# Fishery Management Plan

# for Groundfish of the

# Bering Sea and Aleutian Islands Management Area

## APPENDICES

# Appendix A History of the Fishery Management Plan

The Fishery Management Plan (FMP) for Bering Sea and Aleutian Islands (BSAI) Groundfish was implemented on January 1, 1982. Since that time it has been amended over seventy times, and its focus has changed from the regulation of mainly foreign fisheries to the management of fully domestic fisheries. The FMP was substantially reorganized in Amendment 83. Outdated catch data or other scientific information, and obsolete references, were also removed or updated.

Section A.1 contains a list of amendments to the FMP since its implementation in 1982. A detailed account of each of the FMP amendments, including its purpose and need, a summary of the analysis and implementing regulations, and results of the amendment, is contained in Appendix C to the *Final Programmatic Supplemental Environmental Impact Statement for the Alaska Groundfish Fisheries*, published by National Marine Fisheries Service (NMFS) in 2004.

## A.1 Amendments to the FMP

Amendment 1, implemented January 1, 1984, supersedes Amendments 2 and 4:

1. Established a multi-year, multi-species optimum yield for the groundfish complex.
2. Established a framework procedure for determining and apportioning total allowable catch (TAC), reserves, and domestic annual harvest (DAH).
3. Eliminated the “Misty Moon” grounds south of the Pribilof Islands from the Winter Halibut Savings Area.
4. Allowed experimental year-round domestic trawling in the Winter Halibut Savings Area that will be closely monitored to the extent possible.
5. Allowed year-round domestic trawling in the Bristol Bay Pot Sanctuary and year-round domestic longlining in the Winter Halibut Savings Area.
6. Closed the Petrel Bank area to foreign trawling from July 1 through June 30.
7. Established the Resource Assessment Document as the biological information source for management purposes.
8. Specified that the fishing and FMP year is the calendar year.

Amendment 1a, implemented January 2, 1982:

Set a chinook salmon prohibited species catch (PSC) limit of 55,250 fish for the foreign trawl fisheries for 1982.

Amendment 2, implemented January 12, 1982:

1. For Yellowfin Sole, increased DAH to 26,000 mt from 2,050 mt, increased joint venture processing (JVP) 25,000 mt from 850 mt, and decreased total allowable level of foreign fishing (TALFF) by 24,150 mt.
2. For Other Flatfish, increased DAH to 4,200 mt from 1,300 mt, increased JVP to 3,000 mt from 100 mt, and decreased TALFF by 2,900 mt.
3. For Pacific Cod, decreased maximum sustainable yield to 55,000 mt from 58,700 mt, increased equilibrium yield to 160,000 mt from 58,700 mt, increased acceptable biological catch to 160,000 mt

from 58,700 mt, increased optimum yield to 78,700 mt from 58,700 mt, increased reserves to 3,935 mt from 2,935 mt, increased domestic annual processing (DAP) to 26,000 mt from 7,000 mt, and increased DAH to 43,265 mt from 24,265 mt.

Amendment 3, implemented July 4, 1983, supersedes Amendments 1a and 5:

1. Established procedures for reducing the incidental catch of halibut, salmon, king crab and Tanner crab by the foreign trawl fisheries.
2. Established a Council policy on the domestic groundfish fisheries and their incidental catch of prohibited species.

Amendment 4, implemented May 9, 1983, supersedes Amendment 2:

1. For Pollock, increased JVP for Bering Sea to 64,000 mt from 9,050 mt, increased DAH to 74,500 mt from 19,550 mt, and decreased TALFF to 875,500 mt from 930,450 mt.
2. For Yellowfin Sole, increased JVP to 30,000 mt from 25,000 mt, increased DAH to 31,200 mt from 26,200 mt, and decreased TALFF to 79,950 mt from 84,950 mt.
3. For Other Flatfish, increased JVP to 10,000 mt from 3,000 mt, increased DAH to 11,200 mt from 4,200 mt, and decreased TALFF to 46,750 mt from 53,750 mt.
4. For Atka Mackerel, increased JVP to 14,500 mt from 100 mt, increased DAH to 14,500 mt from 100 mt, and decreased TALFF to 9,060 mt from 23,460 mt.
5. For Other Species, increased JVP to 6,000 mt from 200 mt, increased DAH to 7,800 mt from 2,000 mt, and decreased TALFF to 65,648 mt from 68,537 mt. Also corrected acceptable biological catch to 79,714 mt, optimum yield to 77,314 mt, and reserves to 3,866 mt.
6. For Pacific Cod, increased equilibrium yield and acceptable biological catch to 168,000 mt from 160,000 mt, increased optimum yield to 120,000 mt from 78,700 mt, increased reserves to 6,000 mt from 3,935 mt, and increased TALFF to 70,735 mt from 31,500 mt.
7. For Other Rockfish, assigned DAP of 1,100 mt to BSAI area combined. This caused no change in total DAP. (This conformed FMP with federal regulations.)
8. For Pacific Ocean Perch, assigned DAP of 550 mt to Bering Sea and 550 mt to Aleutians but caused no change in total DAP. Also assigned JVP of 830 mt to Bering Sea and 830 mt to Aleutians without changing total JVP. (This conformed FMP with federal regulations.)
9. For Sablefish, assigned JVP of 200 mt to Bering Sea and 200 mt to Aleutians without changing total JVP. (This conformed FMP with federal regulations.) Changed maximum sustainable yield to 11,600 mt in Bering Sea and 1,900 mt in Aleutians to eliminate inconsistencies with annexes.
10. Changed foreign fisheries restrictions to allow trawling outside 3 miles north of the Aleutian Islands between 170E30' W. and 172E W. longitude, and south of the Aleutian Islands between 170E W. and 172E W. longitude; and to allow longlining outside 3 miles west of 170E W. longitude.

Amendment 5, withdrawn from Secretarial review.

Amendment 6, disapproved by NMFS on December 8, 1983:

Would have established a fishery development zone for exclusive use by U.S. fishing vessels where no foreign directed fishing is permitted.

Amendment 7, implemented August 31, 1983:

Modified the December 1 to May 31 depth restriction on the foreign longline fisheries in the Winter Halibut Savings Area.

Amendment 8, implemented February 24, 1984, supplements Amendment 3:

Established 1984 and 1985 salmon PSCs for the foreign trawl fishery. This amendment was a regulatory amendment which fell within the purview of Amendment 3 and did not require formal Secretarial approval.

Amendment 9, implemented December 1, 1985:

1. Require all catcher/processors that hold their catch for more than two weeks to check in and check out by radio from a regulatory area/district and to provide a written catch report weekly to the NMFS Regional Office.
2. Incorporated habitat protection policy.
3. Established definition for directed fishing as 20 percent or more of the catch.

Amendment 10, implemented March 16, 1987:

1. Established Bycatch Limitation Zones for domestic and foreign fisheries for yellowfin sole and other flatfish (including rock sole); an area closed to all trawling within Zone 1; red king crab, *C. bairdi* Tanner crab, and Pacific halibut PSC limits for DAH yellowfin sole and other flatfish fisheries; a *C. bairdi* PSC limit for foreign fisheries; and a red king crab PSC limit and scientific data collection requirement for U.S. vessels fishing for Pacific cod in Zone 1 waters shallower than 25 fathoms.
2. Revised the weekly reporting requirement for catcher/processors and mothership/processors.
3. Established explicit authority for reapportionment between DAP and JVP fisheries.
4. Established inseason management authority.

Amendment 11, implemented December 30, 1987:

1. Established a schedule for seasonal release of joint venture pollock apportionments in 1988 and 1989 (expires December 31, 1989).
2. Revised the definition of prohibited species.
3. Revised the definition of acceptable biological catch and added definitions for threshold and overfishing.

Amendment 11a, implemented April 6, 1988:

Augmented the current domestic catcher/processor and mothership/ processor reporting requirements with at-sea transfer information and modify the weekly reporting requirements.

Amendment 12, implemented May 26, 1989:

1. Revised federal permit requirements to include all vessels harvesting and processing groundfish from the EEZ.

2. Establish a PSC limit procedure for fully utilized groundfish species taken incidentally in JVP and TALFF fisheries.
3. Removed July 1 deadline for Stock Assessment and Fishery Evaluation Report (SAFE).
4. Established rock sole as a target species distinct from the “other flatfish” group.

