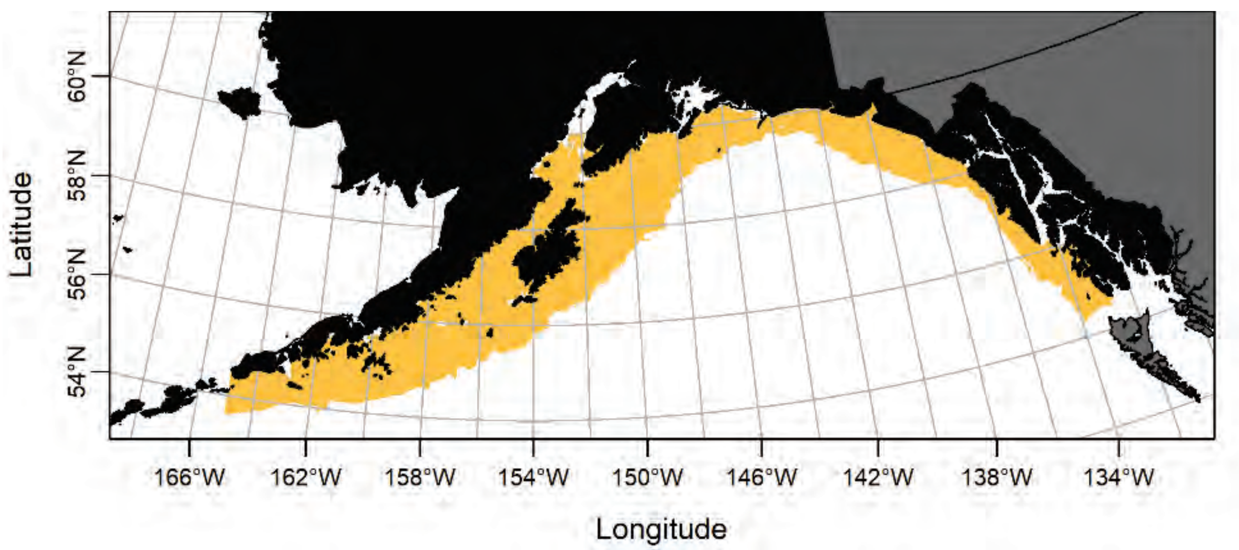

Figure E-137 EFH area of adult northern rock sole, spring

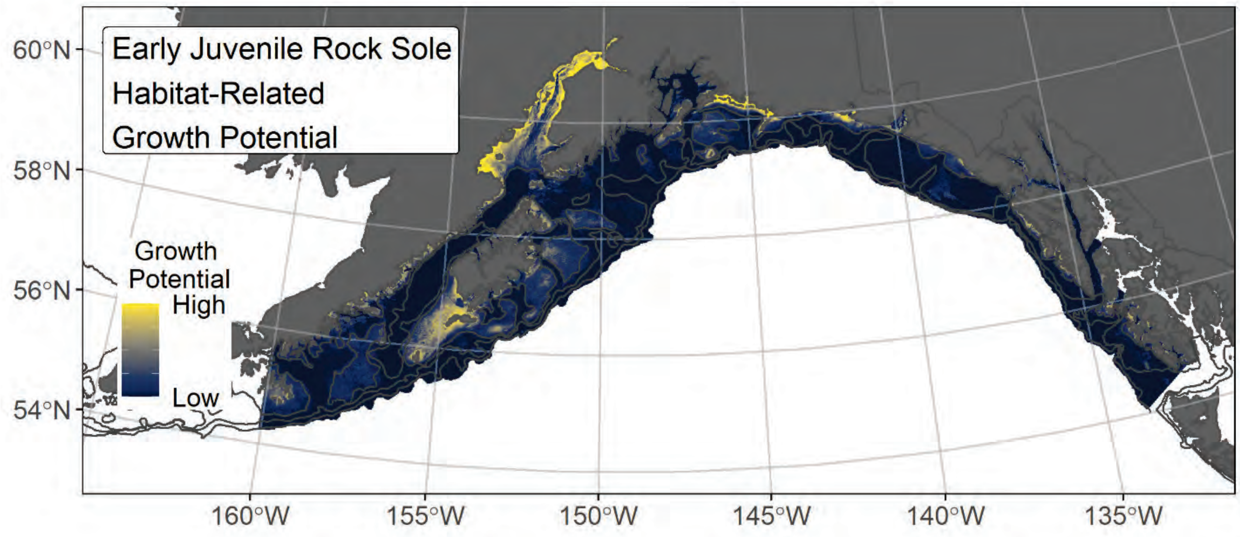

Figure E-138 EFH area of settled early juvenile rock sole, habitat-related growth portential summer

