BSAI Groundfish FMP Amendment 115- 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, and Appendix `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 three supplemental files: Appendix D, Appendix E, Appendix F.1, F.2., and F.3.

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

EFH is described for FMP-managed species by life stage as general distribution using ~~new~~ 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, ~~and~~ NPFMC and NMFS 2010, and Simpson et al. 2017). EFH descriptions include both text (Section 4.2.2.2) 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~~s~~ 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) (EFH EIS) in Section 3.2.1, Biology, Habitat Usage, and Status of Magnuson-Stevens Act Managed Species and detailed by life history stage in Appendix F: EFH Habitat Assessment Reports. This EIS was supplemented in 2010 and 2017 by ~~a~~ the 5-year review cycle, which periodically re-evaluates~~d~~ EFH descriptions and fishing and non-fishing impacts on EFH in light of new information (NPFMC and NMFS 2010 and Simpson et al. 2017).

2. In Section 4.2.2.1, replace Table 4-9 and the associated table notes with the following revised table and table notes:

Table 4-9 Levels of EFH information currently available for BSAI groundfish by life history stage

Species	Eggs	Larvae	Early Juvenile	Late Juvenile	Adults
Pollock	1	1	2	2	2
Pacific cod	x	2	2	2	2
Sablefish	x	x	x	1	1
Yellowfin sole	1	1	1	1	1
Greenland turbot	1	1	1	2	2
Arrowtooth flounder	1	1	1	2	2
Kamchatka flounder	1	1	1	1	1
Northern rock sole	x	1	1	1	1
Alaska plaice	1	1	x	1	1
Rex sole	1	1	1	2	2
Dover sole	1	1	1	2	2
Flathead sole	1	1	2	2	2
Pacific ocean perch	*Sebastes* spp. early life stages grouped 1			2	2
Northern rockfish				2	2
Shortraker rockfish				2	2
Blackspotted/ rougheye rockfish				1	2
Other rockfish (dusky)				1	1
Thornyhead rockfish (shortspine)	x	x	2	2	2
Atka mackerel	1	1	x	1	2
Squids	x	x	x	1	1
Sculpins (Great, Yellow Irish Lord, Bigmouth)	x	x		x	2
Skates (Alaska, Bering, Aleutian)	1	x	1	2	2
Skates (Mud)	x	x	x	x	2
Sharks	x	x	x	x	x
Octopuses (Pacific Giant)	x	x	x	x	2
Forage fish complex	x	x	x	x	x
Grenadiers	x	x	x	x	x

x Indicates insufficient information is available to describe EFH

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

2 Indicates quantitative data (density or habitat-related density) are available for the habitats occupied by a species or life stage One juvenile stage exists – see Late Juveniles

3. In Section 4.2.2.2, replace 4.2.2.2.1 through 4.2.2.2.29 with the revised text below.

4.2.2.2.1 Walleye Pollock

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

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

Early Juveniles: EFH for early juvenile walleye pollock is the 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), middle (50 to 100 m), and outer (100 to 200 m) shelf throughout the BSAI.

Relative abundance of age 1 pollock is used as an early indicator of year class strength and is highly variable (presumably due to survival factors and differential availability between years) , as depicted in Figures E-6 and E-13.

Late Juveniles: EFH for late juvenile walleye pollock is the 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), middle (50 to 100 m), and outer (100 to 200 m) shelf throughout the BSAI. Substrate preferences, if they exist, are unknown, as depicted in Figures E-6 and E-13.

Adults: EFH for adult walleye pollock is the habitat-related density area for this life stage, located in the lower and middle portion of the water column along the entire shelf (~10 to 200 m) and slope (200 to 1,000 m) throughout the BSAI. Substrate preferences, if they exist, are unknown, as depicted in Figures E-1 though E-4 and E-8 through E-11.

4.2.2.2.2 Pacific Cod

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

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

Early Juveniles: EFH for early juvenile Pacific cod is the habitat-related density area for this life stage, centered over the middle (50 to 100 m) EBS shelf between the Pribilof Islands and the Alaska Peninsula and broadly similar to the habitat-related density area for larval Pacific cod, but not extending as far north. The habitat-related density area of early juvenile Pacific cod in the AI is unknown, as depicted in Figures E-19 and E-25.

Late Juveniles: EFH for late juvenile Pacific cod is the habitat-related density area for this life stage, including nearly all of the EBS shelf (0 to 200 m) and upper slope (200 to 500 m), with highest abundances in the inshore portions of the central and southern domains of the EBS shelf, and broadly throughout the AI at depths up to 500 m, as depicted in Figures E-19 and E-25.

Adults: EFH for adult Pacific cod is the habitat-related density area for this life stage, including nearly all of the EBS shelf and slope, with highest abundances in the central and northern domains over the middle (50 to 100 m) and outer (100 to 200 m) shelf, and broadly throughout the AI at depths up to 500 m, as depicted in Figures E-15 through E-18 and E-21 through E-24.

4.2.2.2.3 Sablefish

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

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

Early Juveniles: No EFH description determined. Information is insufficient. Early juveniles have generally been observed in inshore water, bays, and passes, and on shallow shelf pelagic and demersal habitat, as depicted in Figures E-31 and E-36.

Late Juveniles: EFH for late juvenile sablefish is the general distribution area for this life stage, located in the lower portion of the water column, varied habitats, generally softer substrates,

and deep shelf gulleys along the slope (200 to 1,000 m) throughout the BSAI, as depicted in Figures E-31 and E-36.

Adults: EFH for adult sablefish is the general distribution area for this life stage, located in the lower portion of the water column, varied habitats, generally softer substrates, and deep shelf gulleys along the slope (200 to 1,000 m) throughout the BSAI, as depicted in Figures E-27 through E-30 and E-32 through E-35.

4.2.2.2.4 Yellowfin Sole

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

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

Early Juveniles: EFH for early juvenile yellowfin sole is the general distribution area for this life stage, located in the lower portion of the water column within nearshore bays and along the inner (0 to 50 m), middle (50 to 100 m), and outer (100 to 200 m) shelf throughout the BSAI wherever there are soft substrates consisting mainly of sand. Upon settlement in nearshore areas, juveniles preferentially select sediment suitable for feeding on meiofaunal prey and burrowing for protection. Juveniles are separate from the adult population, remaining in shallow areas until they reach approximately 15 cm. Most likely are habitat generalists on abundant physical habitat, as depicted in Figure E-37.

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

Adults: EFH for adult yellowfin sole is the general distribution area for this life stage, located in the lower portion of the water column within nearshore bays and along the inner (0 to 50 m), middle (50 to 100 m), and outer (100 to 200 m) shelf throughout the BSAI wherever there are soft substrates consisting mainly of sand, as depicted in Figures E-39 through 42.

4.2.2.2.5 Greenland Turbot

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

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

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

Late Juveniles: EFH for late juvenile Greenland turbot is the 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), middle (50 to 100 m), and outer (100 to 200 m) shelf and upper slope (200 to

500 m) throughout the BSAI wherever there are softer substrates consisting of mud and sandy mud, as depicted in Figures E-48 and E-54.

Adults: EFH for late adult Greenland turbot is the habitat-related density area for this life stage, located in the lower and middle portion of the water column along the outer shelf (100 to 200 m), upper slope (200 to 500 m), and lower slope (500 to 1,000 m) throughout the BSAI wherever there are softer substrates consisting of mud and sandy mud, as depicted in Figures E-44 through E-47 and E-50 through E-53.

4.2.2.2.6 Arrowtooth Flounder

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

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

Early Juveniles: EFH for early juvenile arrowtooth flounder is the general distribution area for this life stage, located in demersal habitat of the inner (0 to 50 m) and middle (50 to 100 m) shelf, as depicted in Figures E-59 and E-65.

Late Juveniles: EFH for late juvenile arrowtooth flounder is the habitat-related density area for this life stage, located in the lower portion of the water column along the inner (0 to 50 m), middle (50 to 100 m), and outer (100 to 200 m) shelf and upper slope (200 to 500 m) throughout the BSAI wherever there are softer substrates consisting of gravel, sand, and mud, as depicted in Figures E- E-59 and E-65.

Adults: EFH for adult arrowtooth flounder is the habitat-related density area for this life stage, located in the lower portion of the water column along the inner (0 to 50), middle (50 to 100 m), and outer (100 to 200 m) shelf and upper slope (200 to 500 m) throughout the BSAI wherever there are softer substrates consisting of gravel, sand, and mud, as depicted in Figures E-55 through E-58 and E-61 through E-64.

4.2.2.2.7 Kamchatka Flounder

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

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

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

Late Juveniles: EFH for late juvenile Kamchatka flounder is the general distribution area for this life stage, located in the lower portion of the water column along the middle (50 to 100 m), and outer (100 to 200 m) shelf and upper slope (200 to 500 m) throughout the BSAI wherever there are softer substrates consisting of gravel, sand, and mud, as depicted in Figure E-71 and E-76.

Adults: EFH for adult Kamchatka flounder is the general distribution area for this life stage, located in the lower portion of the water column along the middle (50 to 100 m), and outer (100 to 200 m) shelf and slope waters down to 600 m throughout the BSAI wherever there are softer substrates consisting of gravel, sand, and mud, as depicted in Figure E-67 through E-70 and E-72 through E-75.

4.2.2.2.8 Northern Rock Sole

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

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

Early Juveniles: EFH for early juvenile northern rock sole is the general distribution area for this life stage, located in the lower portion of the water column along the inner (0 to 50 m), middle (50 to100 m), and outer (100 to 200 m) shelf throughout the BSAI wherever there are softer substrates consisting of sand, gravel, and cobble. Upon settlement in nearshore areas from 1-40 m deep, juveniles preferentially select sediment suitable for feeding on meiofaunal prey and burrowing for protection but may be prevented from settling inshore by the seasonal inner front. Juveniles are separate from the adult population, remaining in shallow areas until they reach approximately 15-20 cm. Most likely are habitat generalists on abundant physical habitat, as depicted in Figures E-81 and E-87.

Late Juveniles: EFH for late juvenile northern rock sole is the general distribution area for this life stage, located in the lower portion of the water column along the inner (0 to 50 m), middle (50 to100 m), and outer (100 to 200 m) shelf throughout the BSAI wherever there are softer substrates consisting of sand, gravel, and cobble, as depicted in Figures E-81 and E-87.

Adults: EFH for adult northern rock sole is the general distribution area for this life stage, located in the lower portion of the water column along the inner (0 to 50 m), middle (50 to 100 m), and outer (100 to 200 m) shelf throughout the BSAI wherever there are softer substrates consisting of sand, gravel, and cobble, as depicted in Figures E-77 through E-80 and E-83 through E-86.

4.2.2.2.9 Southern Rock Sole

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

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

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

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

Adults: EFH for adult Southern rock sole is the general distribution area for this life stage, located in the lower portion of the water column along the inner (0 to 50 m), middle (50 to 100 m), and outer (100 to 200 m) shelf throughout the BSAI wherever there are soft substrates consisting mainly of sand, gravel, and cobble as depicted in Figures E-257 through E-260 and E-263 through E-266.

4.2.2.2.10 Alaska Plaice

Eggs: EFH for Alaska plaice 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 BSAI in the spring, as depicted in Figure E-93.

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

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

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

Adults: EFH for adult Alaska plaice is the general distribution area for this life stage, located in the lower portion of the water column along the inner (0 to 50 m), middle (50 to 100 m), and outer (100 to 200 m) shelf throughout the BSAI wherever there are softer substrates consisting of sand and mud, as depicted in Figures E-89 through E-92.

4.2.2.2.11 Rex Sole

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

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

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

Late Juveniles: EFH for late juvenile rex sole is the habitat-related density area for this life stage, located in the lower portion of the water column along the inner (0 to 50 m), middle (50 to 100 m), and outer (100 to 200 m) shelf throughout the BSAI wherever there are substrates consisting of gravel, sand, and mud, as depicted in Figures E-100 and E-106.

Adults: EFH for adult rex sole is the habitat-related density area for this life stage, located in the lower portion of the water column along the inner (0 to 50 m), middle (50 to 100 m), and outer (100 to 200 m) shelf throughout the BSAI wherever there are substrates consisting of gravel, sand, and mud, as depicted in Figures E-95 through E-98 and E-101 through 104.

4.2.2.2.12 Dover Sole

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

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

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

Late Juveniles: EFH for late juvenile Dover sole is the habitat-related density area for this life stage, located in the lower portion of the water column along the middle (50 to 100 m), and outer (100 to 200 m) shelf and upper slope (200 to 500 m) throughout the BSAI wherever there are substrates consisting of sand and mud, as depicted in Figures E-110 and E-113.

Adults: EFH for adult Dover sole is the habitat-related density area for this life stage, located in the lower portion of the water column along the middle (50 to 100 m) and outer (100 to 200 m) shelf, and upper (200 to 500 m) and intermediate (500 to 1000 m) slope throughout the BSAI wherever there are substrates consisting of sand and mud, as depicted in Figures E-107 through E-109 and E-111 through E-112.

4.2.2.2.13 Flathead Sole

Eggs: EFH for flathead sole eggs is 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 BSAI in the spring, as depicted in Figures E-120 and E-125.

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

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

Late Juveniles: EFH for late juvenile flathead sole is the habitat-related density area for this life stage, located in the lower portion of the water column along the inner (0 to 50 m), middle (50 to 100 m), and outer (100 to 200 m) shelf throughout the BSAI wherever there are softer substrates consisting of sand and mud, as depicted in Figures E-114 and E-126.

Adults: EFH for adult flathead sole is the habitat-related density area for this life stage, located in the lower portion of the water column along the inner (0 to 50 m), middle (50 to 100 m), and outer (100 to 200 m) shelf throughout the BSAI wherever there are softer substrates consisting of sand and mud, as depicted in Figure E-116 through E-119 and E-121 through E-124.

4.2.2.2.14 Pacific Ocean Perch

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

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

Early Juveniles: EFH for early juvenile Pacific ocean perch is the general distribution area for this life stage, located throughout the water column along the entire shelf (0 to 200 m) , as depicted in Figures E-131 and E-137.

Late Juveniles: EFH for late juvenile Pacific ocean perch is the habitat-related density area for this life stage, located in the middle to lower portion of the water column along middle shelf (50 to 100 m), outer shelf (100 to 200 m), and upper slope (200 to 500 m) throughout the BSAI wherever there are substrates consisting of boulders, cobble, gravel, mud, sandy mud, or muddy sand, as depicted in Figures E-131 and E-137.

Adults: EFH for adult Pacific ocean perch is the habitat-related density area for this life stage, located in the lower portion of the water column along the outer shelf (100 to 200 m) and upper slope (200 to 500 m) throughout the BSAI wherever there are substrates consisting of cobble, gravel, mud, sandy mud, or muddy sand, as depicted in Figures E-127 through E-130 and E-133 through E-136.

4.2.2.2.15 Northern Rockfish

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

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

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

Late Juveniles: EFH for late juvenile northern rockfish is the 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 BSAI, wherever there are substrates of cobble and rock, as depicted in Figure E-147.

Adults: EFH for adult northern rockfish is the 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 BSAI wherever there are substrates of cobble and rock, as depicted in Figures E-139 through E-146.

4.2.2.2.16 Shortraker Rockfish

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

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

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) shelf and slope (200 to 3,000 m), as depicted in Figures E-152 and E-157.

Late Juveniles: EFH for late juvenile shortraker rockfish is the habitat-related density area for this life stage, located in the lower portion of the water column along the outer shelf (100 to 200 m) and upper slope (200 to 500 m) regions throughout the BSAI wherever there are substrates consisting of mud, sand, sandy mud, muddy sand, rock, cobble, and gravel, Figures E-152 and E-157.

Adults: EFH for adult shortraker rockfish is the habitat-related density area for this life stage, located in the lower portion of the water column along the outer shelf (100 to 200 m) and upper slope (200 to 500 m) regions throughout the BSAI wherever there are substrates consisting of mud, sand, sandy mud, muddy sand, rock, cobble, and gravel, as depicted in Figures E-148 through E-151 and E-153 through E-156.

4.2.2.2.17 Blackspotted Rockfishes

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

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

Early Juveniles: EFH for early juvenile 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) shelf and slope (200 to 3,000 m), as depicted in Figures E-158 and E-161.

Late Juveniles: EFH for late juvenile blackspotted/rougheye rockfish is the general distribution area for this life stage, located in the lower portion of the water column along the upper slope (200 to 500 m) regions throughout the BSAI wherever there are substrates consisting of mud, sand, sandy mud, muddy sand, rock, cobble, and gravel, as depicted in Figure E-158 and E-161.

Adults: EFH for adult blackspotted/rougheye rockfish is the habitat-related density area for this life stage, located in the lower portion of the water column along the upper slope (200

to 500 m) regions throughout the BSAI wherever there are substrates consisting of mud, sand, sandy mud, muddy sand, rock, cobble, and gravel, as depicted in Figure E-159 and E-160.

4.2.2.2.18 Rougheye Rockfishes

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

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

Early Juveniles: EFH for early juvenile 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) shelf and slope (200 to 3,000 m), as depicted in Figures E-166 and E-171.

Late Juveniles: EFH for late juvenile blackspotted/rougheye rockfish is the general distribution area for this life stage, located in the lower portion of the water column along the upper slope (200 to 500 m) regions throughout the BSAI wherever there are substrates consisting of mud, sand, sandy mud, muddy sand, rock, cobble, and gravel, as depicted in Figure E-166.

Adults: EFH for adult blackspotted/rougheye rockfish is the habitat-related density area for this life stage, located in the lower portion of the water column along the upper slope (200 to 500 m) regions throughout the BSAI wherever there are substrates consisting of mud, sand, sandy mud, muddy sand, rock, cobble, and gravel, as depicted in Figures E-162 through E-165 and E-167 through E-170.

4.2.2.2.19 Yelloweye Rockfish

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

Larvae: 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.

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

Dusky Rockfish

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

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

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

Late Juveniles: EFH for late juvenile dusky rockfish is the 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) and upper slope (200 to 500 m) throughout the BSAI wherever there are substrates of cobble, rock, and gravel, as depicted in Figure E-180.

Adults: EFH for adult dusky rockfish is the 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) and upper slope (200 to 500 m) throughout the BSAI wherever there are substrates of cobble, rock, and gravel, as depicted in Figure E-172 through E-175 and E-176 through 179.

4.2.2.2.20 Thornyhead Rockfish (Shortspine)

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

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

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

Late Juveniles: EFH for late juvenile thornyhead rockfish is the habitat-related density area for this life stage, located in the lower portion of the water column along the middle and outer shelf (50 to 200 m) and upper to lower slope (200 to 1,000 m) throughout the BSAI wherever there are substrates of mud, sand, rock, sandy mud, muddy sand, cobble, and gravel, as depicted in Figures E-181 and E-190.

Adults: EFH for adult thornyhead rockfish is the habitat-related density area for this life stage, located in the lower portion of the water column along the middle and outer shelf (50 to 200 m) and upper to lower slope (200 to 1,000 m) throughout the BSAI wherever there are substrates of mud, sand, rock, sandy mud, muddy sand, cobble, and gravel, as depicted in Figure E-182 through E-189.

4.2.2.2.21 Atka Mackerel

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

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

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

Late Juveniles: EFH for late juvenile Atka mackerel is the general distribution area for this life stage, located in the entire water column, from sea surface to the sea floor, along the inner (0 to 50 m), middle (50 to 100 m), and outer shelf (100 to 200 m) throughout the BSAI wherever there are substrates of gravel and rock and in vegetated areas of kelp, as depicted in Figure E-201.

Adults: EFH for adult Atka mackerel is the habitat-related density area for this life stage, located in the entire water column, from sea surface to the sea floor, along the inner (0 to 50 m), middle (50 to 100 m), and outer shelf (100 to 200 m) throughout the BSAI wherever there are substrates of gravel and rock and in vegetated areas of kelp. Habitat-related densities of Atka mackerel are available, usually at depths less than 200 m and generally over rough, rocky and uneven bottom near areas where tidal currents are swift, as depicted in Figure E-192 through E-199.

4.2.2.2.22 Bigmouth Sculpins

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

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

Juveniles: EFH for juvenile bigmouth sculpin is the habitat-related density area for this life stage, located in the deeper waters offshore (100 and 300m) in the Bering Sea and Aleutian Islands, as depicted in Figures E-206 and E-211.

Adults: EFH for adult bigmouth sculpins is the habitat-related density area for this life stage, located in the lower portion of the water column along the inner (0 to 50 m), middle (50 to 100 m, and outer shelf (100 to 200 m) and portions of the upper slope (200 to 500 m) throughout the BSAI wherever there are substrates of rock, sand, mud, cobble, and sandy mud, as depicted in Figures E-202 through E-205 and E-207 through E-210.

4.2.2.2.23 Great Sculpins

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

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

Juveniles: EFH for juvenile great sculpin is the habitat-related density area for this life stage, located in pelagic waters along the entire shelf (0 to 200 m) wherever there are substrates of sand and muddy/sand bottoms, as depicted in Figures E-212 and E-220.

Adults: EFH for adult great sculpins is the habitat-related density area for this life stage, located in the lower portion of the water column along the inner (0 to 50 m), middle (50 to 100 m, and outer shelf (100 to 200 m) and portions of the upper slope (200 to 500 m) throughout the BSAI wherever there are substrates of rock, sand, mud, cobble, and sandy mud, as depicted in Figures E-213 through E-219.

4.2.2.2.24 Alaska Skate

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

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

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

Late Juveniles: EFH for late juvenile skates is the habitat-related density area for this life stage, located in the lower portion of the water column on the shelf (0 to 200 m) and the upper slope (200 to 500 m) throughout the BSAI wherever there are of substrates of mud, sand, gravel, and rock, as depicted in Figures E-225 and E-232.

Adults: EFH for adult skates is the habitat-related density area for this life stage, located in the lower portion of the water column on the shelf (0 to 200 m) and the upper slope (200 to 500 m) throughout the BSAI wherever there are of substrates of mud, sand, gravel, and rock, as depicted in Figure E-221 through E-224 and E-226 through E-231.

4.2.2.2.25 Aleutian Skate

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

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

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

Late Juveniles: EFH for late juvenile skates is the habitat-related density area for this life stage, located in the lower portion of the water column on the shelf (0 to 200 m) and the upper slope (200 to 500 m) throughout the BSAI wherever there are of substrates of mud, sand, gravel, and rock, as depicted in Figures E-237 and E-242.

Adults: EFH for adult skates is the habitat-related density area for this life stage, located in the lower portion of the water column on the shelf (0 to 200 m) and the upper slope (200 to 500 m) throughout the BSAI wherever there are of substrates of mud, sand, gravel, and rock, as depicted in Figures E-233 though E-236 and E-238 through E-241.

4.2.2.2.26 Bering Skate

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

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

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

Late Juveniles: EFH for late juvenile skates is the habitat-related density area for this life stage, located in the lower portion of the water column on the shelf (0 to 200 m) and the upper slope (200 to 500 m) throughout the BSAI wherever there are of substrates of mud, sand, gravel, and rock, as depicted in Figures E-244 and E-246.

Adults: EFH for adult skates is the habitat-related density area for this life stage, located in the lower portion of the water column on the shelf (0 to 200 m) and the upper slope (200 to 500 m) throughout the BSAI wherever there are of substrates of mud, sand, gravel, and rock, as depicted in Figures E-243 and E-245.

4.2.2.2.27 Mud Skate

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

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

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

Late Juveniles: EFH for late juvenile skates is the habitat-related density area for this life stage, located in the lower portion of the water column on the shelf (0 to 200 m) and the upper slope (200 to 500 m) throughout the BSAI wherever there are of substrates of mud, sand, gravel, and rock, as depicted in Figures E-251 and E-256.

Adults: EFH for adult skates is the habitat-related density area for this life stage, located in the lower portion of the water column on the shelf (0 to 200 m) and the upper slope (200 to 500 m) throughout the BSAI wherever there are of substrates of mud, sand, gravel, and rock, as depicted in Figures E-247 through E-250 and E-252 through E-255.

4.2.2.2.28 Octopus

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

Larvae: 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.

Adults: EFH for adult octopus is the habitat-related density area for this life stage, located in demersal habitat throughout the intertidal, subtidal, shelf (0 to 200 m), and slope (200 to 2,000 m), as depicted in Figures E-268 through E-275.

4.2.2.2.29 Yellow Irish Lord

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

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

Juveniles: EFH for juvenile yellow Irish lord is the habitat-related density area for this life stage, located from the subtidal areas near shore to the edge of the continental shelf (0 to 200 m) throughout the BSAI, as depicted in Figures E-280 and E-285.

Adults: EFH for adult yellow Irish lord is the habitat-related density area for this life stage, located from the subtidal areas near shore to the edge of the continental shelf (0 to 200 m) throughout the BSAI, as depicted in Figures E-276 through E-279 and E-281 through E-284.

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

From 2014 through 2017, the Council undertook a 5-year review of EFH for the Council's managed species, which was documented in the Final EFH 5-year Review Summary Report (Simpson et al. 2017). The review evaluated new information on EFH, including EFH descriptions and identification, and fishing and non-fishing activities that may adversely affect EFH. The review also assessed information gaps and research needs, and identified whether any revisions to EFH are needed or suggested. The Council identified various elements of the EFH descriptions meriting revision, and approved omnibus amendments 115/105/49/13/2 to the BSAI Groundfish FMP, the GOA Groundfish FMP, the BSAI King and Tanner Crab FMP, the Scallop FMP, Arctic FMP, and the Salmon FMP, respectively, in 2018.

5. In Section 6.3, insert the following reference for NPFMC and NMFS 2017 alphabetically.

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, 115p. ftp://ftp.library.noaa.gov/noaa_documents.lib/NMFS/TM_NMFS_AFKR/TM_NMFS_FAKR_15.pdf.

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

Amendment 115, implemented on _____ *(insert effective date)*_____, revised Amendment 98:

1. Revise EFH description and identification by species, and update life history, distribution, and habitat association information, based on the 2016 EFH 5-year review.
2. Update the model used to determine fishing effects on EFH, and description of EFH impacts from fishing activities.
3. Update description of EFH impacts from non-fishing activities, and EFH conservation recommendations for non-fishing activities.

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

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

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

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

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

12. ***In alphabetical order, Add "GAM" from the list of acronyms used in the FMP (page ES-ix), with the definition "general additive model"***

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 FMP. Each species or species group is described individually, however, summary tables that denote habitat associations (Table D-1), reproductive traits (Table D-2), and predator and 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

BCH	beach (intertidal)
ICS	inner continental shelf (1-50 m)
MCS	middle continental shelf (50-100 m)
OCS	outer continental shelf (100-200 m)
USP	upper slope (200-1000 m)
LSP	lower slope (1000-3000 m)
BSN	basin (>3000 m)
BAY	nearshore bays, with depth if appropriate (e.g., fjords)
IP	island passes (areas of high current), with depth if appropriate

Water column

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

General

U	unknown
NA	not applicable

Bottom Type

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

Oceanographic Features

UP	upwelling
G	gyres
F	fronts
CL	thermo- or pycnocline
E	edges

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

BSAI Groundfish		Nearshore				Shelf			Slope						Stratum Reference						
Species	Life Stage	Freshwater	Estuarine	Intertidal	Subtidal	Inner: 1-50m	Middle: 51-100m	Outer: 101-200m	Upper: 201-300m	301-500m	Intermediate: 501-700m	701-1000m	Lower: 1001-3000m	Basin: >3000m	Shallows	Island Pass	Bay/Fjord	Bank	Flat	Edge	Gully
Walleye Pollock	M						x	x	x	x				x		x	x	x	x	x	x
	J					x	x	x								x	x	x	x	x	x
	L						x	x								x	x	x	x	x	x
	E						x	x	x	x	x	x	x	x		x	x	x	x	x	x
Pacific Cod	M					x	x	x	x	x					x	x	x	x	x	x	x
	LJ					x	x	x	x	x					x	x	x	x	x	x	x
	EJ				x	x	x	x							x	x	x	x	x	x	x
	L					x	x	x							x	x	x	x	x	x	x
	E																				
Sablefish	M								x	x	x	x	x				x				x
	LJ							x	x	x	x						x				x
	EJ					x	x	x									x				
	L						x	x	x	x	x	x	x	x							
	E								x	x	x	x	x	x							
Yellowfin Sole	M					x	x														
	LJ					x	x														
	EJ					x															
	L					x	x														
	E					x	x														
Greenland Turbot	M							x	x	x	x										
	LJ					x	x														
	EJ																				
	L					x	x	x	x	x											
	E					x	x	x	x	x											
Arrowtooth Flounder	M					x	x	x	x	x	x										
	LJ					x	x	x													
	EJ					x	x														
	L					x	x	x	x	x											
	E					x	x	x	x	x											
Kamchatka Flounder	M						x	x	x	x	x	x									
	LJ						x	x	x	x											
	EJ						x	x													
	L						x	x	x	x											
	E						x	x	x	x											
Northern Rock Sole	M					x	x	x													
	LJ					x	x														
	EJ					x															
	L					x	x	x													
	E					x	x	x													
Flathead Sole	M					x	x	x	x												
	LJ					x	x	x													
	EJ					x	x														
	L					x	x	x													
	E					x	x	x													

BSAI Groundfish		Location							Physical Oceanography					Substrate												
Species	Life Stage	Surafce	Near surface	Semi-demersal	Demersal	Pelagic: 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
Walleye Pollock	M		x	x	x	x	x		x	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	
	J		x	x	x	x			x	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	
	L		x	x	x	x			x	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	
	E		x	x		x			x	x	x	x														
Pacific Cod	M			x	x										x	x	x	x	x	x	x	x	x	x	x	
	LJ			x	x										x	x	x	x	x	x	x	x	x	x	x	
	EJ			x	x										x	x	x	x	x	x	x	x	x	x		
	L					x																				
	E				x																					
Sablefish	M				x				x						x	x	x								x	x
	LJ				x				x						x	x	x								x	x
	EJ				x	x	x		x																	
	L	x	x						x																	
	E					x	x		x																	
Yellowfin Sole	M				x										x	x				x						
	LJ				x										x	x				x						
	EJ				x										x	x				x						
	L					x																				
	E					x																				
Greenland Turbot	M				x										x	x	x		x							
	LJ				x										x	x			x							
	EJ				x										x	x			x							
	L					x					x															
	E					x																				
Arrowtooth Flounder	M				x										x	x	x			x						
	LJ				x										x	x	x			x						
	EJ				x										x	x	x			x						
	L					x					x															
	E				x																					
Kamchatka Flounder	M				x										x	x	x			x						
	LJ				x										x	x	x			x						
	EJ				x										x	x	x			x						
	L						x																			
	E																									
Northern Rock Sole	M				x										x	x				x						
	LJ				x										x	x				x						
	EJ				x										x	x				x						
	L					x					x															
	E				x																					
Flathead Sole	M				x								x		x	x	x			x		x				
	LJ				x										x	x	x			x		x				
	EJ				x											x	x									
	L					x					x									x						
	E					x																				

BSAI Groundfish		Structure										Community Associations												Oceano-graphic Properties			
Species	Life Stage	Bars	Sinks	Slumps\Rockfalls\Debris	Channels	Ledges	Pinnacles	Seamounts	Reefs	Vertical Walls	Man-made	Algal Cover	Anenomes	Enchinoderms	Soft Coral	Hard Coral	Mollusca	Drift Algae\Kelp	Kelp	Polychaetes	Sea Grasses	Sea Onions	Tunicates	Temperature (Celsius)	Salinity (ppt)	Oxygen Conc (ppm)	Life Stage
Walleye Pollock	M																							2-10			M
	J																							**2-10**			J
	L																										L
	E																										E
Pacific Cod	M																										M
	LJ																				x						LJ
	EJ																										EJ
	L																										L
	E																							**3-6**	13-23	**2-3**	E
Sablefish	M							x																			M
	LJ																										LJ
	EJ																										EJ
	L																										L
	E																										E
Yellowfin Sole	M																										M
	LJ																										LJ
	EJ																										EJ
	L																										L
	E																										E
Greenland Turbot	M																										M
	LJ																										LJ
	EJ																										EJ
	L																										L
	E																										E
Arrowtooth Flounder	M																										M
	LJ																										LJ
	EJ																										EJ
	L																										L
	E																										E
Kamchatka Flounder	M																										M
	LJ																										LJ
	EJ																										EJ
	L																										L
	E																										E
Northern Rock Sole	M																										M
	LJ																										LJ
	EJ																										EJ
	L																										L
	E																										E
Flathead Sole	M																										M
	LJ																										LJ
	EJ																										EJ
	L																										L
	E																										E

Table D.1 (continued) Summary of habitat associations for BSAI groundfish.

BSAI Groundfish		Nearshore				Shelf			Slope						Stratum Reference							Location							Physical Oceano-graphy					Substrate													Structure								Community Associations											Oceano-graphic Properties			
						Inner	Middle	Outer	Upper		Interme diate		Lower	Basin											Pelagic																																												
Species	Life Stage	Freshwater	Estuarine	Intertidal	Subtidal	1-50m	51-100m	101-200m	201-300m	301-500m	501-700m	701-1000m	1001-3000m	>3000m	Shallows	Island Pass	Bay/Fjord	Bank	Flat	Edge	Gully	Surafce	Near surface	Semi-demersal	Demersal	1-200m (epi)	201-1000m (meso)	> 1000m (bathy)	Upwelling areas	Gyres	Thermo/pycnocline	Fronts	Edges (ice, bath)	Organic Debris	Mud	Sand	Gravel	Mud sand	Mud gravel	Sand mud	Gravel mud	Gravel sand	Gravel sand mud	Gravel mud sand	Cobble	Rock	Bars	Sinks	Slumps\Rockfalls\Debris	Channels	Ledges	Pinnacles	Seamounts	Reefs	Vertical Walls	Man-made	Algal Cover	Anenomes	Enchinoderms	Soft Coral	Hard Coral	Mollusca	Drift Algae\Kelp	Kelp	Polychaetes	Sea Grasses	Sea Onions	Tunicates	Temperature (Celsius)	Salinity (ppt)	Oxygen Conc (ppm)	Life Stage
Alaska Plaice	M					x	x	x																	x									x	x			x																																M
	LJ					x	x	x																	x									x	x			x																																LJ
	EJ					x	x																		x									x	x			x																																EJ
	L					x	x	x																		x				x																																						L
	E					x	x	x																		x																																									E
Rex Sole	M					x	x	x	x	x															x									x	x			x																																M
	LJ					x	x	x	x																x									x	x			x																																LJ
	EJ					x	x																		x									x	x			x																																EJ
	L					x	x	x	x																	x									x	x																																		L
	E					x	x	x	x																	x																																										E
Dover Sole	M					x	x	x	x	x	x	x													x									x	x				x																														M
	LJ					x	x	x	x	x															x									x	x				x																														LJ
	EJ					x	x																		x									x	x				x																														EJ
	L					x	x	x	x	x																x				x																																						L
	E					x	x	x	x	x																x																																									E
Pacific Ocean Perch	M							x	x	x								x	x	x	x			x	x	x			x							x								x	x														x										M
	LJ					x	x	x	x																																																									LJ
	EJ					x	x	x																x	x	x	x	x	x							x								x	x																								EJ
	L																						x	x		x	x	x	x																																							L
Northern Rockfish	M						x	x										x							x																			x	x																							M
	LJ						x	x										x	x						x																			x	x																							LJ
	EJ																									x																																									EJ
	L																																																																		L
Shortraker Rockfish	M								x	x										x					x							x		x	x	x	x	x	x	x	x	x	x	x								x								x									M
	LJ																								x																																										LJ
	EJ						x	x	x	x	x	x	x	x									x																																												EJ
	L																										x																																								L
Blackspotted/ Rougheye Rockfish	M								x	x										x					x							x		x	x	x	x	x	x	x	x	x	x	x							x								x									M
	LJ																								x																																										LJ
	EJ						x	x	x	x	x	x	x	x									x																																												EJ
	L																									x																																									L
Light Dusky Rockfish	M							x	x									x		x	x				x											x								x	x																							M
	LJ						x	x										x		x					x																																				x						LJ
	EJ																																																																		EJ
	L																																																																		L
Thornyhead Rockfish	M								x	x	x	x	x												x											x								x	x							x																	M
	LJ						x	x	x																x											x									x																							LJ
	EJ																									x																																									EJ
	L																									x																																									L
	E																									x																																									E
Atka Mackerel	M					x	x	x	x							x							x	x	x				x			x	x			x	x								x	x																						3-5	>17		M
	J																					x	x																																												J
	L																					x	x																																												L
	E					x	x	x								x									x											x								x	x																						3-10			E

Table D.1 (continued) Summary of habitat associations for BSAI groundfish.

BSAI Groundfish		Nearshore				Shelf			Slope						Stratum Reference							Location							Physical Oceano-graphy					Substrate														Structure								Community Associations													Oceano-graphic Properties			
Species	Life Stage	Freshwater	Estuarine	Intertidal	Subtidal	Inner 1-50m	Middle 51-100m	Outer 101-200m	Upper 201-300m	301-500m	Intermediate 501-700m	701-1000m	Lower 1001-3000m	Basin >3000m	Shallows	Island Pass	Bay/Fjord	Bank	Flat	Edge	Gully	Surafce	Near surface	Semi-demersal	Demersal	Pelagic 1-200m (epi)	201-1000m (meso)	> 1000m (bathy)	Upwelling areas	Gyres	Thermo/pycnocline	Fronts	Edges (ice, bath)	Organic Debris	Mud	Sand	Gravel	Mud sand	Mud gravel	Sand mud	Gravel mud	Gravel sand	Gravel sand mud	Gravel mud sand	Cobble	Rock	Bars	Sinks	Slumps\Rockfalls\Debris	Channels	Ledges	Pinnacles	Seamounts	Reefs	Vertical Walls	Man-made	Algal Cover	Anenomes	Enchinoderms	Soft Coral	Hard Coral	Mollusca	Drift Algae\Kelp	Kelp	Polychaetes	Sea Grasses	Sea Onions	Tunicates	Temperature (Celsius)	Salinity (ppt)	Oxygen Conc (ppm)	Life Stage
Squids	M				x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x																																												
	LJ																																																																							
	EJ																																																																							
	L																																																																							
	E																																																																							
Octopuses	M			x	x	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x				x	x	x																																												
	LJ																																																																							
	EJ																																																																							
	L																																																																							
	E																																																																							
Sharks	M			x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x							x	x	x	x	x	x	x	x	x	x	x	x																														
	LJ																																																																							
	EJ																																																																							
	L																																																																							
	E																																																																							
Sculpins	M			x	x	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x			x	x																											x																					
	LJ																																																																							
	EJ																																																																							
	L																																																																							
	E																																																																							
Skates	M			x	x	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x			x	x																																																
	LJ																																																																							
	EJ																																																																							
	L																																																																							
	E							x	x																																																															
Eulachon	M						x	x	x								x									x			x		x	x																																									
	LJ						x	x																		x			x		x	x																																									
	EJ					x	x																			x			x		x																																										
	L	x	x			x	x										x						x																																															
	E	x																																																																					
Capelin	M						x	x									x									x			x		x	x																																									
	LJ						x	x																		x			x		x	x																																								
	EJ					x	x																			x			x		x																																									
	L		x			x	x										x						x																																															
	E			x											x																					x	x				x																															
Sand Lance	M			x	x	x									x		x					x	x	x	x	x									x	x				x																															
	LJ			x	x	x									x		x					x	x	x	x	x									x	x				x																															
	EJ		x		x	x									x		x					x	x			x																																												
	L		x			x									x		x					x	x			x																																												
	E			x													x																																																				

Life Stage
M
LJ
EJ
L
E

Table D.2 Summary of biological associations for BSAI groundfish.

BSAI Groundfish	Life Stage	Reproductive Traits																											
		Age at Maturity				Fertilization/ Egg Development					Spawning Behavior							Spawning Season											
		Female		Male																									
Species		50%	100%	50%	100%	External	Internal	Oviparous	Aplacental	Viviparous	Batch Spawner	Broadcast Spawner	Egg Case Deposition	Nest Builder	Egg/Young Guarder	Egg/Young Bearer		January	February	March	April	May	June	July	August	September	October	November	December
Walleye Pollock	M	3-4		3-4		x						x							x	x	x	x							
Pacific Cod	M	5	11	5	11	x						x							x	x	x								
Sablefish	M	57-61cm				x						x						x	x	x									
Yellowfin Sole	M	10.5				x					x											x	x	x					
Greenland Turbot	M	5-10				x												x	x	x							x	x	x
Arrowtooth Flounder	M	5		4		x												x	x	x	x							x	x
Kamchatka Flounder	M	10		10		x												x	x	x								x	x
Northern Rock Sole	M	9				x					x							x	x	x									
Flathead Sole	M	9.7				x					x							x	x	x	x								
Alaska Plaice	M	6-7				x														x	x	x							
Rex Sole	M	35cm				x													x	x	x	x	x	x					
Dover Sole	M	33cm				x												x	x	x	x	x	x	x	x				
Pacific Ocean Perch	M	10.5					x			x	x								x	x	x	x							
Northern Rockfish	M	13					x			x	x																		
Shortraker Rockfish	M						x			x	x								x	x	x	x	x	x	x				
Blackspotted/Rougheye Rockfish	M						x			x	x							x	x	x	x								
Thornyhead Rockfish	M	12									x								x				x						
Light Dusky Rockfish	M	11					x			x	x																		
Atka Mackerel	M	3.6		3.6		x					x			x	x								x	x	x	x	x		
Squid	M						x				x																		
Octopus	M						x				x			x	x														
Sharks	M	35		21			x	x	x	x			x			x		x	x	x						x	x	x	x
Sculpins	M					x									x														
Skates	M						x	x					x																
Eulachon	M	3	5	3	5	x		x			x										x	x	x						
Capelin	M	2	4	2	4	x		x			x											x	x	x	x				
Sand Lance	M	1	2	1	2	x		x			x							x	x									x	x

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

Predator to

BSAI Groundfish Species	Life Stage	Algae	Plants	Plankton	Zooplankton	Diatoms	Sponges	Eusphausiid	Hydroids	Amphipoda	Copepods	Starfish	Polychaetes	Squid	Philodae (gunnels)	Bi-valves	Mollusks	Crustaceans	Ophiuroids (brittle stars)	Shrimps, mysidacae	Sand lance	Osmerid (eulachon)	Herring	Myctophid (lantern fishes)	Cottidae (sculpins)	Arrowtooth	Rockfish	Salmon	Pacific cod	Pollock	Halibut
Walleye Pollock	M				x			x			x			x						x	x	x	x	x		x			x	x	x
	LJ				x			x			x			x						x	x	x	x	x		x			x	x	x
	EJ				x			x			x									x	x	x									
	L				x			x			x																				
	E																														
Pacific Cod	M				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
	LJ				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
	EJ				x			x		x	x		x	x		x	x	x	x	x	x		x	x	x	x	x		x	x	x
	L																														
	E																														
Sablefish	M							x	x	x	x		x	x				x		x		x	x		x	x		x	x	x	
	LJ							x	x	x	x		x	x				x		x		x	x		x	x		x	x	x	
	EJ							x		x	x		x	x	x			x		x			x					x			
	L				x						x																				
	E																														
Yellowfin Sole	M							x		x			x			x		x		x					x					x	
	LJ							x		x			x			x		x		x					x						
	EJ				x																										
	L	x		x																											
	E																														
Greenland Turbot	M												x					x	x	x			x	x						x	
	LJ																														
	EJ				x																										
	L	x		x																											
	E																														
Arrowtooth Flounder	M												x	x				x	x	x			x	x						x	
	LJ												x					x	x	x			x	x						x	
	EJ				x																										
	L	x		x																											
	E																														
Kamchatka Flounder	M							x		x			x	x				x		x										x	
	LJ							x		x			x					x		x											
	EJ				x																										
	L	x		x																											
	E																														
Northern Rock Sole	M									x			x			x	x														
	LJ									x			x			x	x														
	EJ				x																										
	L	x		x																											
	E																														

Prey of

BSAI Groundfish Species	Life Stage	Jellyfish	Starfish	Chaetognaths (arrowworms)	Crab	Herring	Salmon	Pollock	Pacific cod	Ling cod	Rockfish	Rock Sole	Flathead Sole	Yellowfin sole	Arrowtooth flounder	Hailbut	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	Terrerstrial Mammals
Walleye Pollock	M								x						x	x	x	x	x	x											
	LJ							x	x						x	x		x	x	x				x			x	x	x		
	EJ							x	x						x	x		x	x	x				x			x	x	x		
	L							x	x						x	x								x			x	x	x		
	E																														
Pacific Cod	M															x	x	x		x		x	x	x							
	LJ								x						x	x	x	x		x		x	x	x							
	EJ							x	x						x	x	x	x		x		x	x	x				x			
	L							x	x						x																
	E																														
Sablefish	M																														
	LJ						x									x									x						
	EJ																														
	L																														
	E																														
Yellowfin Sole	M																														
	LJ								x							x															
	EJ								x							x															
	L																														
	E																														
Greenland Turbot	M																														
	LJ																														
	EJ							x	x					x																	
	L																														
	E																														
Arrowtooth Flounder	M																														
	LJ							x	x																						
	EJ																														
	L																														
	E																														
Kamchatka Flounder	M																														
	LJ							x	x						x	x															
	EJ																														
	L																														
	E																														
Northern Rock Sole	M																														
	LJ							x	x					x		x															
	EJ																														
	L																														
	E																														

Table D.3 (continued) Summary of predator and prey associations for BSAI groundfish.

BSAI Groundfish	Predator to																														
Species	Life Stage	Algae	Plants	Plankton	Zooplankton	Diatoms	Sponges	Eusphausiid	Hydroids	Amphipoda	Copepods	Starfish	Polychaetes	Squid	Philodae (gunnels)	Bi-valves	Mollusks	Crustaceans	Ophiuroids (brittle stars)	Shrimps, mysidacae	Sand lance	Osmerid (eulachon)	Herring	Myctophid (lantern fishes)	Cottidae (sculpins)	Arrowtooth	Rockfish	Salmon	Pacific cod	Pollock	Halibut
Flathead Sole	M							x		x	x		x			x	x	x	x		x	x								x	
	LJ							x		x	x		x			x	x	x	x											x	
	EJ				x								x			x			x											x	
	L	x		x																											
	E																														
Rex Sole	M							x		x			x					x													
	LJ							x		x			x					x													
	EJ																														
	L	x		x																											
	E																														
Dover Sole	M												x				x	x													
	LJ												x				x	x													
	EJ																														
	L	x		x																											
	E																														
Pacifc Ocean Perch	M							x																							
	LJ							x			x																				
	EJ																														
	L			x	x																										
Northern Rockfish	M							x			x																				
	LJ																														
	EJ																														
	L																														
Shortraker Rockfish	M													x						x				x							
	LJ																														
	EJ																														
	L																														
Blackspotted/ Rougheye Rockfish	M													x						x				x							
	LJ																														
	EJ																														
	L																														
Light Dusky Rockfis	M							x																							
	LJ																														
	EJ																														
	L																														
Thornyhead Rockfish	M																			x					x						
	LJ																														
	EJ																														
	L																														
	E																														
Atka Mackerel	M							x			x													x							
	J							x			x																				
	L										x																				
	E																														

BSAI Groundfish	Prey of																														
Species	Life Stage	Jellyfish	Starfish	Chaetognaths (arrowworms)	Crab	Herring	Salmon	Pollock	Pacific cod	Ling cod	Rockfish	Rock Sole	Flathead Sole	Yellowfin sole	Arrowtooth flounder	Hailbut	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	Terrerstrial Mammals
Flathead Sole	M								x				x		x	x															
	LJ																														
	EJ																														
	L																														
	E																														
Rex Sole	M								x						x																
	LJ								x						x																
	EJ																														
	L																														
	E																														
Dover Sole	M								x						x																
	LJ								x						x																
	EJ																														
	L																														
	E																														
Pacifc Ocean Perch	M															x															
	LJ																														
	EJ						x																								
	L																														
Northern Rockfish	M																														
	LJ																														
	EJ																														
	L																														
Shortraker Rockfish	M																														
	LJ																														
	EJ																														
	L																														
Blackspotted/ Rougheye Rockfish	M																														
	LJ																														
	EJ																														
	L																														
Light Dusky Rockfis	M																														
	LJ																														
	EJ																														
	L																														
Thornyhead Rockfish	M																														
	LJ																														
	EJ																														
	L																														
	E																														
Atka Mackerel	M								x						x	x		x	x	x	x			x							
	J																	x		x							x	x			
	L																														
	E																														

Table D.3 (continued) Summary of predator and prey associations for BSAI groundfish

Predator to

BSAI Groundfish Species	Life Stage	Algae	Plants	Plankton	Zooplankton	Diatoms	Sponges	Eusphausiid	Hydroids	Amphipoda	Copepods	Starfish	Polychaetes	Squid	Philodae (gunnels)	Bi-valves	Mollusks	Crustaceans	Ophiuroids (brittle stars)	Shrimps, mysidacae	Sand lance	Osmerid (eulachon)	Herring	Myctophid (lantern fishes)	Cottidae (sculpins)	Arrowtooth	Rockfish	Salmon	Pacific cod	Pollock	Halibut
Squid	M							x			x									x	x	x	x								
	LJ																														
	EJ																														
	L																														
	E																														
Octopus	M															x	x	x	x	x	x				x		x		x		x
	LJ																														
	EJ																														
	L																														
	E																														
Sharks	M							x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
	LJ																														
	EJ																														
	L																														
	E																														
Sculpins	M				x			x	x	x	x	x	x		x	x	x	x	x	x	x	x	x		x	x		x	x		
	LJ																														
	EJ																														
	L																														
	E																														
Skates	M									x		x	x					x		x	x		x		x	x	x	x	x	x	x
	LJ																														
	EJ																														
	L																														
	E																														
Eulachon	M				X			X			X																				
	LJ				X			X			X																				
	EJ				X			X			X																				
	L			X	X	X		X			X																				
	E																														
Capelin	M				X			X			X		X							X											
	LJ				X			X			X																				
	EJ				X			X			X																				
	L			X	X	X		X			X																				
	E																														
Sand Lance	M				X			X		X	X																				
	LJ				X			X		X	X																				
	EJ				X			X		X	X																				
	L			X	X	X		X		X	X																				
	E																														

Prey of

BSAI Groundfish Species	Life Stage	Jellyfish	Starfish	Chaetognaths (arrowworms)	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
Squid	M	x					x	x	x	x	x	x	x			x		x	x	x	x	x		x			x	x	x		
	LJ																														
	EJ																														
	L																														
	E																														
Octopus	M							x	x	x	x		x	x		x		x	x	x		x									
	LJ																														
	EJ																														
	L																														
	E																														
Sharks	M									x						x	x														
	LJ																														
	EJ																														
	L																														
	E																														
Sculpins	M										x		x		x	x		x	x	x	x	x									
	LJ																														
	EJ																														
	L																														
	E																														
Skates	M																														
	LJ																														
	EJ																														
	L																														
	E																														
Eulachon	M						X	X	X							X		X	X	X	X						X	X			X
	LJ						X	X	X							X		X	X	X	X						X	X			
	EJ					X	X	X	X							X															
	L					X	X	X	X							X															
	E																														
Capelin	M						X	X	X						X	X		X	X	X	X						X	X			
	LJ						X	X	X						X	X		X	X	X	X						X	X			
	EJ					X	X	X	X						X	X															
	L					X	X	X	X						X	X															
	E																														
Sand Lance	M						X	X	X						X	X		X	X	X	X						X	X			
	LJ						X	X	X						X	X		X	X	X	X						X	X			
	EJ					X	X	X	X						X	X															
	L					X	X	X	X						X	X															
	E																														

D.1 Walleye pollock (*Theragra calcogramma*)

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

D.1.1 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 Gulf of Alaska, 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: Gulf of Alaska, eastern Bering Sea, Aleutian Islands, and Aleutian Basin. For the contiguous sub-regions (i.e., areas adjacent to their management delineation), there appears to be some relationship among the eastern Bering Sea, Aleutian Islands, and Aleutian Basin stocks. Some strong year classes appear in all three places suggesting that pollock may expand from one area into the others or that discrete spawning areas benefit (in terms of recruitment) from similar environmental conditions. There appears to be stock separation between the Gulf of Alaska stocks and stocks to the north.

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

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

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

The Gulf of Alaska stock extends from southeast Alaska to the Aleutian Islands (170° W.), with the greatest abundance in the western and central regulatory areas (147° W. to 170° W.). Most of the information on pollock distribution in the Gulf of Alaska comes from annual winter echo-integration mid-water trawl surveys and regular (every two or three years) bottom trawl surveys. These surveys indicate that pollock are distributed throughout the shelf regions of the Gulf of Alaska at depths less than 300 m. The bottom

trawl data may not provide an accurate view of pollock distribution because a significant portion of the pollock biomass may be pelagic and unavailable to bottom trawls. The principal spawning location is in Shelikof Strait, but other spawning concentrations in the Shumagin Islands, the east side of Kodiak Island, and near Prince William Sound also contribute to the stock.

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 Gulf of Alaska, 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 Gulf of Alaska, 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 Gulf of Alaska, 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 further north on the shelf than weak year classes which appear to be more concentrated on the outer continental shelf. From age 2 to 3 pollock are primarily pelagic 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. A newly maturing pollock is around 40 cm.

The upper size limit for juvenile pollock in the eastern Bering Sea and Gulf of Alaska is about 38 to 42 cm. This is the size of 50 percent maturity. There is some evidence that this has changed over time.

D.1.2 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.1.3 Habitat and Biological Associations

Egg-Spawning: 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 Gulf of Alaska.

Larvae: Pelagic outer to mid-shelf region in Bering Sea. Pelagic throughout the continental shelf within the top 40 m in the Gulf of Alaska.

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.

Adults: Adults occur both pelagically and demersally on the outer and mid-continental shelf of the Gulf of Alaska, eastern Bering Sea and Aleutian Islands. In the eastern Bering Sea few adult pollock occur in waters shallower than 70 m. Adult pollock also occur pelagically in the Aleutian Basin. Adult pollock range throughout the Bering Sea in both the U.S. and Russian waters; however, the maps provided for this document detail distributions for pollock in the U.S. EEZ and the Aleutian Basin.

Habitat and Biological Associations: Walleye Pollock

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

D.1.4 Literature

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D.2 Pacific cod (Gadus macrocephalus)

D.2.1 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 34° N. latitude, with a northern limit of about 63° N. latitude. Adults are largely demersal and form aggregations during the peak spawning season, which extends approximately from February through April. Pacific cod eggs are demersal and adhesive. Eggs hatch in about 16 to 28 days. Pacific cod larvae undergo metamorphosis at about 25 to 35 mm. Juvenile Pacific cod start appearing in trawl surveys at a fairly small size, as small as 10 cm in the eastern Bering Sea. Pacific cod can grow to be more than a meter in length, with weights in excess of 10 kg. The instantaneous rate of natural mortality is currently estimated to be 0.34 in the Bering Sea and Aleutian Islands (BSAI). Approximately 50 percent of Pacific cod are mature by age 5 in the BSAI. The maximum recorded age of a Pacific cod is 17 years in the BSAI.

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

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

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

D.2.2 Relevant Trophic Information

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

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

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

D.2.3 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 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.

Juveniles: Juveniles occur mostly over the inner continental shelf at depths of 60 to150 m.

Adults: Adults occur in depths from the shoreline to 500 m. Average depth of occurrence tends to vary directly with age for at least the first few years of life, with mature fish concentrated on the outer continental shelf. Preferred substrate is soft sediment, from mud and clay to sand.

Habitat and Biological Associations: Pacific cod

Stage - EFH Level	Duration or Size	Diet/Prey	Season/ Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs	16-28 days	NA	winter–spring	U	D	M, SM, MS ,S	U	optimum 3–6°C optimum salinity 13–23 ppt
Larvae	U77-132 days, to 3.5 cm	NA	winter–spring	MCS, OCS	P	M, SM, MS, S	U	
Early Juveniles	to 9 cm	small calanoid copepods, mysids, gammarid amphipods	winter-spring	MCS, OCS	D	M, SM, MS, S	U	
Late Juveniles	to 46 cm	invertebrates, pollock, flatfish, fishery discards,	all year	ICS, MCS, OCS	D	M, SM, MS, S, CB, G, SAV	U	
Adults	>46 cm	pollock, flatfish, fishery discards, crab	spawning (Feb-Apr)	ICS, MCS, OCS	D	M, SM, MS, S, CB, G	U	
			non-spawning (May-Jan)	ICS, MCS, OCS				

D.2.4 Literature

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D.3 Sablefish (Anoplopoma fimbria)

D.3.1 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 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 leave the nearshore bays. One or two years later, they begin appearing on the continental shelf and move to their adult distribution as late juvniles or mature adults (Hanselman et al. 2015).

Pelagic ocean conditions appear to determine when strong young-of-the-year survival occurs. Water mass movements and temperature appear to be related to recruitment success (Sigler et al. 2001). Above-average young of the year survival was somewhat more likely with northerly winter currents and much less likely for years when the drift was southerlyRecruitment success also appeared related to water temperature and

the position of the North Pacific Polar Front in the fall before spawning (Shotwell et al. 2014). Another study linked recent recruitment variability to high chlorophyll *a* and juvenile pink salmon abundance in Southeast Alaska (Martinson et al.2015). 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).

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 myriad factors that determine their ability to grow, compete for food, avoid predation, and otherwise survive to adults. Perhaps increased competition from predators of juveniles such as the large increases of arrowtooth flounder, have limited the ability of the large year classes that, though abundant at the young-of-the-year stage, survive to adults.

The size at 50 percent maturity is 65 cm for males in the Bering Sea, and 67 cm for females. In the Aleutian Islands, size at 50 percent maturity is 61 cm for males, and 65 cm for females; and in the Gulf of Alaska, it is 57 cm for males, and 65 cm for females. At the end of the second summer (approximately 1.5 years old) they are 35 to 40 cm in length.

D.3.2 Relevant Trophic Information

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

Gao et al. (2004) studied stable isotopes in otoliths of juvenile sablefish from Oregon and Washington and found that as the fish increased in size they shifted from midwater prey to more benthic prey. In nearshore southeast Alaska, juvenile sablefish (20-45 cm) diets included fish such as Pacific herring and smelts and invertebrates such as krill, amphipods and polychaete worms (Coutré et al. 2015). In late summer, juvenile sablefish also consumed post-spawning pacific salmon carcass remnants in high volume revealing opportunistic scavenging (Coutré et al. 2015). Young-of-the-year sablefish are commonly found in the stomachs of salmon taken in the Southeast Alaska troll fishery during the late summer.

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 adult sablefish diet (Laidig et al. 1997). Off the southwest coast of Vancouver Island, euphausiids were the dominant prey (Tanasichuk 1997). Among other groundfish in the GOA, the diet of sablefish overlaps mostly with that of large flatfish, arrowtooth flounder and Pacific halibut (Yang and Nelson 2000).

Nearshore residence during their second year provide 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.3.3 Habitat and Biological Associations

The estimated productivity and sustainable yield of the combined GOA, Bering Sea, and Aleutian Islands sablefish stock have declined steadily since the late 1970s. This is demonstrated by a decreasing trend in recruitment and subsequent estimates of biomass reference points and the inability of the stock to rebuild

to the target biomass levels despite the decreasing level of the targets and fishing rates below the target fishing rate. There were episodic years of strong recruitment in the current physical regime starting in 1977. Since 2000, there has only been one year class that has exceeded the average level. This period of low-recruitment appears to be related to environmental conditions in the larval to settlement stages of the sablefish early life history.

Habitat and Biological Associations: Sablefish

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

D.3.4 Literature

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D.4 Yellowfin sole *(Limanda aspera)*

D.4.1 Life History and General Distribution

Yellowfin sole are distributed in North American waters from off British Columbia, Canada, (approximately latitude 49° N.) to the Chukchi Sea (about latitude 70° N.) and south along the Asian coast to about latitude 35° N. off the South Korean coast in the Sea of Japan. Adults exhibit a benthic lifestyle and occupy separate winter spawning and summertime feeding distributions on the eastern Bering Sea shelf. From over-winter grounds near the shelf margins, adults begin a migration onto the inner shelf in April or early May each year for spawning and feeding. A protracted and variable spawning period may range from as early as late May through August occurring primarily in shallow water. Fecundity varies with size and was reported to range from 1.3 to 3.3 million eggs for fish 25 to 45 cm long. Eggs have been found to the limits of inshore ichthyoplankton sampling over a widespread area to at least as far north as Nunivak Island. Larvae have been measured at 2.2 to 5.5 mm in July and 2.5 to 12.3 mm in late August and early September. The age or size at metamorphosis is unknown. Upon settlement in nearshore areas, juveniles preferentially select sediment suitable for feeding on meiofaunal prey and burrowing for protection. Juveniles are separate from the adult population, remaining in shallow areas until they reach approximately 15 cm. The estimated age of 50 percent maturity is 10.5 years (approximately 29 cm) for females based on samples collected in 1992 and 1993 and 10.14 from an updated study using 2012 collections. Natural mortality rate is believed to range from 0.12 to 0.16.

The approximate upper size limit of juvenile fish is 27 cm.

D.4.2 Relevant Trophic Information

Groundfish predators include Pacific cod, skates, and Pacific halibut, mostly on fish ranging from 7 to 25 cm standard length.

D.4.3 Habitat and Biological Associations

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

Adults: Summertime spawning and feeding on sandy substrates of the eastern Bering Sea shelf. Widespread distribution mainly on the middle and inner portion of the shelf, feeding mainly on bivalves, polychaete, amphipods, and echiurids. Wintertime migration to deeper waters of the shelf margin to avoid extreme cold water temperatures, feeding diminishes.

Habitat and Biological Associations: Yellowfin sole

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

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D.5 Greenland turbot (Reinhardtius hippoglossoides)

D.5.1 Life History and General Distribution

Greenland turbot has an amphiboreal distribution, occurring in the North Atlantic and North Pacific. In the North Pacific, species abundance is centered in the eastern Bering Sea and, secondly, in the Aleutian Islands. On the Asian side, they occur in the Gulf of Anadyr along the Bering Sea coast of Russia, in the Okhotsk Sea, around the Kurile Islands, and south to the east coast of Japan to northern Honshu Island (Hubbs and Wilimovsky 1964, Mikawa 1963, Shuntov 1965). Adults exhibit a benthic lifestyle, living in deep waters of the continental slope but are known to have a tendency to feed off the sea bottom. During their first few years as immature fish, they inhabit relatively shallow continental shelf waters (less than 200 m) until about age 4 or 5 before joining the adult population (200 to 1,000 m or more, Templeman 1973). Adults appear to undergo seasonal shifts in depth distribution moving deeper in winter and shallower in summer (Chumakov 1970, Shuntov 1965). Spawning is reported to occur in winter in the eastern Bering Sea and may be protracted starting in September or October and continuing until March with an apparent peak period in November to February (Shuntov 1965, Bulatov 1983). Females spawn relatively small numbers of eggs with fecundity ranging from 23,900 to 149,300 for fish 83 cm and smaller in the Bering Sea (D'yakov 1982).

Eggs and early larval stages are benthypelagic (Musienko 1970). In the Atlantic Ocean, larvae (10 to 18 cm) have been found in benthypelagic waters which gradually rise to the pelagic zone in correspondence to absorption of the yolk sac which is reported to occur at 15 to 18 mm with the onset of feeding (Pertseva-Ostroumova 1961). The period of larval development extends from April to as late as August or September (Jensen 1935) which results in an extensive larval drift and broad dispersal from the spawning waters of the continental slope. Metamorphosis occurs in August or September at about 7 to 8 cm in length at which time the demersal life begins. Juveniles are reported to be quite tolerant of cold temperatures to less than 0 °C (Hognestad 1969) and have been found on the northern part of the Bering Sea shelf in summer trawl surveys (Alton et al. 1988).

The age of 50 percent maturity is estimated to range from 5 to 10 years (D'yakov 1982, 60 cm used in stock assessment) and a natural mortality rate of 0.112 has been used in the most recent stock assessments (Barbeaux et al. 2015). The approximate upper size limit of juvenile fish is 59 cm.

D.5.2 Relevant Trophic Information

Groundfish predators include Pacific cod, pollock, and yellowfin sole, mostly on fish ranging from 2 to 5 cm standard length (probably age 0).

D.5.3 Habitat and Biological Associations

Larvae/Juveniles: Planktonic larvae for up to 9 months until metamorphosis occurs, usually with a widespread distribution inhabiting shallow waters. Juveniles live on the continental shelf until about age 4 or 5 feeding primarily on euphausiids, polychaetes, and small walleye pollock.

Adults: Inhabit continental slope waters with annual spring/fall migrations from deeper to shallower waters. In the Bering Sea diet consists of primarily walleye pollock, squid, crustaceans, and other miscellaneous fish species. In the Aleutian Islands although there is walleye pollock in the diet, there is a higher proportion of squid and Atka mackerel.

Habitat and Biological Associations: Greenland turbot

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

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D.6 Arrowtooth flounder (*Atheresthes stomias*)

D.6.1 Life History and General Distribution

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

Adults exhibit a benthic lifestyle and occupy separate winter and summer distributions on the eastern Bering Sea shelf. From over-winter grounds near the shelf margins and upper slope areas, adults begin a migration onto the middle and outer shelf in April or early May each year with the onset of warmer water temperatures. A protracted and variable spawning period may range from as early as September through March (Rickey 1994, Hosie 1976). Total fecundity may range from 250,000 to 2,340,000 oocytes (Zimmerman 1997). Larvae have been found from ichthyoplankton sampling over a widespread area of the eastern Bering Sea shelf in April and May and also on the continental shelf east of Kodiak Island during winter and spring (Waldron and Vinter 1978, Kendall and Dunn 1985). The age or size at metamorphosis is unknown. Juveniles are separate from the adult population, remaining in shallow areas until they reach the 10 to 15 cm range (Martin and Clausen 1995). The estimated age at 50 percent maturity is 7.6 years (47.6 cm) for females collected from the Bering Sea (Stark 2011). The natural mortality rate used in stock assessments differs by sex and is estimated at 0.2 for females and 0.35 to 0.37 for females (Turnock et al. 2009, Wilderbuer et al. 2010).

The approximate upper size limit of juvenile fish is 27 cm for males and 37 cm for females.

D.6.2 Relevant Trophic Information

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

D.6.3 Habitat and Biological Associations

Larvae/Juveniles: Planktonic larvae for at least 2 to 3 months until metamorphosis occurs; juveniles usually inhabit shallow areas until about 10 cm in length.

Adults: Widespread distribution mainly on the middle and outer portions of the continental shelf, feeding mainly on walleye pollock and other miscellaneous fish species when arrowtooth flounder attain lengths greater than 30 cm. Wintertime migration 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, MCS, OCS	P			
Larvae	2–3 months?	U phyto/zoo plankton?	spring summer?	BAY, ICS, MCS, OCS	P			
Early Juveniles	to 2 yrs	euphausiids crustaceans amphipods pollock	all year	ICS, MCS	D	GMS		
Late Juveniles	males 2–4 yrs females 2–5 yrs	euphausiids crustaceans amphipods pollock	all year	ICS, MCS, OCS, USP	D	GMS		
Adults	males 4+ yrs females 5+ yrs	pollock misc. fish Gadidae sp. euphausiids	spawning Nov–March non-spawning April–Oct	MCS, OCS, USP	D	GMS	ice edge (EBS)	

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

D.7.1 Life History and General Distribution

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

In the springtime, after spawning, rock sole begin actively feeding and commence a migration to the shallow waters of the continental shelf. This migration has been observed on both the eastern (Alton and Sample 1976) and western (Shvetsov 1978) areas of the Bering Sea. During this time they spread out and form much less dense concentrations than during the spawning period. Summertime trawl surveys indicate most of the population can be found at depths from 50 to 100 m (Armistead and Nichol 1993). The movement from winter/spring to summer grounds is in response to warmer temperatures in the shallow waters and the distribution of prey on the shelf seafloor (Shvetsov 1978). In September, with the onset of cooling in the northern latitudes, rock sole begin the return migration to the deeper wintering grounds. Fecundity varies with size and was reported to be 450,00 eggs for fish 42 cm long. Larvae are pelagic but their occurrence in plankton surveys in the eastern Bering Sea were rare in the early 1960s (Musienko 1963). However, ichthyoplankton surveys conducted since the early 2000s have captured northern rock sole larvae (Lanksbury et al. 2007). Juveniles are separate from the adult population, remaining in shallow areas until they reach age 1 (Forrester 1969). The estimated age of 50 percent maturity is 9 years (approximately 35

cm) for southern rock sole females and 7 years for northern rock sole females (Stark and Somerton 2002). Natural mortality rate is believed to range from 0.18 to 0.20.

The approximate upper size limit of juvenile fish is 34 cm.

D.7.2 Relevant Trophic Information

Groundfish predators include Pacific cod, walleye pollock, skates, Pacific halibut, and yellowfin sole, mostly on fish ranging from 5 to 15 cm standard length.

D.7.3 Habitat and Biological Associations

Larvae/Juveniles: Planktonic larvae for at least 2 to 3 months until metamorphosis occurs, juveniles inhabit shallow areas at least until age 1.

Adults: Summertime feeding on primarily sandy substrates of the eastern Bering Sea shelf. Widespread distribution mainly on the middle and inner portion of the shelf, feeding on bivalves, polychaete, amphipods, and miscellaneous crustaceans. Wintertime migration to deeper waters of the shelf margin for spawning and to avoid extreme cold water temperatures, feeding diminishes.

Habitat and Biological Associations: Rock sole

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

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D.8 Flathead sole (Hippoglossoides elassodon)

D.8.1 Life History and General Distribution

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

Adults exhibit a benthic lifestyle and occupy separate winter spawning and summertime feeding distributions on the eastern Bering Sea shelf and in the Gulf of Alaska. From over-winter grounds near the shelf margins, adults begin a migration onto the mid- and outer continental shelf in April or May each year for feeding. The spawning period may start as early as January but is known to occur in March and April, primarily in deeper waters near the margins of the continental shelf. Eggs are large (2.75 to 3.75 mm) and females have egg counts ranging from about 72,000 (20 cm fish) to almost 600,000 (38 cm fish). Eggs hatch in 9 to 20 days depending on incubation temperatures within the range of 2.4 to 9.8°C (Forrester and Alderdice 1967) and have been found in ichthyoplankton sampling on the southern portion of the Bering Sea shelf in April and May (Waldron 1981). Larvae absorb the yolk sac in 6 to 17 days but the extent of their distribution is unknown. Size at metamorphosis is 18 to 35 mm (Matarese et al. 2003). Juveniles less than age 2 have not been found with the adult population, remaining in shallow areas. Age at 50 percent maturity is 9.7 years (Stark 2004). The natural mortality rate used in recent stock assessments is 0.2 (McGilliard et al. 2015).

D.8.2 Relevant Trophic Information

Groundfish predators include Pacific cod, Pacific halibut, arrowtooth flounder, and cannibalism by large flathead sole, mostly on fish less than 20 cm standard length (Livingston and DeReynier 1996).

D.8.3 Habitat and Biological Associations

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

Adults: Winter spawning and summer feeding on sand and mud substrates of the continental shelf. Widespread distribution mainly on the middle and outer portion of the shelf, feeding mainly on ophiuroids, tanner crab, osmerids, bivalves, and polychaete (Pacunski 1990).

Habitat and Biological Associations: Flathead sole

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

D.8.4 Literature

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D.9 Alaska plaice (Pleuronectes quadrituberculatus)

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

D.9.1 Life History and General Distribution

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

Fecundity estimates (Fadeev 1965) indicate female fish produce an average of 56 thousand eggs at lengths of 28 to 30 cm and 313 thousand eggs at lengths of 48 to 50 cm. The age or size at metamorphosis is unknown. The estimated length of 50 percent maturity is 32 cm from collections made in March and 28 cm from April, which corresponds to an age of 6 to 7 years. Natural mortality rate estimates range from 0.19 to 0.22 (Wilderbuer and Zhang 1999).

The approximate upper size limit of juvenile fish is 27 cm.

D.9.2 Relevant Trophic Information

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

D.9.3 Habitat and Biological Associations

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

Adults: Summertime feeding on sandy substrates of the eastern Bering Sea shelf. Wide-spread distribution mainly on the middle, northern portion of the shelf, feeding on polychaete, amphipods, and echiurids (Livingston and DeReynier 1996). Wintertime migration to deeper waters of the shelf margin to avoid extreme cold water temperatures. Feeding diminishes until spring after spawning.

Habitat and Biological Associations: Alaska plaice

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

D.9.4 Literature

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D.10 Rex sole (Glyptocephalus zachirus)

Rex sole are a constituent of the "other flatfish" management category in the Bering Sea and Aleutian Islands where they are less abundant than in the Gulf of Alaska.

Other members of the "other flatfish" category include:

Dover sole (*Microstomus pacificus*)
Starry flounder (*Platichthys stellatus*)
Longhead dab (*Pleuronectes proboscidea*)
Butter sole (*Pleuronectes isolepis*)

D.10.1 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), and are widely distributed throughout the Gulf of Alaska. Adults exhibit a benthic lifestyle and are generally found in water deeper than 300 meters. From over-winter grounds near the shelf margins, adults begin a migration onto the mid- and outer continental shelf in April or May each year. The spawning period off Oregon is reported to range from January through June with a peak in March and April (Hosie and Horton 1977). Spawning in the Gulf of Alaska was observed from February through July, with a peak period in April and May (Hirschberger and Smith 1983). Eggs have been collected in neuston and bongo nets mainly in the summer, east of Kodiak Island (Kendall and Dunn 1985), but the duration of the incubation period is unknown. Larvae were captured in bongo nets only in summer over midshelf and slope areas (Kendall and Dunn 1985). Fecundity estimates from samples collected off the Oregon coast ranged from 3,900 to 238,100 ova for fish 24 to 59 cm (Hosie and Horton 1977). The age or size at metamorphosis is unknown. Maturity studies from Oregon indicate that males were 50 percent mature at 16 cm and females at 24 cm. Abookire (2006) estimated the female length at 50 percent maturity from Gulf of Alaska samples at 35 cm and 5.6 years. Juveniles less than 15 cm are rarely found with the adult population. The natural mortality rate used in recent stock assessments is 0.17 (Wilderbuer et al. 2010).

The approximate upper size limit of juvenile fish is 15 cm for males and 23 cm for females.

D.10.2 Relevant Trophic Information

Groundfish predators include Pacific cod and most likely arrowtooth flounder.

D.10.3 Habitat and Biological Associations

Larvae/Juveniles: Planktonic larvae for an unknown time period (at least 8 months from October through May) until metamorphosis occurs; juvenile distribution is unknown.

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 polychaete, amphipods, euphausids and snow crabs.

Habitat and Biological Associations: Rex sole

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

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Management Council, Anchorage, AK.

D.11 Dover sole (Microstomus pacificus)

D.11.1 Life History and General Distribution

Dover sole are distributed in deep waters of the continental shelf and upper slope from northern Baja California to the Bering Sea and the western Aleutian Islands (Hart 1973, Miller and Lea 1972), and exhibit a widespread distribution throughout the Gulf of Alaska. Adults are demersal and are mostly found in water deeper than 300 meters. The spawning period off Oregon is reported to range from January through May (Hunter et al. 1992). Spawning in the Gulf of Alaska has been observed from January through August, with a peak period in May (Hirschberger and Smith 1983). Eggs have been collected in neuston and bongo nets in the summer, east of Kodiak Island (Kendall and Dunn 1985), but the duration of the incubation period is unknown. Larvae were captured in bongo nets only in summer over mid-shelf and slope areas (Kendall and Dunn 1985). The age or size at metamorphosis is unknown but the pelagic larval period is known to be protracted and may last as long as two years (Markle et al. 1992). Pelagic postlarvae as large as 48 mm have been reported and the young may still be pelagic at 10 cm (Hart 1973). Dover sole are batch spawners and Hunter et al. (1992) concluded that the average 1 kg female spawns its 83,000 advanced yolked oocytes in about nine batches. Maturity studies from Oregon indicate that females were 50 percent mature at 33 cm total length. Juveniles less than 25 cm are rarely found with the adult population from bottom trawl surveys (Martin and Clausen 1995). The natural mortality rate used in recent stock assessments is 0.2 (Turnock et al. 1996).

The approximate upper size limit of juvenile fish is 32 cm.

D.11.2 Relevant Trophic Information

Groundfish predators include Pacific cod and most likely arrowtooth flounder.

D.11.3 Habitat and Biological Associations

Larvae/Juveniles: Planktonic larvae for up to 2 years until metamorphosis occurs, juvenile distribution is unknown.

Adults: Winter and spring spawning and summer feeding on soft substrates (combination of sand and mud) of the continental shelf and upper slope. Shallower summer distribution mainly on the middle to outer portion of the shelf and upper slope, feeding mainly on polychaete, annelids, crustaceans, and molluscs (Livingston and Goiney 1983).

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, UCS	P			
Larvae	up to 2 years	U phyto/ zooplankton?	all year	ICS? MCS, OCS, UCS	P			
Early Juveniles	to 3 years	polychaetes amphipods annelids	all year	MCS? ICS?	D	S, M		
Late Juveniles	3–5 years	polychaetes amphipods annelids	all year	MCS? ICS?	D	S, M		
Adults	5+ years	polychaetes amphipods annelids molluscs	spawning Jan–August non-spawning July–Jan	MCS, OCS, UCS	D	S, M		

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D.12 Pacific ocean perch (*Sebastes alutus*)

D.12.1 Life History and General Distribution

Pacific ocean perch has a wide distribution in the North Pacific from southern California around the Pacific rim to northern Honshu Island, Japan, including the Bering Sea. The species appears to be most abundant in northern British Columbia, the Gulf of Alaska, and the Aleutian Islands. Adults are found primarily offshore along the continental slope in depths of 180 to 420 m. Seasonal differences in depth distribution have been noted by many investigators. In the summer, adults inhabit shallower depths, especially those between 180 m and 250 m. In the fall, the fish apparently migrate farther offshore to depths of approximately 300 to 420 m. They reside in these deeper depths until about May, when they return to their shallower summer distribution. This seasonal pattern is probably related to summer feeding and winter spawning. Although small numbers of Pacific ocean perch are dispersed throughout their preferred depth range on the continental slope, most of the population occurs in patchy, localized aggregations. Pacific ocean perch is a semipelagic species, and along the EBS slope they have been observed to move into the water column during the day and onto the bottom at night

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

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

For the Aleutian Islands, the approximate upper size limit of juvenile fish is 38 cm for females and unknown for males, but presumed to be slightly smaller than for females based on what is commonly the case in other species of *Sebastes*.

D.12.2 Relevant Trophic Information

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

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

D.12.3 Habitat and Biological Associations

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

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

Juveniles: Again, information is very sparse, especially for younger juveniles. After metamorphosis from the larval stage, juveniles may reside in a pelagic stage for an unknown length of time. They eventually become demersal, and at age 1 through 5 probably live in very rocky shallower areas. Afterward, they move to progressively deeper waters of the continental shelf. Older juveniles are often found together with adults at shallower locations of the continental slope in the summer months. Juvenile Pacific ocean perch are associated with boulders, sponges, and upright coral, and these habitat structures may plan an important role for the juvenile stage of Pacific ocean perch.

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

Habitat and Biological Associations: Pacific ocean perch

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

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D.13 Northern rockfish (*Sebastes polyspinus*)

D.13.1 Life History and General Distribution

Northern rockfish range from northern British Columbia through the Gulf of Alaska and Aleutian Islands to eastern Kamchatka, including the Bering Sea. The species is most abundant from about Portlock Bank in the central Gulf of Alaska to the western end of the Aleutian Islands. Within this range, adult fish appear to be concentrated at discrete, relatively shallow offshore banks of the outer continental shelf. The preferred depth range is approximately 75 to 125 m in the Gulf of Alaska, and approximately 100 to 150 m in the Aleutian Islands. The fish appear to be semipelagic, and along the EBS slope they have been observed to move into the water column during the day and onto the bottom at night. In common with many other rockfish species, northern rockfish tend to have a localized, patchy distribution, even within their preferred habitat, and most of the population occurs in aggregations. Most of what is known about northern rockfish is based on data collected during the summer months from the commercial fishery or in research surveys. Consequently, there is little information on seasonal movements or changes in distribution for this species.

Life history information on northern rockfish is extremely sparse. The fish are assumed to be viviparous, as are other *Sebastes*, with internal fertilization and incubation of eggs. Observations during research surveys in the Gulf of Alaska suggest that parturition (larval release) occurs in the spring, and is mostly completed by summer. Pre-extrusion larvae have been described, but field-collected larvae cannot be

identified to species at present. Length of the larval stage is unknown, but the fish apparently metamorphose to a pelagic juvenile stage, which also has been described. There is no information on when the juveniles become benthic or what habitat they occupy. Older juveniles are found on the continental shelf, generally at locations inshore of the adult habitat.

Northern rockfish have a low population growth rate, with a low rate of natural mortality (estimated at 0.5), a relatively old age at 50 percent maturity (8.2 years for females in the Aleutian Islands), and an old maximum age of 74 years in the Aleutian Islands. No information on fecundity is available.

For the Aleutian Islands, the upper size limit for juveniles is 34 cm for females and unknown for males, but presumed to be slightly smaller than for females based on what is commonly the case in other species of *Sebastes*.

D.13.2 Relevant Trophic Information

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

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

D.13.3 Habitat and Biological Associations

Egg/Spawning: No information known, except that parturition probably occurs in the spring.

Larvae: No information known.

Juveniles: No information known for small juveniles (less than 20 cm), except that juveniles apparently undergo a pelagic phase immediately after metamorphosis from the larval stage. Larger juveniles have been taken in bottom trawls at various localities of the continental shelf, usually inshore of the adult fishing grounds.

Adults: Commercial fishery and research survey data have indicated that adult northern rockfish are primarily found over hard, rocky, or uneven bottom of offshore banks of the outer continental shelf at depths of 75 to 150 m. Generally, the fish appear to be semipelagic, extending into the water column, and most of the population occurs in large aggregations. There is no information on seasonal migrations. Northern rockfish often co-occur with dusky rockfish.

Habitat and Biological Associations: Northern Rockfish

Stage - EFH Level	Duration or Age	Diet/Prey	Season/ Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs	U	NA	U	NA	NA	NA	NA	NA
Larvae	U	U	spring–summer?	U	P (assumed)	NA	U	U
Early Juveniles	from end of larval stage to ?	U	all year	MCS, OCS	P? (early juvenile only), D	U (juvenile< 20 cm); substrate (juvenile> 20 cm)	U	U
Late Juveniles	to 8 yrs	U	all year	OCS	D	CB, R	U	U
Adults	8 – 57 years of age	euphausiids	U, except that larval release is probably in the spring in the Gulf of Alaska	OCS, USP	SD/SP	CB, R	U	U

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D.14 Shortraker rockfish (*Sebastes borealis*)

D.14.1 Life History and General Distribution

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

Though relatively little is known about their biology and life history, shortraker rockfish appear to be *K*-selected with late maturation, slow growth, extreme longevity, and low natural mortality. Age at 50 percent maturity has been estimated at 21.4 years for female shortraker rockfish in the Gulf of Alaska (Hutchinson 2004); maturity information is not available for the Bering Sea and Aleutian Islands (BSAI) management area. Hutchinson (2004) estimated a maximum age of 116 years. Shortraker rockfish are among the largest *Sebastes* species in Alaskan waters; samples as large as 109 cm have been obtained in Aleutian Islands trawl surveys.