Amendment 12a, implemented September 3, 1989, replaced Amendment 10:

Established a bycatch control procedure to limit the incidental take of *C. bairdi* Tanner crab, red king crab, and halibut in groundfish fisheries.

Amendment 13, implemented January 1, 1990:

1. Allocated sablefish in the Bering Sea and the Aleutian Islands Management Subareas.
2. Established a procedure to set fishing seasons on an annual basis by regulatory amendment.
3. Established groundfish fishing closed zones near the Walrus Islands and Cape Peirce.
4. Established a new data reporting system.
5. Established a new observer program.
6. Clarified the Secretary's authority to split or combine species groups within the target species management category by a framework procedure.

Amendment 14, implemented January 1, 1991:

1. Prohibited roe-stripping of pollock; and established Council policy that the pollock harvest is to be used for human consumption to the maximum extent possible;
2. Divided the pollock TAC into two seasonal allowances: roe-bearing (“A” season) and non roe-bearing (“B” season). The percentage of the TAC allocated to each allowance shall be determined annually during the TAC specifications process.

Amendment 15, approved by the Secretary on January 29, 1993, implemented March 15, 1995:

1. Established an Individual Fishing Quota (IFQ) program for directed fixed gear sablefish fisheries in the Bering Sea and Aleutian Islands management areas.
2. Established a Western Alaska Community Development Quota (CDQ) Program.

Amendment 16, implemented January 1, 1991, replaced Amendment 12a:

1. Extended the effective date of Amendment 12a (originally scheduled to expire December 31, 1990) with the following three changes:

a) PSC apportionments would be established for the DAP rock sole and deep water turbot/arrowtooth flounder fisheries;

b) PSC limits could be seasonally apportioned; and

c) An interim incentive program established to encourage vessels to avoid excessive bycatch rates.

2. Established a definition of overfishing;
3. Established procedures for interim TAC specifications; and

4. Provided for fishing gear restrictions to be modified by regulatory amendments.

Amendment 16a, implemented July 12, 1991.

1. Established inseason authority to temporarily close statistical areas, or portions thereof, to reduce high prohibited species bycatch rates.
2. Provided authority to the Regional Administrator, in consultation with the Council, to set a limit on the amount of the pollock TACs that may be taken with other than pelagic trawl gear.
3. Established a framework for determining an annual herring PSC limit as 1 percent of the estimated herring biomass, attainment of which triggers trawl closures in three Herring Savings Areas.

Amendment 17, implemented April 24, 1992:

1. Authorize the NMFS Regional Administrator to approve exempted fishing permits after consultation with the Council.
2. Establish a unique Bogoslof District as part of the Bering Sea subarea, for which a pollock harvest quota would be annually specified. Fishing for pollock in the remaining parts of the Bering Sea subarea will be unaffected by any closure of the Bogoslof District.

Amendment 18, implemented June 1, 1992 and revised Amendment 18 on December 18, 1992:

1. The Pollock TAC in the BSAI, after subtraction of the reserve, is allocated between inshore and offshore components during the years 1992 through 1995. The inshore component receives 35 percent of the pollock TAC, and the offshore component receives 65 percent.
2. A Catcher Vessel Operational Area (CVOA) is established to limit access to pollock within the area to catcher vessels delivering to the inshore component. This area is between 163E W. and 168E W. longitude, south of 56E N. latitude, and north of the Aleutian Islands. During the 1992 "B" season, the offshore component will not be allowed to fish within the CVOA.
3. Half of the amount of BSAI pollock assigned to the nonspecific reserve (7.5 percent of the BSAI TAC) is allocated as Western Alaska CDQ Program.

Amendment 19, implemented September 23, 1992, supplemented Amendment 16:

1. Revise time and area closure (hotspot) authority in the BSAI to authorize, by regulatory amendment, the establishment of time and area closures to reduce bycatch rates of prohibited species. Any closure of an area would require a determination by the Secretary, in consultation with the Council.
2. Expand the Vessel Incentive Program to include all trawl fisheries in the BSAI.
3. Delay opening of all trawl fisheries in the BSAI until January 20. The opening date for non-trawl fisheries, including hook and line, pot and jigging, will continue to be January 1.
4. Establish, for the 1992 season only, a halibut PSC limit of 5,033 mt for the BSAI trawl fishery. Also, a 750 mt halibut PSC mortality limit for the non-trawl fisheries will be established for one year.
5. Establish new halibut and crab PSC apportionment categories. A trawl fishery category closes when it reaches a PSC bycatch allowance allocated to that category.
6. Establish new fishery definitions. The fishery definitions for both the Vessel Incentive Program and the PSC allowance limits would be the same. The definitions of fisheries for these programs would be as follows:
   a) Mid-water pollock if pollock is ∃ to 95 percent of the total catch.

b) Other targets determined by the dominate species in terms of retained catch.

c) For the BSAI, a flatfish fishery consisting of rocksole, yellowfin sole, and other flatfish (excluding Greenland turbot and arrowtooth flounder) will be defined and then subdivided into three fisheries. If yellowfin sole accounts for at least 70% of the retained flatfish catch, it is a yellowfin sole fishery. Otherwise, it is a rock sole or other flatfish fishery depending on the which is dominant in terms of retained catch.

7. To allow more effective enforcement of directed fishery closures and to further limit trawl bycatch amounts of halibut after a halibut PSC bycatch allowance has been reached, changes to Directed Fishing Standards include:

a) Directed fishing standards would be seven percent of the aggregate amounts of GOA and BSAI groundfish other than pollock, that are caught while fishing for pollock with pelagic trawl gear.

b) For purposes of the directed fishing rule, the operator of a vessel is engaged in a single fishing trip, from the date when fishing commences or continues in an area after the effective date of a notice prohibiting directed fishing in that area, until the first date on which at least one of following occurs: 1) a weekly reporting period ends; 2) the vessel enters or leaves a reporting area for which an area specific TAC or directed fishing standard is established; or 3) any fish or fish product is offloaded or transferred from that vessel.

Amendment 20, implemented January 19, 1992:

Prohibit trawling year round in the BSAI within 10 nautical miles of 27 Steller sea lion rookeries. In addition, five of these rookeries will have 20 nautical mile trawl closures during the pollock “A” season. These closures will revert back to 10 nautical miles when the “A” season is over, either on or before April 15.

Amendment 21, implemented March 17, 1993, superseded Amendment 16:

Established FMP authority to specify trawl and non-trawl gear halibut bycatch mortality limits by regulatory amendment.

Amendment 21a, implemented January 20, 1995:

Established a Pribilof Islands Habitat Conservation Area.

Amendment 21b, implemented November 29, 1995:

Established trawl closure areas called the Chinook Salmon Savings Areas.

Amendment 22, implemented December 22, 1992:

Established trawl test areas for the testing of trawl gear in preparation of the opening of fishing seasons. Fishermen are allowed to test trawl gear when the BSAI would otherwise be closed to trawling.

Amendment 23, implemented August 10, 1995 and effective on September 11, 1995:

Created a moratorium on harvesting vessels entering the BSAI groundfish fisheries other than fixed gear sablefish after January 1, 1996. The vessel moratorium will last until the Council replaces or rescinds the action, but in any case will end on December 31, 1998. The Council extended the moratorium to January 1, 1999 under Amendment 59. The Council may however extend the moratorium up to 2 additional years, if a permanent limited access program is imminent.

Amendment 24, implemented February 28, 1994, and effective through December 31, 1996:

1. Established the following gear allocations of BSAI Pacific cod TAC as follows: 2 percent to vessels using jig gear; 44.1 percent to vessels using hook-and-line or pot gear, and 53.9 percent to vessels using trawl gear.
2. Authorized the seasonal apportionment of the amount of Pacific cod allocated to gear groups. Criteria for seasonal apportionments and the seasons authorized to receive separate apportionments will be set forth in regulations.

Amendment 25, implemented May 20, 1994, superseded Amendment 21:

Eliminated the primary halibut bycatch mortality limit established for the trawl gear fisheries (3,300 mt). The overall bycatch mortality limit established for these fisheries (3,775 mt) remained unchanged.