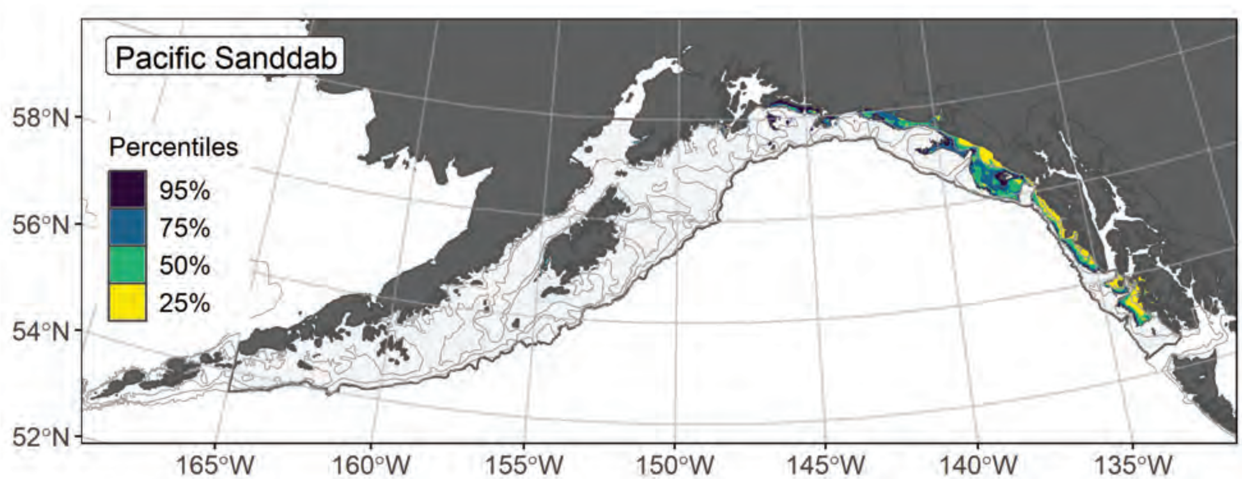

Figure E-139 EFH area of subadult/adult Pacific sanddab, summer

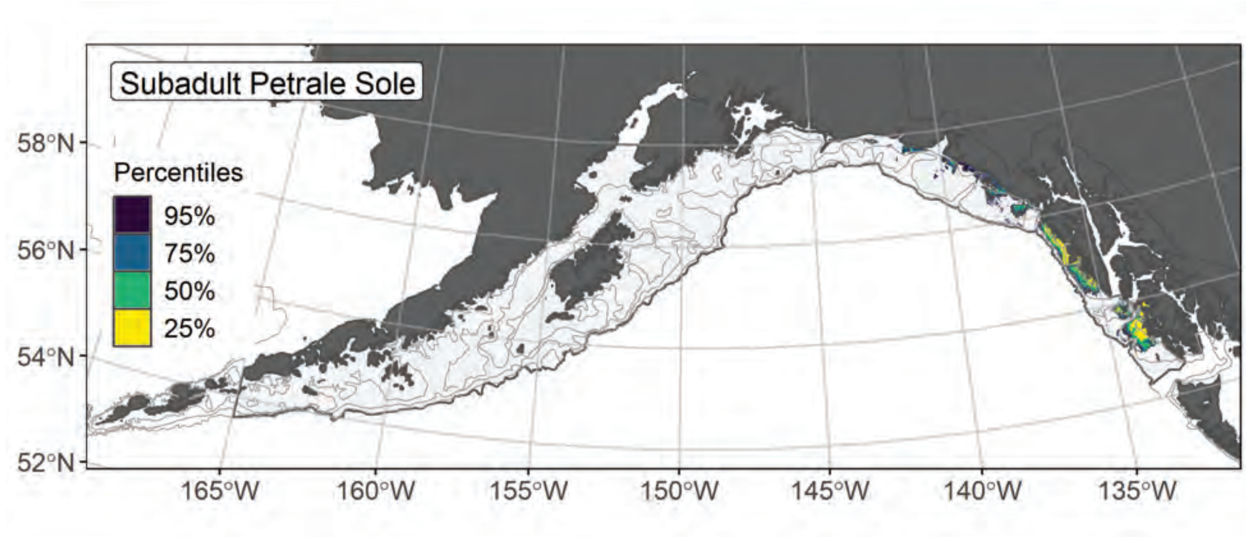

Figure E-140 EFH area of subadult Petrale sole, summer

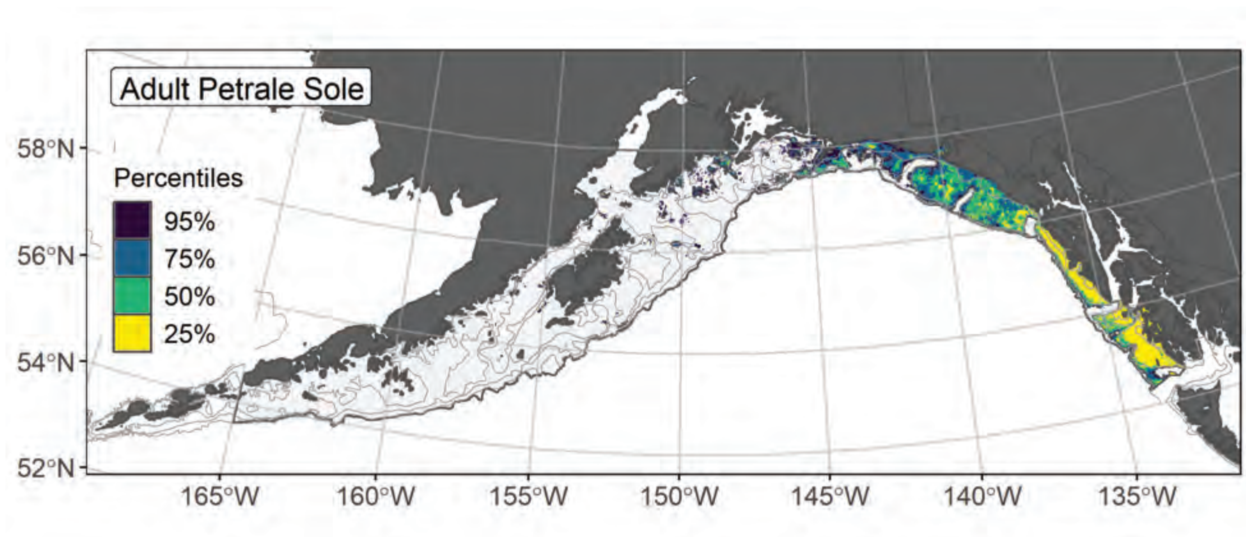

Figure E-141 EFH area of adult Petrale sole, summer

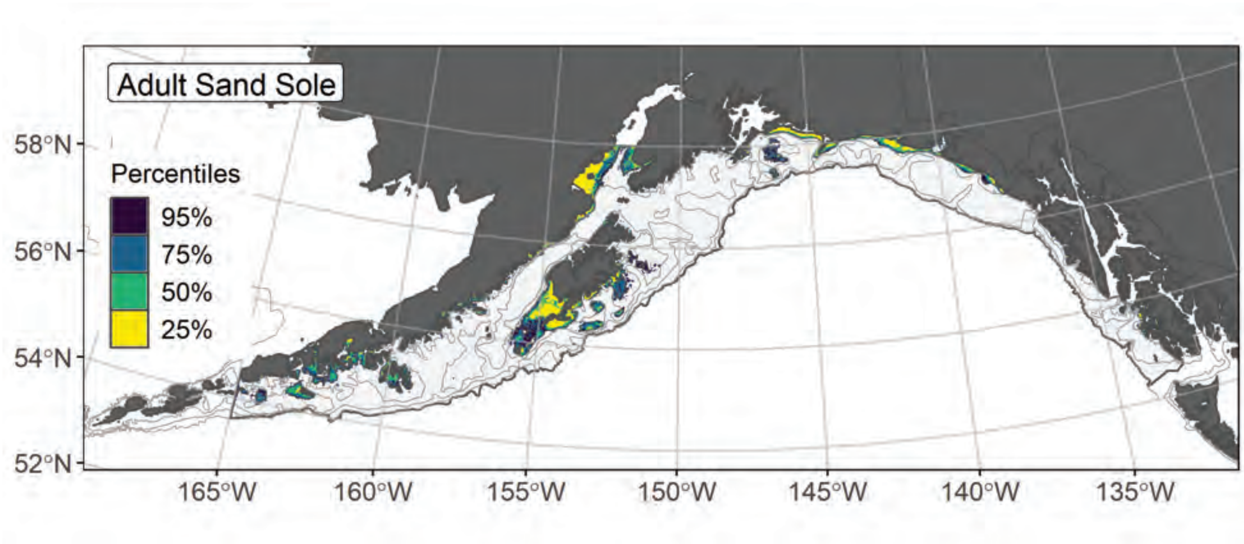

Figure E-142 EFH area of adult sand sole, summer

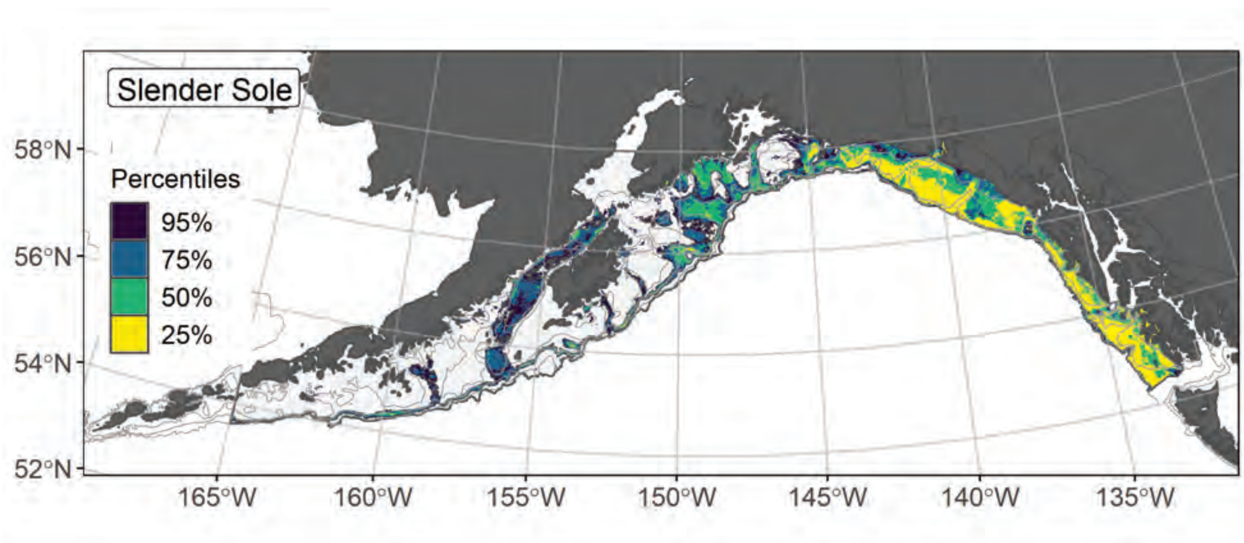

Figure E-143 EFH area of subadult/adult slender sole, summer

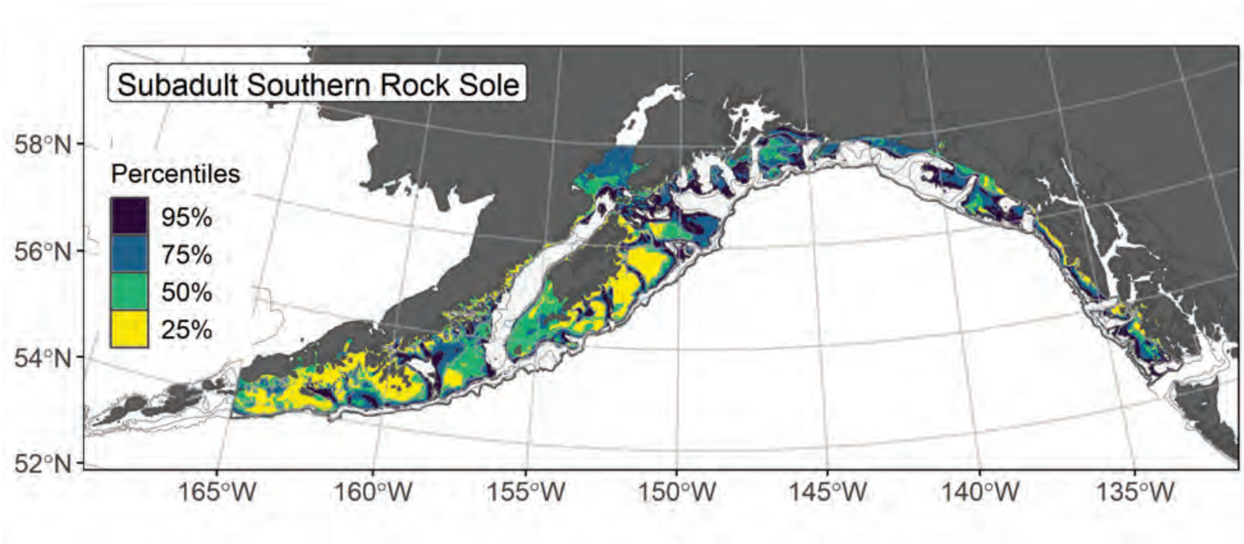

Figure E-144 EFH area of subadult southern rock sole, summer

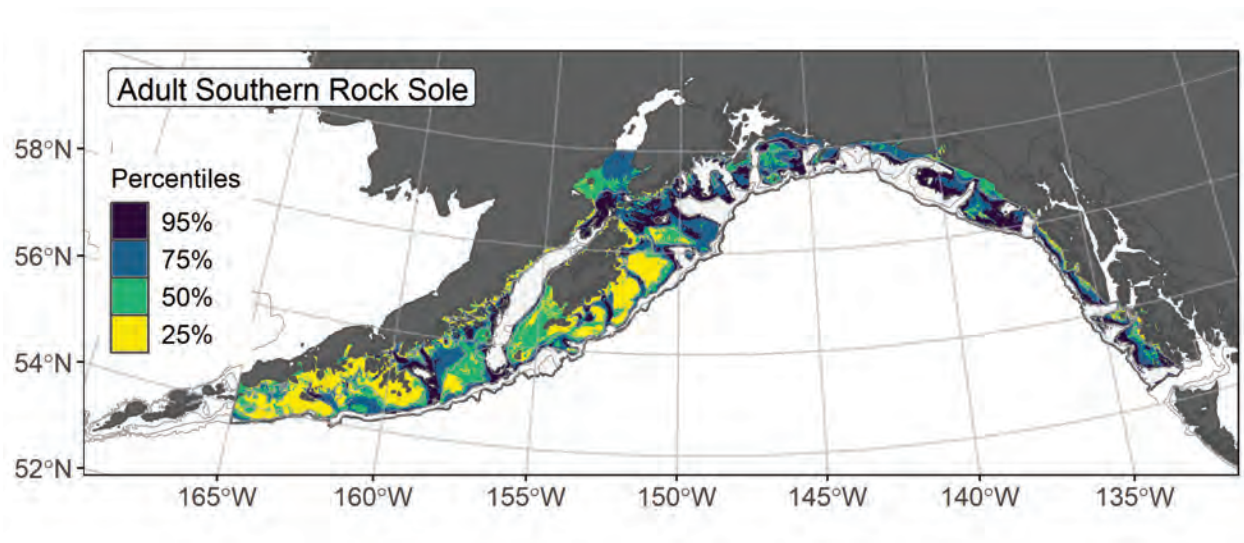

Figure E-145 EFH area of adult southern rock sole, summer

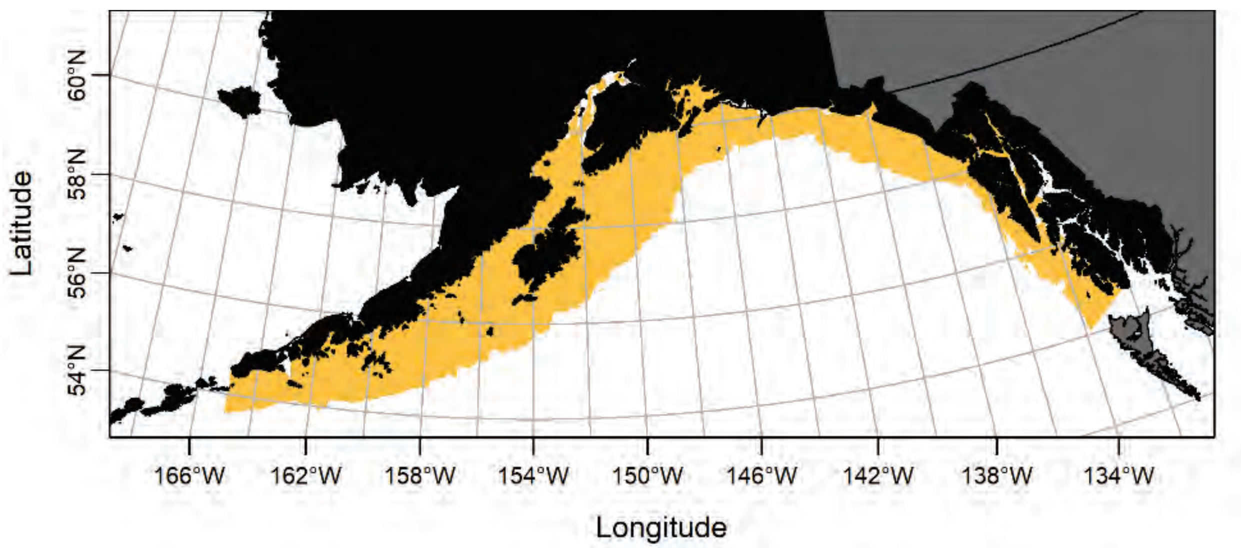

Figure E-146 EFH area of southern rock sole larvae, summer

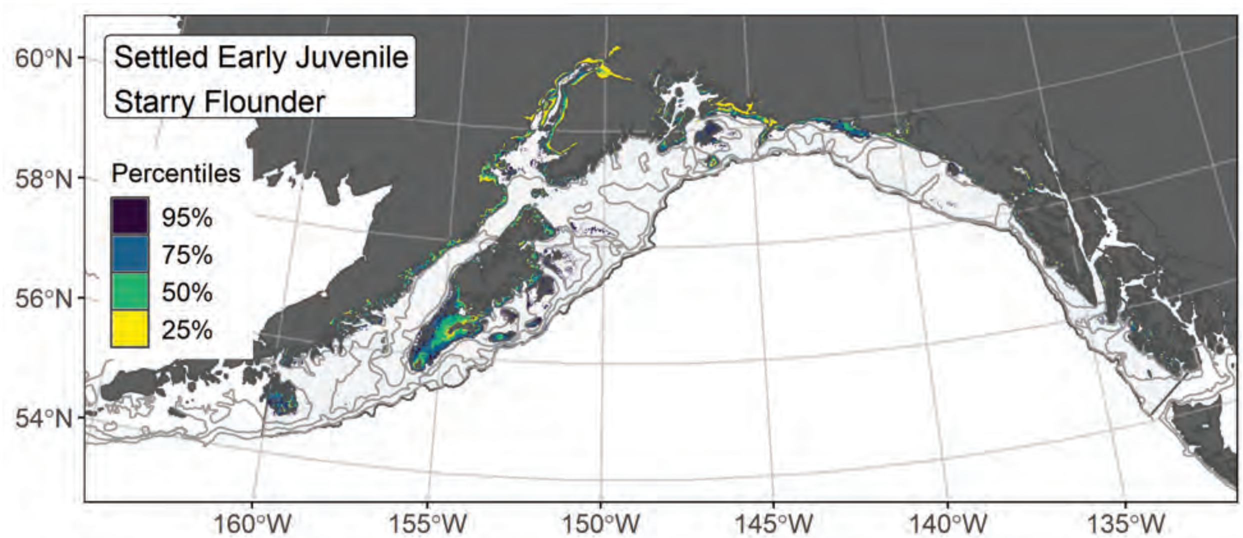