D.14.2 Relevant Trophic Information

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

D.14.3 Habitat and Biological Associations

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

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

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

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

Habitat and Biological Associations: Shortraker and Rougheye Rockfish

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

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D.15 Blackspotted rockfish (*Sebastes melanostictus*) and rougheye rockfish (*S. aleutianus*)

D.15.1 Life History and General Distribution

Fish in Alaska previously referred to as rougheye rockfish have recently been recognized as consisting of two species, the rougheye rockfish (*Sebastes aleutianus*) and blackspotted rockfish (*Sebastes melanostictus*) (Orr and Hawkins 2008). Most of the information on blackspotted/rougheye rockfish was obtained prior to recognition of blackspotted rockfish as a separate species, and thus refers to the two species complex. Love et al. (2002) reports that rougheye rockfish are found along the northwest slope of the eastern Bering Sea, throughout the Aleutian Islands, west to the Kamchatka Peninsula and Japan, and south

to Point Conception, California, although this distribution likely reflects the combined blackspotted/rougheye group. Recent trawl surveys indicate that rougheye rockfish are uncommon in the Aleutian Islands, where the two species complex is predominately composed of blackspotted rockfish. Methods for distinguishing the two species from each other are still being refined, but have improved recently (based on verifying field IDs with genetic IDs).

Information for the larval and juvenile stages of blackspotted/rougheye rockfish are very limited. Blackspotted/rougheye rockfish are viviparous, as females release larvae rather than eggs. Parturition (the release of larvae) can occur from December through April (McDermott 1994). Identification of larvae can be made with genetic techniques (Gray et al. 2006), although this technique has not been used to produce a broad scale distribution of the larval stage. Species identification based on morphological characteristics is difficult because of overlapping characteristics among species, as few rockfishes species in the north Pacific have published descriptions of the complete larval developmental series. Length frequency distributions from Aleutian Islands summer trawl survey indicate that small blackspotted/rougheye rockfish (less than 35 cm) are found throughout a range of depths but primarily in shallower water (200 to 300 m) than larger fish. As adults, blackspotted/rougheye rockfish occur primarily at depths from 300 to 500 m.

Though relatively little is known about their biology and life history, blackspotted/rougheye rockfish appear to be *K*-selected with late maturation, slow growth, extreme longevity, and low natural mortality. Age at 50 percent maturity has been estimated at 20.3 years for female blackspotted/rougheye rockfish in the Gulf of Alaska (McDermott 1994); maturity information is not available for the Bering Sea and Aleutian Islands (BSAI) management area. A maximum age of 121 has been reported from sampling in the Aleutian Islands trawl survey.

D.15.2 Relevant Trophic Information

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

D.15.3 Habitat and Biological Associations

Egg/Spawning: The timing of reproductive events is apparently protracted. Parturition (the release of larvae) may occur from December to April (McDermott 1994).

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

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

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

Habitat and Biological Associations: Shortraker and Rougheye Rockfish

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

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D.16 Other/Dusky rockfish (*Sebastes variabilis*)

D.16.1 Life History and General Distribution

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

Life history information on dusky rockfish is extremely sparse. The fish are assumed to be viviparous, as are other *Sebastes*, with internal fertilization and incubation of eggs. Observations during research surveys in the Gulf of Alaska suggest that parturition (larval release) occurs in the spring, and is probably completed by summer. Another, older source, however, lists parturition as occurring "after May." Pre-extrusion larvae have been described, but field-collected larvae cannot be identified to species at present. Length of the larval stage, and whether a pelagic juvenile stage occurs, are unknown. There is no information on habitat and abundance of young juveniles (less than 25 cm fork length), as catches of these have been virtually nil in research surveys. Even the occurrence of older juveniles has been very uncommon in surveys, except for one year. In this latter instance, older juveniles were found on the continental shelf, generally at locations inshore of the adult habitat.

Dusky rockfish is a slow growing species, with a low rate of natural mortality estimated at 0.09. However, it appears to be faster growing than many other rockfish species. Maximum age is 49 to 59 years. No information on age of maturity or fecundity is available.

The approximate upper size limit for juvenile fish is 47 cm for females; unknown for males, but presumed to be slightly smaller than for females based on what is commonly the case in other species of *Sebastes*.

D.16.2 Relevant Trophic Information

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

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

D.16.3 Habitat and Biological Associations

Egg/Spawning: No information known, except that parturition probably occurs in the spring, and may extend into summer.

Larvae: No information known.

Juveniles: No information known for small juveniles less than 25 cm fork length. Larger juveniles have been taken infrequently in bottom trawls at various localities of the continental shelf, usually inshore of the adult fishing grounds.

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

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	ICS, MCS, OCS,	U (small juvenile< 25 cm): D? (larger juvenile)	U (juvenile<25 cm); Trawlable substrate? (juvenile>25 cm)	U	U
Late Juveniles	U	U	U	U	U	CB, R, G	U	observed associated with *primnoa* coral
Adults	Up to 49–50 years.	euphausiids	U, except that larval release may be in the spring in the Gulf of Alaska	OCS, USP	SD, SP	CB, R, G	U	observed associated with large vase type sponges

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D.17 Thornyhead rockfish (*Sebastolobus sp.*)

D.17.1 Life History and General Distribution

Thornyhead rockfish of the northeastern Pacific Ocean are comprised of two species, the shortspine thornyhead (*Sebastolobus alascanus*) and the longspine thornyhead (*S. altivelis*). The longspine thornyhead is not common in the Bering Sea and Aleutian Islands. The shortspine thornyhead is a demersal species which inhabits deep waters from 93 to 1,460 m from the Bering Sea to Baja California. This species is common throughout the Gulf of Alaska, eastern Bering Sea, and Aleutian Islands. The population structure of shortspine thornyheads, however, is not well defined. Thornyhead rockfish are slow-growing and long-lived with maximum age in excess of 50 years and maximum size greater than 75 cm and 2 kg. Thornyheads spawn buoyant masses of eggs during the late winter and early spring that resemble bilobate "balloons" which float to the surface (Pearcy 1962). Juvenile shortspine thornyhead rockfish have a pelagic period of about 14 to 15 months and settle out on the shelf (100 m) at about 22 to 27 mm (Moser 1974). Fifty percent of female shortspine thornyheads are sexually mature at about 21 cm and 12 to 13 years of age.

The approximate upper size limit of juvenile fish is 27 mm at the pelagic stage, and 60 mm at the benthic stage (see Moser 1974). Female shortspine thornyheads appear to be mature at about 21 to 22 cm (Miller 1985).

D.17.2 Relevant Trophic Information

Shortspine thornyhead rockfish prey mainly on epibenthic shrimp and fish. Yang (1996, 2003) showed that shrimp were the top prey item for shortspine thornyhead rockfish in the Gulf of Alaska; whereas, cottids were the most important prey item in the Aleutian Islands region. Differences in abundance of the main prey between the two areas might be the main reason for the observed diet differences. Predator size might by another reason for the difference since the average shortspine thornyhead in the Aleutian Islands area was larger than that in the Gulf of Alaska (33.4 cm vs 29.7 cm).

D.17.3 Habitat and Biological Associations

Egg/Spawning: Eggs float in masses of various sizes and shapes. Frequently the masses are bilobed with the lobes 15 to 61 cm in length, consisting of hollow conical sheaths containing a single layer of eggs in a gelatinous matrix. The masses are transparent and not readily observed in the daylight. Eggs are 1.2 to 1.4 mm in diameter with a 0.2 mm oil globule. They move freely in the matrix. Complete hatching time is unknown but is probably more than 10 days.

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

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

Adults: Adults are demersal and can be found at depths ranging from about 90 to 1,500 m. Groundfish species commonly associated with thornyheads include: arrowtooth flounder (*Atheresthes stomias*), Pacific ocean perch (*Sebastes alutus*), sablefish *(Anoplopoma fimbria*), rex sole (*Glyptocephalus zachirus*), Dover sole (*Microstomus pacificus*), shortraker rockfish (*Sebastes borealis*), rougheye rockfish (*Sebastes aleutianus*), and grenadiers (family Macrouridae). Two congeneric thornyhead species, the longspine thornyhead (*Sebastolobus altivelis*) and a species common off of Japan , broadbanded thornyhead, *S. macrochir*, are infrequently encountered in the Gulf of Alaska.

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	
Juveniles	> 15 months when settling to bottom occurs (?)	U shrimp, amphipods, mysids, euphausiids?	U	MCS, OCS, USP	D	M, S, R, SM, CB, MS, G	U	
Adults	U	shrimp fish (cottids), small crabs	year-round?	MCS, OCS, USP, LSP	D	M, S, R, SM, CB, MS, G	U	

D.17.4 Literature

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D.18 Atka mackerel (Pleurogrammus monopterygius)

D.18.1 Life History and General Distribution

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

Adult Atka mackerel occur in large localized aggregations usually at depths less than 200 m and generally over rough, rocky, and uneven bottom near areas where tidal currents are swift. Associations with corals and sponges have been observed for Aleutian Islands Atka mackerel. Adults are semi-demersal, displaying strong diel behavior with vertical movements away from the bottom occurring almost exclusively during the daylight hours, presumably for feeding, and little to no movement at night (when they are closely associated with the bottom). Atka mackerel are a substrate-spawning fish with male parental care. Single or multiple clumps of adhesive eggs are laid on rocky substrates in individual male territories within nesting colonies where males brood eggs for a protracted period. Nesting colonies are widespread across the continental shelf of the Aleutian Islands and western Gulf of Alaska down to bottom depths of 144 m. Possible factors limiting the upper and lower depth limit of Atka mackerel nesting habitat include insufficient light penetration and the deleterious effects of unsuitable water temperatures, wave surge, or high densities of kelp and green sea urchins. The spawning phase begins in late July, peaks in early September, and ends in mid-October. After spawning ends, territorial males with nests continue to brood

egg masses until hatching. Eggs develop and hatch in 40 to 45 days, releasing planktonic larvae which have been found up to 800 km from shore. Little is known of the distribution of young Atka mackerel prior to their appearance in trawl surveys and the fishery at about age 2 to 3 years. Atka mackerel exhibit intermediate life history traits. R-traits include young age at maturity (approximately 50 percent are mature at age 3), fast growth rates, high natural mortality (mortality equals 0.3) and young average and maximum ages (about 5 and 15 years, respectively). K-selected traits include low fecundity (only about 30,000 eggs/female/year, large egg diameters (1 to 2 mm) and male nest-guarding behavior).

The approximate upper size limit of juvenile fish is 35 cm.

D.18.2 Relevant Trophic Information

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

D.18.3 Habitat and Biological Associations

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

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

Adults: Adults occur in localized aggregations usually at depths less than 200 m and generally over rough, rocky and uneven bottom near areas where tidal currents are swift. Associations with corals and sponges have been observed for Aleutian Islands Atka mackerel. Adults are semi-demersal/pelagic during much of the year, but the males become demersal during spawning; females move between nesting and offshore feeding areas.

Habitat and Biological Associations: Atka mackerel

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

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D.19 Squids (Cephalopoda)

The species representatives for squids are:

Gonaditae:	red or magistrate armhook squid (*Berryteuthis magister*)
Onychoteuthidae:	boreal clubhook squid (*Onychoteuthis borealjaponicus)*
	giant or robust clubhook squid (*Moroteuthis robusta*)
Sepiolidae:	eastern Pacific bobtail squid (*Rossia pacifica*)

D.19.1 Life History and General Distribution:

Squids are members of the molluscan class Cephalopoda along with octopus, cuttlefish, and nautiloids. In the Bering Sea and Aleutian Islands (BSAI), gonatid and onychoteuthid squids are generally the most

common, along with chiroteuthids. All cephalopods are stenohaline, occurring only at salinities greater than 30 ppt. Fertilization is internal, and for many species development is direct ("larval" stages are only small versions of adults). The eggs of inshore neritic species are often enveloped in a gelatinous matrix attached to rocks, shells, or other hard substrates, while the eggs of some offshore oceanic species are extruded as large, sausage-shaped drifting masses. Little is known of the seasonality of reproduction, but most species probably breed in spring and early summer, with eggs hatching during the summer. Most small squids are generally thought to live only 2 years or less but the giant *Moroteuthis robusta* may live longer.

B. magister is widely distributed in the boreal north Pacific from California, throughout the Bering Sea, to Japan in waters of depth 30 to 1,500 m; adults most often found at mesopelagic depths or near bottom, rising to the surface at night; juveniles are widely distributed across shelf, slope, and abyssal waters in mesopelagic and epipelagic zones, and rise to surface at night. It migrates seasonally, moving northward and inshore in summer, and southward and offshore in winter, particularly in the western north Pacific. In the BSAI, most *B. magister* occur along the continental slope. The maximum size for females is 50 cm mantle length (ML), and for males is 40 cm ML. Spermatophores transferred into the mantle cavity of female, and eggs are laid on the bottom on the upper slope (200 to 800 m). Fecundity is estimated at 10,000 eggs/female. Spawning occurs in February and March in Japan; timing of spawning in Alaska is not known but there appear to be multiple seasonal spawning cohorts each year. Eggs hatch after 1 to 2 months of incubation; development is direct. Adults are thought to die after mating and/or spawning.

O. borealjaponicus, an active, epipelagic species, is distributed in the north Pacific from the Sea of Japan, throughout the Aleutian Islands and south to California, but is absent from the Sea of Okhotsk and not common in the Bering Sea. Juveniles can be found over shelf waters at all depths and near shore. Adults apparently prefer the upper layers over slope and abyssal waters and are diel migrators and gregarious. Development includes a larval stage; maximum size is about 55 cm.

M. robusta, a giant squid, lives near the bottom on the slope, and mesopelagically over abyssal waters; it is rare on the shelf. It is distributed in all oceans, and is found in the Bering Sea, Aleutian Islands, and GOA. Mantle length can be up to 2.5 m long (at least 7 m with tentacles), but most are about 2 m long.

R. pacifica is a small (maximum length with tentacles of less than 20 cm) demersal, neritic and shelf, boreal species, distributed from Japan to California in the North Pacific and in the Bering Sea in waters of about 20 to 300 m depth. It is the only squid observed in abundance on the shelf by bottom trawl surveys. Other *Rossia* species deposit demersal egg masses.

For *B. magister*, the approximate upper size limit of juveniles 20 cm ML for males and 25 cm ML for females; both are at approximately 1 year of age.

D.19.2 Relevant Trophic Information

The principal prey items of squid are small forage fish, pelagic crustaceans (e.g., euphausiids and shrimp), and other cephalopods; cannibalism is not uncommon. After hatching, early juvenile squid eat small zooplankton (e.g. copepods). Squid are preyed upon by marine mammals, seabirds, and to a lesser extent by fish and occupy an important role in marine food webs worldwide. Predation on various species and life stages of squids differs with the size and foraging behavior of the predator, e.g. adult *B. magister* are eaten mainly by marine mammals. In some areas squids may constitute up to 80% of the diets of sperm whales, bottlenose dolphins, and beaked whales, and about half of the diet of Dall s porpoise in the eastern Bering Sea and Aleutian Islands. Seabirds (e.g., kittiwakes, puffins, murres) on island rookeries close to the shelf break (e.g., Buldir Island, Pribilof Islands) are also known to feed heavily on squid. However, squid play a larger role in the diet of salmon.

D.19.3 Habitat and Biological Associations for *Berryteuthis magister*

Egg/Spawning: Eggs are laid on the bottom on the upper slope (200 to 800 m); incubate for 1 to 2 months.

Young Juveniles: Distributed epipelagically (top 100 m) from the coast to open ocean.

Old Juveniles and Adults: Distributed mesopelagically (most from 150 to 500 m), mostly in outer shelf/slope waters (and to an unknown extent out over basin, where very little sampling has been conducted). Migrate to slope waters to mate and spawn demersally.

Habitat and Biological Associations: *B. magister*

Stage - EFH Level	Duration or Age	Diet/Prey	Season/ Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs	1–2 months	NA	varies	USP, LSP	D	M, SM, MS	U	
Young juveniles	4–6 months	zooplankton	varies	all shelf, slope, BSN	P, N	NA	UP, F?	
Older Juveniles and Adults	1–2 years (may be up to 4 yrs)	euphausiids, shrimp, small forage fish, and other cephalopods	summer winter	OS, USP, LSP, BSN OS, USP, LSP, BSN	SP SP	U U	UP, F? UP, F?	euhaline waters, 2–4 °C

D.19.4 Literature

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D.20 Octopuses

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

D.20.1 Life History and General Distribution

Octopuses are members of the molluscan class Cephalopoda, along with squid, cuttlefish, and nautiloids. The octopuses (order Octopoda) have only eight appendages or arms and unlike other cephalopods, they lack shells, pens, and tentacles. There are two groups of Octopoda, the cirrate and the incirrate. The cirrate have cirri and are by far less common than the incirrate, which contain the more traditional forms of octopus. Octopuses are found in every ocean in the world and range in size from less than 20 cm (total length) to over 3 m (total length); the latter is a record held by *Enteroctopus dofleini*.

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

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

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

Sasakiopus salebrosus is a small benthic octopus recently identified from the Bering Sea slope in depths ranging from 200 to1200 m (Jorgensen 2010). It was previously identified in surveys as *Benthoctopus sp*. or as *Octopus sp. n.* In recent groundfish surveys of the Bering Sea slope this was the most abundant octopus collected; multiple specimens were collected in over 50% of the tows. *Sasakiopus salebrosus* is a small-sized species with a maximum total length < 25 cm. Mature females collected in the Bering Sea carried 100 to 120 eggs (Laptikhovsky 1999). Hatchlings and paralarvae have not been collected or described (Jorgensen 2009).

Benthoctopus leioderma is a medium sized species, with a maximum total length of approximately 60 cm. Its life span is unknown. It occurs from 250 to 1400 m and is found throughout the shelf break region. It is a common octopus and often occurs in the same areas where *E. dofleini* are found. The eggs are brooded by the female but mating and spawning times are unknown. Members of this genus in the North Pacific Ocean have been found to attach their eggs to hard substrate under rock ledges and crevices (Voight and Grehan 2000). *Benthoctopus* tend to have small numbers of eggs (< 200) that develop into benthic hatchlings.

Benthoctopus oregonensis is larger than *B. leioderma*, with a maximum total length of approximately 1 m. This is the second largest octopus in the Bering Sea and based on size could be confused with *E. dofleini*. We know very little about this species of octopus. Other members of this genus brood their eggs and we would assume the same for this species. The hatchlings are demersal and likely much larger than those of *E. dofleini*. The samples of *B. oregonensis* all come from deeper than 500 m. This species is the least collected incirrate octopus in the Bering Sea and may occur in depths largely outside of the sampling range of AFSC surveys.

Graneledone boreopacifica is a deep water octopus with only a single row of suckers on each arm (the

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

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

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

D.20.2 Relevant Trophic Information

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

D.20.3 Habitat and Biological Associations

Egg/Spawning: 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.

Young Juveniles: semi-demersal; widely dispersed on shelf, upper slope

Old Juveniles and Adults: demersal, widely dispersed on shelf and upper slope, preferentially among rocks, cobble, but also on sand/mud.

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

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

D.20.4 Literature

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D.21 Sharks

The species representatives for sharks are:

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

D.21.1 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. Salmon shark are large (up to 3 m in length), aplacental, viviparous (with small litters of one to four pups and embryos nourished by yolk sac and 5 oophagy), widely migrating sharks, with homeothermic capabilities and highly active predators (salmon and white sharks). Salmon sharks are distributed epipelagically along the shelf (can be found in shallow waters) from California through the Gulf of Alaska (GOA) to the northern Bering Sea and off Japan. In groundfish fishery and survey data, salmon sharks occur chiefly on outer shelf/upper slope areas in the Bering Sea, but near the coast to the outer shelf in the GOA, particularly near Kodiak Island. Salmon sharks are not commonly seen in Aleutian Islands.

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

Spiny dogfish are widely distributed throughout the North Pacific Ocean. In the North Pacific, spiny dogfish may be most abundant in the GOA; 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.

D.21.2 Relevant Trophic Information

Sharks are top level predators in the GOA. The only likely predator would be larger fish or mammals preying on young/small sharks. Spiny dogfish 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, sculpins, and gadids, Pacific sleeper shark are predators of flatfish, cephalopods, rockfish, crabs, seals, and salmon and may also prey on pinnipeds.

D.21.3 Habitat and Biological Associations

Egg/Spawning: 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.

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

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

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

Habitat and Biological Associations: Sharks

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

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D.22 Sculpins (Cottidae)

The species representatives for sculpins are:

Yellow Irish lord (*Hemilepidotus jordani)*
Warty (*Myoxocephalus verrucosus*)
Bigmouth sculpin (*Hemitripterus bolini*)
Great sculpin (*Myoxocephalus polyacanthocephalus*)
Plain sculpin (*Myoxocephalus jaok*)

D.22.1 Life History and General Distribution

The Cottidae (sculpins) is a large circumboreal family of demersal fishes inhabiting a wide range of habitats in the North Pacific Ocean and Bering Sea. Most species live in shallow water or in tidepools, but some inhabit the deeper waters (to 1,000 m) of the continental shelf and slope. Most species do not attain a large size (generally 10 to 15 cm), but those that live on the continental shelf and are caught by fisheries can be 30 to 50 cm; the cabezon is the largest sculpin and can be as long as 100 cm. Most sculpins spawn in the winter. All species lay eggs, but in some genera, fertilization is internal. The female commonly lays demersal eggs amongst rocks where they are guarded by males. Egg incubation duration is unknown; larvae were found across broad areas of the shelf and slope, and were found all year-round, in ichthyoplankton collections from the southeast Bering Sea and Gulf of Alaska (GOA). Larvae exhibit diel vertical migration (near surface at night and at depth during the day). Sculpins generally eat small invertebrates (e.g., crabs, barnacles, mussels), but fish are included in the diet of larger species; larvae eat copepods.

Yellow Irish lords: distributed from subtidal areas near shore to the edge of the continental shelf (down to 200 m) throughout the Bering Sea, Aleutian Islands, and eastward into the GOA as far as Sitka, Alaska; up to 40 cm in length. Larvae from 12 to 26 mm have been collected in spring on the western GOA shelf.

Warty: distributed from rocky, intertidal areas to about 100 m depth on the middle continental shelf (most shallower than 50 m), from California (Monterey Bay) to Kamchatka; throughout the Bering Sea and GOA; rarely over 30 cm in length. Spawns masses of pink eggs in shallow water or intertidally. Larvae were 7 to 20 mm long in spring in the western GOA.

Bigmouth sculpin: distributed in deeper waters offshore, between about 100 m and 300 m in the Bering Sea, Aleutian Islands, and throughout the GOA; up to 70 cm in length.

Great sculpin: distributed from the intertidal to 200 m, but may be most common on sand and muddy/sand bottoms in moderate depths (50 to 100 m); up to 80 cm in length. Found throughout the Bering Sea, Aleutian Islands, and GOA, but may be less common east of Prince William Sound. *Myoxocephalus* spp. larvae ranged in length from 9 to 16 mm in spring ichthyoplankton collections in the western GOA.

Plain sculpin: distributed throughout the Bering Sea and GOA (not common in the Aleutian Islands) from intertidal areas to depths of about 100 m, but most common in shallow waters (less than 50 m); up to 50 cm in length. *Myoxocephalus* spp. larvae ranged in length from 9 to 16 mm in spring ichthyoplankton collections in the western GOA.

The approximate upper size limit of juvenile fish is unknown.

D.22.2 Relevant Trophic Information

Feed on bottom invertebrates (e.g., crabs, barnacles, mussels, and other molluscs); larger species eat fish.

D.22.3 Habitat and Biological Associations

Egg/Spawning: Lay demersal eggs in nests guarded by males; many species in rocky shallow waters near shore.

Larvae: Distributed pelagically and in neuston across broad areas of shelf and slope, but predominantly on inner and middle shelf; have been found all year-round.

Juveniles and Adults: Sculpins are demersal fish, and live in a broad range of habitats from rocky intertidal pools to muddy bottoms of the continental shelf, and rocky, upper slope areas. Most commercial bycatch occurs on middle and outer shelf areas used by bottom trawlers for Pacific cod and flatfish.

Habitat and Biological Associations: Sculpins

Stage - EFH Level	Duration or Age	Diet/Prey	Season/ Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs	U	NA	winter?	BCH, ICS (MCS, OCS?)	D	R (others?)	U	
Larvae	U	copepods	all year?	ICS, MCS, OCS, US	N, P	NA?	U	
Juveniles and Adults	U	bottom invertebrates (crabs, molluscs, barnacles) and small fish	all year	BCH, ICS, MCS, OCS, US	D	R, S, M, SM	U	

D.22.4 Literature

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D.23 Skates (Rajidae)

The species representatives for skates are:

Alaska skate (*Bathyraja parmifera*)
Aleutian skate (*Bathyraja aleutica*)
Bering skate (*Bathyraja interrupta*)

D.23.1 Life History and General Distribution:

Skates (Rajidae) in the Bering Sea and Aleutian Islands (BSAI) occur in two main taxonomic groups: skates of the genus *Bathyraja* (soft nosed) and those of the genera *Raja* and *Beringraja* (hard nosed). *Bathyraja* skates make up the vast majority of the skate biomass in the BSAI. Skates are oviparous: fertilization is internal and eggs are encased in leathery, horned pouches. Eggcases are then deposited at highly localized nursery sites along the upper contintal slope, where the embryos develop for up to 3.5 years. Nursery sites are small, have a high density of eggcases, and appear to be used over many years. Six sites have been designated as Habitat Areas of Particular Concern (HAPC) by the North Pacific Fishery Management Council, although no protections (i.e. fishing gear restrictions) were mandated for the sites. Adults and juveniles are demersal, and feed on bottom invertebrates and fish. The habitat utilized by skates depends on the species. Adult Alaska skates are mostly distributed at a depth of 50 to 200 m on the shelf in eastern Bering Sea (EBS), where they make up ~95% of the biomass, and in the Aleutian Islands (AI). The Aleutian skate is found mainly in the outer shelf and upper slope of the eastern Bering Sea and the Aleutian Islands at depths of 100 to 350 m. The Bering skate is found throughout the eastern Bering Sea and less commonly in the Aleutian Islands at depths of 100 to 350 m. In the EBS, Alaska skates appear to make ontogenetic migrations from the nursery sites on the upper slope to the inner EBS shelf, reaching the inner shelf at approximately the age of maturity (9 years). Adults then likely make long-distance seasonal movements for reproduction and feeding. The biomass of BSAI skates estimated from the survey more than doubled between 1982 and 1996 and has been stable since. The approximate upper size limit of juvenile fish is unknown.

D.23.2 Relevant Trophic Information

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

D.23.3 Habitat and Biological Associations

Egg/Spawning: Deposits eggs in leathery, horned cases in nursery sites along the upper continental slope.

Juveniles and Adults: After hatching, juveniles probably remain in shelf and slope waters, but distribution is unknown. Adults found across wide areas of shelf and slope and distribution varies

by species; surveys found most skates at depths less than 500 m in the eastern Bering Sea, but greater than 500 m in the Aleutian Islands.

Habitat and Biological Associations: Skates

Stage - EFH Level	Duration or Age	Diet/Prey	Season / Time	Location	Water Column	Bottom Type	Oceanographic Features	Other
Eggs	U	NA	U	OCS, USP	D	U	U	
Larvae	NA	NA	NA	NA	NA	NA	NA	
Juveniles	U	invertebrates small fish	all year	ICS, MCS, OCS, USP	D	U	U	
Adults	U	invertebrates small fish	all year	MCS, OCS, USP	D	U	U	

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D.24 Capelin (*Mallotus villosus*; Osmeridae)

D.24.1 Life History and General Distribution

Capelin is a short-lived , pelagic, schooling fish species with a circumpolar distribution that includes the entire coastline of Alaska and the Bering Sea and extends south along British Columbia to the Strait of Juan de Fuca. In the North Pacific, capelin grow to a maximum of 25 cm and 5 years of age. Capelin, a member of the Osmeridae (smelts), spawn at ages 2 to 4 in spring and summer (May through August; earlier in south, later in north) when about 11 to 17 cm on coarse sand, fine gravel beaches, especially in Norton

Sound, northern Bristol Bay, and along the Alaska Peninsula. Age at 50 percent maturity is 2 years. Each female produces 10,000 to 15,000 eggs. Eggs hatch in 2 to 3 weeks. Most capelin die after spawning. Larvae and juveniles are distributed on the inner mid-shelf in summer (rarely found in waters deeper than about 200 m), and juveniles and adults congregate in fall in mid-shelf waters east of the Pribilof Islands, west of St. Matthew and St. Lawrence Islands, and north into the Gulf of Anadyr. Larvae, juveniles, and adults have diurnal vertical migrations following scattering layers; at night they are near surface and at depth during the day. Smelts are captured during trawl surveys, but their small size and patchy distribution reduce the reliability of biomass estimates. The approximate upper size limit of juvenile fish is 13 cm.

D.24.2 Relevant Trophic Information

Capelin are important prey for marine birds and mammals as well as other fish. Surface feeding (e.g., gulls and kittiwakes), as well as shallow and deep diving piscivorous birds (e.g., murres and puffins) largely consume small schooling fishes such as capelin, eulachon, herring, sand lance, and juvenile pollock. Both pinnipeds (Steller sea lions, northern fur seals, harbor seals, and ice seals) and cetaceans (such as harbor porpoise, and fin, sei, humpback, and beluga whales) feed on smelts, which may provide an important seasonal food source near the ice-edge in winter, and as they assemble nearshore in spring to spawn. Smelts are also found in the diets of some commercially exploited fish species, such as Pacific cod, walleye pollock, arrowtooth flounder, Pacific halibut, sablefish, Greenland turbot, and salmon throughout the North Pacific Ocean and the Bering Sea.

D.24.3 Habitat and Biological Associations

Egg/Spawning: Spawn adhesive eggs (about 1 mm in diameter) on fine gravel or coarse sand (0.5 to 1 mm grain size) beaches intertidally to depths of up to 10 m in May through July in Alaska (later to the north in Norton Sound). Hatching occurs in 2 to 3 weeks. Most intense spawning when coastal water temperatures are 5 to 9 °C.

Larvae: After hatching, 4 to 5 mm larvae remain on the middle-inner shelf in summer; distributed pelagically; centers of distribution are unknown, but have been found in high concentrations north of Unimak Island, in the western Gulf of Alaska, and around Kodiak Island.

Juveniles: In fall, juveniles are distributed pelagically in mid-shelf waters (50 to 100 m depth; -2 to 3 °C), and have been found in highest concentrations east of the Pribilof Islands, west of St. Matthew and St. Lawrence Islands, and north into the Gulf of Anadyr.

Adults: Found in pelagic schools in inner-mid shelf in spring-fall, feed along semi-permanent fronts separating inner, mid, and outer shelf regions (approximately 50 and 100 m). In winter, found in concentrations under ice-edge and along mid-outer shelf.

Habitat and Biological Associations: Capelin

Stage - EFH Level	Duration or Age	Diet/Prey	Season/ Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs	2–3 weeks to hatch	na	May–August	BCH (to 10 m)	D	S, CB		5–9 °C peak spawning
Larvae	4–8 months?	copepods phytoplankton	summer/fall/ winter	ICS, MCS	N, P	U NA?	U	
Juveniles	1.5+ yrs up to age 2	copepods euphausiids	all year	ICS, MCS	P	U NA?	U F? ice edge in winter	
Adults	2 yrs ages 2–4+	copepods euphausiids polychaetes small fish	spawning (May–August) non-spawning (Sep–Apr)	BCH (to 10 m) ICS, MCS, OCS	D, SD P	S, CB, G NA?	F ice edge in winter	-2 – 3°C peak distributions in EBS?

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D.25 Eulachon (*Thaleichthys pacificus*; Osmeridae)

D.25.1 Life History and General Distribution

Eulachon is a relatively short-lived, anadromous, schooling fish species distributed from the Pribilof Islands in the eastern Bering Sea (EBS), throughout the Gulf of Alaska (GOA), and south to California. Eulachon, a member of the Osmeridae (smelts), are pelagic but often occur near the bottom and are generally found in deep water. In the EBS during summer, their distribution is concentrated in the Bering Canyon area northwest of Unimak Island on the outer shelf and upper slope. In the North Pacific, eulachon grow to a maximum age of 5 years and a maximum size of 23 cm. They spawn at ages 3 to 5 (14-20 cm) in spring and early summer (April through June) in rivers on coarse sandy bottom. Spawning rivers in the EBS are not well known. Age at 50 percent maturity is 3 years. Each female produces approximately 25,000 eggs, which adhere to sand grains and other substrates on the river bottom. Eggs hatch in 30 to 40 days at 4 to 7 °C. Most eulachon die after first spawning. Larvae drift out of rivers and develop at sea. Smelts are captured during trawl surveys, but their small size and patchy distribution reduces the reliability of biomass estimates. The approximate upper size limit of juvenile fish is 14 cm.

D.25.2 Relevant Trophic Information

Eulachon are important prey for marine birds and mammals as well as other fish. Surface feeding (e.g., gulls and kittiwakes), as well as shallow and deep diving piscivorous birds (e.g., murres and puffins) largely consume small schooling fishes such as capelin, eulachon, herring, sand lance, and juvenile pollock. Pinnipeds (Steller sea lions, northern fur seals, harbor seals, and ice seals) and cetaceans (such as harbor porpoise, and fin, sei, humpback, and beluga whales) feed on smelts, which may provide an important seasonal food source near the ice-edge in winter, and as they assemble nearshore in spring to spawn. Smelts also comprise significant portions of the diets of some commercially exploited fish species, such as Pacific cod, walleye pollock, arrowtooth flounder, Pacific halibut, sablefish, Greenland turbot, and salmon throughout the North Pacific Ocean and the Bering Sea.

D.25.3 Habitat and Biological Associations

Egg/Spawning: Anadromous; return to spawn in spring (May through June) in rivers; demersal eggs adhere to bottom substrate (e.g., sand, cobble). Hatching occurs in 30 to 40 days.

Larvae: After hatching, 5 to 7 mm larvae drift out of river and develop pelagically in coastal marine waters; centers of distribution are unknown.

Juveniles and Adults: Distributed pelagically in mid-shelf to upper slope waters (50 to 1000 m water depth), and have been found in highest concentrations between the Pribilof Islands and Unimak Island on the outer shelf, west of St. Matthew and St. Lawrence Islands and north into the Gulf of Anadyr.

Habitat and Biological Associations: Eulachon

Stage - EFH Level	Duration or Age	Diet/Prey	Season/ Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs	30–40 days	na	April–June	rivers, FW	D	S (CB?)		4 – 8°C for egg development
Larvae	1–2 months?	copepods phytoplankton mysids, larvae	summer/fall	ICS ?	P?	U, NA?	U	
Juveniles	2.5+ yrs up to age 3	copepods euphausiids	all year	MCS, OCS, USP	P	U, NA?	U F?	
Adults	3 yrs ages 3–5+	copepods euphausiids	spawning (May–June) non-spawning (July–Apr)	rivers, FW MCS, OCS, USP	D P	S (CB?) NA?	F?	

D.25.4 Literature

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D.26 Grenadiers (family *Macrouridae*)

D.26.1 Life History and General Distribution

At least seven species of grenadier are known to occur in Alaskan waters, but only three are commonly found at depths shallow enough to be encountered in commercial fishing operations or in fish surveys: giant grenadier (*Albatrossia pectoralis*), Pacific grenadier (*Coryphaenoides acrolepis*), and popeye grenadier (*Coryphaenoides cinereus*). Of these, giant grenadier has the shallowest depth distribution and the largest biomass, and hence is by far the most frequently caught grenadier in Alaska. On the slope (>400 meters) giant grenadier have by far the highest catch per unit effort and biomass in NMFS trawl surveys. Adults are caught in NMFS longline and trawl surveys but no other life stages are found in any NMFS surveys. The great majority of giant grenadier caught in surveys are female (96-99%). These results imply that much of the male population may reside in depths >1,000 that are not covered by the survey, at least during the summer period when the survey is occurring.

Giant grenadier range from Baja California, Mexico around the arc of the north Pacific Ocean to Japan, including the Bering Sea and the Sea of Okhotsk, and they are also found on seamounts in the Gulf of Alaska and on the Emperor Seamount chain in the North Pacific. In Alaska, they are especially abundant on the continental slope in waters >400 m depth. Giant grenadier are the largest in size of the world's grenadier species; maximum weight of one individual in a Bering Sea trawl survey was 41.8 kg. In a female maturity study, the maximum age was 58 years and the age at 50% maturity for females in the GOA was 23 years and the length at 50% maturity was 26 cm (pre-anal fin length).

Pacific grenadier have a geographic range nearly identical to that of giant grenadier, i.e., Baja California, Mexico to Japan. Popeye grenadier range from Oregon to Japan. Compared to giant grenadier, both species are much smaller and generally found in deeper water. Food studies off the U.S. West Coast indicate that Pacific grenadier are more benthic in their habitat than are giant grenadier, as the former species fed mostly on bottom organisms such as polychaetes, mysids, and crabs.

D.26.2 Relevant Trophic Information

The only food studies on grenadiers in the northeast Pacific have been on adults. One study of giant grenadier off the U.S. west coast concluded that the fish fed primarily off-bottom on bathy- and mesopelagic food items that included gonatid squids, viperfish, deep-sea smelts, and myctophids. Smaller studies of giant grenadier food habits in Alaska showed generally similar results. In the Aleutian Islands, the diet comprised mostly squid and myctophids (Yang 2003), whereas in the Gulf of Alaska, squid and pasiphaeid shrimp predominated as prey (Yang et al. 2006). Research on these deep-sea prey organisms in Alaska has been virtually non-existent, so information on prey availability or possible variations in abundance of prey are unknown.

In contrast to giant grenadier, a study of Pacific grenadier food habits off the U.S. west coast found a much higher consumption of benthic food items such as polychaetes, cumaceans, mysids, and juvenile Tanner crabs (*Chionoecetes* sp.), especially in smaller individuals. Carrion also contributed to its diet, and larger individuals consumed some pelagic prey including squids, fish, and bathypelagic mysids.

The only documented predators of giant grenadier are Pacific sleeper sharks and Baird's beaked whales. Sperm whales are another potential predator, as they are known to dive to depths inhabited by giant grenadier on the slope and have been observed depredating on longline catches of giant grenadier. Giant grenadier is a relatively large animal that is considered an apex predator in its environment on the deep slope, so it may have relatively few predators as an adult.

D.26.3 Habitat and Biological Associations

Little or no environmental information has been collected in Alaska for the deep slope habitat in which grenadiers live. The absence of larvae or post-larvae giant grenadier in larval surveys in Alaska, which have nearly all been conducted in upper parts of the water column, implies that larval giant grenadier may reside in deeper water.

Habitat and Biological Associations: Grenadiers

Stage - EFH Level	Duration or Age	Diet/Prey	Season/ Time	Location	Water Column	Bottom Type	Oceano -graphic Features	Other
Eggs	U	na	U	U	U	U	U	
Larvae	U	U	U	U	U	U	U	
Juveniles	U to 20 years	U	all year	continental slope, deep shelf gulleys and other habitats (few juveniles have been found)	Sometimes caught with bottom tending gear. presumably D	U	U	
Adults	20-58 years	opportunistic: gonatid squids, viperfish, deep-sea smelts, myctophids, pasiphaeid shrimp	Spawning may be year-round	continental slope, and deep shelf gulleys	Caught with bottom tending gear. presumably D	Likley in most bottom types	U	

D.26.4 Literature

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E Appendix E Maps of Essential Fish Habitat

Maps of essential fish habitat are included in this section for the following species (life stage is indicated in parentheses):

Figures E-1 to E-14	Walleye pollock (adult, juvenile, larvae, egg)
Figures E-15 to E-26	Pacific cod (adult, juvenile, larvae)
Figures E-27 to E-36	Sablefish (adult, juvenile)
Figures E-37 to E-43	Yellowfin sole (adult, juvenile, larvae, egg)
Figures E-44 to E-54	Greenland turbot (adult, juvenile, larvae)
Figures E-55 to E-66	Arrowtooth flounder (adult, juvenile, larvae,)
Figures E-67 to E-76	Kamchatka flounder (adult, juvenile)
Figures E-77 to E-88	Northern rock sole (adult, juvenile, larvae)
Figures E-89 to E-94	Alaska Plaice (adult, juvenile, larvae, egg)
Figures E-95 to E-106	Rex sole (adult, juvenile, larvae, egg)
Figures E-107 to E-113	Dover sole (adult, juvenile)
Figures E-114 to E-126	Flathead sole (adult, juvenile, larvae, egg)
Figures E-127 to E-138	Pacific ocean perch (adult, juvenile, larvae)
Figures E-139 to E-147	Northern rockfish (adult, juvenile)
Figures E-148 to E-157	Shortraker rockfish (adult, juvenile)
Figures E-158 to 161	Blackspotted (adult, juvenile)
Figures E-162 to E-171	Rougheye rockfish (late juveniles/adults)
Figures E-172 to E-180	Dusky rockfish (adult, juvenile)
Figure E-181 to E-190	Shortspine thornyhead rockfish (adult, juvenile)
Figures E-191 to E-201	Atka mackerel (adult, juvenile, larvae, egg)
Figures E-202 to E-211	Bigmouth sculpin (adult, juvenile)
Figures E-212 to E-220	Great sculpin (adult, juvenile)
Figures E-221 to E-232	Alaska skate (adult, juvenile
Figures E-233 to E-242	Aleutian skate (adult, juvenile)
Figures E-243 to E-246	Bering skate (adult, juvenile)
Figures E-247 to E-256	Mud skates (adults, juvenile)
Figures E-257 to E-267	Southern rock sole (adult, juvenile, larvae)
Figures E-268 to E-275	Octopus (adult)
Figures E-276 to E-285	Yellow Irish lord (adult, juvenile)

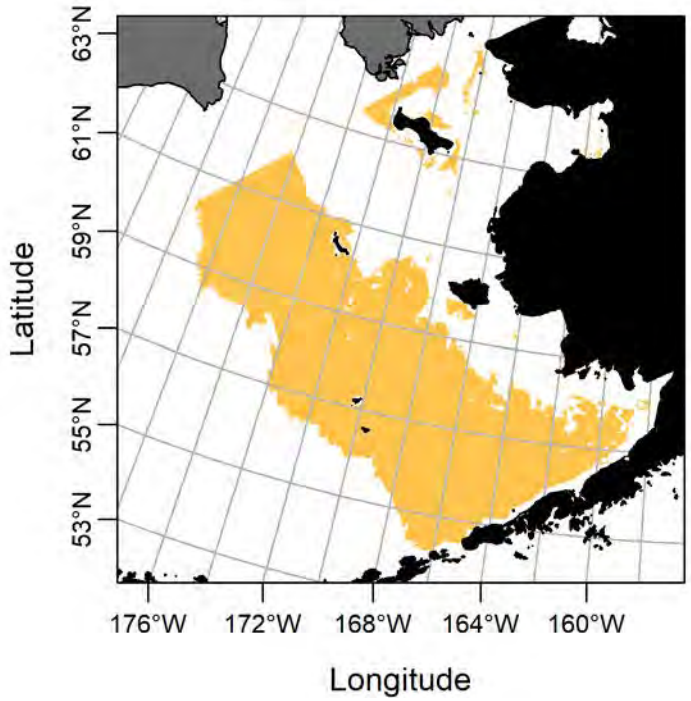

Figure E-1 EFH distribution of EBS Walleye Pollock adult, fall.

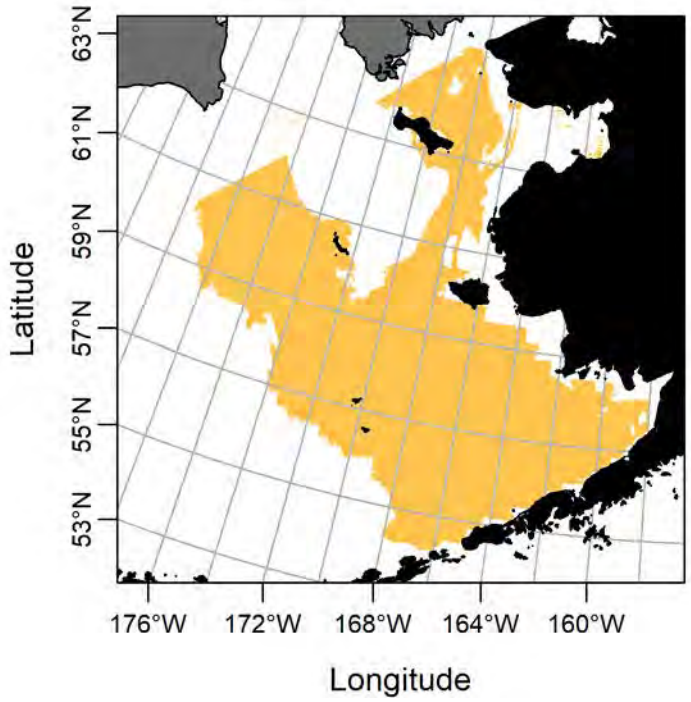

Figure E-2 EFH distribution of EBS Walleye pollock adult, spring.

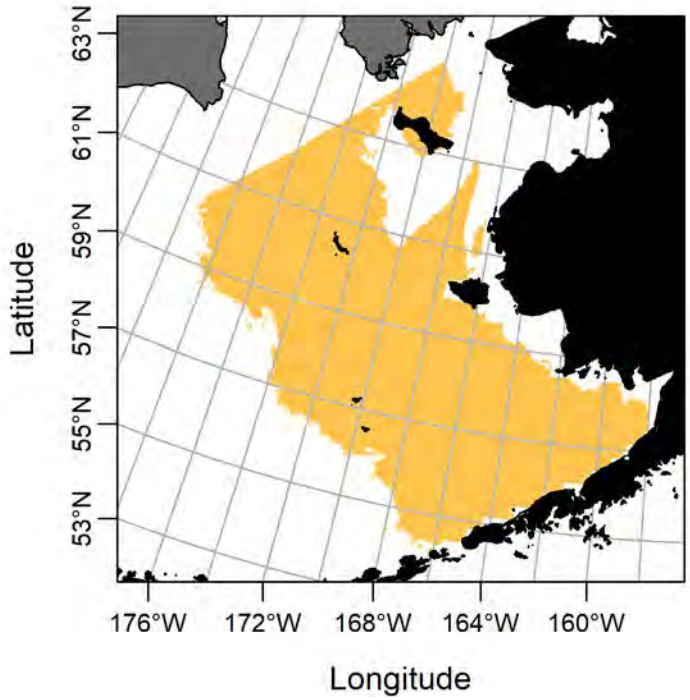

Figure E-3 EFH distribution of EBS Walleye pollock adult, summer

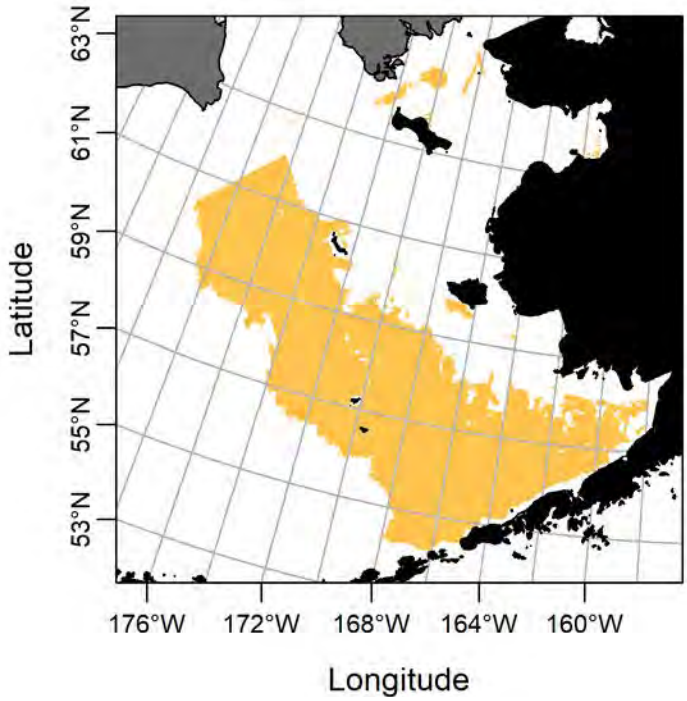

Figure E-4 EFH distribution of EBS Walleye pollock adult, winter.

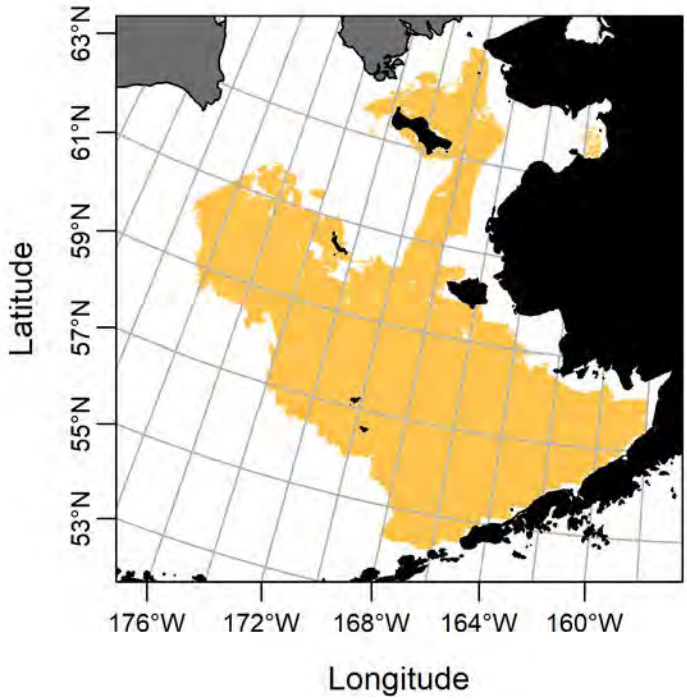

Figure E-5 EFH distribution of EBS Walleye pollock eggs, summer.

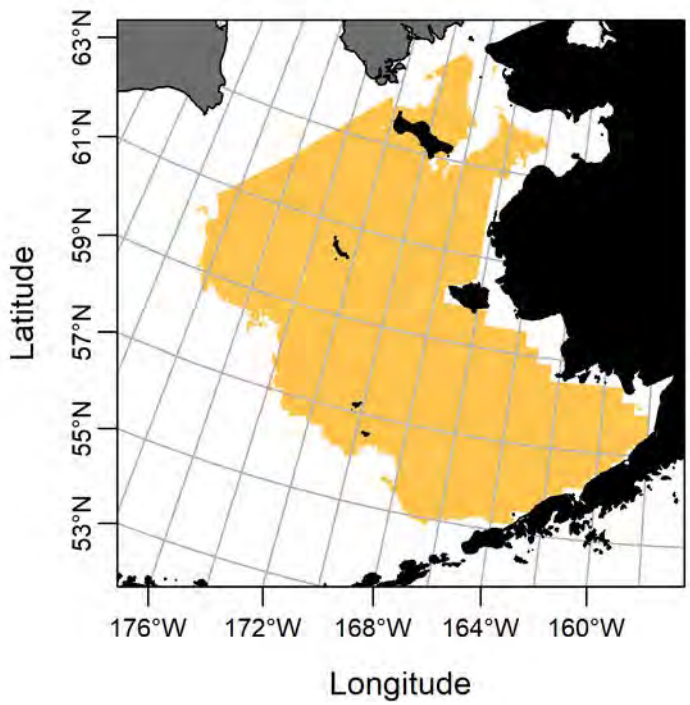

Figure E-6 EFH distribution of EBS Walleye pollock juvenile, summer.

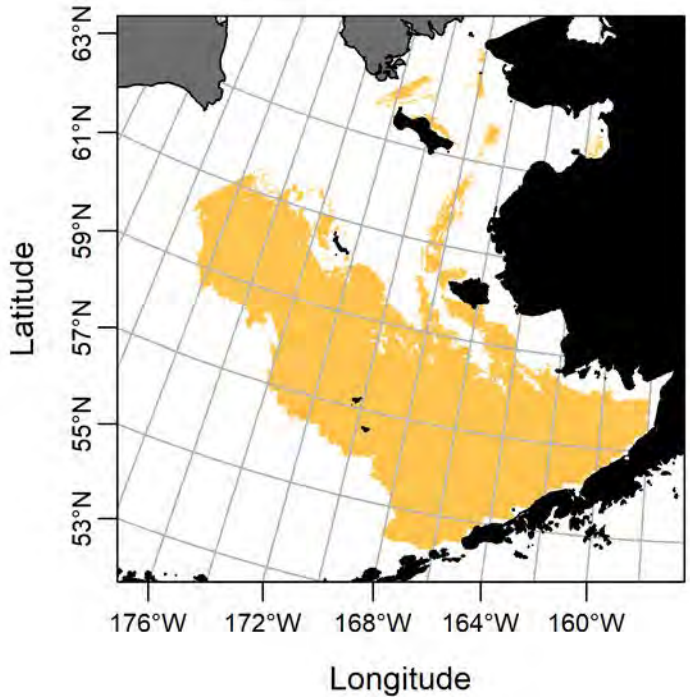

Figure E-7 EFH distribution of EBS Walleye pollock larvae, summer.

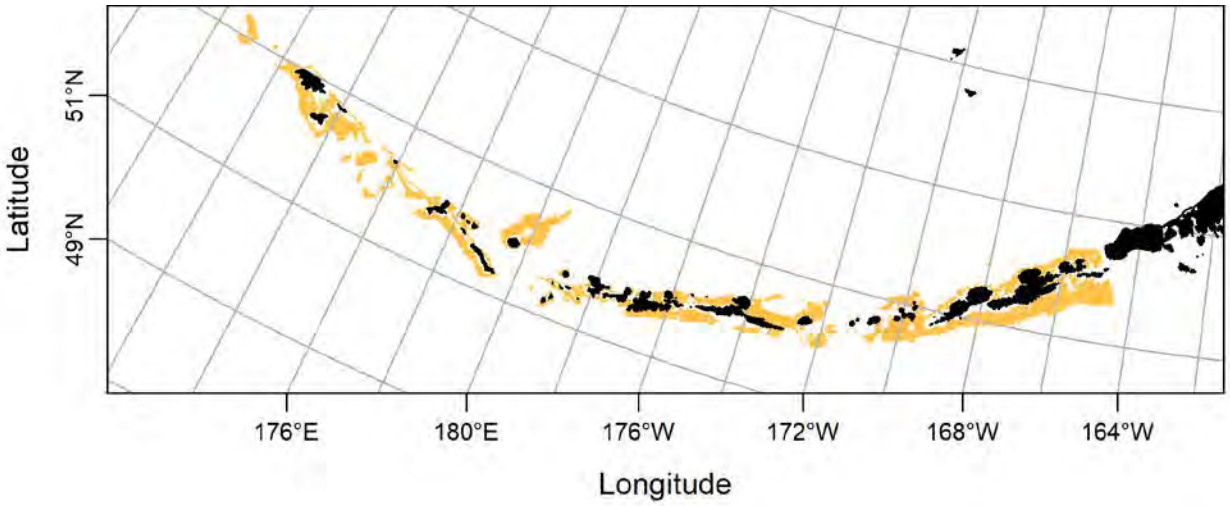

Figure E-8 EFH distribution of AI Walleye pollock adult, fall.

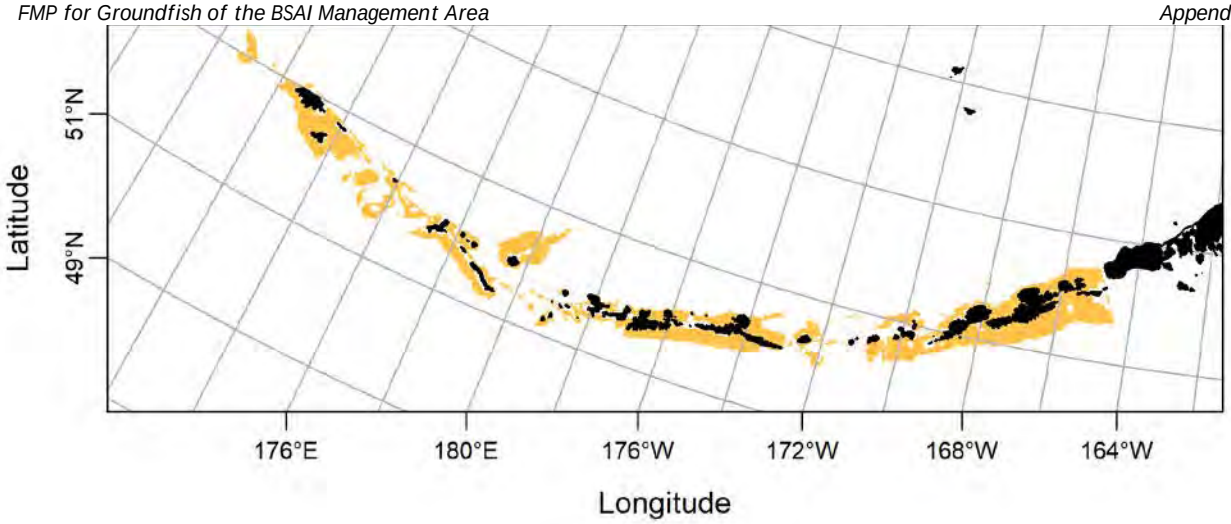

Figure E-9 EFH distribution of AI Walleye pollock adult, spring.

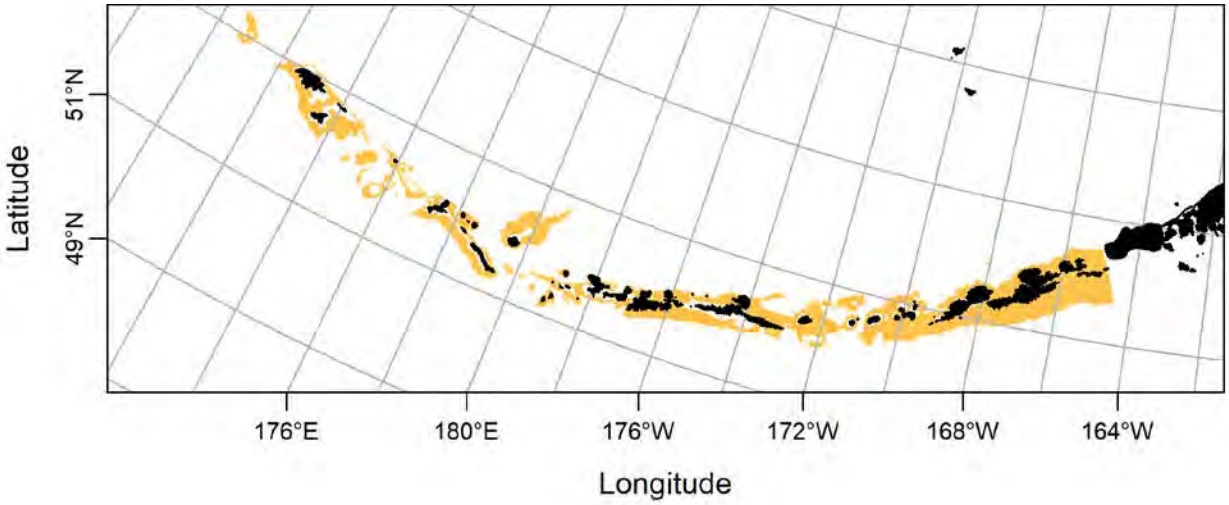

Figure E-10 EFH distribution of AI Walleye pollock adult, summer.

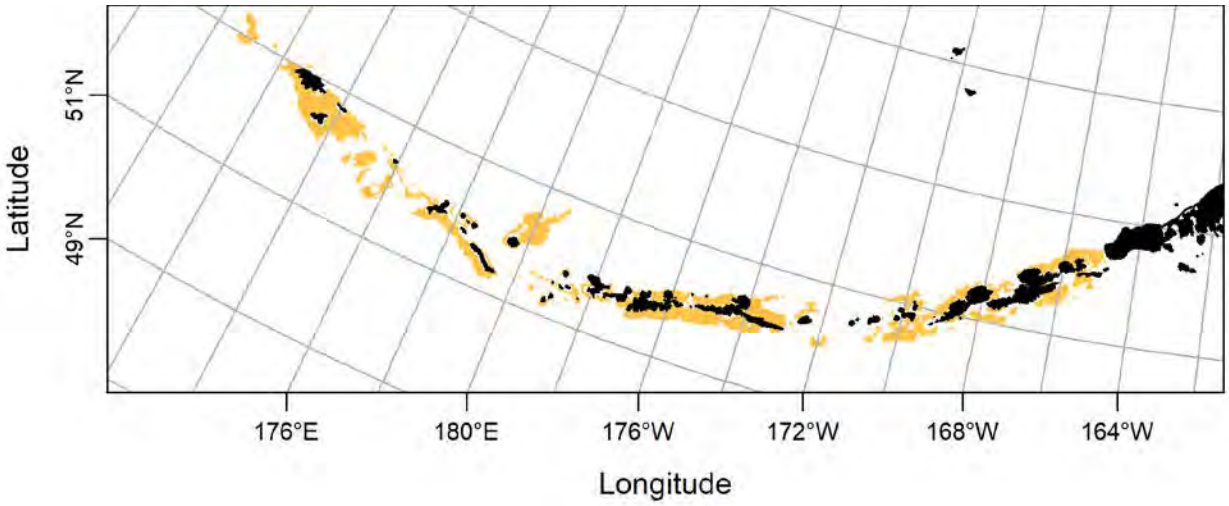

Figure E-11 EFH distribution of AI Walleye pollock adult, winter.

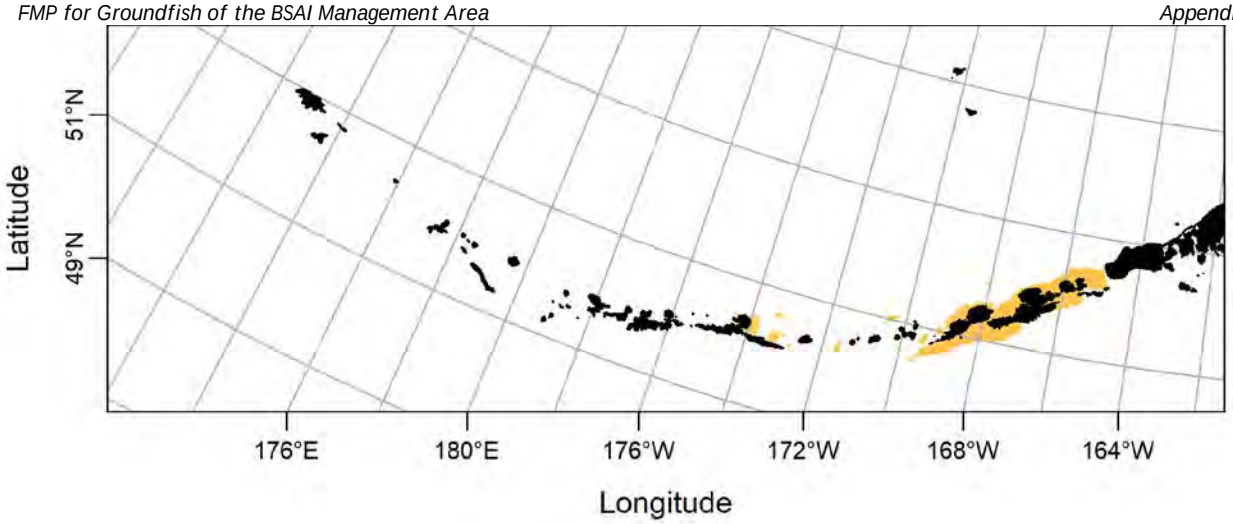

Figure E-12 EFH distribution of AI Walleye pollock egg, summer.

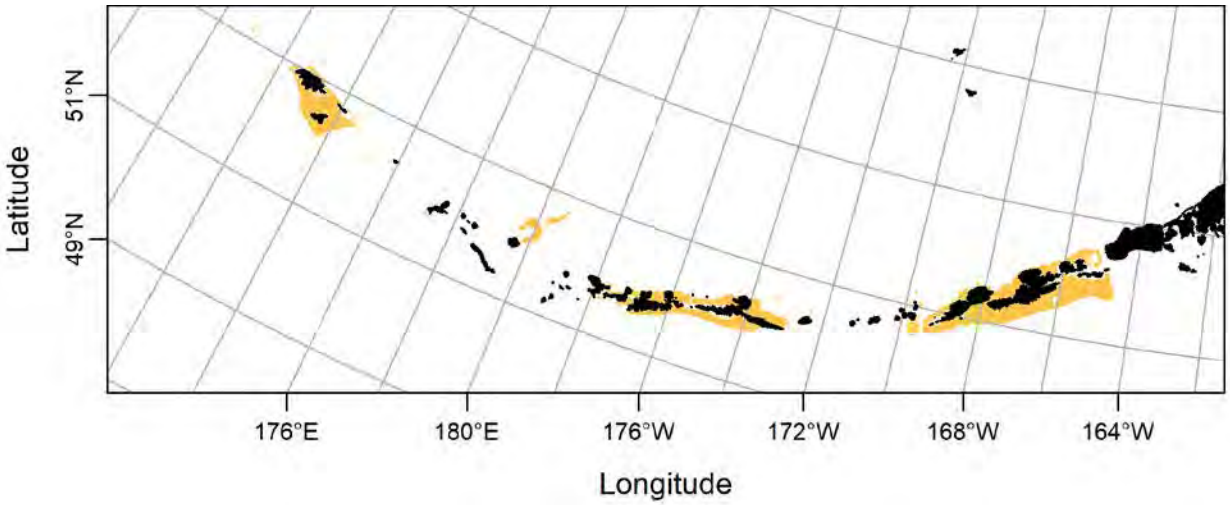

Figure E-13 EFH distribution of AI Walleye pollock juvenile, summer.

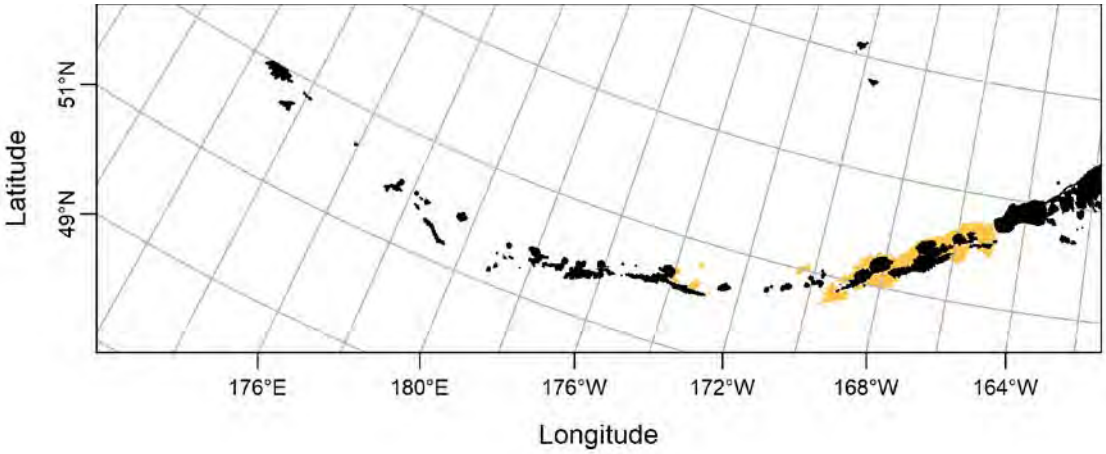

Figure E-14 EFH distribution of AI Walleye pollock larvae, summer.

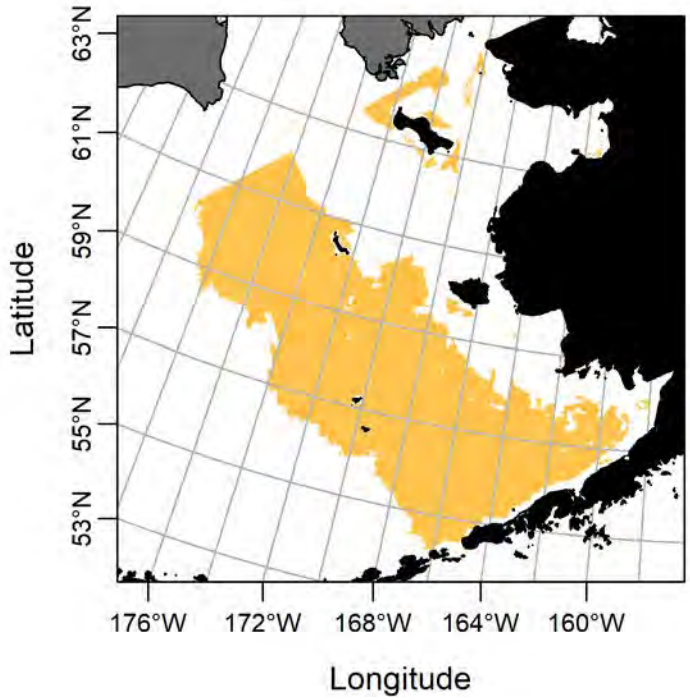

Figure E-15 EFH distribution of EBS Pacific cod adult, fall.

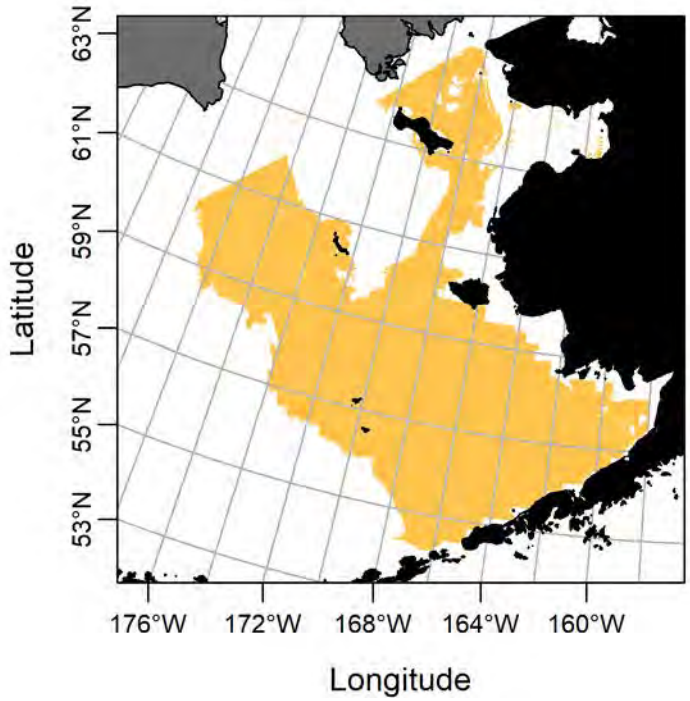

Figure E-16 EFH distribution of EBS Pacific cod adult, spring.

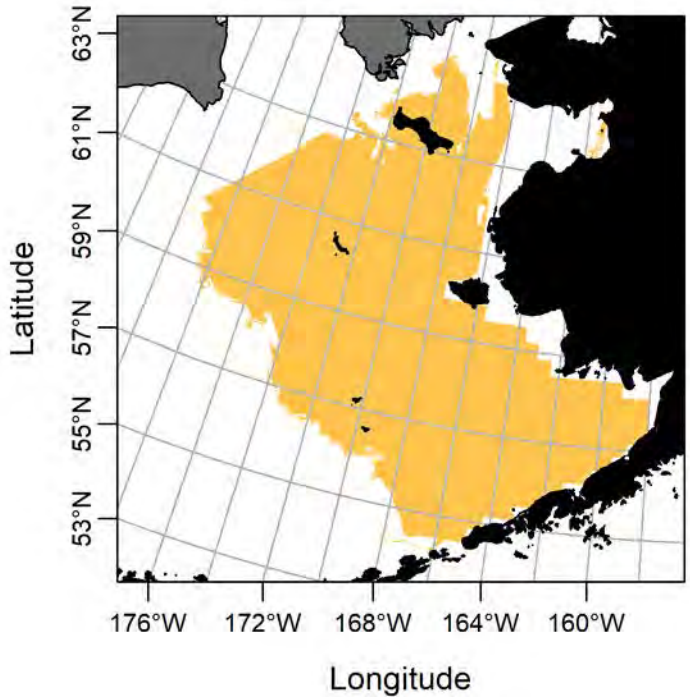

Figure E-17 EFH distribution of EBS Pacific cod adult, summer.

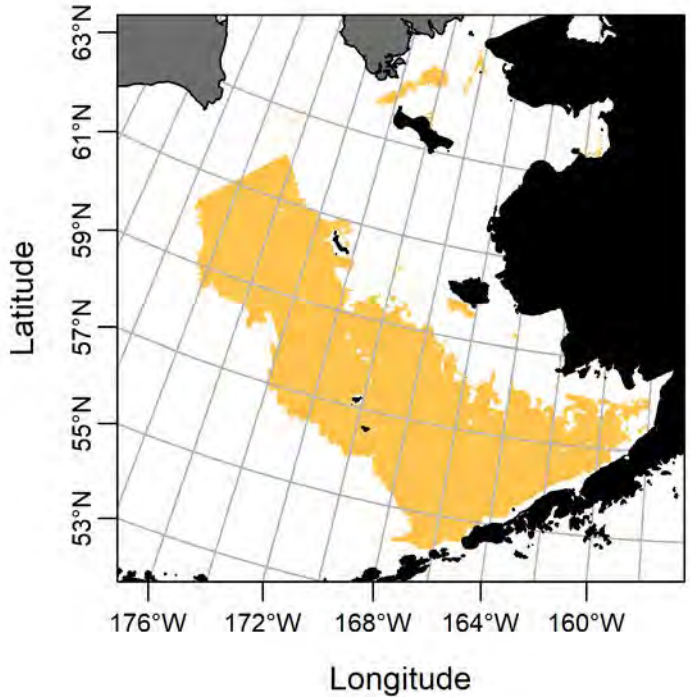

Figure E-18 EFH distribution of EBS Pacific cod adult, winter.

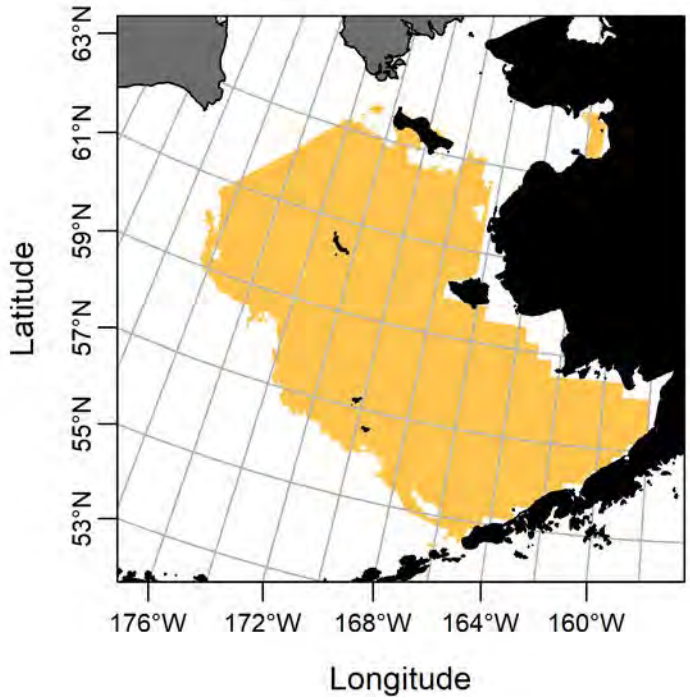

Figure E-19 EFH distribution of EBS Pacific cod juvenile, summer.

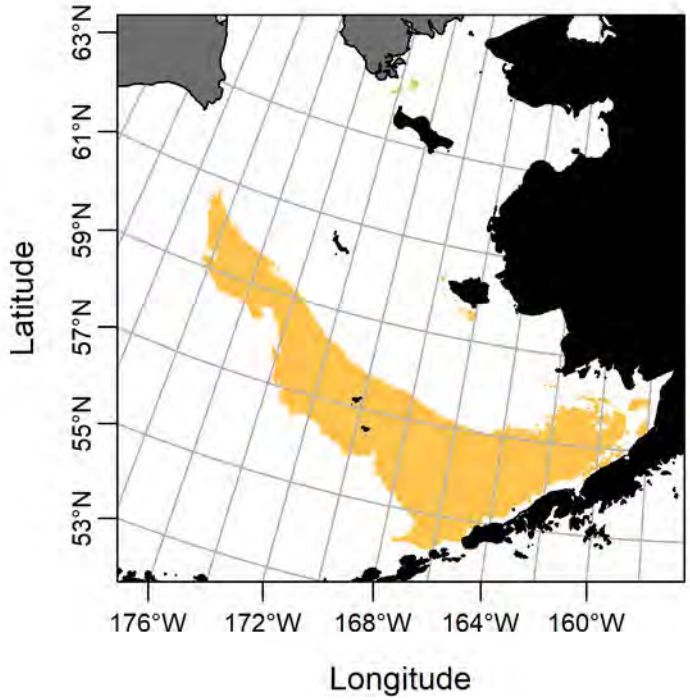

Figure E-20 EFH distribution of EBS Pacific cod larvae, summer.

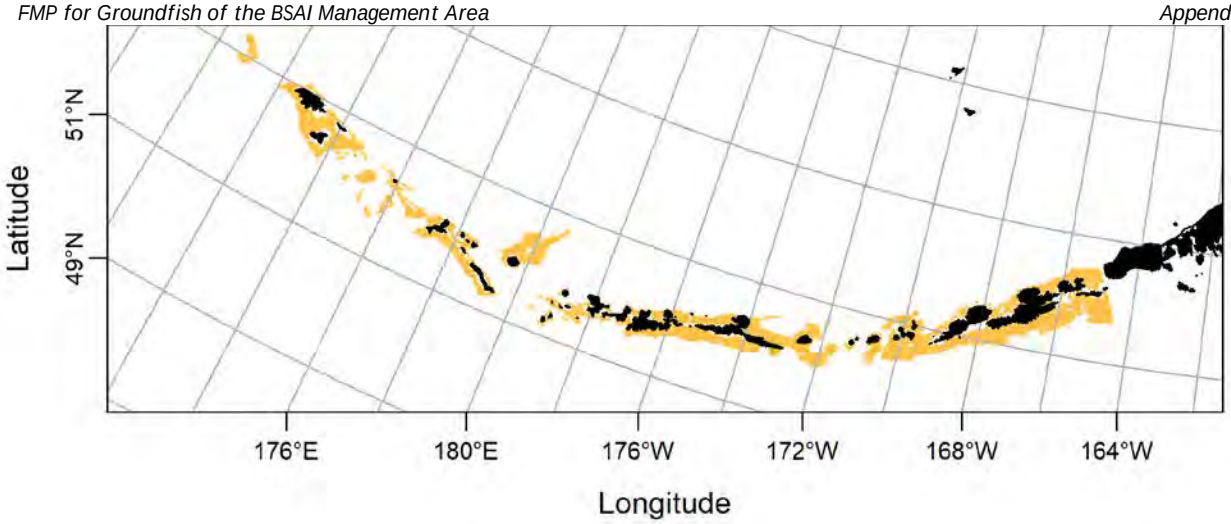

Figure E-21 EFH distribution of AI Pacific cod adult, fall.

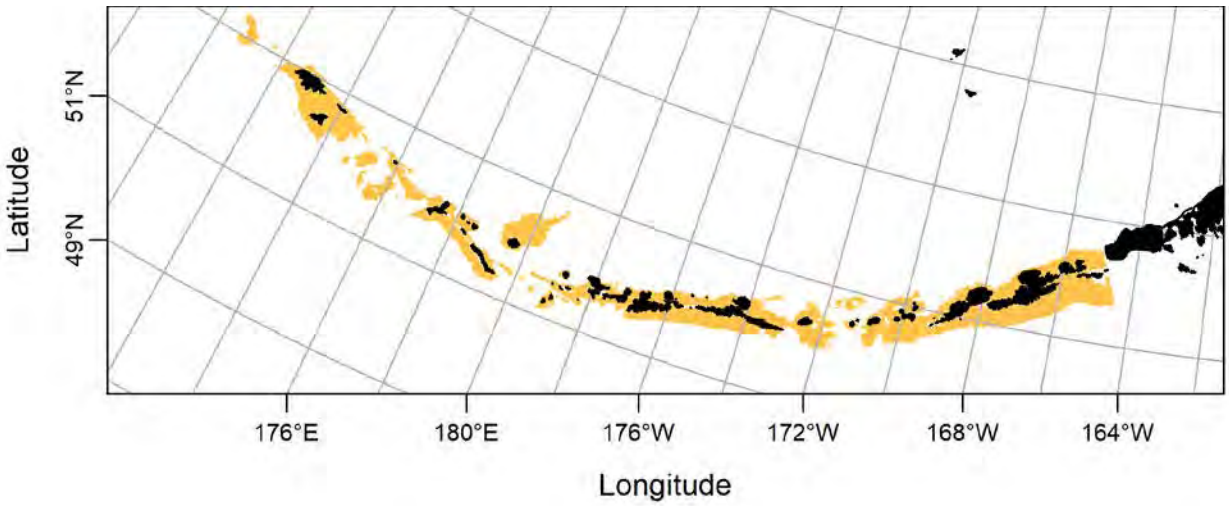

Figure E-22 EFH distribution of AI Pacific cod adult, spring.

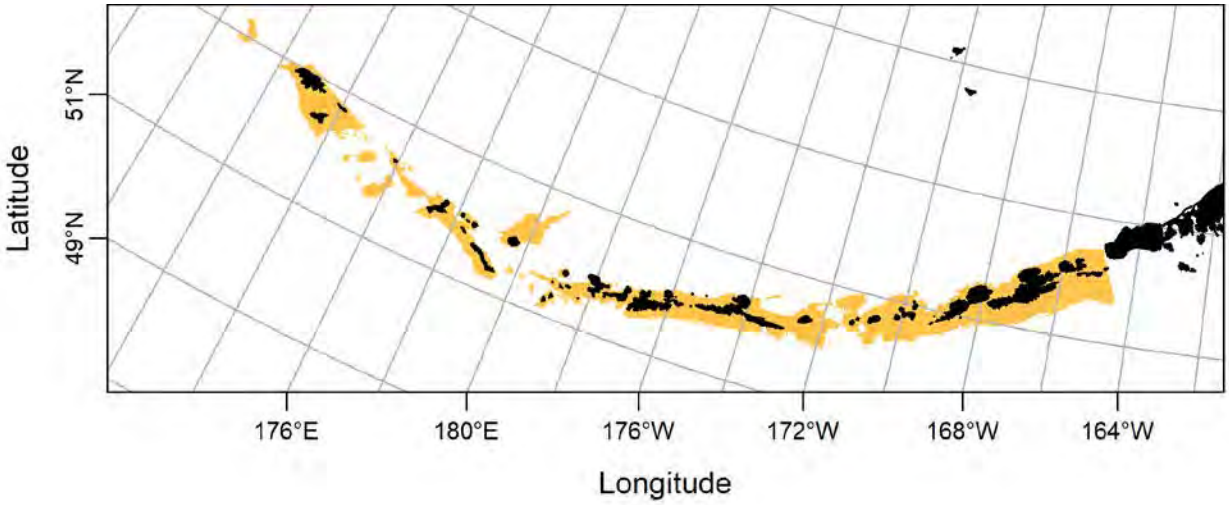

Figure E-23 EFH distribution of AI Pacific cod adult, summer.