Amendment 26, implemented July 24, 1996:

Established a Salmon Donation Program that authorizes the voluntary retention and distribution of salmon taken as bycatch in the groundfish trawl fisheries off Alaska to economically disadvantaged individuals.

Amendment 27, implemented October 6, 1994, superseded Amendments 13 and 18, repealed and replaced by Amendment 47:

Implemented language changes to the Fishery Management Plans to indicate that observer requirements under the FMPs are contained in the North Pacific Fisheries Research Plan.

Amendment 28, implemented August 11, 1993, supplemented Amendment 20:

Established three districts in the Aleutian Islands management subarea for purposes of distributing the groundfish TACs spatially.

Amendment 29, not submitted.

Amendment 30, implemented September 23, 1994, revised Amendment 18:

Raised the CDQ allocation limit for qualified applicants from 12 to 33 percent.

Amendment 31, implemented November 7, 1994, revised Amendment 15:

Implemented the Modified Block plan to prevent excessive consolidation of the halibut and sablefish fisheries, and clarifies the transfer process for the IFQ program.

Amendment 32, implemented February 23, 1996, revised Amendment 15:

Established a one-time transfer of halibut and sablefish IFQ for CDQ.

Amendment 33, implemented July 26, 1996, revised Amendment 15:

Allowed freezing of non-IFQ species when fishing sablefish IFQ.

Amendment 34, implemented January 30, 1994:

Allocated Atka mackerel to vessels using jig gear. Annually, up to 2 percent of the TAC specified for this species in the eastern Aleutian Islands District/Bering Sea subarea will be allocated to vessels using jig gear in this area.

Amendment 35, implemented August 1, 1995:

Established a trawl closure area called the *Chum Salmon Savings Area*.

Amendment 36, implemented April 16, 1998:

Defined a forage fish species category and authorized that the management of this species category be specified in regulations in a manner that prevents the development of a commercial directed fishery for forage fish which are a critical food source for many marine mammal, seabird and fish species.

Amendment 37, implemented January 1, 1997

Established a non-pelagic trawl closure area called the *Red King Crab Savings Area*, a trawl closure area called the Nearshore Bristol Bay Trawl Closure, and revised the red king crab PSC limits.

Amendment 38, implemented January 1, 1996, superseded Amendment 18:

Extended provision of Amendment 18, inshore/offshore allocation and modified the Catcher Vessel Operating Area.

Amendment 39, implemented January 1, 1999, except for some parts on January 1, 2000, replaced Amendment 23 and revised Amendment 18:

1. Created a license program for vessels targeting groundfish in the BSAI, other than fixed gear sablefish that is pending regulatory implementation. The license program will replace the vessel moratorium and will last until the Council replaces or rescinds the action.
2. Allocated 7.5 percent of groundfish TACs to the CDQ multispecies fishery.

Amendment 40, implemented January 21, 1998:

Established PSC limits for *C. opilio* crab in trawl fisheries and a snow crab bycatch limitation zone.

Amendment 41, implemented April 23, 1997, revised Amendment 12a:

Revised the *C. bairdi* Tanner crab PSC limit in Zones 1 and 2.

Amendment 42, implemented August 16, 1996, revised Amendment 15

Increased sweep-up levels for small quota share blocks for sablefish managed under the sablefish and halibut IFQ program.

Amendment 43, implemented December 20, 1996, revised Amendment 15:

Established sweep-up provisions to consolidate very small quota share blocks for halibut and sablefish.

Amendment 44, implemented January 9, 1997, revised Amendment 16:

Established a more conservative definition of overfishing.

Amendment 45, implemented January 21, 1999, superseded Amendment 38:

Reauthorized the pollock CDQ allocation.

Amendment 46, implemented January 1, 1997, superseded Amendment 24:

Replaced the three year Pacific cod allocation established with Amendment 24, with the following gear allocations in BSAI Pacific cod: 2 percent to vessels using jig gear; 51 percent to vessels using hook-and-line or pot gear; and 47 percent to vessels using trawl gear. The trawl apportionment will be divided 50 percent to catcher vessels and 50 percent to catcher processors. These allocations as well as the seasonal apportionment authority established in Amendment 24 will remain in effect until amended.

Amendment 47, not submitted.

Amendment 48, implemented December 8, 2004:

1. Revised the harvest specifications process.
2. Changed the title of the FMP.
3. Update the FMP to reflect current groundfish fisheries.

Amendment 49, implemented January 3, 1998:

Implemented an Increased Retention/Increased Utilization Program for pollock and Pacific cod beginning January 1, 1998 and rock sole and yellowfin sole beginning January 1, 2003.

Amendment 50, implemented July 13, 1998, revised Amendment 26:

Established a Prohibited Species Donation Program that expands the Salmon Donation Program to include halibut taken as bycatch in the groundfish trawl fisheries off Alaska to economically disadvantaged individuals.

Amendment 51, partially implemented January 20, 1999, superseded Amendment 38:

Replaced the three year inshore/offshore allocation established with Amendment 38, with the following allocations of BSAI pollock after subtraction of reserves: 39 percent inshore; 61 percent offshore. That portion of the Bering Sea inshore "B" season allocation which is equivalent to 2.5 percent of the BSAI pollock TAC, after subtraction of reserves, shall be made available only to vessels under 125 ft length overall for delivery to the inshore sector, prior to the Bering Sea "B" season, starting on or about August 25. Any overages or underages will be subtracted/added as part of the inshore "B" season. The rules and regulations pertaining to the CVOA shall remain the same, except that during the "B" season, operations in the CVOA will be restricted to catcher vessels delivering to the inshore sector. These allocations will remain in effect until December 31, 2001, unless replaced by another management regime approved by the Secretary.

Amendment 52, not submitted.

Amendment 53, implemented July 22, 1998:

Allocates shortraker and rougheye rockfish TAC 70 percent to trawl fisheries and 30 percent to non-trawl fisheries.

Amendment 54, implemented April 29, 2002, revised Amendment 15:

Revised use and ownership provisions of the sablefish IFQ program.

Amendment 55, implemented April 26, 1999:

Implemented the Essential Fish Habitat (EFH) provisions contained in the Magnuson-Stevens Fishery Conservation and Management Act and 50 CFR 600.815. Amendment 55 describes and identifies EFH fish habitat for BSAI groundfish and describes and identifies fishing and non-fishing threats to BSAI groundfish EFH, research needs, habitat areas of particular concern, and EFH conservation and enhancement recommendations.

Amendment 56, implemented March 8, 1999, revised Amendment 44:

Revised the overfishing definition.

Amendment 57, implemented June 15, 2000, revised Amendment 37 and Amendment 40:

1. Prohibited the use of nonpelagic trawl gear in the directed pollock fishery.
2. Reduced the PSC limit for red king crab by 3,000 animals.

Amendment 58, implemented November 13, 2000, revised Amendment 21b:

Revised Chinook Salmon Savings Areas trawl closure areas.

Amendment 59, implemented January 19, 1999, superseded Amendment 23:

Extended the vessel moratorium through December 31, 1999.

Amendment 60, implemented October 24, 2001 and January 1, 2002; superseded Amendment 59:

1. Required that the vessel would be a specific characteristic of the license and could not be severed from it.
2. Authorized license designations for the type of gear to harvest LLP groundfish as either "trawl" or "non-trawl" gear (or both).
3. Rescinded the requirement that CDQ vessels hold a crab or groundfish license.
4. Added a crab recency requirement which requires one landing during 1/1/96-2/7/98 in addition to the general license and area endorsement qualifications.
5. Allowed limited processing (1 mt) for vessels less than 60 ft LOA with catcher vessel designations.

Amendment 61, implemented January 21, 2000, conformed the FMP with the American Fisheries Act (AFA) of 1998 that:

1. Removed excess capacity in the offshore pollock sector through the retirement of 9 factory trawlers.
2. Established U.S. ownership requirements for the harvest sector vessels.
3. Established specific allocations of the BSAI pollock quota as follows - 10 percent to the western Alaska CDQ Program, with the remainder allocated 50 percent to the onshore sector, 40 percent to the offshore sector, and 10 percent to the mothership sector.
4. Identified the specific vessels and processors eligible to participate in the BSAI pollock fisheries
5. Established the authority and mechanisms by which the pollock fleet can form fishery cooperatives.
6. Established specific measures to protect the non-AFA (non-pollock) fisheries from adverse impacts resulting from the AFA or pollock fishery cooperatives.