Figure E-147 EFH area of settled early juvenile starry flounder, summer

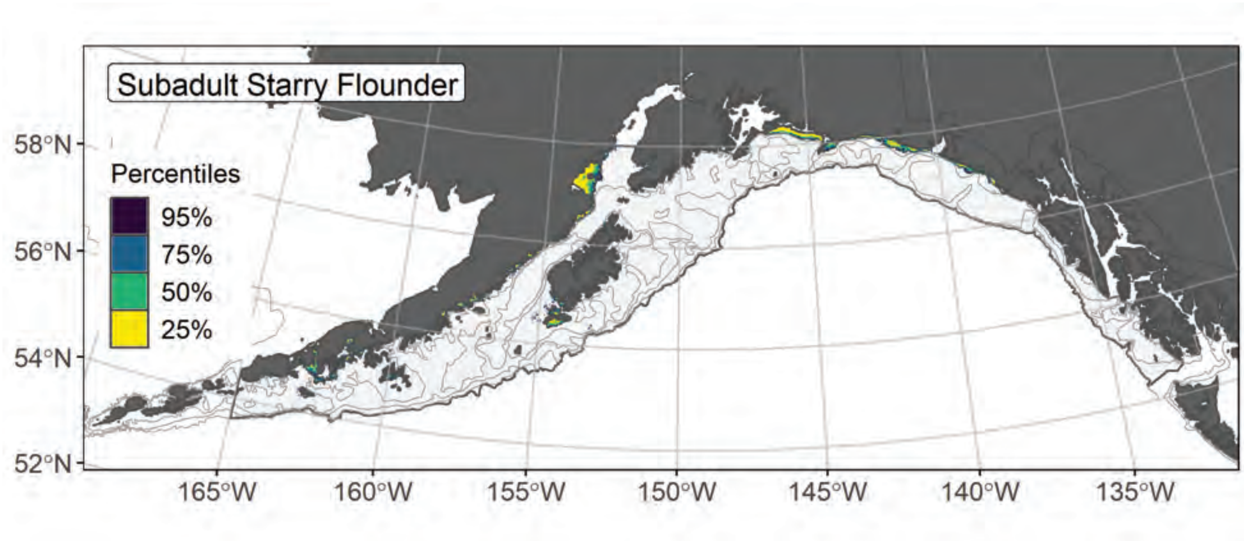

Figure E-148 EFH area of subadult starry flounder, summer

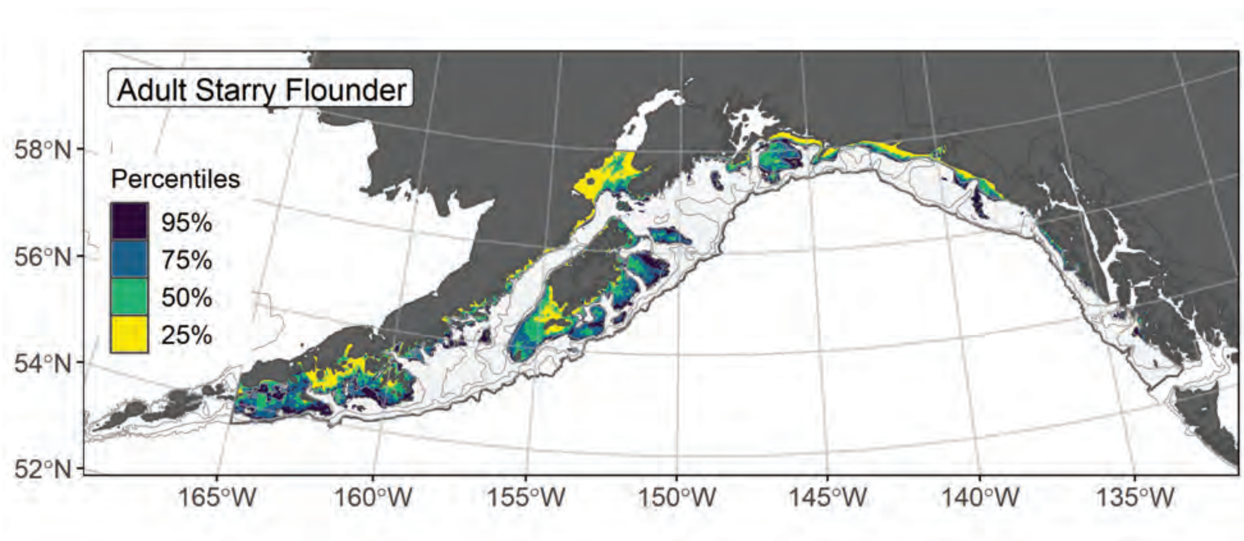

Figure E-149 EFH area of adult starry flounder, summer

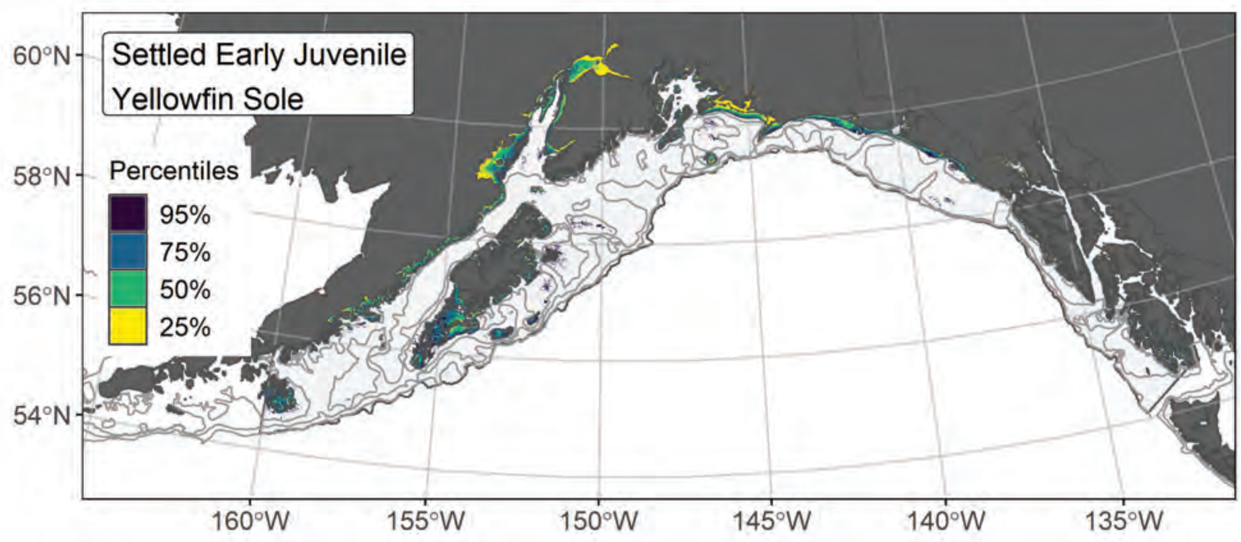

Figure E-150 EFH area of settled early juvenile yellowfin sole, summer

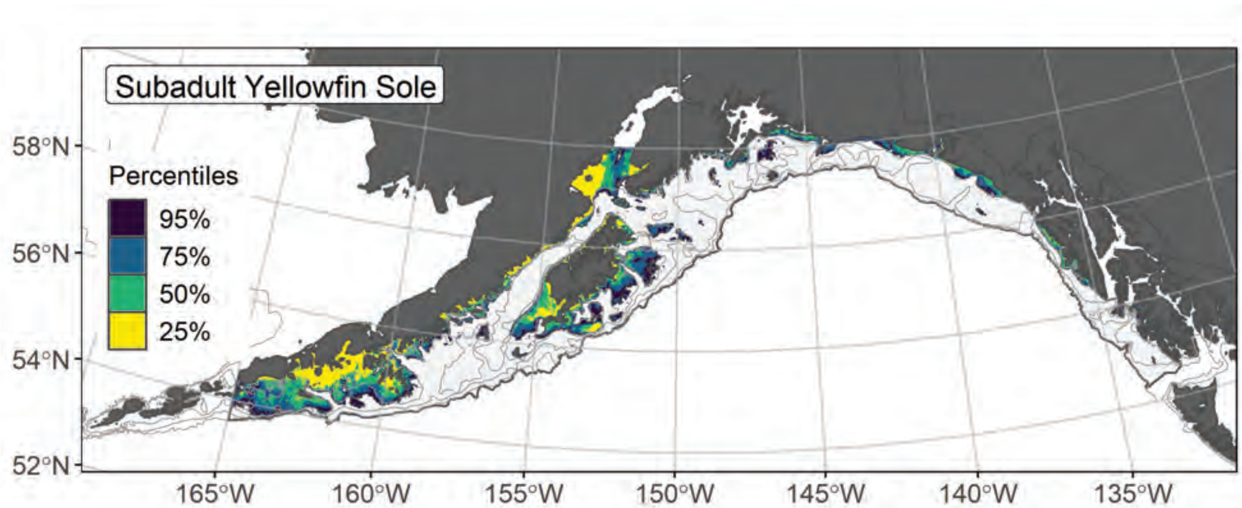

Figure E-151 EFH area of subadult yellowfin sole, summer

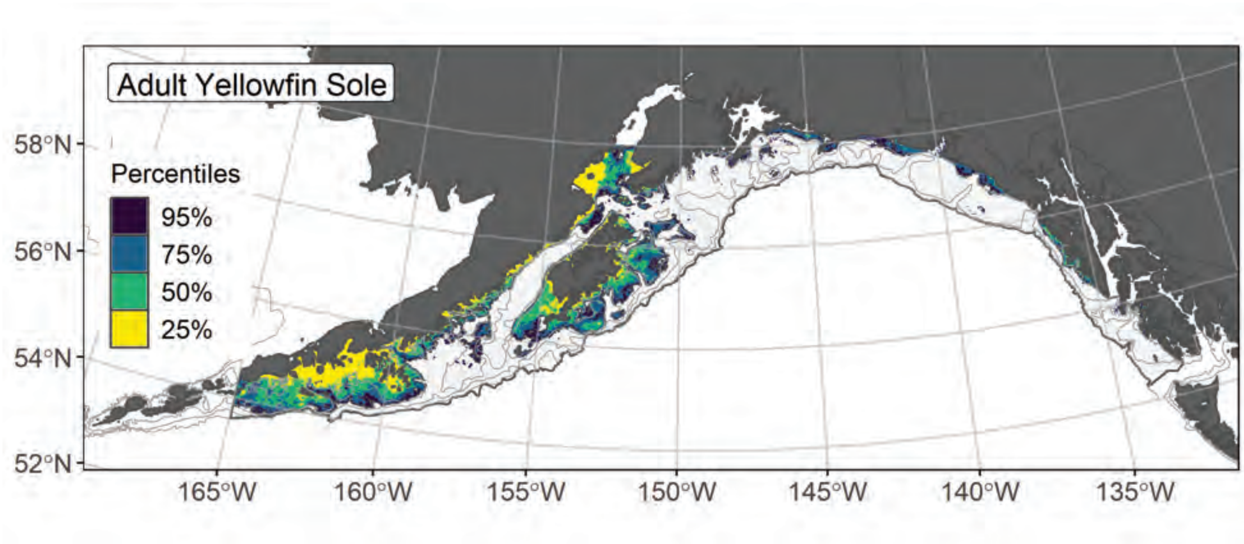

Figure E-152 EFH area of adult yellowfin sole, summer

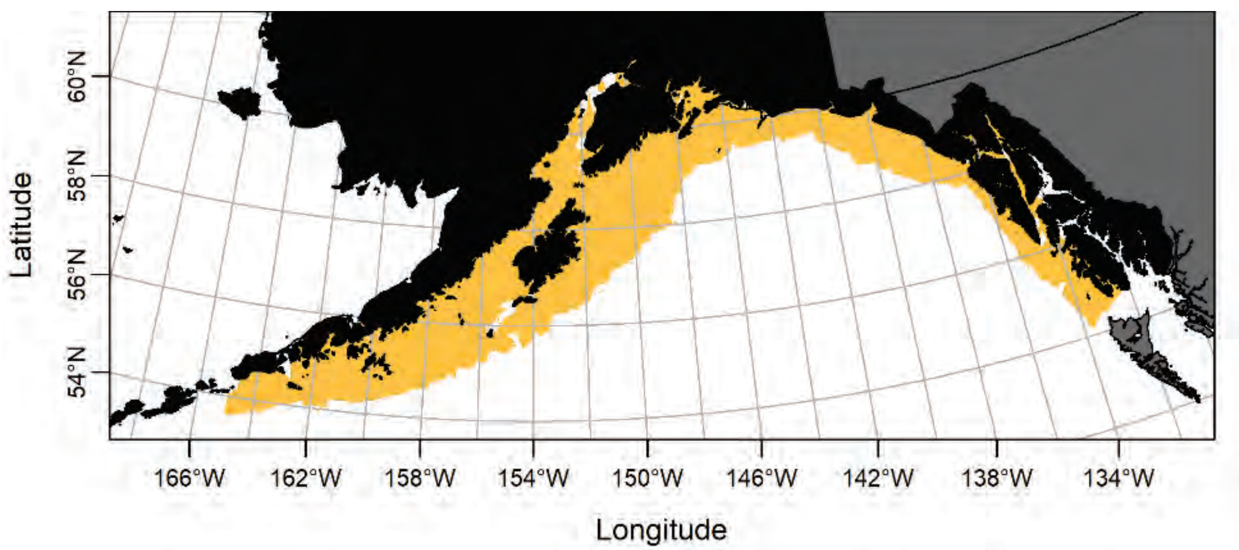

Figure E-153 EFH area of yellowfin sole eggs, summer

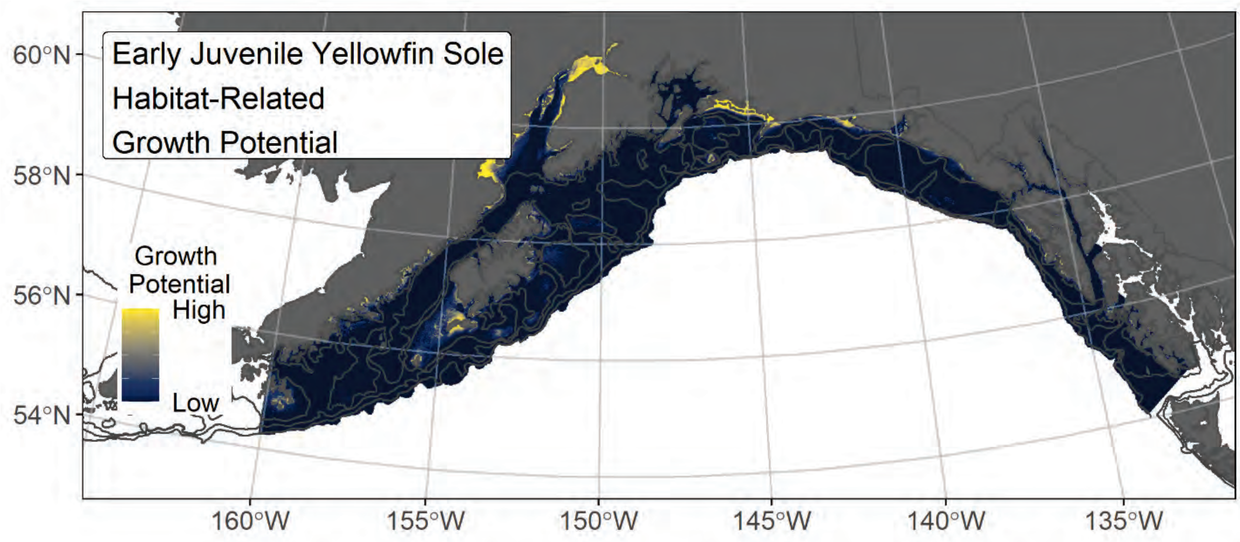

Figure E-154 **EFH area of settled early juvenile yellowfin sole, habitat-related growth potential, summer**