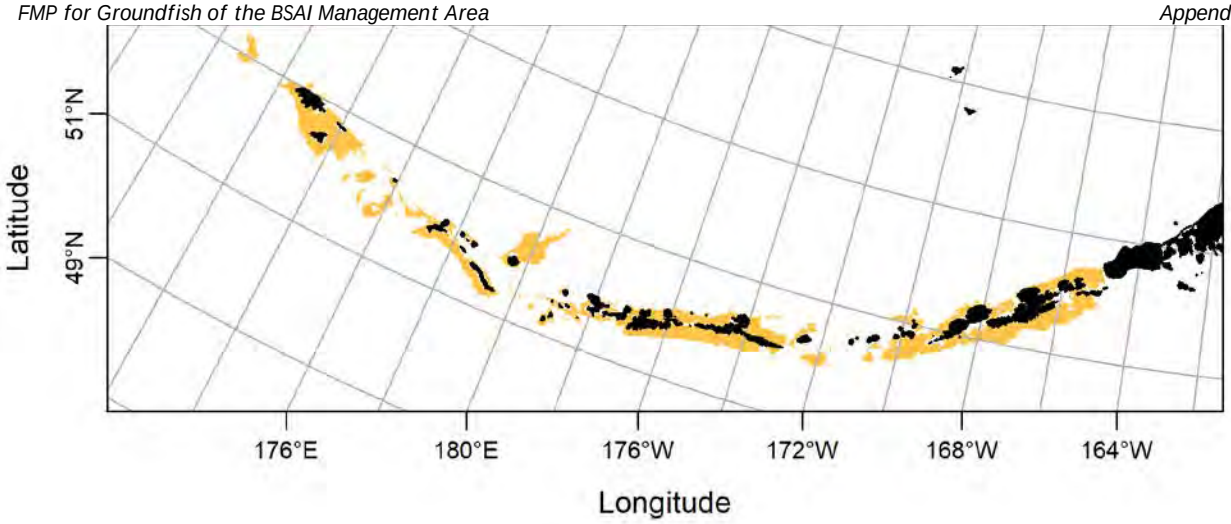

Figure E-24 EFH distribution of AI Pacific cod adult, winter.

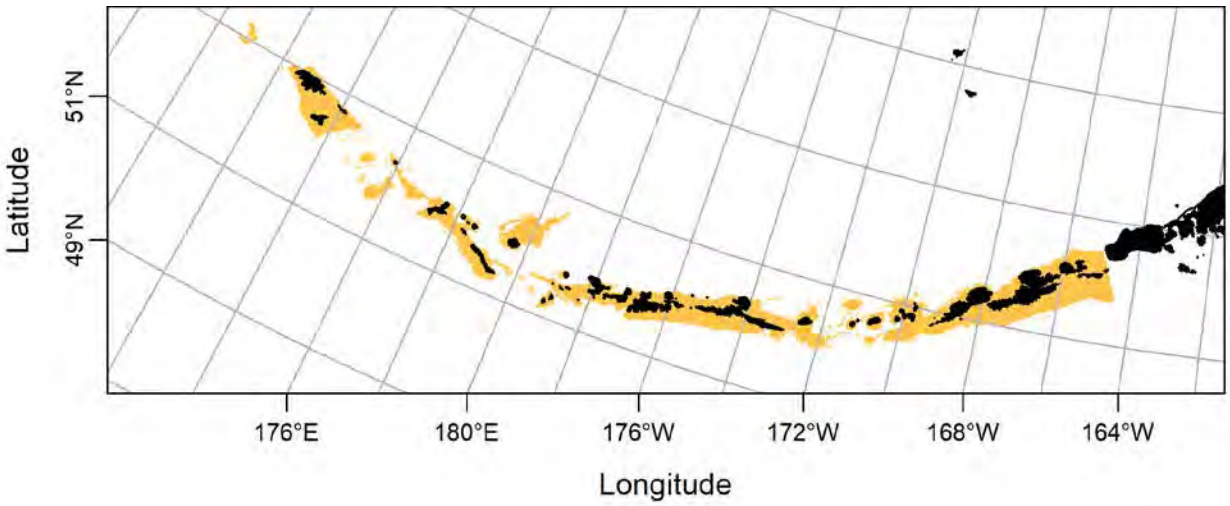

Figure E-25 EFH distribution of AI Pacific cod juvenile, summer.

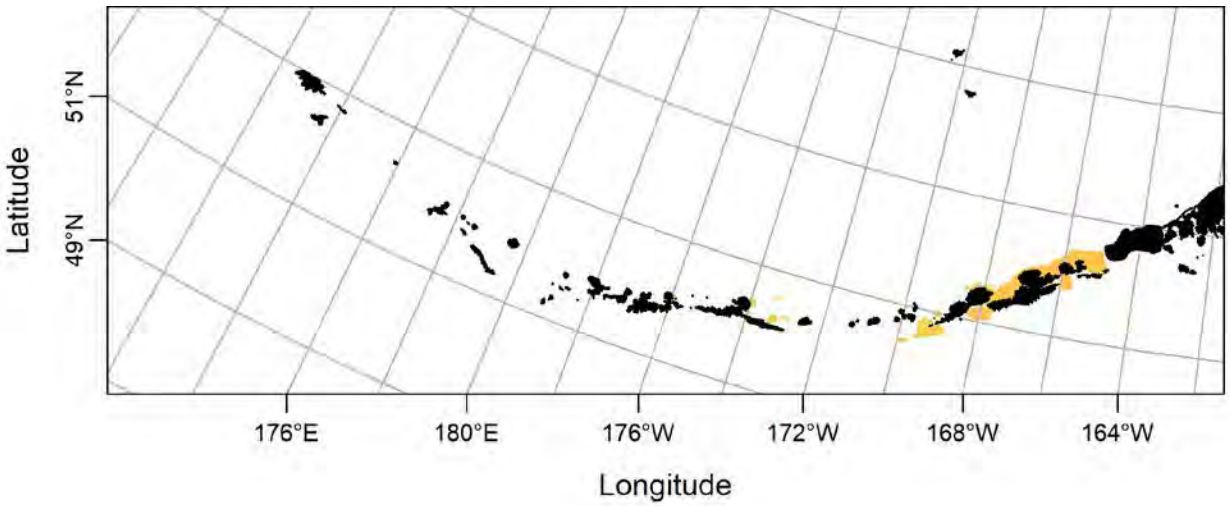

Figure E-26 EFH distribution of AI Pacific cod larvae, summer.

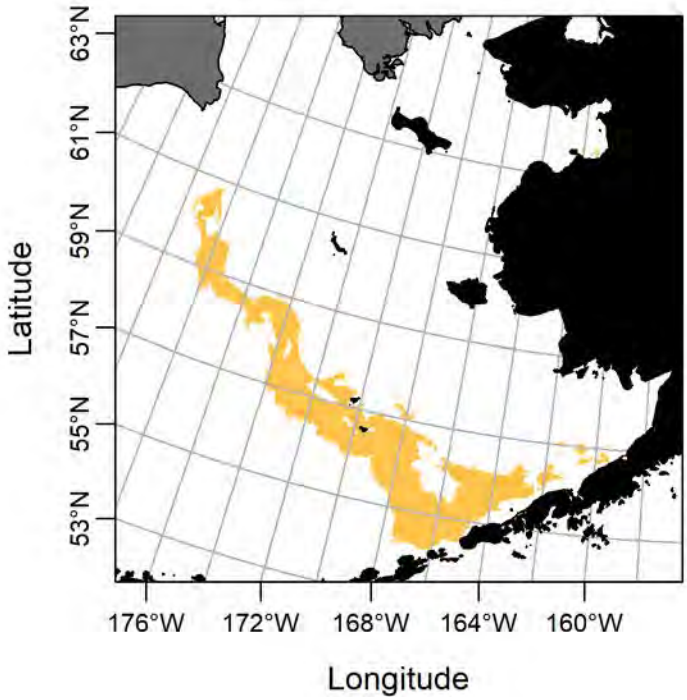

Figure E-27 EFH distribution of EBS Sablefish adult, fall.

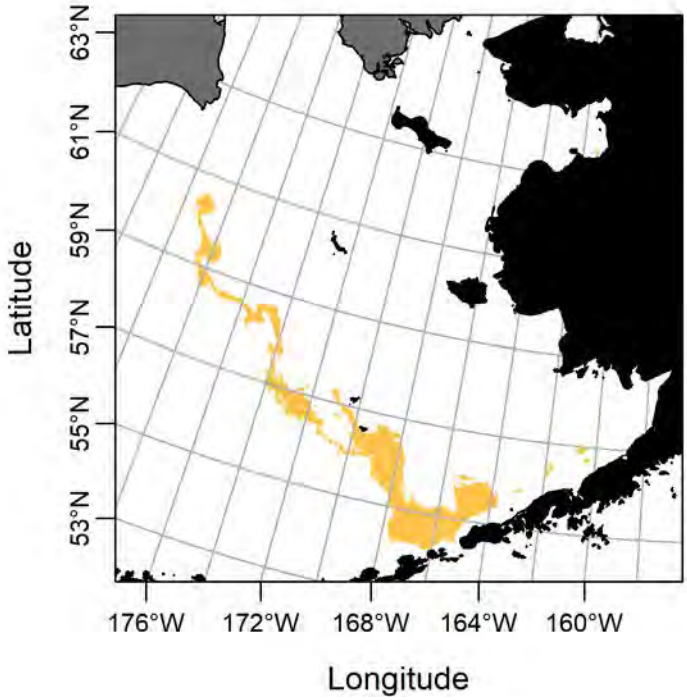

Figure E-28 EFH distribution of EBS Sablefish adult, spring.

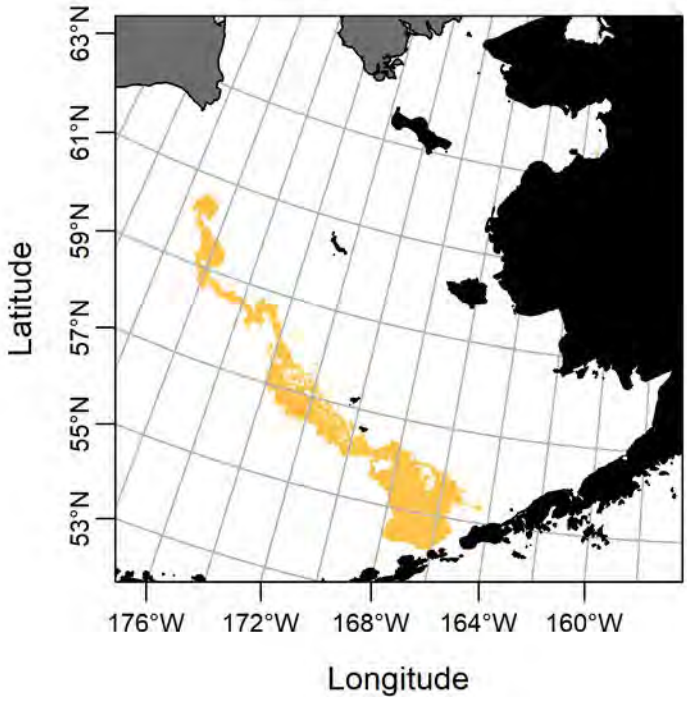

Figure E-29 EFH distribution of EBS Sablefish adult, summer.

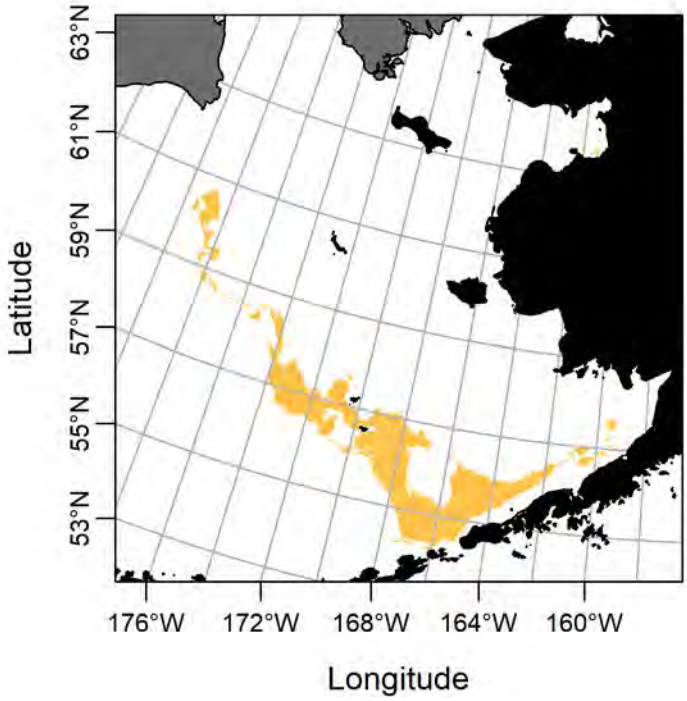

Figure E-30 EFH distribution of EBS Sablefish adult, winter.

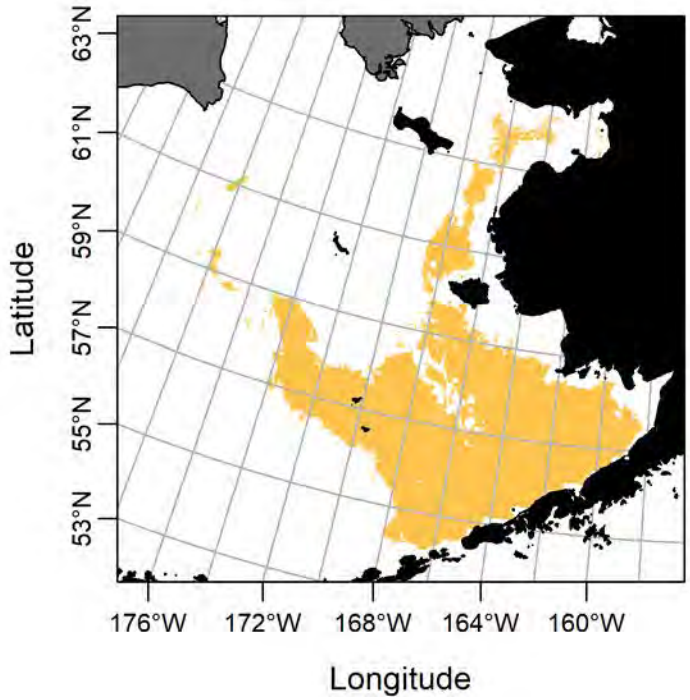

Figure E-31 EFH distribution of EBS Sablefish juvenile, summer.

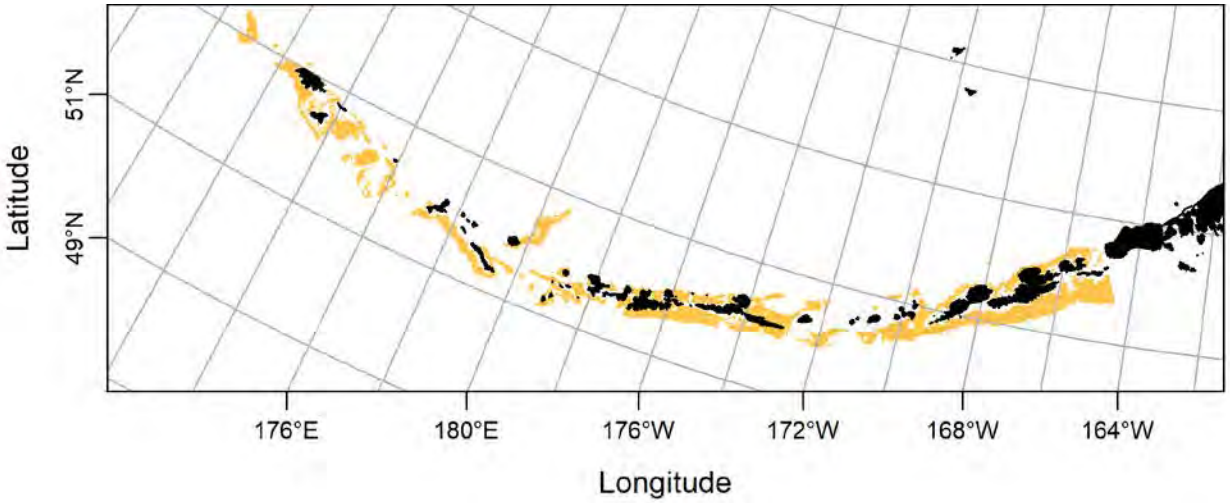

Figure E-32 EFH distribution of AI Sablefish adult, fall.

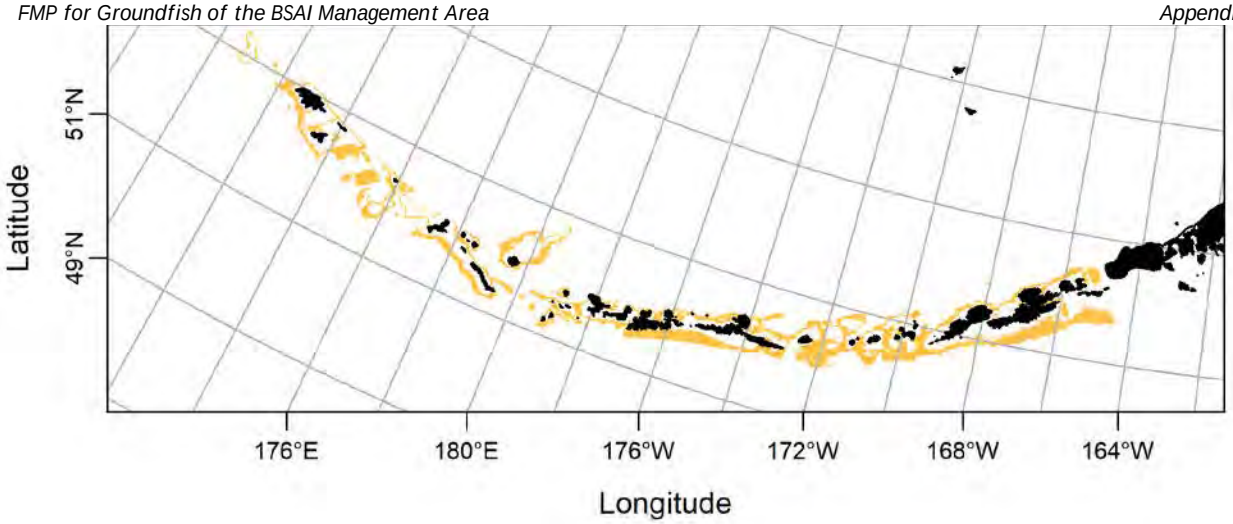

Figure E-33 EFH distribution of AI Sablefish adult, spring.

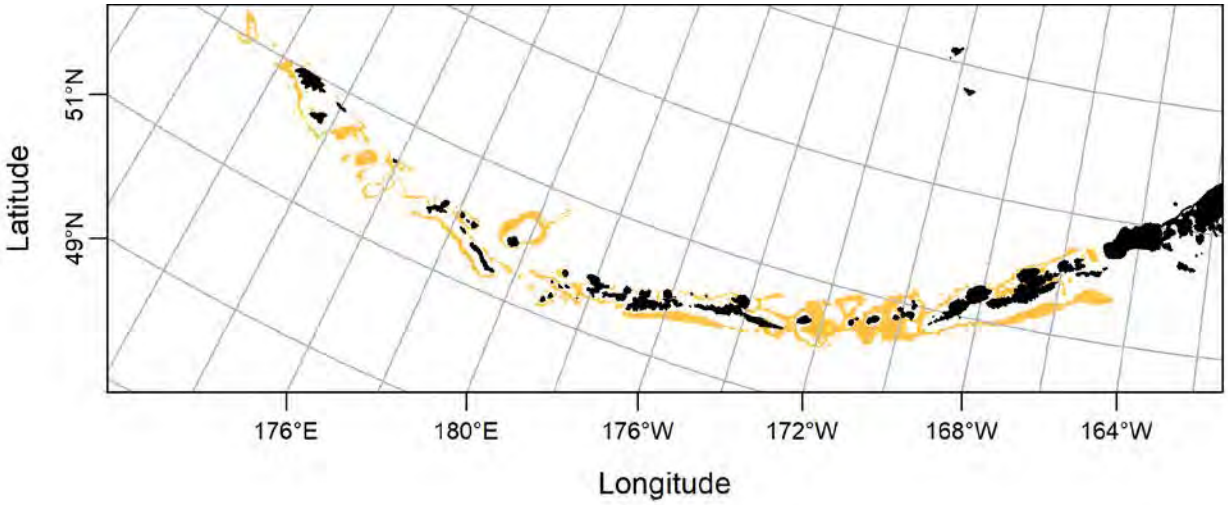

Figure E-34 EFH distribution of AI Sablefish adult, summer.

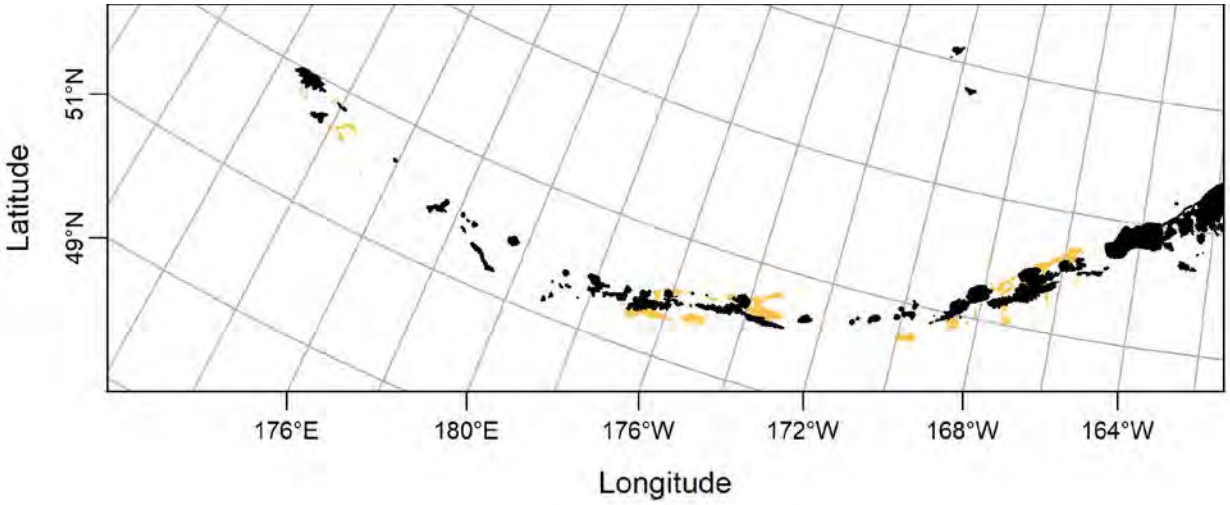

Figure E-35 EFH distribution of AI Sablefish adult, winter.

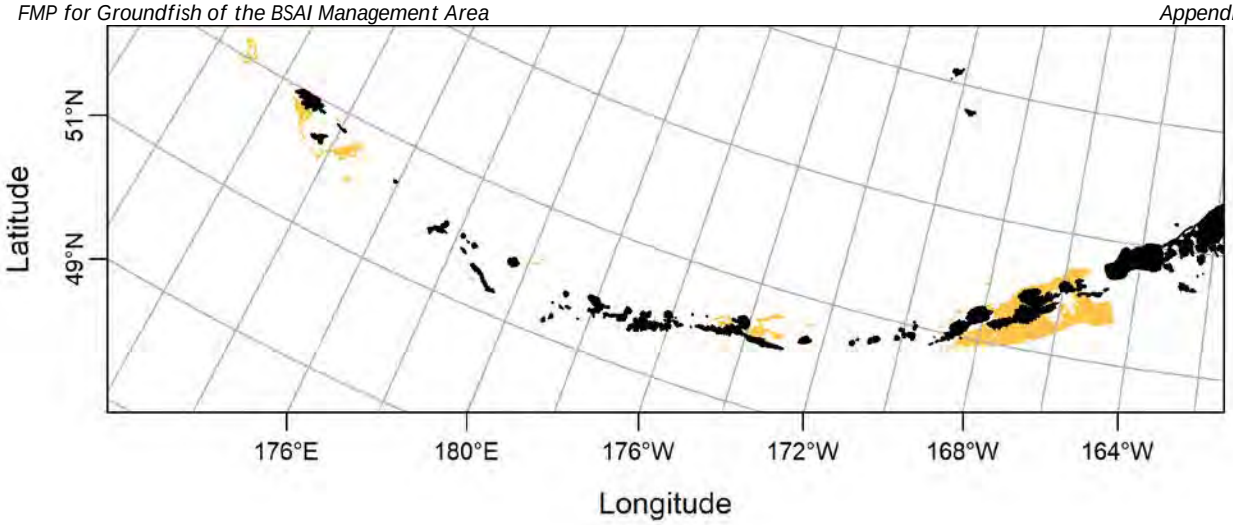

Figure E-36 EFH distribution of AI Sablefish juvenile, summer.

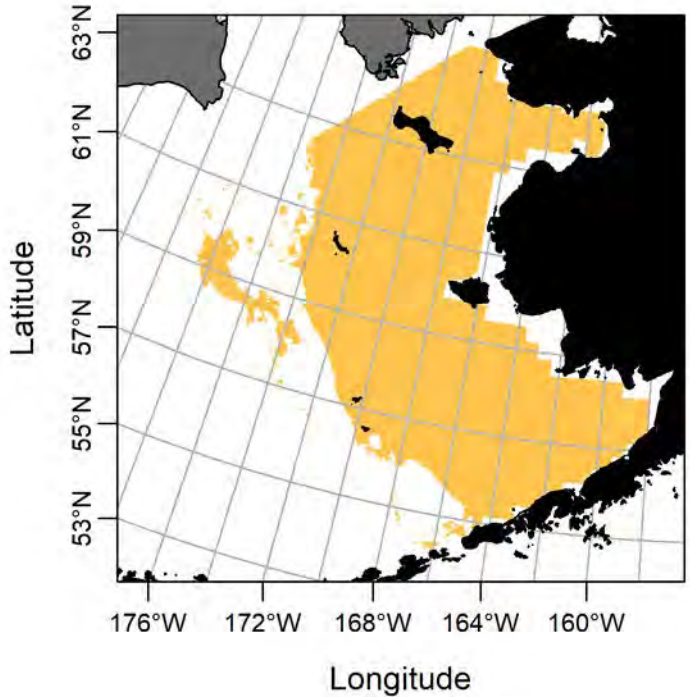

Figure E-37 EFH distribution of EBS Yellowfin sole juvenile, summer.

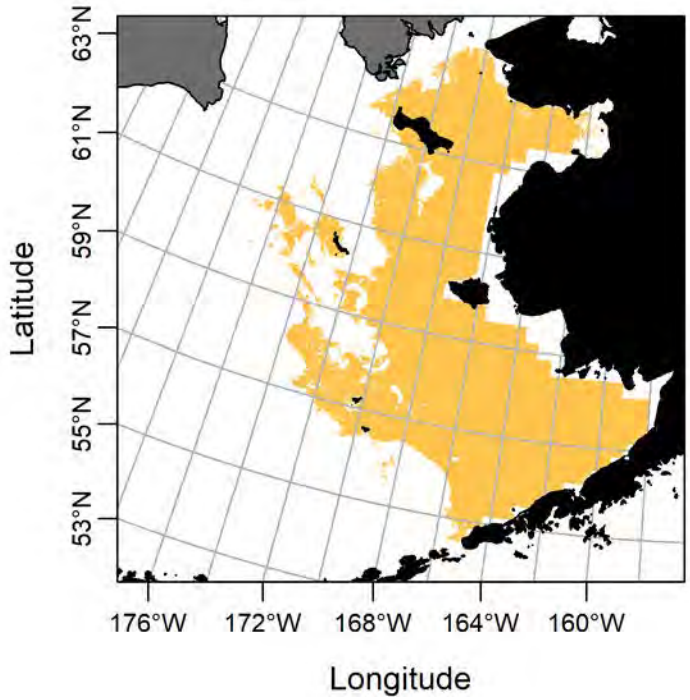

Figure E-38 EFH distribution of EBS Yellowfin sole larvae, summer.

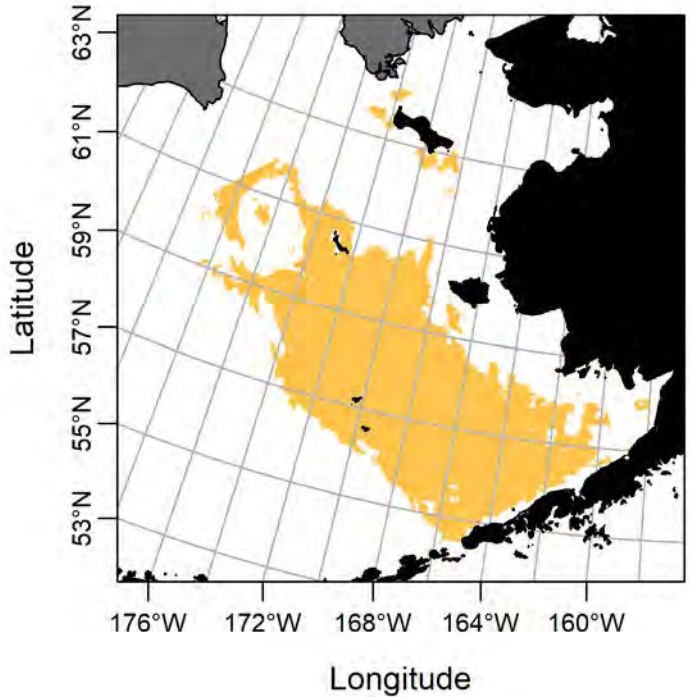

Figure E-39 EFH distribution of EBS Yellowfin sole adult, fall.

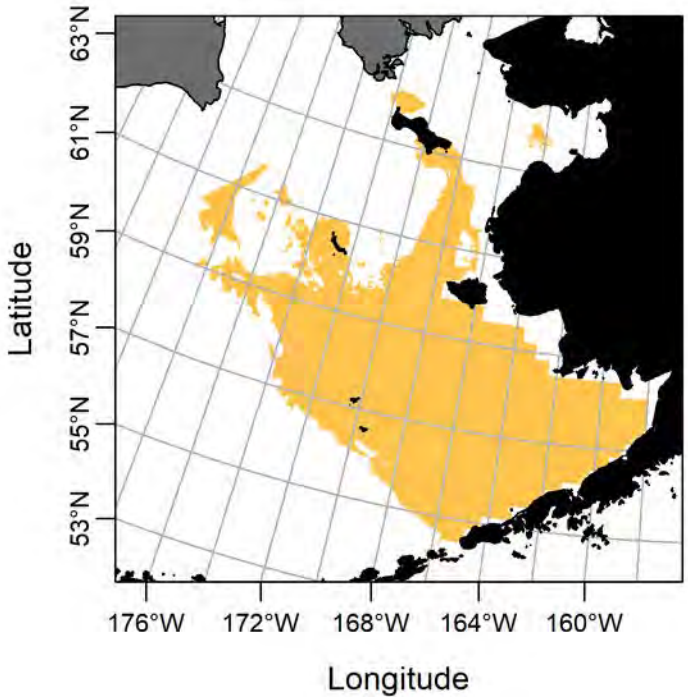

Figure E-40 EFH distribution of EBS Yellowfin sole adult, spring.

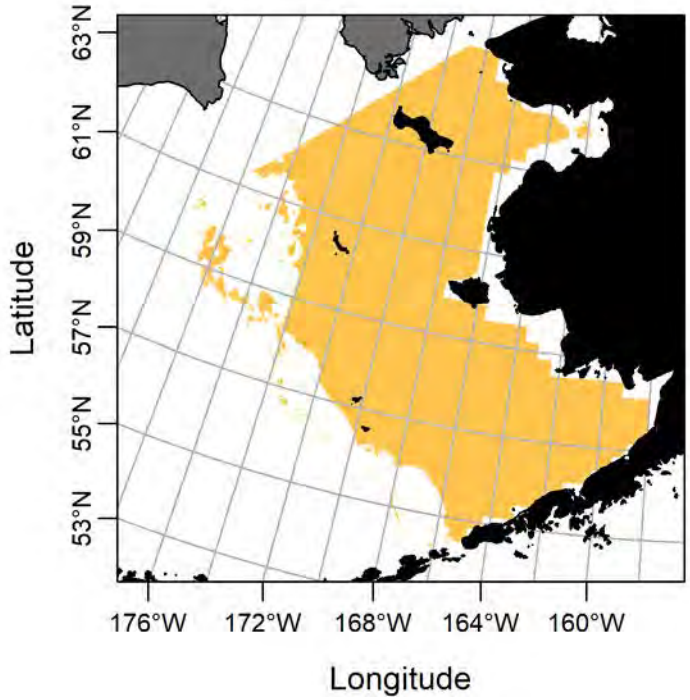

Figure E-41 EFH distribution of EBS Yellowfin sole adult, summer.

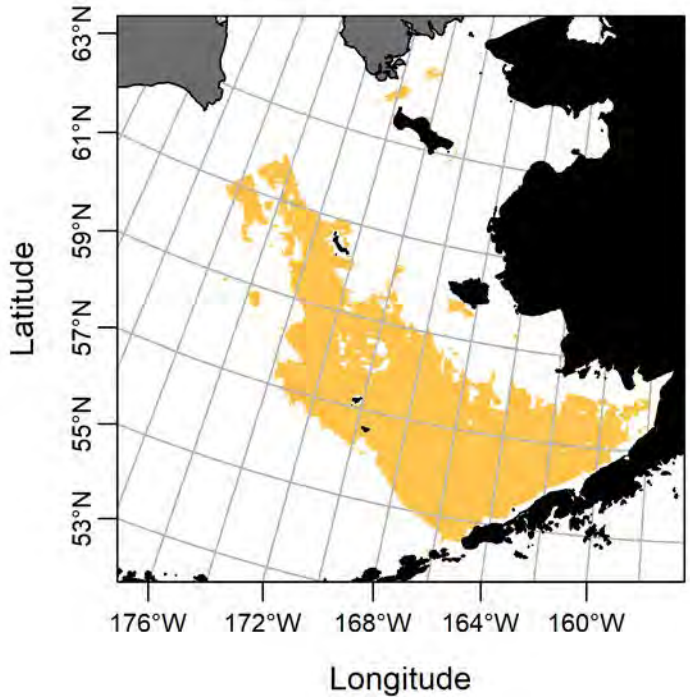

Figure E-42 EFH distribution of EBS Yellowfin sole adult, winter.

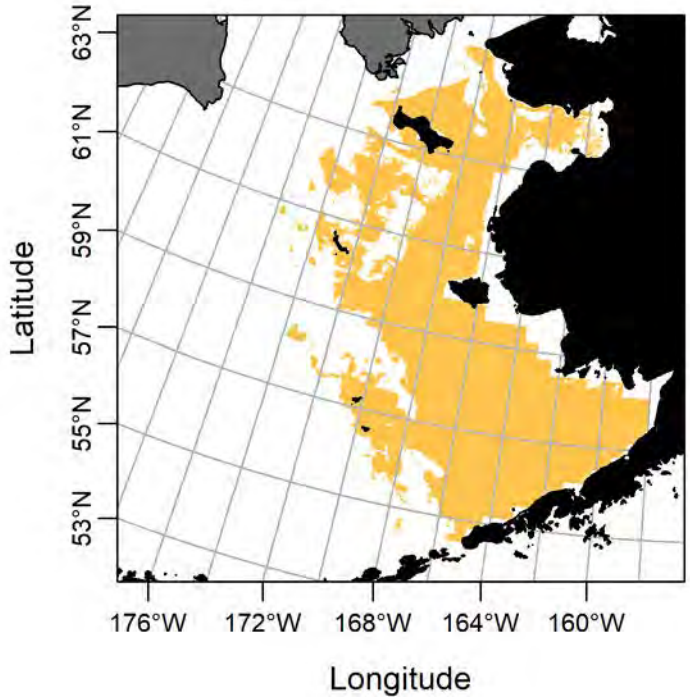

Figure E-43 EFH distribution of EBS Yellowfin sole egg, summer.

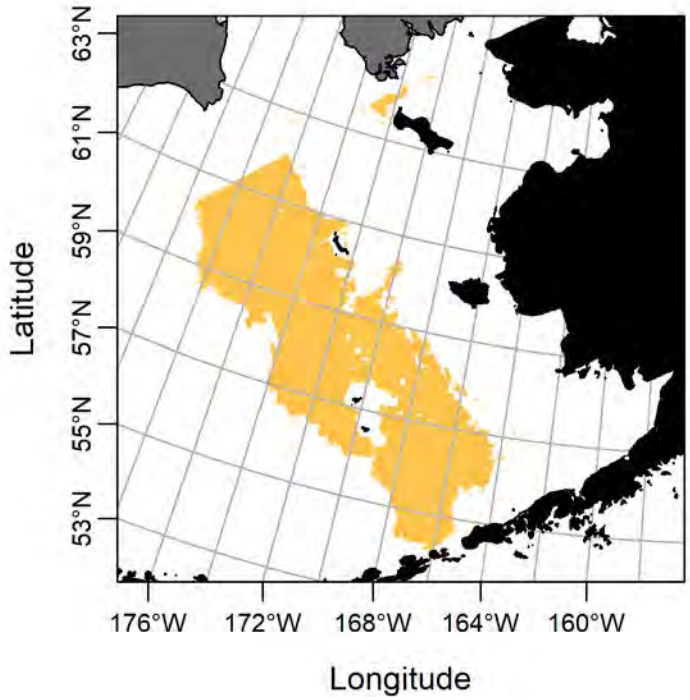

Figure E-44 EFH distribution of EBS Greenland turbot adult, fall.

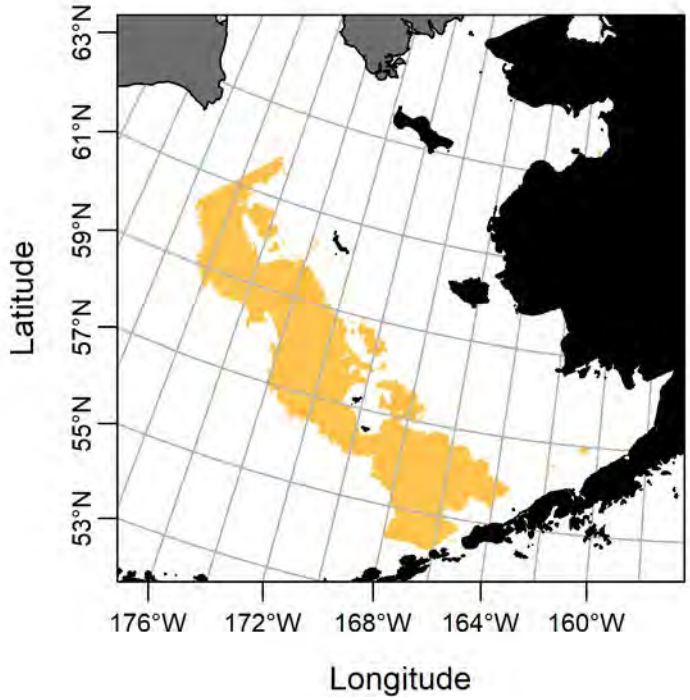

Figure E-45 EFH distribution of EBS Greenland turbot adult, spring.

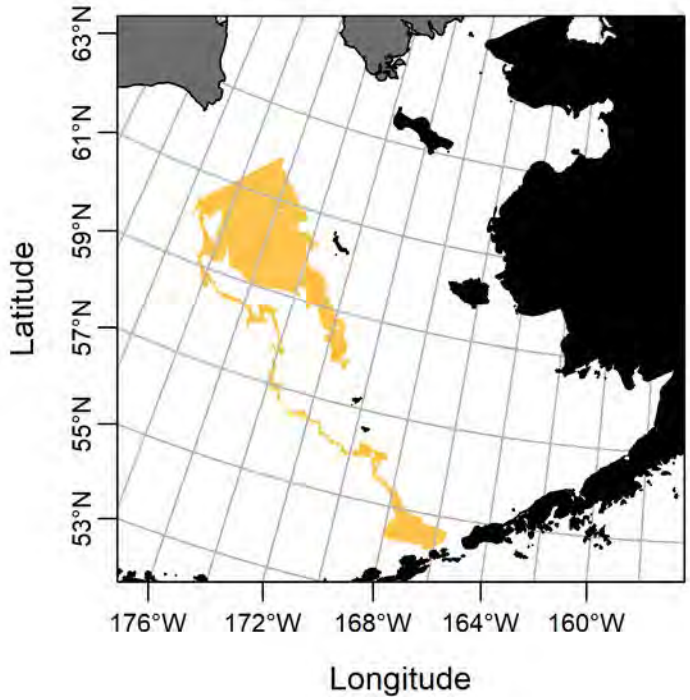

Figure E-46 EFH distribution of EBS Greenland turbot adult, summer.

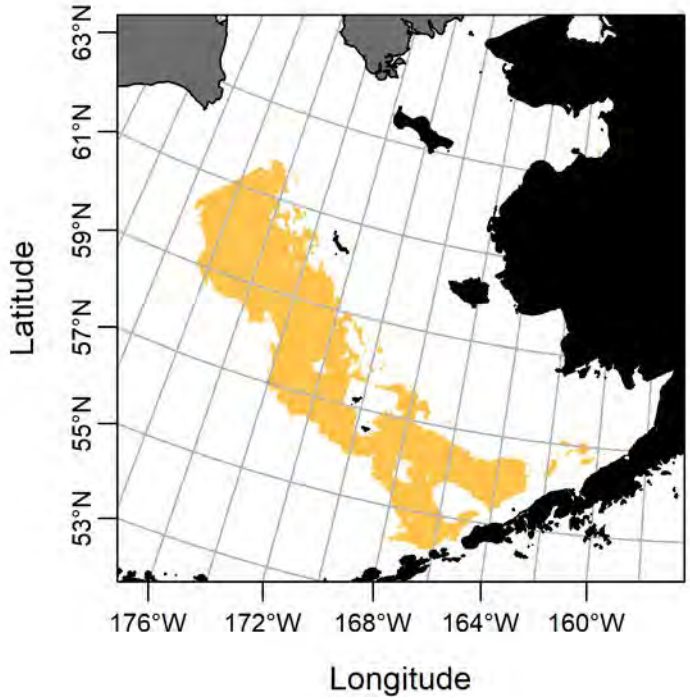

Figure E-47 EFH distribution of EBS Greenland turbot adult, winter.

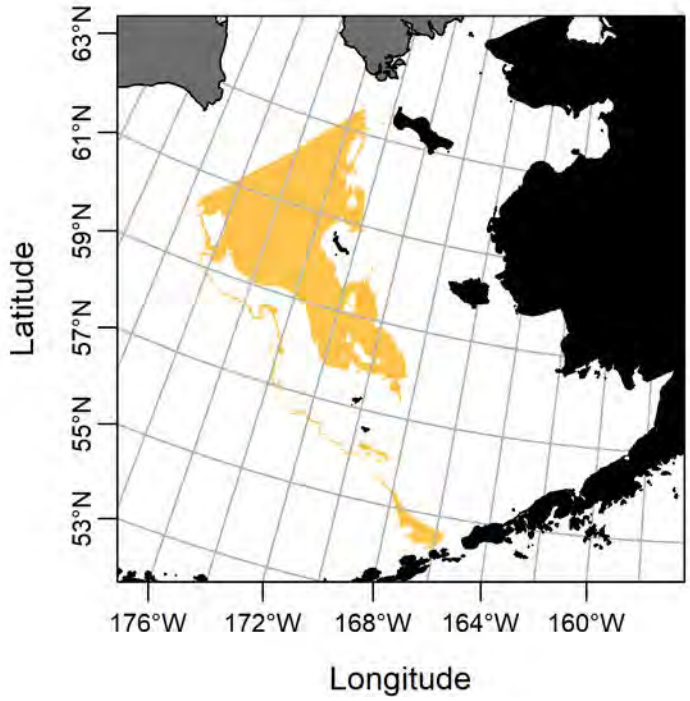

Figure E-48 EFH distribution of EBS Greenland turbot, juvenile, summer.

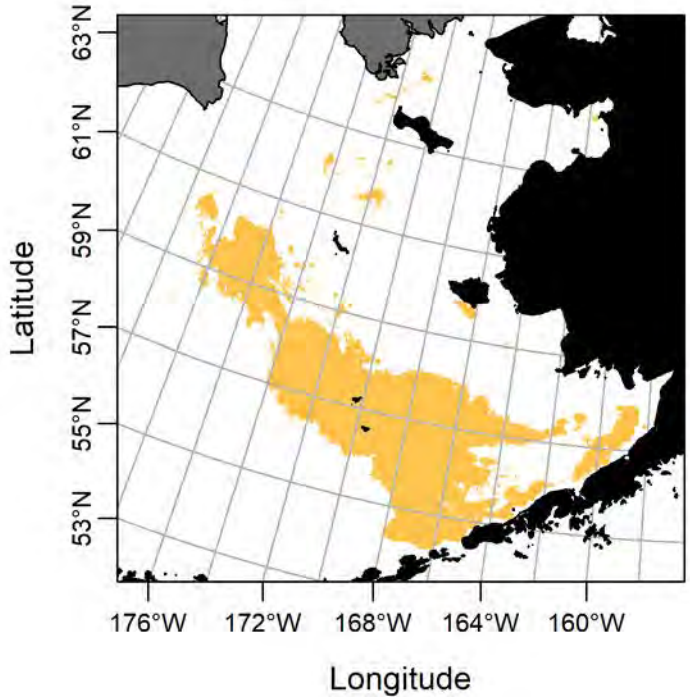

Figure E-49 EFH distribution of EBS Greenland turbot larvae, summer.

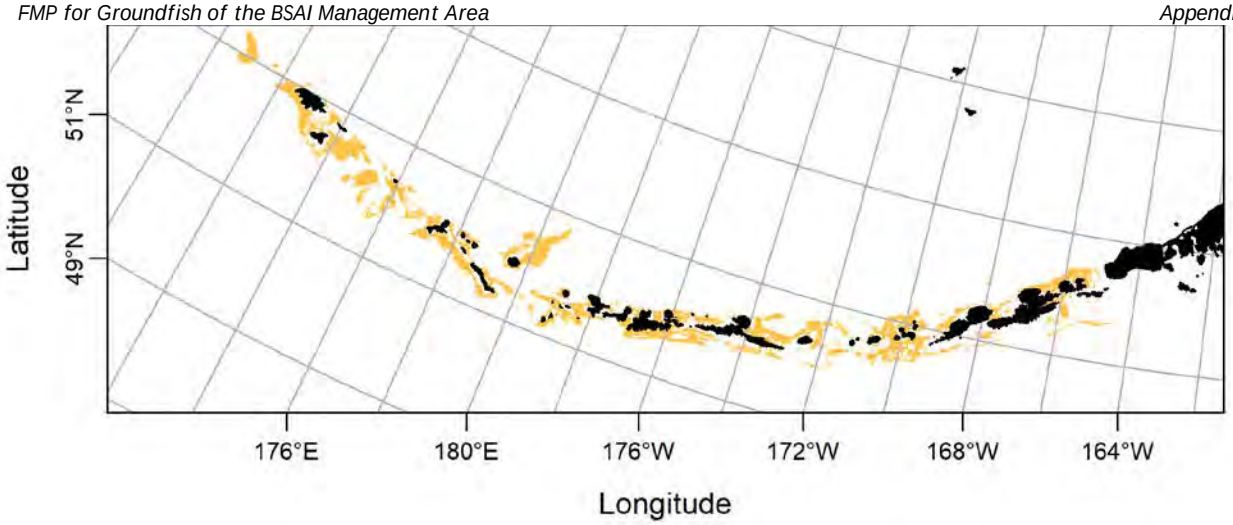

Figure E-50 EFH distribution of AI Greenland turbot adult, fall.

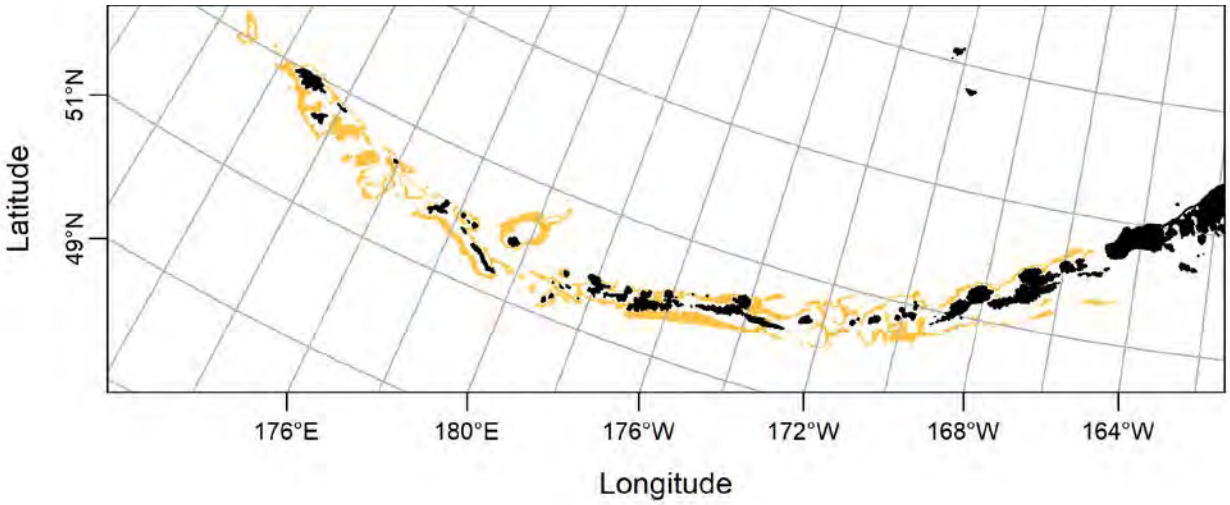

Figure E-51 EFH distribution of AI Greenland turbot adult, spring.

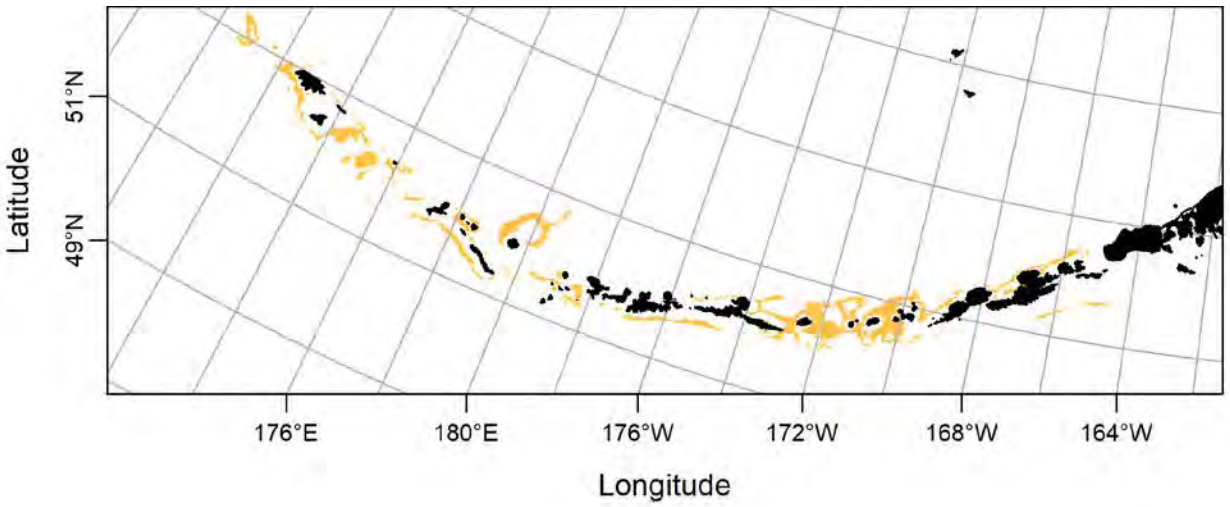

Figure E-52 EFH distribution of AI Greenland turbot adult, summer.

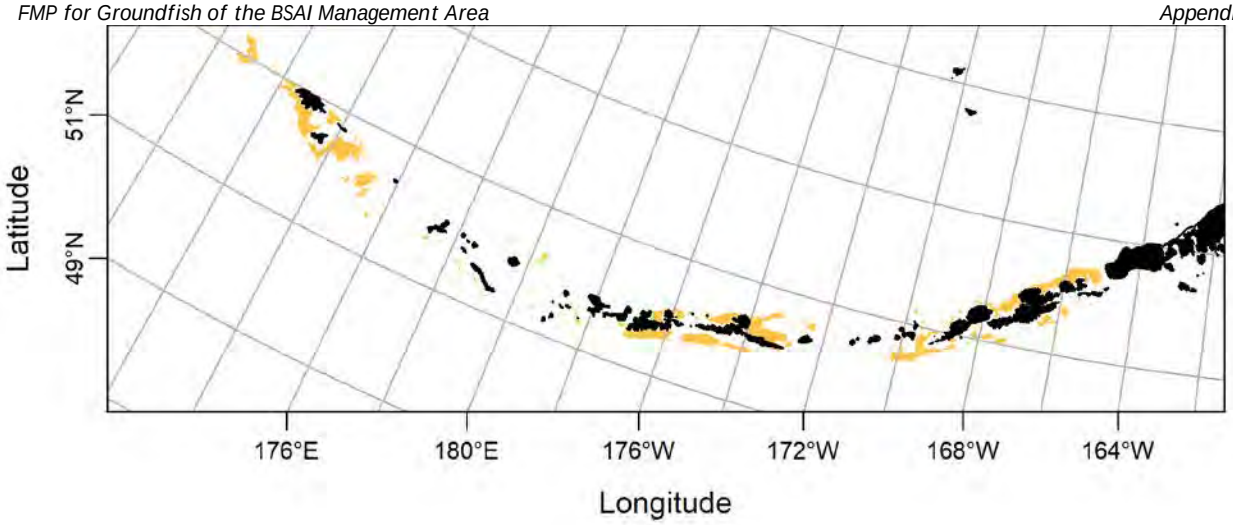

Figure E-53 EFH distribution of AI Greenland turbot adult, winter.

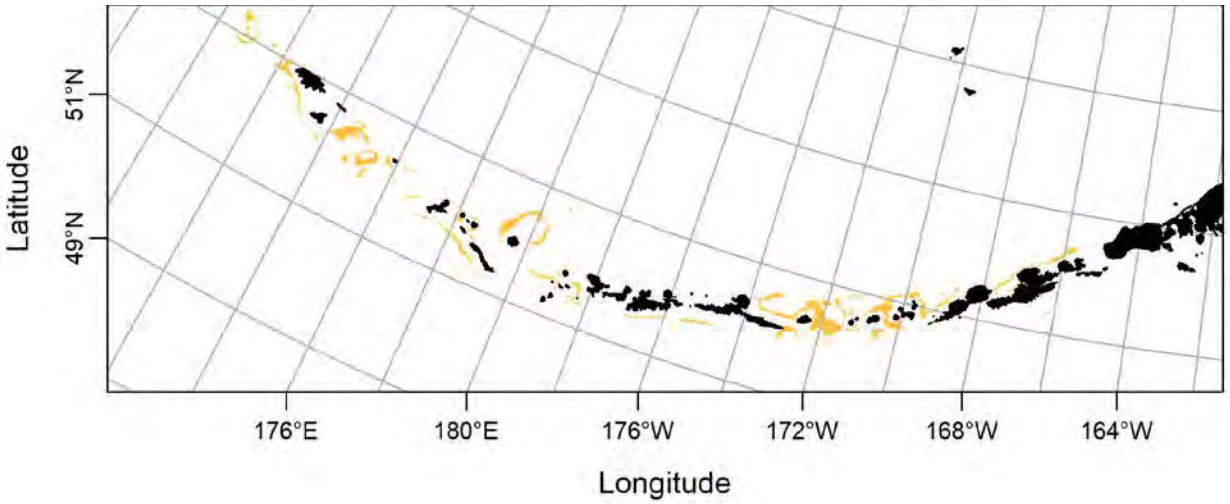

Figure E-54 EFH distribution of AI Greenland turbot juvenile, summer.

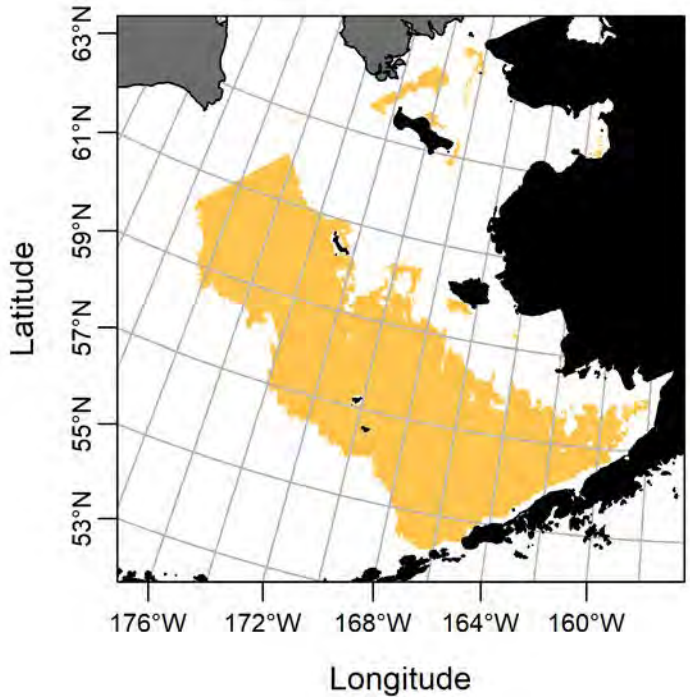

Figure E-55 EFH distribution of EBS Arrowtooth flounder adult, fall.

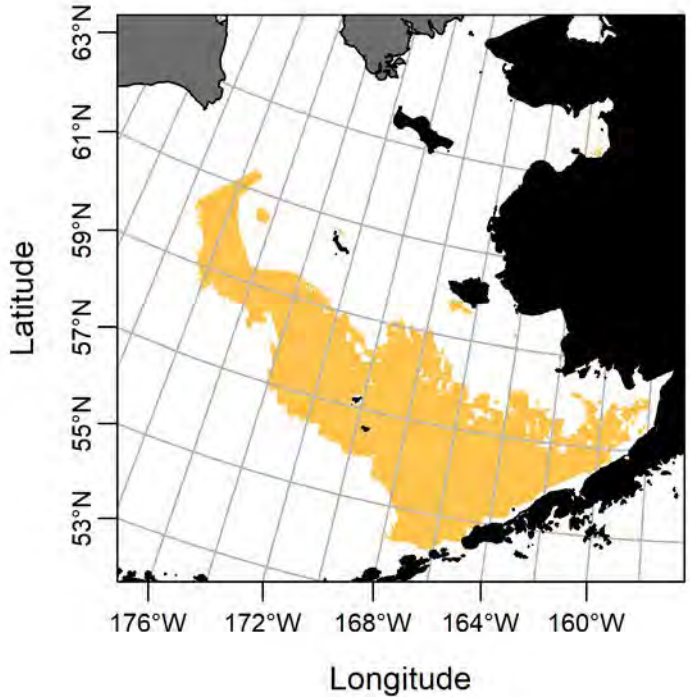

Figure E-56 EFH distribution of EBS Arrowtooth flounder adult, spring.

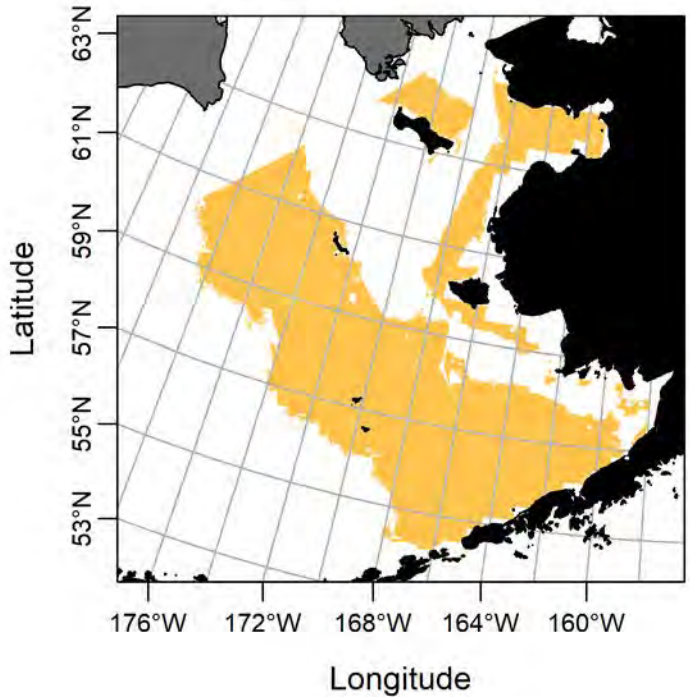

Figure E-57 EFH distribution of EBS Arrowtooth flounder adult, summer.

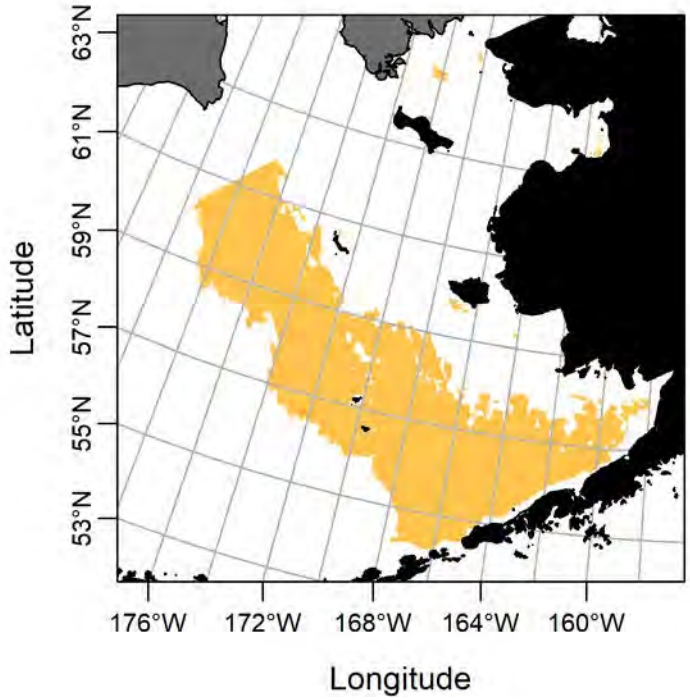

Figure E-58 EFH distribution of EBS Arrowtooth flounder adult, winter.

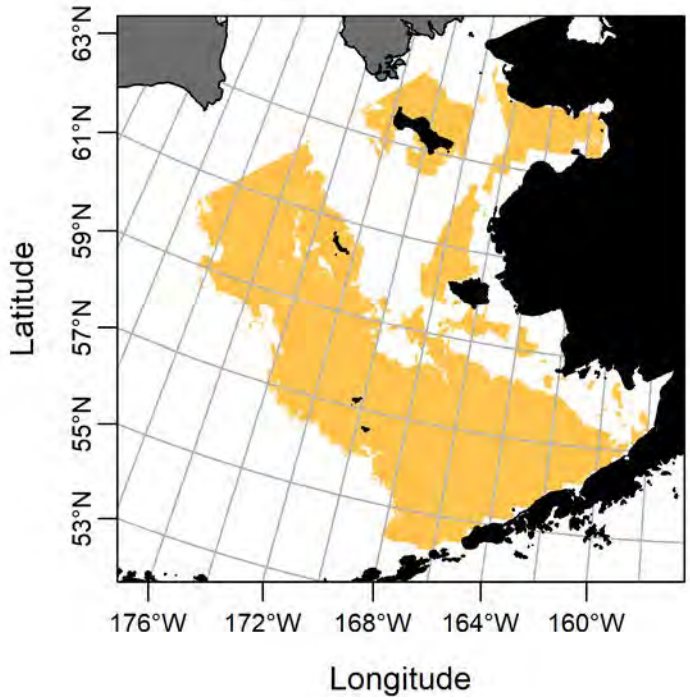

Figure E-59 EFH distribution of EBS Arrowtooth flounder juvenile, summer.

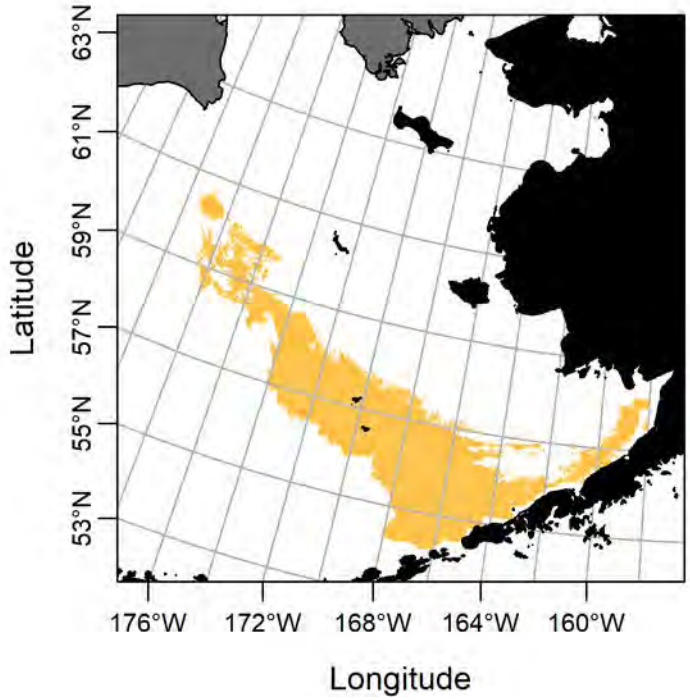

Figure E-60 EFH distribution of EBS Arrowtooth flounder larvae, summer.

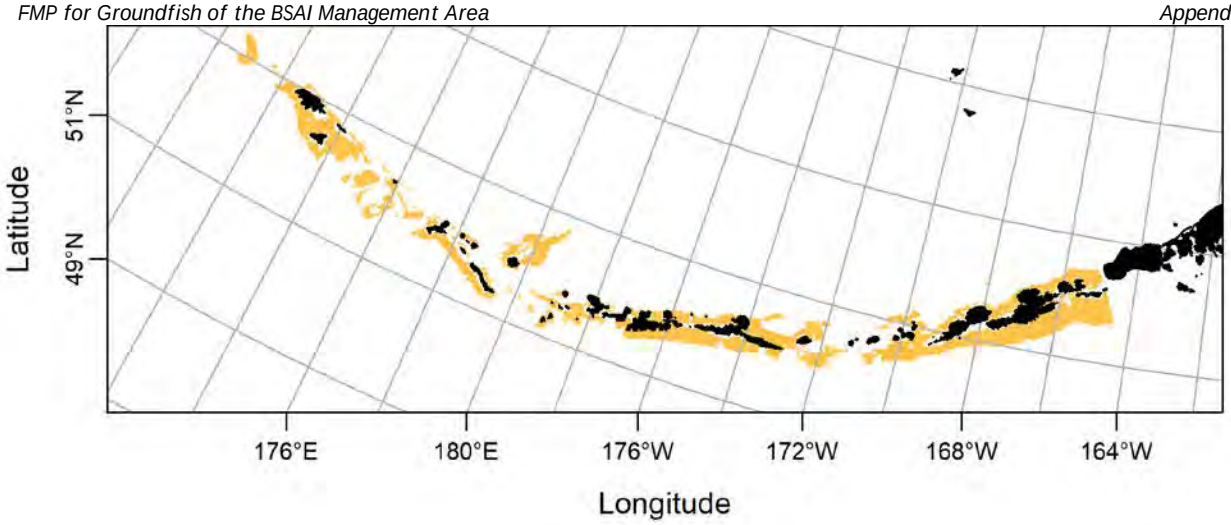

Figure E-61 EFH distribution of AI Arrowtooth flounder adult, fall.

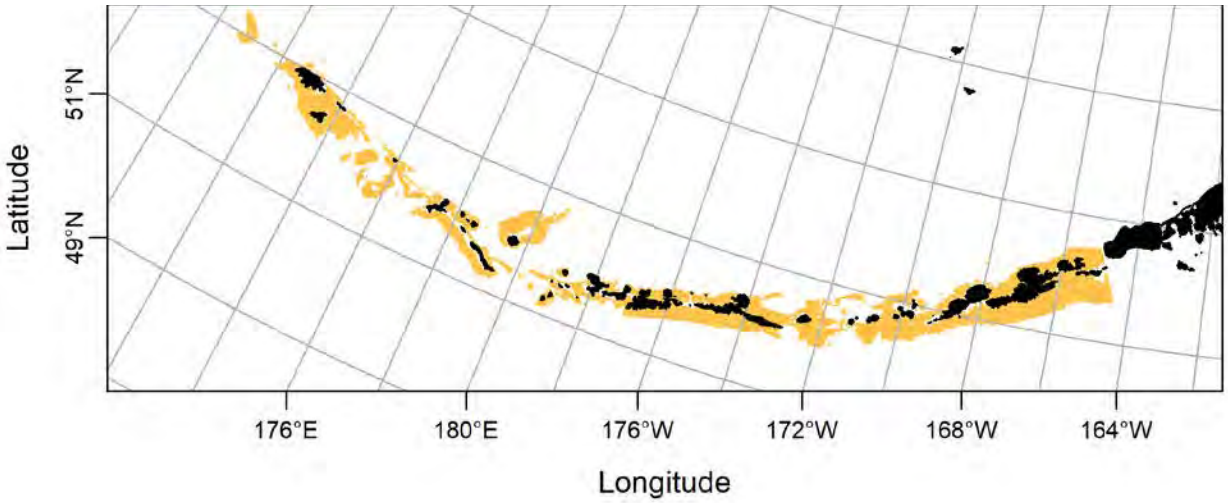

Figure E-62 EFH distribution of AI Arrowtooth flounder adult, spring.

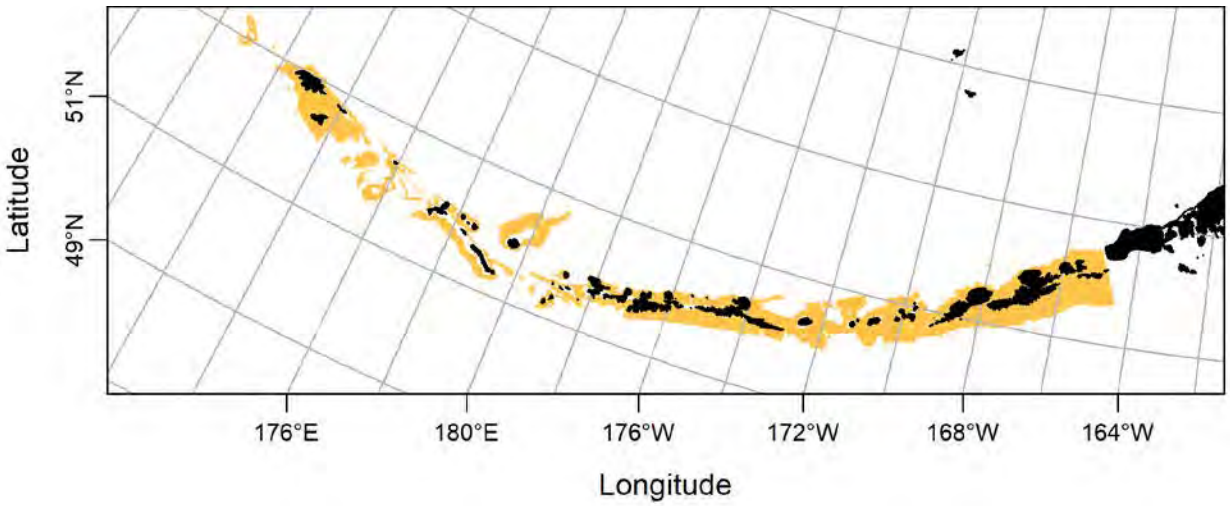

Figure E-63 EFH distribution of AI Arrowtooth flounder adult, summer.

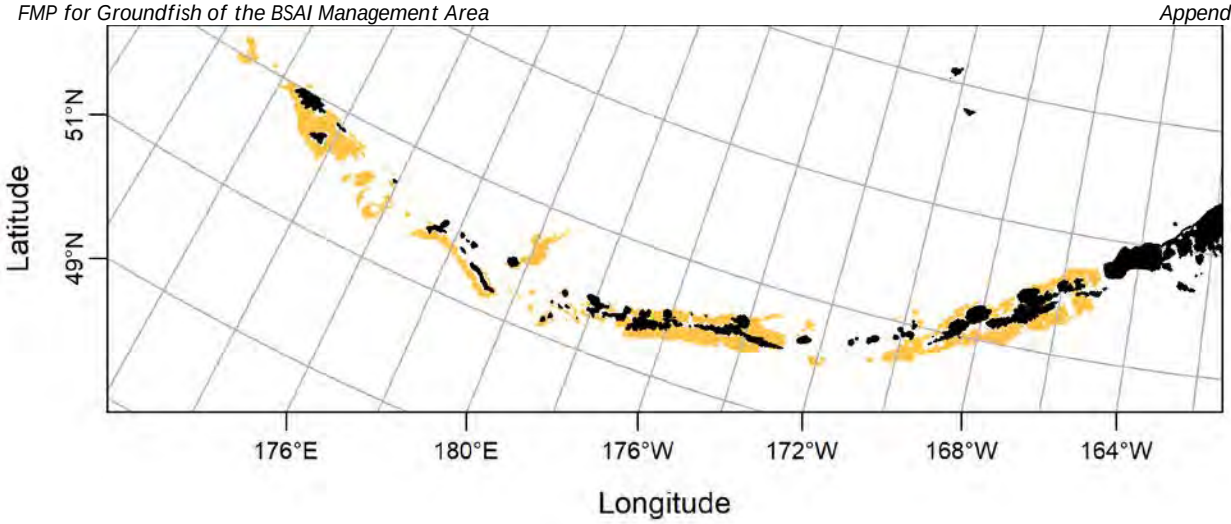

Figure E-64 EFH distribution of AI Arrowtooth flounder adult, winter.

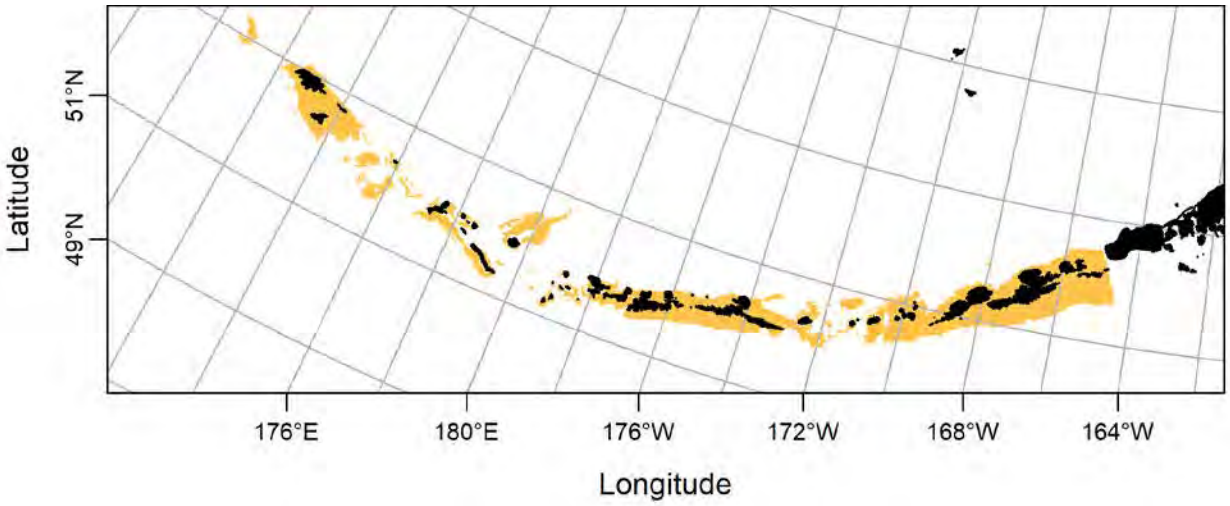

Figure E-65 EFH distribution of AI Arrowtooth flounder juvenile, summer.

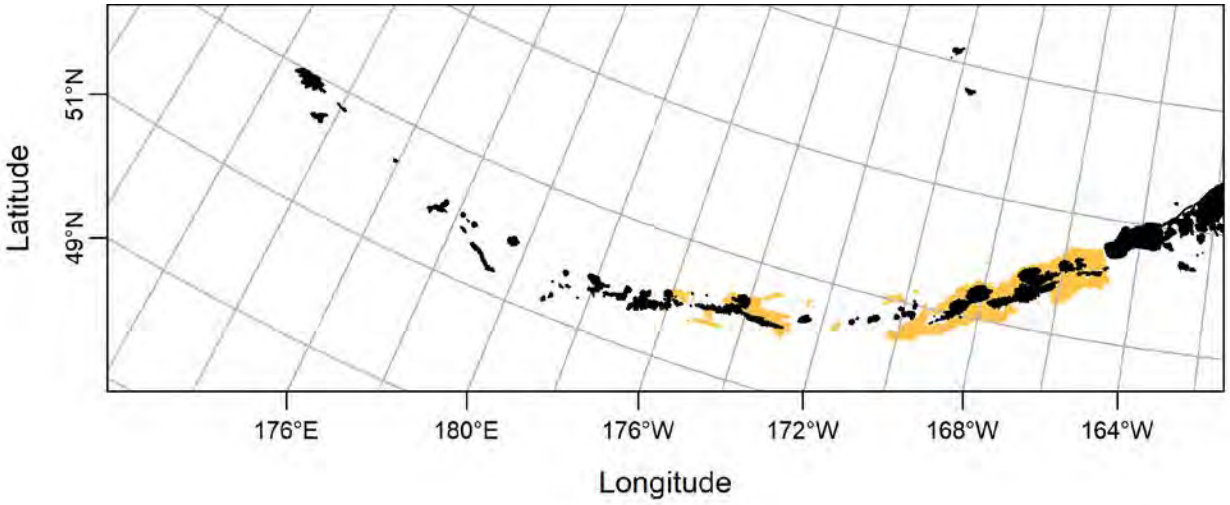

Figure E-66 EFH distribution of AI Arrowtooth flounder larvae, summer.

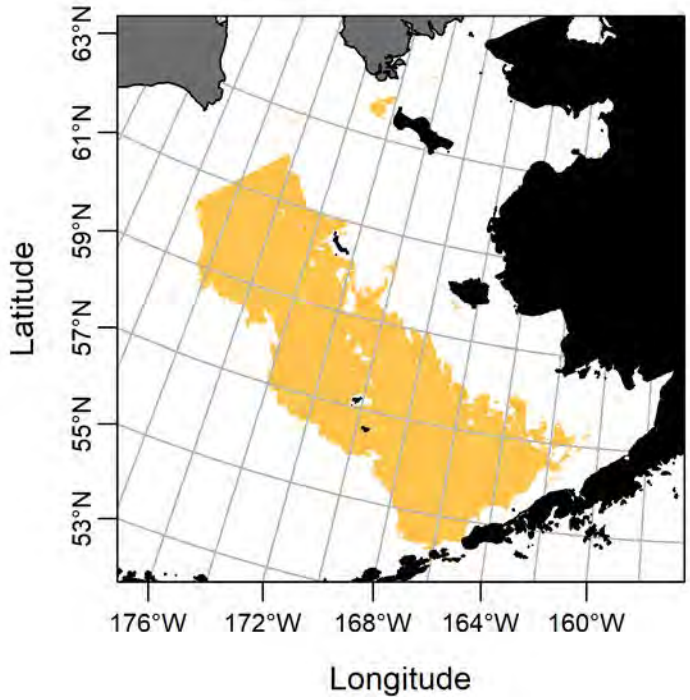

Figure E-67 EFH distribution of EBS Kamchatka flounder adult, fall.

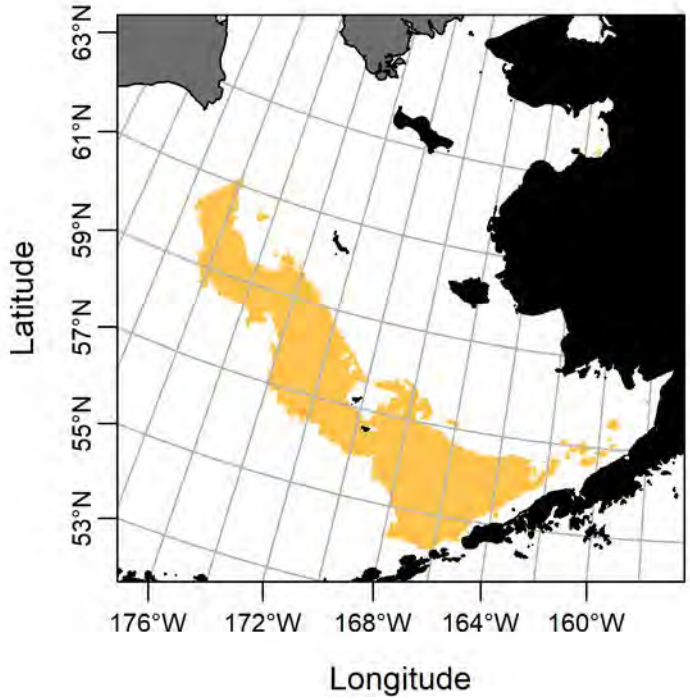

Figure E-68 EFH distribution of EBS Kamchatka flounder adult, spring.

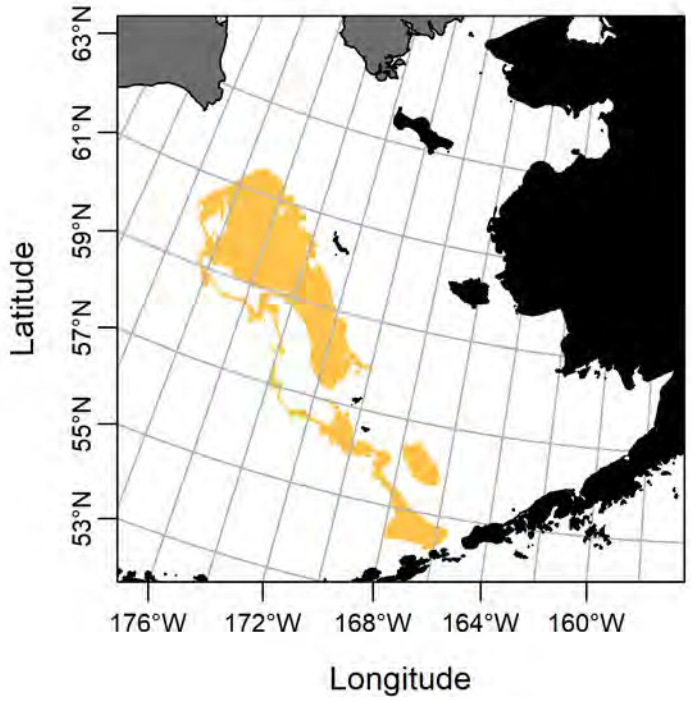

Figure E-69 EFH distribution of EBS Kamchatka flounder adult, summer.

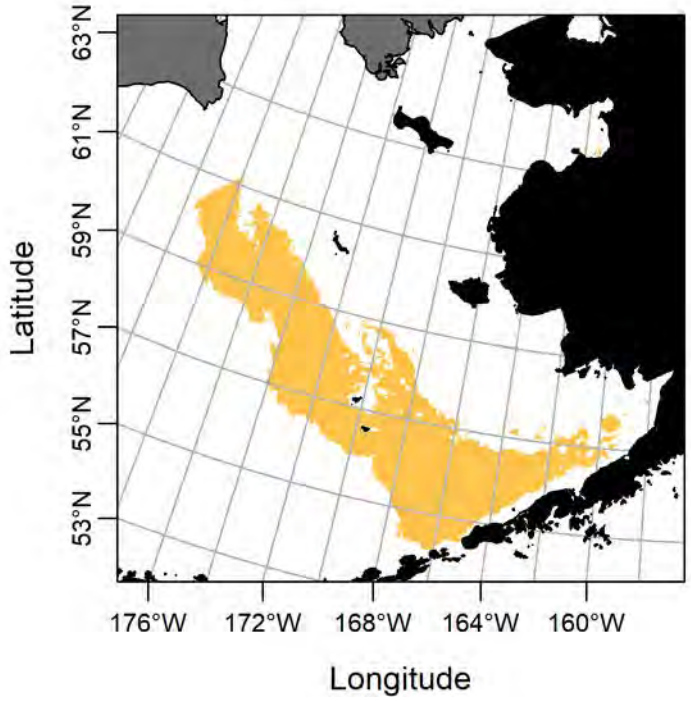

Figure E-70 EFH distribution of EBS Kamchatka flounder adult, winter.