Amendment 62, approved by the Council in October 2002, reviewed by the Council in April 2008, revised Amendment 61:

Updates the use restrictions on the Bering Sea Catcher Vessel Operational Area to reflect the changes in the American Fisheries Act.

Amendment 63, pending.

Amendment 64, implemented September 1, 2000, revised Amendment 46:

Allocated the Pacific cod Total Allowable Catch to the jig gear (2 percent), fixed gear (51 percent), and trawl gear (47 percent) sectors.

Amendment 65, implemented July 28, 2006:

Identified four specific sites as habitat areas of particular concern, and established management measures to reduce potential adverse effects of fishing. The sites are: Aleutian Islands Coral Habitat Protection Areas and the Alaska Seamount Habitat Protection Areas, in which the use of bottom contact gear is prohibited; and the Bowers Ridge Habitat Conservation Zone, in which the use of mobile bottom contact gear is prohibited.

Amendment 66, implemented April 6, 2002:

Exempted squid from the CDQ Program.

Amendment 67, implemented May 15, 2002, revised Amendment 39:

Established participation and harvest requirements to qualify for a BSAI Pacific cod fishery endorsement for fixed gear vessels.

Amendment 68, not submitted.

Amendment 69, implemented March 13, 2003, revised Amendment 61:

Allows an inshore pollock cooperative to contract with AFA catcher vessels that are qualified for the inshore sector, but outside their cooperative, to harvest the cooperative's pollock allocation.

Amendment 70, not submitted.

Amendment 71, not submitted.

Amendment 72, implemented August 28, 2003, revised Amendment 15:

Required a verbal departure report instead of a vessel clearance requirement for vessels with IFQ halibut or sablefish leaving the jurisdiction of the Council.

Amendment 73, implemented December 31, 2008

Remove dark rockfish (*S. ciliatus*) from the FMP, which allows the State of Alaska to manage this species.

Amendment 74, unassigned.

Amendment 75, partially implemented May 29, 2003, revised Amendment 49:

Delayed indefinitely the implementation of the flatfish retention and utilization requirements.

Amendment 76, not submitted.

Amendment 77, implemented January 1, 2004, revised Amendment 64:

Implemented a Pacific cod fixed gear allocation between hook and line catcher processors (80 percent), hook and line catcher vessels (0.3 percent), pot catcher processors (3.3 percent), pot catcher vessels (15 percent), and catcher vessels (pot or hook and line) less than 60 feet (1.4 percent).

Amendment 78, implemented July 28, 2006, supersedes Amendment 55:

1. Refined and updated the description and identification of EFH for managed species.

2. Revised approach for identifying Habitat Areas of Particular Concern within EFH, by adopting a site-based approach.
3. Established a new area (Aleutian Islands Habitat Conservation Area) in which non-pelagic trawling is prohibited, to protect sensitive habitats from potential adverse effects of fishing.

<u>Amendment 79,</u> implemented on August 31, 2005.

Implemented a groundfish retention standard in the non-AFA trawl catcher-processor fleet.

<u>Amendment 80,</u> implemented on July 26, 2007, superseded Amendments 49 and 75:

1. Allocates non-pollock groundfish in the BSAI among trawl sectors
2. Creates a limited access privilege program to facilitate the formation of harvesting cooperative in the non-American Fisheries Act trawl catcher/processor sector.

<u>Amendment 81,</u> implemented August 27, 2004:

Revised the management policy and objectives.

<u>Amendment 82,</u> implemented February 24, 2005:

1. Created separate Chinook Salmon PSC limits for the Bering Sea and Aleutian Islands subareas, and modified the closures when the PSC limits are attained.
2. Allocated the non-CDQ directed pollock fishery in the AI subarea to the Aleut Corporation for the purpose of economic development in Adak, Alaska.

<u>Amendment 83,</u> implemented June 13, 2005:

1. Updated the FMP's descriptive sections, technically edited the language, and reorganized the content of the FMP.
2. Required the TAC for a species or species complex to be equal or less than ABC.

<u>Amendment 84,</u> implemented on June 22, 2007:

Established the salmon bycatch intercooperative agreement which allows vessels participating in the directed fisheries for pollock in the Bering Sea to utilize their internal cooperative structure to reduce salmon bycatch using a method called the ‘‘voluntary rolling hotspot system.’’

<u>Amendment 85</u>, partially implemented on March 5, 2007, superseded Amendments 46 and 77:

Implemented a gear allocation among all non-CDQ fishery sectors participating in the directed fishery for Pacific cod. After deduction of the CDQ allocation, the Pacific cod TAC is apportioned to vessels using jig gear (1.4 percent); catcher processors using trawl gear listed in Section 208(e)(1)-(20) of the AFA (2.3 percent); catcher processors using trawl gear as defined in Section 219(a)(7) of the Consolidated Appropriations Act, 2005 (Public Law 108-447) (13.4 percent); catcher vessels using trawl gear (22.1 percent); catcher processors using hook-and-line gear (48.7 percent); catcher vessels ≥60' LOA using hook-and-line gear (0.2 percent); catcher processors using pot gear (1.5 percent);

catcher vessels ≥60’ LOA using pot gear (8.4 percent); and catcher vessels <60’ LOA that use either hook-and-line gear or pot gear (2.0 percent).

Amendment 86, implemented January 1, 2013, revised Amendment 13:

1. Modified the observer program to include vessels and processors of all sizes, including the commercial halibut sector.
2. Established two coverage categories for all vessels and processors: <100% observer coverage and ≥100% observer coverage.
3. Modified the observer program such that vessels in the <100% observer coverage category are subject to an ex-vessel value based fee not to exceed 2%, and are required to carry an observer as determined by NMFS. Vessels and processors in the ≥100% observer coverage category obtain observer coverage by contracting directly with observer providers, to meet coverage requirements in regulation.

Amendment 87, (CDQ eligibility) recommended by the Council in April 2006, but not yet approved by the Secretary of Commerce, superseded by 2006 MSA amendments.

Amendment 88 implemented on February 19, 2008:

Revised the Aleutian Islands Habitat Conservation Area to close additional waters near Buldir Island and to open waters near Agattu Island to nonpelagic trawl gear.

Amendment 89 implemented on May 19, 2008:

1. Established new habitat conservation areas (HCA) (Bering Sea HCA; St. Matthew Island HCA; St. Lawrence Island HCA; and Nunivak Island, Etolin Strait, and Kuskokwim Bay HCA) in which nonpelagic trawling is prohibited, to protect bottom habitat from potential adverse effects of fishing.
2. Established the Northern Bering Sea Research Area in which nonpelagic trawling is prohibited except under an exempted fishing permit that is consistent with a research plan approved by the Council to study the effects of nonpelagic trawling on the management of crab species, marine mammals, ESA-listed species, and subsistence needs for Western Alaska communities.

Amendment 90 implemented on March 16, 2009:

Allowed unlimited post-delivery transfers of cooperative quota

Amendment 91 implemented on September 29, 2010 revised Amendment 84:

Established the Bering Sea Chinook Salmon Bycatch Management Program to revise the Chinook salmon prohibited species catch limit in the Bering Sea pollock fishery, to provide a higher cap to vessel owners and CDQ groups participating in an incentive plan agreement, and to provide for transferable Chinook salmon PSC allocations under certain circumstances.

Amendment 92 implemented on March 11, 2009 revised Amendment 60:

1. Revoked Bering Sea and Aleutian Islands area endorsements on trawl groundfish licenses unless the license met historical trawl groundfish landings criteria.
2. Created a limited number of new AI endorsements on non-AFA trawl catcher vessel licenses; new AI endorsements earned on licenses with a <60’ MLOA are severable and transferable from the overall license.

Amendment 93, implemented on December 5, 2011:

Modified the criteria for forming and participating in an Amendment 80 harvesting cooperative by—

1. Reducing the minimum number unique persons and licenses required to form a harvesting cooperative from 3 persons and 9 licenses to 2 persons and 7 licenses, and
2. Requiring that for the 2014 fishing year and thereafter, a person assign all QS permits either to one or more cooperatives or to the limited access fishery, but not to both during the same calendar year (Beginning 2014).