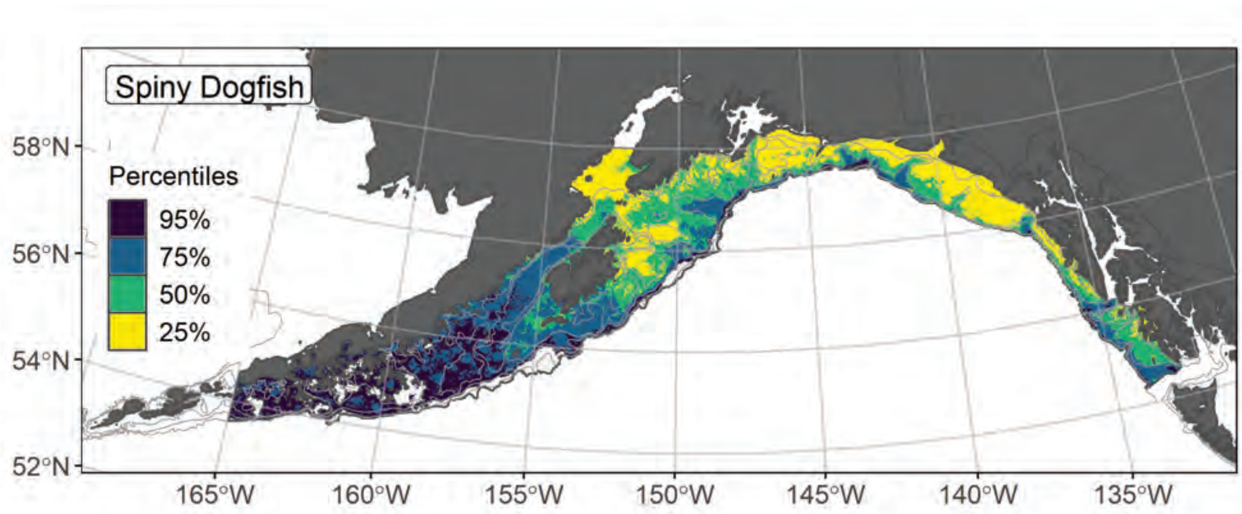

Figure E-155 **EFH area of subadult/adult spiny dogfish, summer**

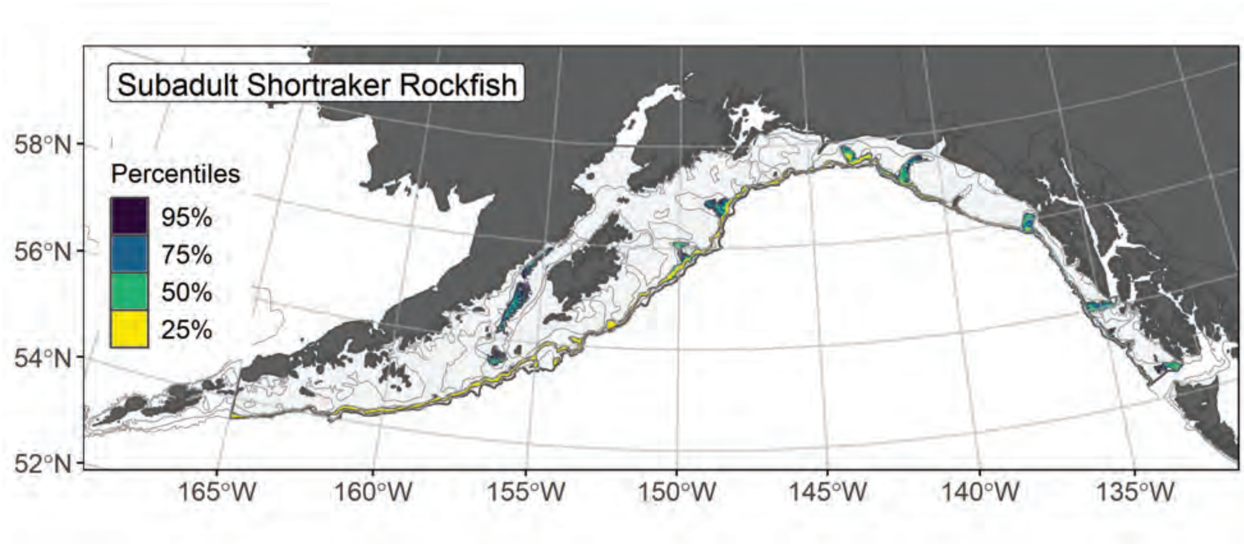

Figure E-156 EFH area of subadult shortraker rockfish, summer

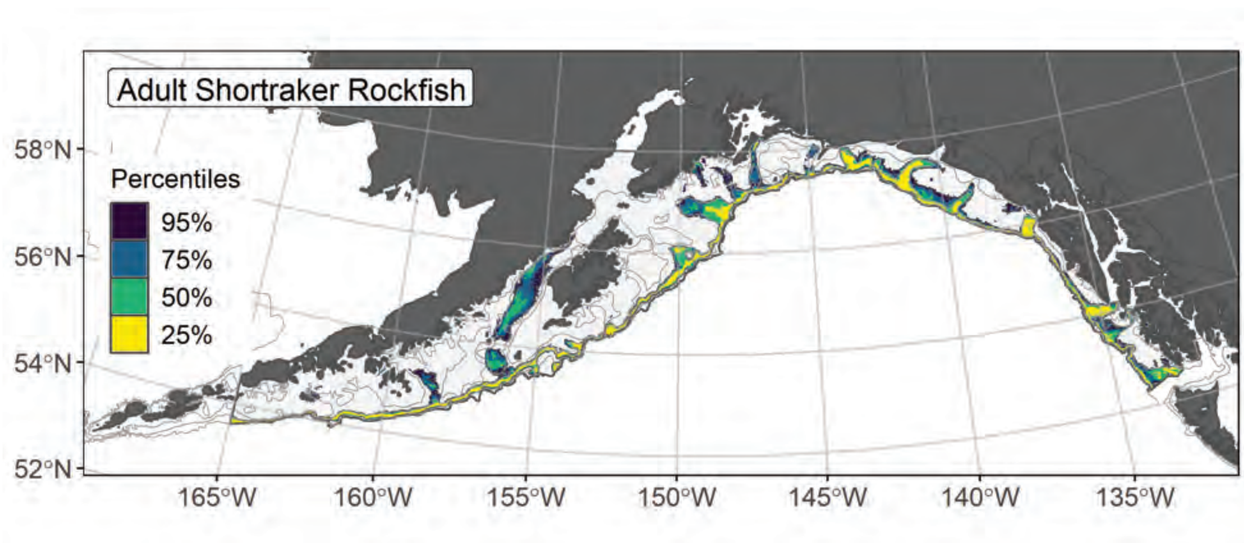

Figure E-157 EFH area of adult shortraker rockfish, summer

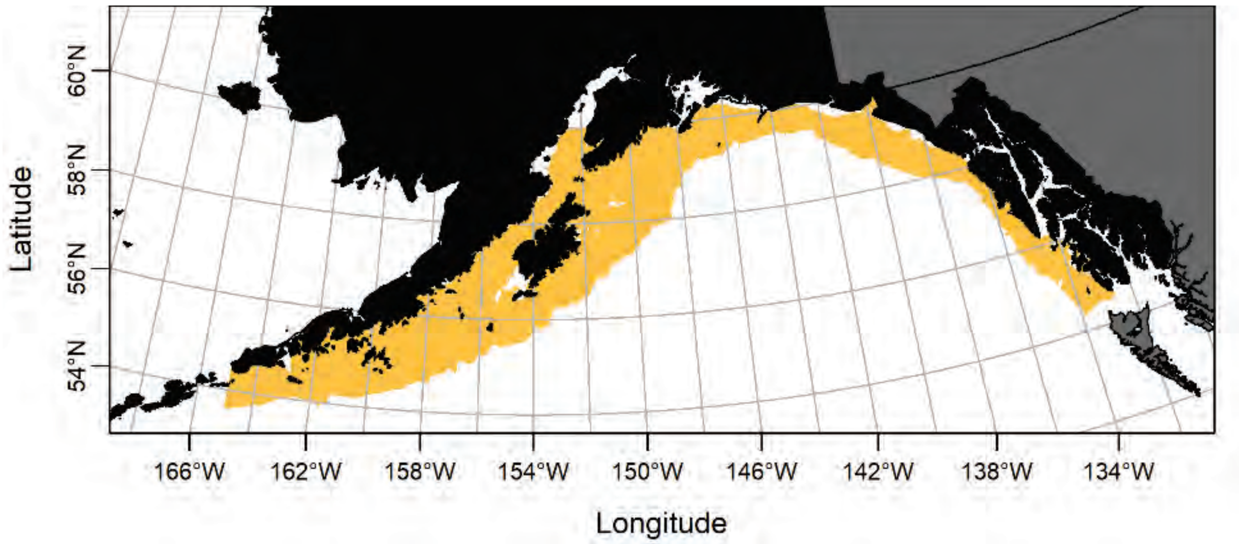

Figure E-158 EFH area of adult shortraker rockfish, fall

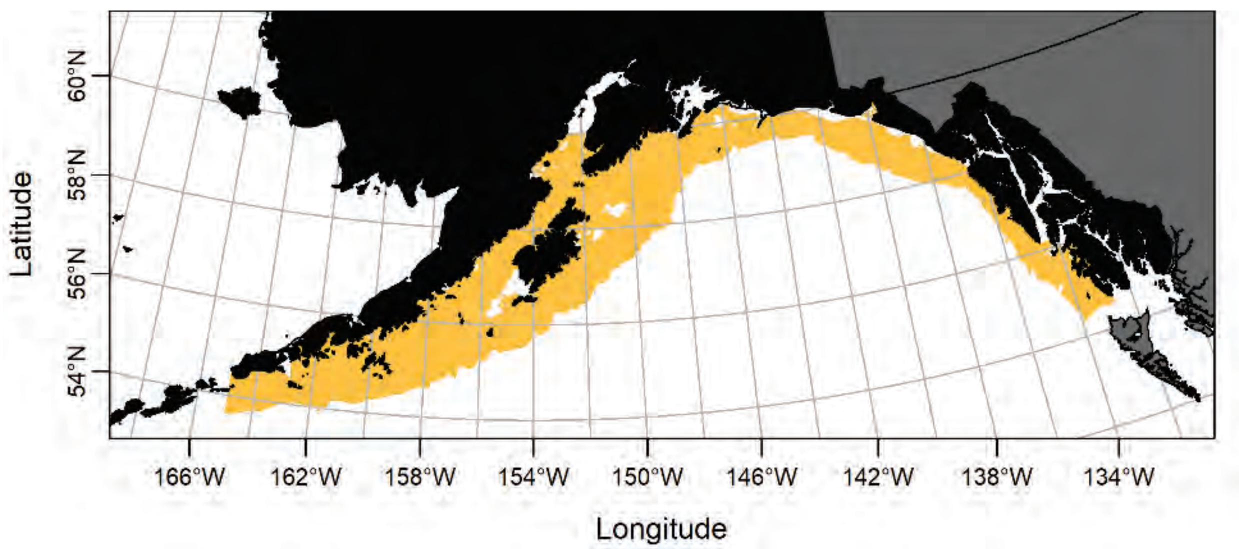

Figure E-159 EFH area of adult shortraker rockfish, spring

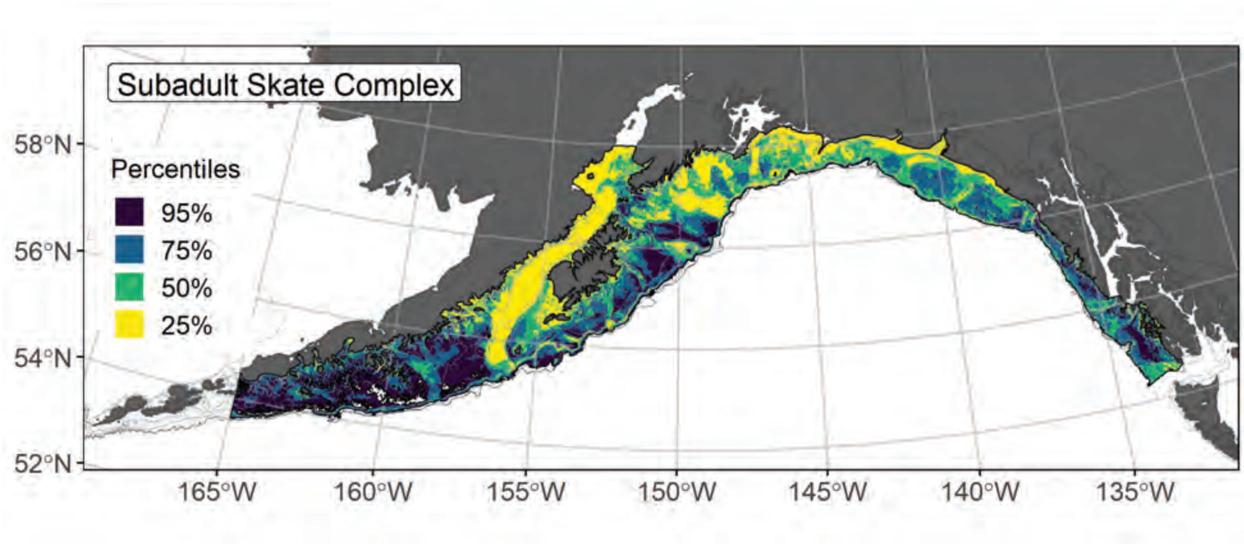

Figure E-160 EFH area of subadult skate complex, summer

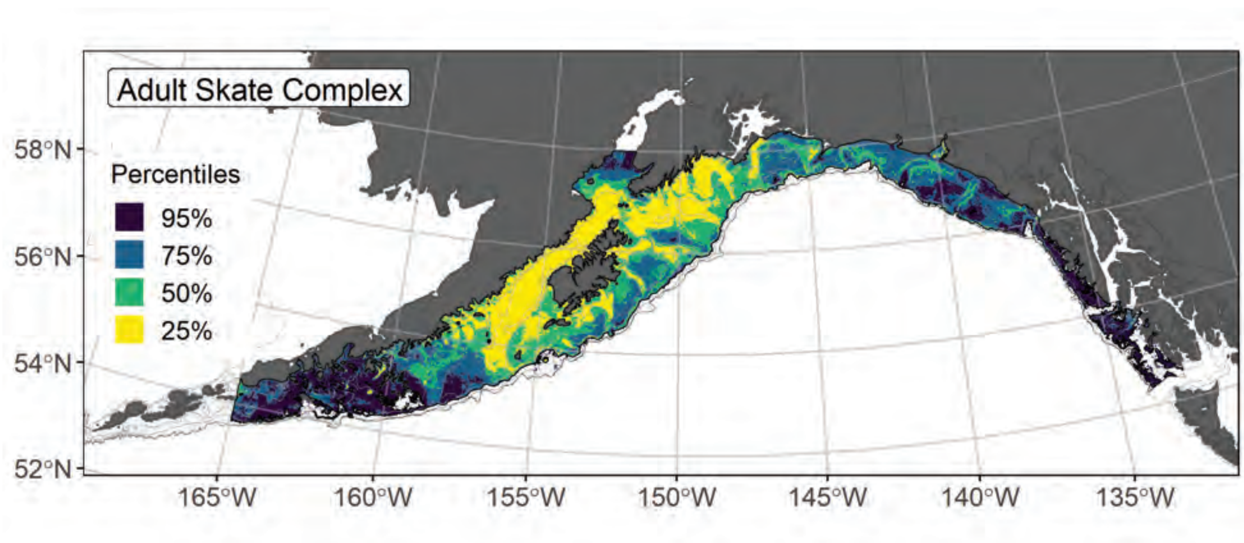

Figure E-161 EFH area of adult skate complex, summer

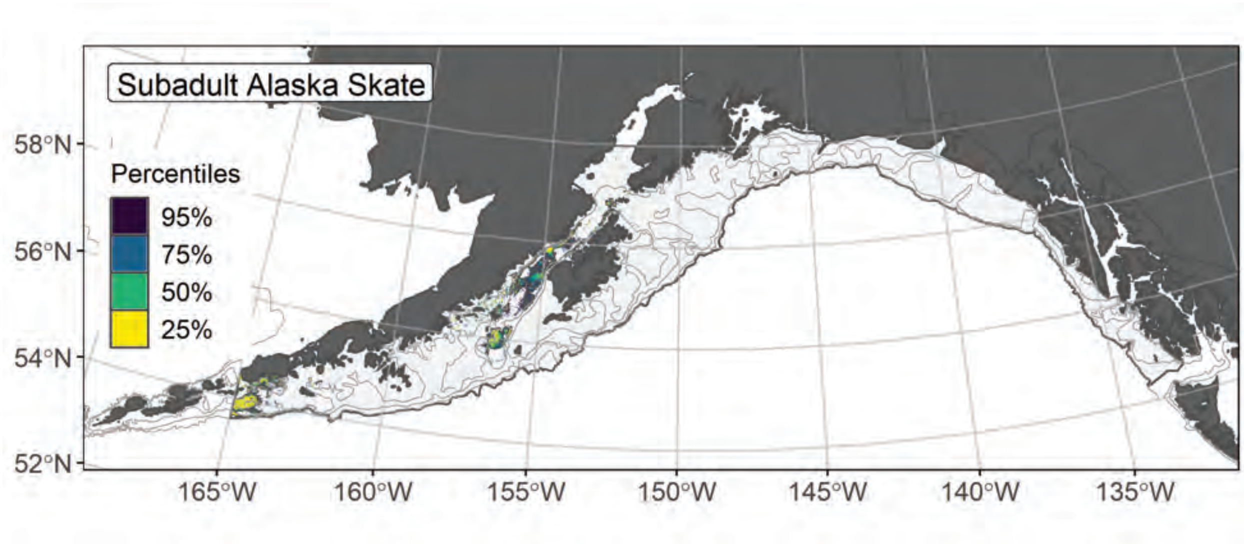

Figure E-162 EFH area of subadult Alaska skate, summer

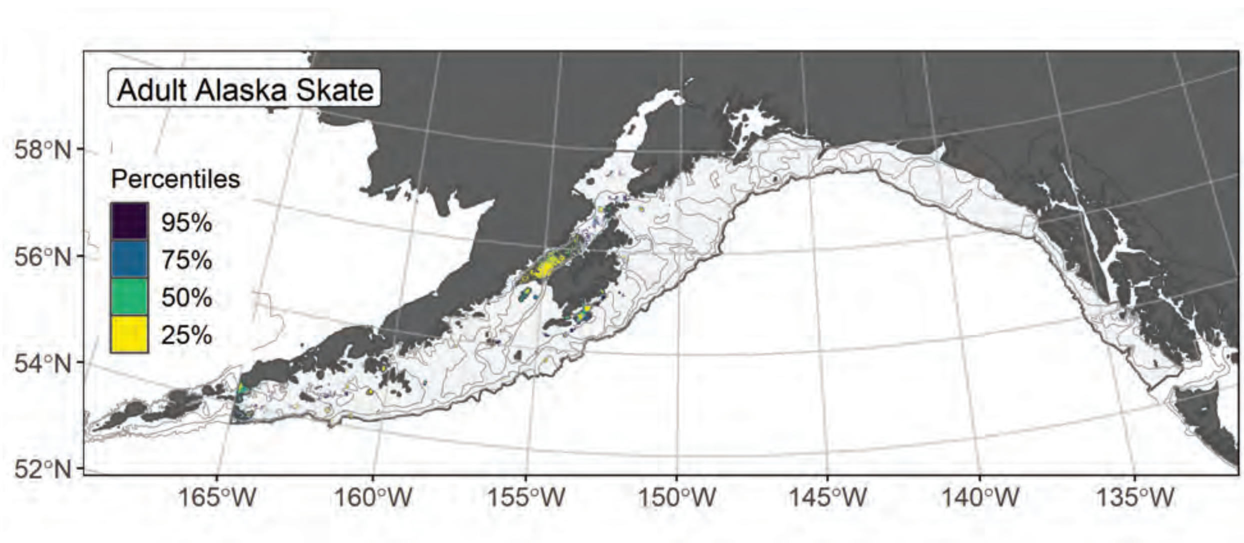

Figure E-163 EFH area of adult Alaska skate, summer

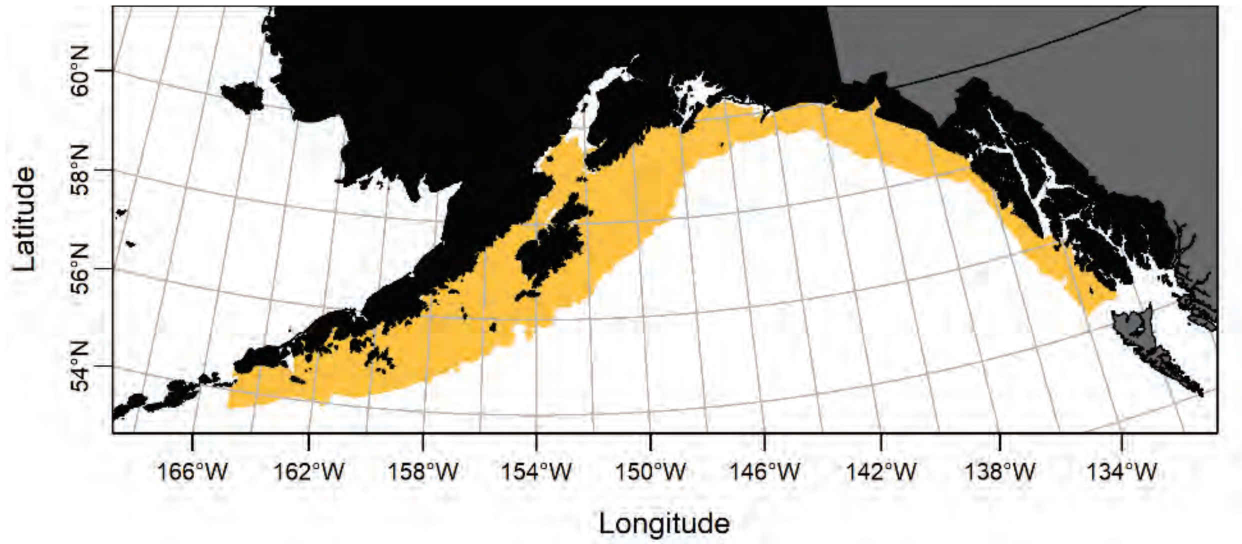

Figure E-164 EFH area of adult Alaska skate, fall

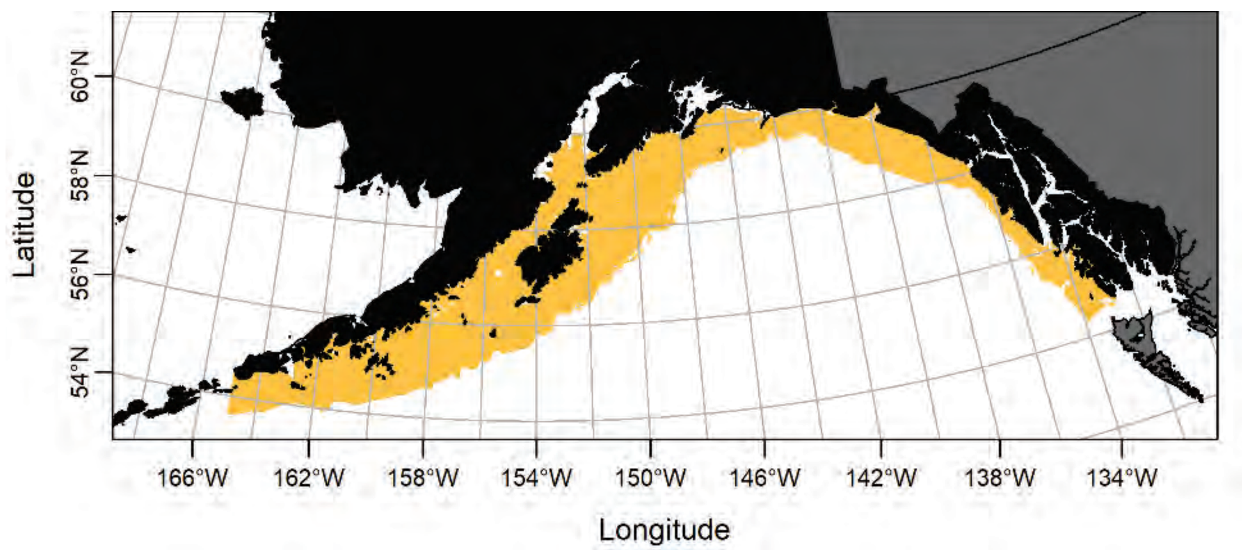

Figure E-165 EFH area of adult Alaska skate, winter

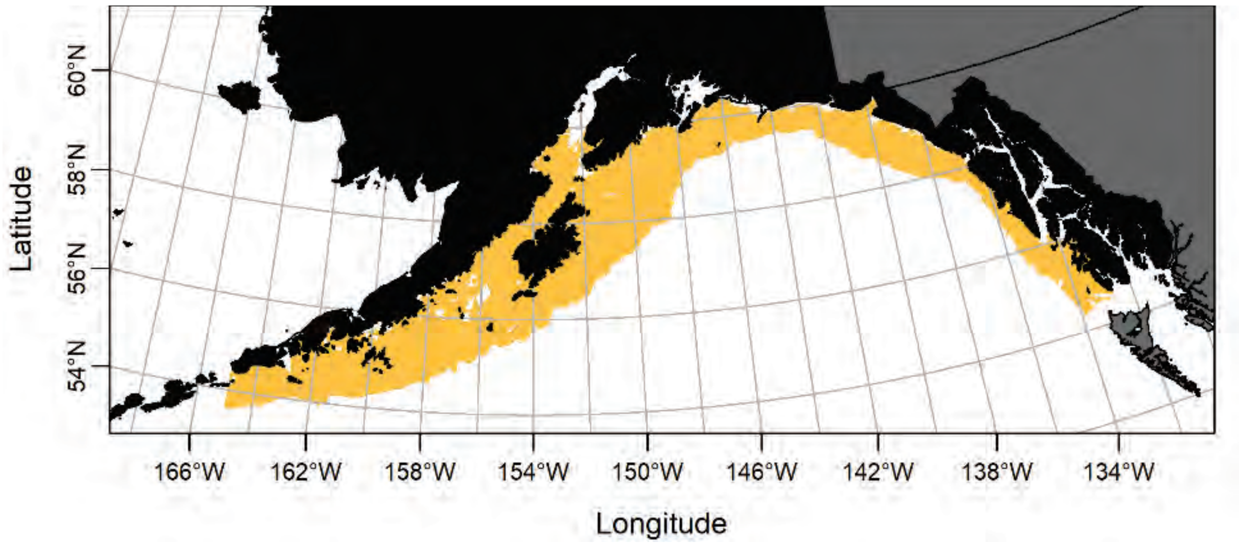

Figure E-166 EFH area of adult Alaska skate, spring

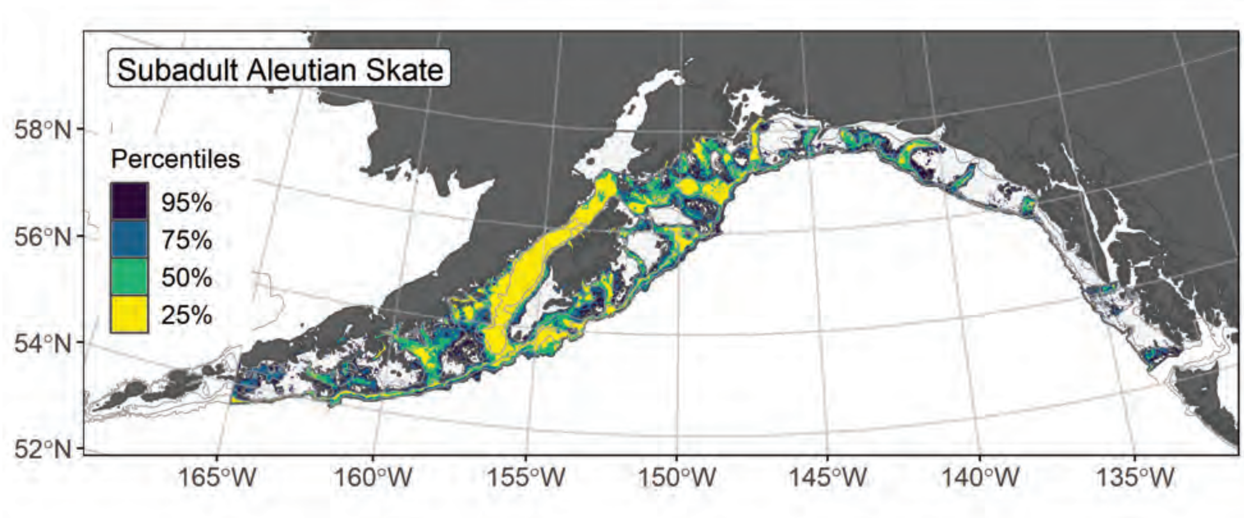

Figure E-167 EFH area of subadult Aleutian skate, summer