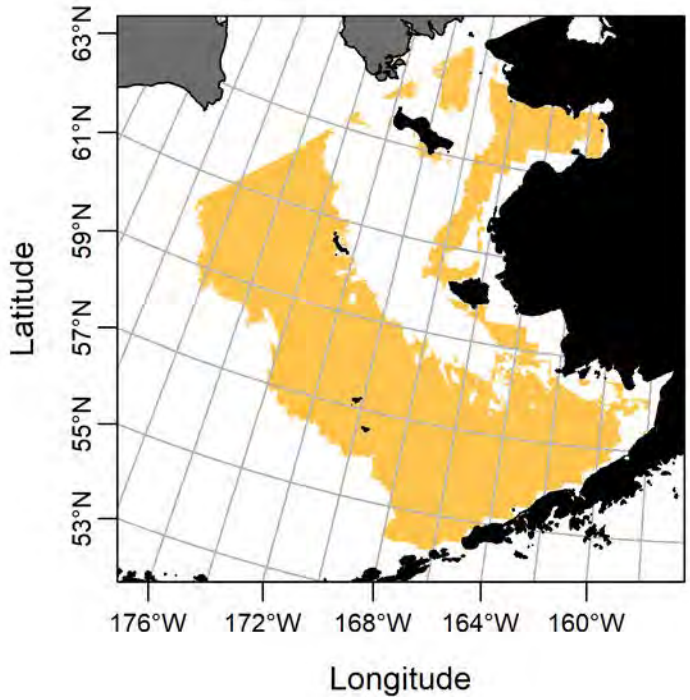

Figure E-71 EFH distribution of EBS Kamchatka flounder juvenile, summer.

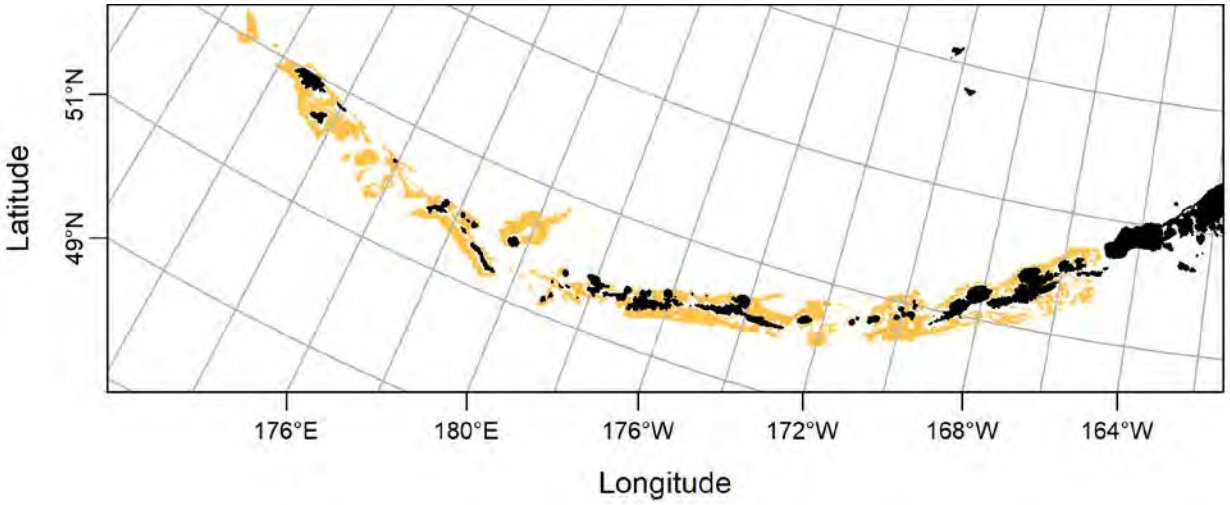

Figure E-72 EFH distribution of AI Kamchatka flounder adult, fall.

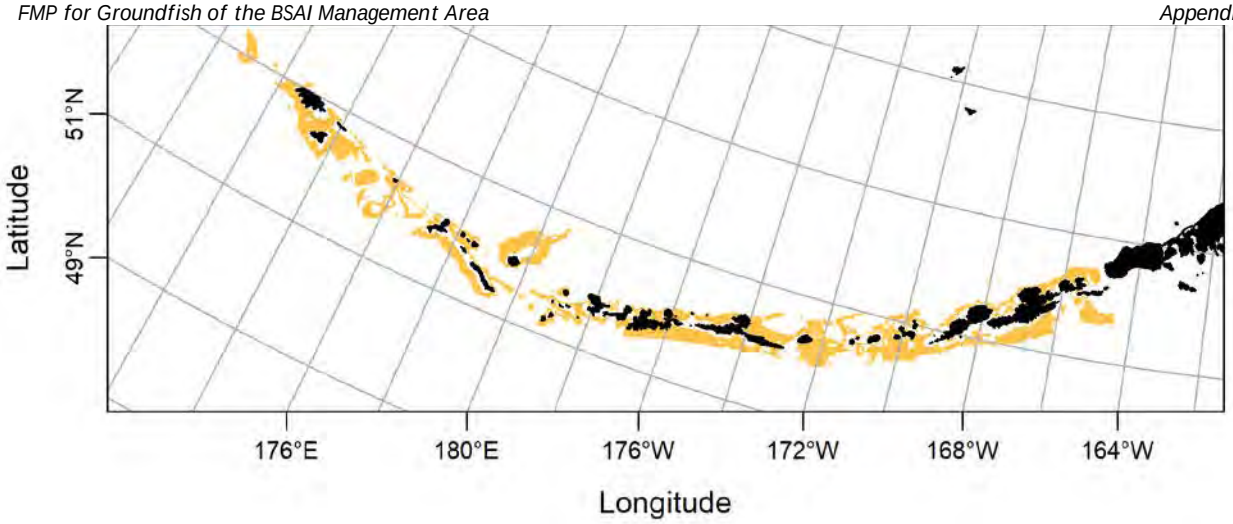

Figure E-73 EFH distribution of AI Kamchatka flounder adult, spring.

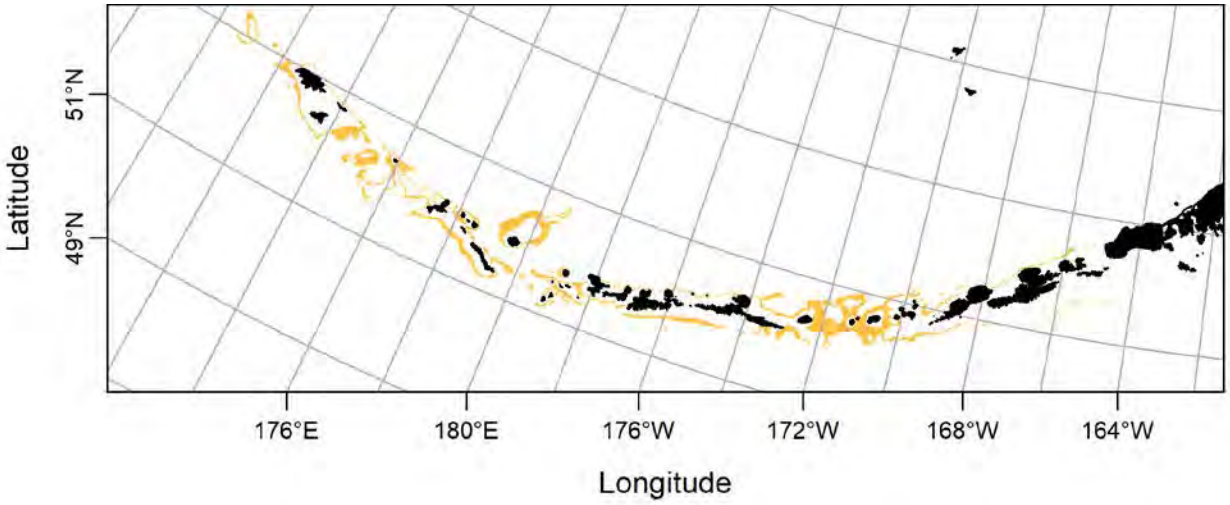

Figure E-74 EFH distribution of AI Kamchatka flounder adult, summer.

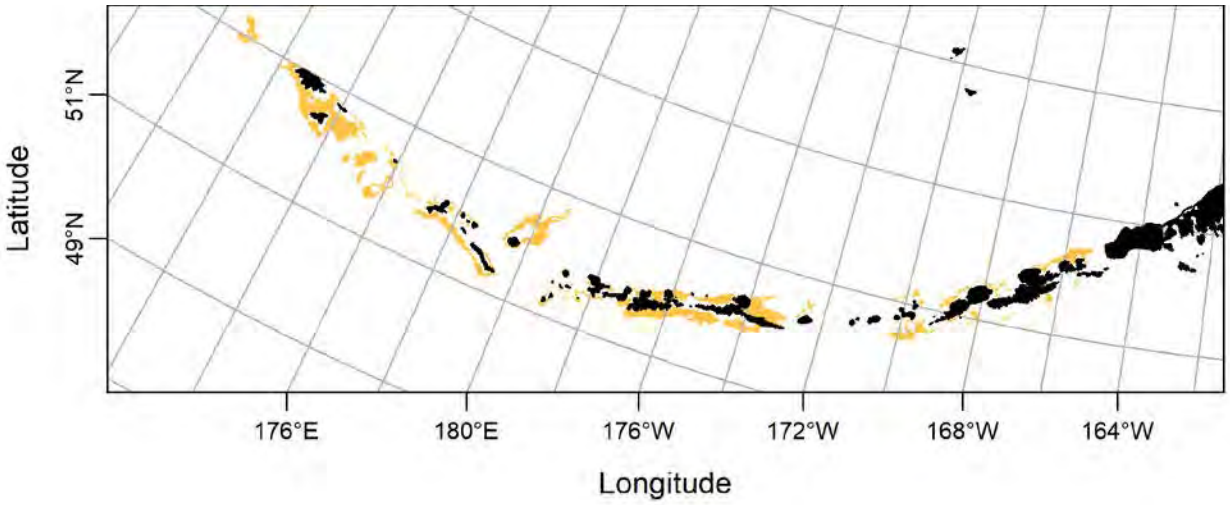

Figure E-75 EFH distribution of AI Kamchatka flounder adult, winter.

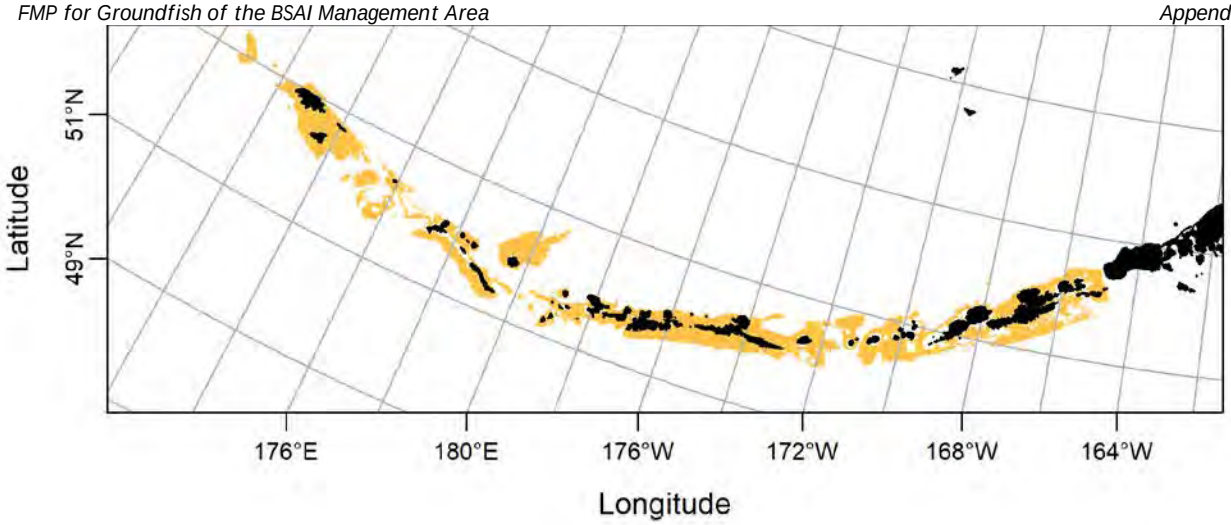

Figure E-76 EFH distribution of AI Kamchatka flounder juvenile, summer.

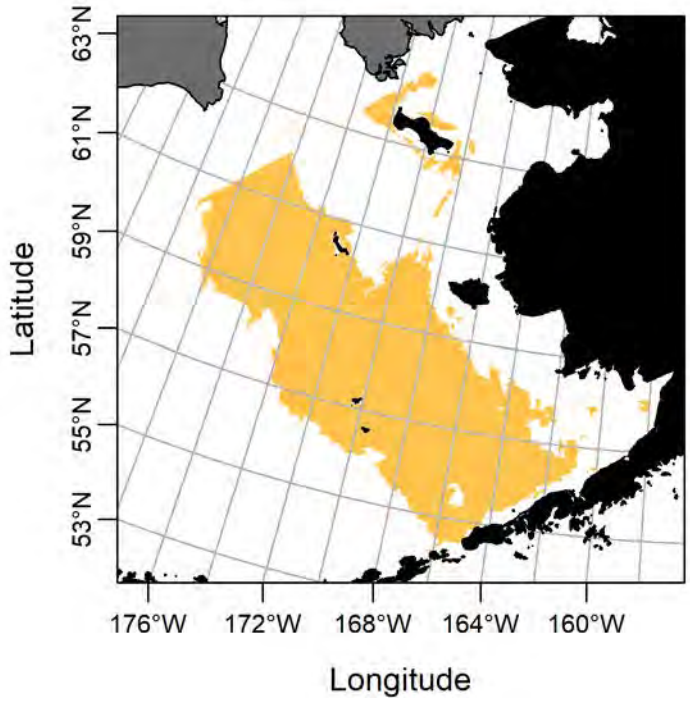

Figure E-77 EFH distribution of EBS Northern rock sole adult, fall.

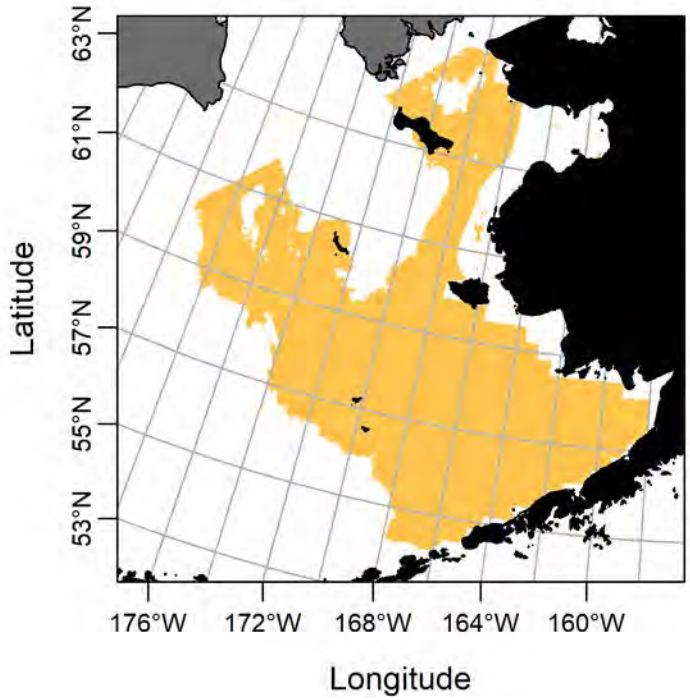

Figure E-78 EFH distribution of EBS Northern rock sole adult, spring.

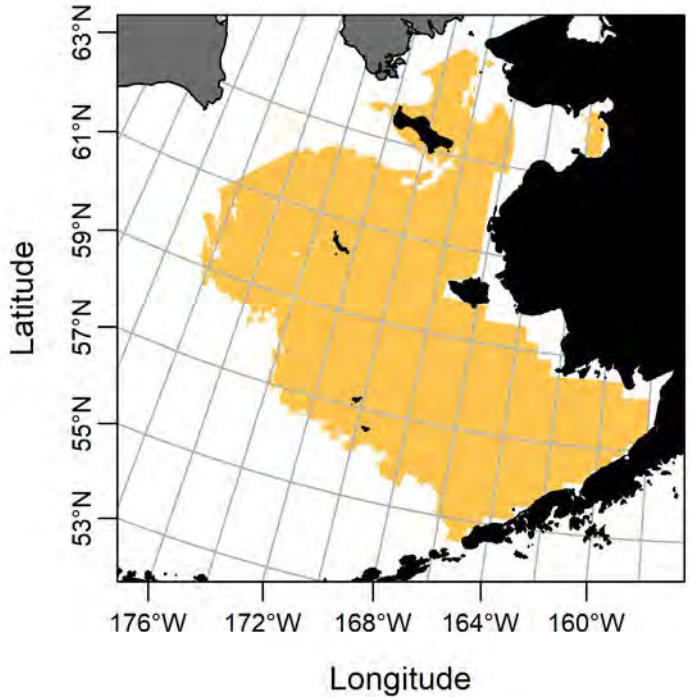

Figure E-79 EFH distribution of EBS Northern rock sole adult, summer.

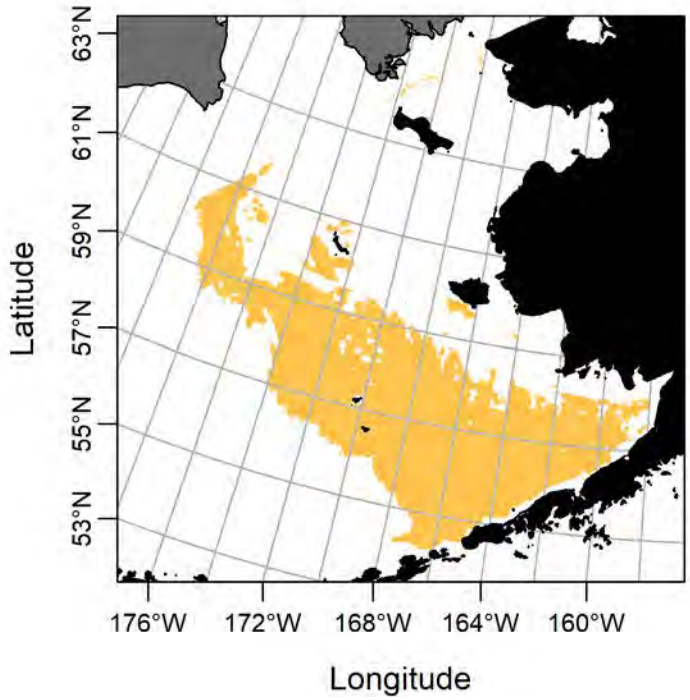

Figure E-80 EFH distribution of EBS Northern rock sole adult, winter.

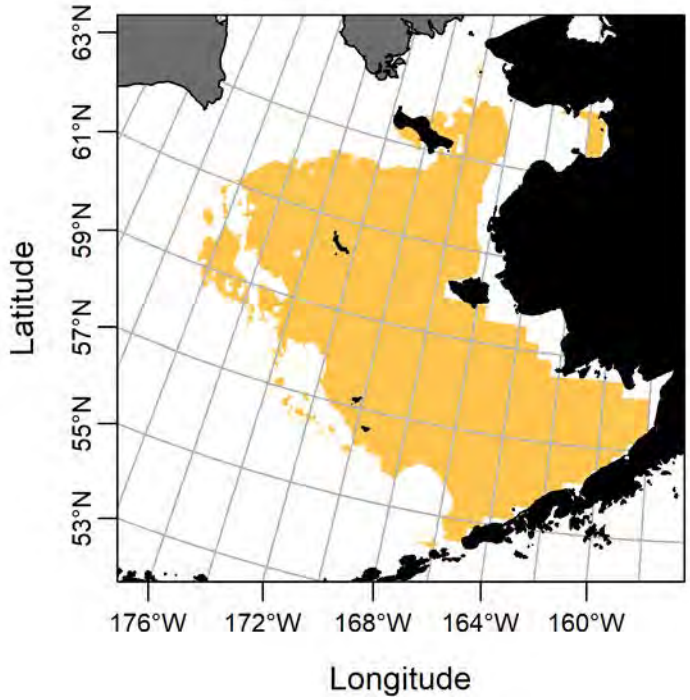

Figure E-81 EFH distribution of EBS Northern rock sole juvenile, summer.

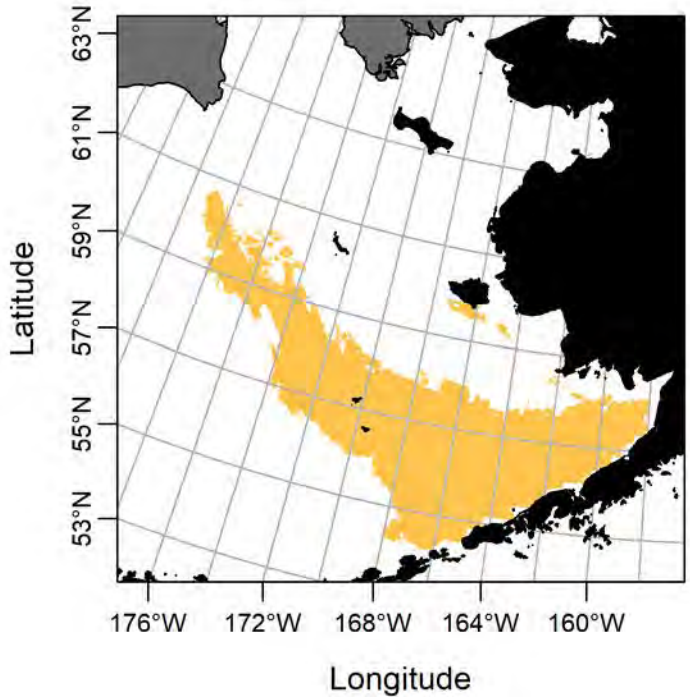

Figure E-82 EFH distribution of EBS Northern rock sole larvae, summer.

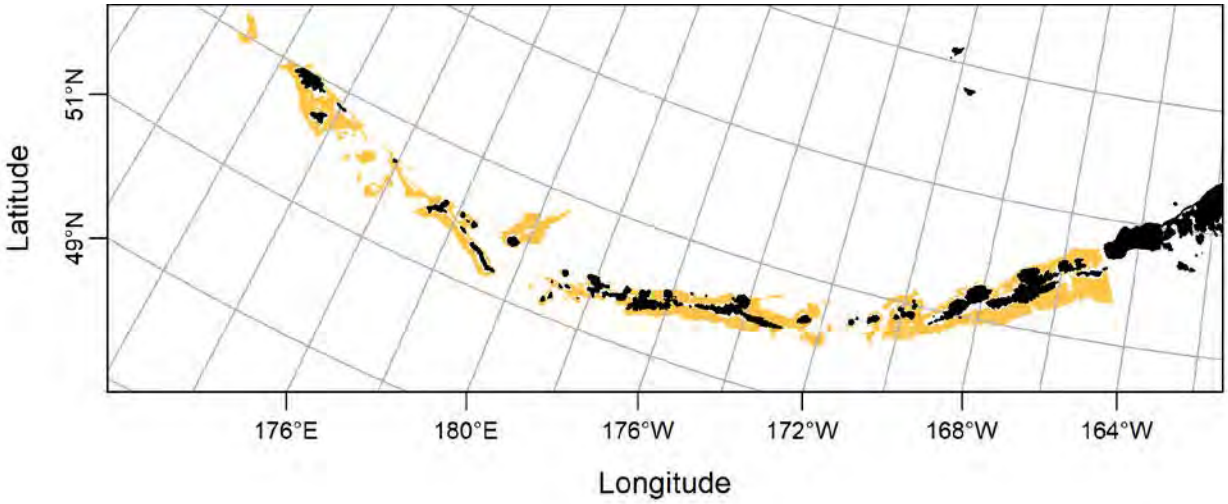

Figure E-83 EFH distribution of AI Northern rock sole adult, fall.

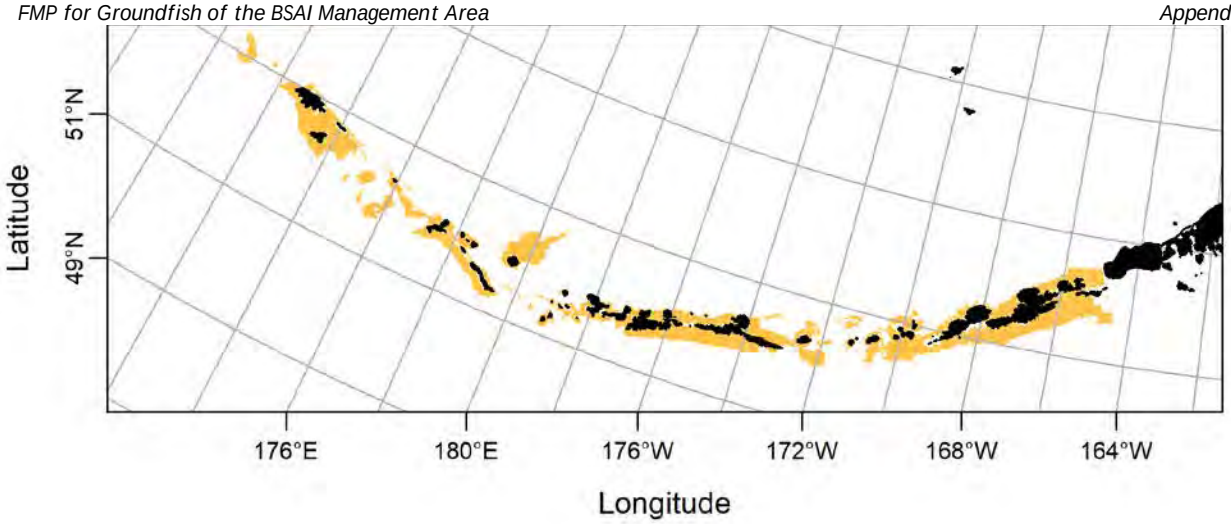

Figure E-84 EFH distribution of AI Northern rock sole adult, spring.

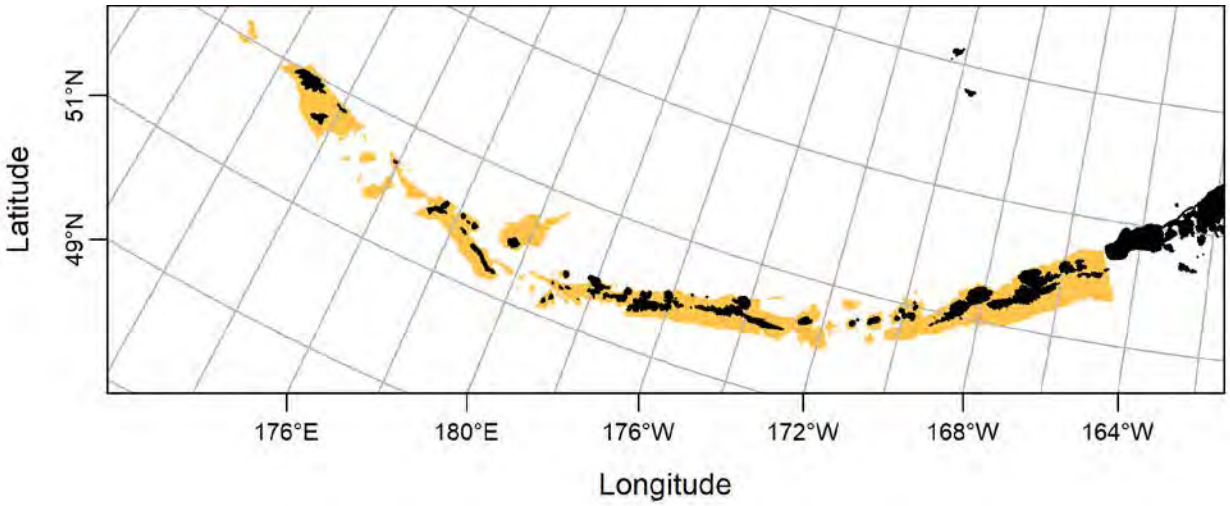

Figure E-85 EFH distribution of AI Northern rock sole adult, summer.

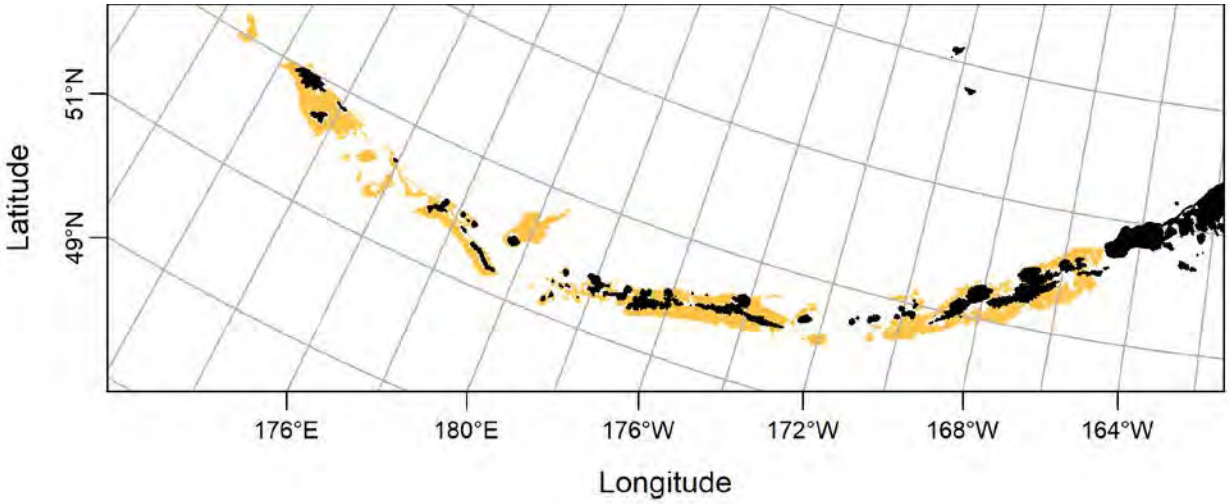

Figure E-86 EFH distribution of AI Northern rock sole adult, winter.

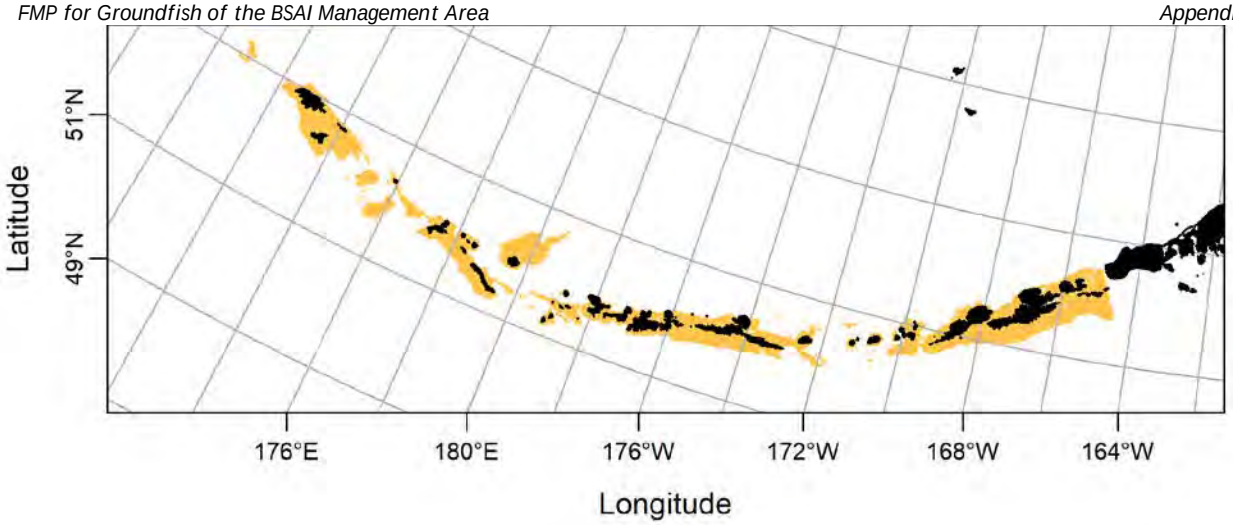

Figure E-87 EFH distribution of AI Northern rock sole juvenile, summer.

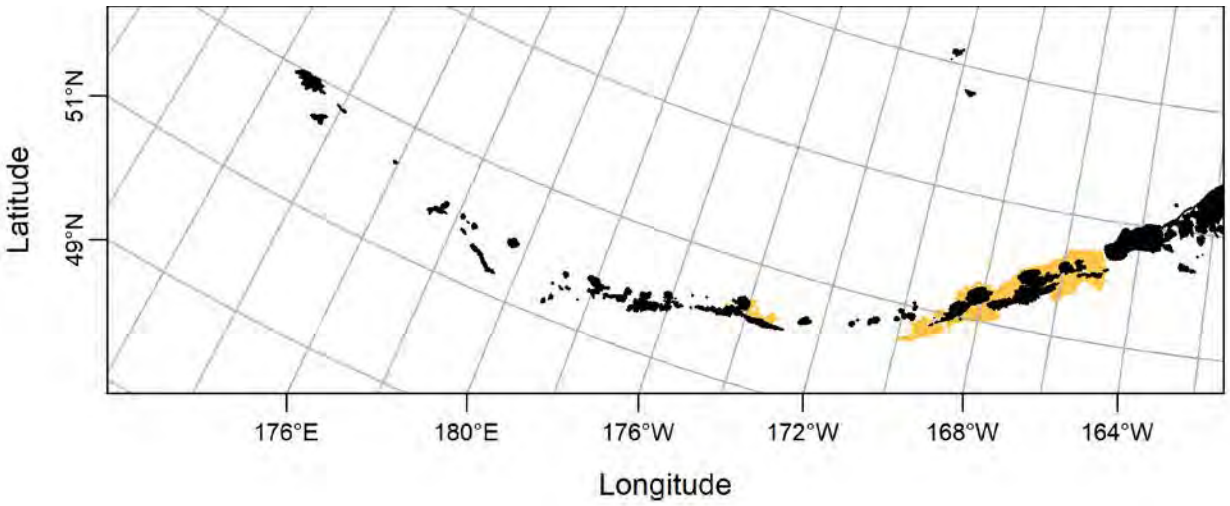

Figure E-88 EFH distribution of AI Northern rock sole larvae, summer.

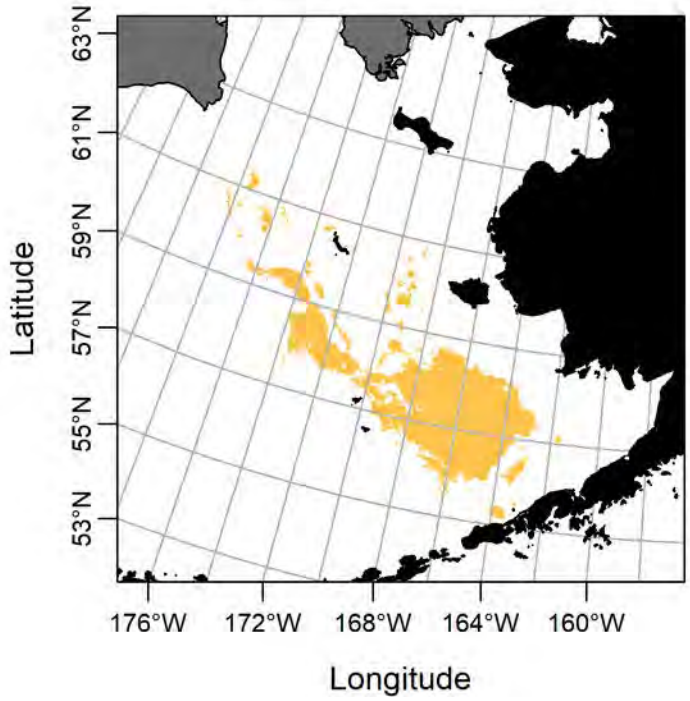

Figure E-89 EFH distribution of EBS Alaska plaice adult, fall.

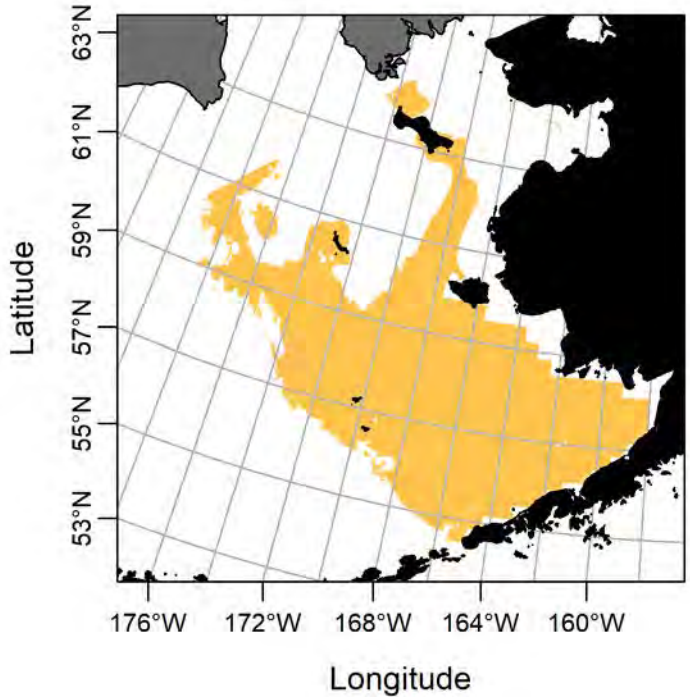

Figure E-90 EFH distribution of EBS Alaska plaice adult, spring.

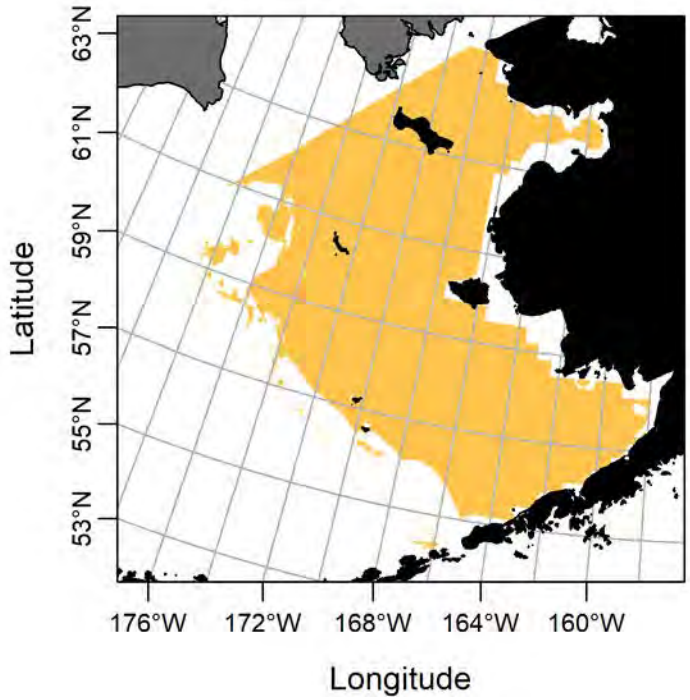

Figure E-91 EFH distribution of EBS Alaska plaice adult, summer.

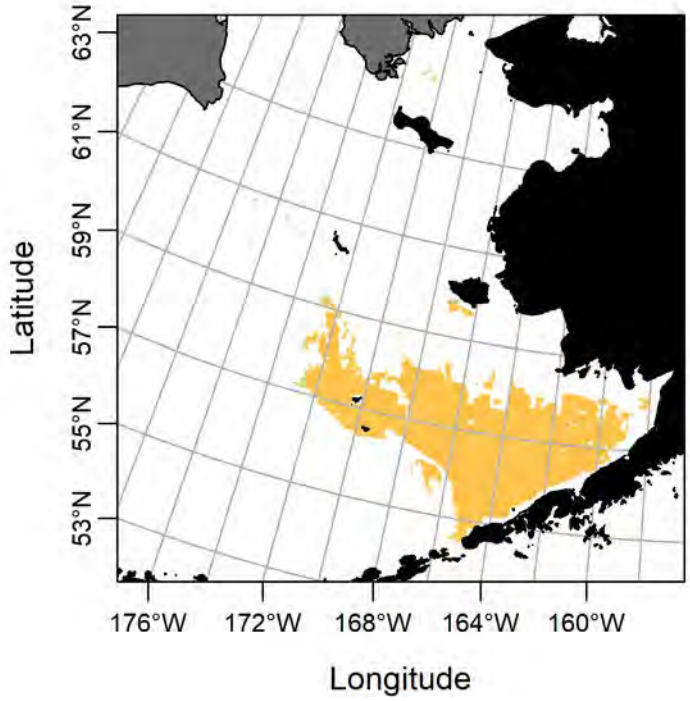

Figure E-92 EFH distribution of EBS Alaska plaice adult, winter.

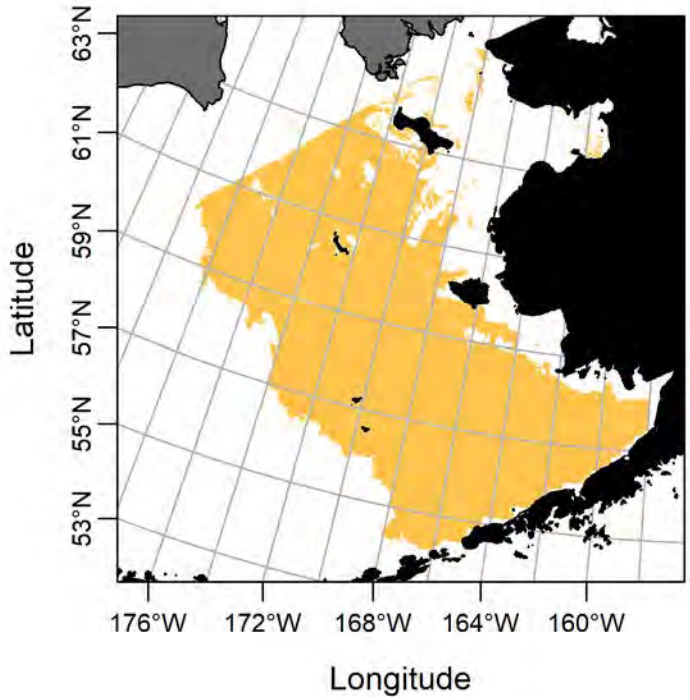

Figure E-93 EFH distribution of EBS Alaska plaice egg, summer.

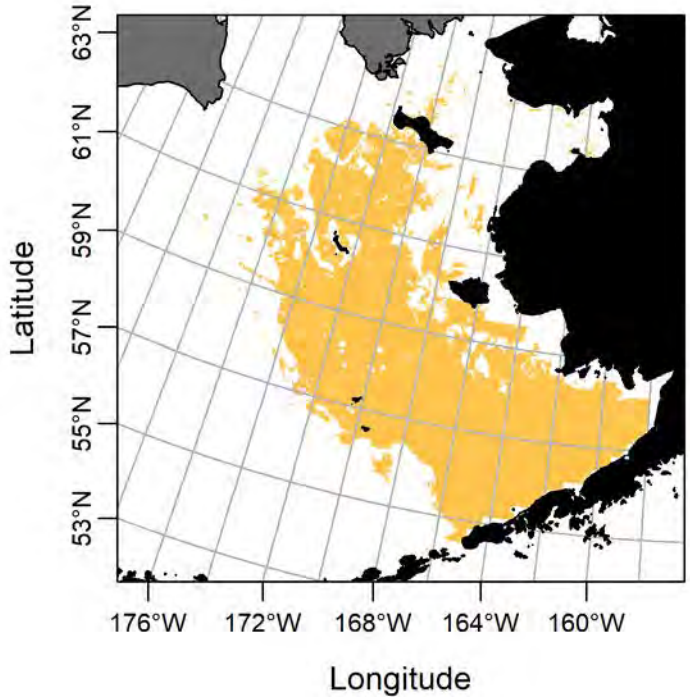

Figure E-94 EFH distribution of EBS Alaska plaice larvae, summer.

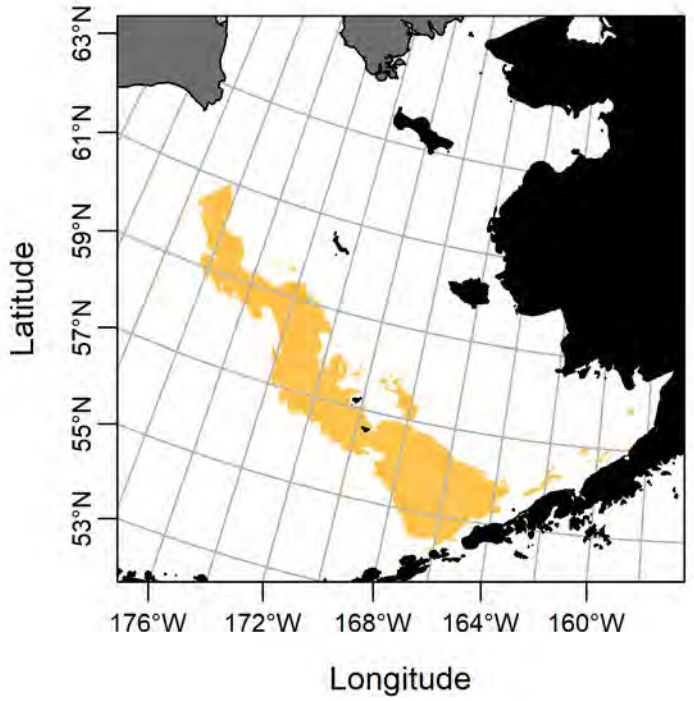

Figure E-95 EFH distribution of EBS Rex sole adult, fall.

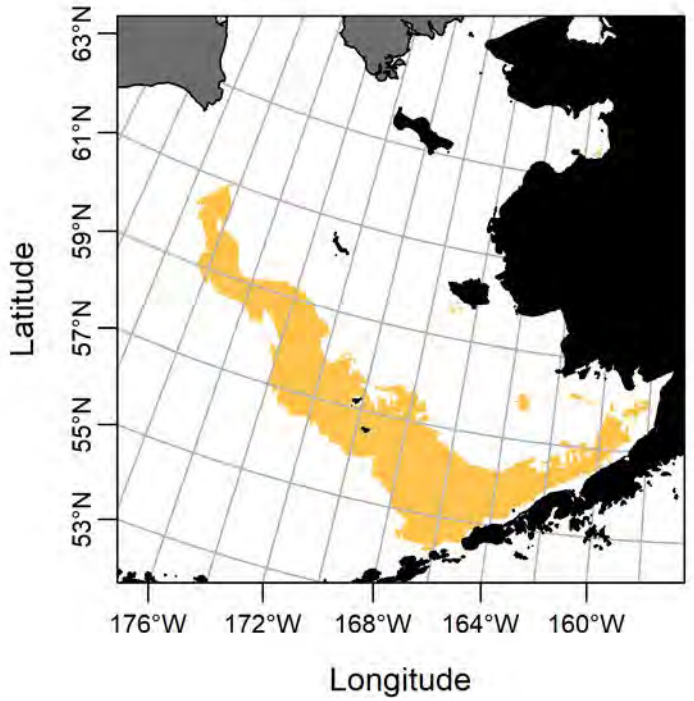

Figure E-96 EFH distribution of EBS Rex sole adult, spring.

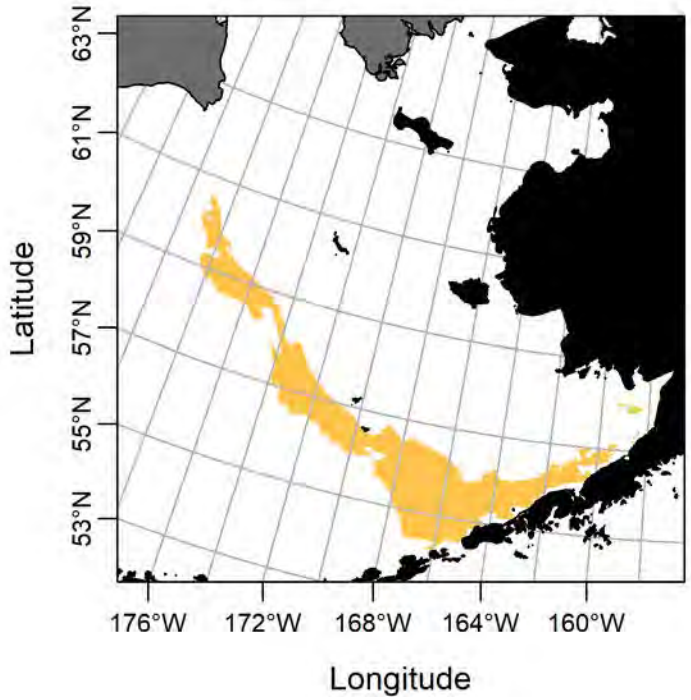

Figure E-97 EFH distribution of EBS Rex sole adult, summer.

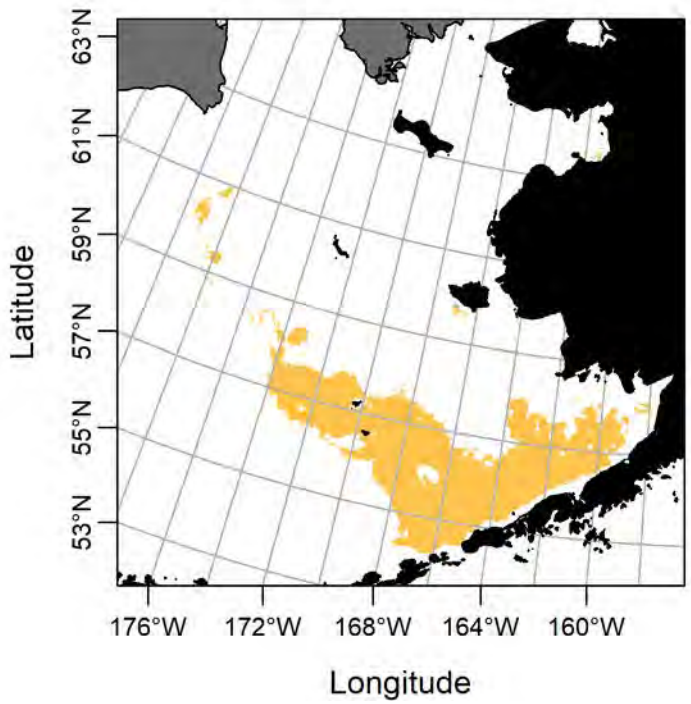

Figure E-98 EFH distribution of EBS Rex sole adult, winter.

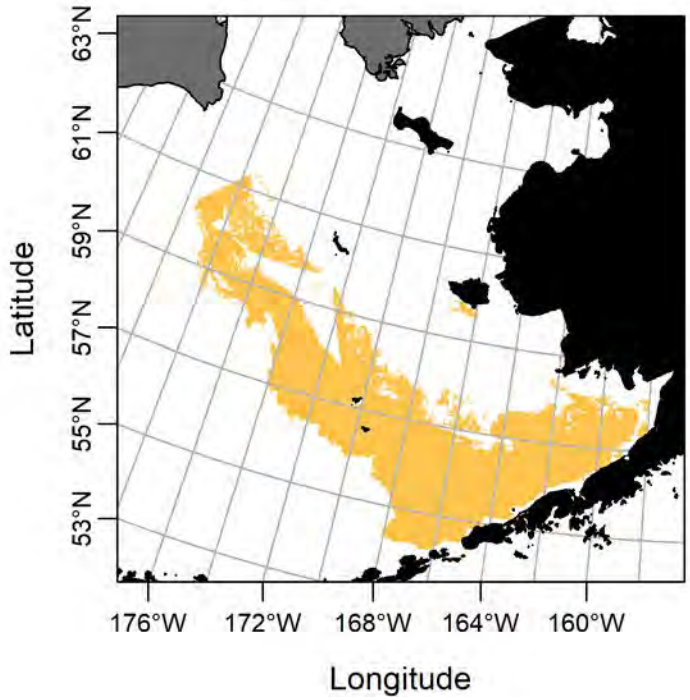

Figure E-99 EFH distribution of EBS Rex sole egg, summer.

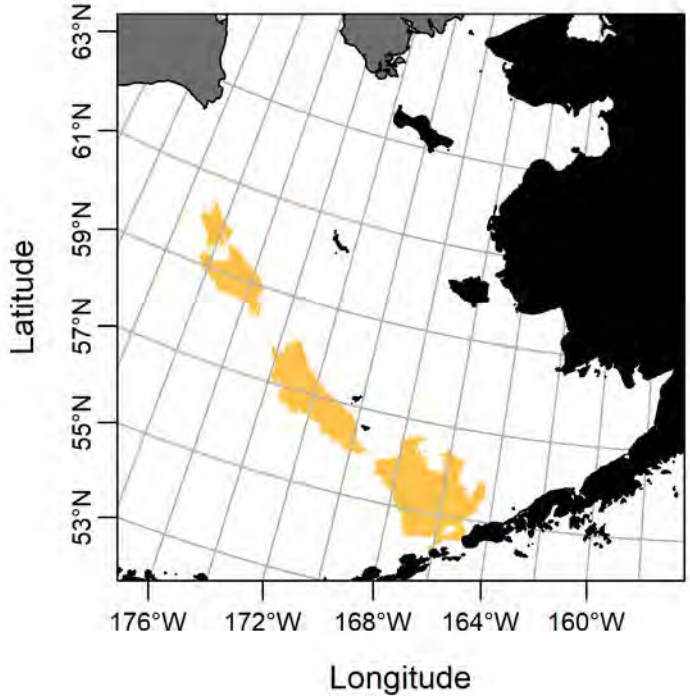

Figure E-100 EFH distribution of EBS Rex sole juvenile, summer.

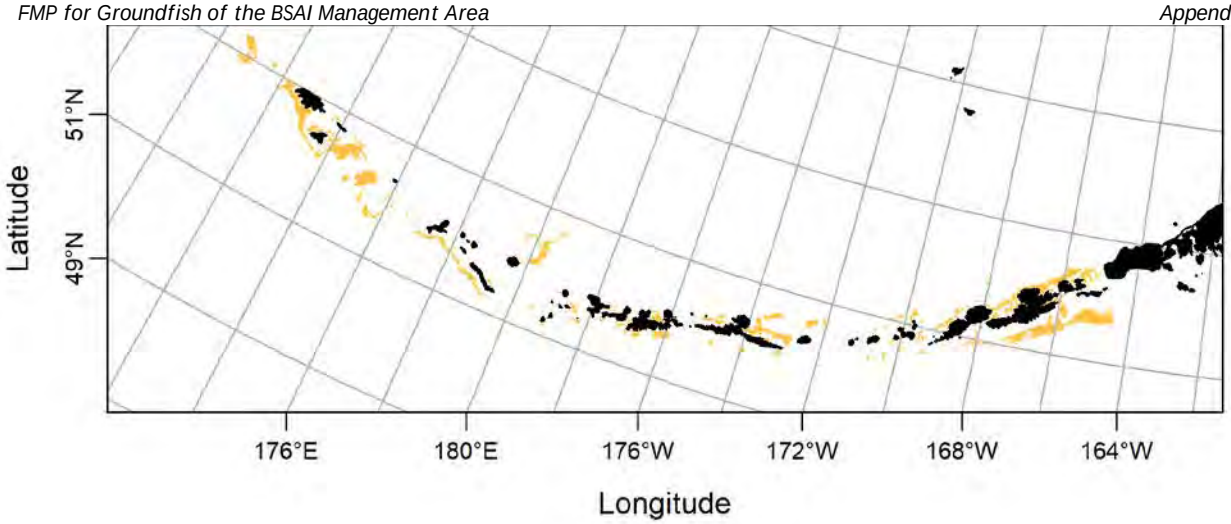

Figure E-101 EFH distribution of AI Rex sole adult, fall.

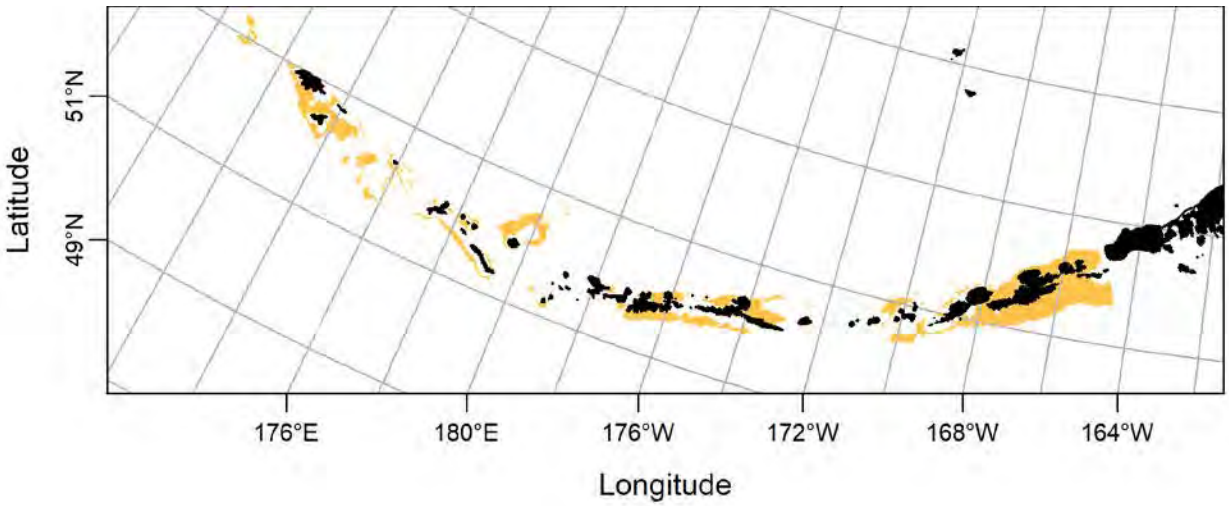

Figure E-102 EFH distribution of AI Rex sole adult, spring.

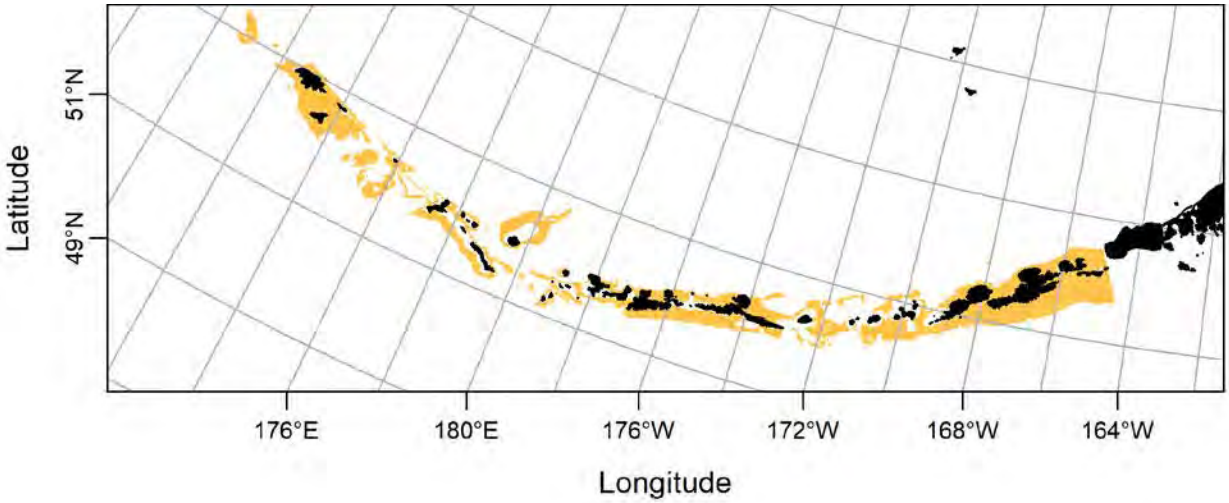

Figure E-103 EFH distribution of AI Rex sole adult, summer.

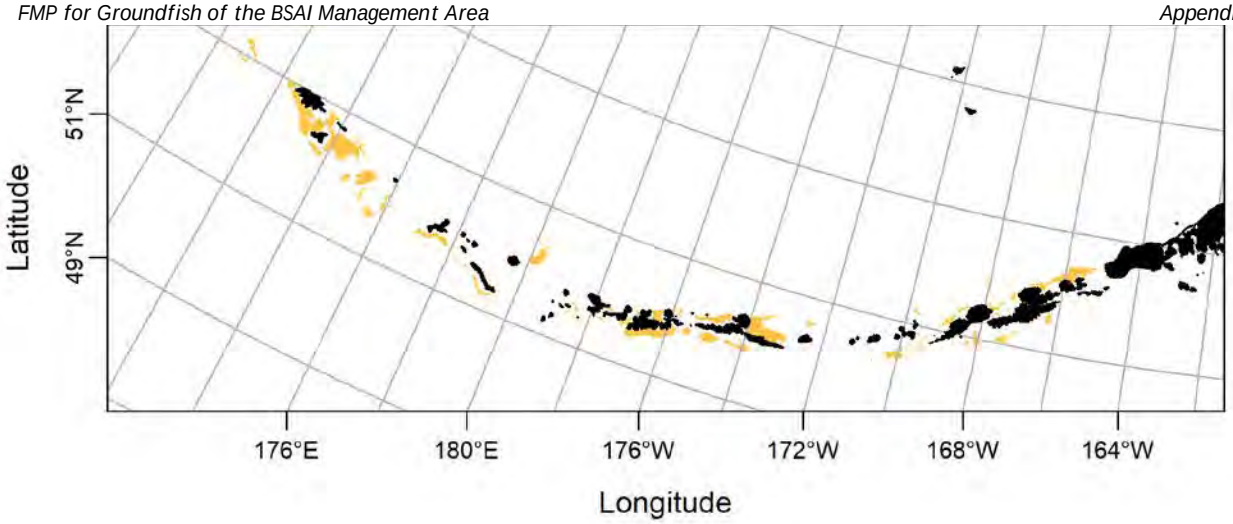

Figure E-104 EFH distribution of AI Rex sole adult, winter.

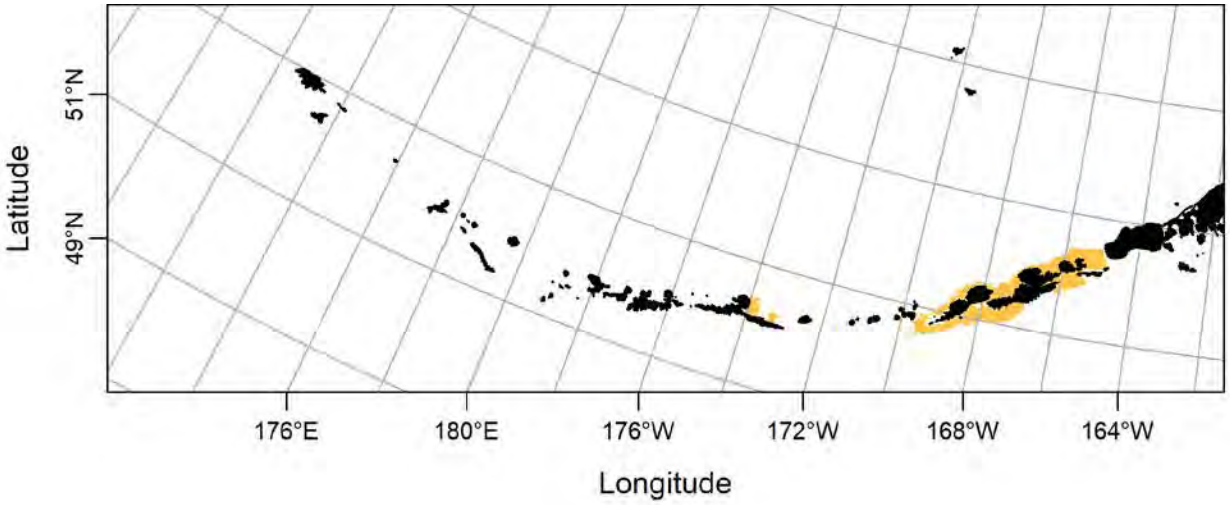

Figure E-105 EFH distribution of AI Rex sole egg, summer.

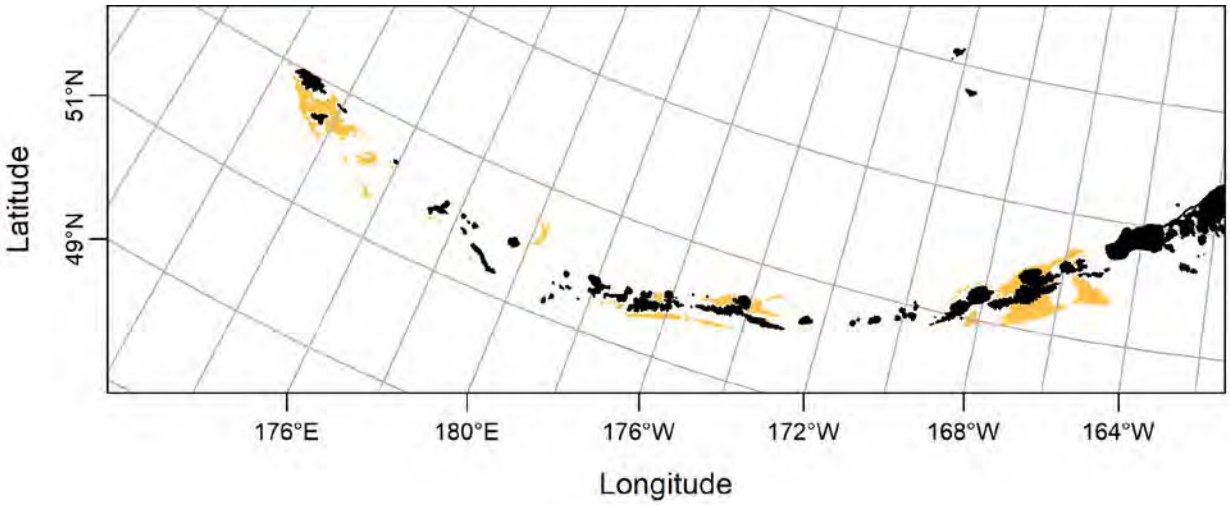

Figure E-106 EFH distribution of AI Rex sole juvenile, summer.

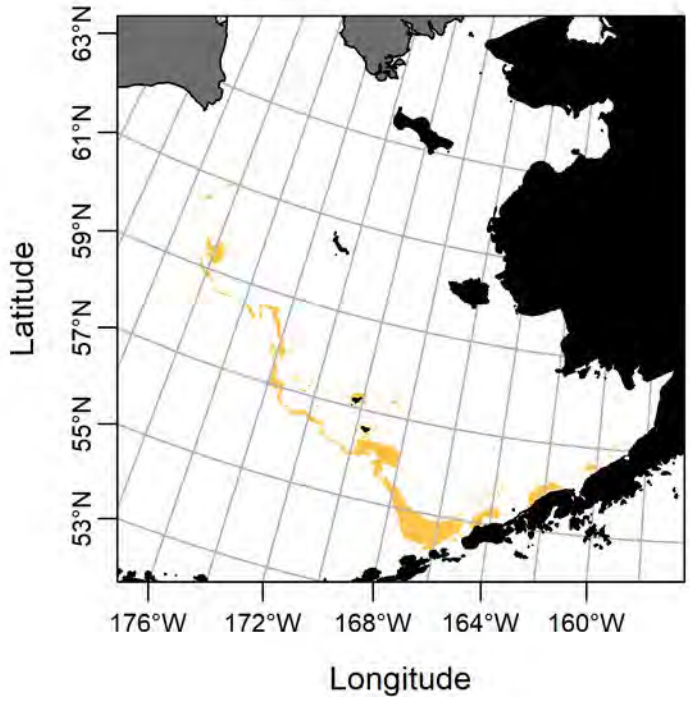

Figure E-107 EFH distribution of EBS Dover sole adult, spring.

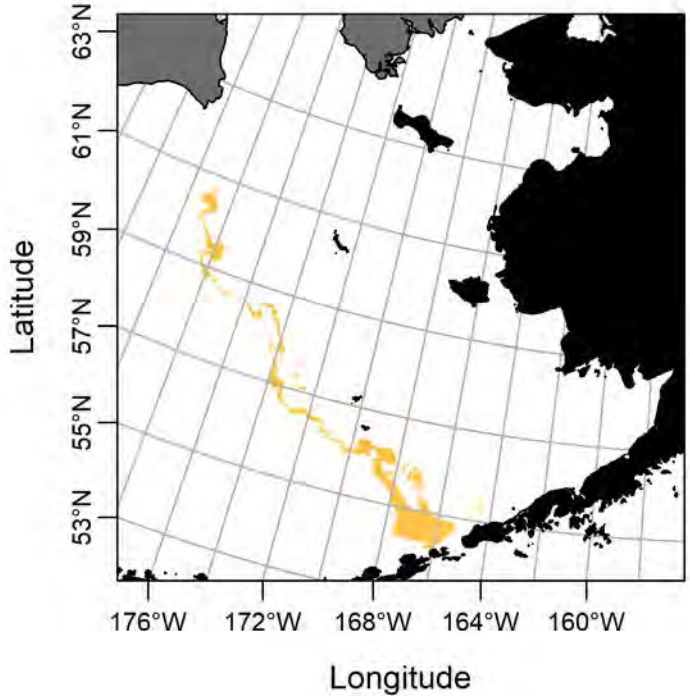

Figure E-108 EFH distribution of EBS Dover sole adult, summer.

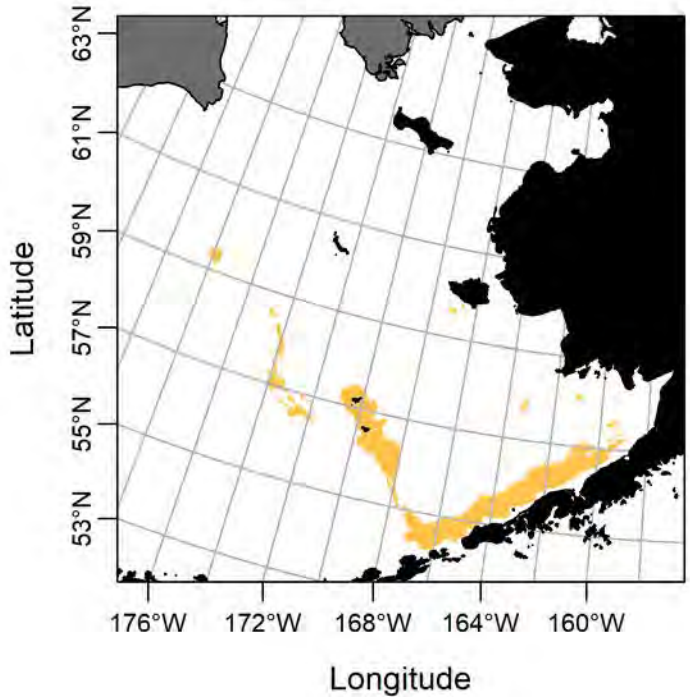

Figure E-109 EFH distribution of EBS Dover sole adult, winter.

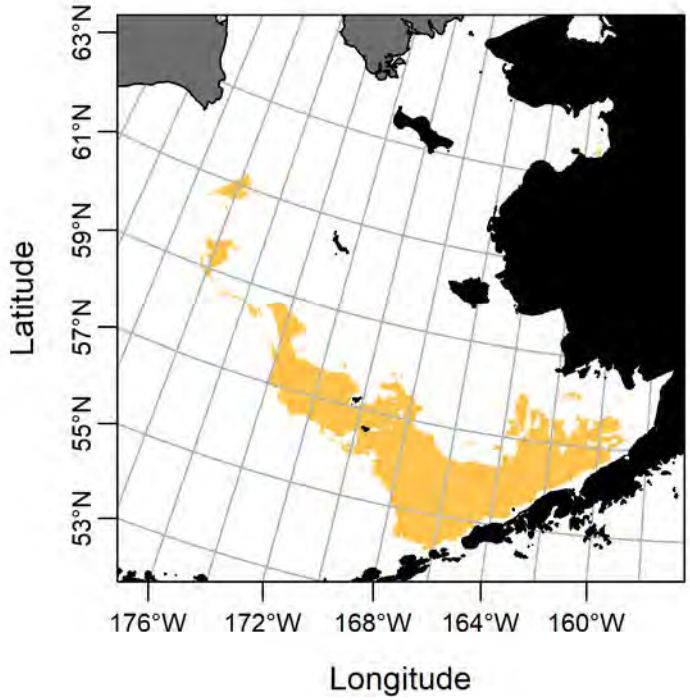

Figure E-110 EFH distribution of EBS Dover sole juvenile, summer.

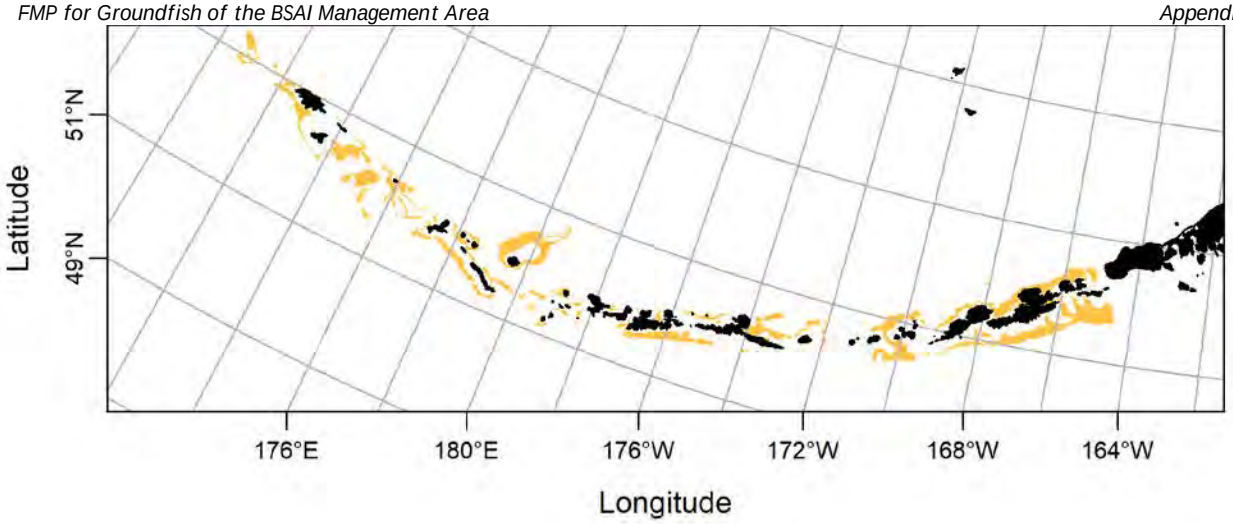

Figure E-111 EFH distribution of AI Dover sole adult, spring.

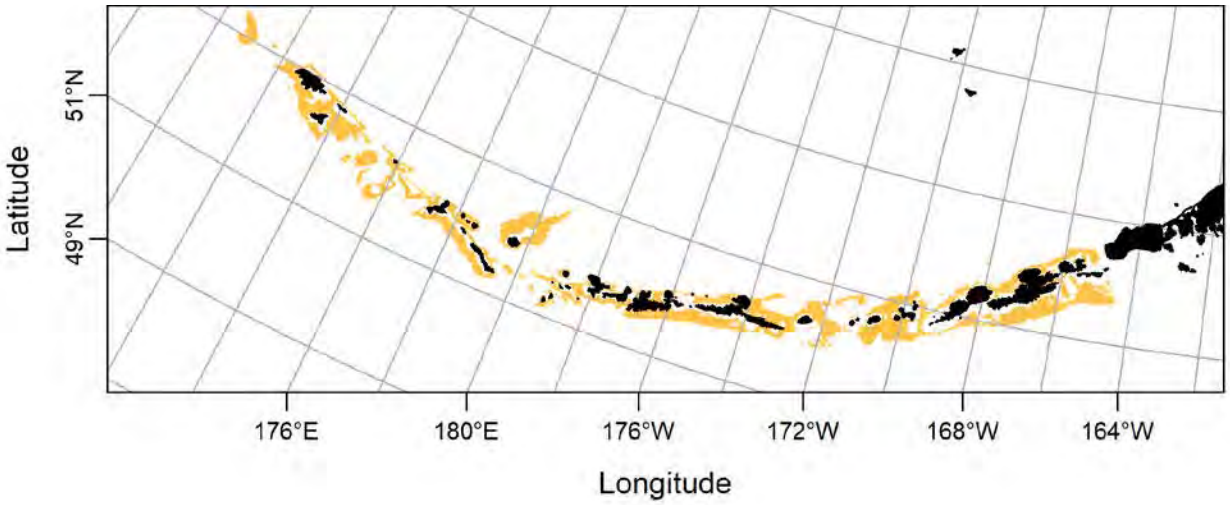

Figure E-112 EFH distribution of AI Dover sole adult, summer.

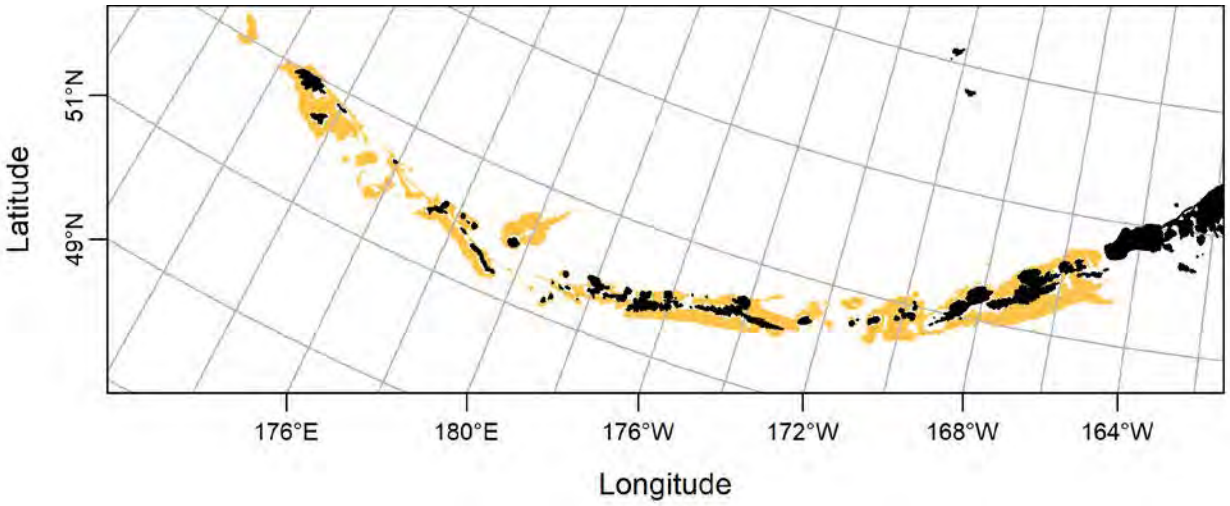

Figure E-113 EFH distribution of AI Dover sole juvenile, summer.

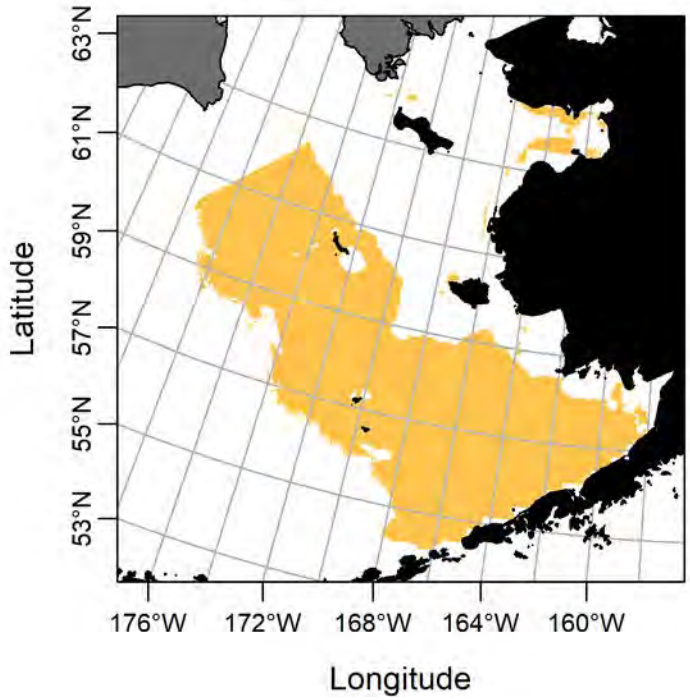

Figure E-114 EFH distribution of EBS Flathead sole juvenile, summer.

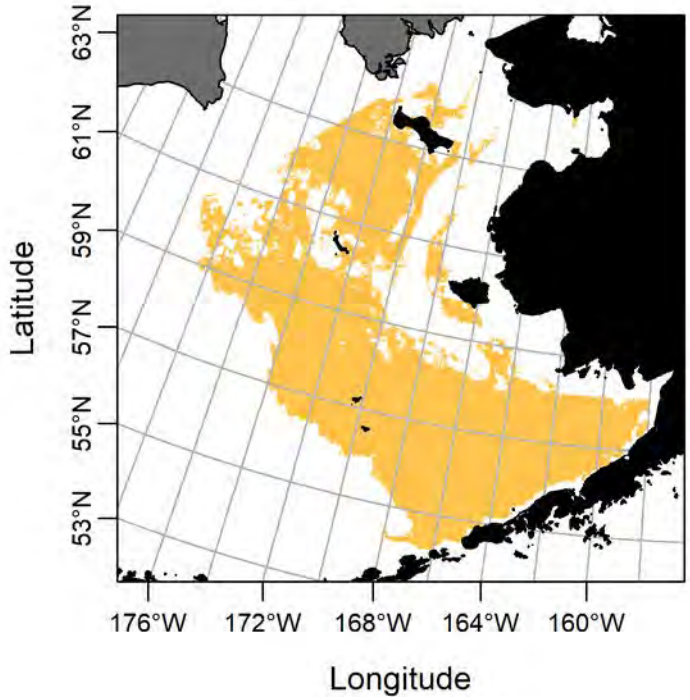

Figure E-115 EFH distribution of EBS Flathead sole larvae, summer.

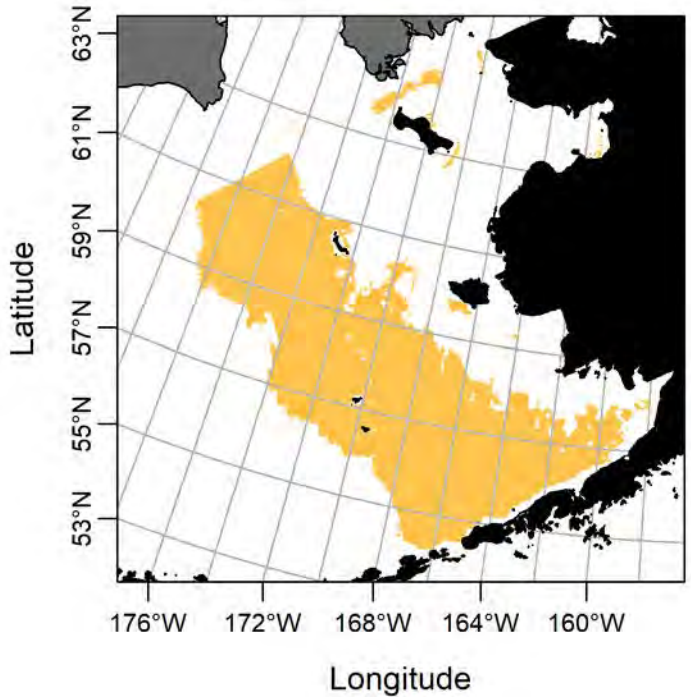

Figure E-116 EFH distribution of EBS Flathead sole adult, fall.