Amendment 94, implemented September 17, 2010, partly revises Amendment 89:

1. Required use of modified nonpelagic trawl gear in the Bering Sea flatfish nonpelagic trawl fishery to reduce the potential impact of nonpelagic trawl gear on bottom habitat.
2. Created the Modified Gear Trawl Zone, in which anyone fishing with nonpelagic trawl gear must use modified nonpelagic trawl gear.
3. Revised the northern and southern boundaries of the Northern Bering Sea Research Area, and the eastern boundary of the St Matthew Island Habitat Conservation Area.
4. Removed reference to the Crab and Halibut Protection Zone which was superseded by the Nearshore Bristol Bay Trawl Closure.
5. Renumbered figures and tables in the FMP and corrected cross-references.
6. Updated the Community Development Quota eligibility list to be consistent with the Magnuson-Stevens Act.

Amendment 95, implemented on November 5, 2010:

Moves skates from the other species category to the target species category.

Amendment 96, implemented on November 5, 2010:

1. Places species groups managed under the other species category into the target species category and removes the other species category from the FMP.
2. Places target species in the fishery, which requires annual catch limits, accountability measures, and the description of essential fish habitat (EFH) and 5-year review of EFH information for listed species and species groups.
3. Revises the FMP to describe current practices for setting annual catch limits and the use of accountability measures to ensure annual catch limits are not exceeded, as required by National Standard 1 guidelines.
4. Removes the nonspecified species category from the FMP

5. Establishes an Ecosystem Component category and places Prohibited Species and Forage Fish Species in this category.

Amendment 97, implemented on October 31, 2012:

Established a process for the owners of originally qualifying Amendment 80 vessels to replace each trawl catcher/processor vessels for any purpose, limited the length of Amendment 80 replacement vessels, established up to a one-for-one replacement; restricted replaced vessels from entering an Amendment 80 fishery, and established sideboard limits of zero for all BSAI and GOA groundfish fisheries for Amendment 80 vessels not assigned to the Amendment 80 fishery.

Amendment 98, implemented on October 31, 2013, revised Amendment 78:

1. Revise EFH description and identification by species, and update life history, distribution, and habitat association information, based on the 2010 EFH 5-year review.
2. Update description of EFH impacts from non-fishing activities, and EFH conservation recommendations for non-fishing activities.
3. Revise the timeline associated with the HAPC process to a 5-year timeline.
4. Update EFH research priority objectives.

Amendment 99, implemented on January 6, 2014 (effective February 6, 2014):

Allows holders of license limitation program (LLP) licenses endorsed to catch and process Pacific cod in the Bering Sea/Aleutian Islands hook-and-line fisheries to use their LLP license on larger newly built or existing vessels by:

1. Increasing the maximum vessel length limits of the LLP license, and
2. Waiving vessel length, weight, and horsepower limits of the American Fisheries Act.

Amendment 100, implemented on August 14, 2014, effective on January 1, 2015:

Adds grenadiers to the ecosystem component category in section 3.1.2 and in Table 3-1.

Amendment 102, implemented on February 14, 2014:

1. Created a Community Quota Entity Program in halibut IFQ regulatory area 4B and the sablefish Aleutian Islands regulatory area.
2. Allows individual fishing quota derived from D share halibut quota share to be fished on category C vessels in Area 4B

Amendment 103, implemented December 2, 2014:

Revise the Pribilof Islands Habitat Conservation Zone to close to fishing for Pacific cod with pot gear (in addition to the closure to all trawling).

Amendment 104, implemented on January 9, 2015:

1. Establishes Six Areas of Skate Egg Concentration as HAPCs.

Amendment 105, implemented on September 23, 2014:

Modifies the annual harvest specifications process to:

1. Create an ABC surplus and an ABC reserve for flathead sole, rock sole, and yellowfin sole and allocate the ABC reserve for each species.
2. Enable Amendment 80 cooperatives and Western Alaska Community Development Quota (CDQ) groups to exchange harvest quota of one or two of three flatfish species (flathead sole, rock sole,

or yellowfin sole) for an equivalent amount of their allocation of the ABC reserve of one other of these species.

Amendment 106, implemented September 12, 2014, revised Amendment 61 and conformed the FMP to section 602 of the Coast Guard Authorization Act of 2010 that:

Specified the conditions under which the owners of AFA vessels could rebuild AFA vessels, replace AFA vessels, and remove AFA catcher vessels that are members of inshore cooperatives from the Bering Sea directed pollock fishery.

Amendment 107, implemented January 5, 2015:

Identified open transit areas through the walrus protection areas at Round Island and Cape Peirce, northern Bristol Bay, Alaska.

Amendment 108, implemented on May 5, 2015:

This amendment corrects an omission in the FMP text that establishes vessel length limits for small vessels exempted from the license limitation program (LLP) in the Bering Sea and Aleutian Islands Management Area (BSAI) groundfish fishery. This amendment makes the FMP text consistent with the original intent of the LLP, operations in the fisheries, and Federal regulations.

Amendment 109, implemented on May 4, 2016:

Revised provisions regarding the Western Alaska CDQ Program to update information and to facilitate increased participation in the groundfish CDQ fisheries (primarily Pacific cod) by:

1. Exempting CDQ group-authorized catcher vessels greater than 32 ft LOA and less than or equal to 46 ft LOA using hook-and-line gear from License Limitation Program license requirements while groundfish CDQ fishing,

2. Modifying observer coverage category language to allow for the placement of catcher vessels less than or equal to 46 ft LOA using hook-and-line gear into the partial observer coverage category while groundfish CDQ fishing, and

3. Updating CDQ community population information, and making other miscellaneous editorial revisions to CDQ Program-related text in the FMP.

Amendment 110, implemented on June 10, 2016 revised Amendment 91 and Amendment 84:

Changed the Bering Sea Chinook Salmon Bycatch Management Program into the Bering Sea Salmon Bycatch Management Program by: (1) adding two new Chinook salmon PSC limits in the Bering Sea pollock fishery for years of low Chinook salmon abundance, (2) incorporating chum salmon avoidance incentives into the incentive plan agreements, (3) enacting more stringent measures for avoiding Chinook salmon bycatch, and (4) removing Amendment 84 management measures.

Amendment 111, implemented on April 27, 2016, revised Amendment 80:

1. Reduced halibut mortality PSC limits for the Non-AFA Trawl Catcher Processor (Amendment 80), BSAI trawl limited access, and CDQ sectors.

2. Established a halibut mortality PSC limit in the FMP for the Non-Trawl sector that was previously only in regulation.

Amendment 112, implemented on March 29, 2016:

Revised regulations governing the basis for NMFS to place small catcher/processors in the partial observer coverage category in the North Pacific Groundfish and Halibut Observer

Program (Observer Program) in the Gulf of Alaska and the Bering Sea and Aleutian Islands Management Area.

Amendment 113, implemented on November 23, 2016:

1. Reserves up to 5,000 mt of TAC in the AI non-CDQ Pacific cod fishery exclusively for harvest by vessels directed fishing for AI Pacific cod for processing by Aleutian Islands shoreplants from January 1 until March 15.
2. Limits the amount of the trawl CV sector's BSAI Pacific cod A-season allocation that can be caught in the Bering Sea subarea before March 21.
3. Imposes the Aleutian Islands Catcher Vessel Harvest Set-Aside if NMFS is notified in advance as specified in regulations implementing the FMP amendment and certain performance measures are met.

Amendment 114, implemented on September 7, 2017, revised Amendment 86:

Authorizes NMFS to place electronic monitoring systems for collecting at-sea data on vessels in the partial coverage category of the North Pacific Observer Program.

Amendment 115, implemented on July 5, 2018, revised Amendment 98:

1. Revises EFH descriptions and identification by species, and update life history, distribution, and habitat association information, based on the 2016 EFH 5-year review.

2. Updates the model used to determine fishing effects on EFH, and description of EFH impacts from fishing activities.

3. Updates descriptions of EFH impacts from non-fishing activities, and EFH conservation recommendations for non-fishing activities.

Amendment 116, implemented on November 5, 2018:

Allows holders of a license limitation program (LLP) license endorsed to catch groundfish in the BSAI with trawl gear to use their LLP license to catch and deliver to a mothership BSAI TLAS yellowfins sole.