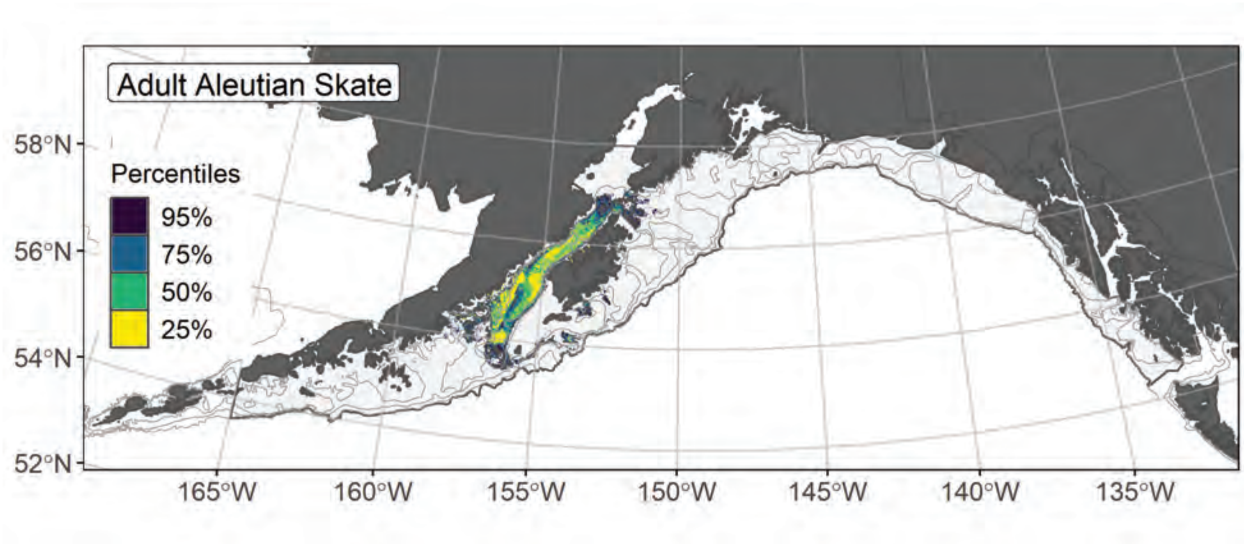

Figure E-168 EFH area of adult Aleutian skate, summer

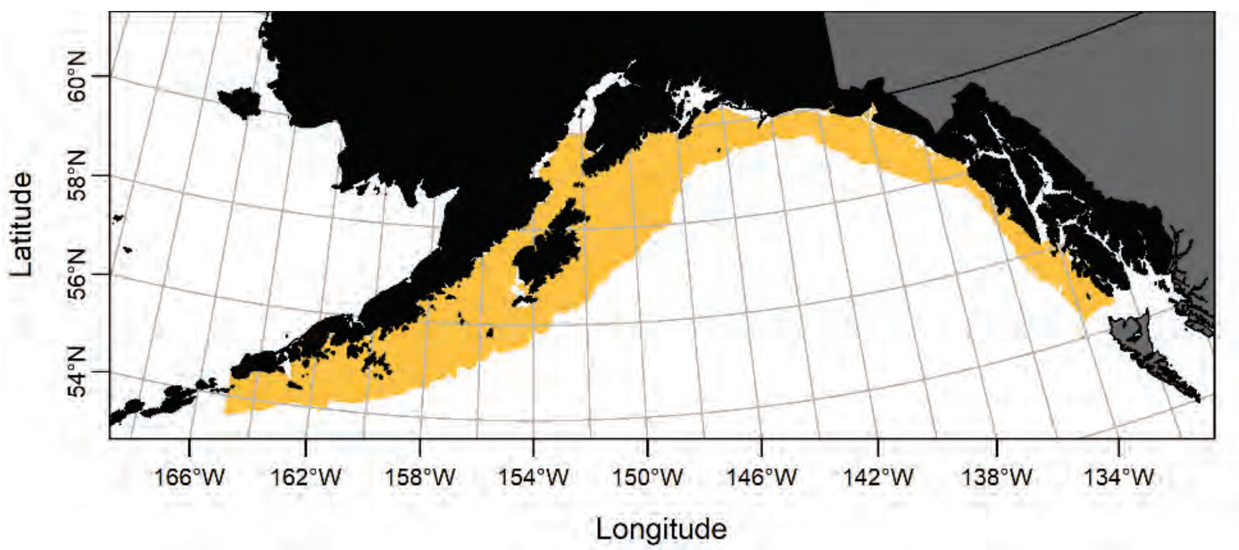

Figure E-169 EFH area of adult Aleutian skate, fall

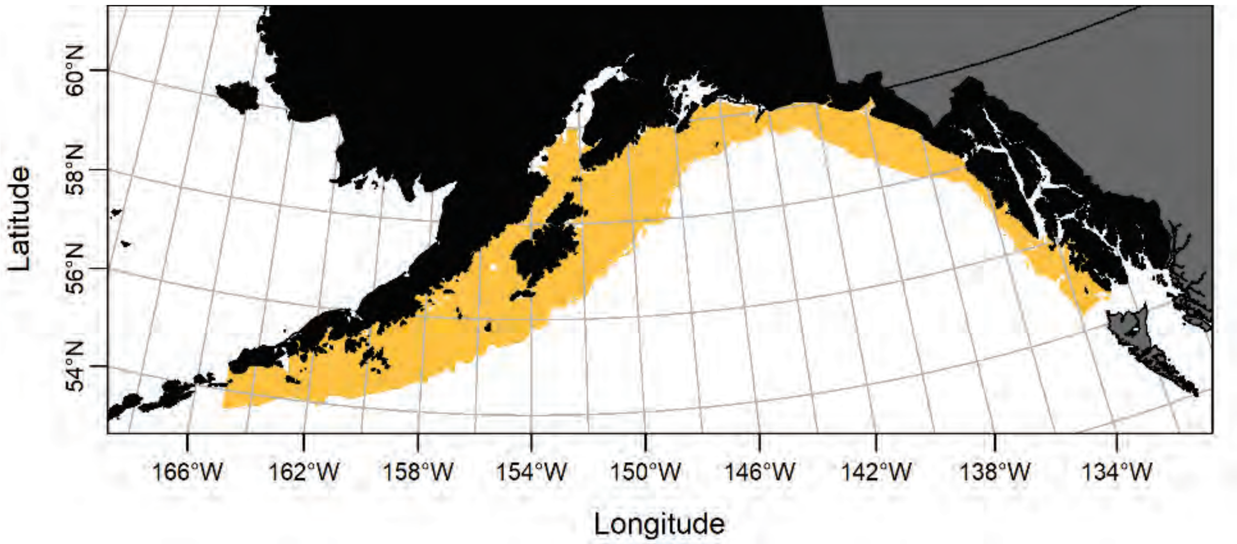

Figure E-170 EFH area of adult Aleutian skate, winter

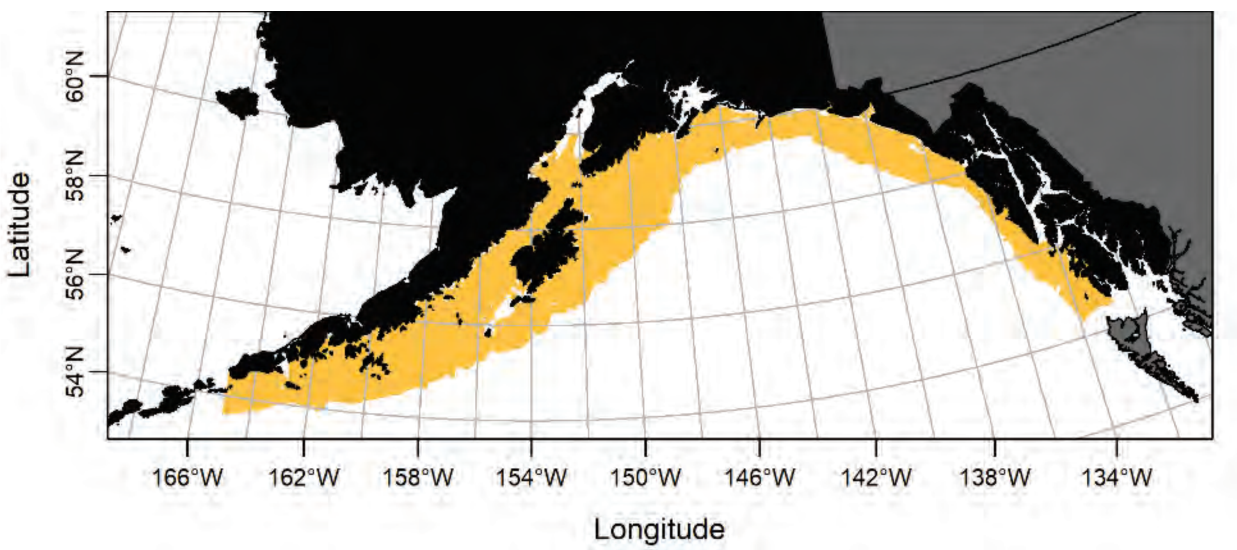

Figure E-171 EFH area of adult Aleutian skate, spring

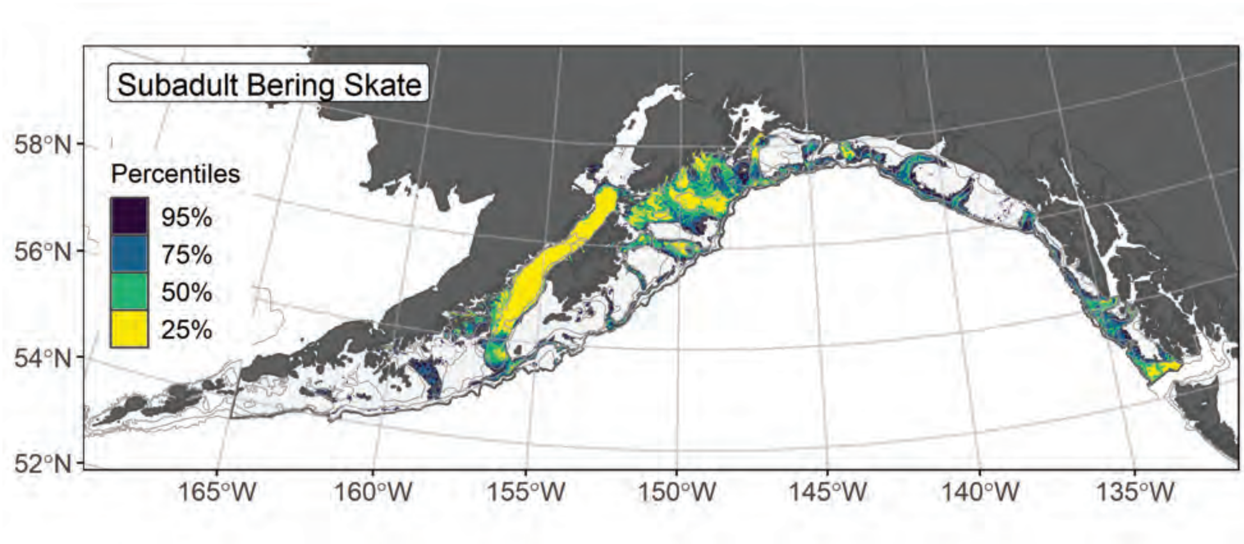

Figure E-172 EFH area of subadult Bering skate, summer

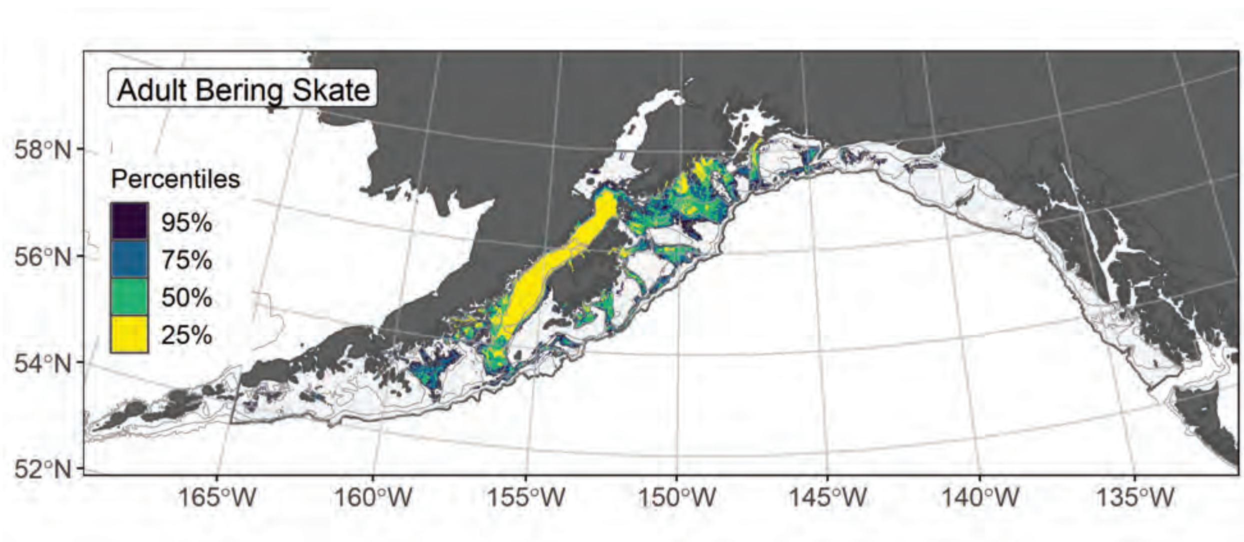

Figure E-173 EFH area of adult Bering skate, summer

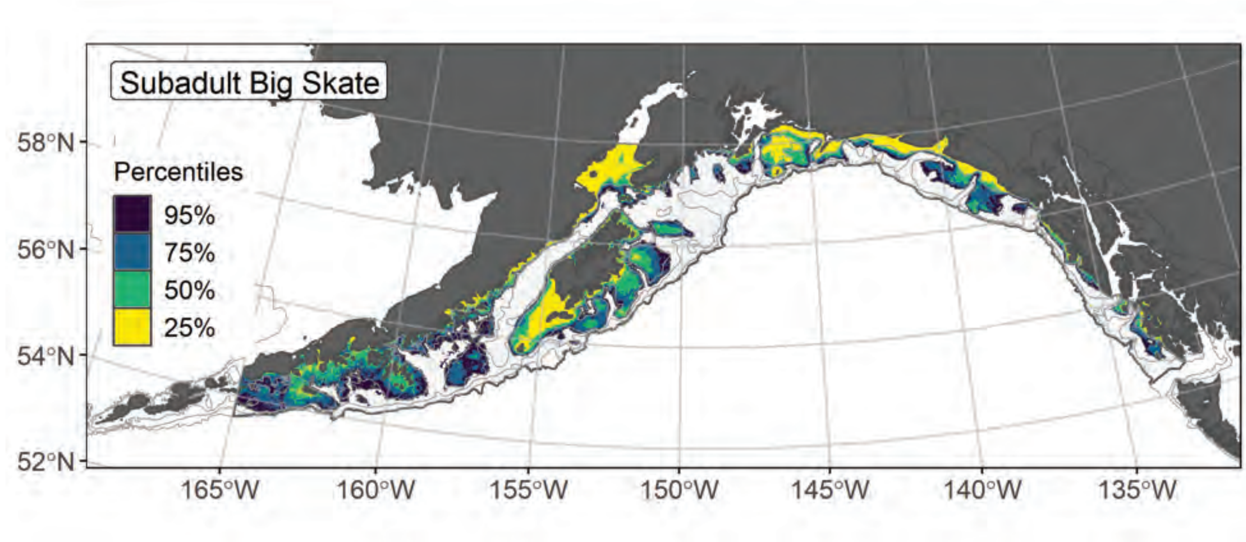

Figure E-174 EFH area of subadult big skate, summer

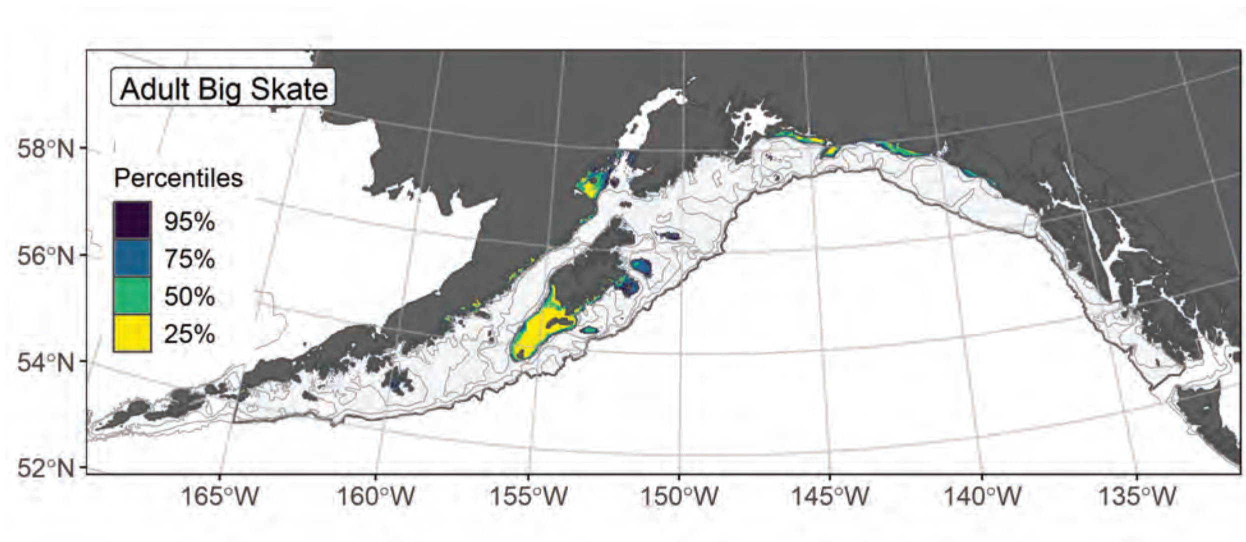

Figure E-175 EFH area of adult big skate, summer

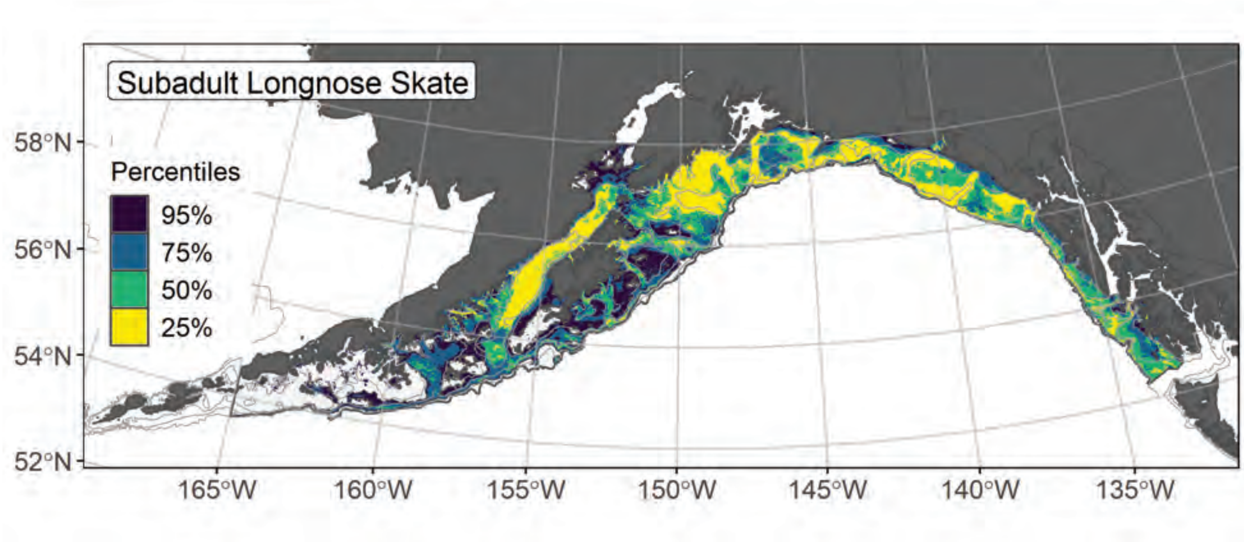

Figure E-176 EFH area of subadult longnose skate, summer

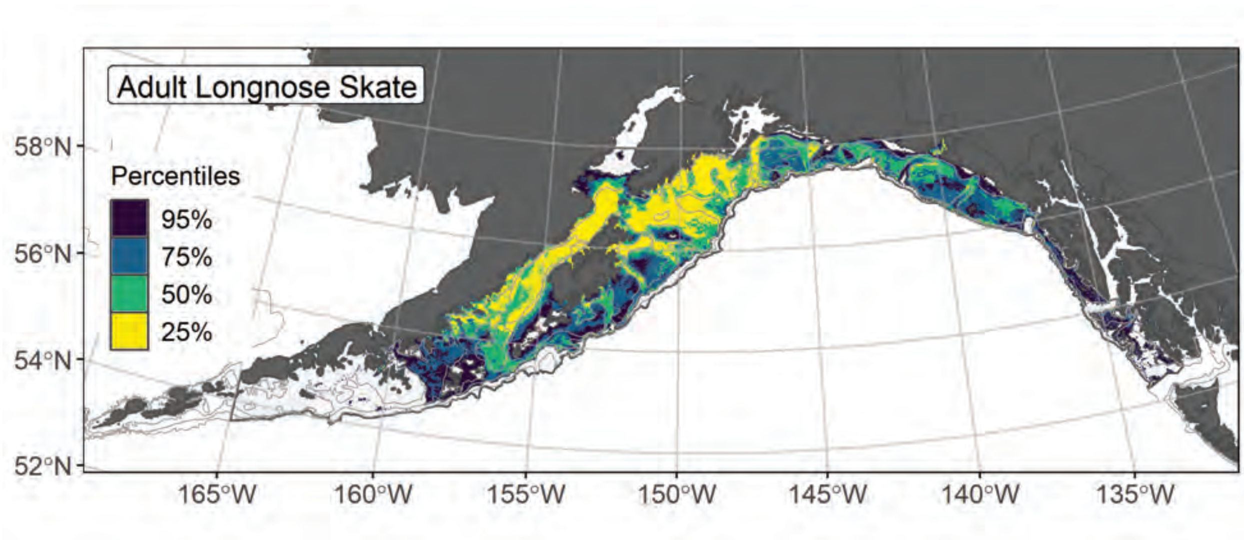

Figure E-177 EFH area of adult longnose skate, summer

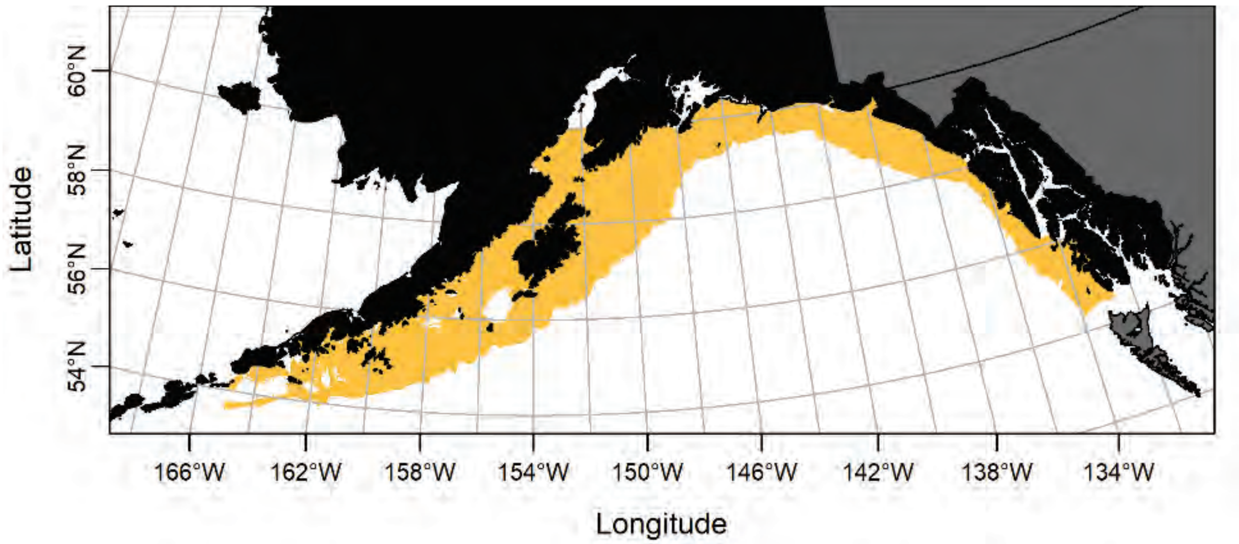

Figure E-178 **EFH area of adult longspine thornyhead rockfish, spring**

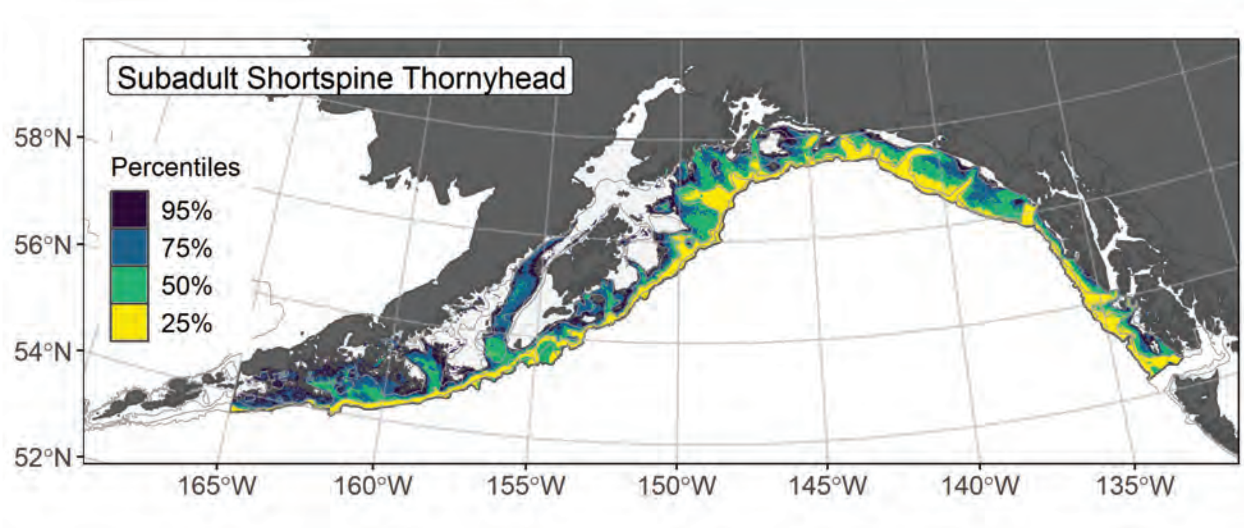

Figure E-179 **EFH area of subadult shortspine thornyhead rockfish, summer**

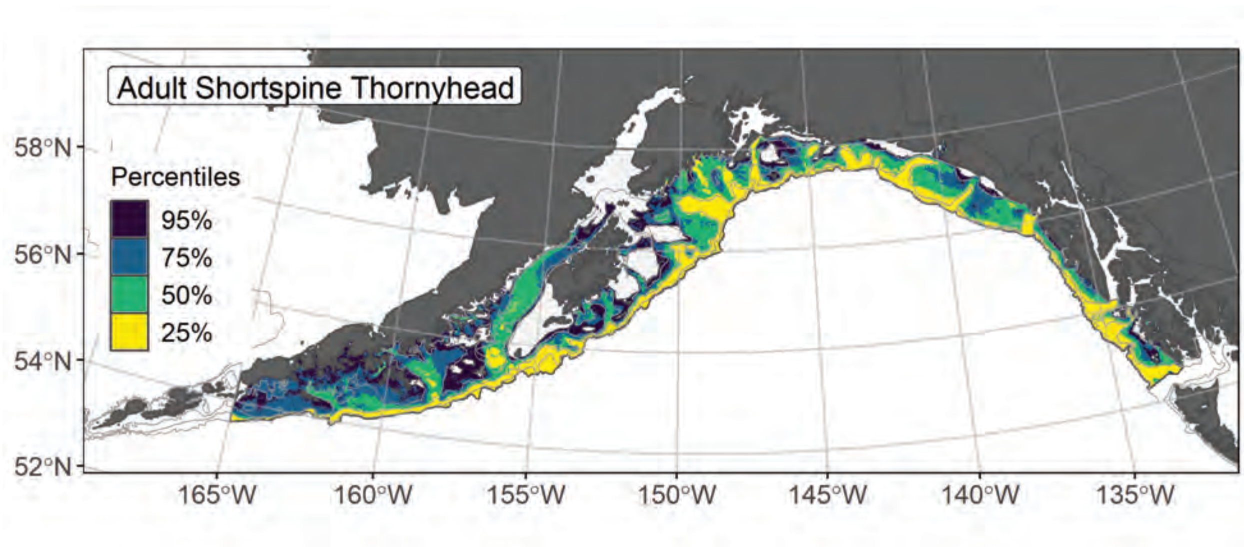

Figure E-180 **EFH area of adult shortspine thornyhead rockfish, summer**