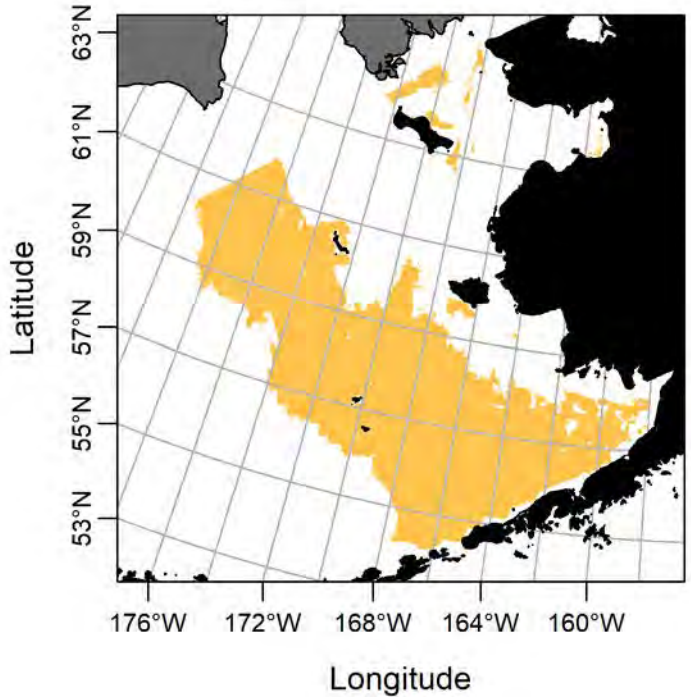

Figure E-117 EFH distribution of EBS Flathead sole adult, spring.

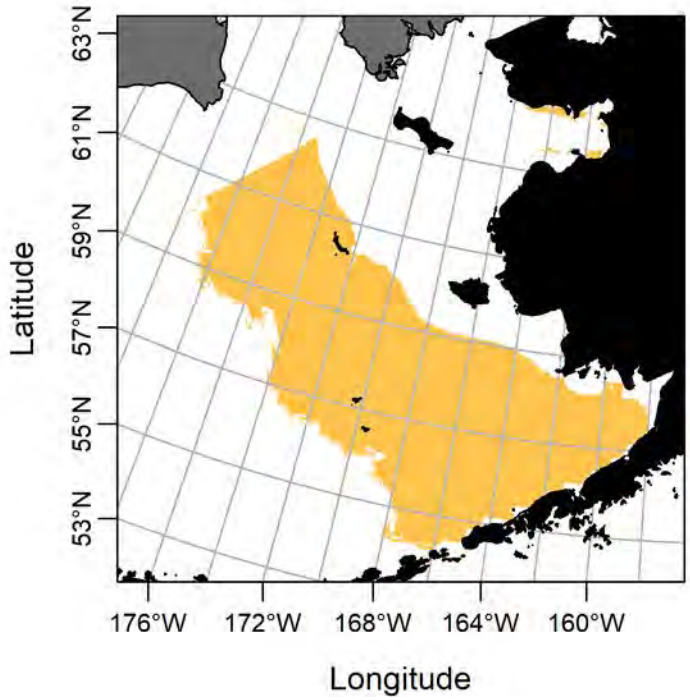

Figure E-118 EFH distribution of EBS Flathead sole adult, summer.

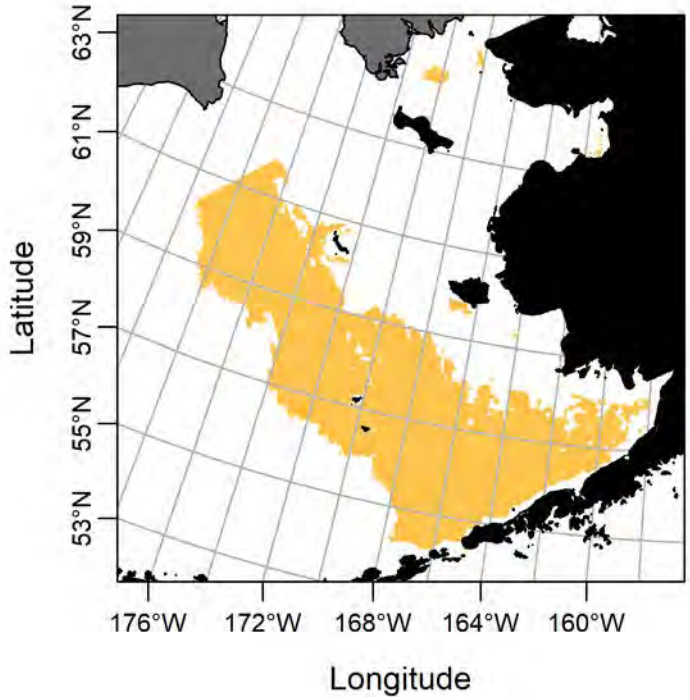

Figure E-119 EFH distribution of EBS Flathead sole adult, winter.

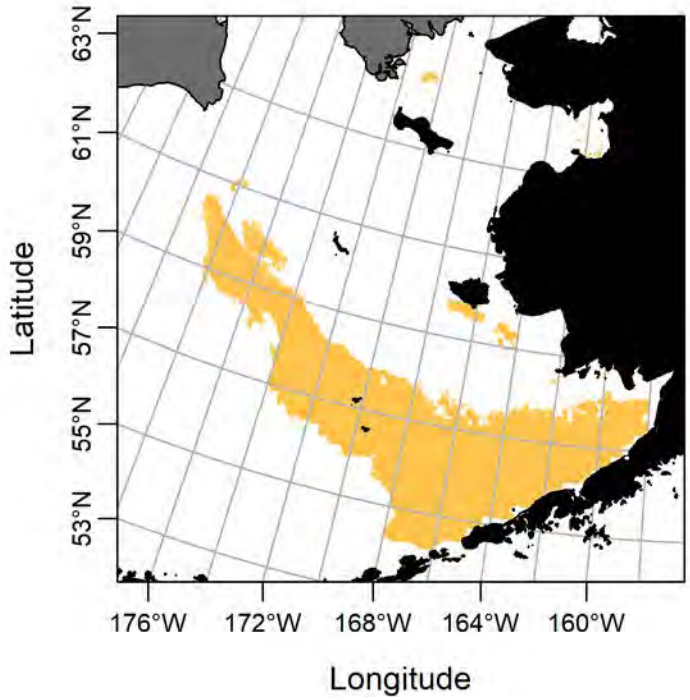

Figure E-120 EFH distribution of EBS Flathead sole egg, summer.

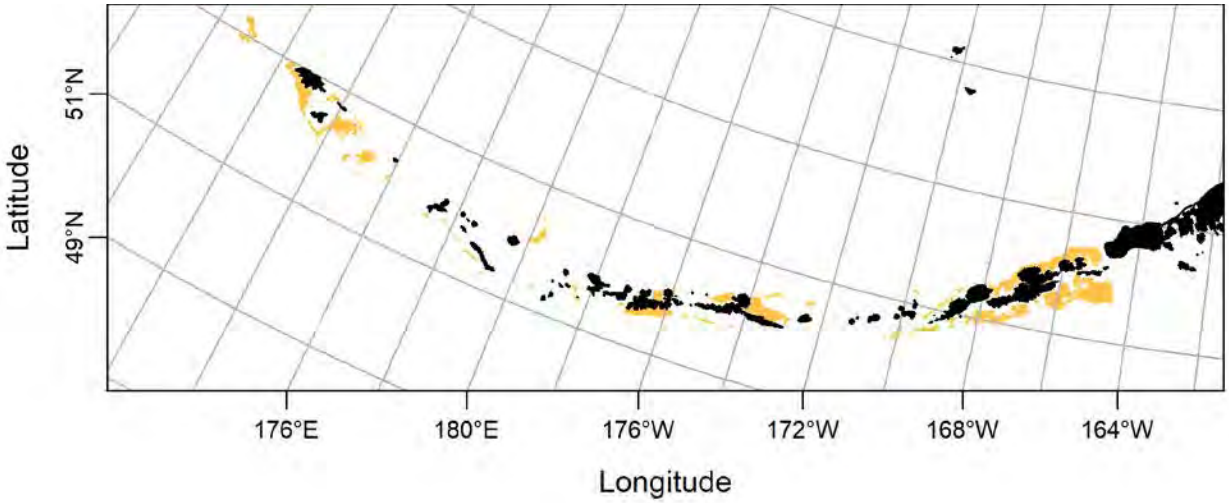

Figure E-121 EFH distribution of AI Flathead sole adult, fall.

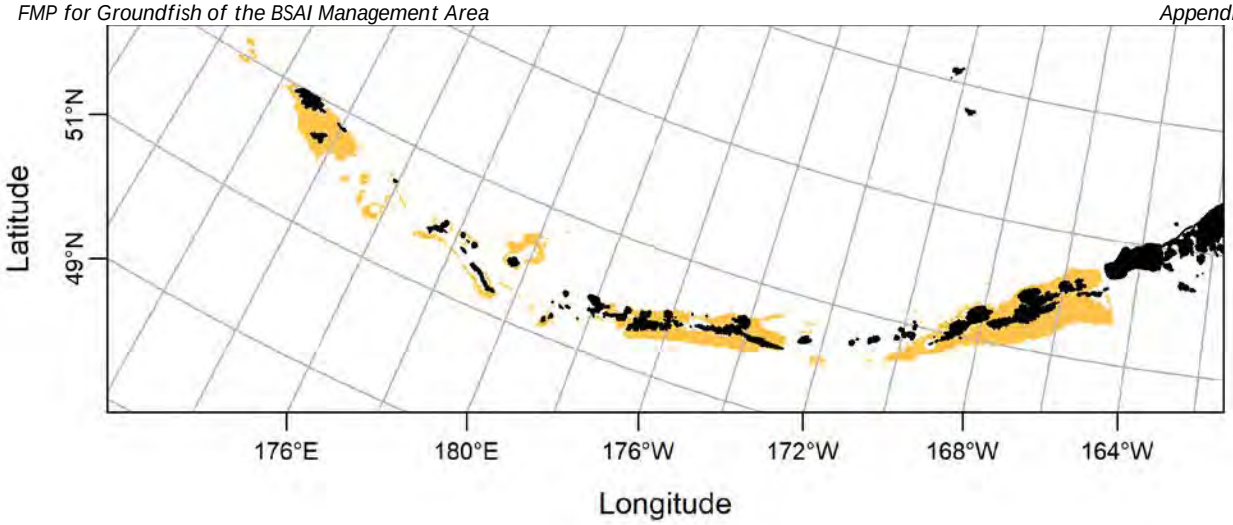

Figure E-122 EFH distribution of AI Flathead sole adult, spring.

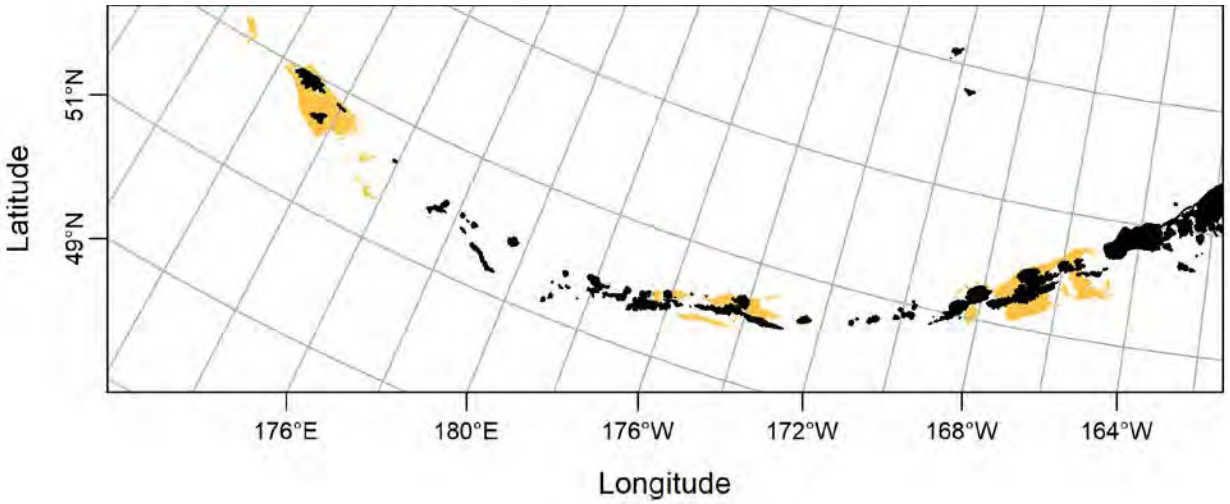

Figure E-123 EFH distribution of AI Flathead sole adult, summer.

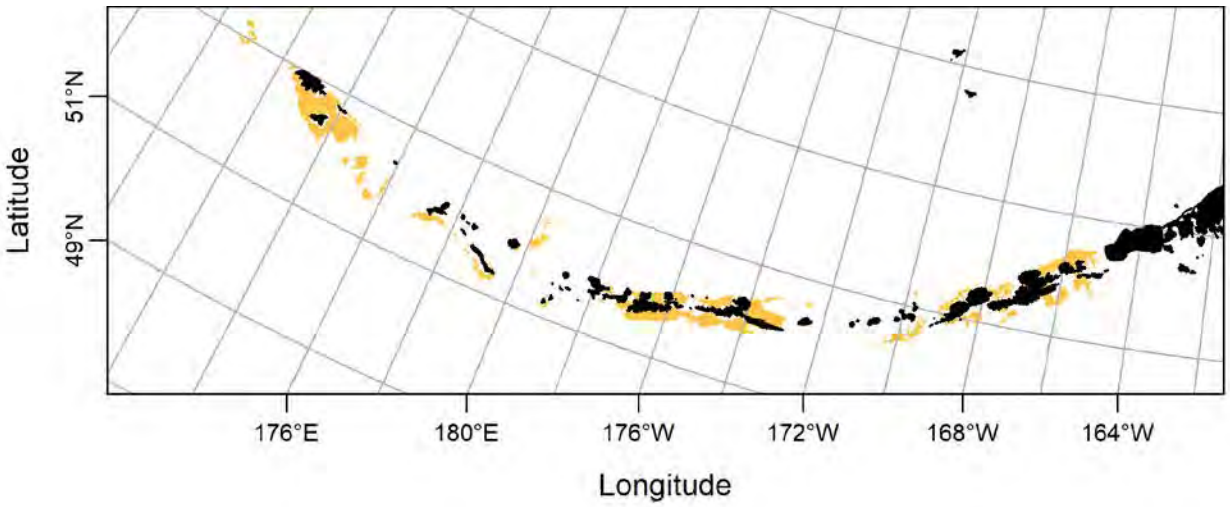

Figure E-124 EFH distribution of AI Flathead sole adult, winter.

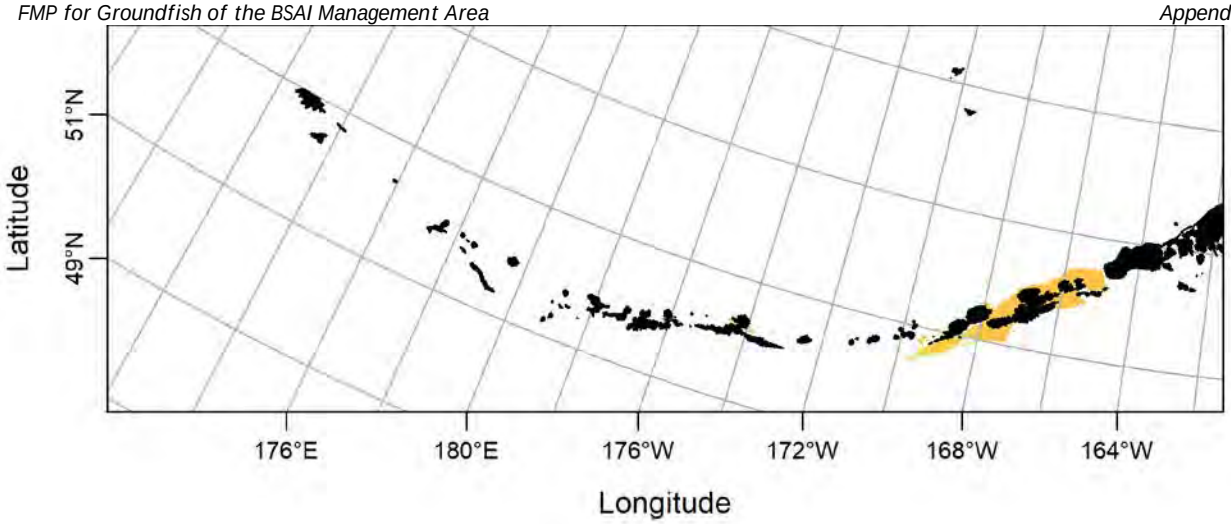

Figure E-125 EFH distribution of AI Flathead sole egg, summer.

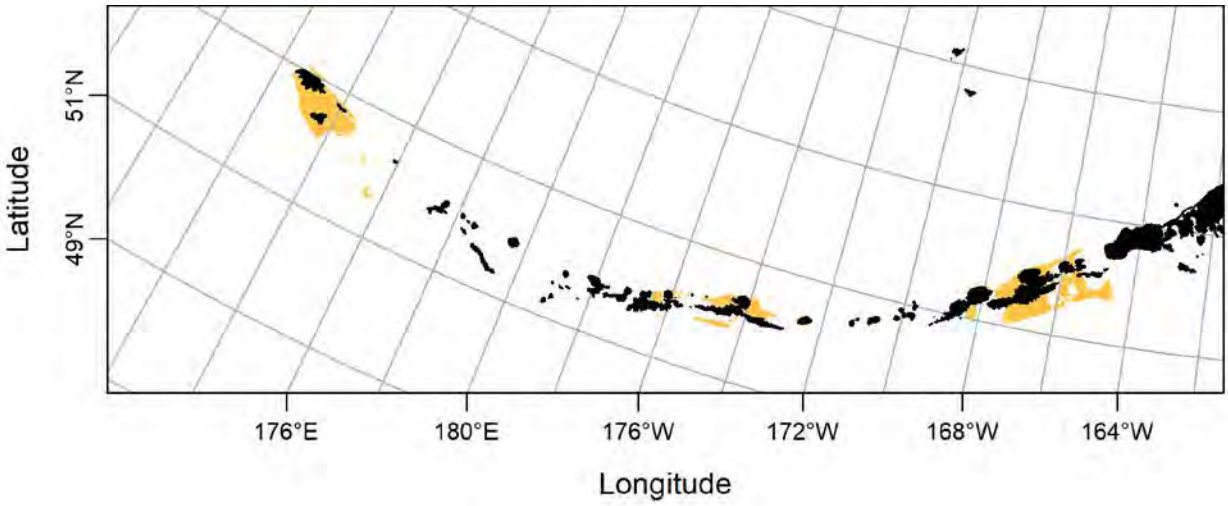

Figure E-126 EFH distribution of AI Flathead sole juvenile, summer.

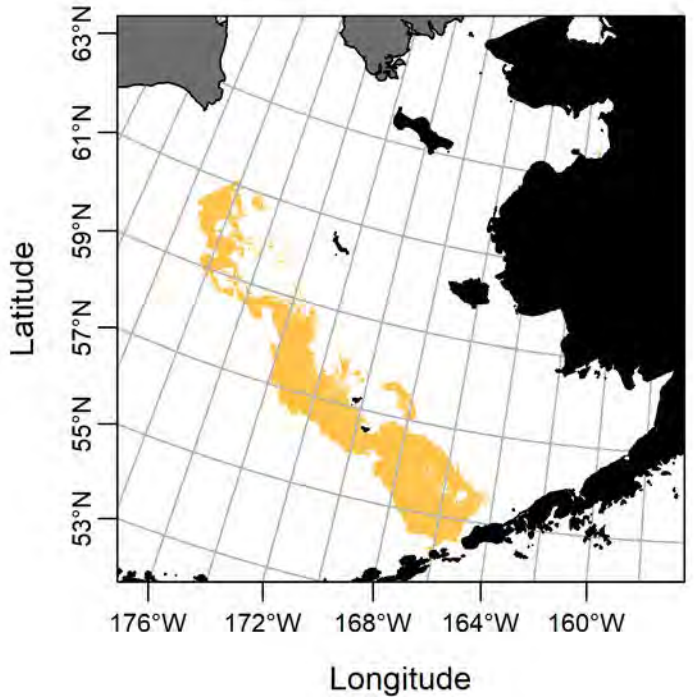

Figure E-127 EFH distribution of EBS Pacific ocean perch adult, fall.

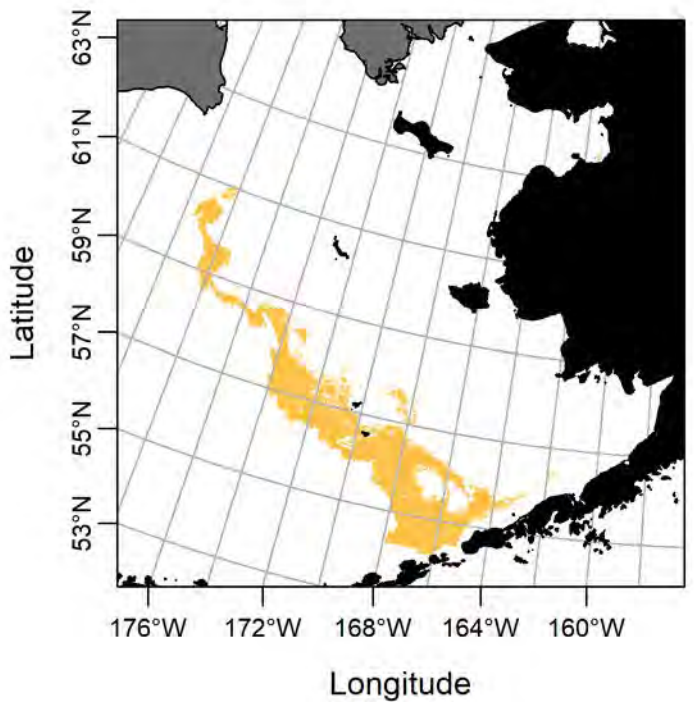

Figure E-128 EFH distribution of EBS Pacific ocean perch adult, spring.

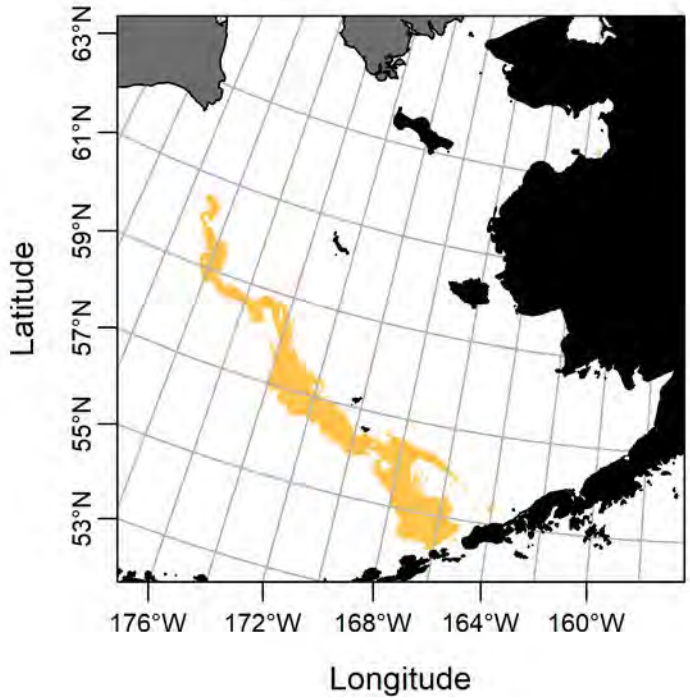

Figure E-129 EFH distribution of EBS Pacific ocean perch adult, summer.

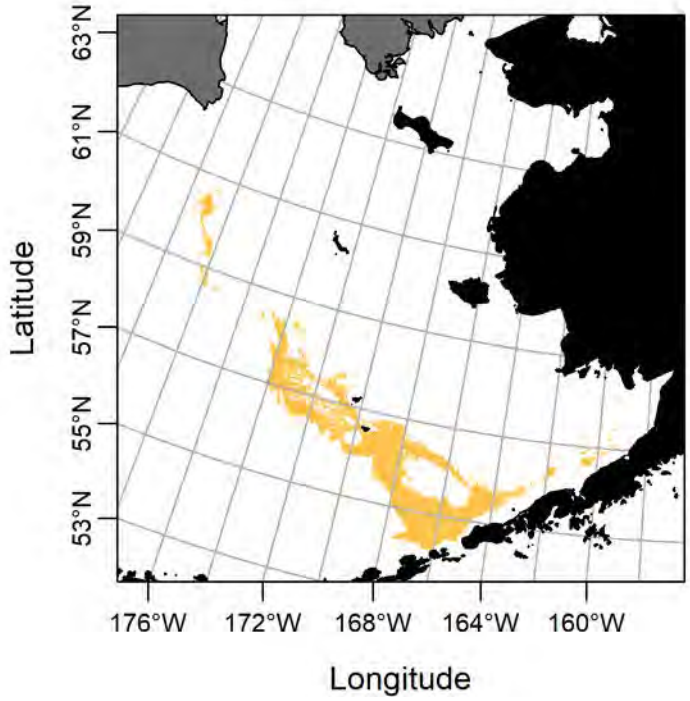

Figure E-130 EFH distribution of EBS Pacific ocean perch adult, winter.

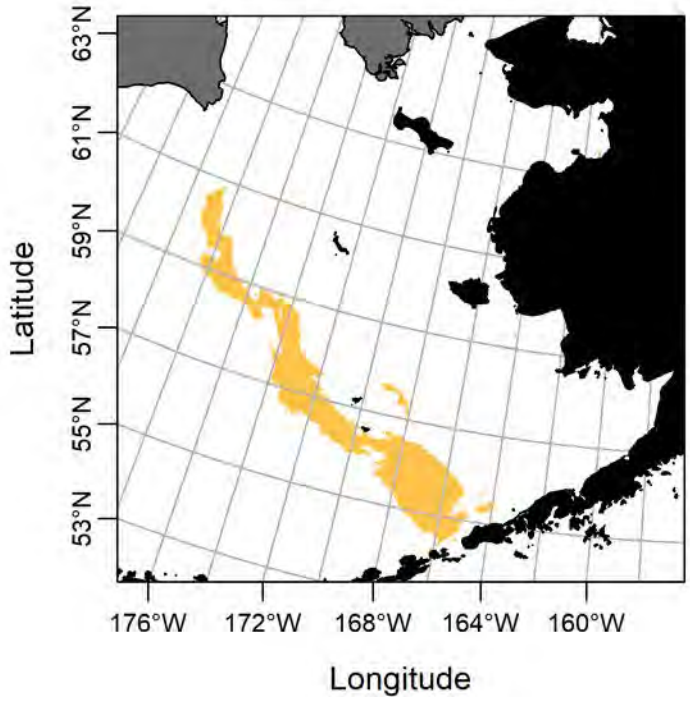

Figure E-131 EFH distribution of EBS Pacific ocean perch juvenile, summer.

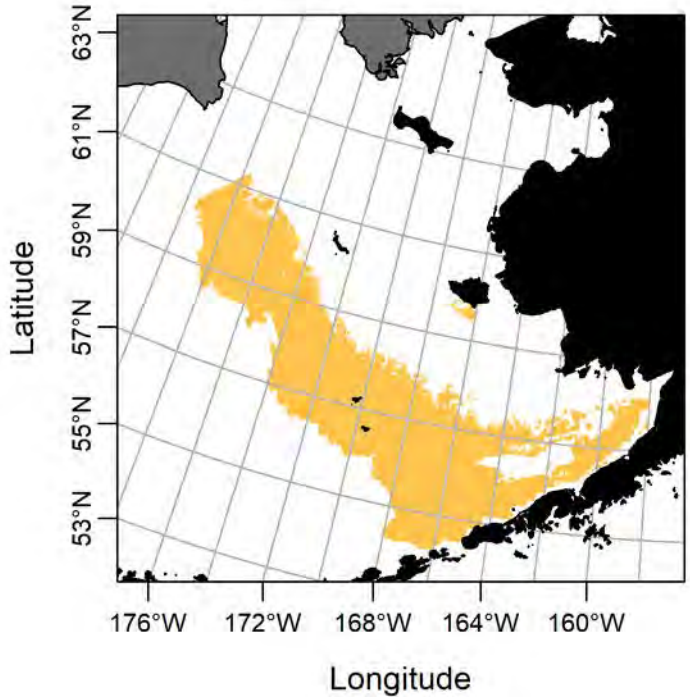

Figure E-132 EFH distribution of EBS Pacific ocean perch larvae, summer.

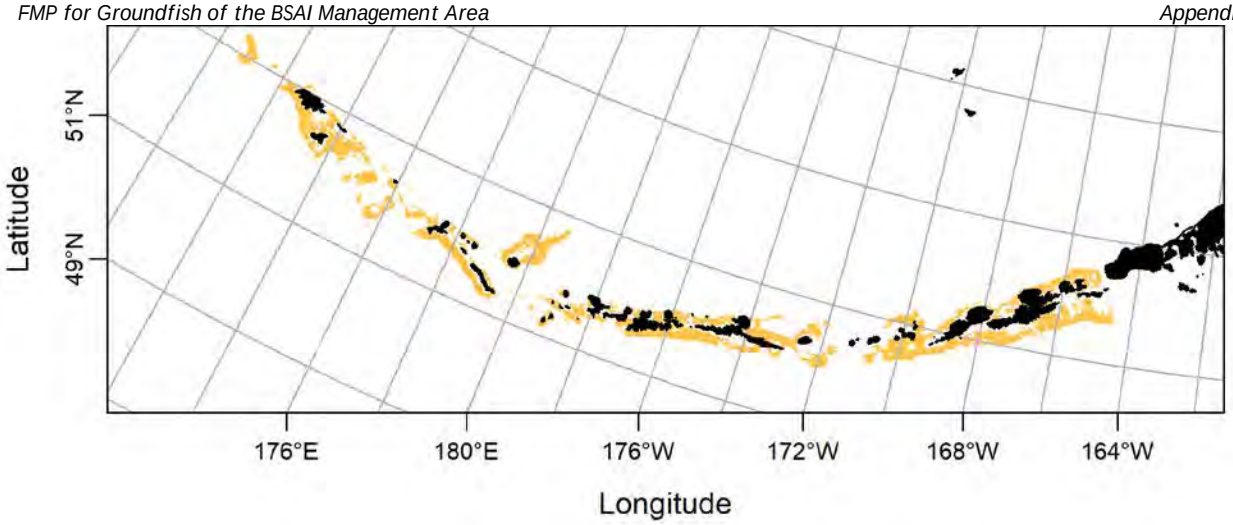

Figure E-133 EFH distribution of AI Pacific ocean perch adult, fall.

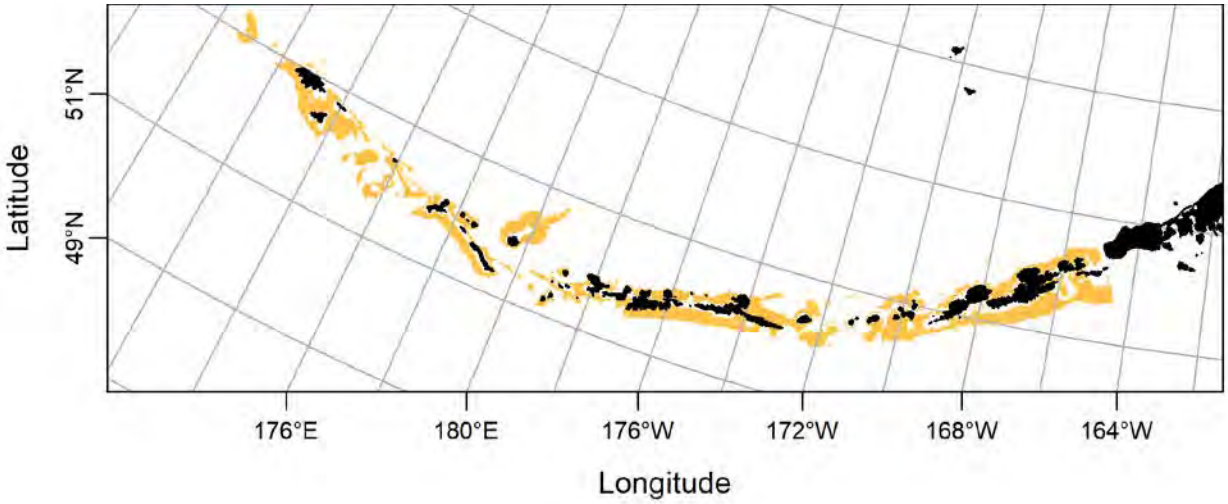

Figure E-134 EFH distribution of AI Pacific ocean perch adult, spring.

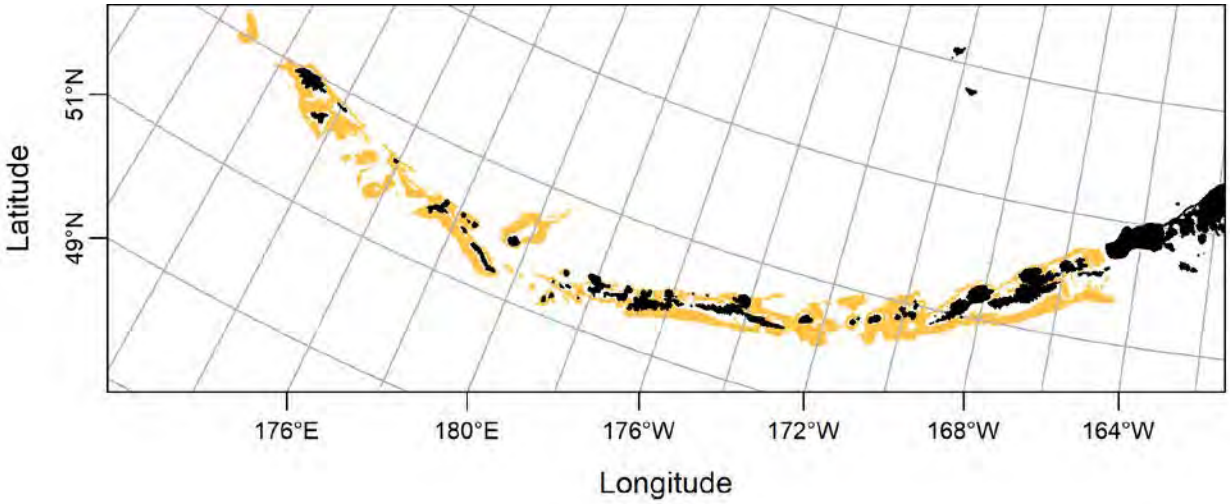

Figure E-135 EFH distribution of AI Pacific ocean perch adult, summer.

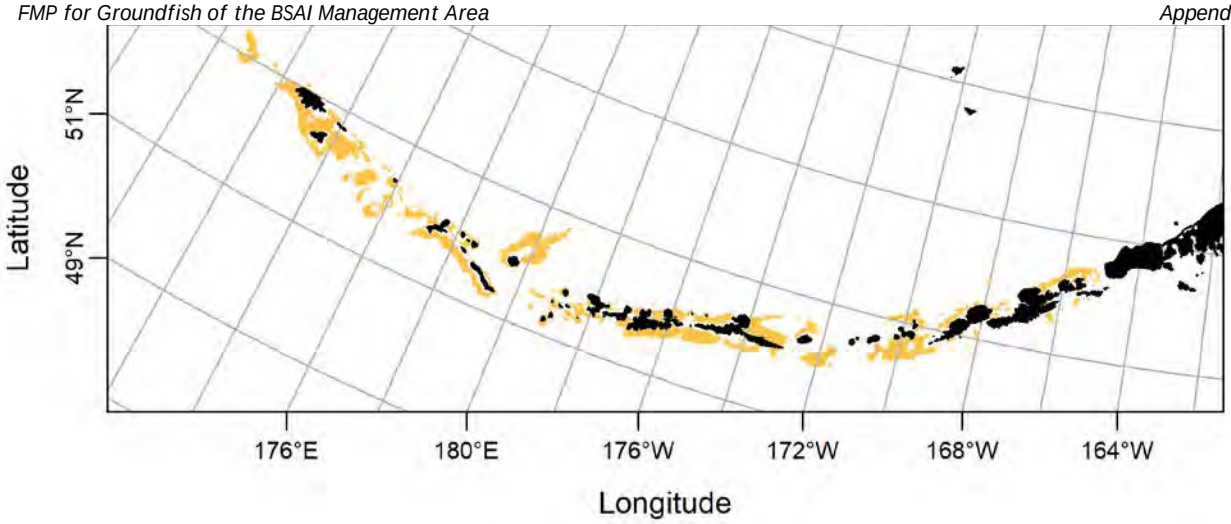

Figure E-136 EFH distribution of AI Pacific ocean perch adult, winter.

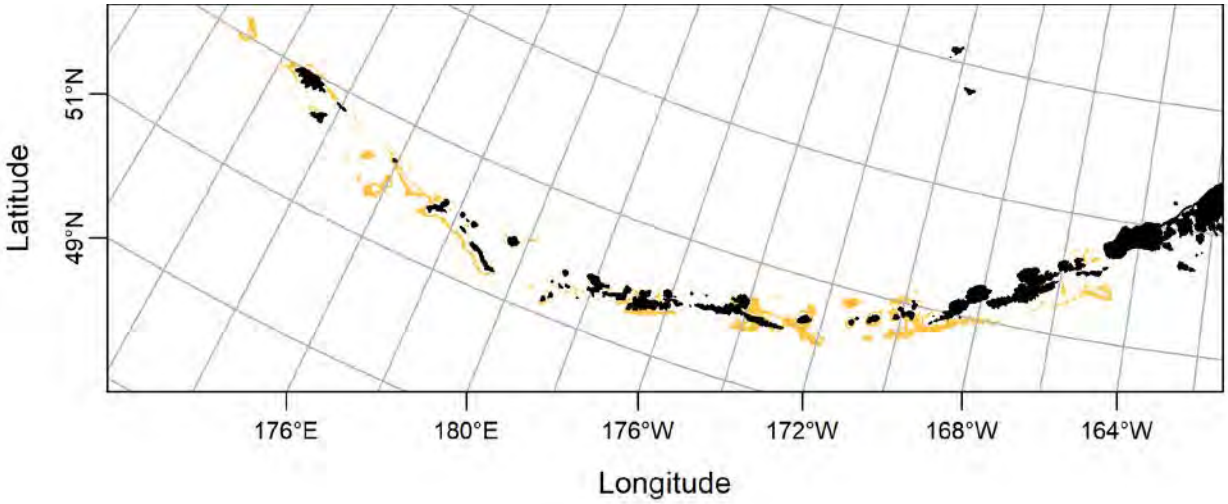

Figure E-137 EFH distribution of AI Pacific ocean perch juvenile, summer.

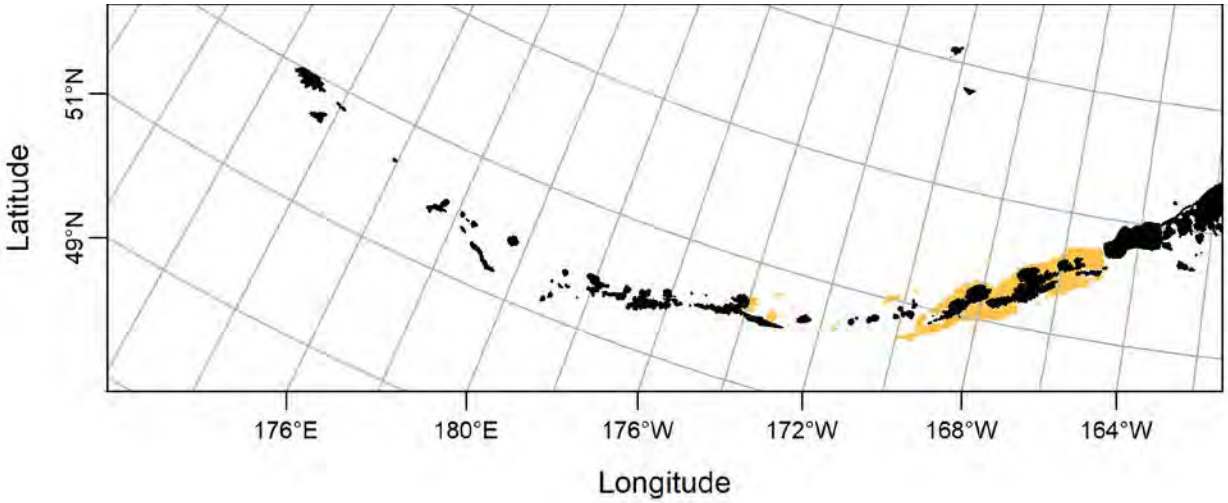

Figure E-138 EFH distribution of AI Pacific ocean perch larvae, summer.

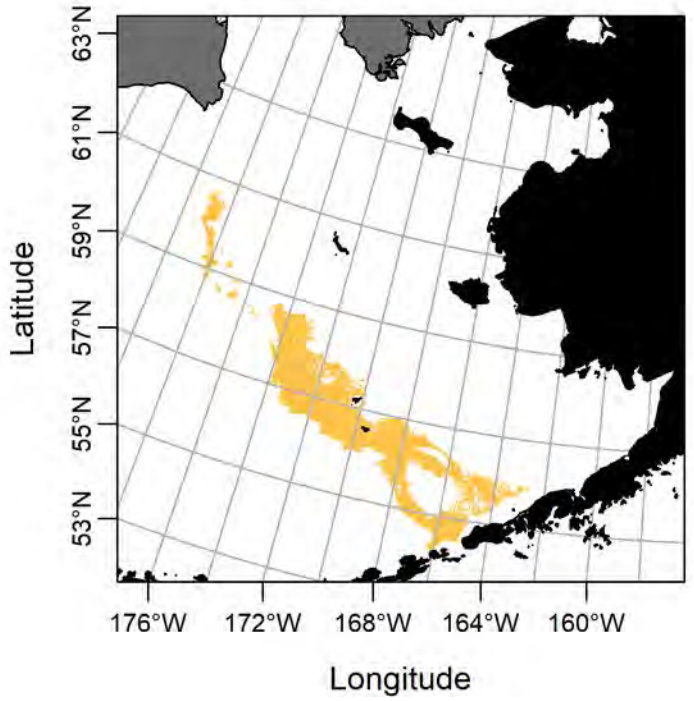

Figure E-139 EFH distribution of EBS Northern rockfish adult, spring.

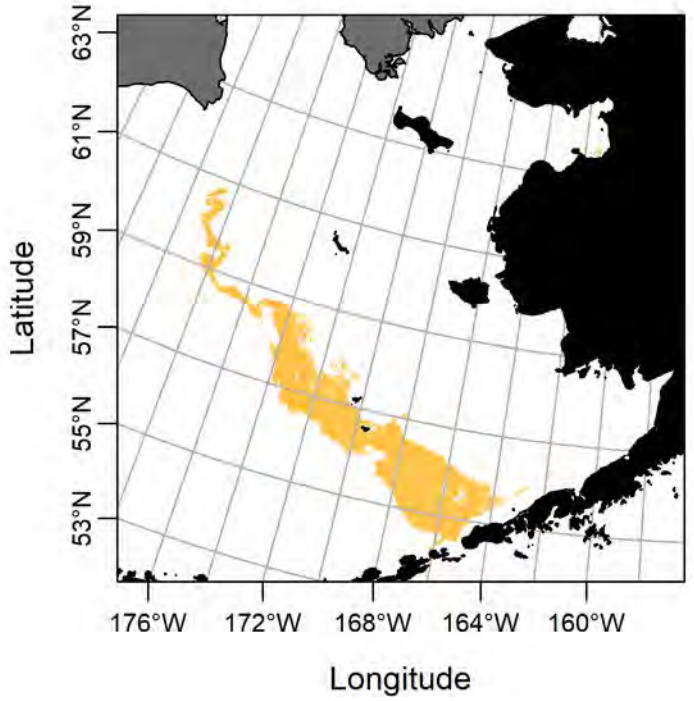

Figure E-140 EFH distribution of EBS Northern rockfish adult, fall.

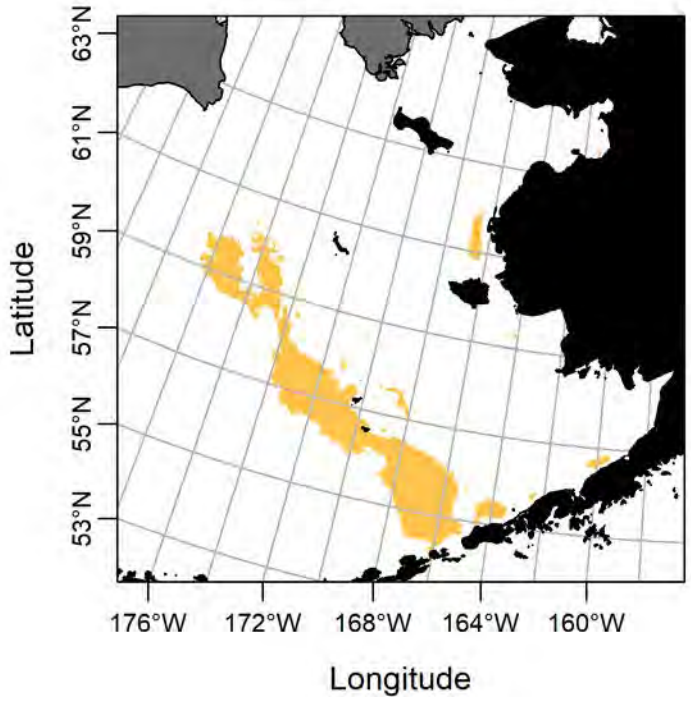

Figure E-141 EFH distribution of EBS Northern rockfish adult, summer.

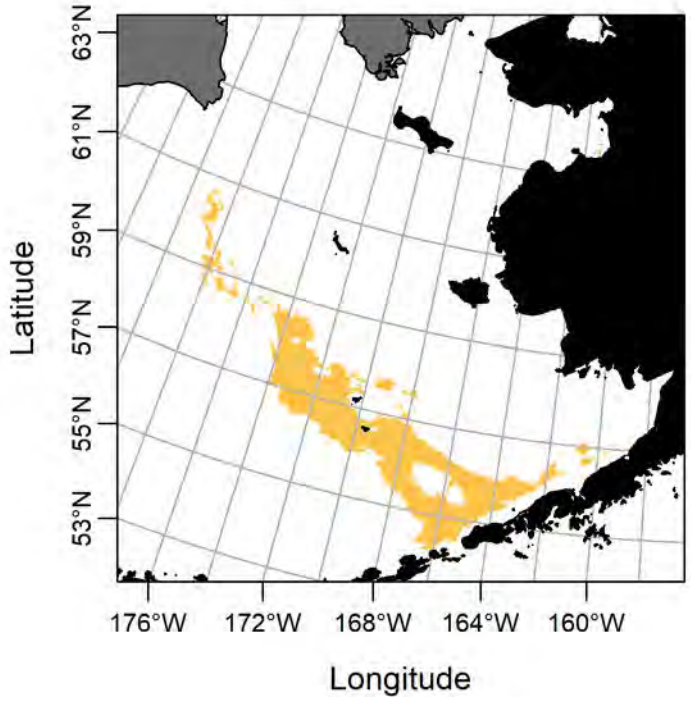

Figure E-142 EFH distribution of EBS Northern rockfish adult, winter.

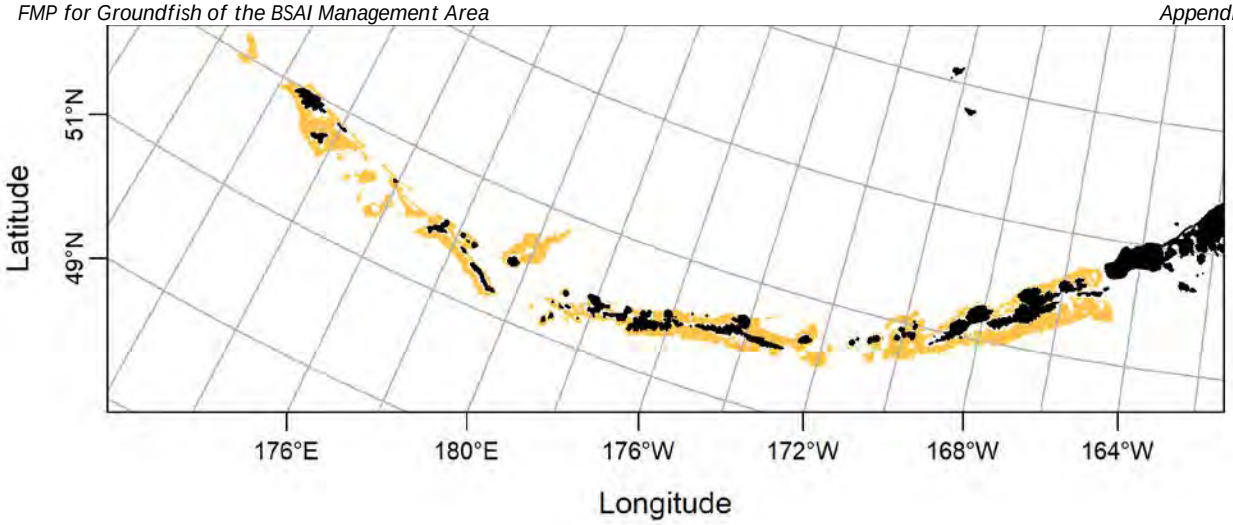

Figure E-143 EFH distribution of AI Northern rockfish adult, fall.

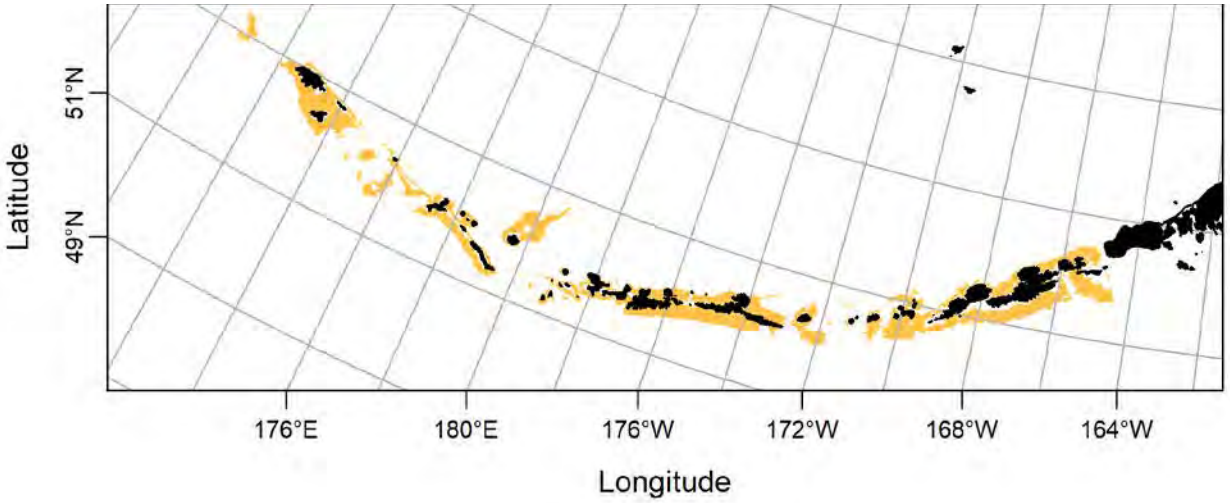

Figure E-144 EFH distribution of AI Northern rockfish adult, spring.

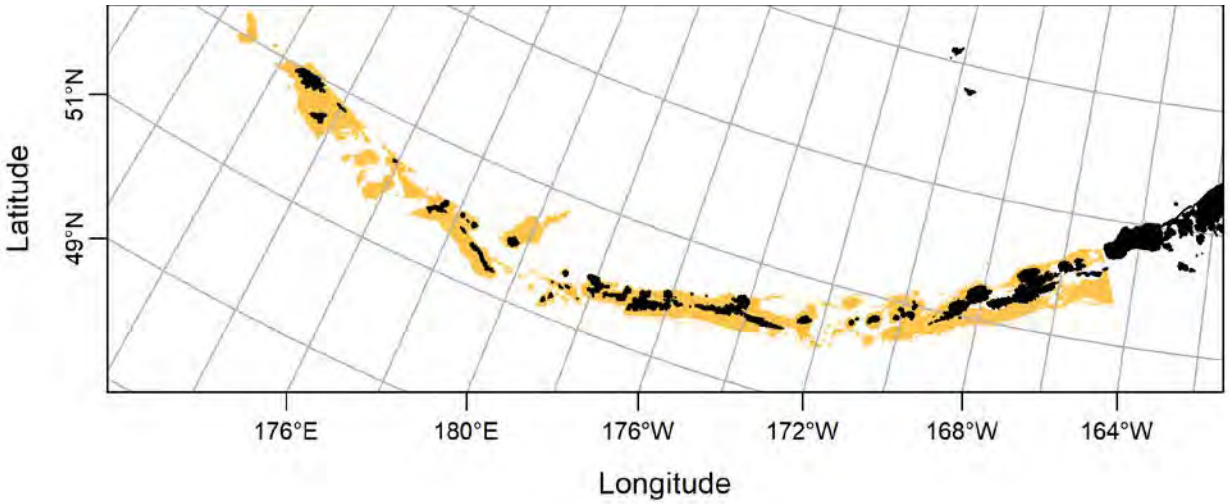

Figure E-145 EFH distribution of AI Northern rockfish adult, summer.

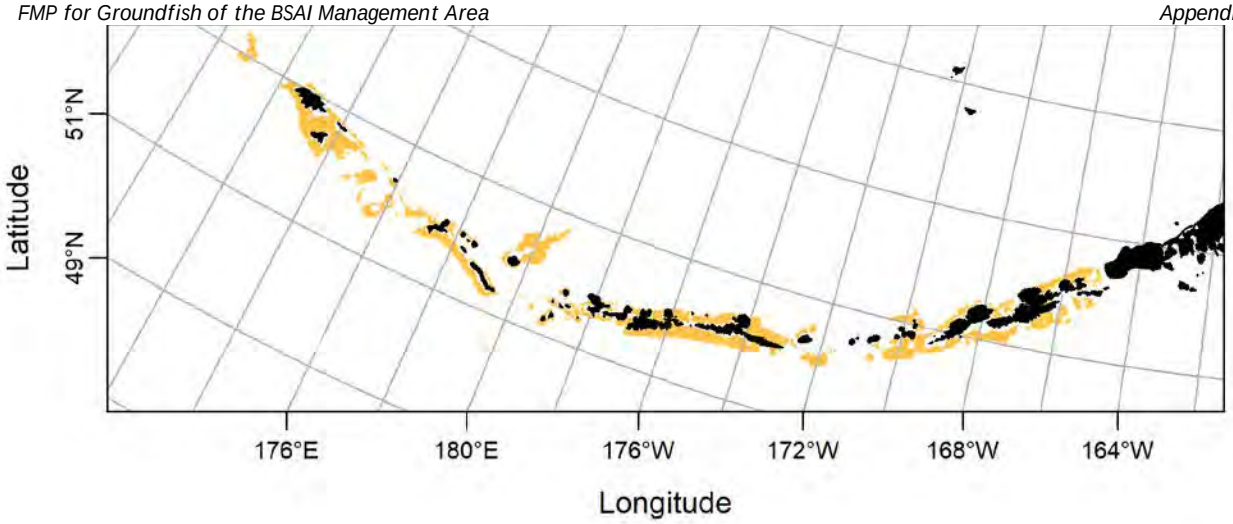

Figure E-146 EFH distribution of AI Northern rockfish adult, winter.

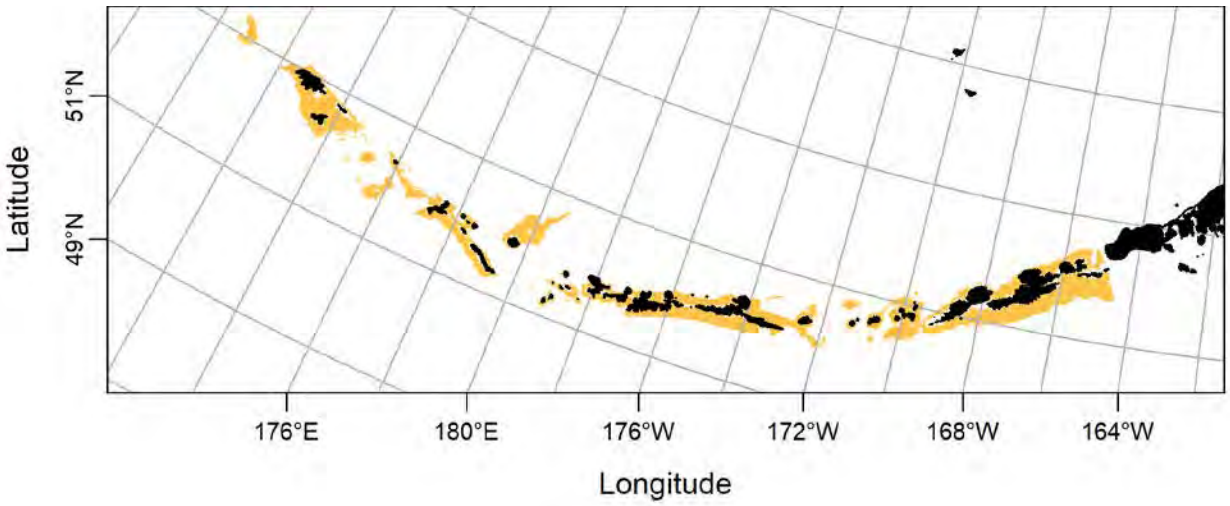

Figure E-147 EFH distribution of AI Northern rockfish juvenile, summer.

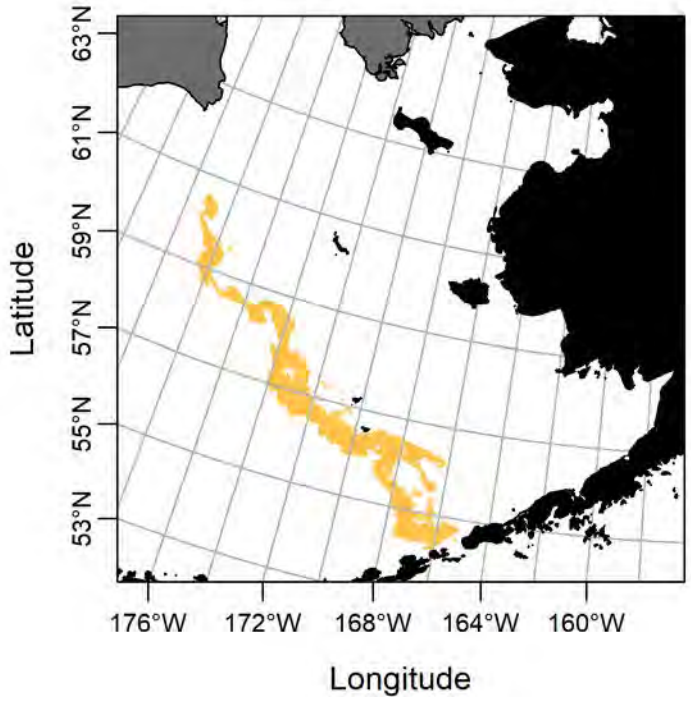

Figure E-148 EFH distribution of EBS Shortraker rockfish adult, fall.

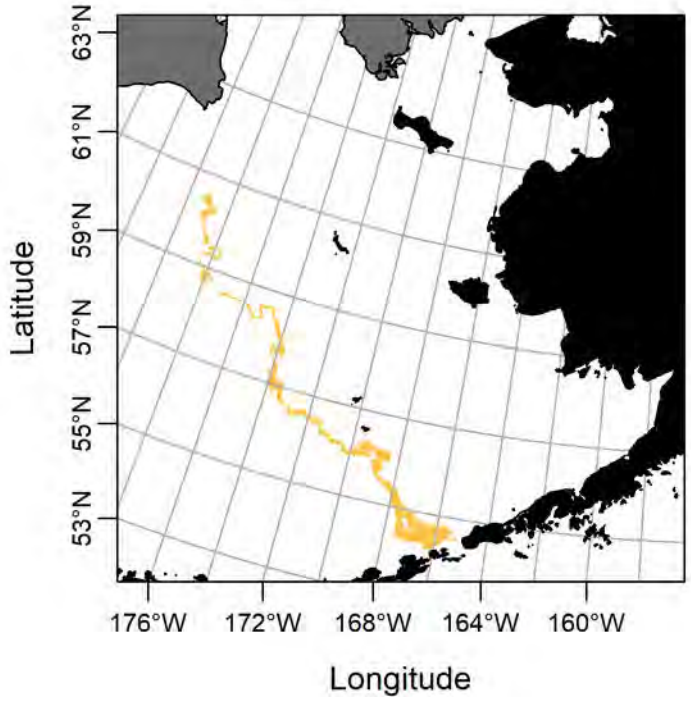

Figure E-149 EFH distribution of EBS Shortraker rockfish adult, spring.

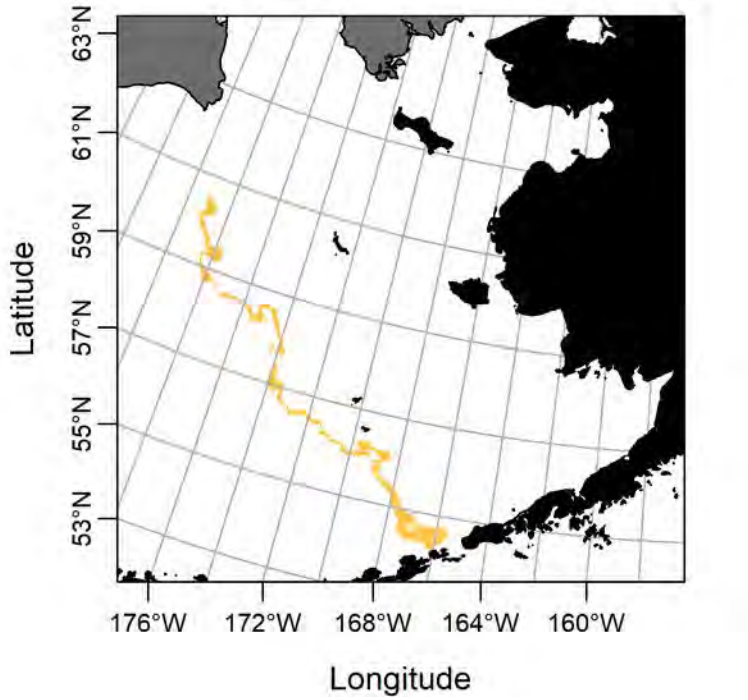

Figure E-150 EFH distribution of EBS Shortraker rockfish adult, summer.

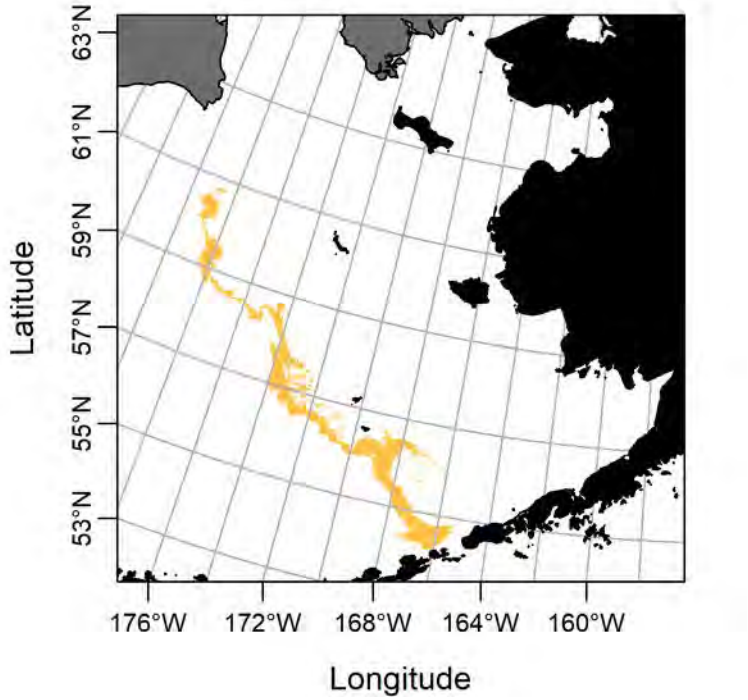

Figure E-151 EFH distribution of EBS Shortraker rockfish adult, winter.

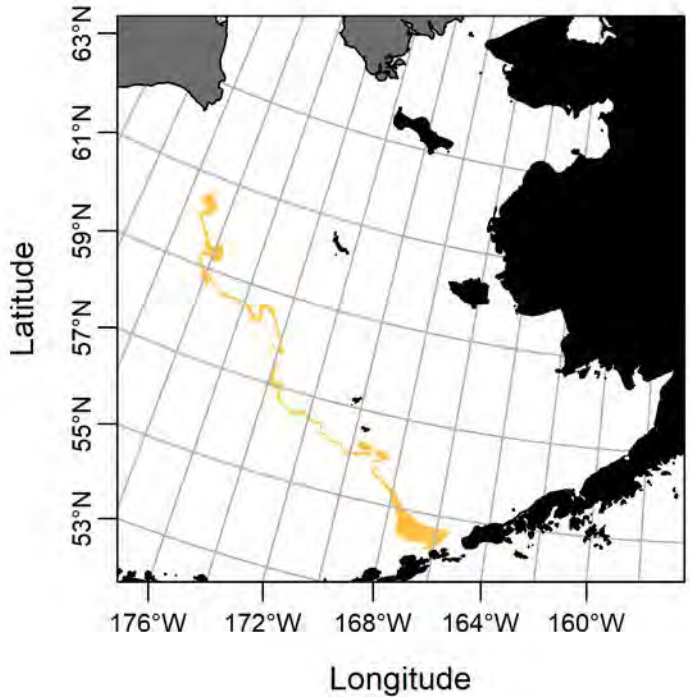

Figure E-152 EFH distribution of EBS Shortraker rockfish juvenile, summer.

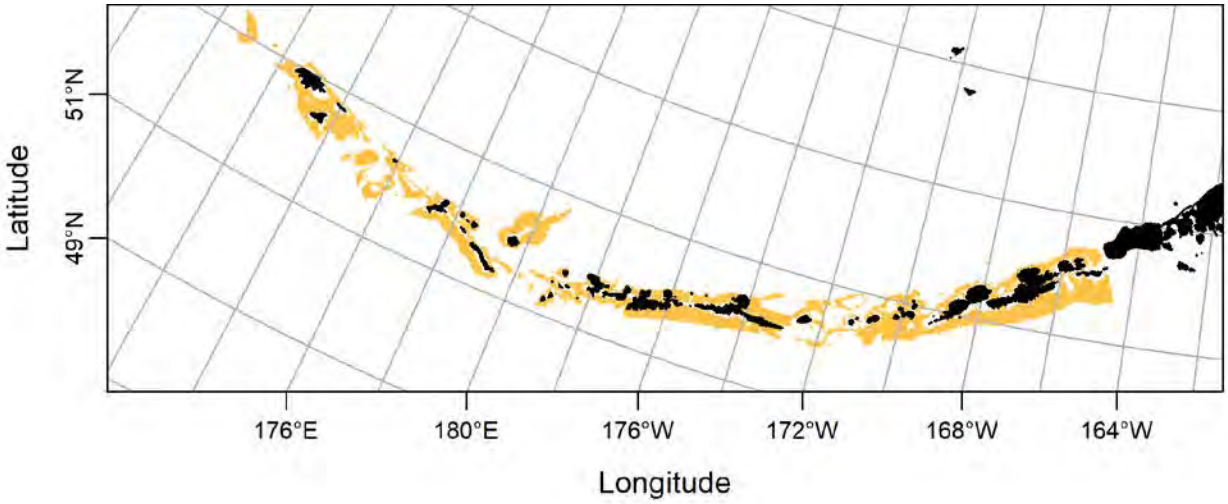

Figure E-153 EFH distribution of AI Shortraker rockfish adult, fall.

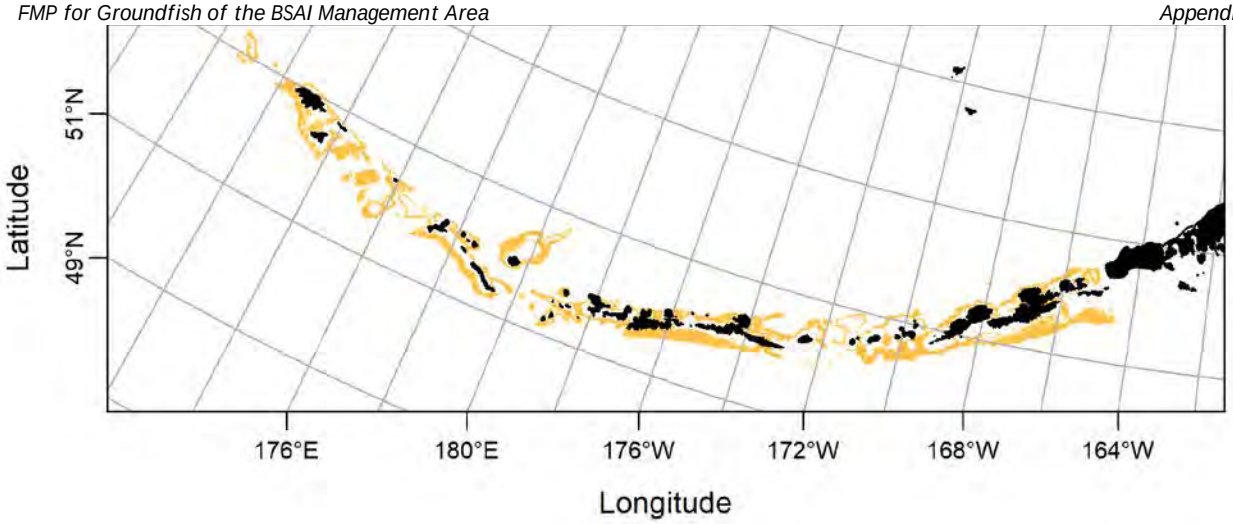

Figure E-154 EFH distribution of AI Shortraker rockfish adult, spring.

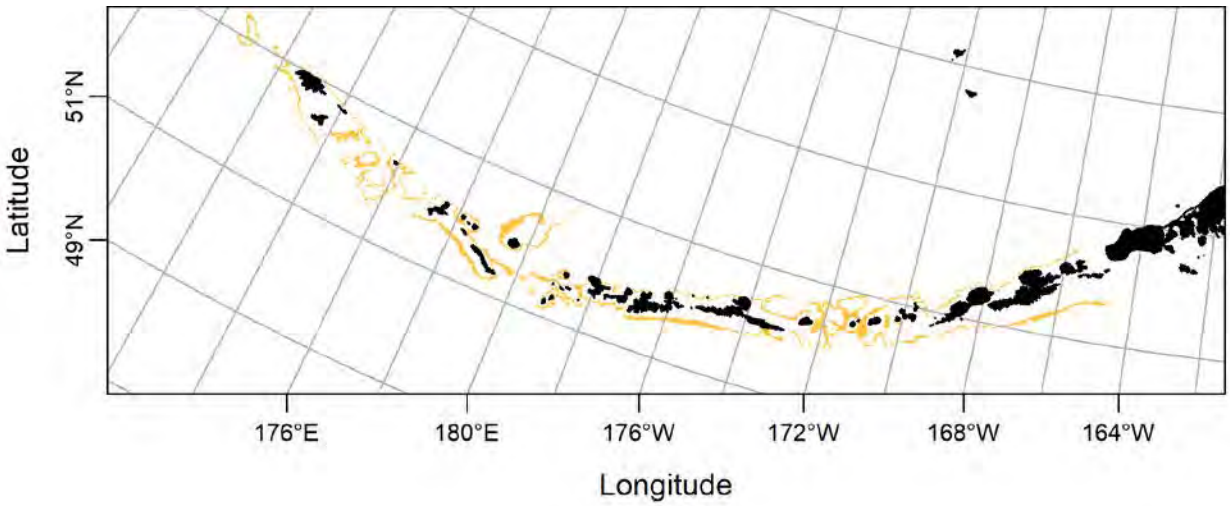

Figure E-155 EFH distribution of AI Shortraker rockfish adult, summer.

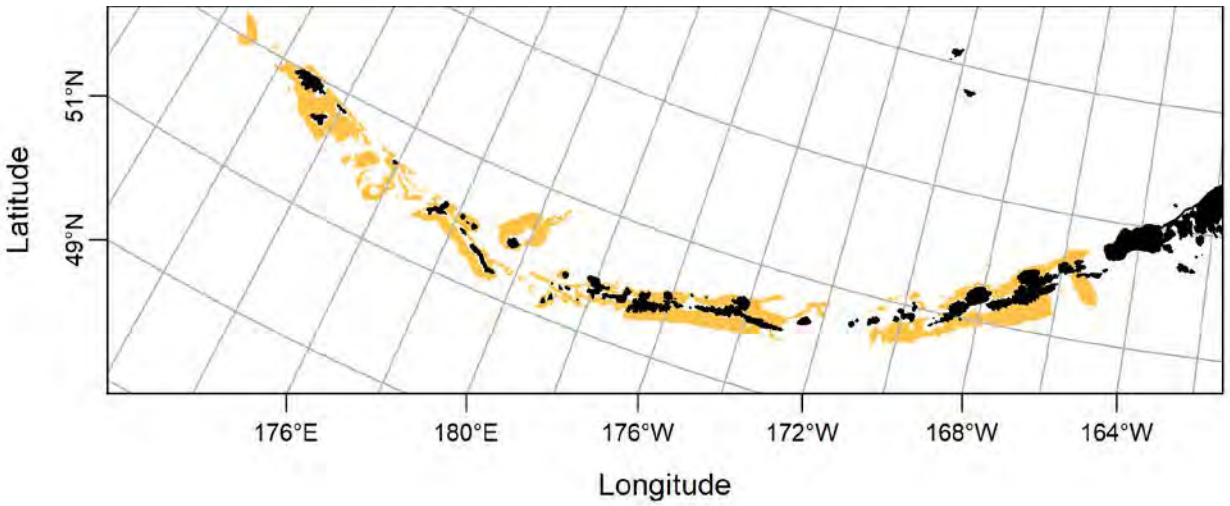

Figure E-156 EFH distribution of AI Shortraker rockfish adult, winter.

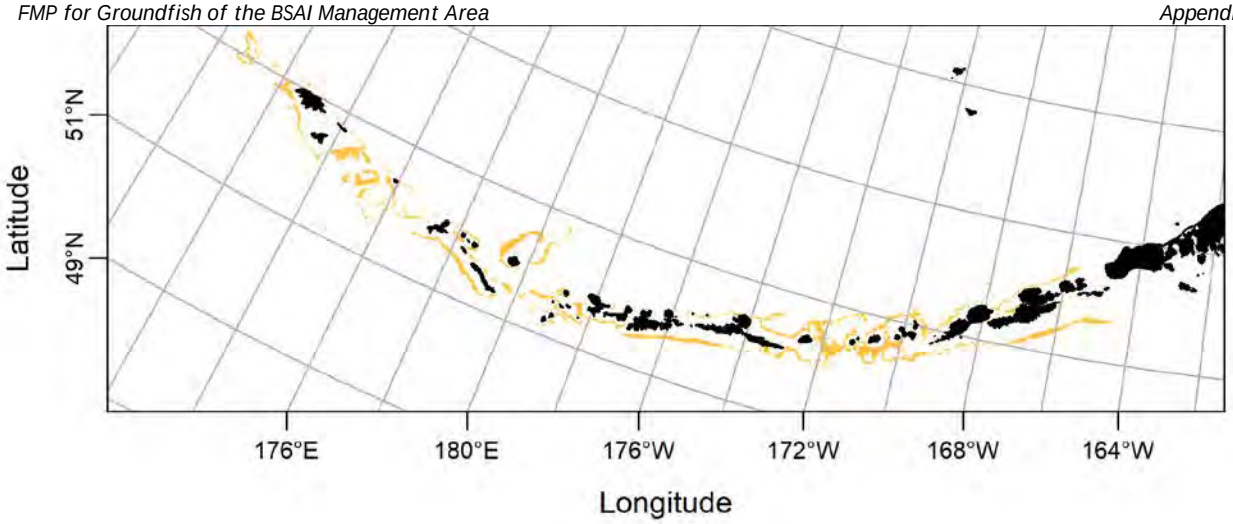

Figure E-157 EFH distribution of AI Shortraker rockfish juvenile, summer.

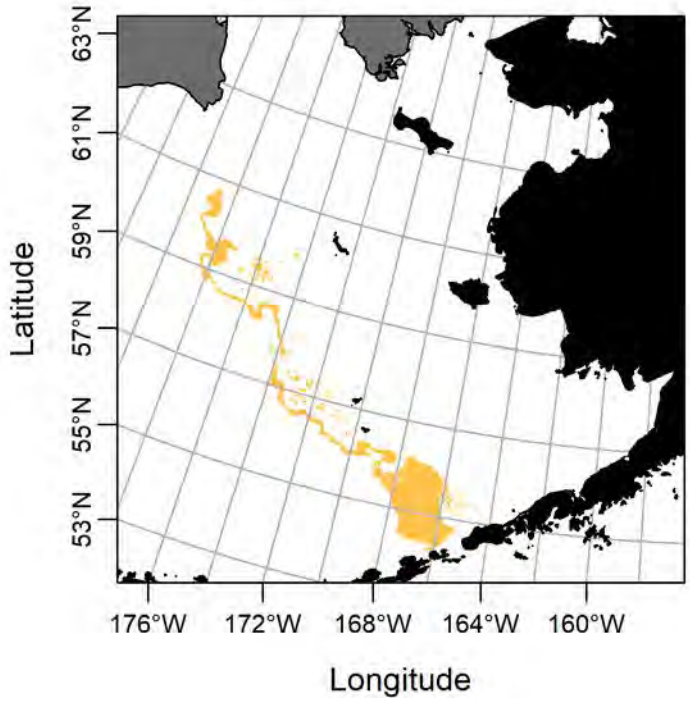

Figure E-158 EFH distribution of EBS Blackspotted rockfish juvenile, summer.

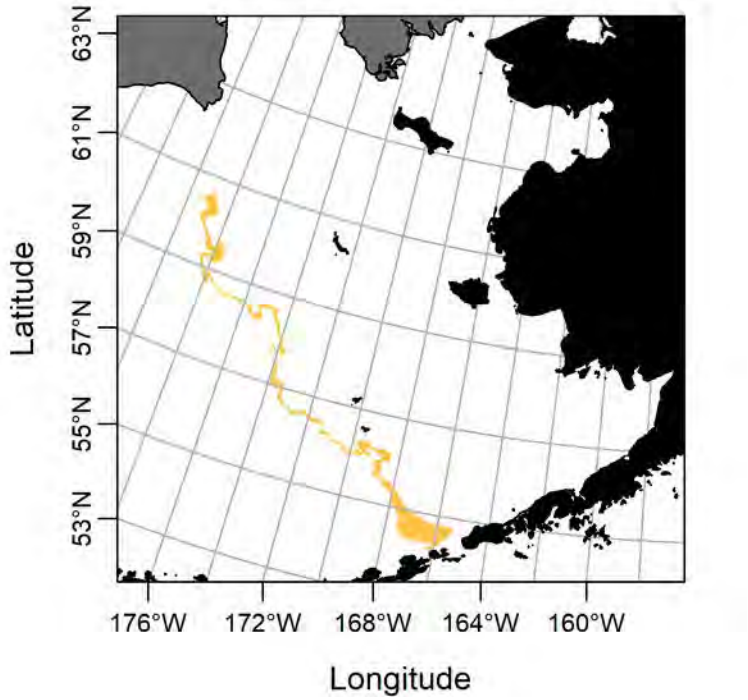

Figure E-159 EFH distribution of EBS Blackspotted rockfish adult, summer.

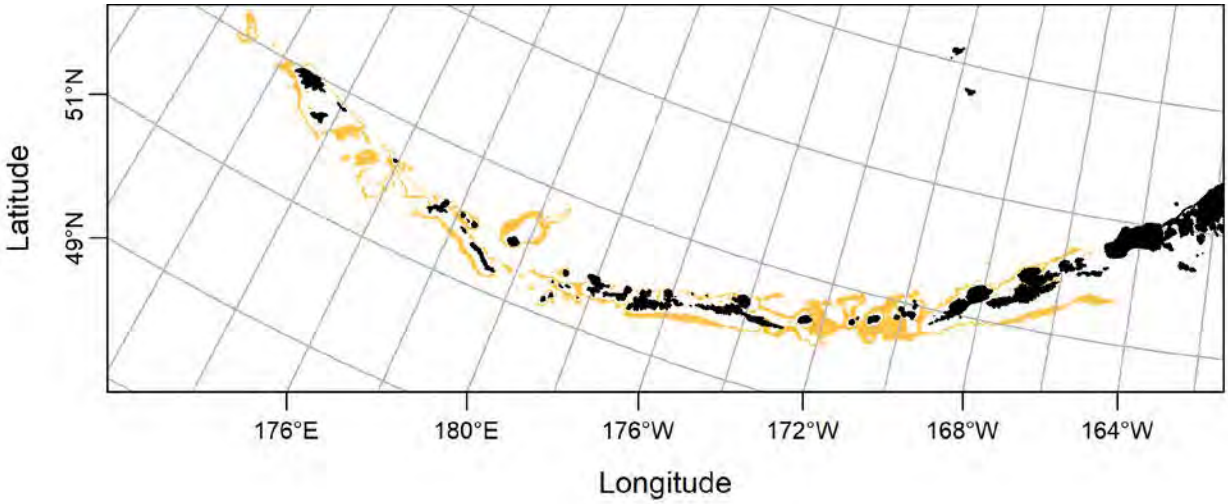

Figure E-160 EFH distribution of AI Blackspotted rockfish adult, summer.

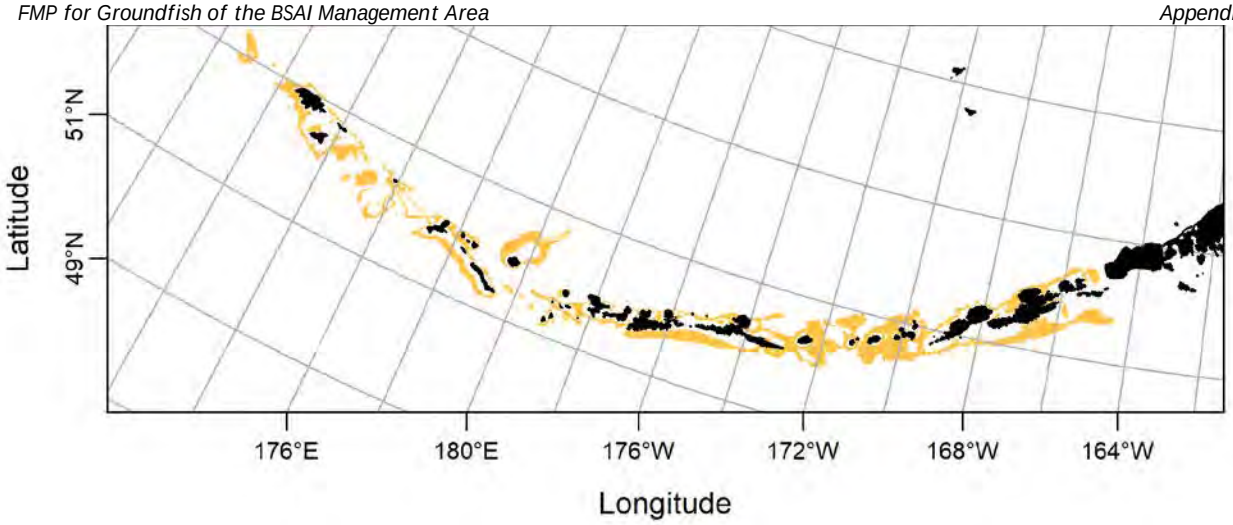

Figure E-161 EFH distribution of AI Blackspotted rockfish juvenile, summer.