Amendment 117, implemented on August 6, 2018:

Adds squids to the ecosystem component category in section 3.1.2 and in Table 3-1. Removes squids from target species category "In the Fishery" in section 3.1.2 and in Table 3-1.

Amendment 118, implemented on February 7, 2020:

Allows retention of halibut in pot gear in the BSAI IFQ or CDQ halibut or IFQ or CDQ sablefish fishery.

Amendment 119, implemented on March 23, 2020:

Requires that the operator of a catcher vessel using hook-and-line, pot, or jig gear participating in groundfish or halibut fisheries in Federal waters retain and land all rockfish. (*Sebastes* and *Sebastolobus* species) caught.

Amendment 120, implemented on January 1, 2020:

Allows holders of a groundfish license limitation program (LLP) license endorsed to receive and process Pacific cod harvested by catcher vessels directed fishing using trawl gear in the BSAI non-Community Development Quota Program Pacific cod fishery in the BSAI to use their groundfish LLP license to receive and process Pacific cod harvested by catcher vessels directed fishing using trawl gear in the BSAI non-Community Development Quota Program Pacific cod fishery. Prohibits all Amendment 80 vessels not designated on an Amendment 80 QS permit and an Amendment 80 LLP license or on an Amendment 80 LLP/QS license from receiving and processing Pacific cod harvested by a vessels directed fishing for Pacific cod in the BSAI.

Amendment 121, implemented on August 10, 2020:

Adds sculpins to the ecosystem component category in section 3.1.2 and in Table 3-1. Removes sculpins from target species category "In the Fishery" in section 3.1.2 and in Table 3-1.

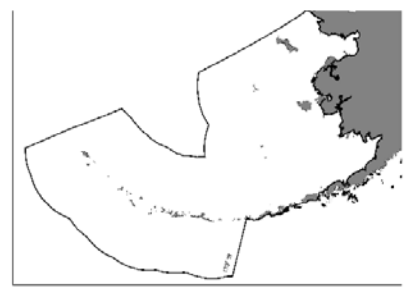
# Appendix B Geographical Coordinates of Areas Described in the Fishery Management Plan

This appendix describes the geographical coordinates for the areas described in the Fishery Management Plan (FMP). This appendix divides the descriptions into three types: Bering Sea and Aleutian Islands (BSAI) management area, subareas, and districts (Section B.1), closed areas (Section B.2), and prohibited species bycatch (PSC) bycatch limitation zones (Section B.3).

## B.1 Management Area, Subareas, and Districts

### Management Area

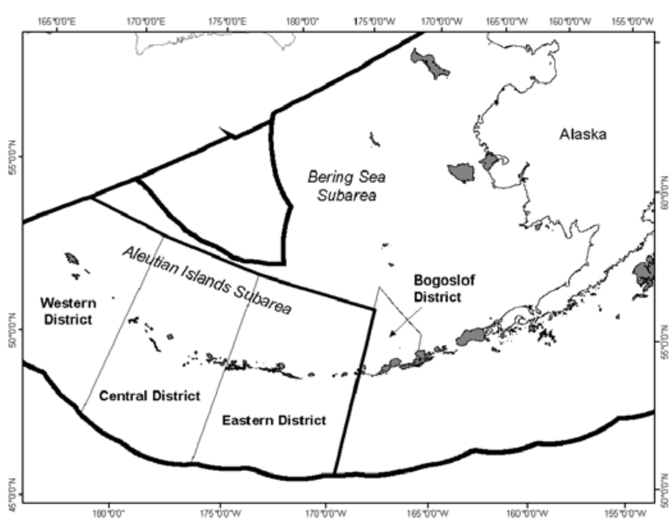
The management area for the BSAI groundfish FMP is the United States (U.S.) Exclusive Economic Zone (EEZ) of the Bering Sea, including Bristol Bay and Norton Sound, and that portion of the North Pacific Ocean adjacent to the Aleutian Islands which is between 170° W. longitude and the U.S.-Russian Convention Line of 1867. To the north, the management area is bounded by the Bering Strait.



### Subareas

Two subareas are described in Section 3.1 of the FMP and are defined as follows:

| | |
|---|---|
| Bering Sea subarea: | The area of the EEZ east of 170° W. longitude that is north of the Aleutian Islands, and the area of the EEZ west of 170E W. longitude that is north of 55E N. latitude. |
| Aleutian Islands subarea: | The area of the EEZ west of 170EW. longitude and south of 55EN. latitude. |



### Districts

The Bering Sea subarea contains one district, defined as follows:

Bogoslof District: The area of the EEZ east of 170E W. longitude, west of 167E W. longitude, south of the straight line connecting the coordinates (55E46' N., 170E W.) and (54E30' N., 167E W.), and north of the Aleutian Islands.

The Aleutian Islands subarea is divided into three districts, defined as follows:

Eastern District: That part of the Aleutian Islands subarea between 170E W. longitude and 177E W. longitude.

Central District: That part of the Aleutian Islands subarea between 177E W. longitude and 177E E. longitude.

Western District: That part of the Aleutian Islands subarea west of 177E E. longitude.

## B.2 Closed Areas

Specific areas of the BSAI are closed to some or all fishing during certain times of the year and are described in Section 3.5.2 of the FMP.

### Pribilof Islands Habitat Conservation Area

Trawling and fishing for Pacific cod with pot gear are prohibited at all times in the EEZ within the area bounded by a straight line connecting the following pairs of coordinates in the following order:


(57E 57.0' N., 168E 30.0' W.)

(56E 55.2' N., 168E 30.0' W.)

(56E 48.0' N., 169E 2.4' W.)

(56E 34.2' N., 169E 2.4' W.)

(56E 30.0' N., 169E 25.2' W.)

(56E 30.0' N., 169E 44.1' W.)

(56E 55.8' N., 170E 21.6' W.)

(57E 13.8' N., 171E 0.0' W.)

(57E 57.0' N., 171E 0.0' W.)

(57E 57.0' N., 168E 30.0' W.)

### Chum Salmon Savings Area

Trawling is prohibited from August 1 through August 31 within the area bounded by a straight line connecting the following pairs of coordinates in the order listed:

(56°00' N., 167°00' W.)

(56°00' N., 165°00' W.)

(55°30' N., 165°00' W.)

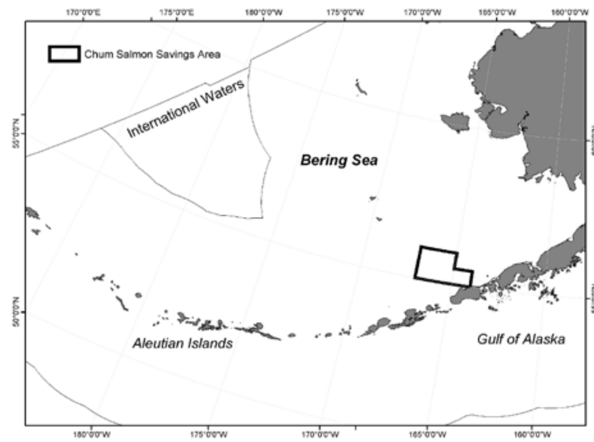
(55°30' N., 164°00' W.)

(55°00' N., 164°00' W.)

(55°00' N., 167°00' W.)

(56°00' N., 167°00' W.)

Trawling is also prohibited for the remainder of the period September 14 through October 14 upon the attainment of an 'other salmon' bycatch limit; see Section B.3.




## Red King Crab Savings Area

Non-pelagic trawling is prohibited year round within the area bounded by a straight line connecting the following pairs of coordinates in the order listed below:

(56E N., 162E W.)

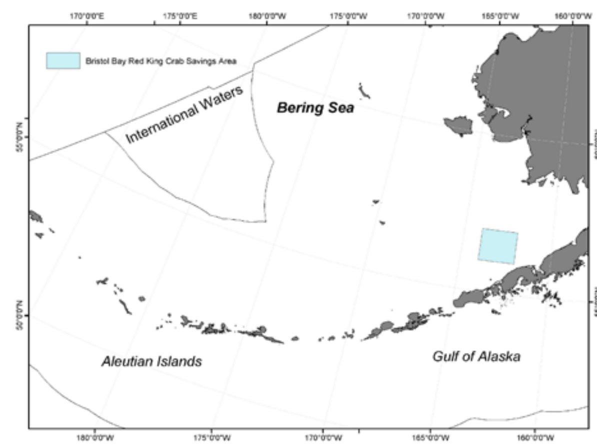
(56E N., 164E W.)