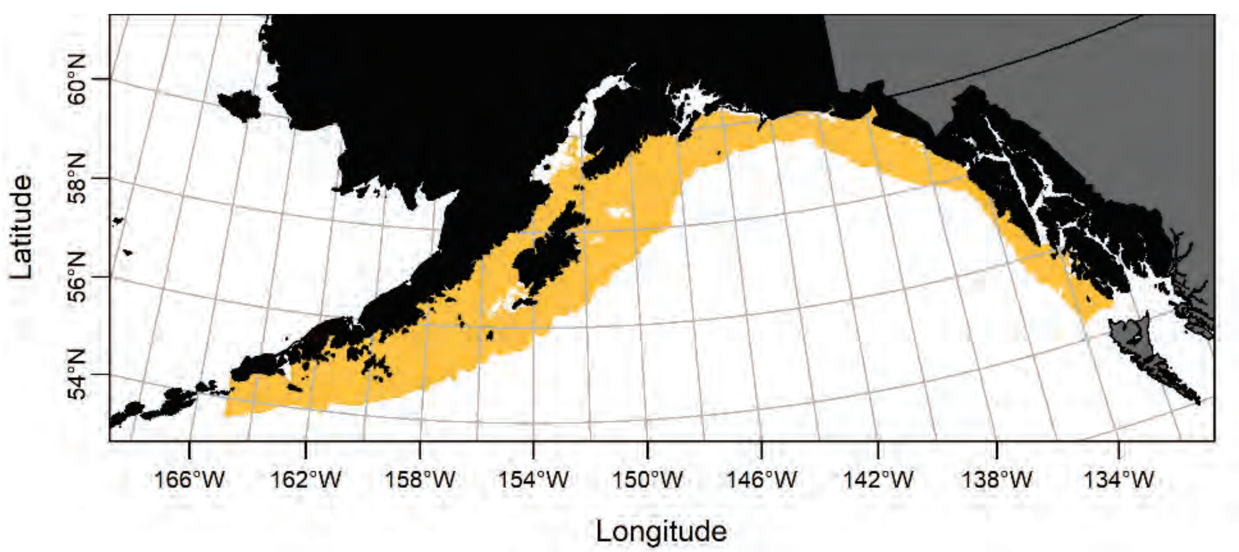

Figure E-181 **EFH area of adult shortspine thornyhead rockfish, fall**

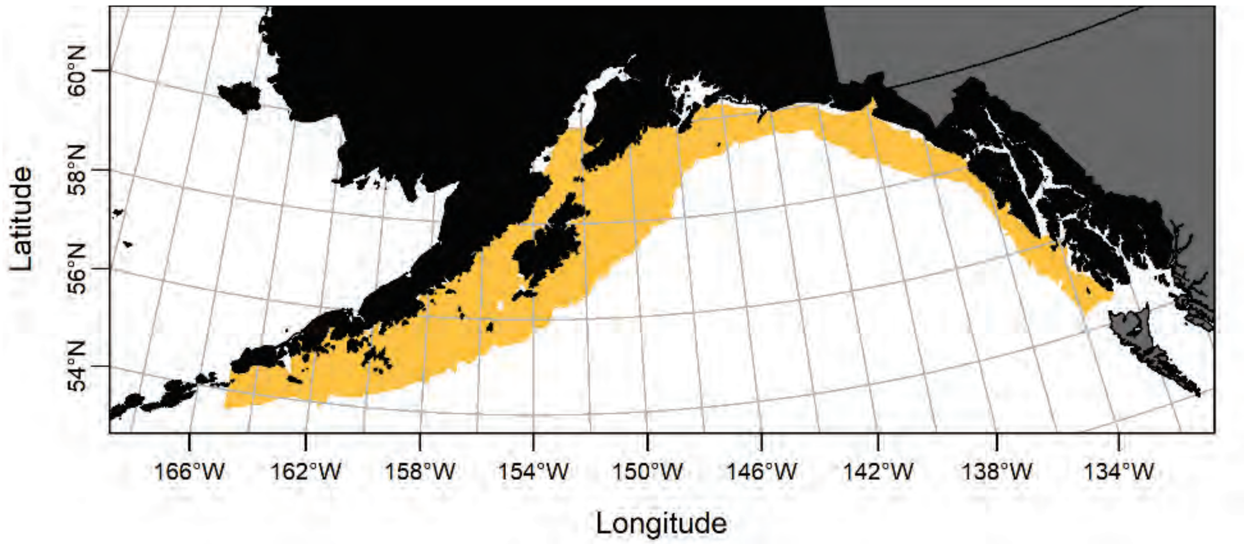

Figure E-182 EFH area of adult shortspine thornyhead rockfish, winter

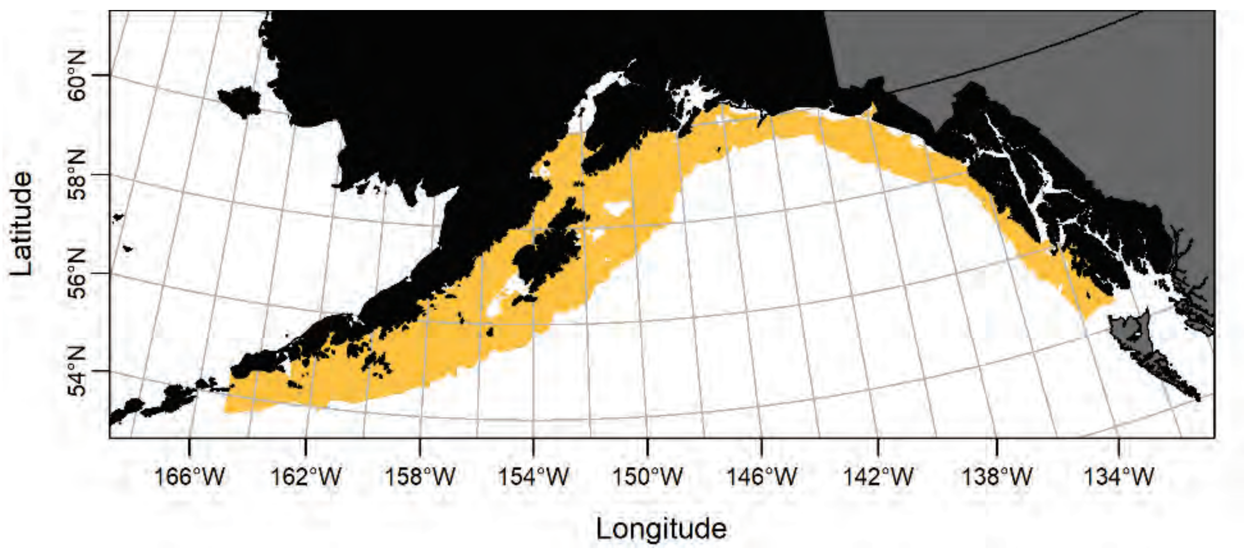

Figure E-183 EFH area of adult shortspine thornyhead rockfish, spring

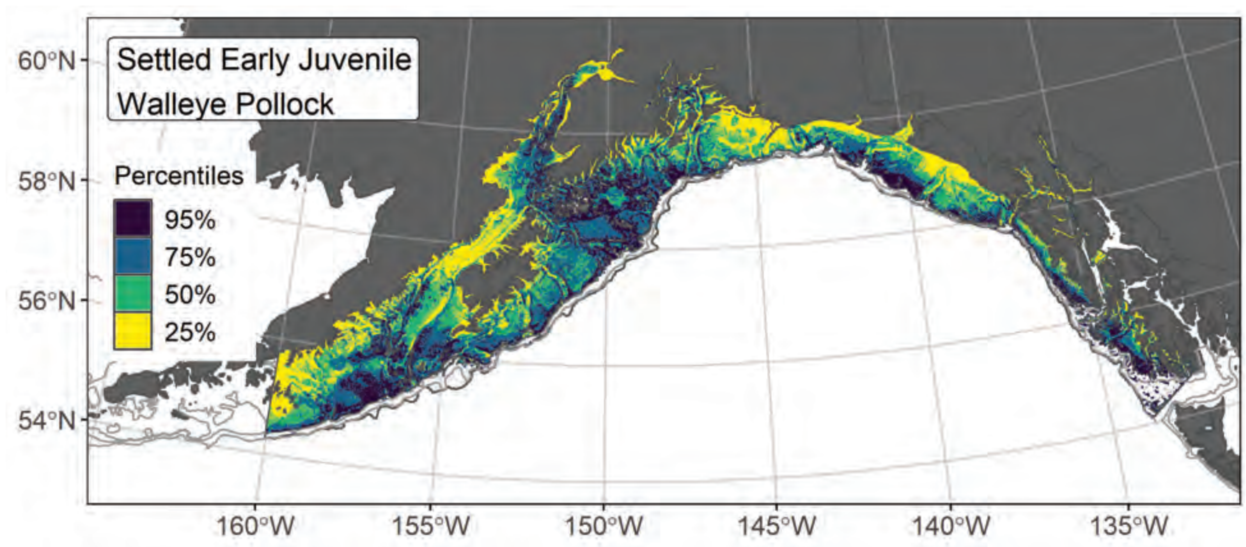

Figure E-184 EFH area of settled early juvenile walleye pollock, summer

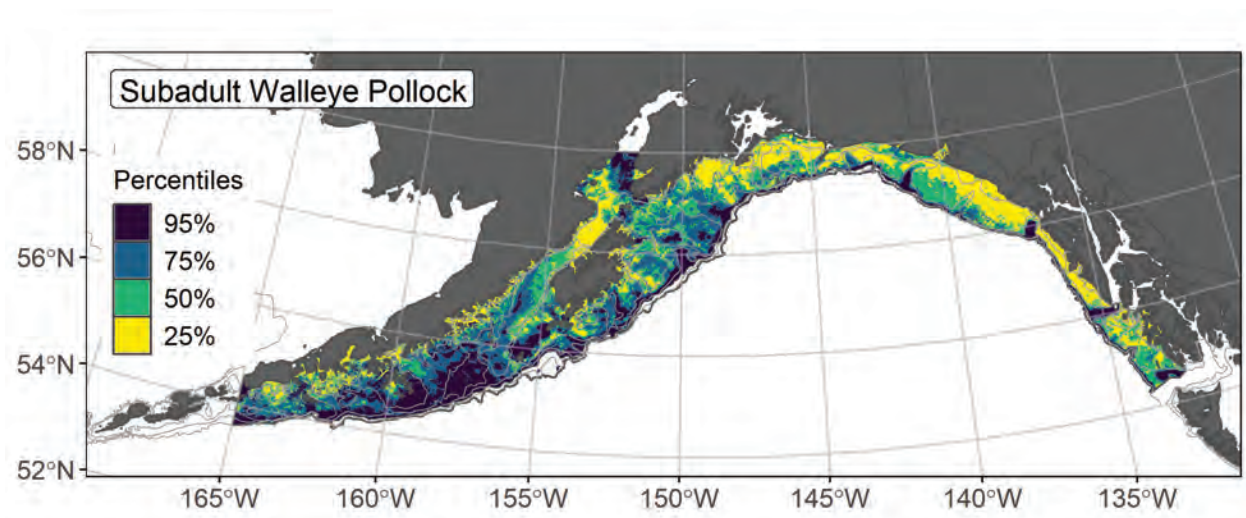

Figure E-185 EFH area of subadult walleye pollock, summer

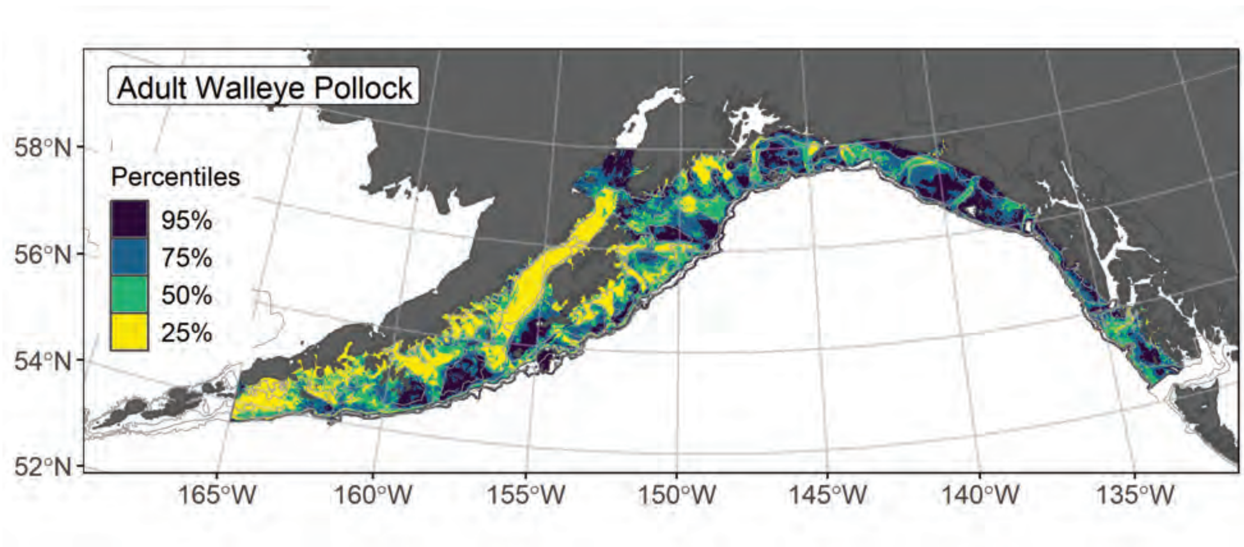

Figure E-186 EFH area of adult walleye pollock, summer

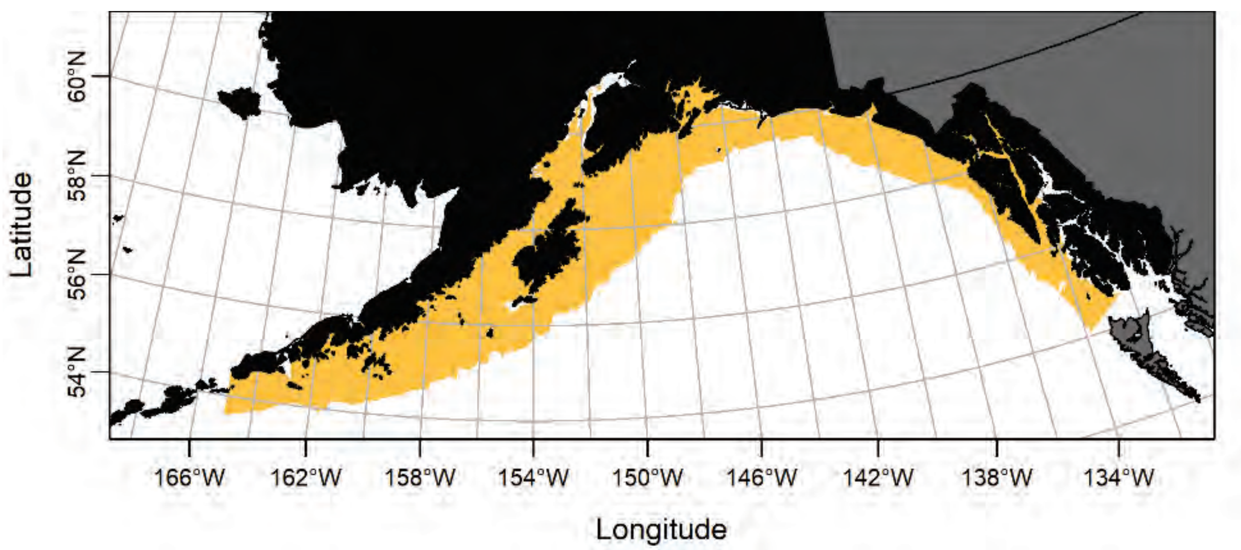

Figure E-187 EFH area of walleye pollock eggs, summer

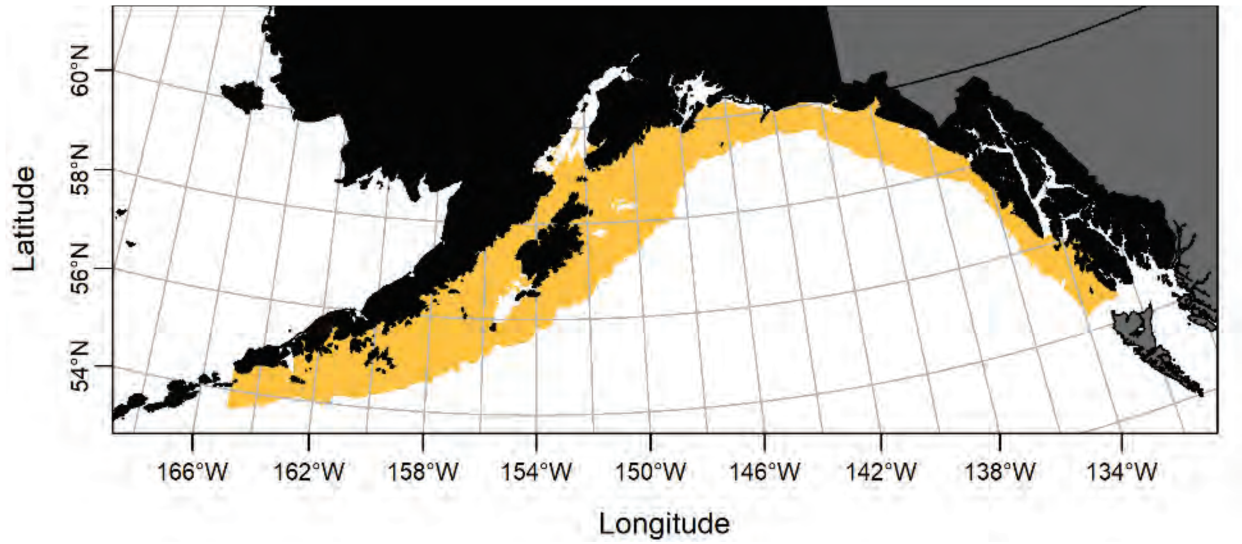

Figure E-188 EFH area of adult walleye pollock, fall

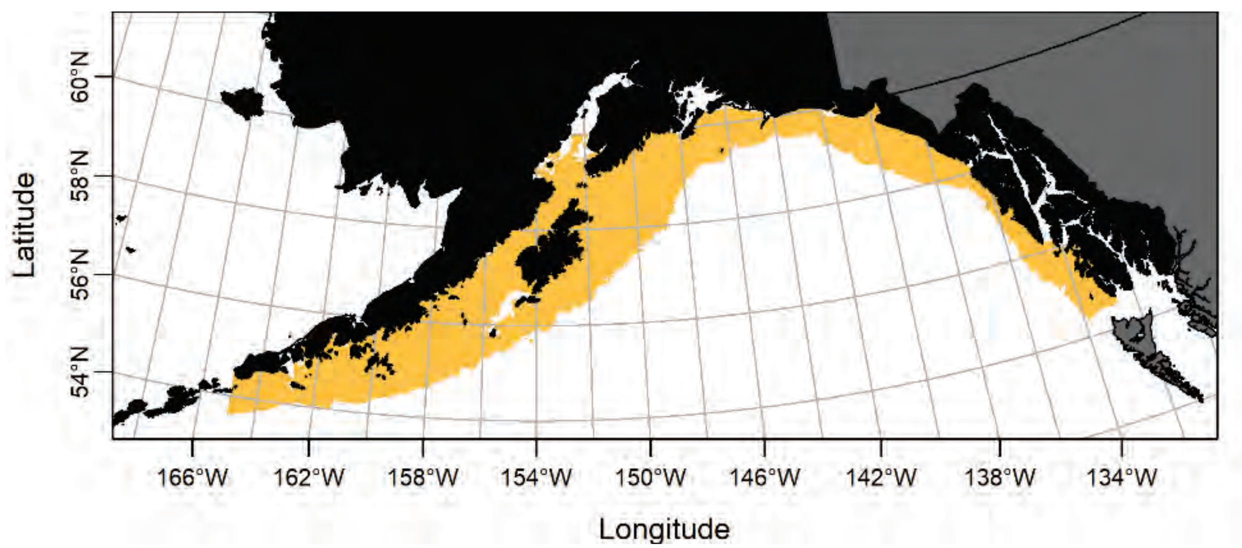

Figure E-189 EFH area of adult walleye pollock, winter

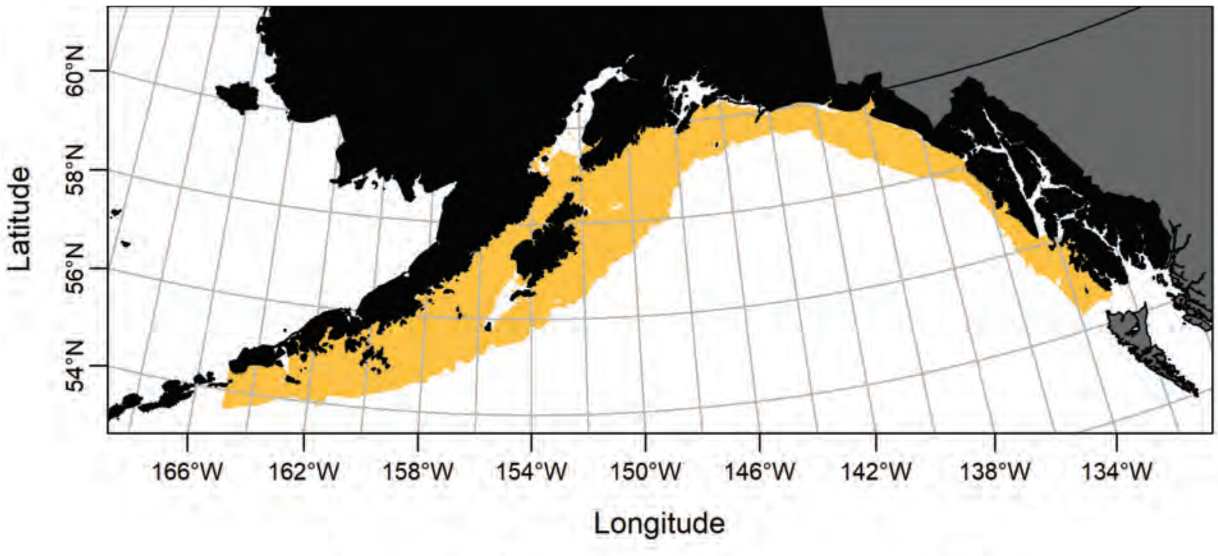

Figure 96. GOA adult Walleye pollock spring EFH.

Figure E-190 EFH area of adult walleye pollock, spring

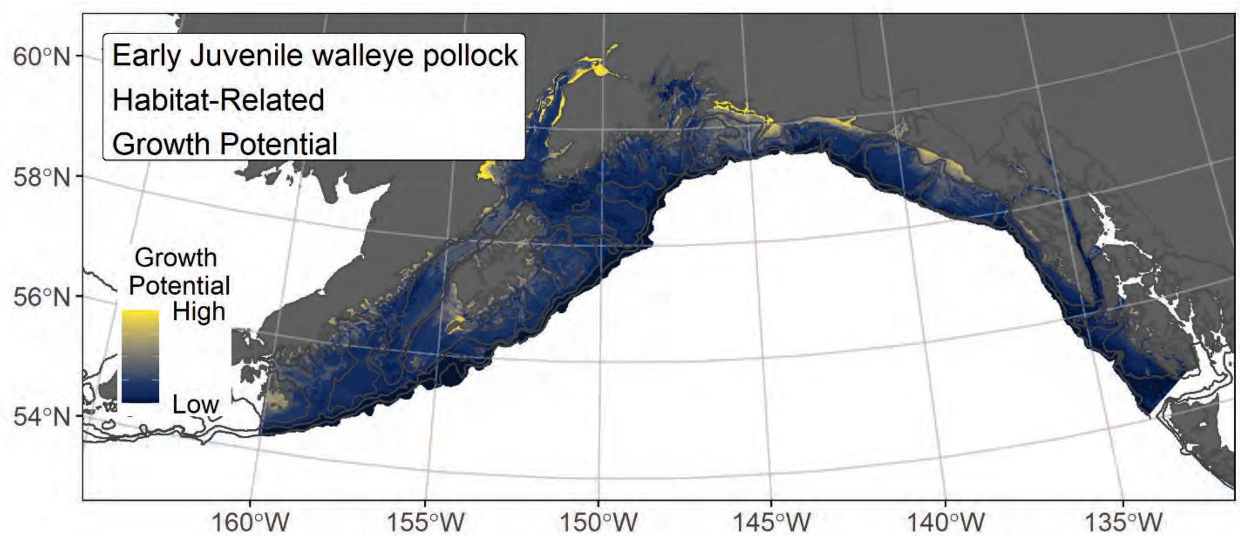

Figure E-191 EFH area of settled early juvenile walleye pollock, habitat-related growth potential, summer

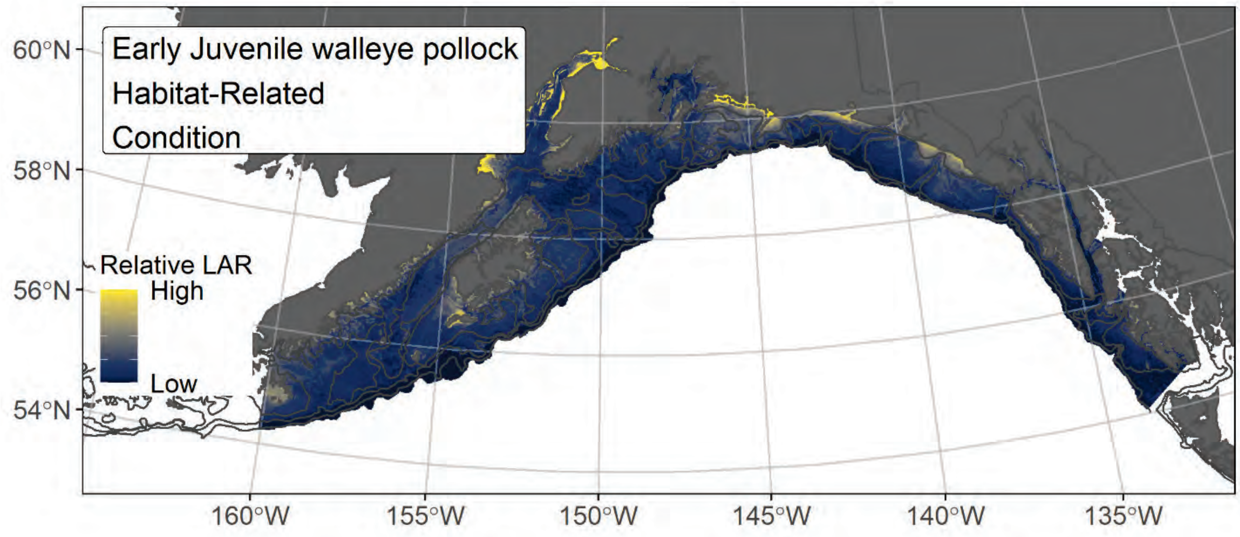