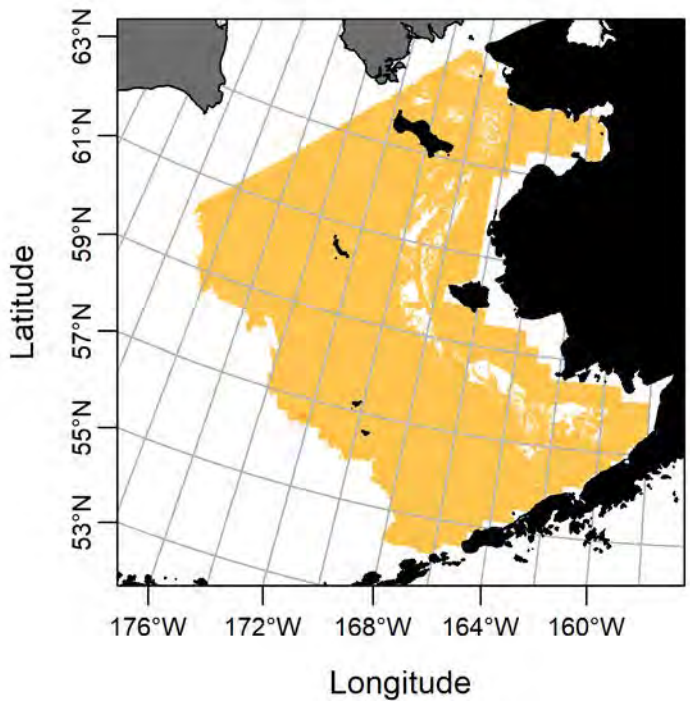

Figure E-162 EFH distribution of EBS Rougheye rockfish adult, fall.

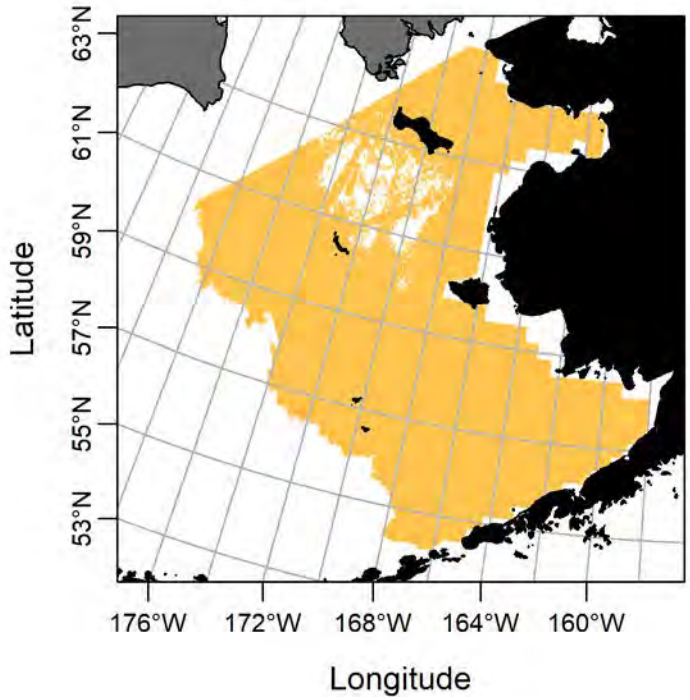

Figure E-163 EFH distribution of EBS Rougheye rockfish adult, spring.

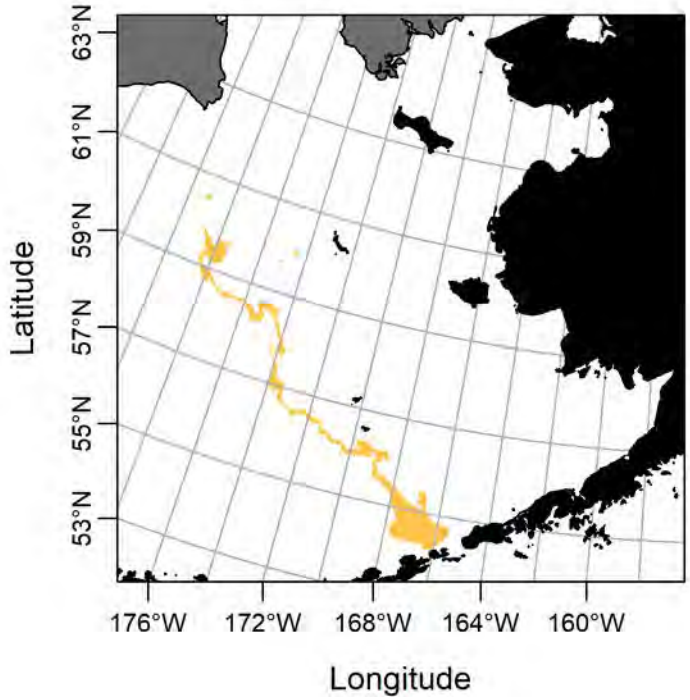

Figure E-164 EFH distribution of EBS Rougheye rockfish adult, summer.

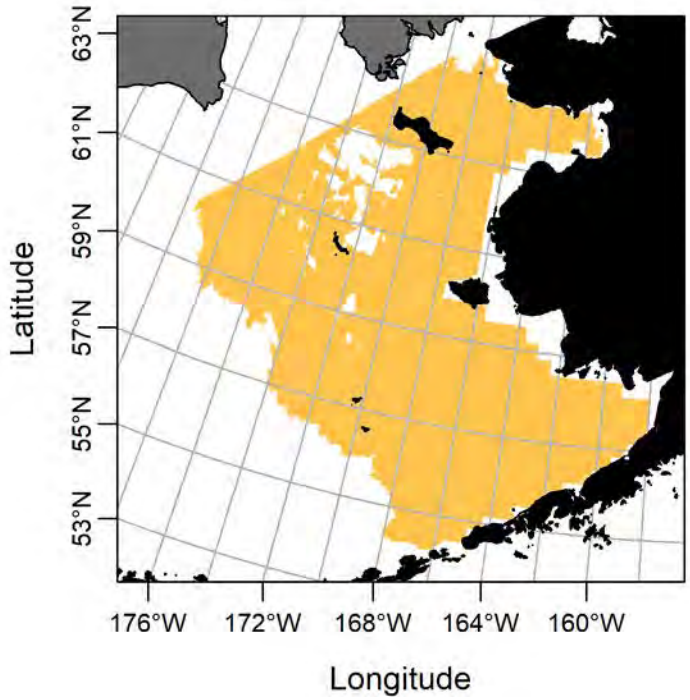

Figure E-165 EFH distribution of EBS Rougheye rockfish adult, winter.

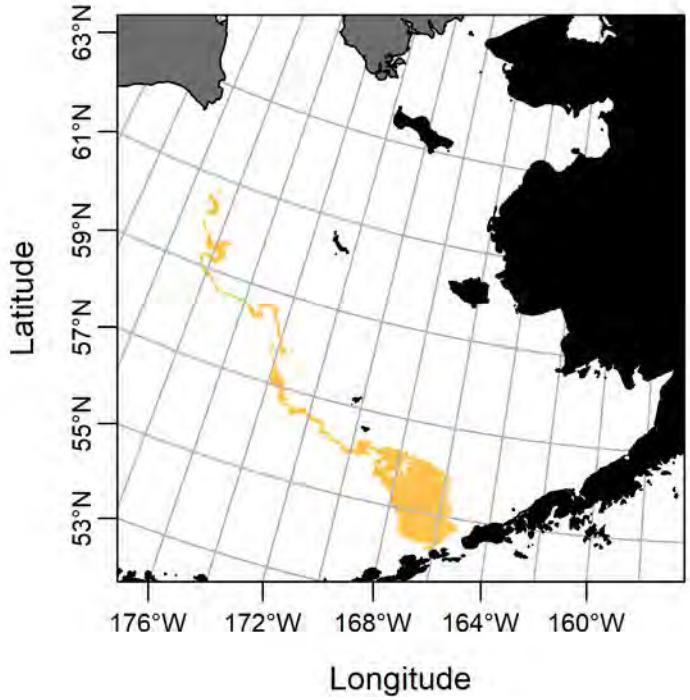

Figure E-166 EFH distribution of EBS Rougheye rockfish juvenile, summer.

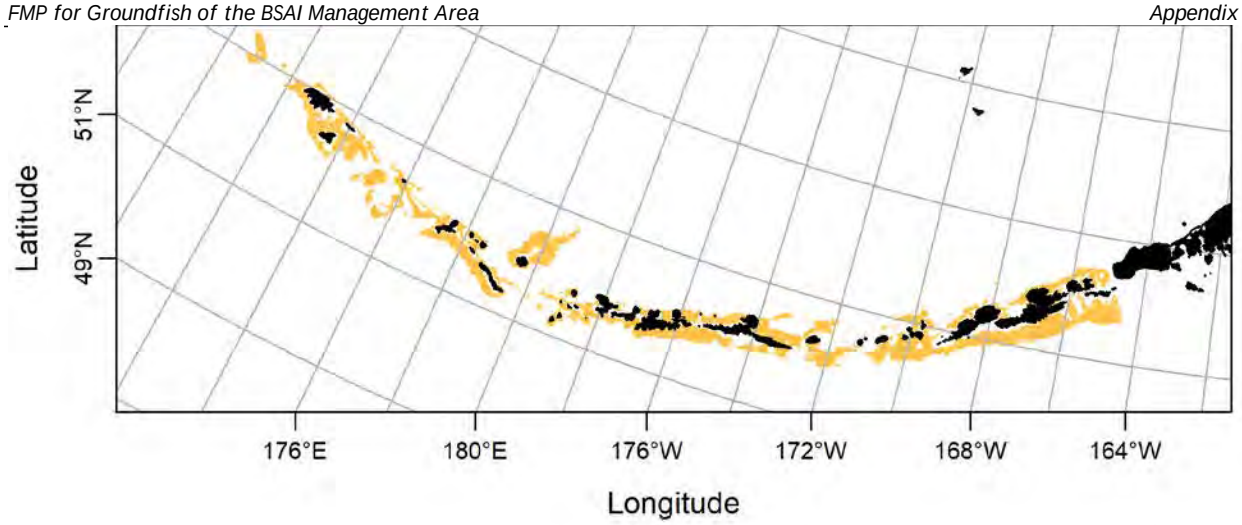

Figure E-167 EFH distribution of AI Rougheye rockfish adult, fall.

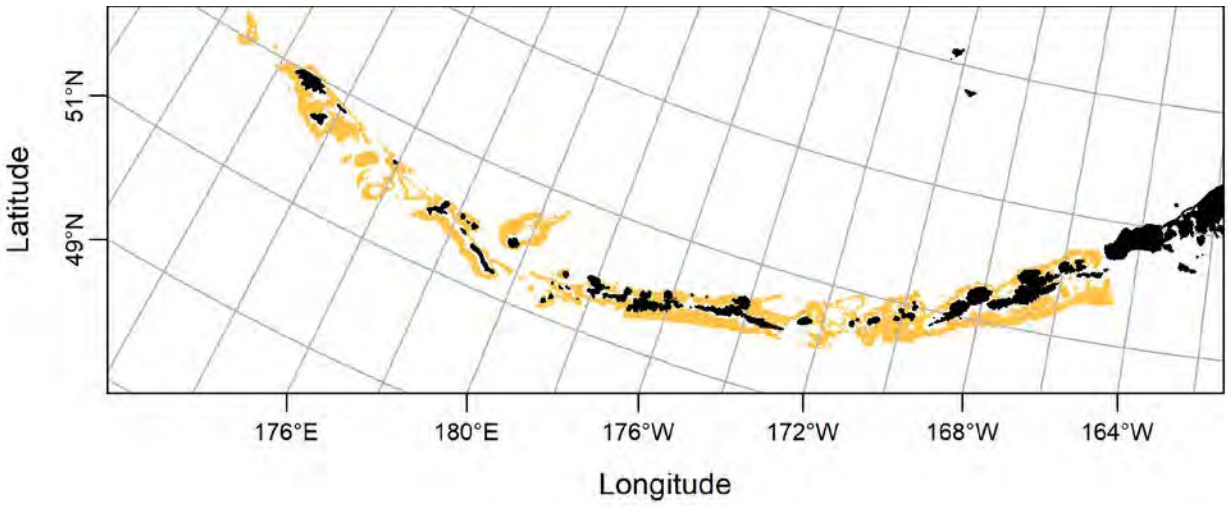

Figure E-168 EFH distribution of AI Rougheye rockfish adult, spring.

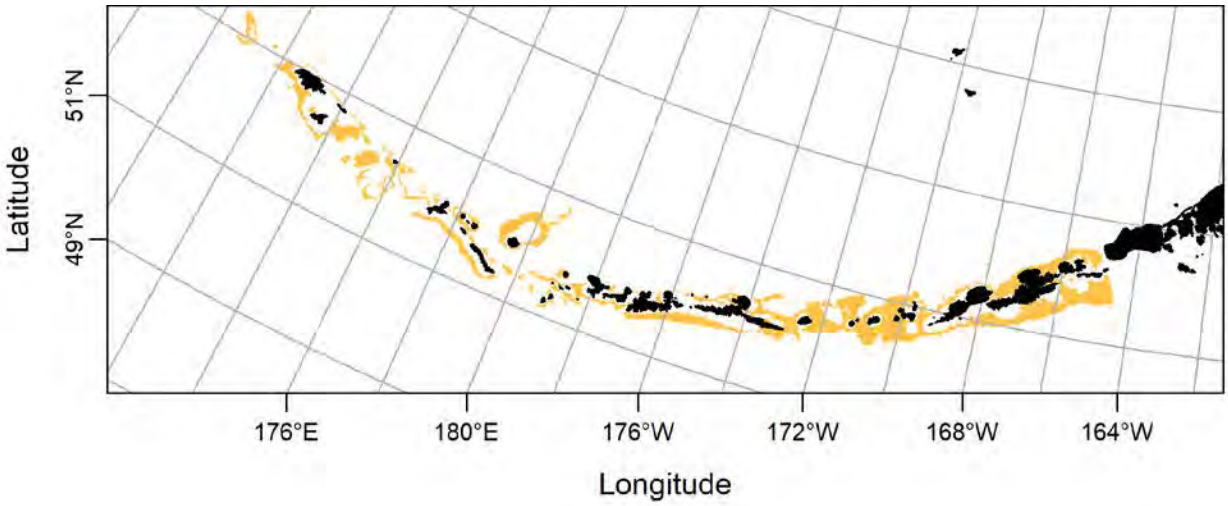

Figure E-169 EFH distribution of AI Rougheye rockfish adult, summer.

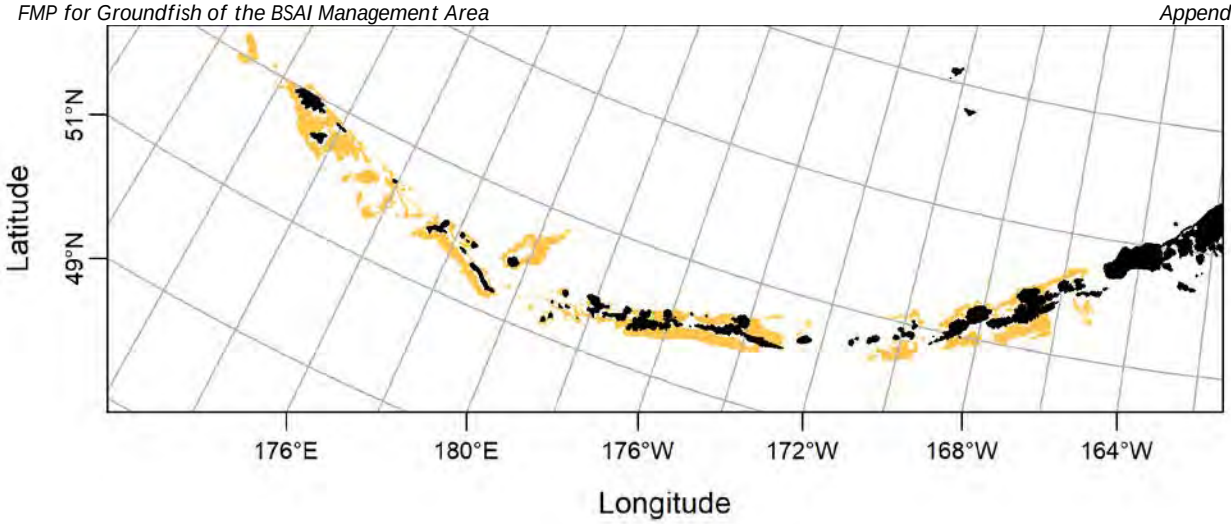

Figure E-170 EFH distribution of Rougheye rockfish adult, winter.

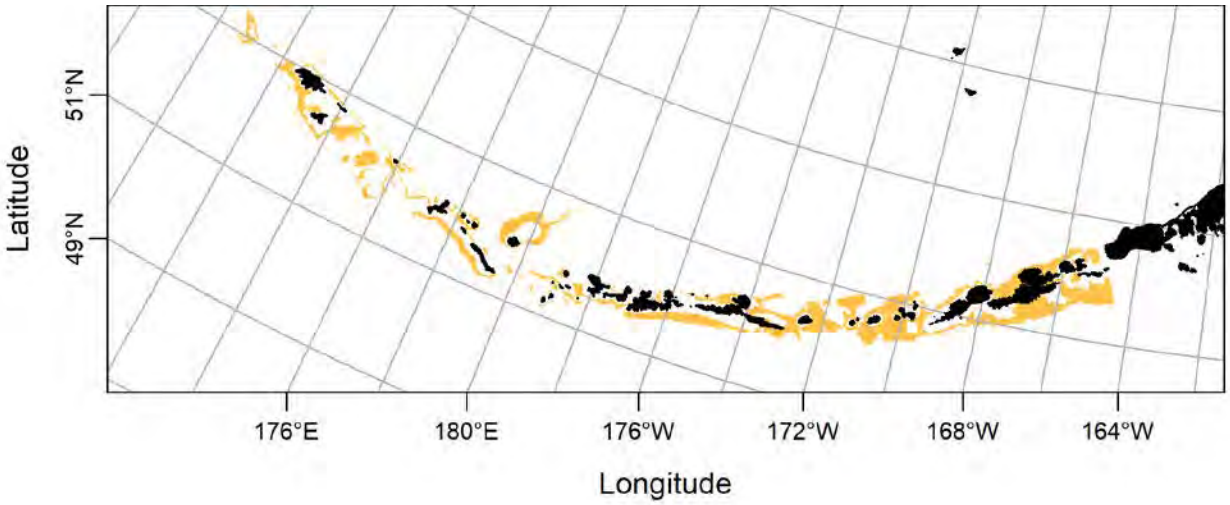

Figure E-171 EFH distribution of AI Rougheye rockfish juvenile, summer.

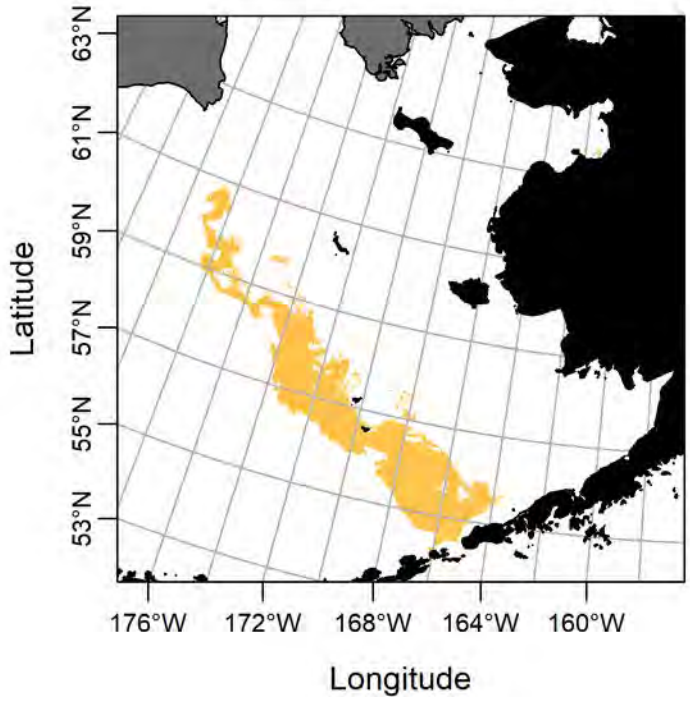

Figure E-172 EFH distribution of EBS Dusky rockfish adult, fall.

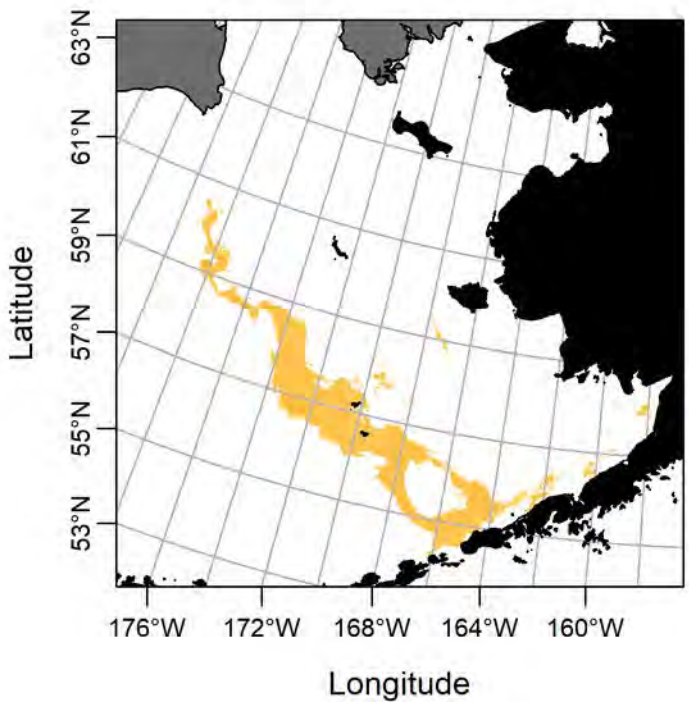

Figure E-173 EFH distribution of EBS Dusky rockfish adult, spring.

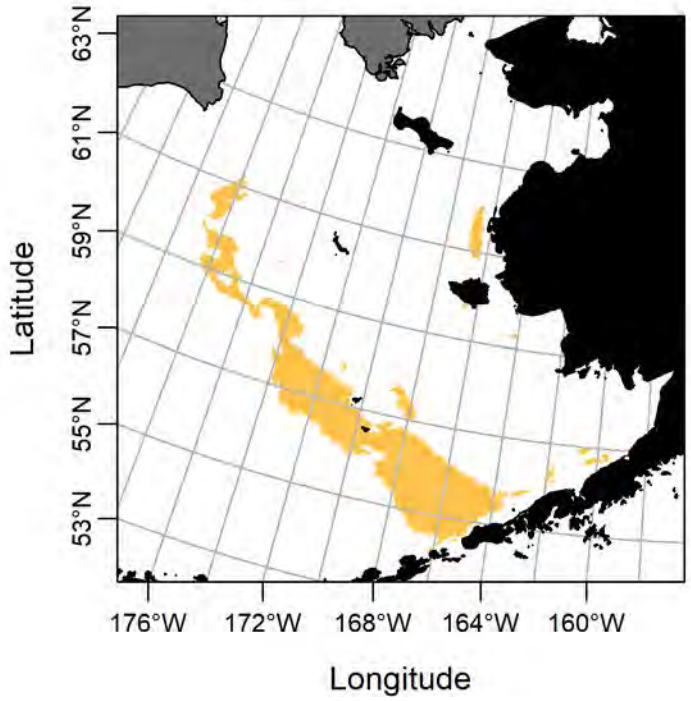

Figure E-174 EFH distribution of EBS Dusky rockfish adult, summer.

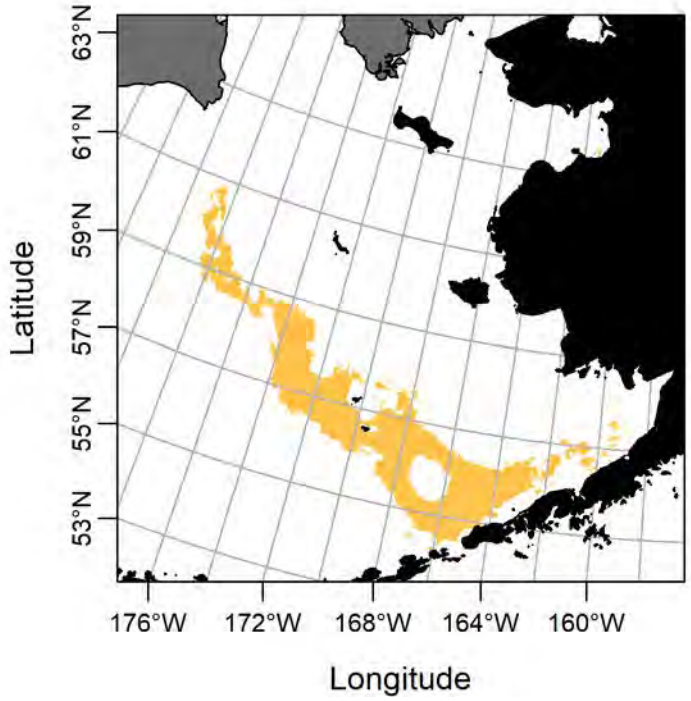

Figure E-175 EFH distribution of EBS Dusky rockfish adult, winter.

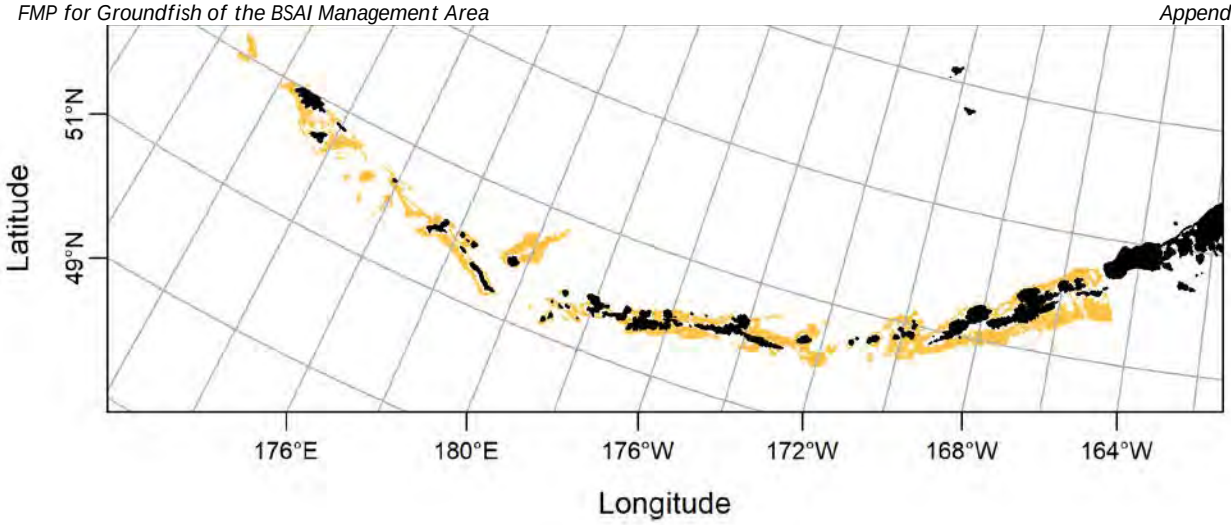

Figure E-176 EFH distribution of AI Dusky rockfish adult, fall.

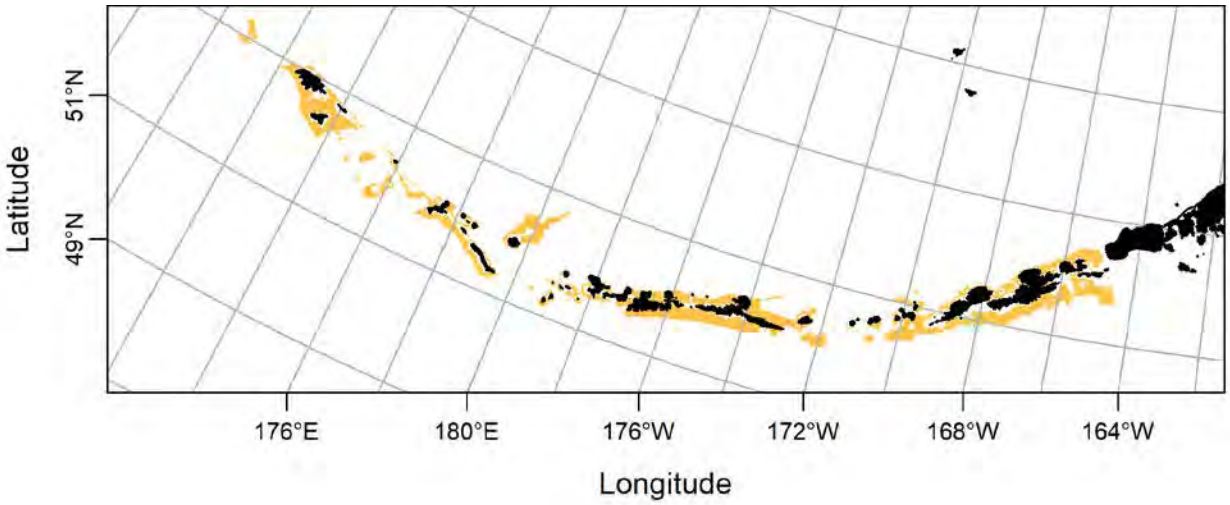

Figure E-177 EFH distribution of AI Dusky rockfish adult, spring.

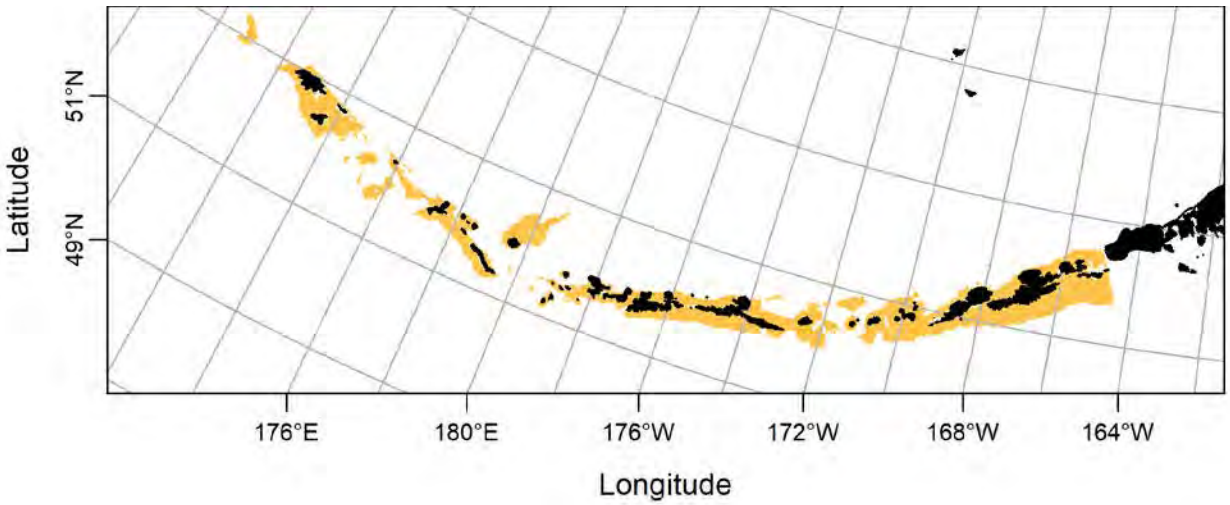

Figure E-178 EFH distribution of AI Dusky rockfish adult, summer.

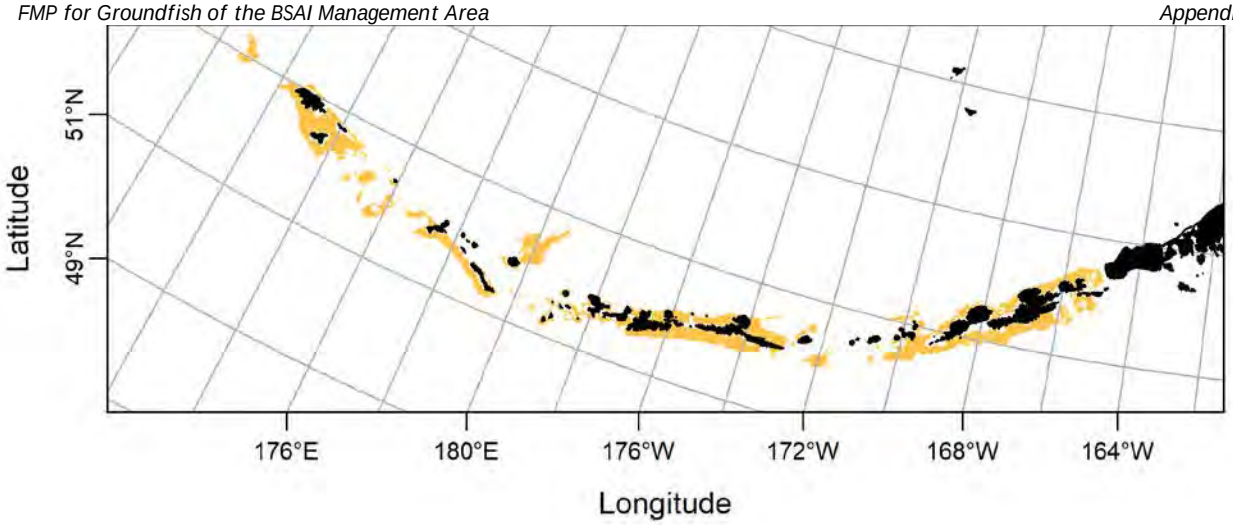

Figure E-179 EFH distribution of AI Dusky rockfish adult, winter.

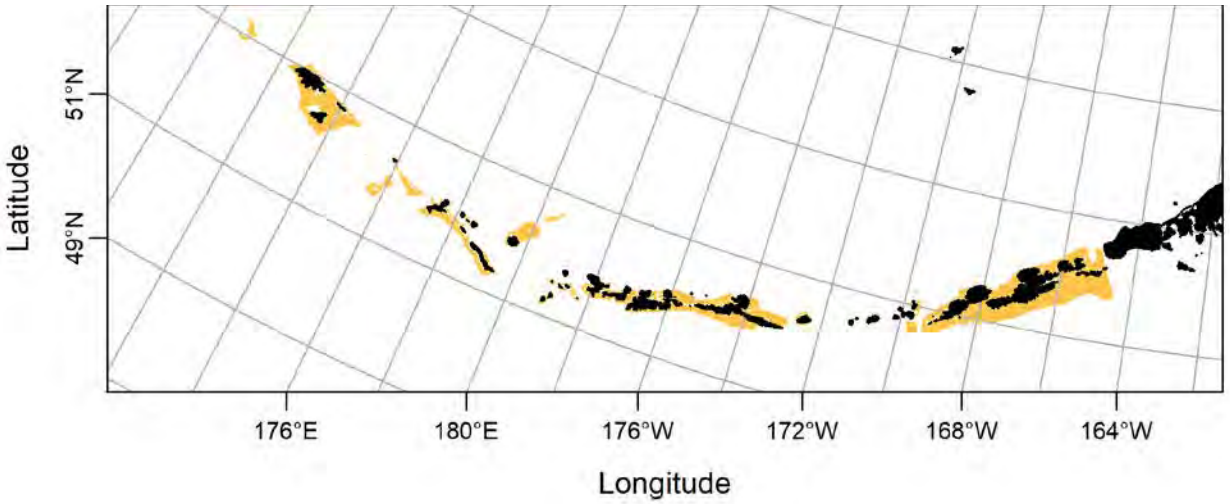

Figure E-180 EFH distribution of AI Dusky rockfish juvenile, summer.

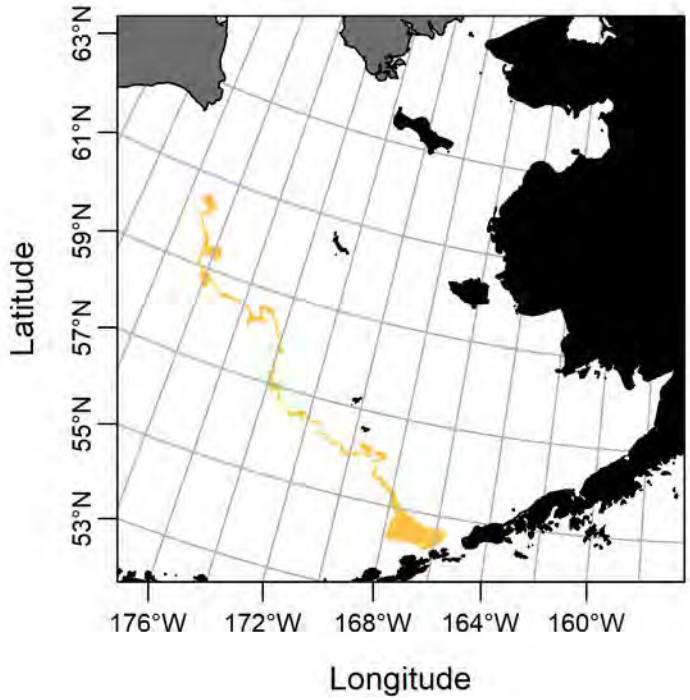

Figure E-181 EFH distribution of EBS Shortspine thornyhead rockfish juvenile, summer.

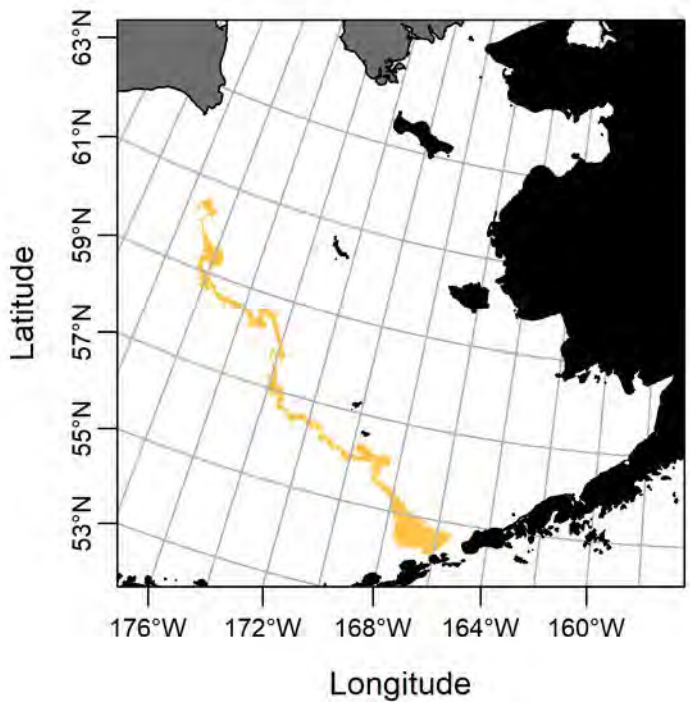

Figure E-182 EFH distribution of EBS Shortspine thornyhead rockfish adult, fall.

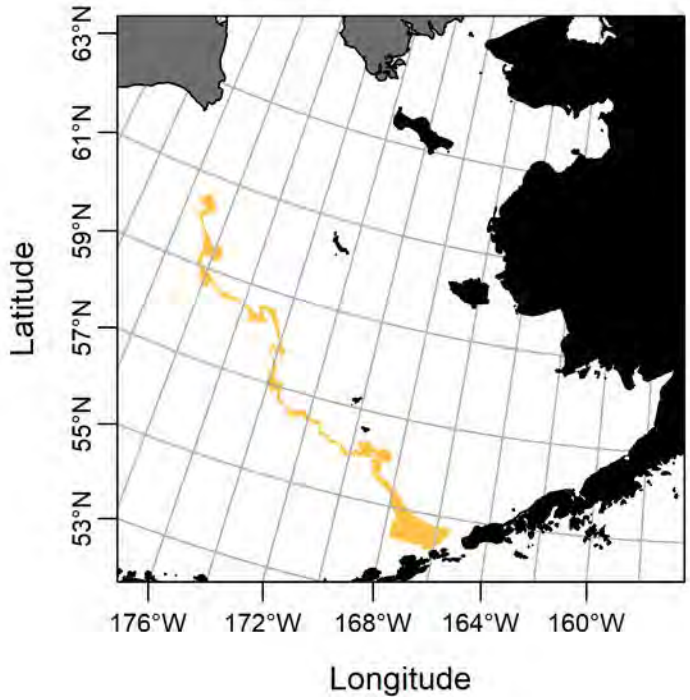

Figure E-183 EFH distribution of EBS Shortspine thornyhead rockfish adult, spring.

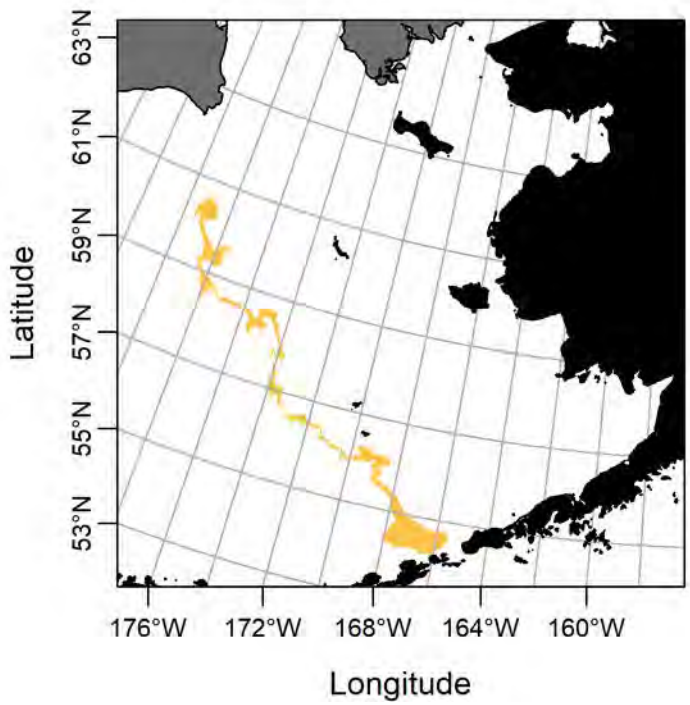

Figure E-184 EFH distribution of EBS Shortspine thornyhead rockfish adult, summer.

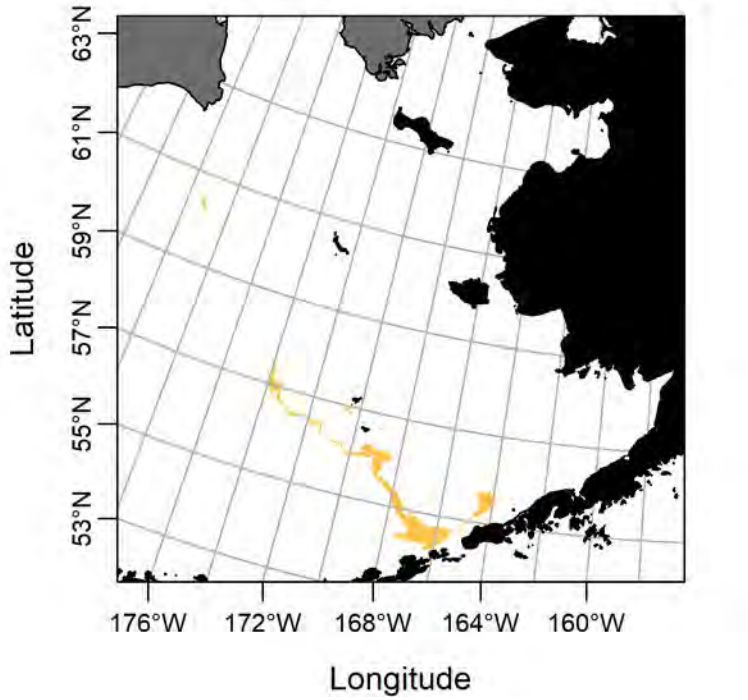

Figure E-185 EFH distribution of EBS Shortspine thornyhead rockfish adult, winter.

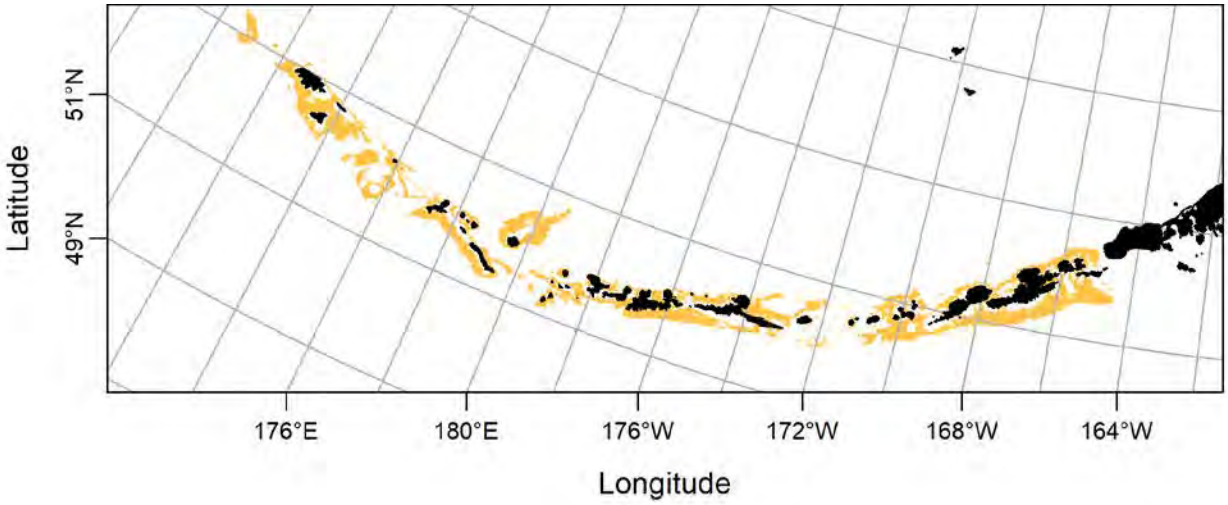

Figure E-186 EFH distribution of AI Shortspine thornyhead rockfish adult, fall.

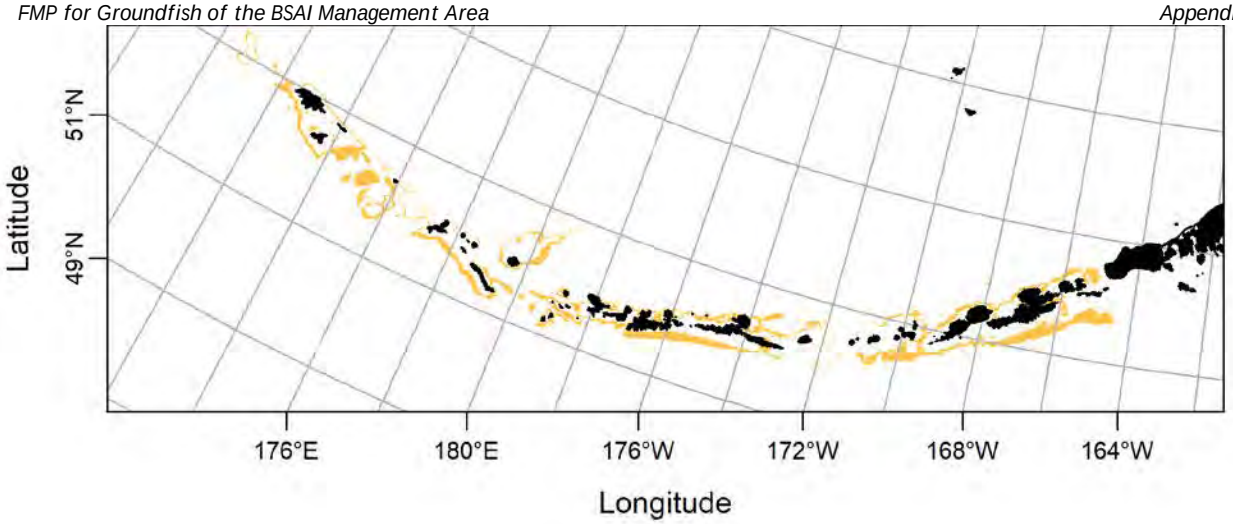

Figure E-187 EFH distribution of AI Shortspine thornyhead rockfish adult, spring.

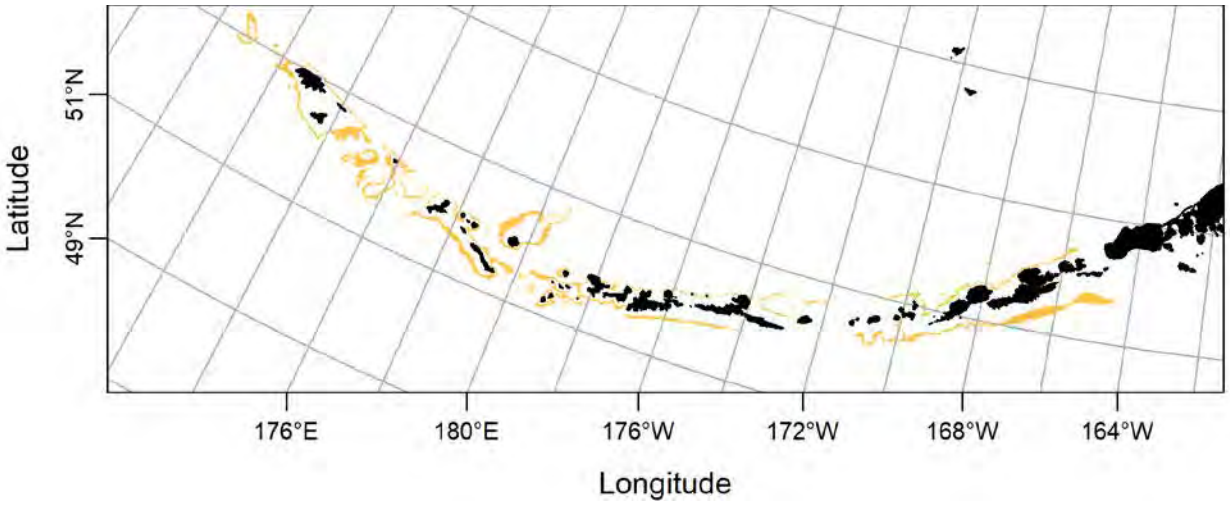

Figure E-188 EFH distribution of AI Shortspine thornyhead rockfish adult, summer.

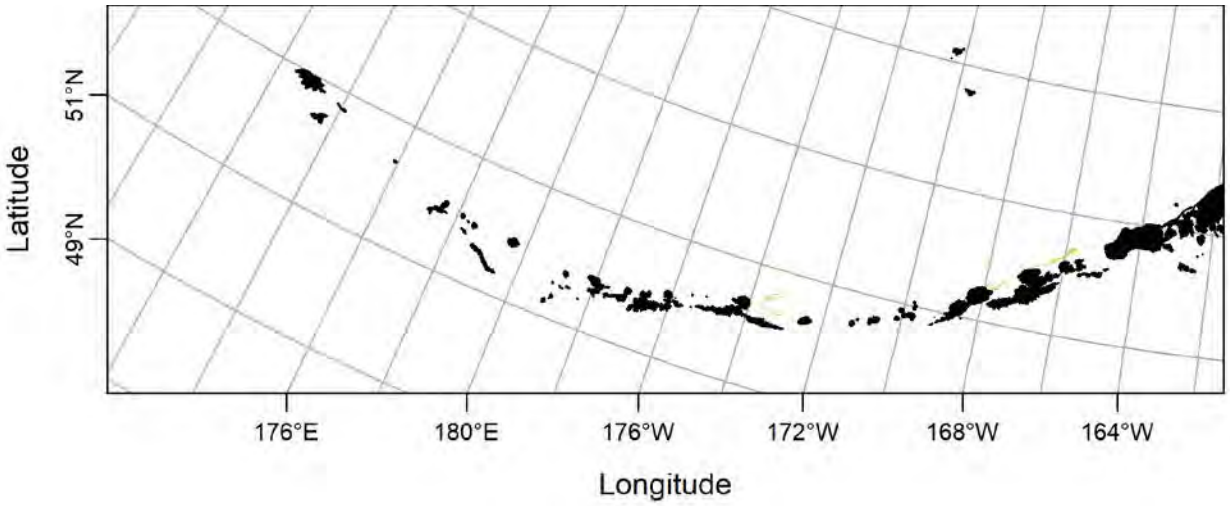

Figure E-189 EFH distribution of AI Shortspine thornyhead rockfish adult, winter.

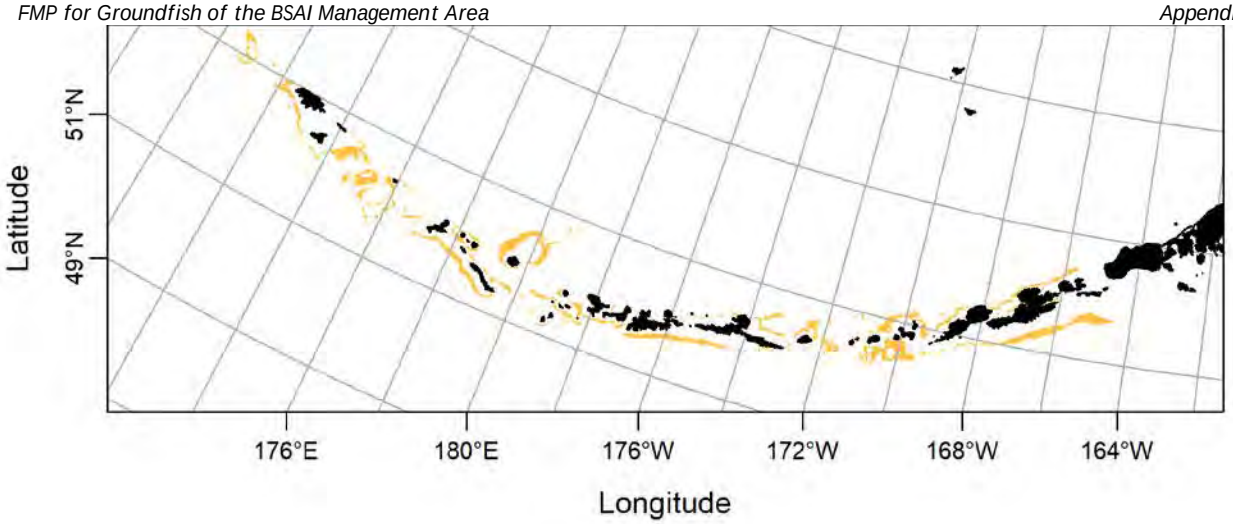

Figure E-190 EFH distribution of AI Shortspine thornyhead rockfish juvenile, summer.

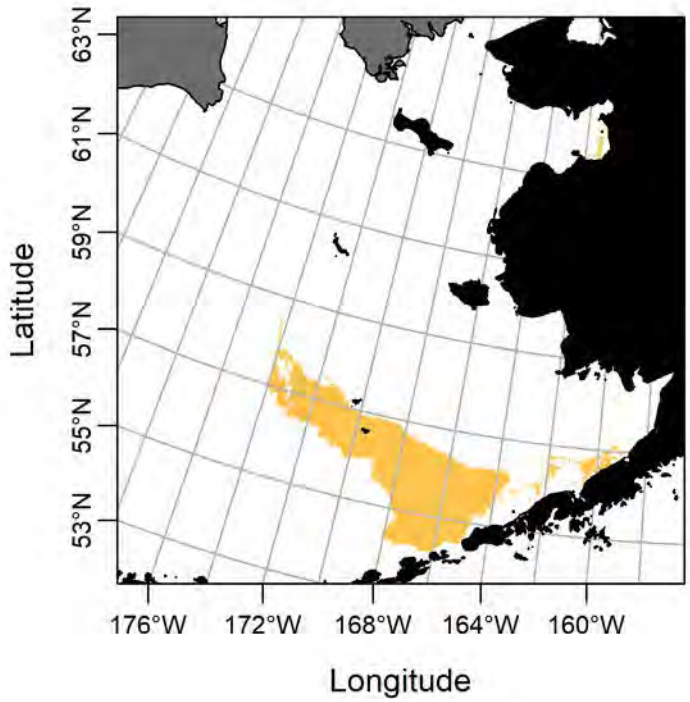

Figure E-191 EFH distribution of EBS Atka mackerel larvae, summer.

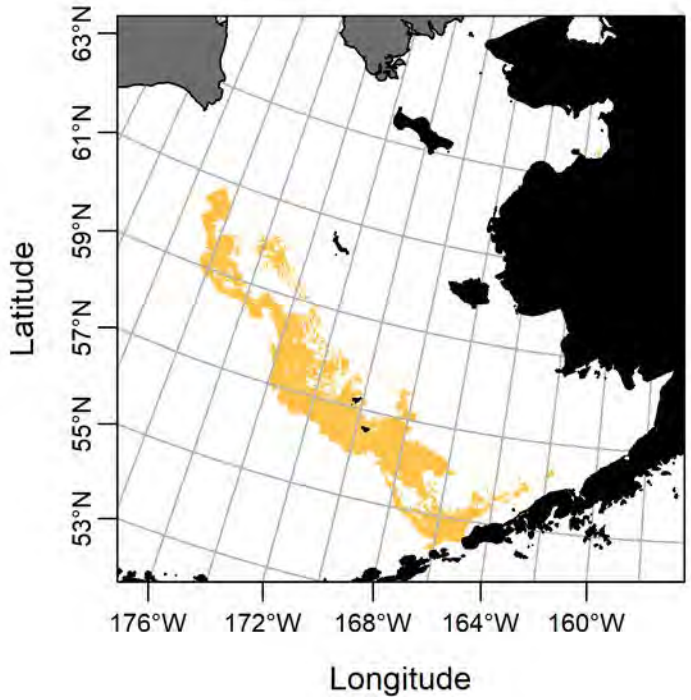

Figure E-192 EFH distribution of EBS Atka mackerel adult, fall.

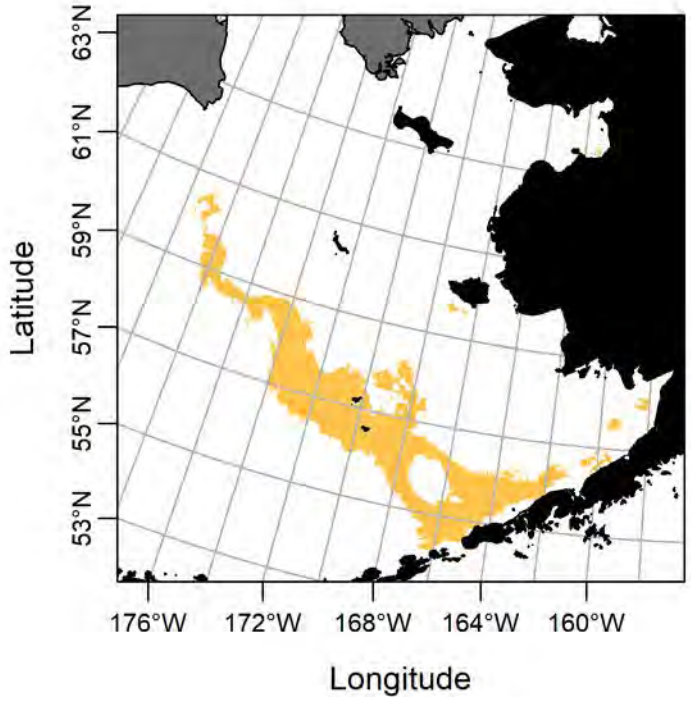

Figure E-193 EFH distribution of EBS Atka mackerel adult, spring.

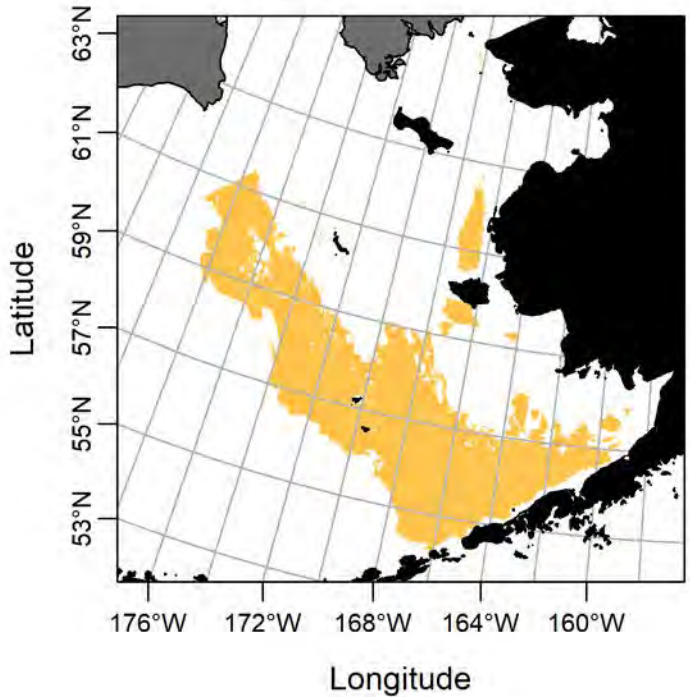

Figure E-194 EFH distribution of EBS Atka mackerel adult, summer.

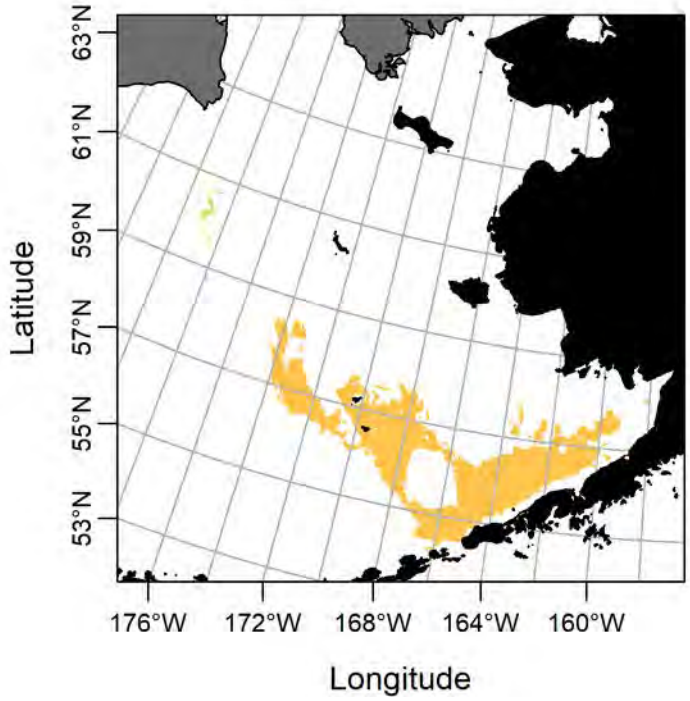

Figure E-195 EFH distribution of EBS Atka mackerel adult, winter.

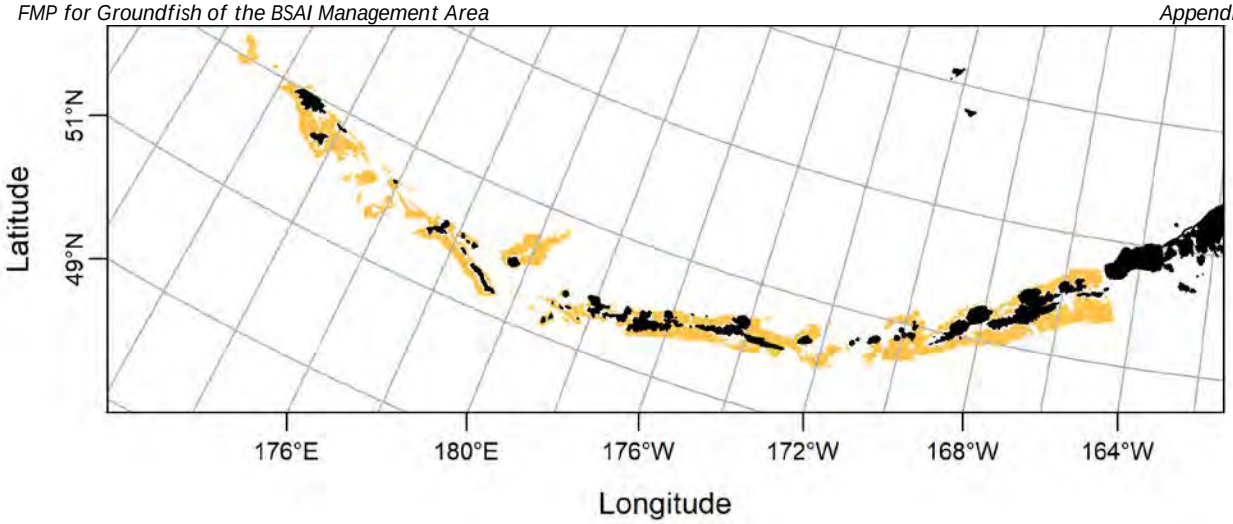

Figure E-196 EFH distribution of AI Atka mackerel adult, fall.

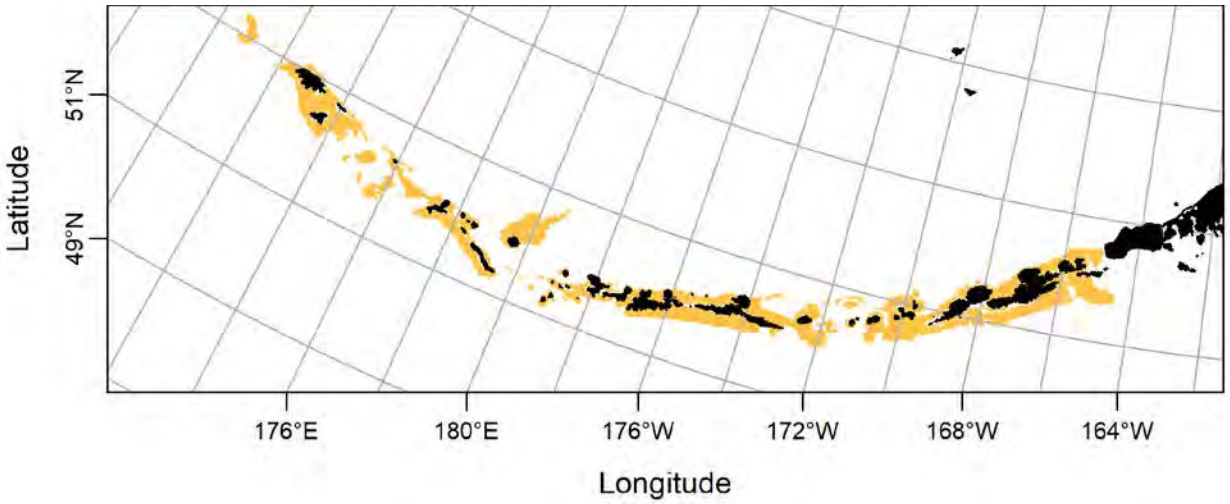

Figure E-197 EFH distribution of AI Atka mackerel adult, spring.

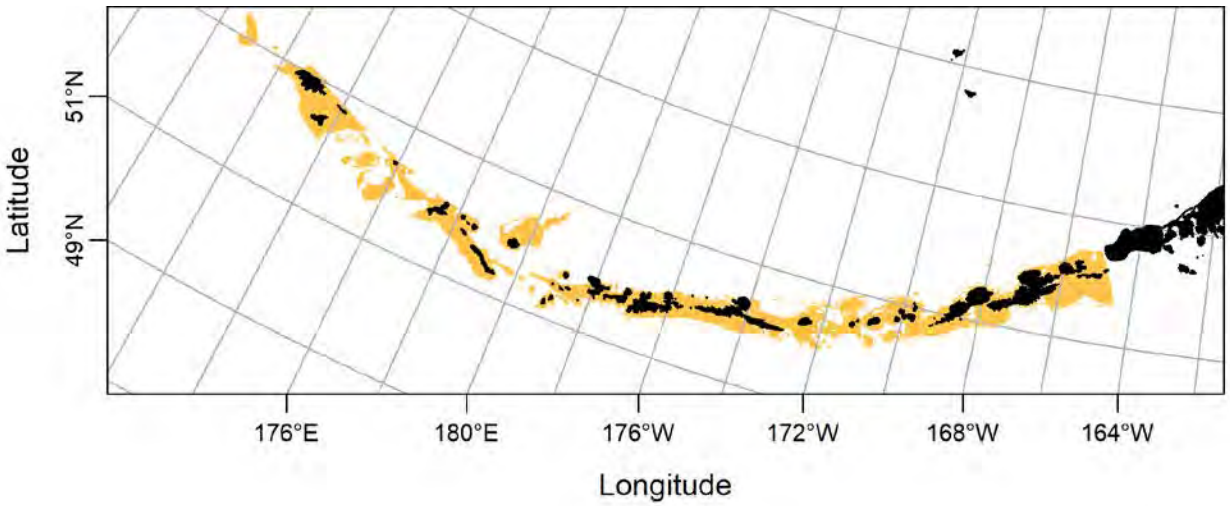

Figure E-198 EFH distribution of AI Atka mackerel adult, summer.

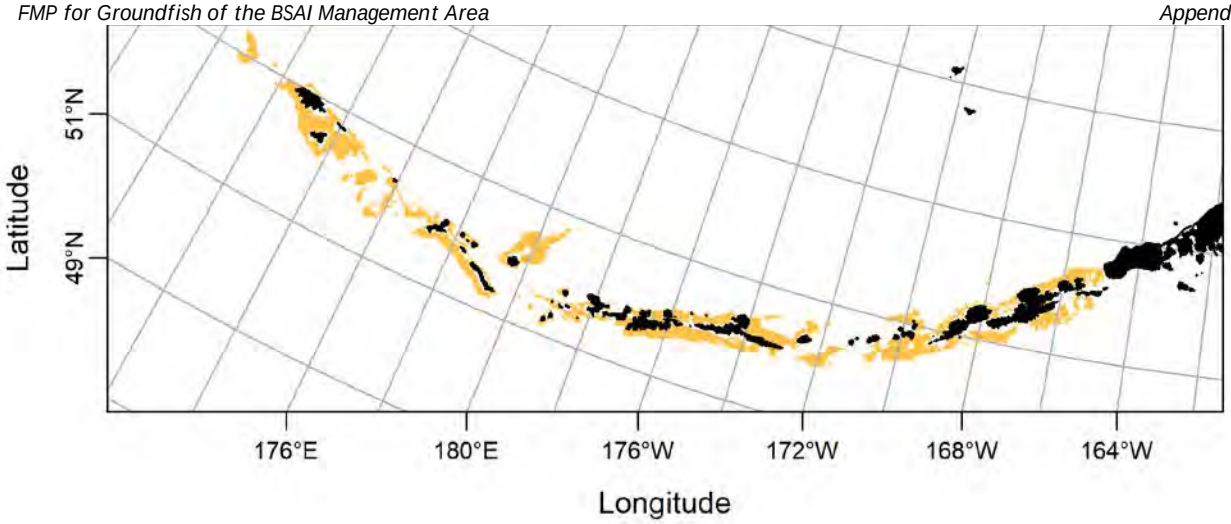

Figure E-199 EFH distribution of AI Atka mackerel adult, winter.

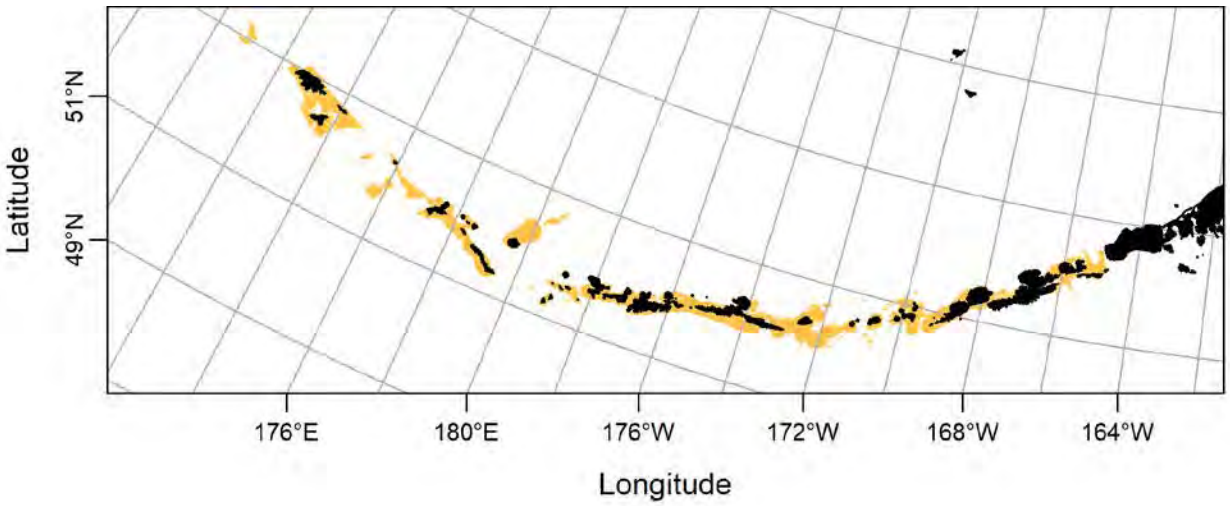

Figure E-200 EFH distribution of AI Atka mackerel egg, summer.

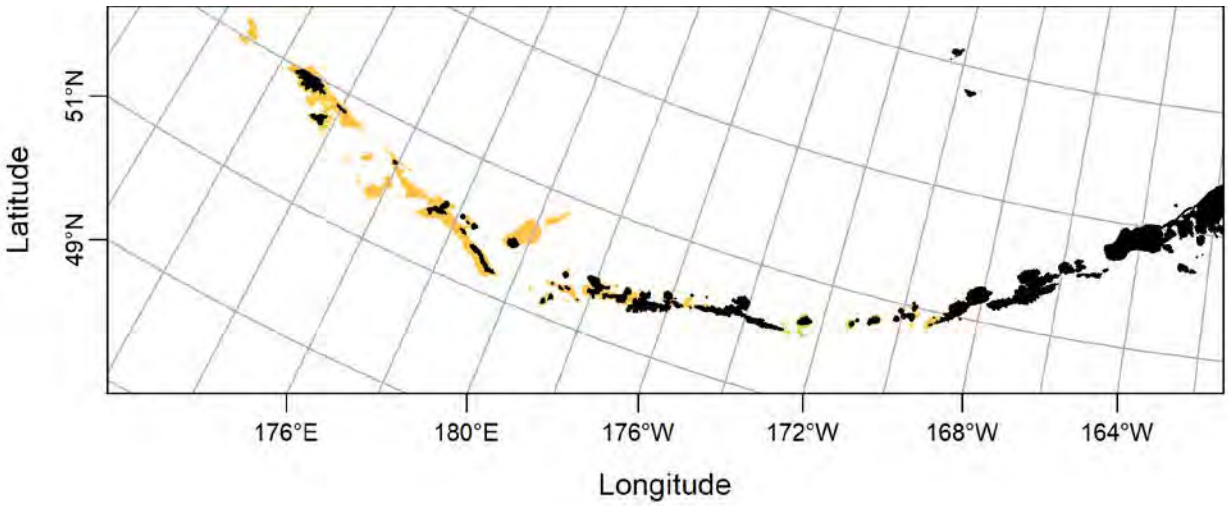

Figure E-201 EFH distribution of AI Atka mackerel juvenile, summer.

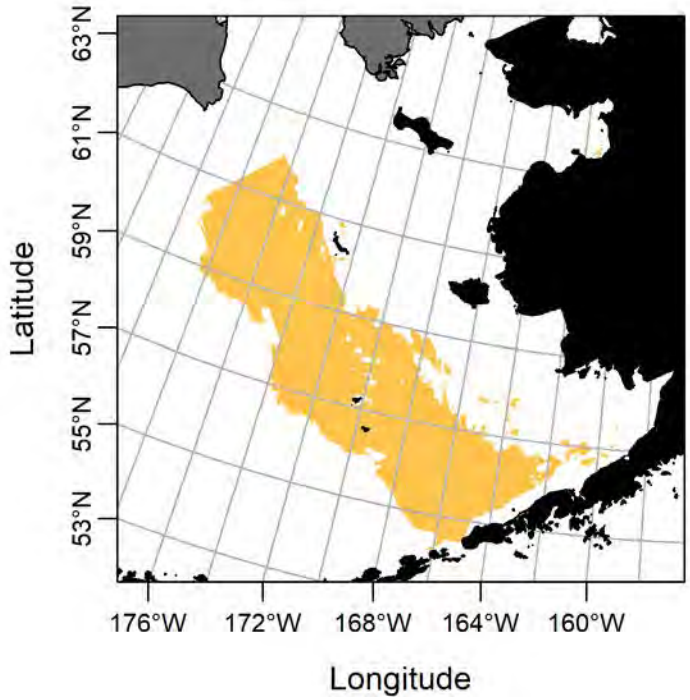

Figure E-202 EFH distribution of EBS Bigmouth sculpin adult, fall.

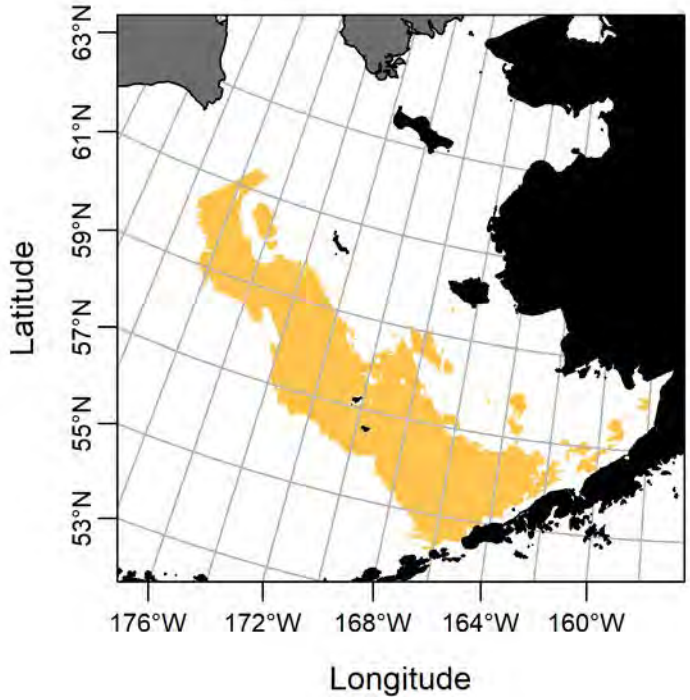

Figure E-203 EFH distribution of EBS Bigmouth sculpin adult, spring.

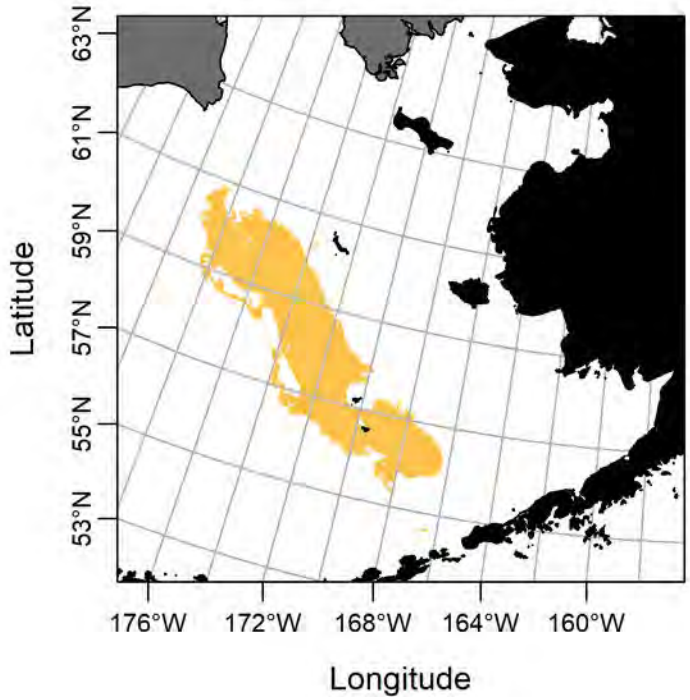

Figure E-204 EFH distribution of EBS Bigmouth sculpin adult, summer.

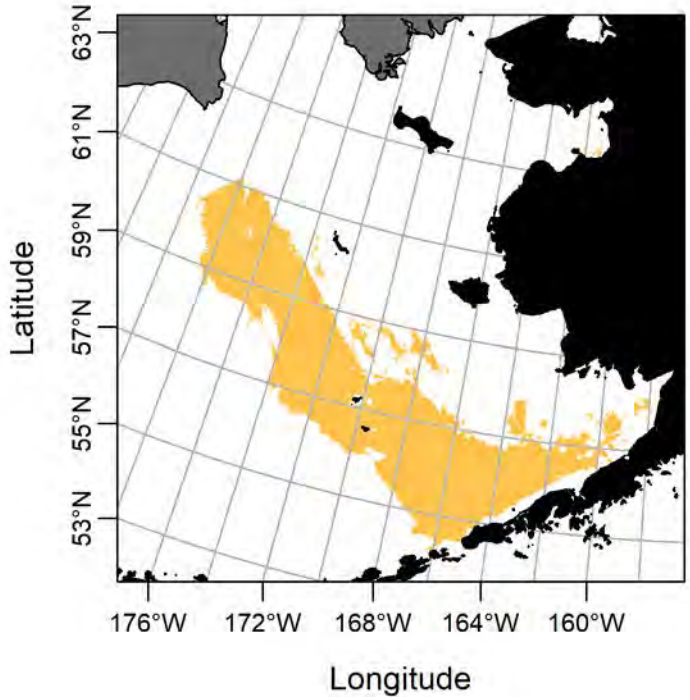

Figure E-205 EFH distribution of EBS Bigmouth sculpin adult, winter.

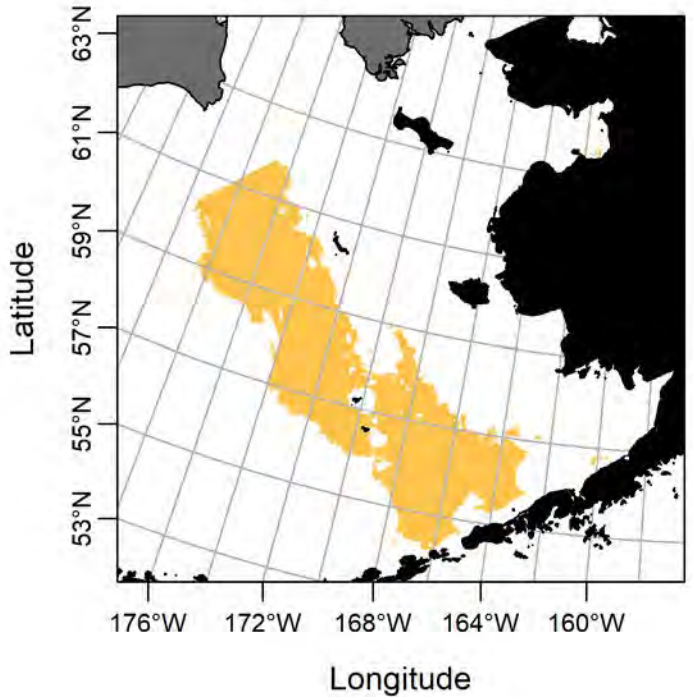

Figure E-206 EFH distribution of EBS Bigmouth sculpin juvenile, summer.