(57E N., 164E W.)

(57E N., 162E W.)

(56E N., 162E W.)

with the exception that a subarea of the Red King Crab Savings Area between 56E00' N. and 56E10' N. latitude and 162E W. and 164E W. longitude may be opened as outlined in Section 3.5.2.1.




## Nearshore Bristol Bay Trawl Closure

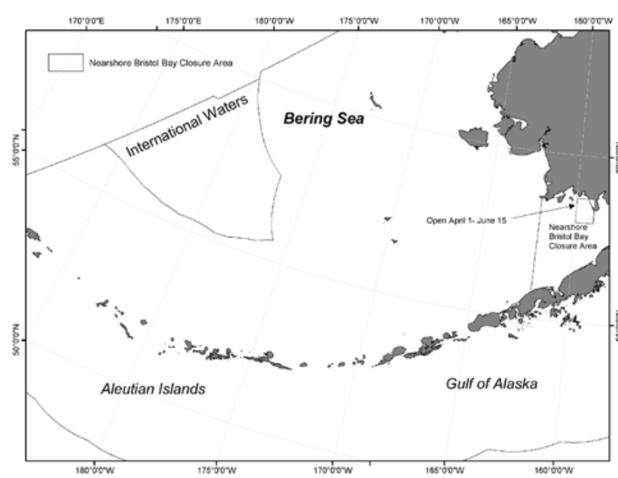
All trawling is prohibited year round in Bristol Bay east of 162° W. longitude, except the subarea bounded by a straight line connecting the following pairs of coordinates in the order listed below that is open to trawling during the period April 1 to June 15 each year:

(58E00' N., 160E W.)

(58E43' N., 160E W.)

(58E43' N., 159E W.)

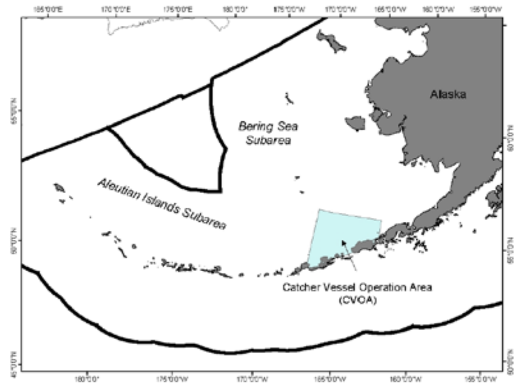
(58E00' N., 159E W.)



(58E00' N., 160E W.)

### Catcher Vessel Operational Area (CVOA)

The CVOA is defined as the area of the BSAI east of 167E30' W. longitude, west of 163E W. longitude, south of 56E N. latitude, and north of the Aleutian Islands. The CVOA shall be in effect during the pollock "B" season from September 1 until the date that closes the inshore component "B" season allocation to directed fishing. Vessels in the offshore component or vessels catching pollock for processing by the offshore component are prohibited from conducting directed fishing for pollock in the CVOA unless they are participating in a CDQ fishery.




### Alaska Seamount Habitat Protection Area (ASHPA)

Bottom contact gear fishing is prohibited in the portion of the Alaska Seamount Habitat Protection Area located in the BSAI. Coordinates for this habitat protection area are listed in the table below.

| Name | Latitude | | | Longitude | | |
|---|---|---|---|---|---|---|
| Bowers Seamount | 54 | 9.00 | N | 174 | 52.20 | E |
| | 54 | 9.00 | N | 174 | 42.00 | E |
| | 54 | 4.20 | N | 174 | 42.00 | E |
| | 54 | 4.20 | N | 174 | 52.20 | E |

Note: The area is delineated by connecting the coordinates in the order listed by straight lines. The last set of coordinates is connected to the first set of coordinates by a straight line. The projected coordinate system is North American Datum 1983, Albers.

### Aleutian Islands Habitat Conservation Area (AIHCA)

Nonpelagic trawl gear fishing is prohibited in the AIHCA. Note: Unless otherwise footnoted (see footnotes at end of table), each area is delineated by connecting in order the coordinates listed by straight lines. Except for the Amlia North/Seguam donut and the Buldir donut, each area delineated in the table is open to nonpelagic trawl gear fishing. The remainder of the entire Aleutian Islands subarea and the areas delineated by the coordinates for the Amlia North/Seguam and Buldir donuts are closed to nonpelagic trawl gear fishing, as specified at § 679.22. Unless otherwise noted, the last set of coordinates for each area is connected to the first set of coordinates for the area by a straight line. The projected coordinate system is North American Datum 1983, Albers.

| Name | Latitude | | | Longitude | | | Footnote |
|---|---|---|---|---|---|---|---|
| Islands of 4 Mountains North | 52 | 54.00 | N | 170 | 18.00 | W | |
| | 52 | 54.00 | N | 170 | 24.00 | W | |
| | 52 | 42.00 | N | 170 | 24.00 | W | |
| | 52 | 42.00 | N | 170 | 18.00 | W | |
| Islands of 4 Mountains West | 53 | 12.00 | N | 170 | 0.00 | W | |
| | 53 | 12.00 | N | 170 | 12.00 | W | |
| | 53 | 6.00 | N | 170 | 12.00 | W | |
| | 53 | 6.00 | N | 170 | 30.00 | W | |

| Name | Latitude | | | Longitude | | | Footnote |
|---|---|---|---|---|---|---|---|
| | 53 | 0.00 | N | 170 | 30.00 | W | |
| | 53 | 0.00 | N | 170 | 48.00 | W | |
| | 52 | 54.00 | N | 170 | 48.00 | W | |
| | 52 | 54.00 | N | 170 | 54.00 | W | |
| | 52 | 48.00 | N | 170 | 54.00 | W | |
| | 52 | 48.00 | N | 170 | 30.00 | W | |
| | 52 | 54.00 | N | 170 | 30.00 | W | |
| | 52 | 54.00 | N | 170 | 24.00 | W | |
| | 53 | 0.00 | N | 170 | 24.00 | W | |
| | 53 | 0.00 | N | 170 | 0.00 | W | |
| Yunaska I South | 52 | 24.00 | N | 170 | 30.00 | W | |
| | 52 | 24.00 | N | 170 | 54.00 | W | |
| | 52 | 12.00 | N | 170 | 54.00 | W | |
| | 52 | 12.00 | N | 170 | 30.00 | W | |
| Amukta I North | 52 | 54.00 | N | 171 | 6.00 | W | |
| | 52 | 54.00 | N | 171 | 30.00 | W | |
| | 52 | 48.00 | N | 171 | 30.00 | W | |
| | 52 | 48.00 | N | 171 | 36.00 | W | |
| | 52 | 42.00 | N | 171 | 36.00 | W | |
| | 52 | 42.00 | N | 171 | 12.00 | W | |
| | 52 | 48.00 | N | 171 | 12.00 | W | |
| | 52 | 48.00 | N | 171 | 6.00 | W | |
| Amukta Pass North | 52 | 42.00 | N | 171 | 42.00 | W | |
| | 52 | 42.00 | N | 172 | 6.00 | W | |
| | 52 | 36.00 | N | 172 | 6.00 | W | |
| | 52 | 36.00 | N | 171 | 42.00 | W | |
| Amlia North/Seguam | 52 | 42.00 | N | 172 | 12.00 | W | |
| | 52 | 42.00 | N | 172 | 30.00 | W | |
| | 52 | 30.00 | N | 172 | 30.00 | W | |
| | 52 | 30.00 | N | 172 | 36.00 | W | |
| | 52 | 36.00 | N | 172 | 36.00 | W | |
| | 52 | 36.00 | N | 172 | 42.00 | W | |
| | 52 | 39.00 | N | 172 | 42.00 | W | |
| | 52 | 39.00 | N | 173 | 24.00 | W | |
| | 52 | 36.00 | N | 173 | 30.00 | W | |
| | 52 | 36.00 | N | 173 | 36.00 | W | |
| | 52 | 30.00 | N | 173 | 36.00 | W | |
| | 52 | 30.00 | N | 174 | 0.00 | W | |
| | 52 | 27.00 | N | 174 | 0.00 | W | |
| | 52 | 27.00 | N | 174 | 6.00 | W | |
| | 52 | 23.93 | N | 174 | 6.00 | W | 1 |
| | 52 | 13.71 | N | 174 | 6.00 | W | |
| | 52 | 12.00 | N | 174 | 6.00 | W | |
| | 52 | 12.00 | N | 174 | 0.00 | W | |
| | 52 | 9.00 | N | 174 | 0.00 | W | |
| | 52 | 9.00 | N | 173 | 0.00 | W | |
| | 52 | 6.00 | N | 173 | 0.00 | W | |
| | 52 | 6.00 | N | 172 | 45.00 | W | |
| | 51 | 54.00 | N | 172 | 45.00 | W | |
| | 51 | 54.00 | N | 171 | 48.00 | W | |
| | 51 | 48.00 | N | 171 | 48.00 | W | |
| | 51 | 48.00 | N | 171 | 42.00 | W | |
| | 51 | 54.00 | N | 171 | 42.00 | W | |
| | 52 | 12.00 | N | 171 | 42.00 | W | |
| | 52 | 12.00 | N | 171 | 48.00 | W | |
| | 52 | 18.00 | N | 171 | 48.00 | W | |
| | 52 | 18.00 | N | 171 | 42.00 | W | |
| | 52 | 30.00 | N | 171 | 42.00 | W | |