Figure E-192 EFH area of settled early juvenile walleye pollock, habitat-related condition, summer

E.4 References

Gibson, G. A., W. T. Stockhausen, S. K. Shotwell, A. L. Deary, J. L. Pirtle, K. O. Coyle, and A. J. Hermann. 2023. Can seamounts in the Gulf of Alaska be a spawning ground for sablefish settling in coastal nursery grounds? Fisheries Research. 261: 106625. https://doi.org/10.1016/j.fishres.2023.106625

Hinckley, S., W. Stockhausen, K. Coyle, B. Laurel, G. Gibson, C. Parada, A. Hermann, M. Doyle, and T. Hurst. 2019. Connectivity between spawning and nursery areas for Pacific cod (*Gadus macrocephalus*) in the Gulf of Alaska. Deep Sea Res. Pt. II. 165: 113–126. https://doi.org/10.1016/j.dsr2.2019.05.007

Pirtle, J. L., E. A. Laman, J. Harris, M. C. Siple, C. N. Rooper, T. P. Hurst, C. L. Conrath, and G. A. Gibson. 2023. Advancing model-based essential fish habitat descriptions for North Pacific species in the Gulf of Alaska. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-468, 541 p. https://doi.org/10.25923/ygdf-5f65

Shotwell, S. K., G. A.Gibson, W. T. Stockhausen, J. L. Pirtle, C. N. Rooper, A. L. Deary, K. O. Coyle, and A. J. Hermann, A.J. In preparation. Developing a novel approach to estimate habitat-related survival rates for early life history stages using individual-based models.