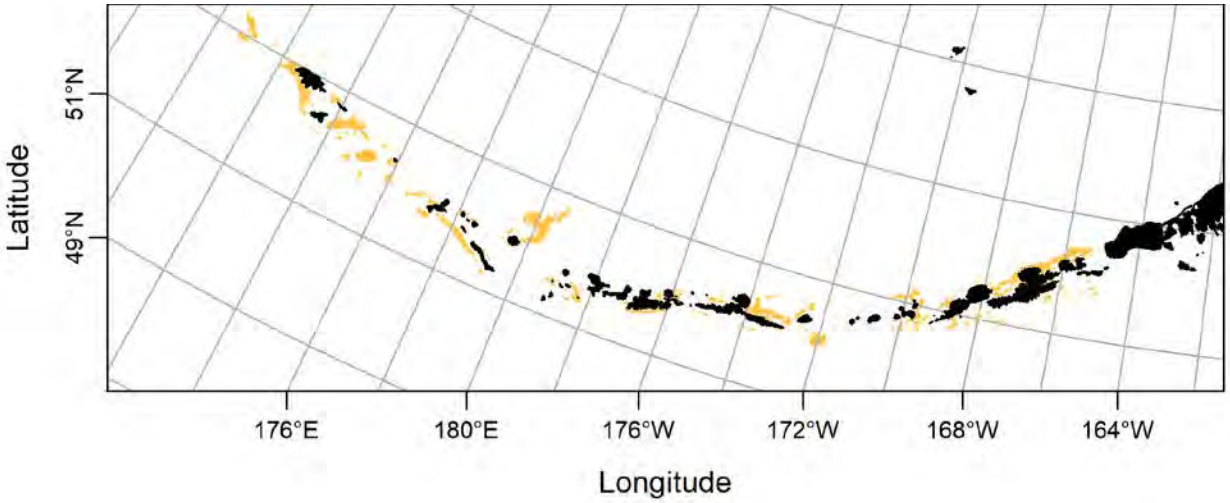

Figure E-207 EFH distribution of AI Bigmouth sculpin adult, fall.

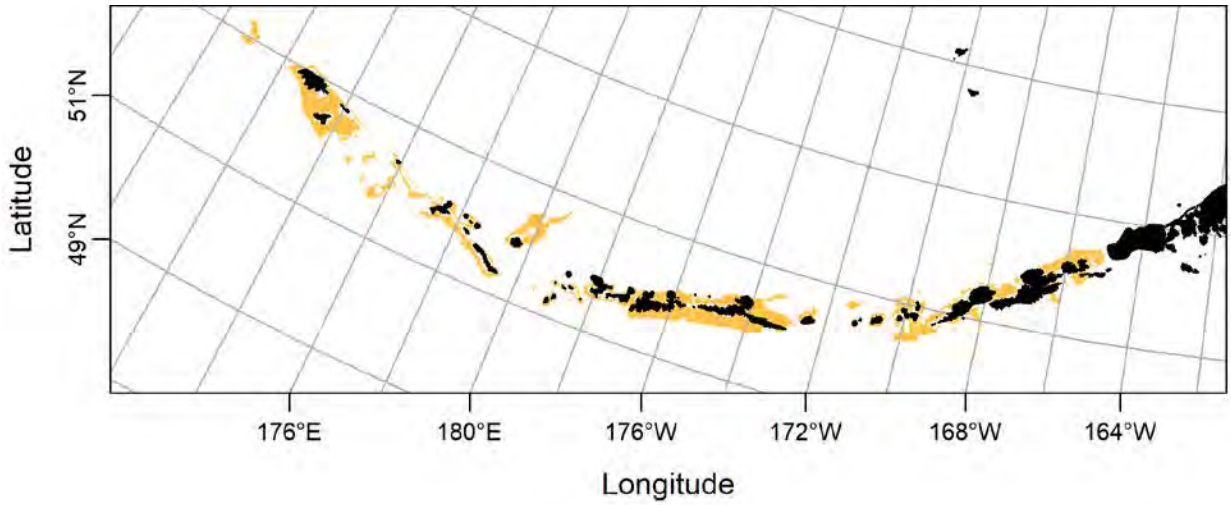

Figure E-208 EFH distribution of AI Bigmouth sculpin adult, spring.

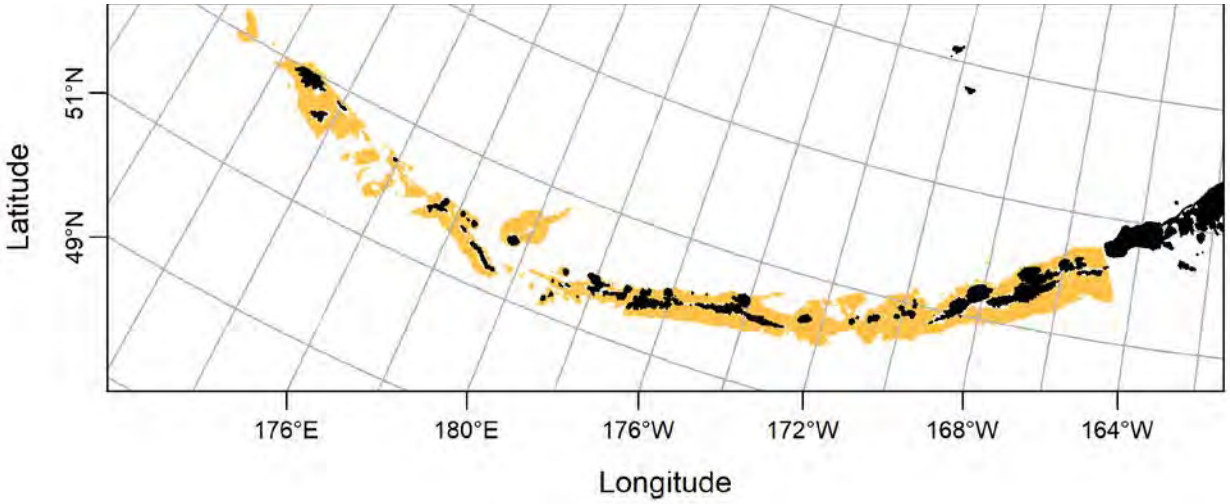

Figure E-209 EFH distribution of AI Bigmouth sculpin adult, summer.

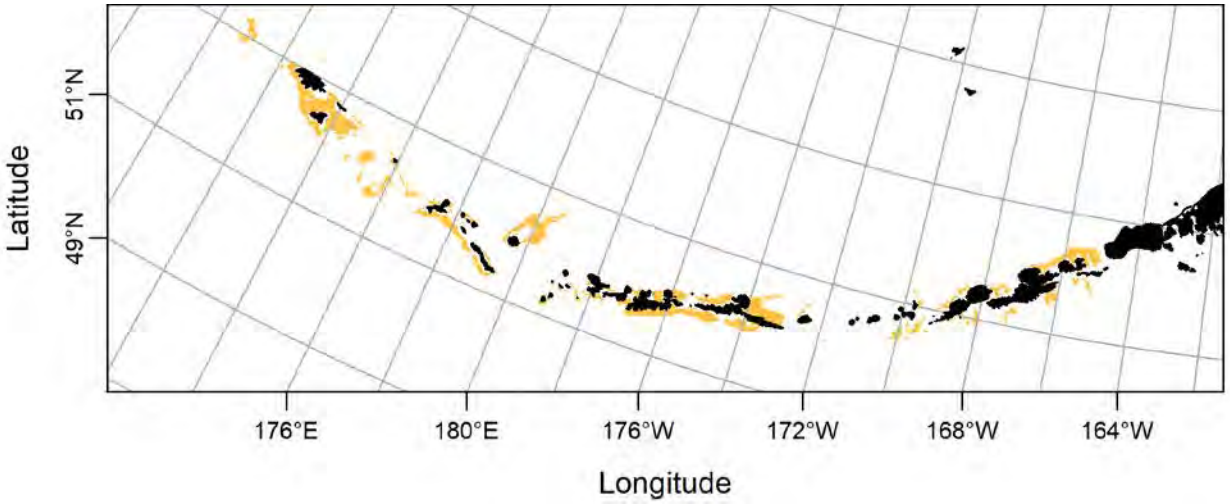

Figure E-210 EFH distribution of AI Bigmouth sculpin adult, winter.

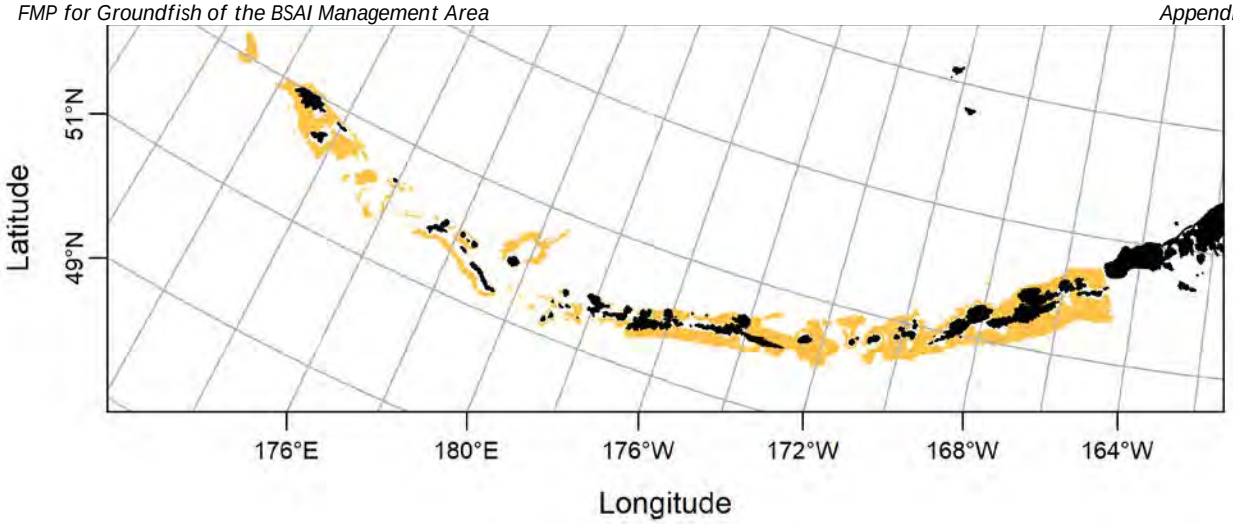

Figure E-211 EFH distribution of AI Bigmouth sculpin juvenile, summer.

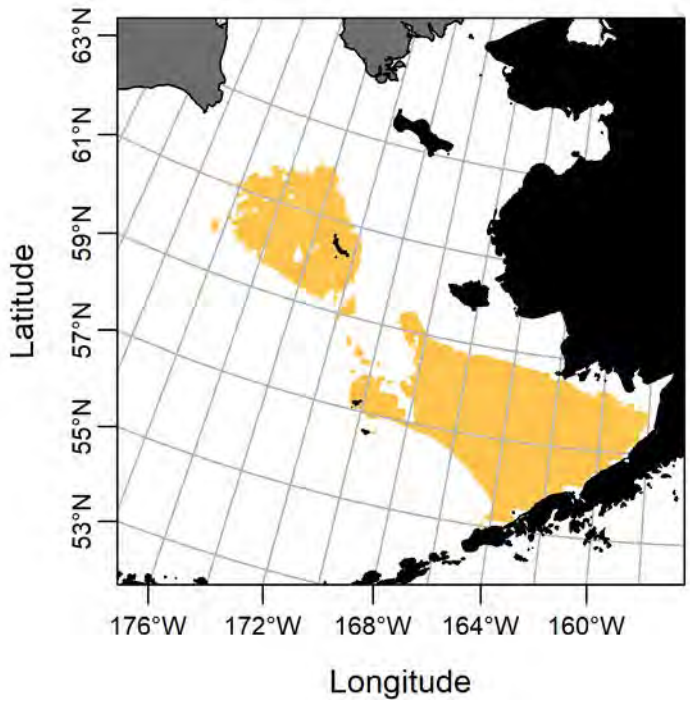

Figure E-212 EFH distribution of EBS Great sculpin juvenile, summer.

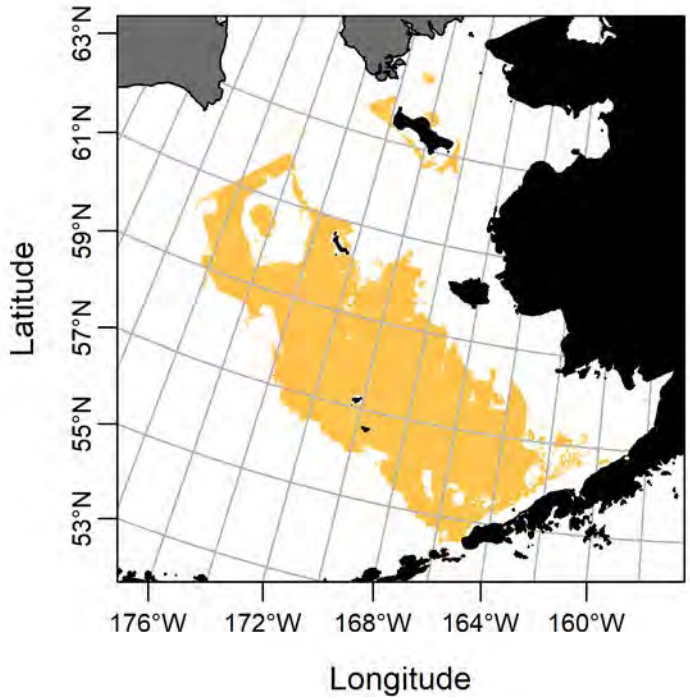

Figure E-213 EFH distribution of EBS Great sculpin adult, fall.

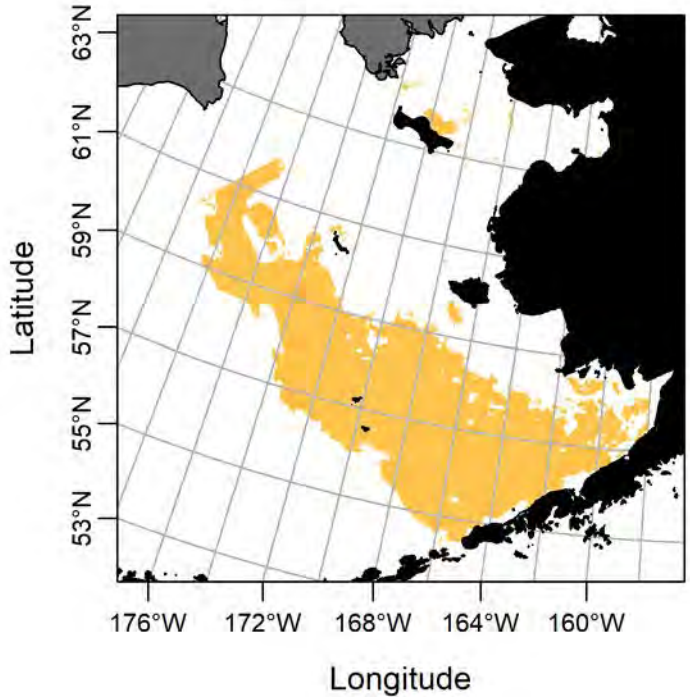

Figure E-214 EFH distribution of EBS Great sculpin adult, spring.

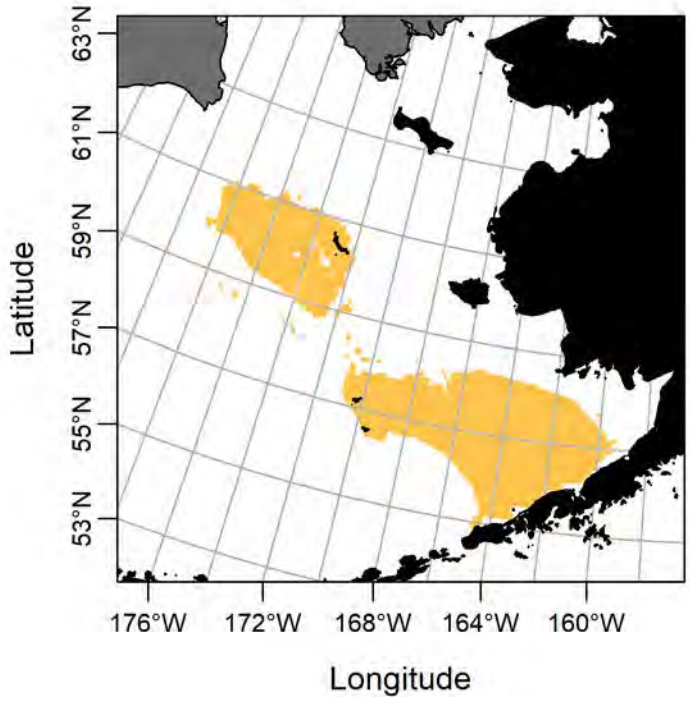

Figure E-215 EFH distribution of EBS Great sculpin adult, summer.

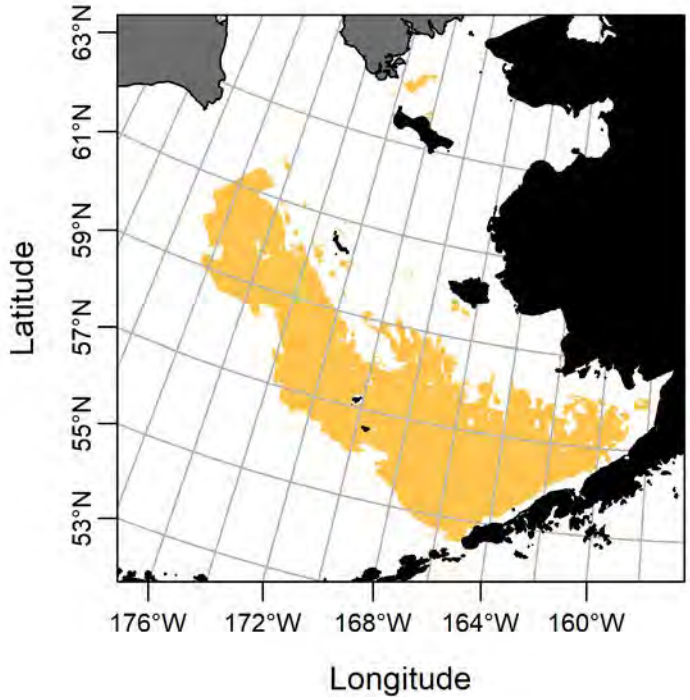

Figure E-216 EFH distribution of EBS Great sculpin adult, winter.

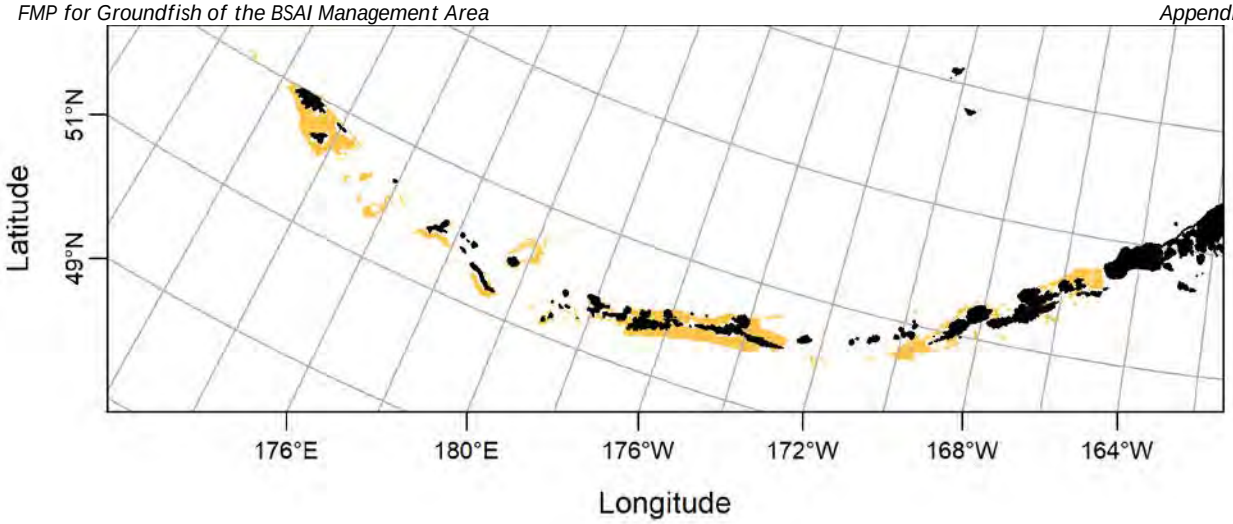

Figure E-217 EFH distribution of AI Great sculpin adult, spring.

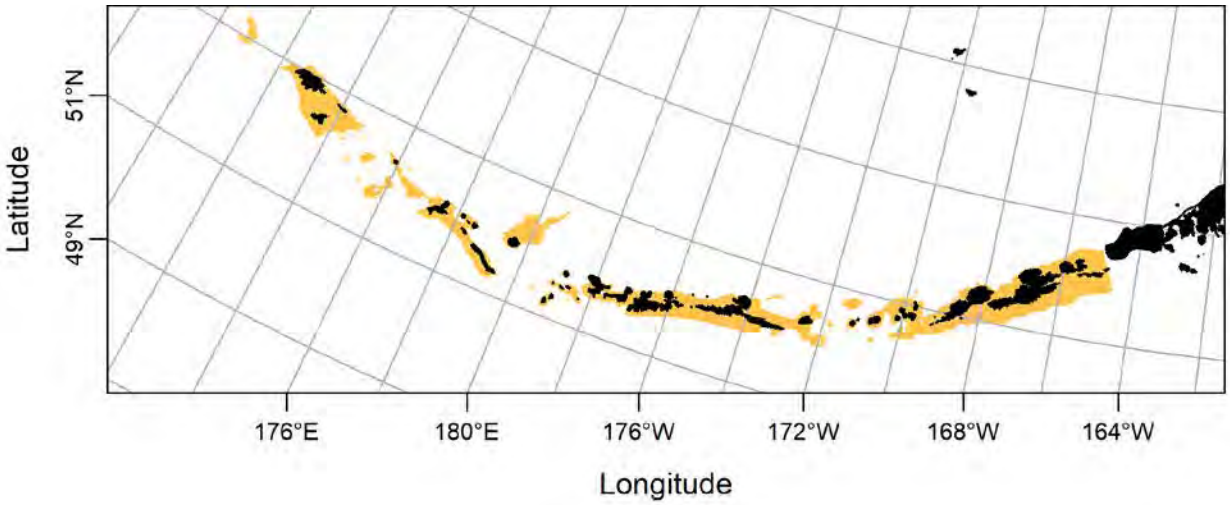

Figure E-218 EFH distribution of AI Great sculpin adult, summer.

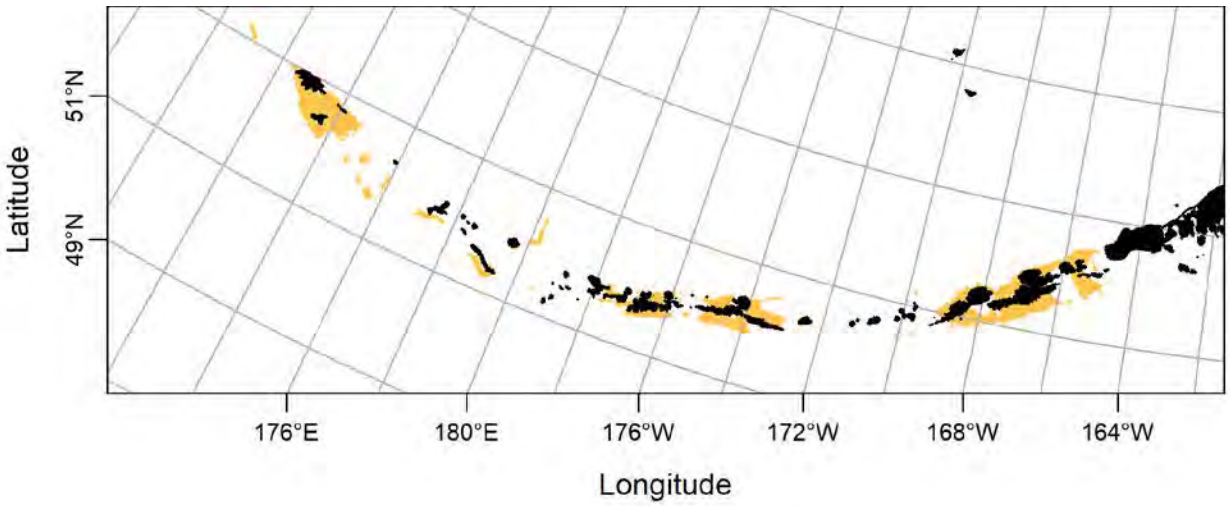

Figure E-219 EFH distribution of AI Great sculpin adult, winter.

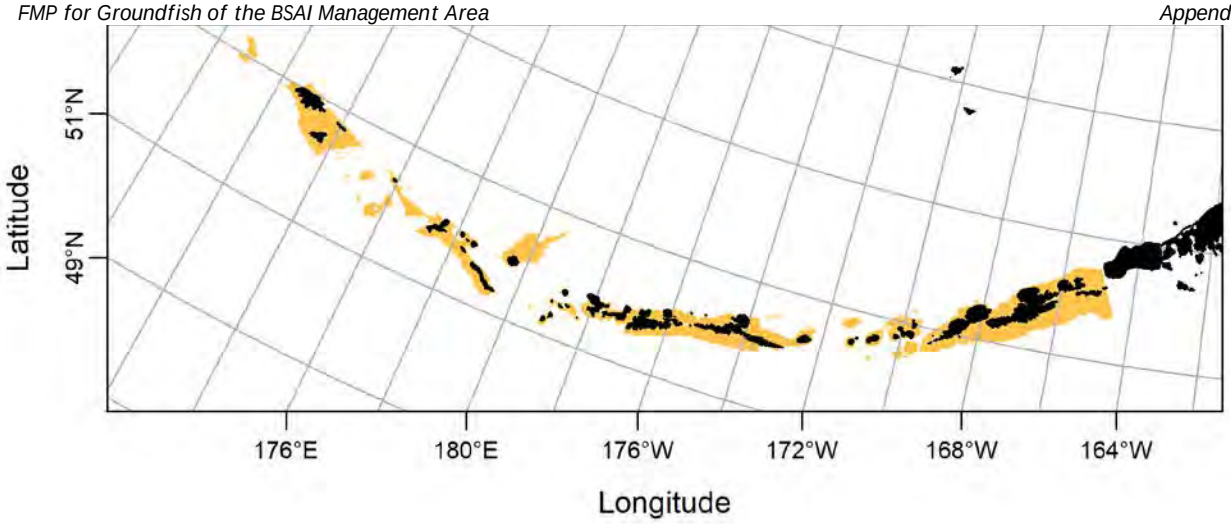

Figure E-220 EFH distribution of AI Great sculpin juvenile, summer.

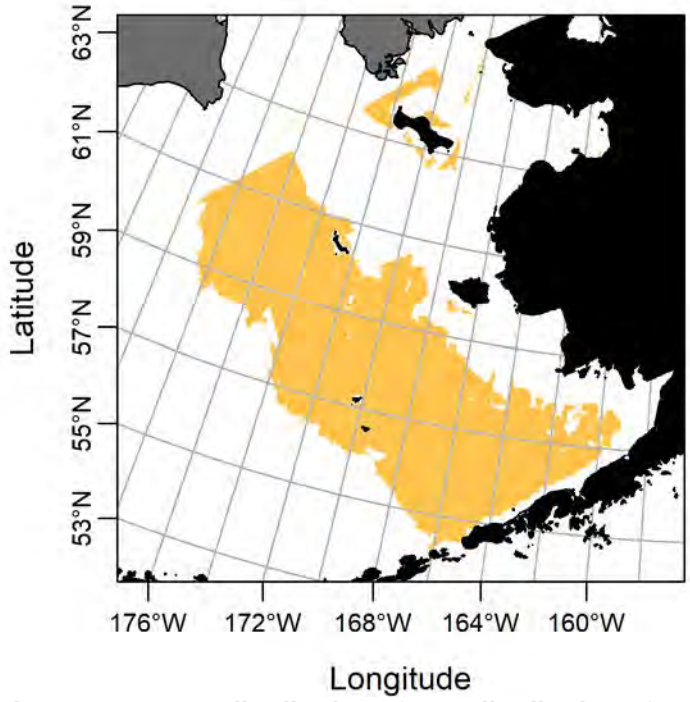

Figure E-221 EFH distribution of EFH distribution of EBS Alaska skate adult, fall.

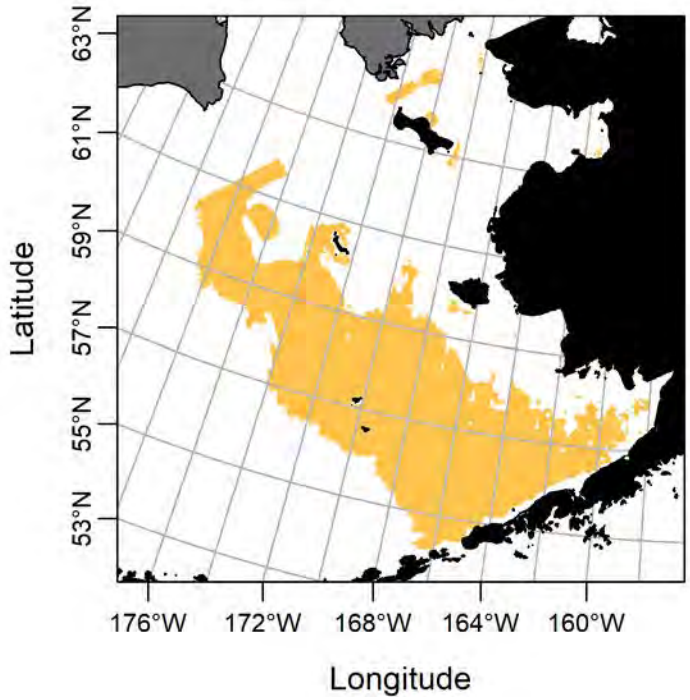

Figure E-222 EFH distribution of EBS Alaska skate adult, spring.

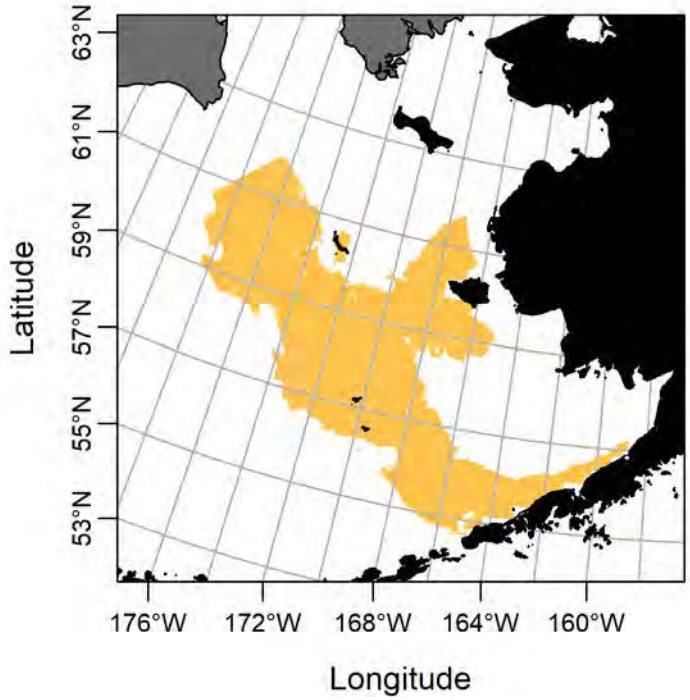

Figure E-223 EFH distribution of EBS Alaska skate adult, summer.

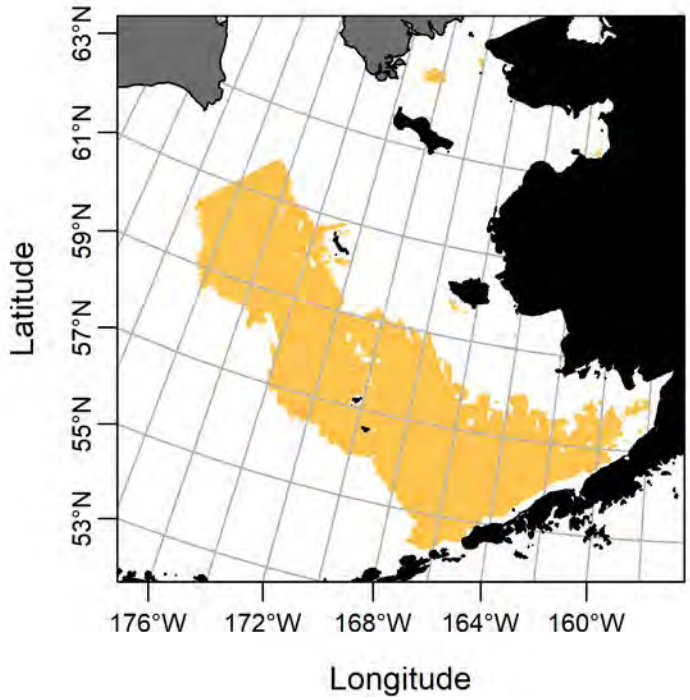

Figure E-224 EFH distribution of EBS Alaska skate adult, winter.

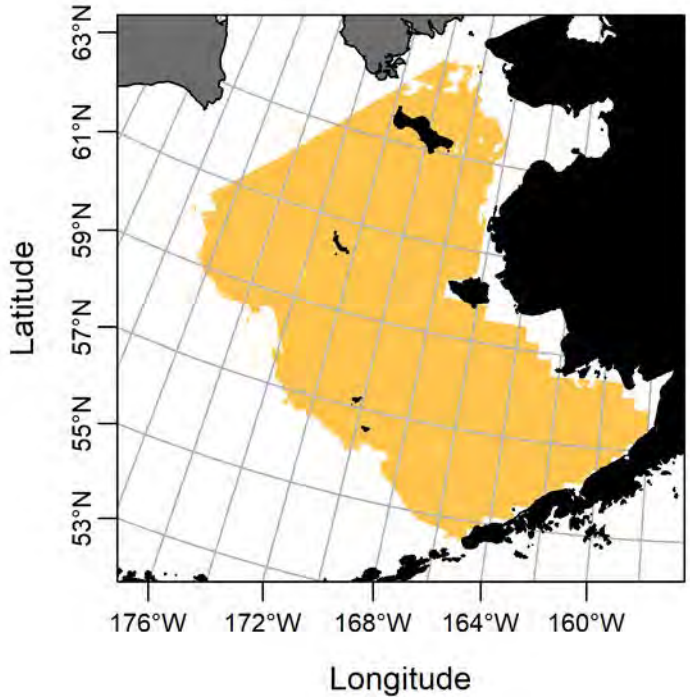

Figure E-225 EFH distribution of EBS Alaska skate juvenile, summer.

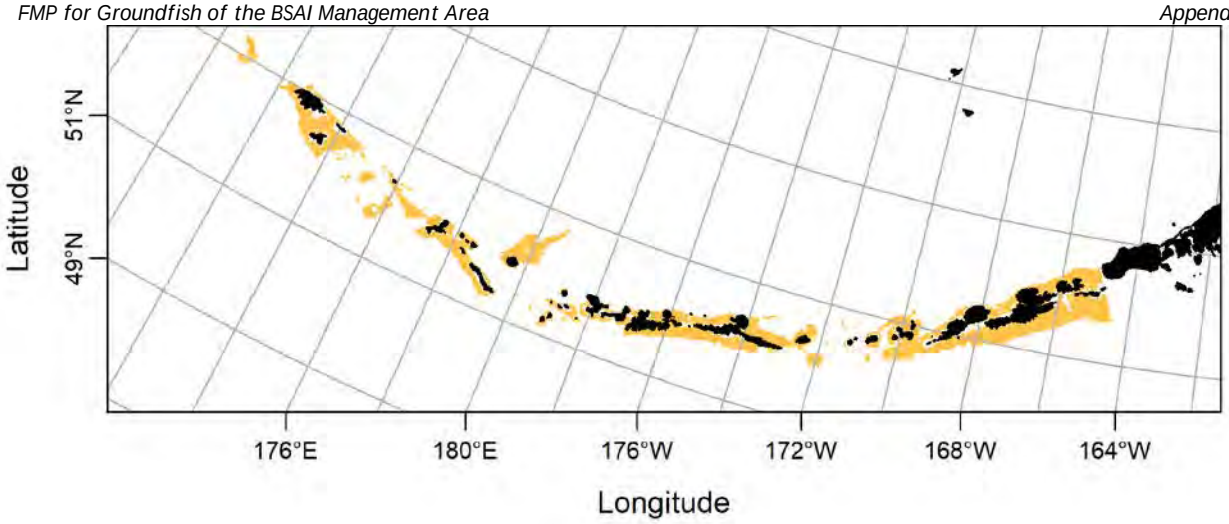

Figure E-226 EFH distribution of AI Alaska skate adult, fall.

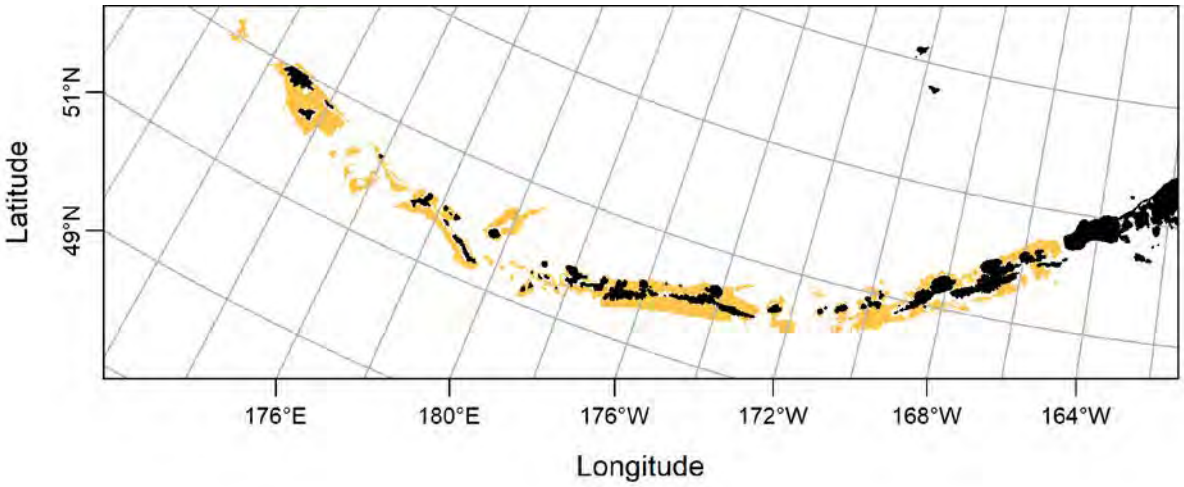

Figure E-227 EFH distribution of AI Alaska skate adult, spring.

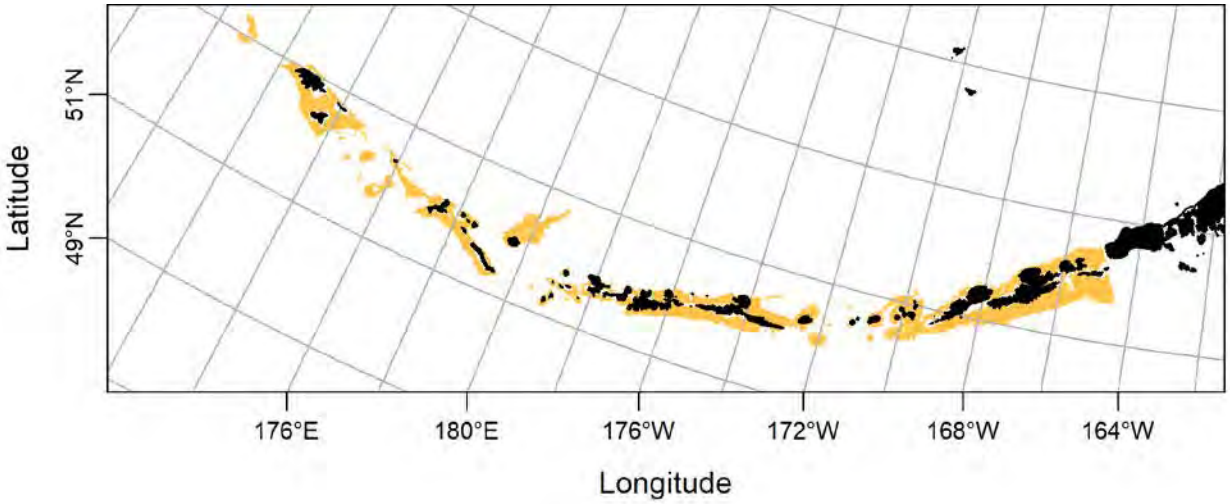

Figure E-228 EFH distribution of AI Alaska skate adult, fall.

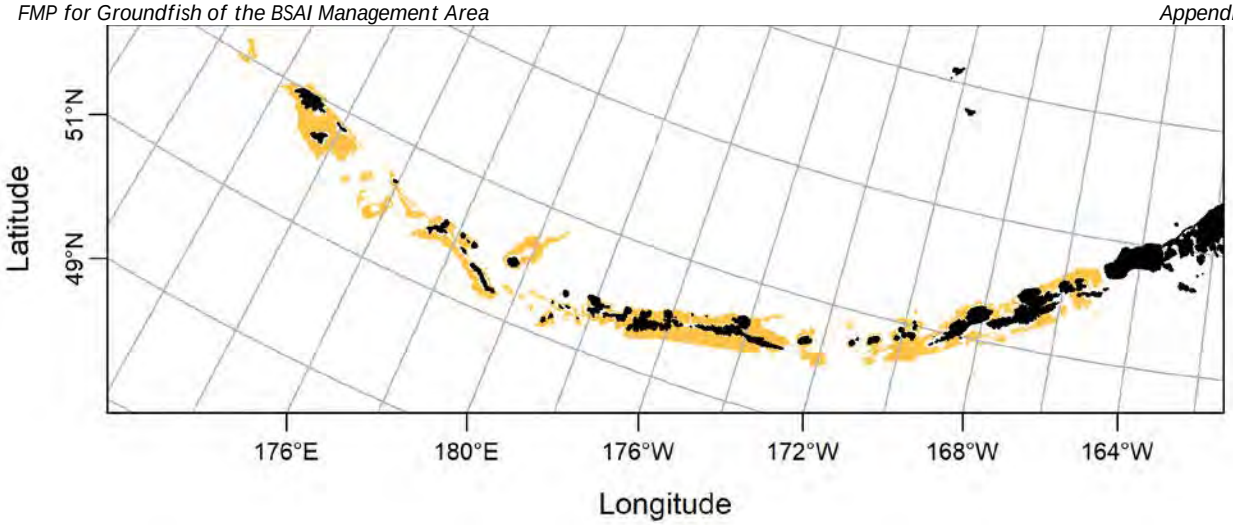

Figure E-229 EFH distribution of AI Alaska skate adult, spring.

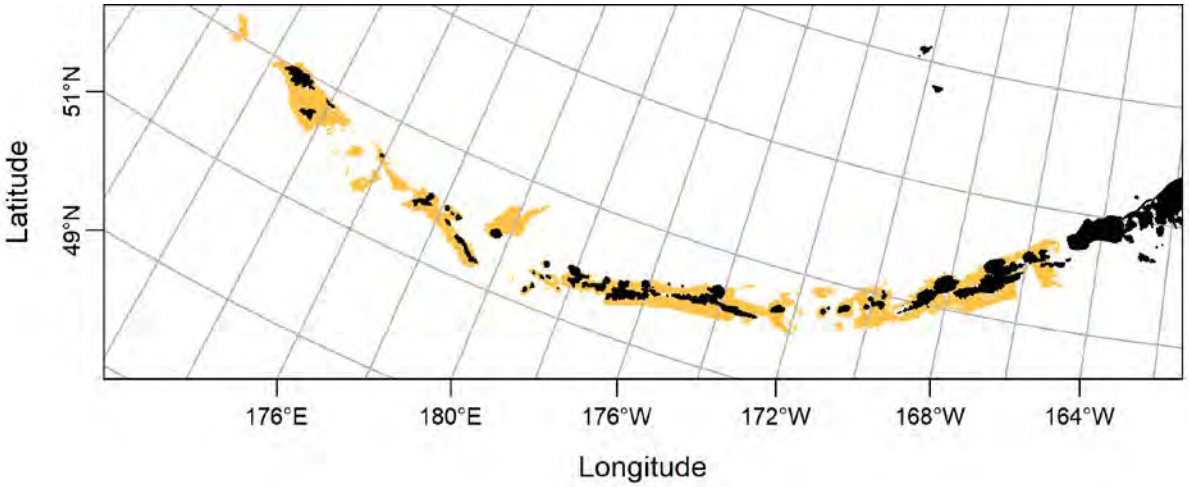

Figure E-230 EFH distribution of AI Alaska skate adult, summer.

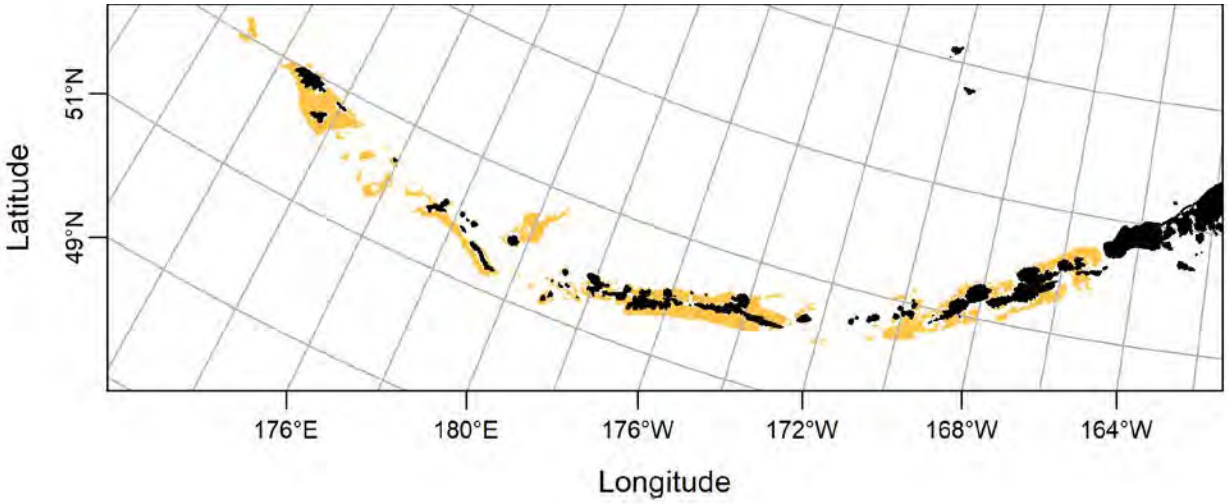

Figure E-231 EFH distribution of AI Alaska skate adult, winter.

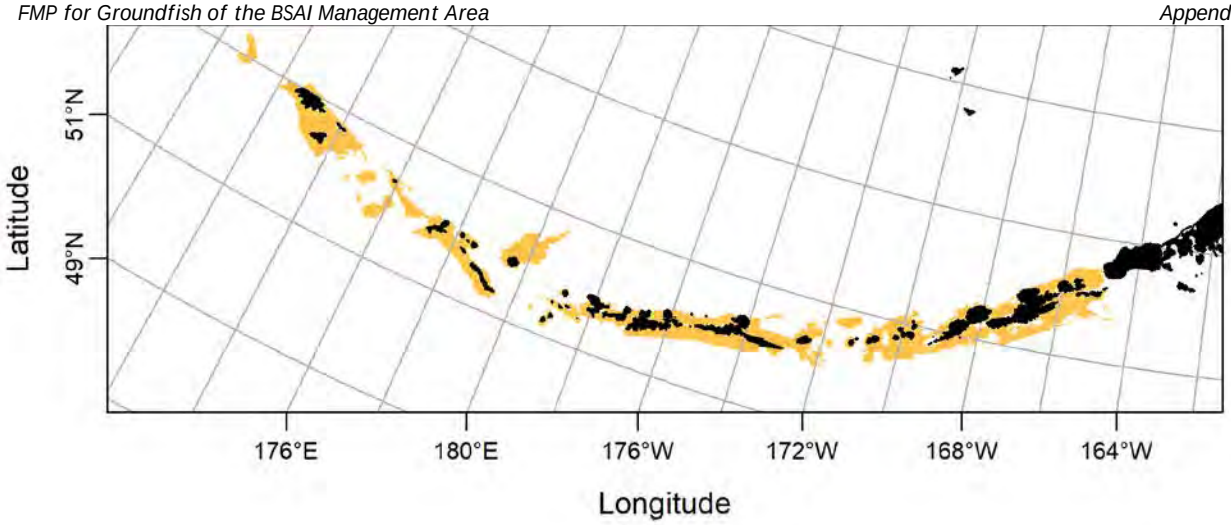

Figure E-232 EFH distribution of AI Alaska skate juvenile, summer.

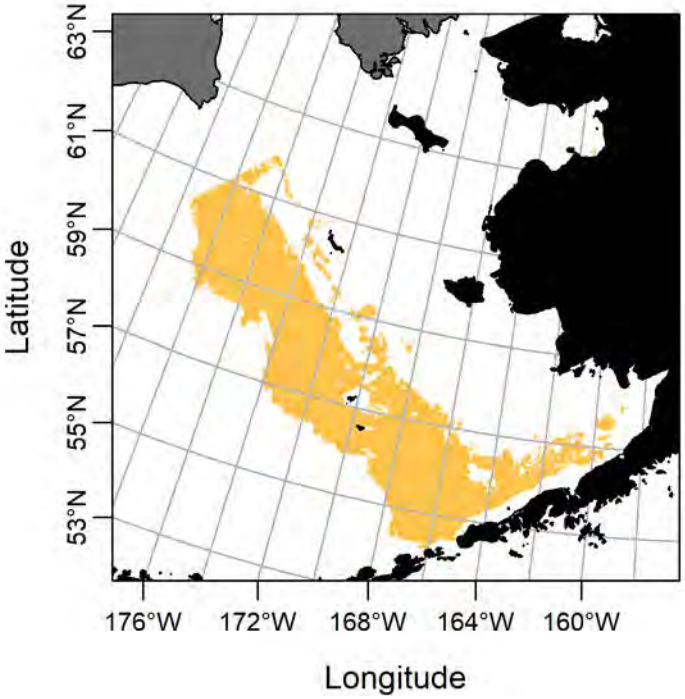

Figure E-233 EFH distribution of EBS Aleutian skate adult, fall.

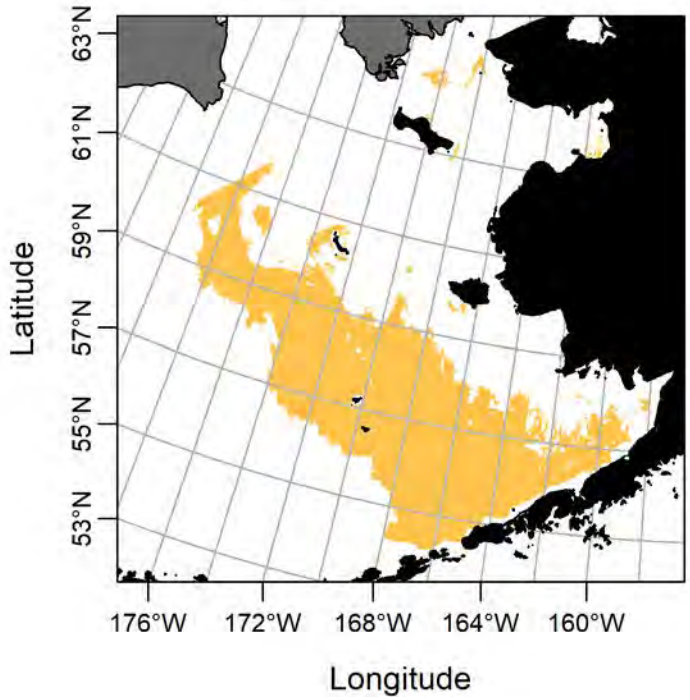

Figure E-234 EFH distribution of EBS Aleutian skate adult, spring.

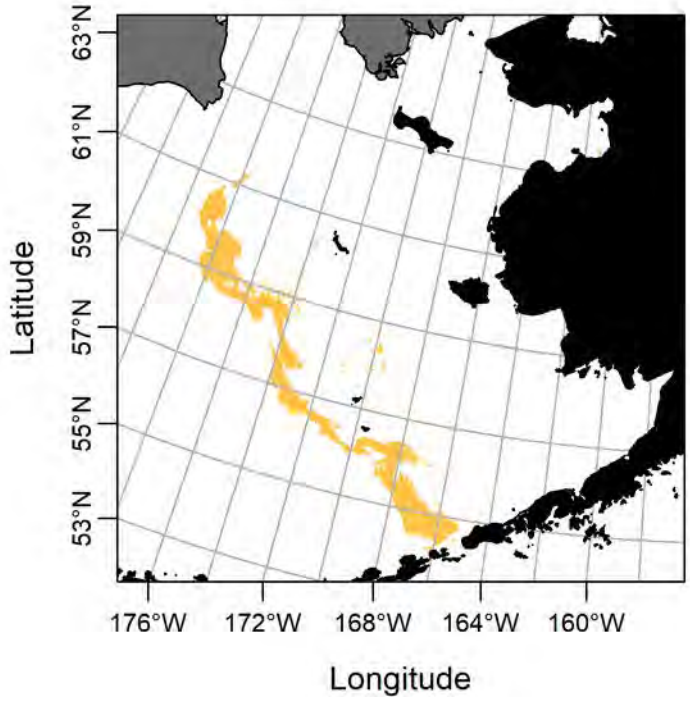

Figure E-235 EFH distribution of EBS Aleutian skate adult, summer.

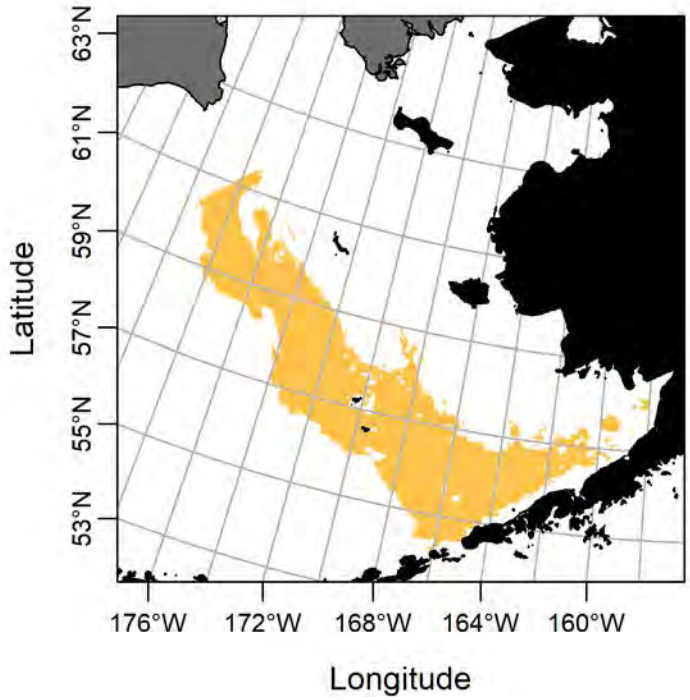

Figure E-236 EFH distribution of EBS Aleutian skate adult, winter.

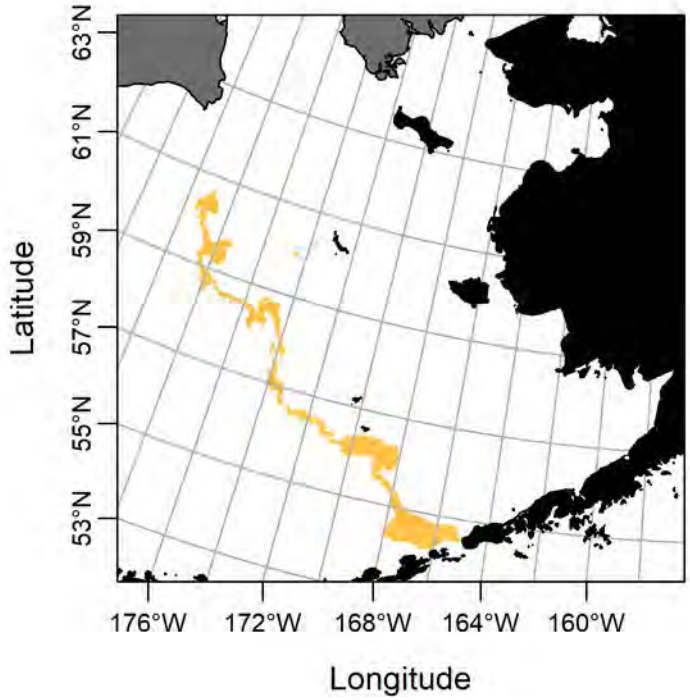

Figure E-237 EFH distribution of Aleutian skate juvenile, summer.

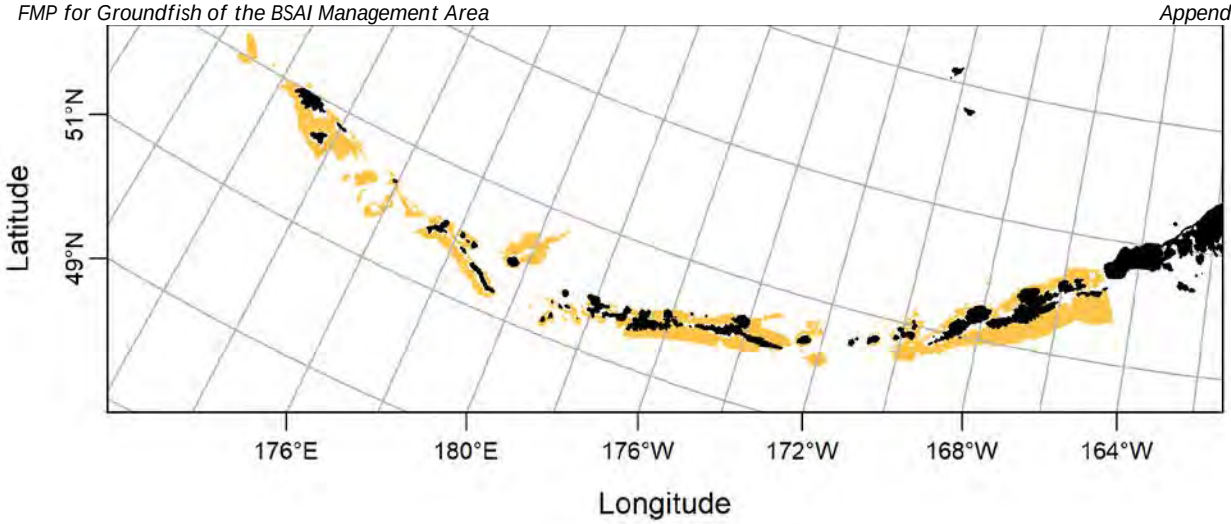

Figure E-238 EFH distribution of AI Aleutian skate adult, fall.

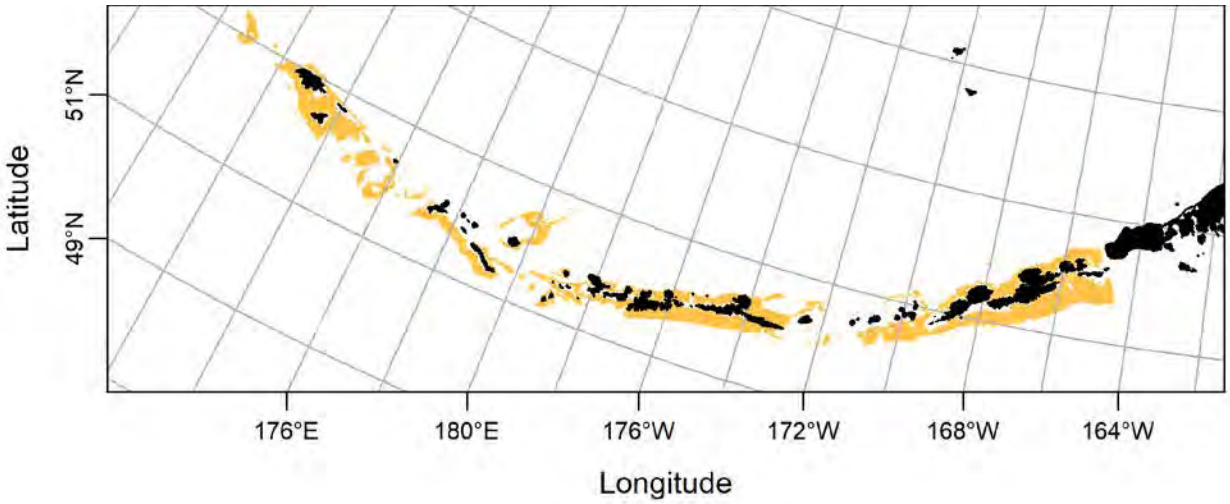

Figure E-239 EFH distribution of AI Aleutian skate adult, spring.

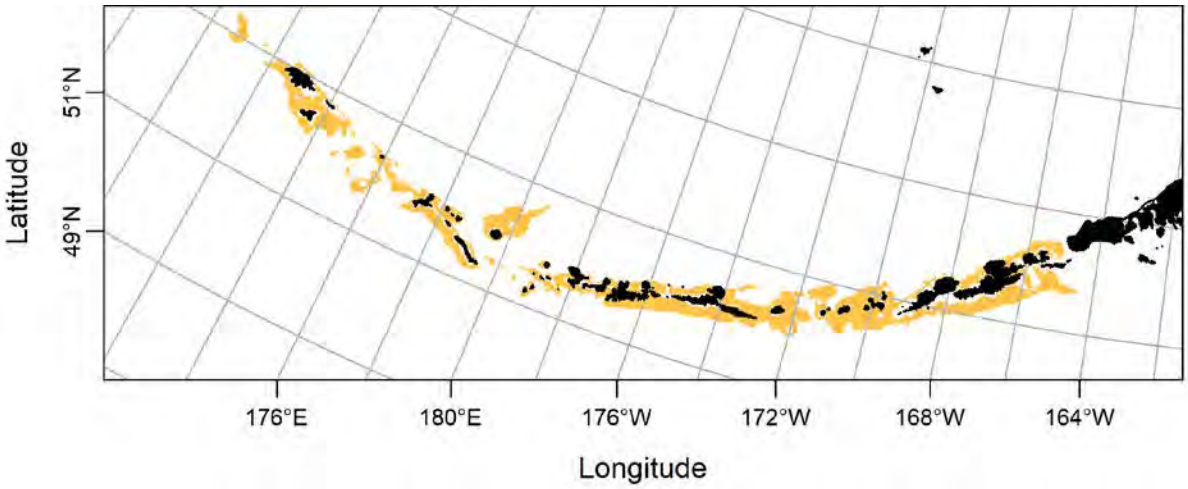

Figure E-240 EFH distribution of AI Aleutian skate adult, summer.

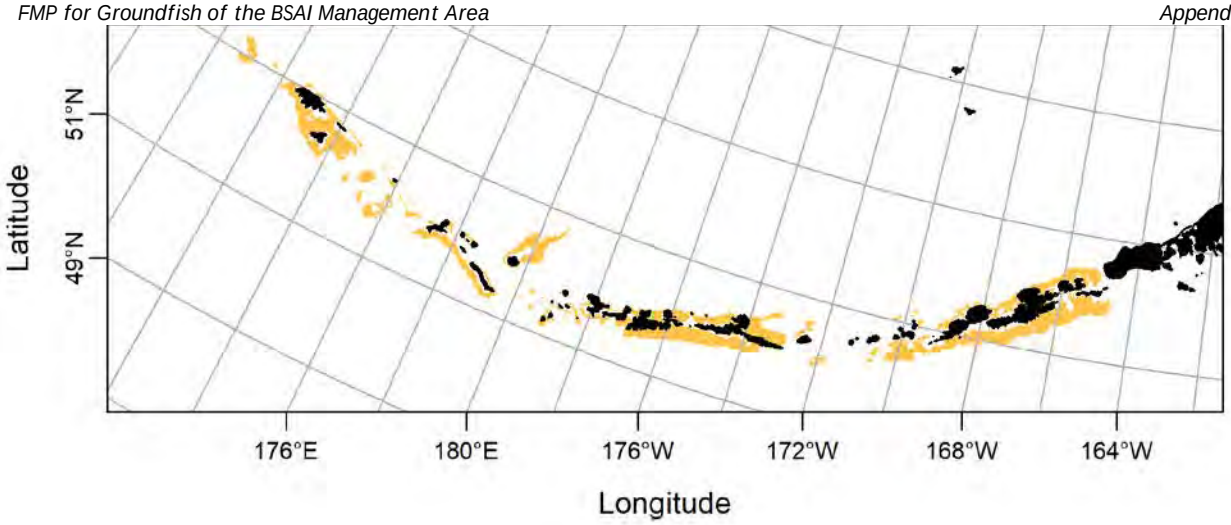

Figure E-241 EFH distribution of AI Aleutian skate adult, winter.

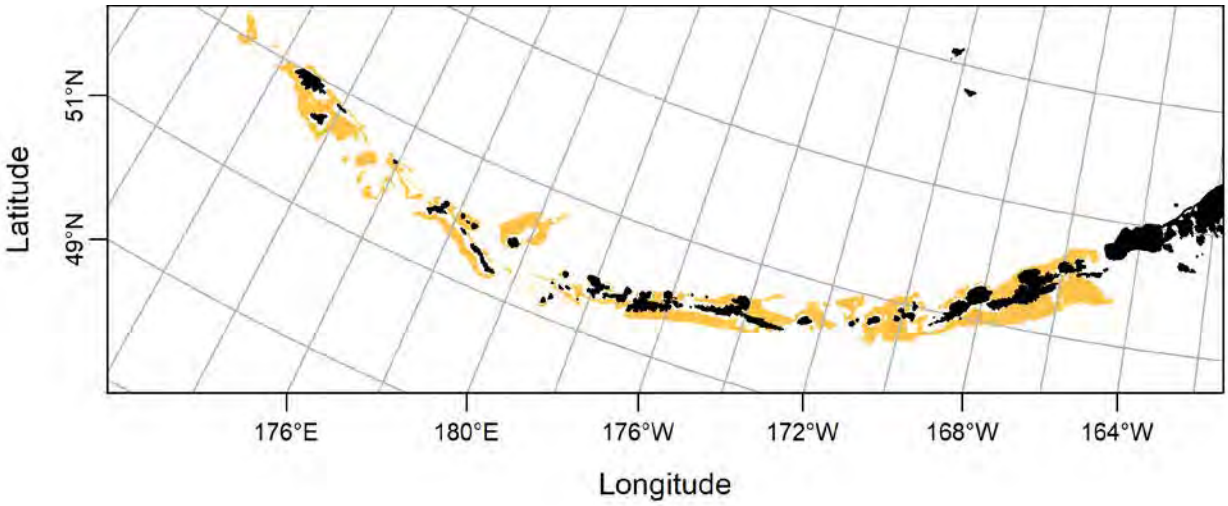

Figure E-242 EFH distribution of AI Aleutian skate juvenile, summer.

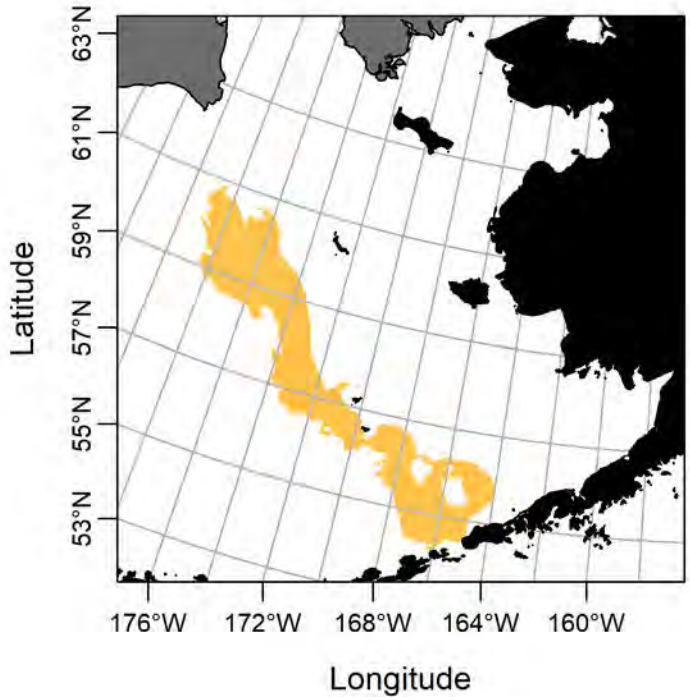

Figure E-243 EFH distribution of EBS Bering skate adult, summer.

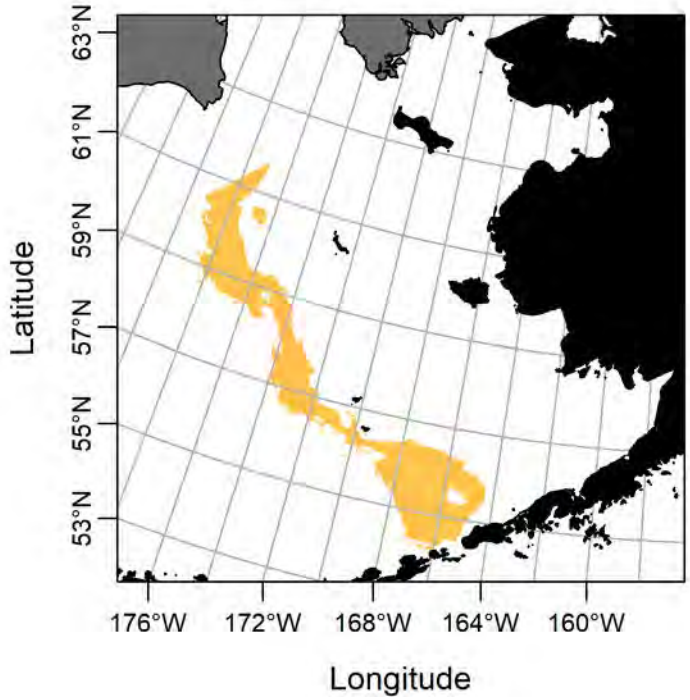

Figure E-244 EFH distribution of EBS Bering skate juvenile, summer.

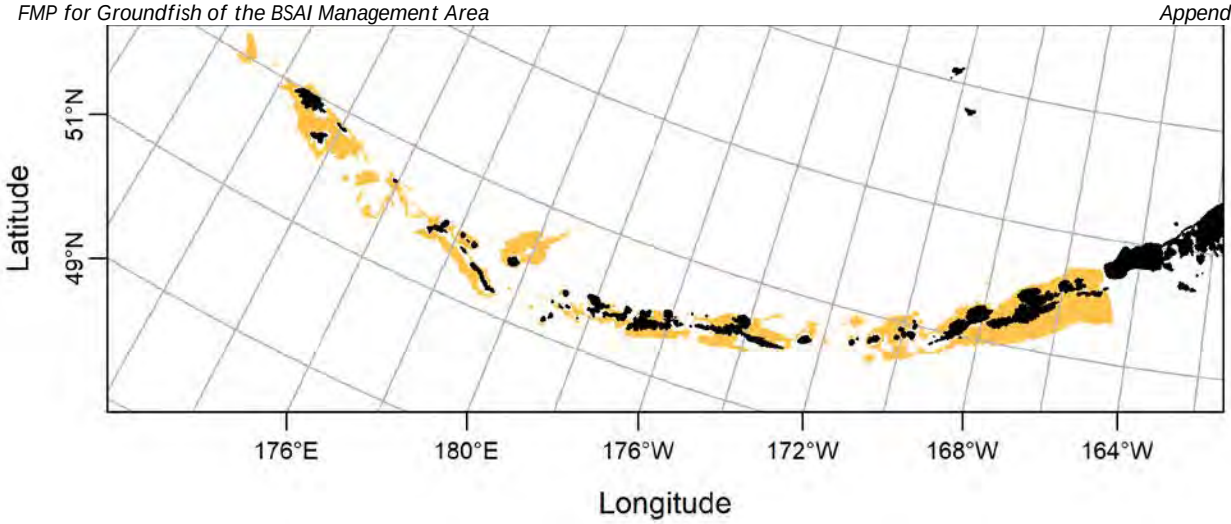

Figure E-245 EFH distribution of AI Bering skate adult, summer.

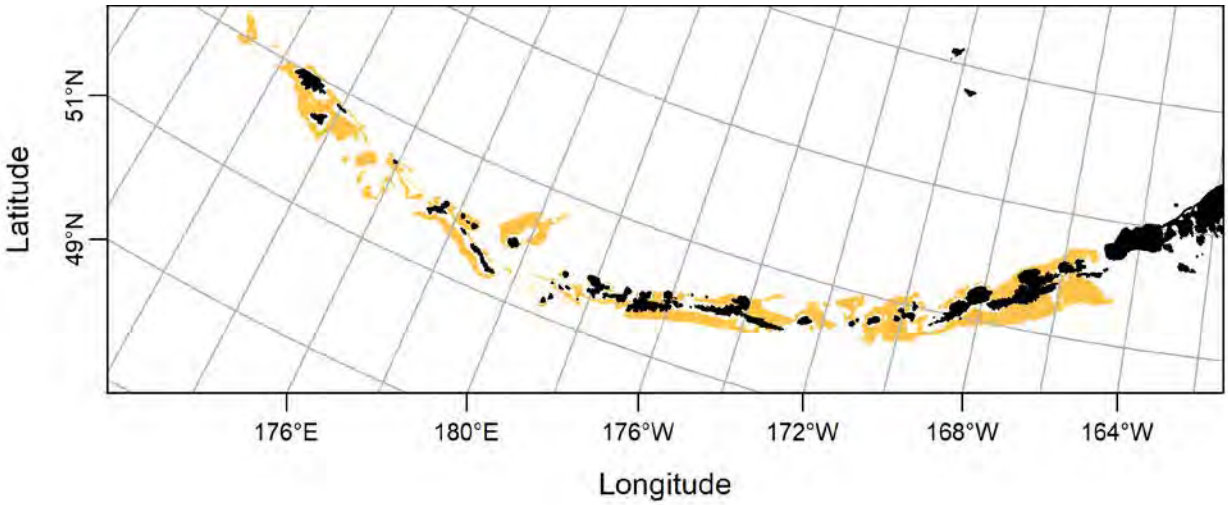

Figure E-246 EFH distribution of AI Bering skate juvenile, summer.

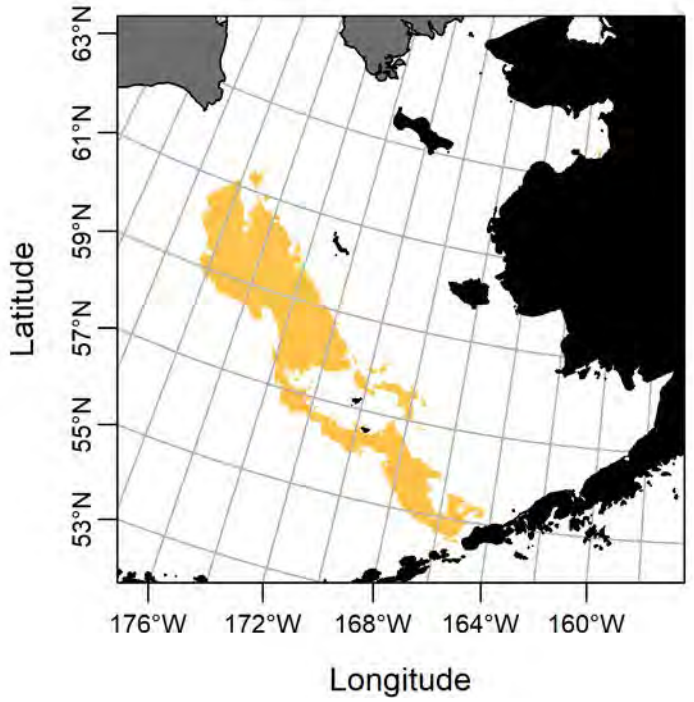

Figure E-247 EFH distribution of EBS Mud skate adult, fall.

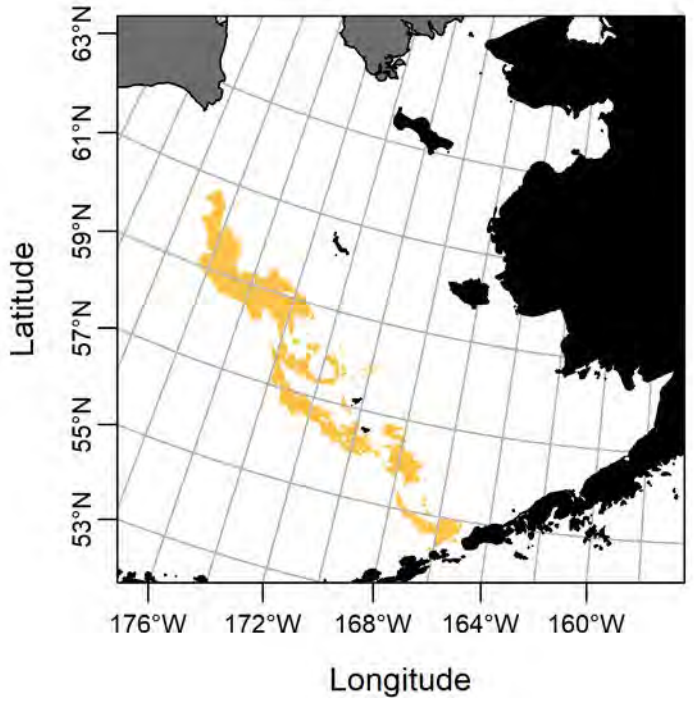

Figure E-248 EFH distribution of EBS Mud skate adult, spring.

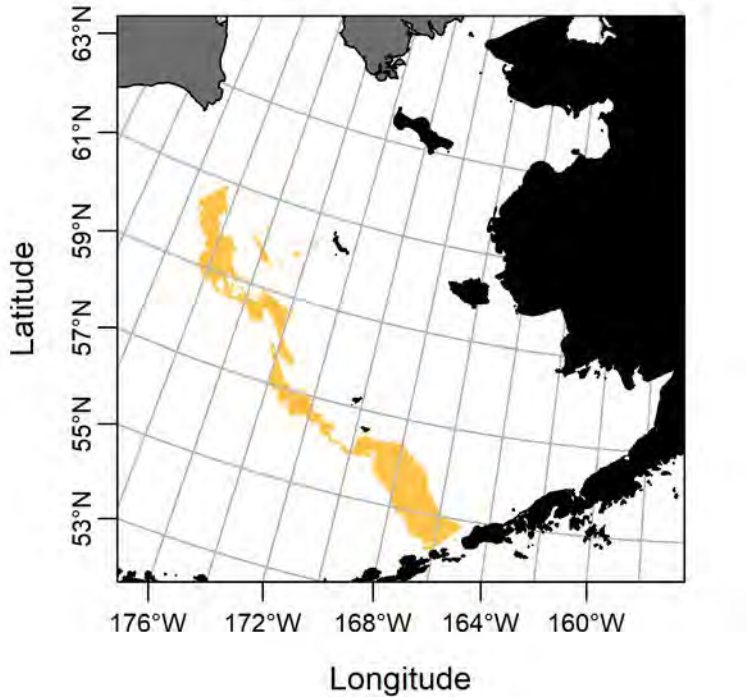

Figure E-249 EFH distribution of EBS Mud skate adult, summer.

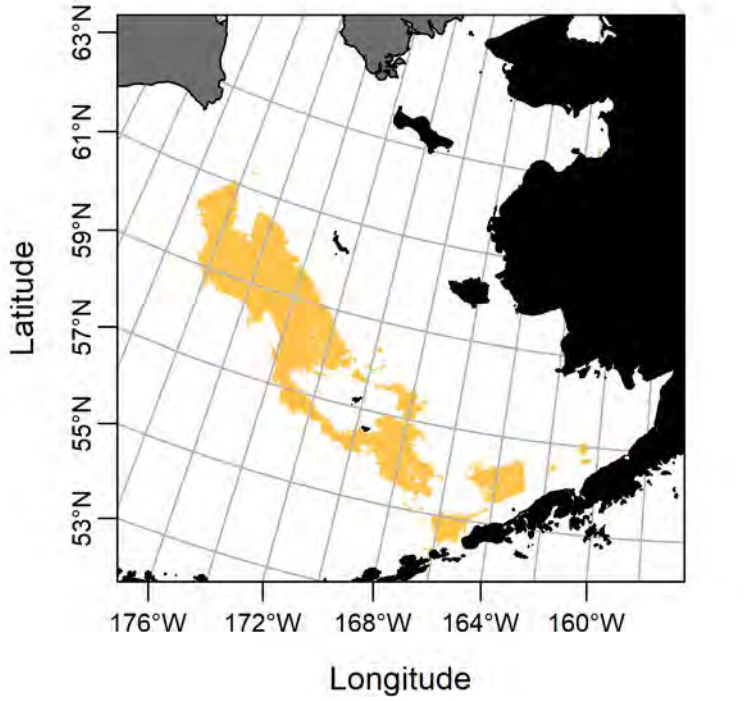

Figure E-250 EFH distribution of EBS Mud skate adult, winter.

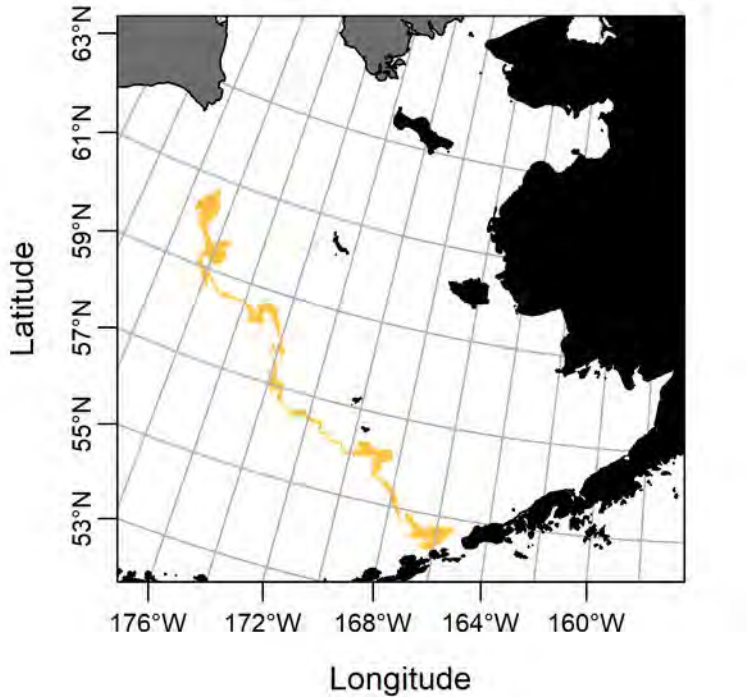

Figure E-251 EFH distribution of EBS Mud skate juvenile, summer.

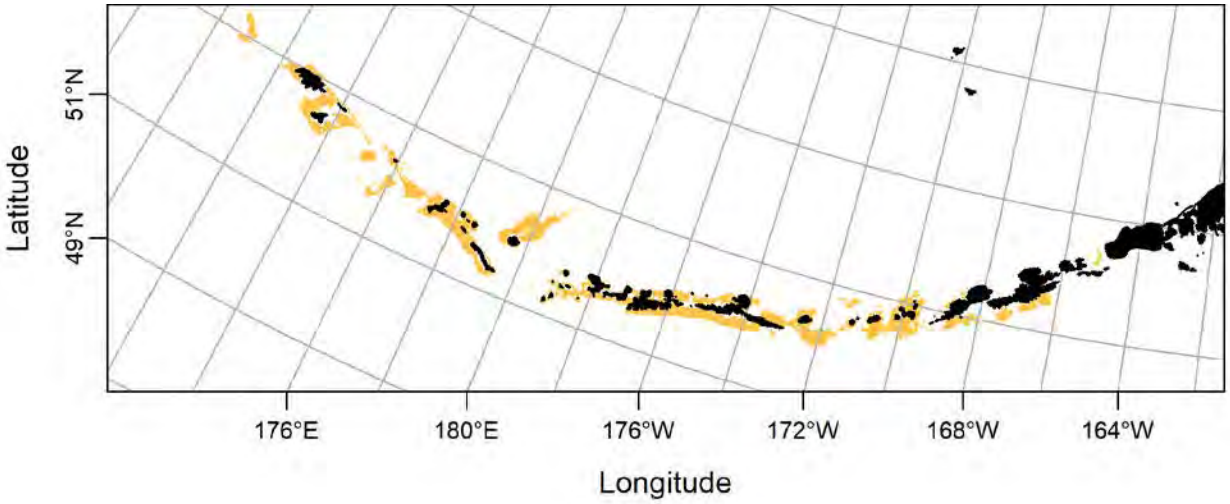

Figure E-252 EFH distribution of AI Mud skate adult, fall.