Appendix F Adverse Effects on Essential Fish Habitat

F.1 Fishing Effects on Essential Fish Habitat

F.1.1 Overview

This appendix addresses the requirement in Essential Fish Habitat (EFH) regulations (50 Code of Federal Regulations [CFR] 600.815(a)(2)(i)) that each FMP must contain an evaluation of the potential adverse effects of all regulated fishing activities on EFH. This evaluation should consider the effects of each fishing activity on each type of habitat found within EFH. FMPs must describe each fishing activity, review and discuss all available relevant information (such as information regarding the intensity, extent, and frequency of any adverse effect on EFH; the type of habitat within EFH that may be affected adversely; and the habitat functions that may be disturbed), and provide conclusions regarding whether and how each fishing activity adversely affects EFH.

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

F.1.2 Evaluation of fishing effects on EFH

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

The full evaluation of the estimated fishing effects on species' core EFH areas are in the FE Report (Zaleski et al. 2023). It includes a description of the stock assessment author review process, whereby stock authors were provided with the FE model output and requested to quantitatively or qualitatively evaluate if the estimated habitat disturbance was adversely affecting EFH more than minimally and not temporarily. The FE Report includes each stock author's evaluations in Appendix 5. For the GOA (Figure 1) groundfish species or species complexes, none had estimates of habitat disturbance ≥ 10% of their core EFH area, and no species were elevated for possible mitigation to reduce fishing effects to EFH.

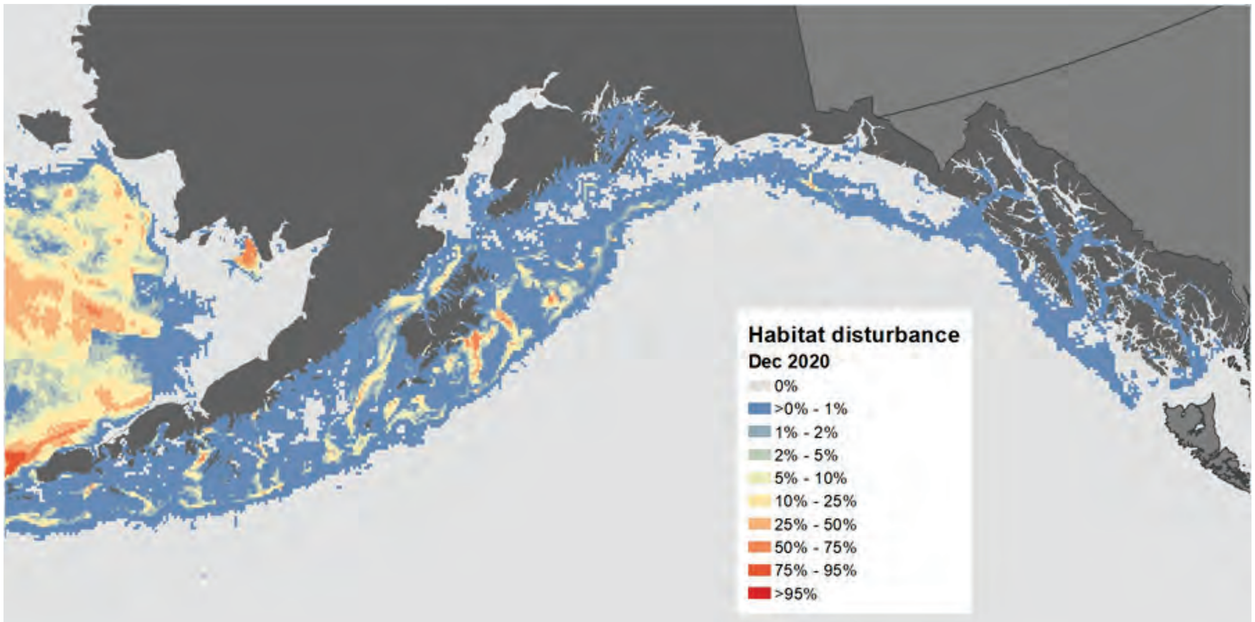

Figure 1 Gulf of Alaska cumulative percentage habitat disturbed. All gears combined.

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.2.1 Non-Fishing Impacts and EFH 5-year Review from 2018-2023

The most recent report, *Impacts to Essential Fish Habitat from Non-Fishing Activities in Alaska* (Limpinsel et al. 2023), presents a brief history of the Magnuson-Stevens Act and the language, provisions, and purpose supporting conservation of EFH. The report emphasizes the growing importance and implementation of Ecosystem Based Fisheries Management. This iteration recognizes climate change as an anthropogenic threat influencing EFH. Chapter 2 provides a discussion on how greenhouse gas emissions are warming the Arctic and influencing the atmosphere, ocean, and fisheries across Alaska. Chapters 3, 4 and 5 of this report address watersheds, estuaries and nearshore zones, and offshore zones, starting by highlighting the more commonly recognized physical, chemical, and biological processes that make each zone distinct. Each chapter discusses ecosystem processes, EFH attributes, sources of anthropogenic impacts that could compromise EFH, and proposes conservation recommendations to reduce the severity of those impacts. This report reflects the best available science.

F.2.2 Regulatory Alignment

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

EFH conservation recommendations are non-binding to Federal and state agencies. EFH consultations do not supersede regulations or jurisdictions of Federal or state agencies. NMFS has no authority to issue permits for projects or mandate measures to minimize impacts of non-fishing activities. Most non-fishing activities identified in this report are subject to numerous Federal, state, and local environmental laws and regulations designed to minimize and mitigate impacts to fish, wildlife and habitat.

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 with updated references for the new reports.

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

The cumulative effects from multiple non-fishing anthropogenic sources are increasingly recognized as having synergistic effects that may degrade EFH and associated ecosystem processes that support sustainable fisheries. Non-fishing activities may have potential long term cumulative impacts due to the long term additive and chronic nature of the activities combined with climate change (Limpinsel et al. 2023). However, the magnitude of the effects of non-fishing activities cannot currently be quantified with available information. NMFS does not have regulatory authority over non-fishing activities, but frequently provides recommendations to other agencies to avoid, minimize, or otherwise mitigate the effects of these activities.

Fishing and each activity identified in the analysis of non-fishing activities may or may not significantly affect the function of EFH. The synergistic effect of the combination of all of these activities is also a cause for concern. Unfortunately, available information is not sufficient to assess how the cumulative effects of fishing and non-fishing activities influence the function of EFH on an ecosystem or watershed scale. The magnitude of the combined effect of all of these activities cannot be quantified, so the 2017 EFH 5-year Review concluded that the cumulative level of concern is unknown.

F.4 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, 226 p. https://doi: 10.25923/9z4h-n860

National Marine Fisheries Service (NMFS). 2005. Final Environmental Impact Statement for Essential Fish Habitat Identification and Conservation in Alaska. March 2005. NMFS PO Box 21668, Juneau, AK 99801

Simpson, S. C., Eagleton, M. P., Olson, J. V., Harrington, G. A., and Kelly, S. R. 2017. Final Essential Fish Habitat (EFH) 5-year Review, Summary Report: 2010 through 2015. U.S. Dep. Commer., NOAA Tech Memo. NMFS-F/AKR-15, 118p. https://doi.org/10.7289/V5/TM-F/AKR-15

Smeltz, T.S., Harris, B., Olson, J., and Sethi, S. 2019. A seascape-scale habitat model to support management of fishing impacts on benthic ecosystems. Canadian Journal of Fisheries and Aquatic Sciences, 2019, 76(10): 1836-1844, https://doi.org/10.1139/cjfas-2018-0243

Zaleski, M., T. S. Smetlz, S. Rheinsmith, J. L. Pirtle, and G. Harrington. 2023. 2022 Evaluation of Fishing Effects on Essential Fish Habitat. NOAA Technical Memorandum NMFS-F/AKR-29, 208 p. https://doi.org/10.25923/c2gh-0w03

Appendix H Research Needs

H.4 Essential Fish Habitat Research and Information Need

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. 2023). The Alaska EFH Research Plans have included five long term research goals that remain consistent with minor, meaningful updates since 2005. EFH research recommendations were informed during the 2023 EFH 5-year Review by contributing researchers, stock assessment scientists, and Council advisory bodies. These recommendations were summarized as three objectives for the new Alaska EFH Research Plan. In addition, as part of the 2023 EFH 5-year Review, each stock assessment author provided a stock-specific evaluation of EFH research needs. Table 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 GOA 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. 2023)—

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

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

- Field and laboratory experiments are necessary to understand ecological mechanisms that underlie habitat association, vital rates and productivity, and how human activities (including fishing, development, and climate change) cause changes in habitat conditions and resulting utilization and productivity. In particular, understanding causality is not possible without experimental support. Understanding ecological mechanisms (i.e., causality) is also necessary to predict the likely impact of human impacts that have not previously been observed;

- Long-term monitoring is necessary to understand habitat utilization and productivity at regional scales;
- Analysis including statistical and mathematical modeling is needed to map the geographic distribution of the area of occupied habitat (EFH) for life stages of targeted FMP species and their prey and is also necessary to identify changes in habitat utilization likely resulting from human activities and climate change.

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

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

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

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

3. **Improved methods to integrate both monitoring and process research:** Continued development of new analytical methods to integrate process research is recommended when identifying species habitat utilization, vital rates, and productivity. Analytical methods might include individual- and agent-based models (IBMs) that "scale up" laboratory measurements, particularly when IBM output is used as a covariate or otherwise combined with survey and other

species sampling information. This process research might include juvenile survival, growth, and movement experiments and habitat-specific observations. Ideally, these new methods would include process information and monitoring data simultaneously, rather than either a. seeking to validate an IBM via comparison with monitoring data without explicitly incorporating these data, or b. fitting to monitoring data without incorporating field or laboratory experimental data.

Objective 2: Improve fishing effects assessment

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

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

Objective 3: Improve understanding of nearshore habitat and forage species

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

1. **Nearshore habitat:** Ongoing and expanded scientific efforts to understand habitat utilization and productivity into nearshore environments (EFH component 1). This nearshore habitat is critical for juvenile life stages of many targeted FMP species (e.g., Pacific cod, flatfishes, salmonids) and prey species (EFH component 7) and is also subject to substantial impacts from human development. Improved understanding of nearshore habitat is intended to support the EFH consultations that are done near areas with human development (urban areas as well as shipping activities) (EFH components 4 and 5). Understanding nearshore habitat may also support improved understanding of recruitment processes and population connectivity. Data are available in the Nearshore Fish Atlas of Alaska and ShoreZone, and analytical methods have already been demonstrated (e.g., Grüss et al. 2021), but there remains substantial work to scale these methods to more species and within geographic areas of specific interest.
2. **Prey species:** Increased efforts are recommended to understand habitat utilization and productivity for those species that represent the primary prey for targeted FMP species (EFH component 7). This can include pelagic forage fishes (e.g., herring, eulachon, sand lance, etc.), juvenile stages of numerically abundant species (e.g., pollock, Pacific cod, salmonids), as well as invertebrates (e.g., Euphausiids, snow crab). Improved understanding of habitat-specific densities (i.e., Level-2 EFH information) can then be used as a covariate for understanding habitat suitability for their predators (i.e., targeted FMP species).

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

Table 1. Stock assessment author research recommendations for Gulf of Alaska groundfish species. These include focus areas of research and identify data sources for future EFH map iterations.

Gulf of Alaska 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	Explore EFH over different time blocks representing different environmental conditions, and also regulations in place over the time series.
Dover sole	The length-stage definitions should be revisited and future maps and descriptions should try to account for subregional growth and size-at-age differences.
dusky rockfish	Prioritize research into fishery location data and early life history information. Include fishery observer data for additional species distribution data.
flathead sole	Research impacts of environmental indicators such as temperature on growth and/or distribution of recruits, since we don't see these in the surveys.
northern rockfish	Research early life history. Incorporate stakeholder/fleet understanding of fish locations.
other rockfish complex, demersal subgroup	ADF&G currently uses their ROV surveys to assess and manage this stock in the EGOA and recommend incorporating data from those surveys into the SDM ensemble framework.
other rockfish complex, slope subgroup	Research should include data from the AFSC and IPHC longline surveys, the GOA rockfish fishery data, and underwater images from untrawlable habitats in future EFH mapping efforts for these rockfish species.
greenstriped rockfish	Incorporate AFSC longline survey data and IPHC survey data as additional species distribution data.
harlequin rockfish	Incorporate GOA fishery data to more accurately represent the spatial extent of the population.
pygmy rockfish	Incorporate GOA fishery data for additional distribution data.
silvergray rockfish	Incorporate AFSC longline survey data and IPHC survey data as additional species distribution data.

Gulf of Alaska Species	Research notes from Stock Assessment Authors
redbanded rockfish	Incorporate both longline survey indices and length data when available.
rex sole	Reevaluate the length categories for subadults and adults with regard to regional and temporal growth differences.
rougheye/ blackspotted rockfish complex	Incorporate AFSC longline survey data as additional species distribution data.
sablefish	Incorporate longline survey data into the SDM. Collect data to better understand spawning areas (requires winter sampling) and ELH [early life history] habitat preferences. Develop a better understanding of connectivity among management units within the Alaska-wide sablefish population, particularly the dynamics of juvenile fish and how they utilize the EBS shelf.
Shark complex	(Note: only spiny dogfish maps were advanced by EFH analysts, however Pacific sleeper shark maps were reviewed and the stock assessment author provided the research recommendation below.)
Pacific sleeper shark	Research the spatial distribution of length data collected during surveys.
spiny dogfish	Incorporate the AFSC and IPHC longline surveys, with their length data, as additional data sources.
shortraker rockfish	Incorporate AFSC longline survey data as additional species distribution data.

H.4.3 References

Grüss, A., J. L. Pirtle, J. T. Thorson, M. R. Lindeberg, A. D. Neff, S. G. Lewis, and T. E. Essington. 2021. Modeling nearshore fish habitats using Alaska as a regional case study. Fisheries Research 238: 105905 https://doi.org/10.1016/j.fishres.2021.105905

Pirtle, J. L., J. T. Thorson, S. R. Bayer, T. P. Hurst, M. E. Matta, and M. C. Siple. 2023. Alaska Essential Fish Habitat Research Plan: A Research Plan for the National Marine Fisheries Service’s Alaska Fisheries Science Center and Alaska Regional Office. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-F/AKR-33, 17 p. https://doi.org/10.25923/sf79-ym32

Sigler, M. F., M. P. Eagleton, T. E. Helser, J. V. Olson, J. L. Pirtle, C. N. Rooper, S. C. Simpson, and R. P. Stone. 2017. Alaska Essential Fish Habitat Research Plan: A research plan for the National Marine Fisheries Service's Alaska Fisheries Science Center and Alaska Regional Office. AFSC Processed Report 2015-05, 22 p. Alaska Fish. Sci. Cent., NOAA, Natl. Mar. Fish. Serv., 7600

Sand Point Way NE, Seattle WA 98115. https://apps-afsc.fisheries.noaa.gov/Publications/ProcRpt/PR2017-05.pdf

Smeltz, T. S., B. Harris, J. Olson, and S. Sethi. 2019. A seascape-scale habitat model to support management of fishing impacts on benthic ecosystems. Canadian Journal of Fisheries and Aquatic Sciences 76(10): 1836-1844 https://doi.org/10.1139/cjfas-2018-0243