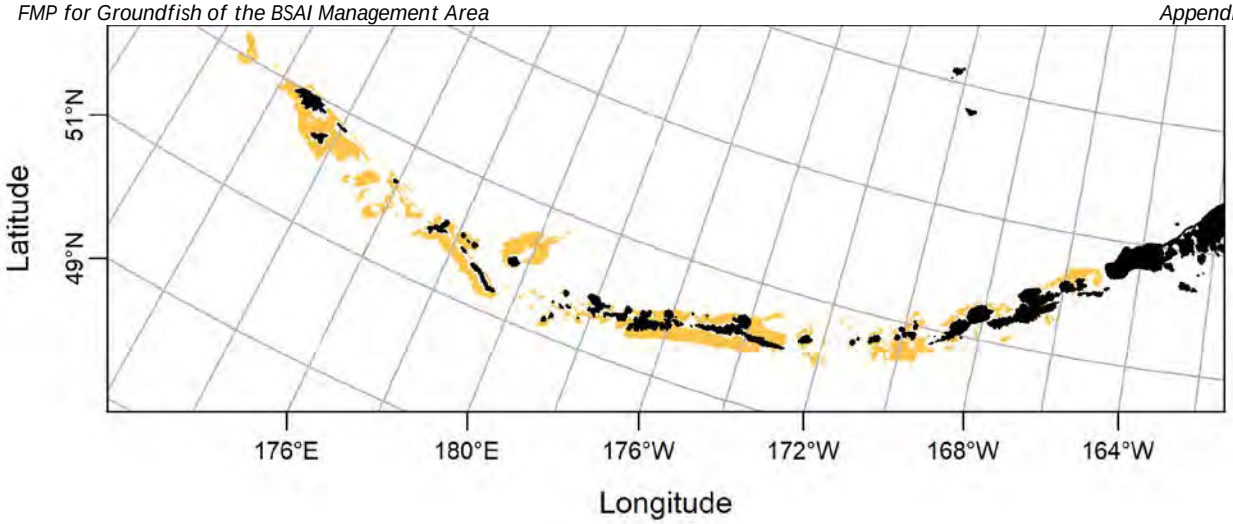

Figure E-253 EFH distribution of AI Mud skate adult, spring.

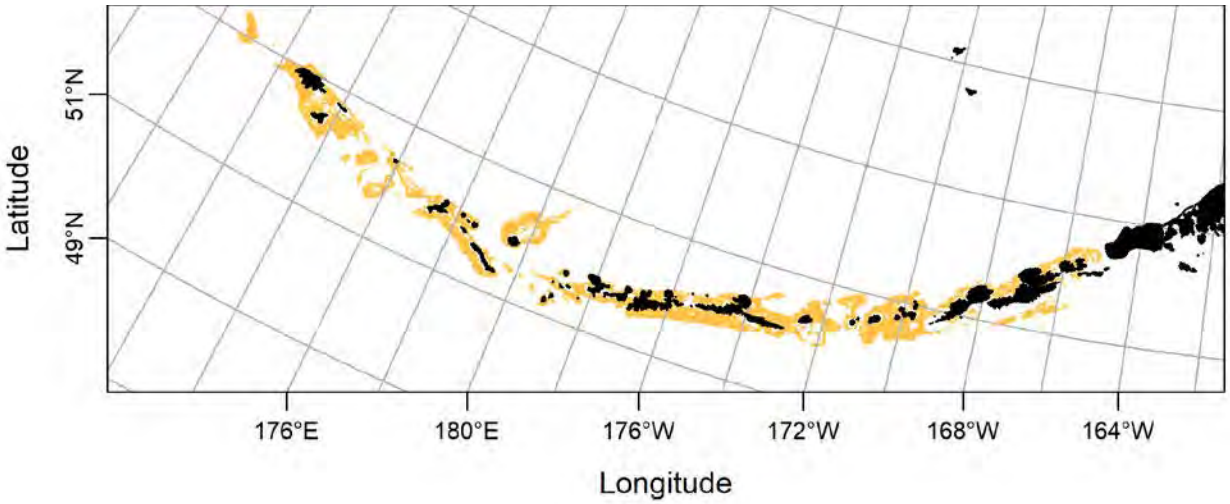

Figure E-254 EFH distribution of AI Mud skate adult, summer.

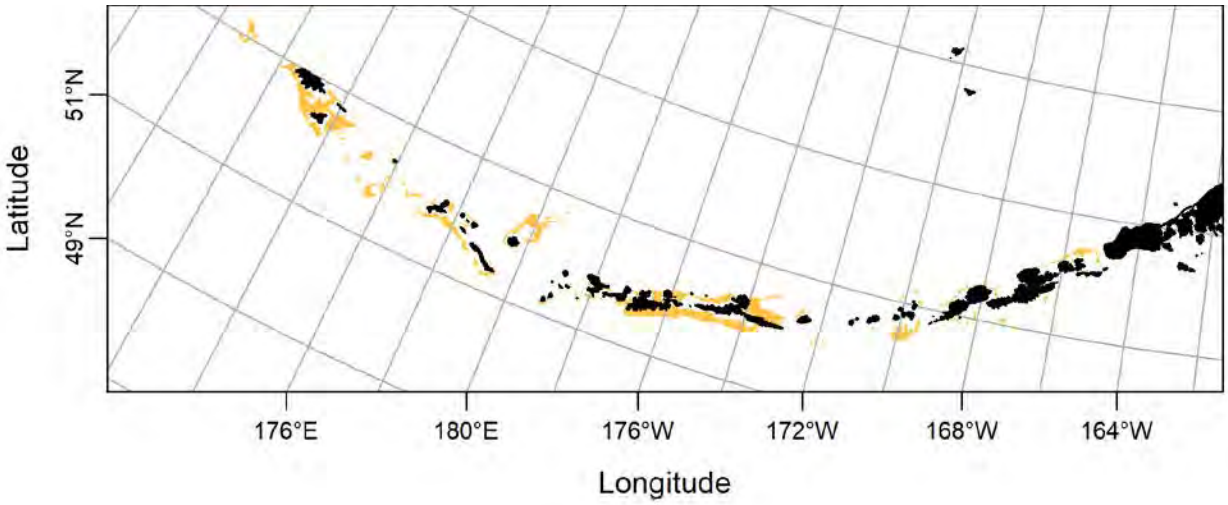

Figure E-255 EFH distribution of AI Mud skate adult, winter.

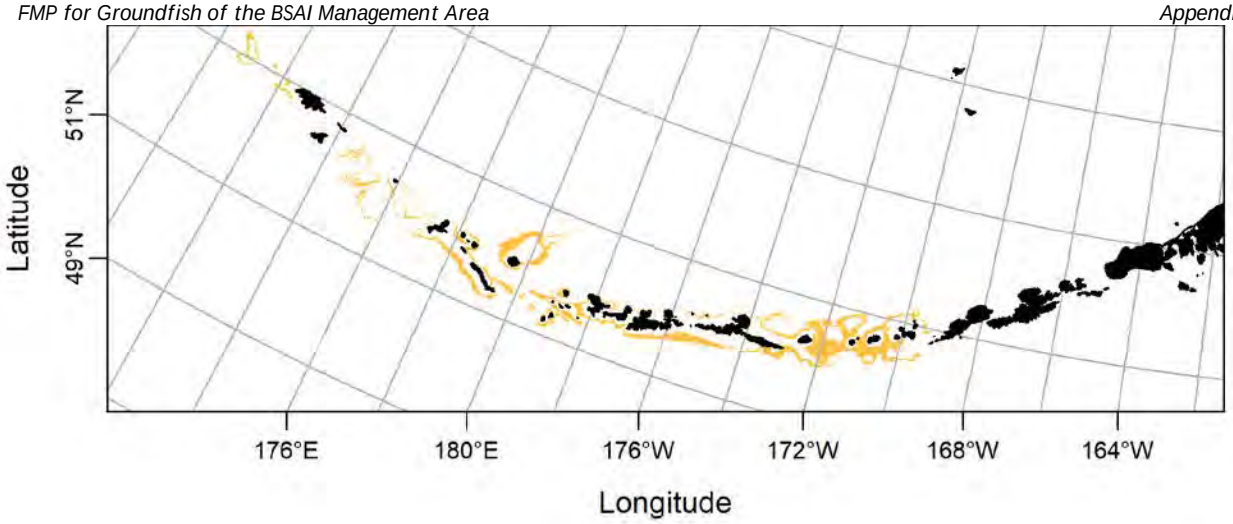

Figure E-256 EFH distribution of AI Mud skate juvenile, summer.

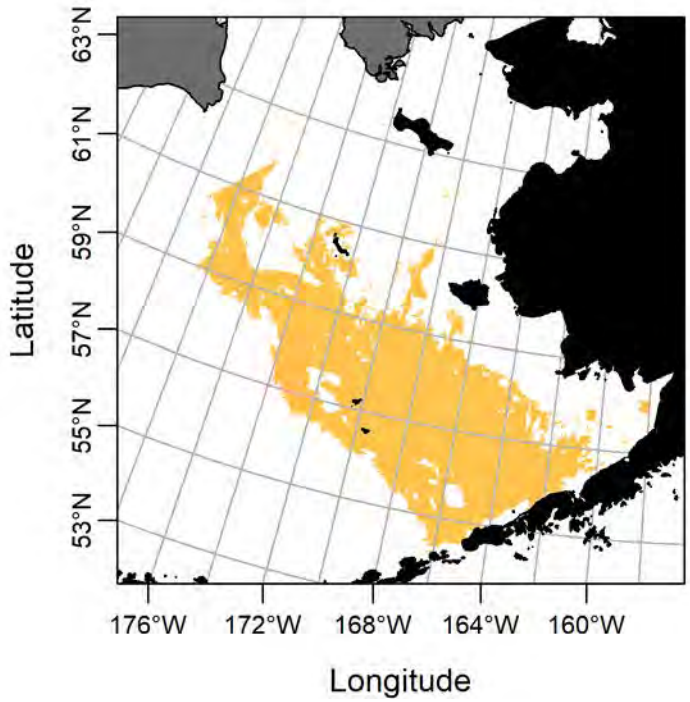

Figure E-257 EFH distribution of EBS Southern rock sole adult, fall.

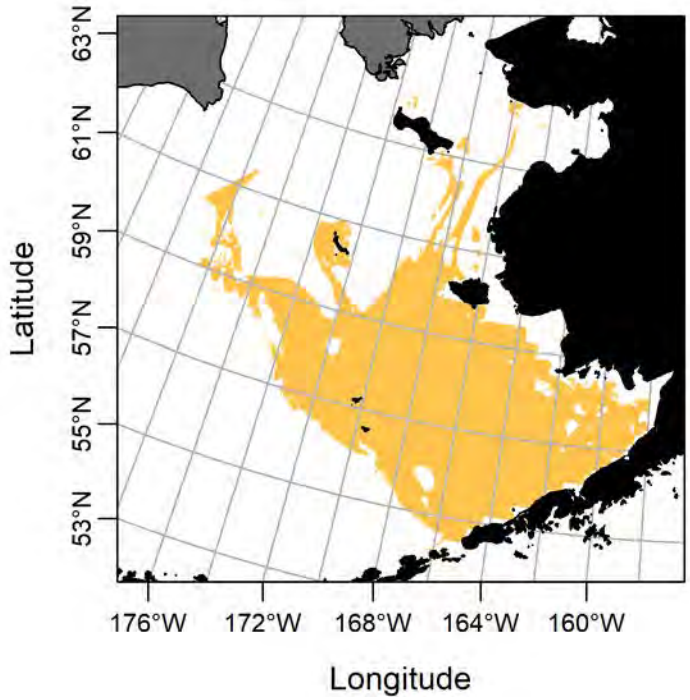

Figure E-258 EFH distribution of EBS Southern rock sole adult, spring.

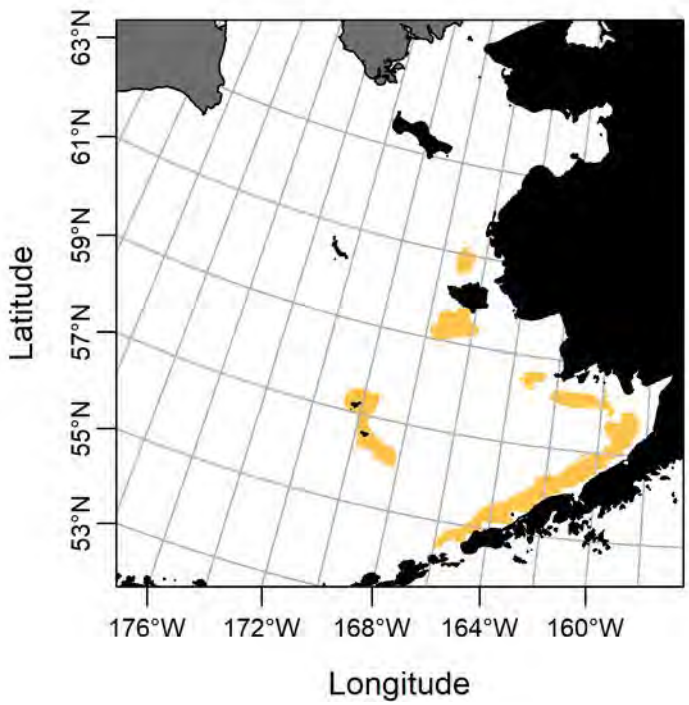

Figure E-259 EFH distribution of EBS Southern rock sole adult, summer.

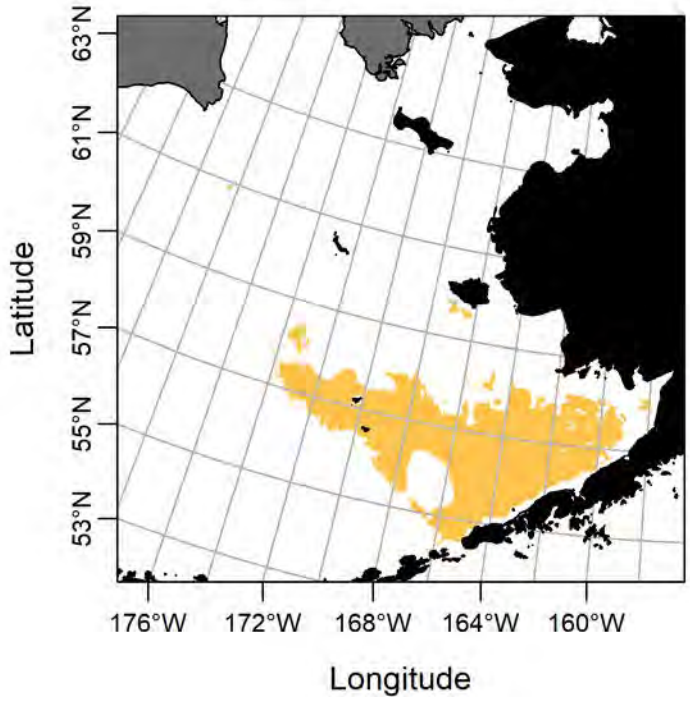

Figure E-260 EFH distribution of EBS Southern rock sole adult, winter.

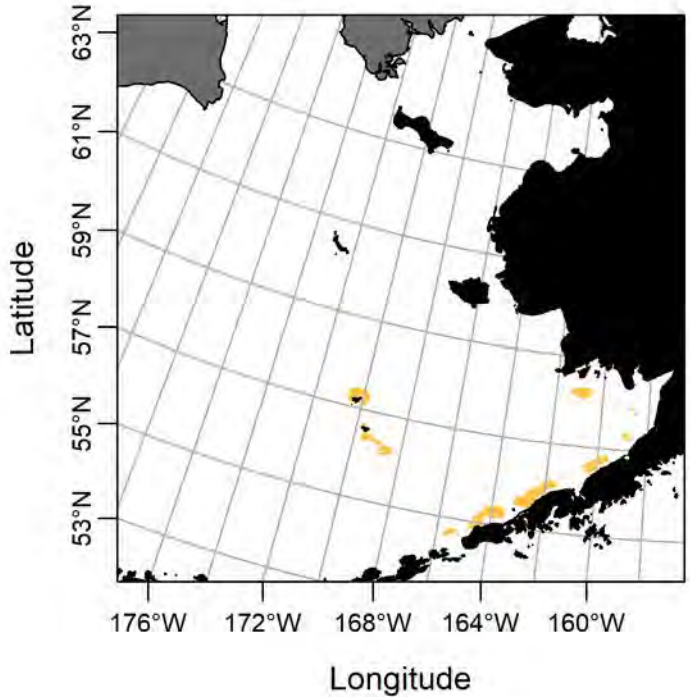

Figure E-261 EFH distribution of EBS Southern rock sole juvenile, summer.

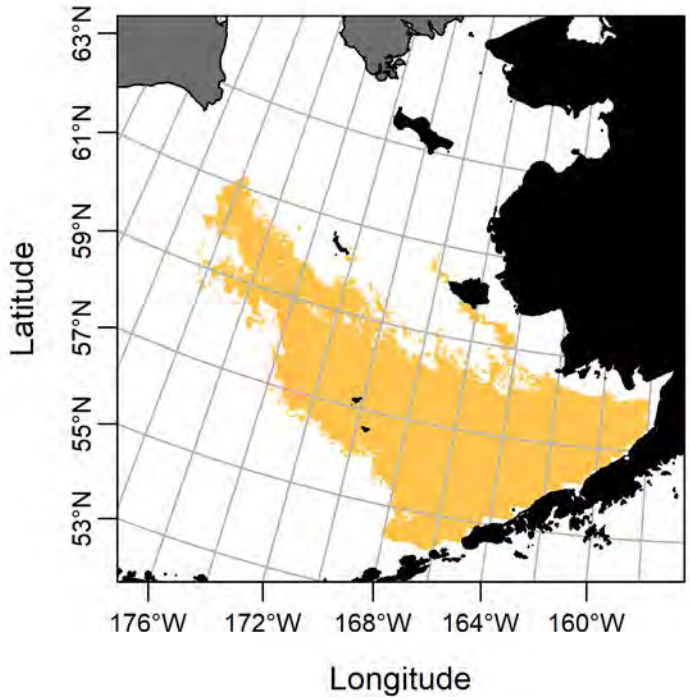

Figure E-262 EFH distribution of EBS Southern rock sole larvae, summer.

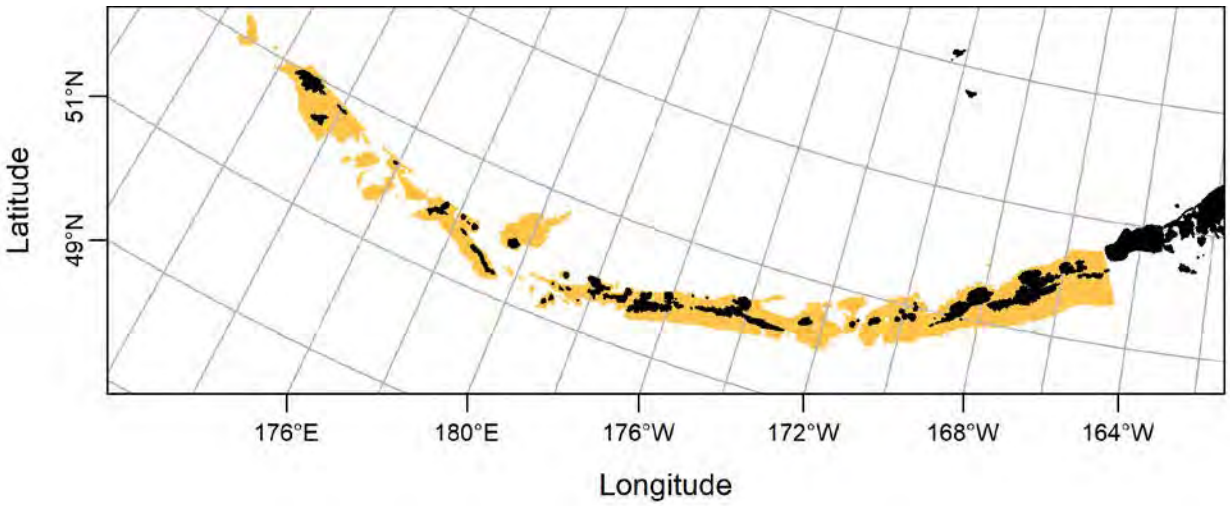

Figure E-263 EFH distribution of AI Southern rock sole adult, sole.

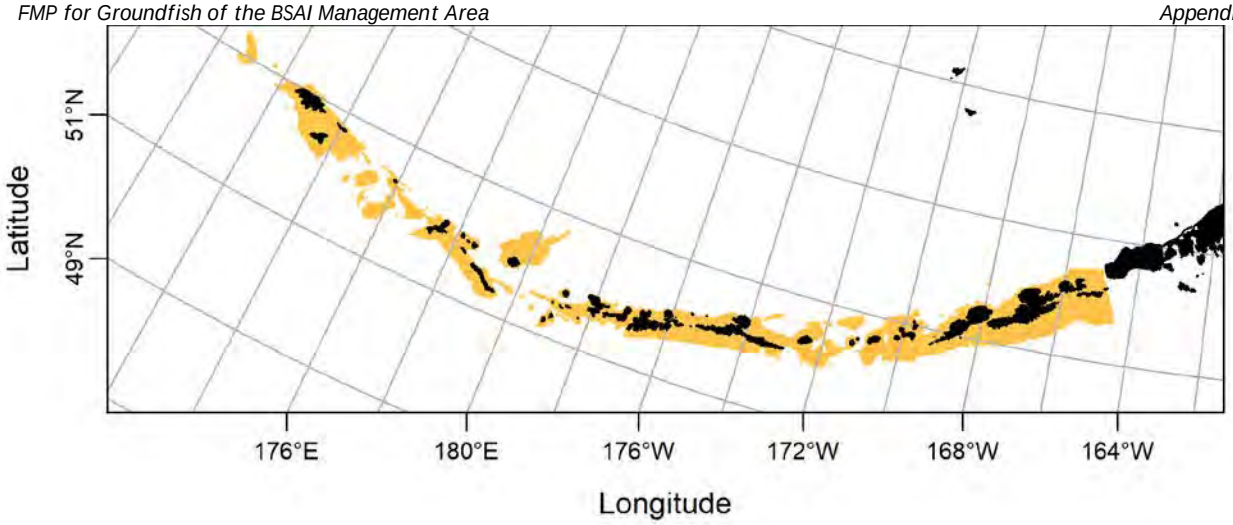

Figure E-264 EFH distribution of AI Southern rock sole adult, spring.

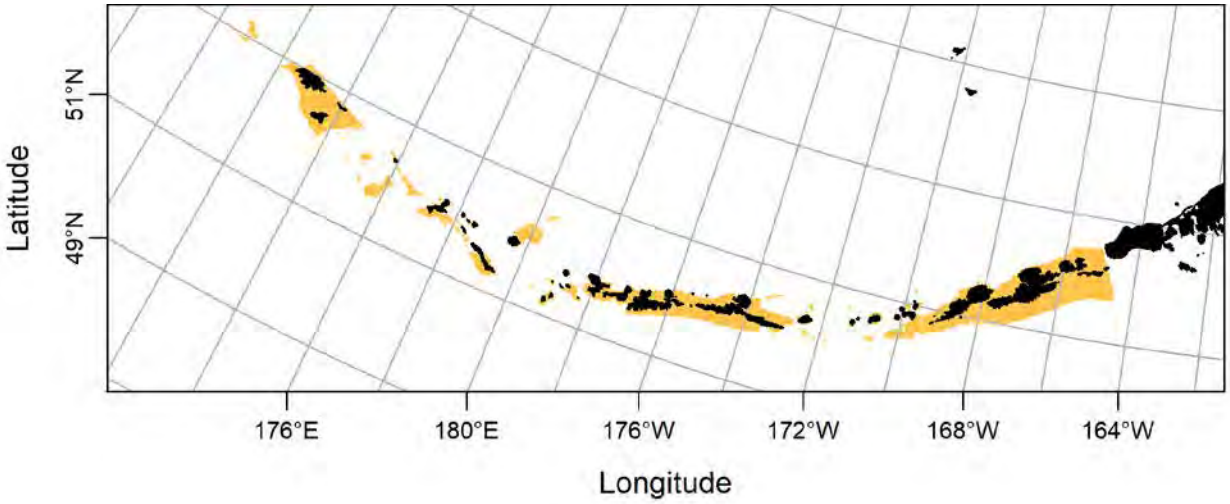

Figure E-265 EFH distribution of AI Southern rock sole adult, summer.

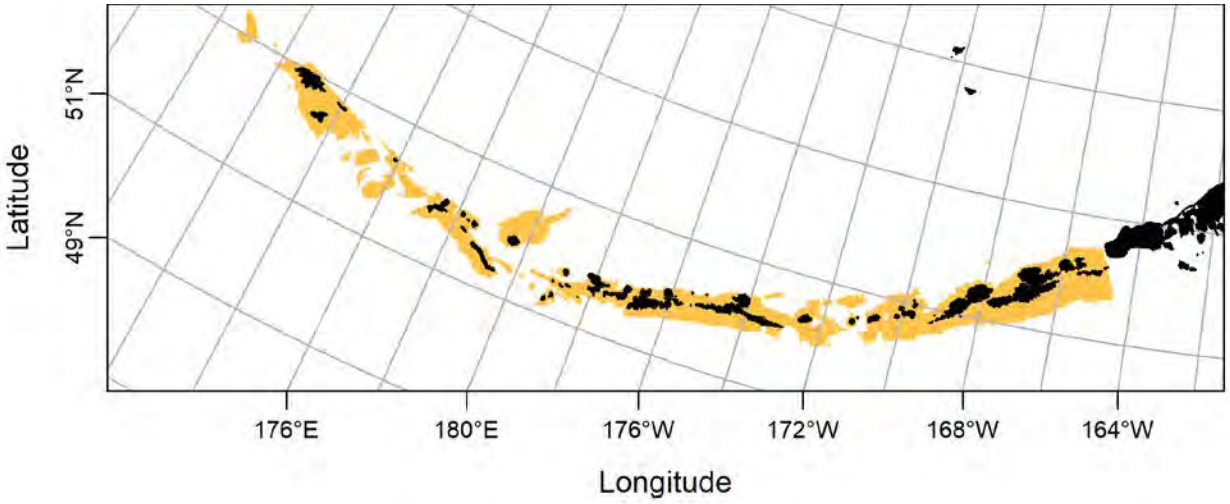

Figure E-266 EFH distribution of AI Southern rock sole adult, winter.

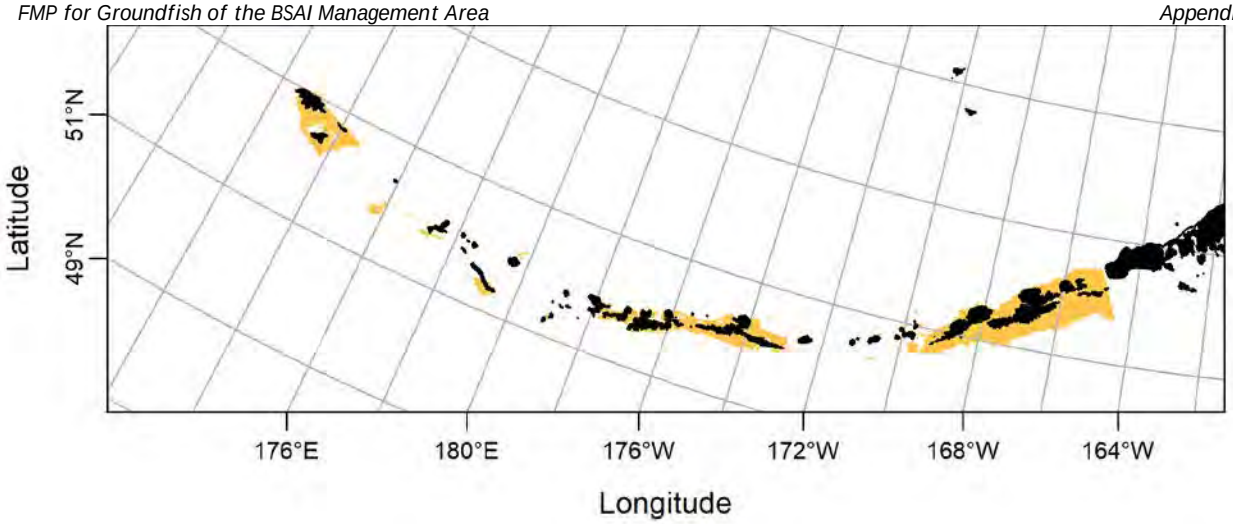

Figure E-267 EFH distribution of AI Southern rock sole juvenile, summer.

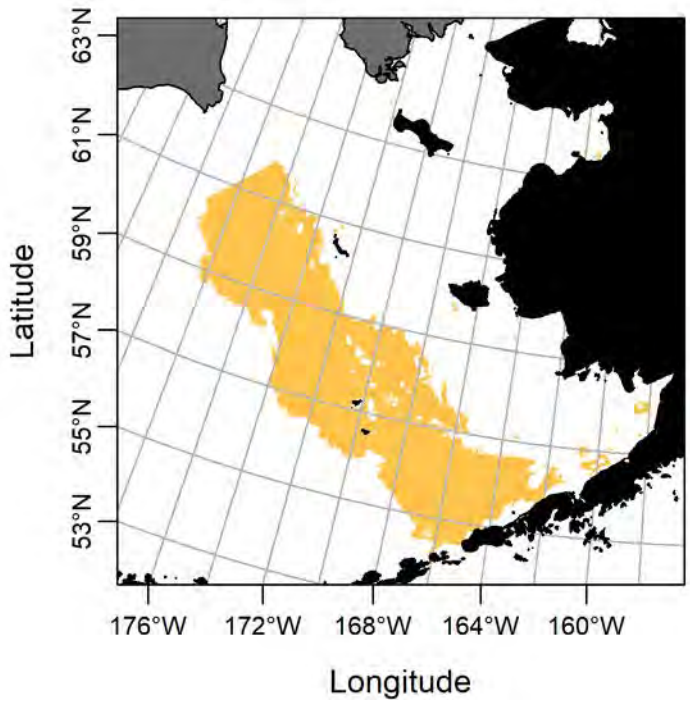

Figure E-268 EFH distribution of EBS Octopus adult, fall.

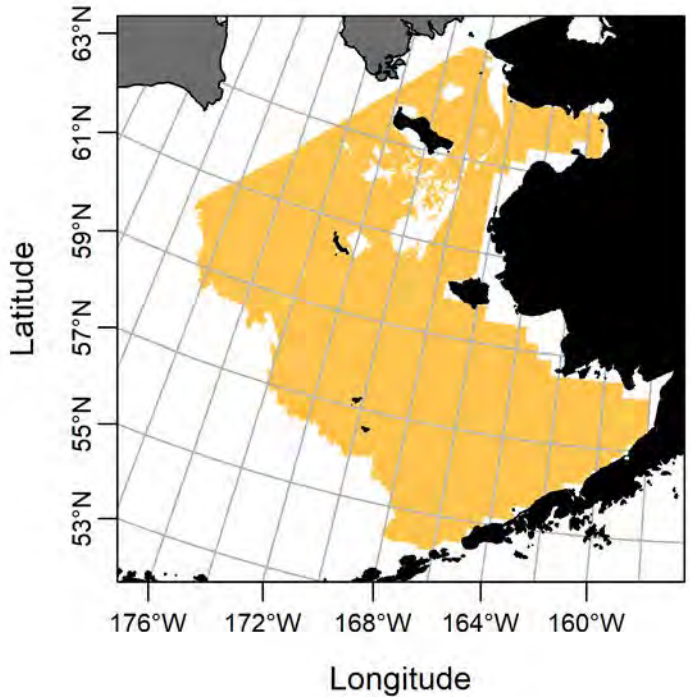

Figure E-269 EFH distribution of EBS Octopus adult, spring.

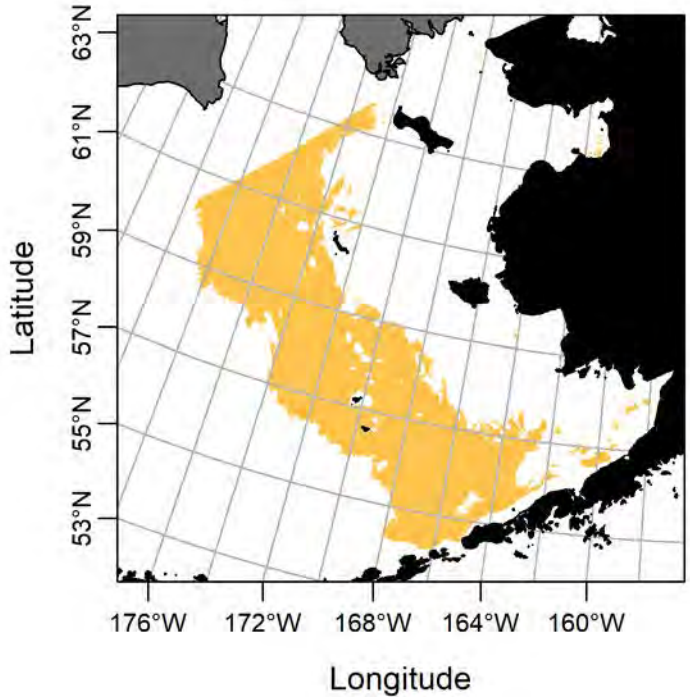

Figure E-270 EFH distribution of EBS Octopus adult, summer.

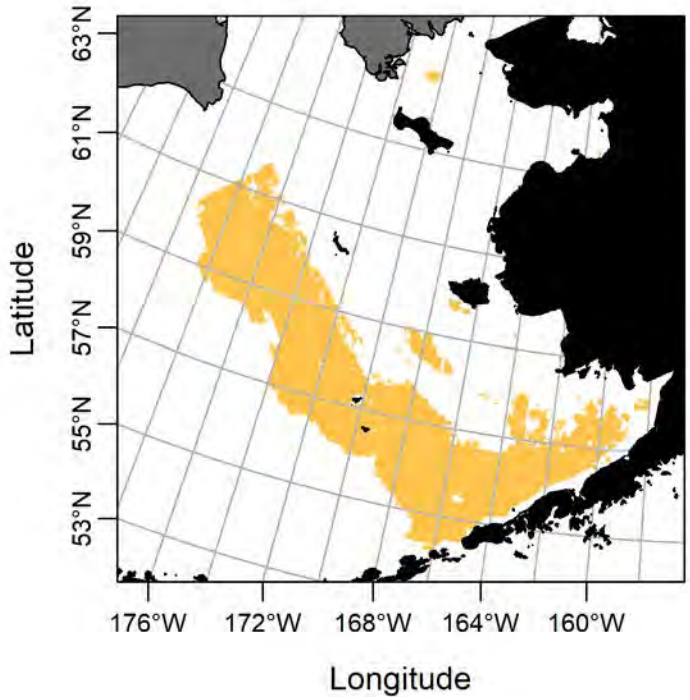

Figure E-271 EFH distribution of EBS Octopus adult, winter.

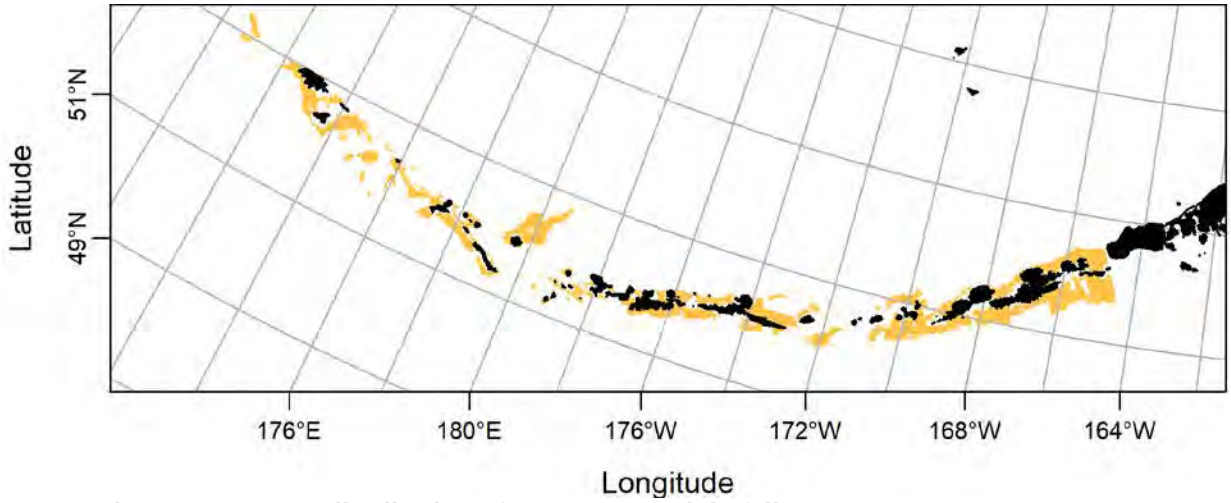

Figure E-272 EFH distribution of AI Octopus adult, fall.

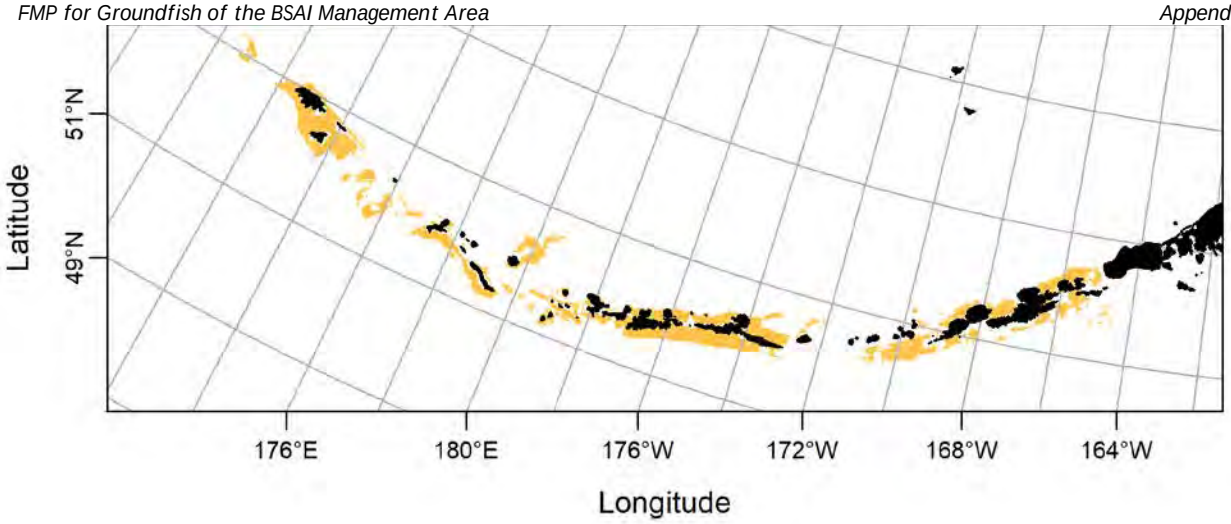

Figure E-273 EFH distribution of AI Octopus adult, spring.

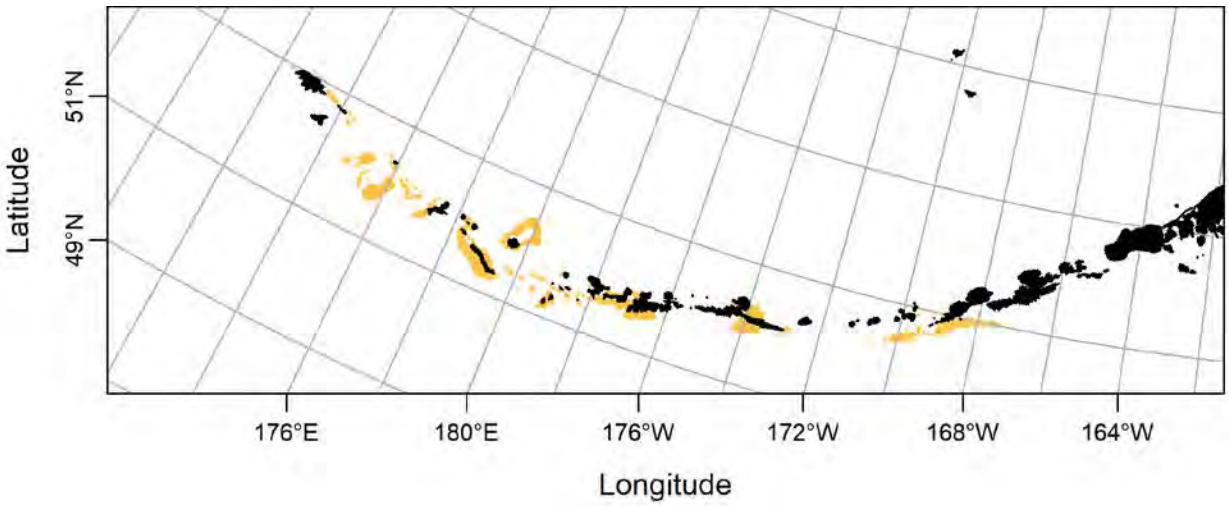

Figure E-274 EFH distribution of AI Octopus adult, summer.

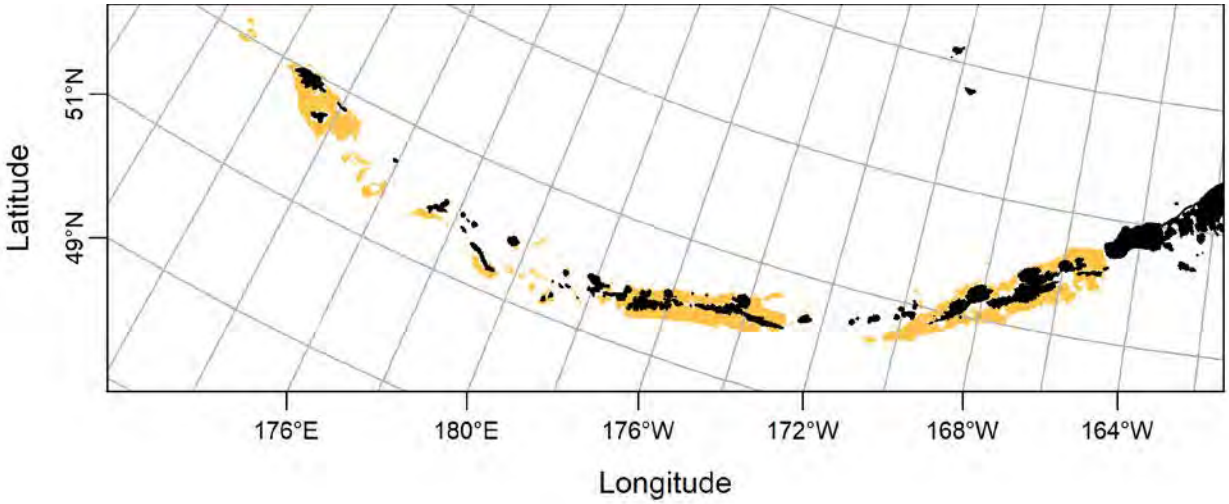

Figure E-275 EFH distribution of AI Octopus adult, winter.

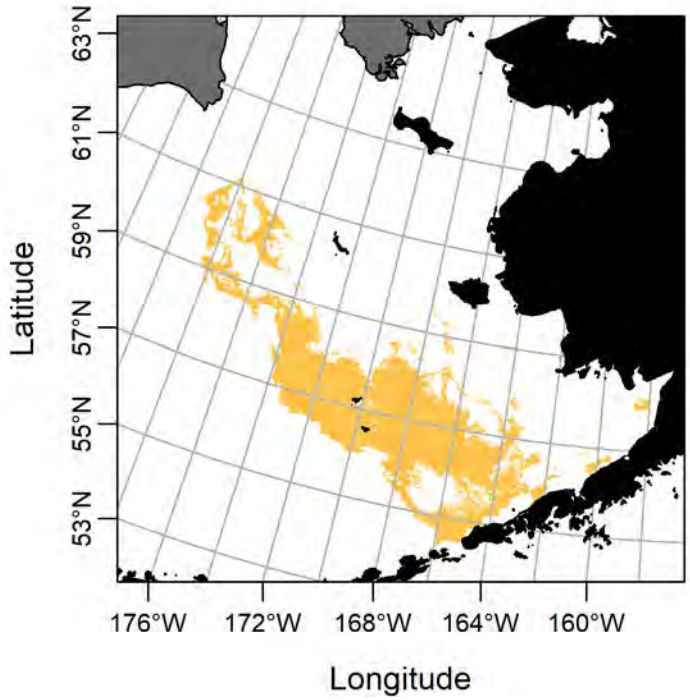

Figure E-276 EFH distribution of EBS Yellow Irish lord adult, fall.

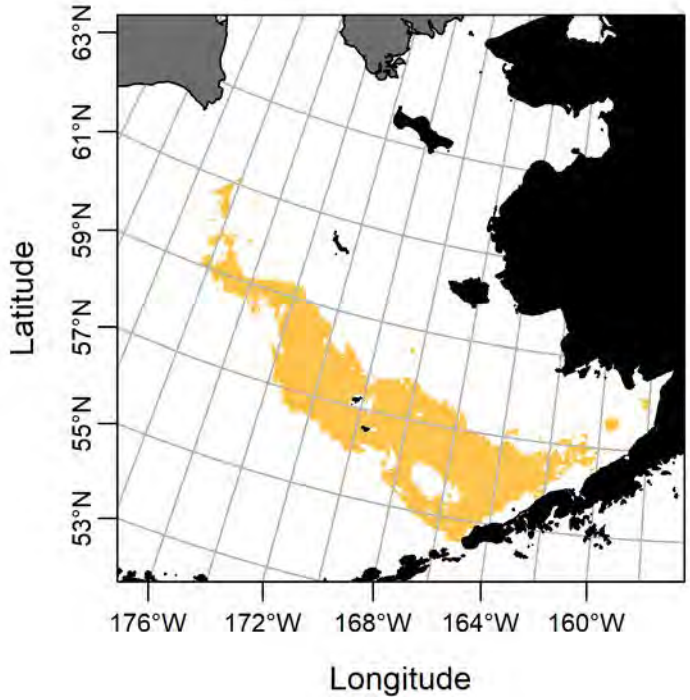

Figure E-277 EFH distribution of EBS Yellow Irish lord adult, spring.

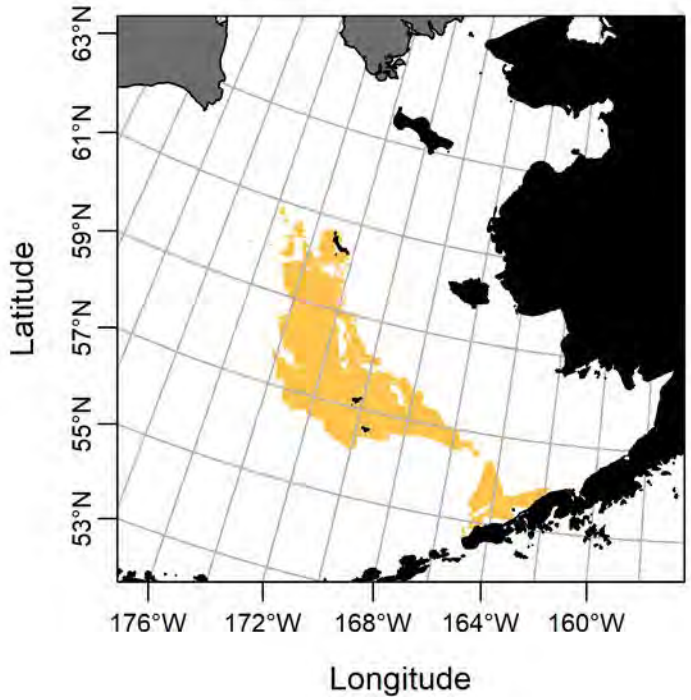

Figure E-278 EFH distribution of EBS Yellow Irish lord adult, summer

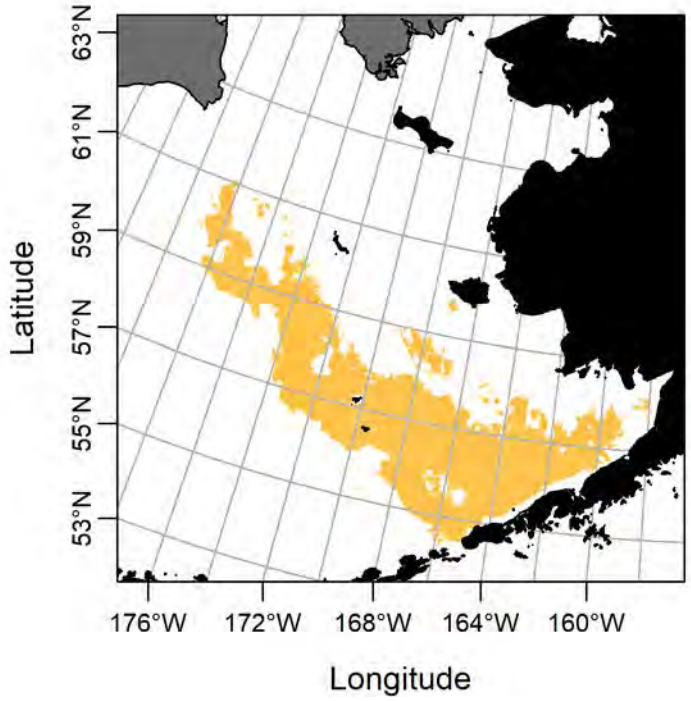

Figure E-279 EFH distribution of EBS Yellow Irish lord adult, winter.

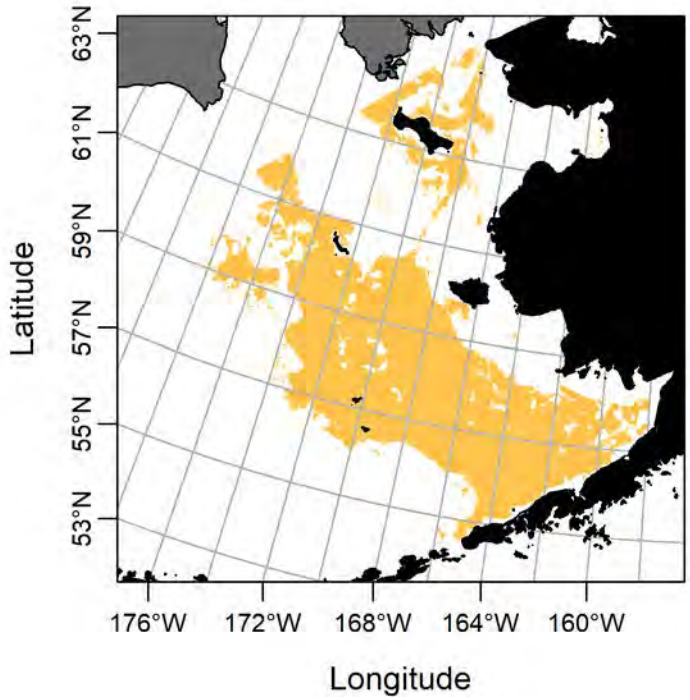

Figure E-280 EFH distribution of EBS Yellow Irish lord juvenile, summer.

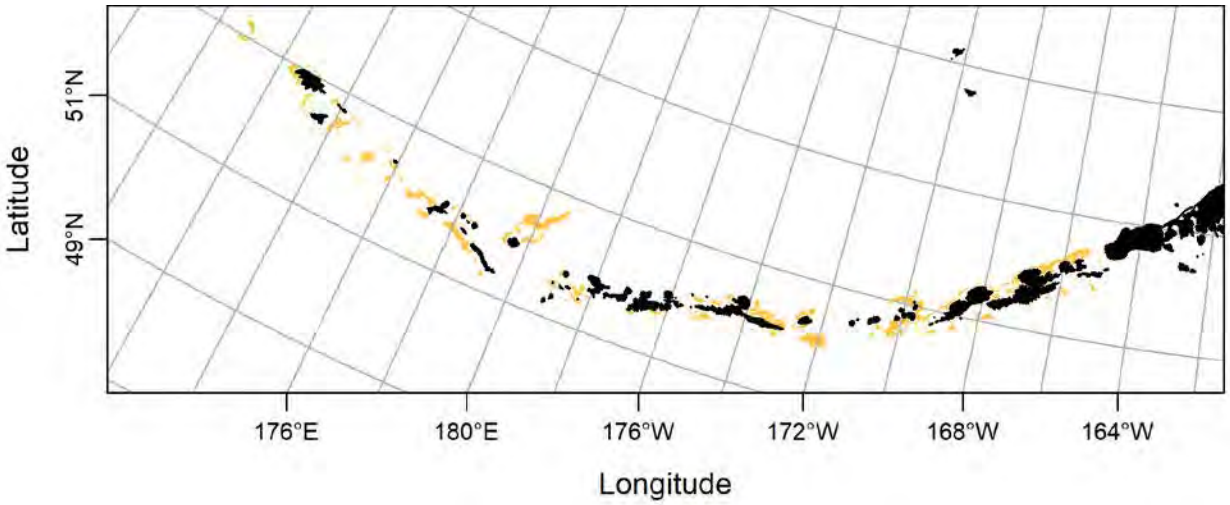

Figure E-281 EFH distribution of AI Yellow Irish lord adult, fall.

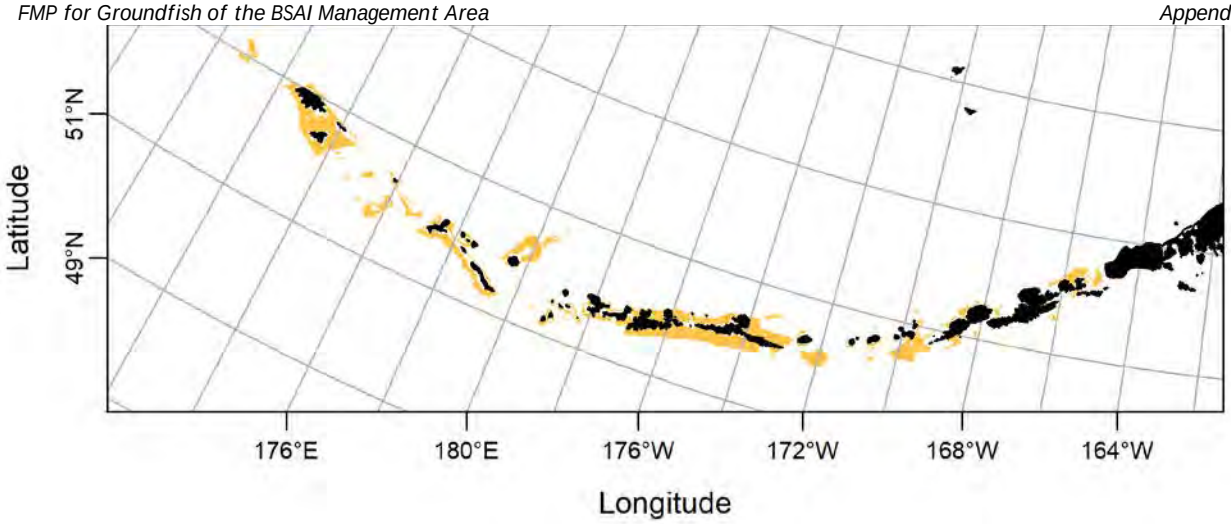

Figure E-282 EFH distribution of AI Yellow Irish lord adult, spring.

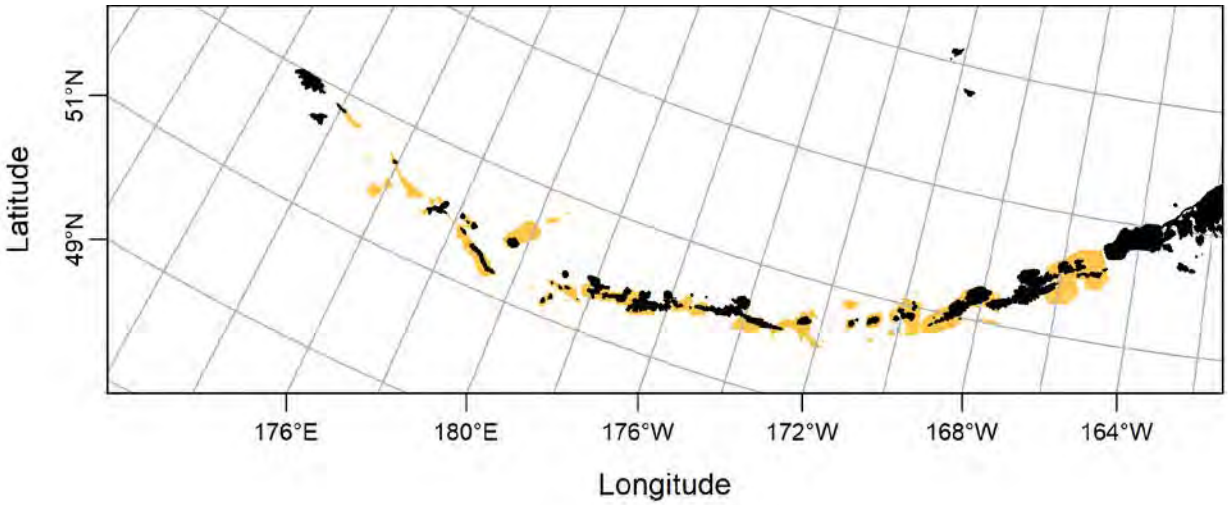

Figure E-283 EFH distribution of AI Yellow Irish lord adult, summer.

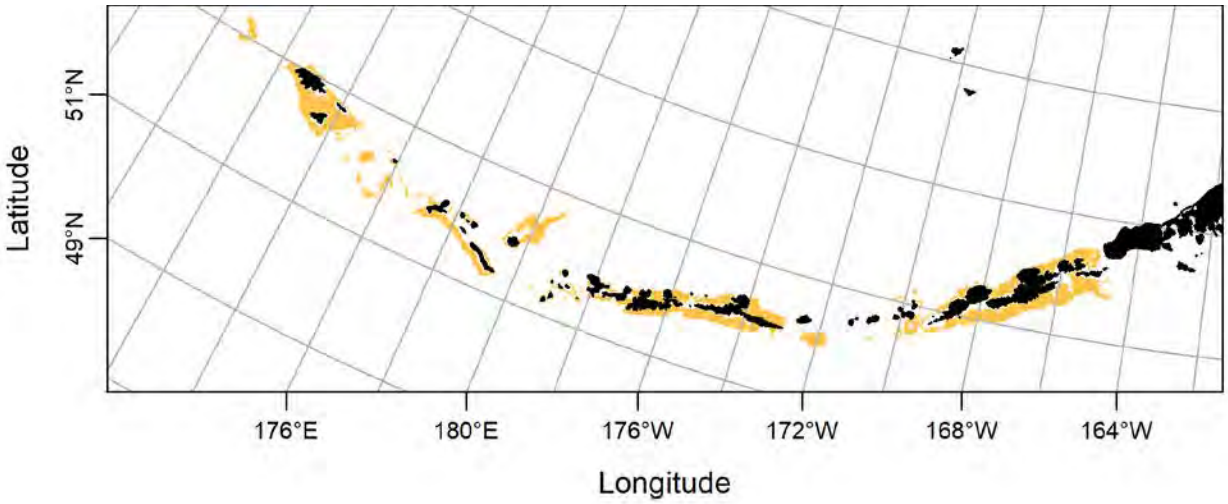

Figure E-284 EFH distribution of AI Yellow Irish lord adult, winter.

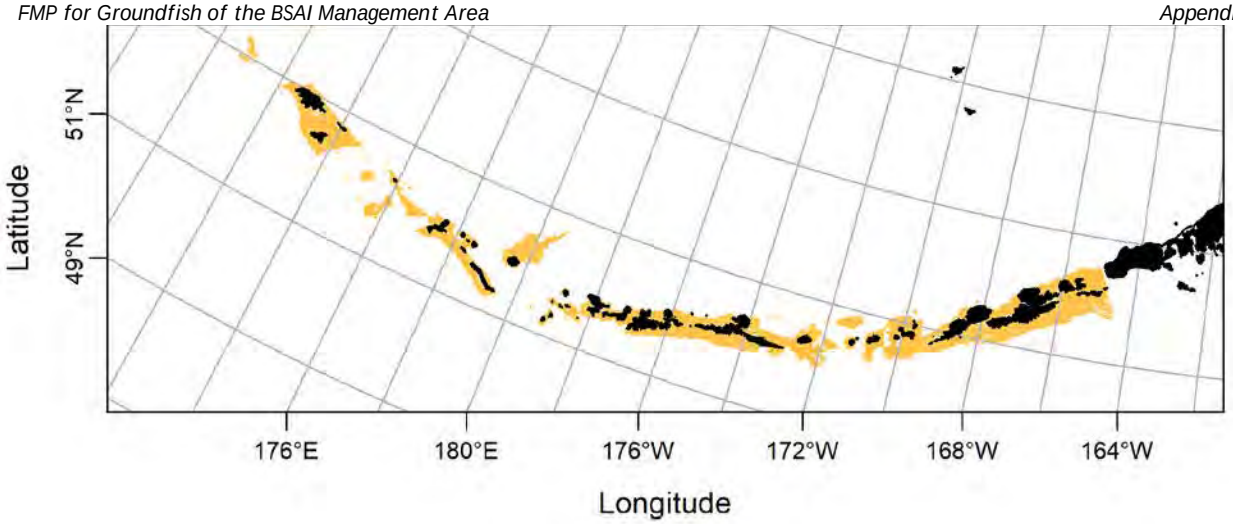

Figure E-285 EFH distribution of AI Yellow Irish lord juvenile, summer.

F. Appendix F Adverse Effects on Essential Fish Habitat

This appendix includes a discussion of fishing (Section F.1) and non-fishing (Section F.2) activities that may adversely affect essential fish habitat (EFH) for Bering Sea and Aleutian Islands (BSAI) groundfish, as well as a discussion of the potential impact of cumulative effects on EFH (Section F.3).

F.1 Fishing Activities that may Adversely Affect 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 must 1) describe each fishing activity, 2) review and discuss all available relevant information, and 3) provide conclusions regarding whether and how each fishing activity adversely affects EFH. Relevant information includes the intensity, extent, and frequency of any adverse effect on EFH; the type of habitat within EFH that may be affected adversely; and the habitat functions that may be disturbed.

In addition, the evaluation should 1) consider the cumulative effects of multiple fishing activities on EFH, 2) list and describe the benefits of any past management actions that minimize potential adverse effects on EFH, 3) give special attention to adverse effects on habitat areas of particular concern (HAPCs) and identify any EFH that is particularly vulnerable to fishing activities for possible designation as HAPCs, 4) consider the establishment of research closure areas or other measures to evaluate the impacts of fishing activities on EFH, and use the best scientific information available, as well as other appropriate information sources.

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

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

F.1.2 Background on Fishing Effects modeling

The Council is required to minimize adverse effects of fishing on EFH that are more than minimal and not temporary in nature. Scientists from AFSC developed the Long-term Effects Index (LEI) for the purpose of analyzing the effects of fishing activities on EFH (Fujioka 2006). The 2005 EFH FEIS concluded that

no Council-managed fishing activities have more than minimal and temporary adverse effects on EFH. Nonetheless, the Council initiated a variety of practicable and precautionary measures to conserve and protect EFH.

The Center for Independent Experts (CIE) completed an independent peer review of the technical aspects and assessment methodology used by NMFS to evaluate the effects of fishing on EFH in Alaska for the 2005 EFH EIS (CIE 2004). Specifically, the reviewers focused on two broad issues: 1) the fishing effects model used to assess the impact of fishing on different habitat types, and 2) the analytical approach employed to evaluate the effects of fishing on EFH, particularly the use of stock abundance relative to the Minimum Stock Size Threshold (MSST) to assess possible influence of habitat degradation on the productivity of fish stocks. Many of the panel's comments, criticisms, and concerns are provided in the panel chair's summary report and are embodied as a succinct set of short-term and long-term recommendations (https://alaskafisheries.noaa.gov/habitat/cie-review). NMFS' response (available on the same website) to many of the technical recommendations raised by the CIE review panel provide additional points of clarification and propose additional analyses and activities. Issues of a policy nature (e.g., the appropriate level of precaution; inclusion of the opinions, information and data of stakeholders; etc.) were outside the scope of this technical response.

The CIE panel's reports included the following findings:

- The model was well conceived and is useful in providing estimates of the possible effects of fishing on benthic habitat. However, the parameters estimates are not well resolved and have high uncertainty due in large part to a paucity of data. Results must be viewed as rough estimates only.
- Validation of the model using data from Alaskan waters as well as other regions is essential to confirm the usefulness of the model. A hindcast using the model would also help to clarify how existing conditions relate to historical patterns.
- The use of stock status relative to the Minimum Stock Size Threshold to assess possible influence of habitat degradation on fish stocks is inappropriate. MSST is not a sufficiently responsive indicator and provides no spatial information about areas with potential adverse effects. Instead, the approach should include examination of time series indices such as size-at-age, population size structure, fecundity, gut fullness, spatial patterns in fish stocks relative to fishing effort, and the history of stock abundance.
- The analysis may underestimate the recovery rate of sponge habitat, and should incorporate more information about the rate of destruction of hard corals and sponges.
- Use the precautionary approach especially where data are unclear, recovery times are long (e.g., coral and sponge), or habitat reduction is high, even if stock abundance levels are above MSST.
- The analysis did not give adequate consideration to localized (versus population level) habitat impacts.
- The evaluations for effects on individual species should include clearer standards for incorporating professional judgment, and should be supplemented with information from stakeholders.

The conclusion that effects of fishing on EFH are no more than minimal is premature. In the 2010 EFH Review, NMFS reviewed the status of the LEI model with work done both within and outside the ASFC but found there was little new information to update the model as structured.

For the 2015 EFH Review, the Fishing Effects (FE) model was developed by the NMFS Alaska Region Office – HCD and scientists at Alaska Pacific University to make input parameters more intuitive and to draw on the best available data. Most of the comments from the 2004 CIE review have been addressed, with the exception of issues related to long-lived species such as corals, and localized impacts. HCD plans to work with stock authors on issues related to localized impacts, and the SSC supported an updated CIE review in 2018.

F.1.3 Effects of Fishing Analysis

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

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

1. The FE model is cast in a discrete time framework. This means rates such as impact or recovery are defined over a specific time interval, compared to the LEI model which used continuous time. Using discrete time makes fishing impacts and habitat recovery more intuitive to interpret compared to continuous time.

2. The FE model implements sub-annual (monthly) tracking of fishing impacts and habitat disturbance. While this was theoretically possible in the LEI model, the LEI model was developed primarily to estimate long term habitat disturbance given a constant rate of fishing and recovery. The FE model allows for queries of habitat disturbance for any month from the start of the model run (January 2003). This aids in the implications of variable fishing effort within season and among years.

3. The FE model draws on the spatially explicit Catch-In-Areas (CIA) database to use the best available spatial data of fishing locations. The CIA database provides line segments representing the locations of individual tows or other bottom contact fishing activities. This provides a more accurate allocation of fishing effort among grid cells. In comparison, the LEI model used haulback locations summarized to the 25 km^2 grids to represent fishing activity. The description of fishing gears that may contact benthic habitat was also greatly improved with significant input from fishing industry representatives.

4. The FE model incorporates an extensive, global literature review from Grabowski et al. (2014) to estimate habitat susceptibility and recovery dynamics. The FE model identifies 27 unique biological and geological habitat features and incorporates impact and recovery rates to predict habitat reduction and recovery over time. The FE model is also designed to be flexible to produce output based on any single habitat feature or unique combination of features.

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

F.1.4 Habitat categorization

The FE and LEI model both consider habitat impacts and recovery at the level of habitat features, where habitat is the sum total of all habitat features. Aside from structural differences between models (i.e., continuous vs discrete time), both LEI and FE treat habitat features in the same way, just define them differently. The 2005 EFH FEIS analyzed approximately 2,000 sediment point data and divided Bering Sea habitat types into four sediment types—sand, mixed sand and mud, and mud. Additional categories were added for the slope below 200 m depth and the northern shelf. The ability to classify habitats in the Aleutian Islands and Gulf of Alaska was highly constrained due to the lack of comprehensive sediment distribution data, so the RACE survey strata, split into shallow, deep, and slope were used. The LEI model defined four broad habitat features: infaunal prey, epifaunal prey, biological structure, and physical

structure. The FE model, in contrast, defines 27 habitat features which can be grouped into biological or geological features. These 27 habitat features were drawn from the literature review described above. The FE model, however, is flexible to produce results over any combination of habitat features, if for example a specific subset of habitat features was important for a specific species.

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

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

F.1.5 General Fishing Gear Impacts

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

F.1.5.1 Bottom Trawls

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

Infaunal Prey

Infaunal organisms, such as polychaetes, other worms, and bivalves, are significant sources of prey for Alaska groundfish species. Studies of the effects of representative trawl gear on infauna included Kenchington et al. (2001), Bergman and Santbrink (2000), Brown (2003), Brylinsky et al. (1994), and Gilkinson et al. (1998).

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

Bergman and Santbrink (2000) studied effects on infauna (mostly bivalves) from an otter trawl equipped with

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

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

Brylinsky et al. (1994) investigated effects of trawling on infauna, mainly in trawl door tracks, at an intertidal estuary. Eight results on the effects of trawl doors on species biomass were available for polychaetes and nemerteans. These results had a median of 31 percent reduction in biomass and a 75th percentile of 42 percent reduction in biomass. Gilkinson et al. (1998) used a model trawl door on a prepared substrate to estimate that 64 percent of clams in the door's path were exposed after one pass, but only 5 percent were injured.

Epifaunal Prey

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

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

The study of McConnaughey et al. (2000) compared the effects of fishing on an area that received heavy fishing pressure between 4 and 8 years previously, using an adjacent unfished area as a control. Therefore, results included a combination of species reductions and recovery, were not adjusted for multiple contacts, and were not directly comparable to the results of the studies above.

Freese et al. (1999) studied the effects of tire gear on the epifauna of a pebble and boulder substrate. Eight epifaunal species gave a median response of 17 percent reduction in biomass and a 75th percentile of 43 percent reduction in biomass. The authors noted a strong transition to apparently smaller effects outside of the direct path of the tire gear.

Living Structure

Organisms that create habitat structure in Alaska waters include sponges, bryozoans, sea pens, soft and stony corals, anemones, and stalked tunicates. Studies of the effects of representative trawls on these groups include Van Dolah et al. (1987), Freese et al. (1999), Moran and Stephenson (2000), Prena et al. (1999), and

McConnaughey et al. (2000). The first three studies examined the effects on epifauna on substrates such as pebble, cobble, and rock that support attached erect organisms, while the last two studies were located on sandy substrates. Effect estimates were available for only one type of structure-providing organism, the soft coral *Gersemia*, from Prena et al. (1999).

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

Hard Corals

While numerous studies have documented damage to hard corals from trawls (e.g., Fossa 2002, Clark and O'Driscoll 2003), only one (Krieger 2001) was found that related damage to a known number of trawl encounters. Fortunately, this study occurred in the GOA with a common species of gorgonian coral (*Primnoa rubi*) and with gear not unlike that used in Alaska commercial fisheries. Krieger used a submersible to observe a site where large amounts of *Primnoa* were caught during a survey trawl. An estimated 27 percent of the original volume of coral was removed by the single trawl effort. The site was in an area closed to commercial trawling, so other trawling effects were absent.

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

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

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

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

plans (especially juveniles) and the contribution of deep-sea coral and sponge ecosystems to fisheries production;

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

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

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

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

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

Non-living Structure

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

Sand and Silt Substrates:

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

marks; these papers include Gilkinson et al. (1998), who describe the scouring process in detail as part of a model door study.

For effects on sedimentary forms, the action of roller gear trawls replaces one set of cm-scale forms, such as hummocks and sand ripples, with door and roller tracks of similar scales. In habitats with an abundance of such structures, this can represent a decrease in seabed complexity, while in relatively smooth areas, an increase in complexity will result (Smith et al. 2000). The effects on internal sediment structure are considered too small in scale to provide shelter directly to the juveniles of managed species. The extent to which they affect the availability of prey for managed species is better measured by directly considering the abundance or those prey species.

Pebble to Boulder Substrates:

In substrates composed of larger particles (large pebbles to boulders), the interstitial structure of the substrate has a greater ability to provide shelter to juveniles and adults of managed species. The association of species aggregations with such substrates provides evidence of their function as structure (Krieger 1992, 1993). Freese et al. (1999) documented that the tire gear section of a trawl disturbed an average of 19 percent of the large boulders (more than 0.75-m longest axis) in its path. They noted that displaced boulders can still provide cover, while breaking up boulder piles can reduce the number and complexity of crevices.

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

F.1.5.2 Pelagic Trawls

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

Sessile organisms that create structural habitat may be uprooted or pass under pelagic trawl footropes, while those that are more mobile or attached to light substrates may pass over the footrope, with less resulting damage. Non-living structures may be more affected by pelagic trawl footropes than by bottom trawl footropes because of the continuous contact and smaller, more concentrated, surfaces over which weight and towing force are applied. In contrast, bottom trawls may capture and remove more of the large organisms that provide structural habitat than pelagic trawls because of their smaller mesh sizes. The bottom trawl doors and footropes could add complexity to sedimentary bedforms as mentioned previously, while pelagic trawls have an almost entirely smoothing effect.

F.1.5.3 Longlines

The light weight of the lines used with longline gear, effects on either infaunal or epifaunal prey organisms are considered to be limited to anchors and weights. Since these components make up less than 1/500th of the length of the gear, their effects are considered very limited (0.05 percent reduction per contact was the value

used). Similarly, effects on the non-living structure of soft bottoms are also likely to be very limited.

Organisms providing structure may be hooked or otherwise affected by contact with the line. Observers have recorded anemones, corals, sea pens, sea whips, and sponges being brought to the surface hooked on longline gear (Stellar sea lion protection measures SEIS, 2001), indicating that the lines move some distance across the seafloor and can affect some of the benthic organisms. The effects on non-living structure in hard-bottom areas due to hang-ups on smaller boulder piles and other emergent structures are limited to what may occur at forces below those necessary to break the line. Similar arguments to those used for bottom trawl effects on hard non-living structure would justify an even lower effect than the value generated for bottom-trawling (1 percent). Unfortunately, there are no data to indicate what proportion the retained organisms represent of those contacted on the seafloor or the level of damage to any of the affected organisms.

F.1.5.4 Pots

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

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

F.1.5.5 Dinglebar

Dinglebar troll gear (Figure 3-9 of the HAPC EA) consists of a single line that is retrieved and set with a power or hand troll gurdy, with a terminally attached weight (cannon ball -12 lbs. or iron bar), from which one or more leaders with one or more lures or baited hooks are pulled through the water while a vessels is underway (NPFMC 2003). Dinglebar troll gear is essentially the same as power or hand troll gear, the difference lies in the species targeted and the permit required. For example, dinglebar troll gear can be used in the directed fisheries for groundfish (e.g., cod) or halibut. These species may only be taken incidentally while fishing for salmon with power or hand troll gear. There is a directed fishery for ling cod in Southeast Alaska using dinglebar troll gear. Trolling can occur over any bottom type and at almost any depths. Trollers work in shallower coastal waters, but may also fish off the coast, such as on the Fairweather Grounds. The dinglebar is usually made of a heavy metal, such as iron, is used in nearly continuous contact with the bottom, and therefore, is likely to disturb bottom habitat.

F.1.5.6 Dredge Gear

Dredging for scallops may affect groundfish habitat by causing unobserved mortality to marine life and modification of the benthic community and sediments. Similar to trawling, dredging places fine sediments into suspension, buries gravel below the surface and overturns large rocks that are embedded in the substrate (NEFMC 1982, Caddy 1973). Dredging can also result in dislodgement of buried shell material, burying of gravel under re-suspended sand, and overturning of larger rocks with an appreciable roughening of the sediment surface (Caddy 1968). A study of scallop dredging in Scotland showed that dredging caused significant physical disturbance to the sediments, as indicated by furrows and dislodgement of shell fragments and small stones (Eleftheriou and Robertson 1992). The authors note, however, that these changes in bottom topography did not change sediment disposition, sediment size, organic carbon content, or chlorophyll content. Observations of the Icelandic scallop fishery off Norway indicated that dredging changed the bottom substrate from shell-sand to clay with large stones within a 3-year period (Aschan 1991). Mayer et al. (1991), investigating the effects of a New Bedford scallop dredge on

sedimentology at a site in coastal Maine, found that vertical redistribution of bottom sediments had greater implications than the horizontal translocation associated with scraping and plowing the bottom. The scallop dredge tended to bury surficial metabolizable organic matter below the surface, causing a shift in sediment metabolism away from aerobic respiration that occurred at the sediment-water interface and instead toward subsurface anaerobic respiration by bacteria (Mayer et al. 1991). Dredge marks on the sea floor tend to be short-lived in areas of strong bottom currents, but may persist in low energy environments (Messieh et al. 1991).

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

F.1.6 Fishing Effects Vulnerability Assessment

A goal of the vulnerability assessment is to base estimates of susceptibility and recovery of features to gear impacts on the scientific literature to the extent possible. In previous EFH fishing effects analyses (2005 and 2010), an overview of new and existing research on the effects of fishing on habitat was included section F.1.4 of this document. Each of the inputs to the fishing effects model were evaluated, including the distribution of fishing intensity for each gear type, spatial habitat classifications, classification of habitat features, habitat- and feature-specific recovery rates, and gear- and habitat-specific sensitivity of habitat features. Many of these estimates were best professional judgement by fisheries managers and scientists.

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

A Microsoft Access database was developed to organize the review and to identify in detail the gear types and habitat features evaluated in each study. In addition to identifying gear types and features, the database included field codes for basic information about study location and related research; study design, relevance and appropriateness to the vulnerability assessment; depth; whether recovery of features is addressed; and substrate types found in the study area. Analysts interacted with the database via an Access form (Figure 2).

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

As a model parameterization tool, the vulnerability assessment quantifies both the magnitude of the impacts that result from the physical interaction of fish habitats and fishing gears, and the duration of recovery following those interactions. This vulnerability information from this database has been

F.1.9 References

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modified to condition area swept (i.e., fishing effort) in the FE model via a series of susceptibility and recovery parameters.

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

F.1.7 Impact Assessment Methods

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

In December 2016, the Council approved a three-tiered method to evaluate whether there are adverse effects of fishing on EFH (Figure 4). This analysis considers impacts of commercial fishing first at the population level, then uses objective criteria to determine whether additional analysis is warranted to evaluate if habitat impacts caused by fishing are adverse and more than minimal or not temporary.

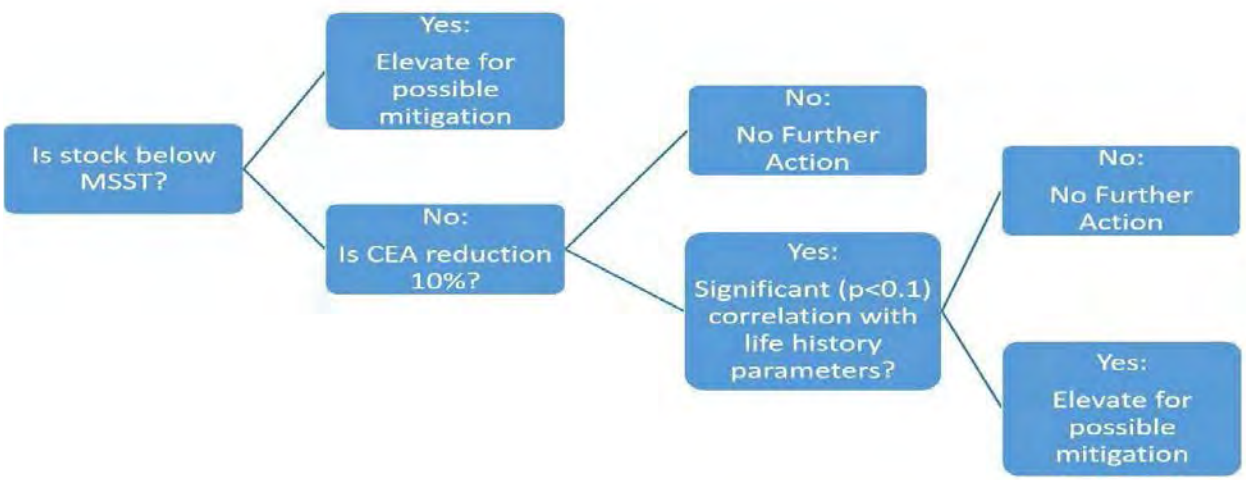

Figure F-1 Three-tiered method to evaluate effects of fishing on Essential Fish Habitat in Alaska.

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

To investigate the potential relationships between fishing effects and stock production, the stock assessment authors examined trends in life history parameters and the amount of disturbed habitat in the "core EFH Area" (CEA) for each species. The CEA is identified as the predicted 50 percent quantile threshold of suitable habitat or summer abundance (Laman et al., In Press, Turner et al. In Press, Rooney

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

Reports from the stock assessment authors were collated and presented to representatives of the GOA and BSAI Groundfish Plan Teams and the Crab Plan Team. Plan Team representatives reviewed the reports on March 7, 2017. Representatives concurred with the stock assessment authors determinations in all cases. None of the stock assessment authors concluded that habitat reduction within the CEA for their species was affecting their stocks in ways that were more than minimal or not temporary. None of the authors recommended any change in management with regard to fishing within EFH.

F.1.8 Cumulative Effects of Fishing on Essential Fish Habitat

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

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

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

In April 2016, the SSC recommended that new methods and criteria be developed to evaluate whether the effects of fishing on EFH are more than minimal and not temporary. Criteria were developed by NMFS and researchers at Alaska Pacific University, and reviewed by the Council and its advisory committees in 2016, and the stock assessment authors in 2017. In April 2017, based on the analysis with the FE model, the Council concurred with the Plan Team consensus that the effects of fishing on EFH do not currently meet the threshold of more than minimal and not temporary, and mitigation action is not needed at this time.

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

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F.2 Non-fishing Activities that may Adversely Affect Essential Fish Habitat

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

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

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

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

mitigation, as defined for section 404 of the Clean Water Act (CWA) should be adhered too.

Table 11 identifies activities other than fishing that may adversely affect EFH and identifies known and potential adverse effects to EFH. More information on these activities and the potential adverse effects is provided in the non-fishing impacts report (Limpensel et al. 2017).

Table 1 Summary on Non-Fishing Effects on Habitat

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

* - short term impact

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

As previously identified in Section 4.4 EFH-EIS (NMFS 2005), historical fishing practices may have had effects on EFH that have led to declining trends in some of the criteria examined (Table 4.4-1). For fishing impacts to EFH, the FE model calculates habitat reductions at a monthly time step since 2003 and incorporates susceptibility and recovery dynamics, allowing for an assessment of cumulative effects from fishing activities for the first time. As identified in Section A.4, the effects of current fishing activities on EFH are considered as minimal and temporary or unknown using the new methods.

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

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