| Name | Latitude | | | Longitude | | | Footnote |
|---|---|---|---|---|---|---|---|
| | 52 | 30.00 | N | 171 | 54.00 | W | |
| | 52 | 24.00 | N | 171 | 54.00 | W | |
| | 52 | 24.00 | N | 172 | 0.00 | W | |
| | 52 | 12.00 | N | 172 | 0.00 | W | |
| | 52 | 12.00 | N | 172 | 42.00 | W | |
| | 52 | 18.00 | N | 172 | 42.00 | W | |
| | 52 | 18.00 | N | 172 | 37.13 | W | 2 |
| | 52 | 18.64 | N | 172 | 36.00 | W | |
| | 52 | 24.00 | N | 172 | 36.00 | W | |
| | 52 | 24.00 | N | 172 | 12.00 | W | 6 |
| Amlia North/Seguam donut | 52 | 33.00 | N | 172 | 42.00 | W | 5 |
| | 52 | 33.00 | N | 173 | 6.00 | W | 5 |
| | 52 | 30.00 | N | 173 | 6.00 | W | 5 |
| | 52 | 30.00 | N | 173 | 18.00 | W | 5 |
| | 52 | 24.00 | N | 173 | 18.00 | W | 5 |
| | 52 | 24.00 | N | 172 | 48.00 | W | 5 |
| | 52 | 30.00 | N | 172 | 48.00 | W | 5 |
| | 52 | 30.00 | N | 172 | 42.00 | W | 5, 7 |
| Atka/Amlia South | 52 | 0.00 | N | 173 | 18.00 | W | |
| | 52 | 0.00 | N | 173 | 54.00 | W | |
| | 52 | 3.08 | N | 173 | 54.00 | W | 2 |
| | 52 | 6.00 | N | 173 | 58.00 | W | |
| | 52 | 6.00 | N | 174 | 6.00 | W | |
| | 52 | 0.00 | N | 174 | 18.00 | W | |
| | 52 | 0.00 | N | 174 | 12.00 | W | |
| | 51 | 54.00 | N | 174 | 12.00 | W | |
| | 51 | 54.00 | N | 174 | 18.00 | W | |
| | 52 | 6.00 | N | 174 | 18.00 | W | |
| | 52 | 6.00 | N | 174 | 21.86 | W | 1 |
| | 52 | 4.39 | N | 174 | 30.00 | W | |
| | 52 | 3.09 | N | 174 | 30.00 | W | 1 |
| | 52 | 2.58 | N | 174 | 30.00 | W | |
| | 52 | 0.00 | N | 174 | 30.00 | W | |
| | 52 | 0.00 | N | 174 | 36.00 | W | |
| | 51 | 54.00 | N | 174 | 36.00 | W | |
| | 51 | 54.00 | N | 174 | 54.00 | W | |
| | 51 | 48.00 | N | 174 | 54.00 | W | |
| | 51 | 48.00 | N | 173 | 24.00 | W | |
| | 51 | 54.00 | N | 173 | 24.00 | W | |
| | 51 | 54.00 | N | 173 | 18.00 | W | |
| Atka I North | 52 | 30.00 | N | 174 | 24.00 | W | |
| | 52 | 30.00 | N | 174 | 30.00 | W | |
| | 52 | 24.00 | N | 174 | 30.00 | W | |
| | 52 | 24.00 | N | 174 | 48.00 | W | |
| | 52 | 18.00 | N | 174 | 48.00 | W | |
| | 52 | 18.00 | N | 174 | 54.00 | W | |
| | 52 | 12.00 | N | 174 | 54.00 | W | |
| | 52 | 12.00 | N | 175 | 18.00 | W | |
| | 52 | 1.14 | N | 175 | 18.00 | W | 1 |
| | 52 | 2.19 | N | 175 | 12.00 | W | |
| | 52 | 6.00 | N | 175 | 12.00 | W | |
| | 52 | 6.00 | N | 174 | 55.51 | W | 1 |
| | 52 | 6.00 | N | 174 | 54.04 | W | |
| | 52 | 6.00 | N | 174 | 48.00 | W | |
| | 52 | 12.00 | N | 174 | 48.00 | W | |
| | 52 | 12.00 | N | 174 | 26.85 | W | 1 |
| | 52 | 12.94 | N | 174 | 18.00 | W | |
| | 52 | 16.80 | N | 174 | 18.00 | W | 1 |

| Name | Latitude | | | Longitude | | | Footnote |
|---|---|---|---|---|---|---|---|
| | 52 | 17.06 | N | 174 | 18.00 | W | |
| | 52 | 17.64 | N | 174 | 18.00 | W | 1 |
| | 52 | 18.00 | N | 174 | 19.12 | W | |
| | 52 | 18.00 | N | 174 | 20.04 | W | 1 |
| | 52 | 19.37 | N | 174 | 24.00 | W | |
| Atka I South | 52 | 0.68 | N | 175 | 12.00 | W | 2 |
| | 52 | 0.76 | N | 175 | 18.00 | W | |
| | 52 | 0.00 | N | 175 | 18.00 | W | |
| | 52 | 0.00 | N | 175 | 12.00 | W | |
| Adak I East | 52 | 12.00 | N | 176 | 36.00 | W | |
| | 52 | 12.00 | N | 176 | 0.00 | W | |
| | 52 | 2.59 | N | 176 | 0.00 | W | 1 |
| | 52 | 1.79 | N | 176 | 0.00 | W | |
| | 52 | 0.00 | N | 176 | 0.00 | W | |
| | 52 | 0.00 | N | 175 | 48.00 | W | |
| | 51 | 57.74 | N | 175 | 48.00 | W | 1 |
| | 51 | 55.48 | N | 175 | 48.00 | W | |
| | 51 | 54.00 | N | 175 | 48.00 | W | |
| | 51 | 54.00 | N | 176 | 0.00 | W | 1 |
| | 51 | 53.09 | N | 176 | 6.00 | W | |
| | 51 | 51.40 | N | 176 | 6.00 | W | 1 |
| | 51 | 49.67 | N | 176 | 6.00 | W | |
| | 51 | 48.73 | N | 176 | 6.00 | W | 1 |
| | 51 | 48.00 | N | 176 | 6.36 | W | |
| | 51 | 48.00 | N | 176 | 9.82 | W | 1 |
| | 51 | 48.00 | N | 176 | 9.99 | W | |
| | 51 | 48.00 | N | 176 | 16.19 | W | 1 |
| | 51 | 48.00 | N | 176 | 24.71 | W | |
| | 51 | 48.00 | N | 176 | 25.71 | W | 1 |
| | 51 | 45.58 | N | 176 | 30.00 | W | |
| | 51 | 42.00 | N | 176 | 30.00 | W | |
| | 51 | 42.00 | N | 176 | 33.92 | W | 1 |
| | 51 | 41.22 | N | 176 | 42.00 | W | |
| | 51 | 30.00 | N | 176 | 42.00 | W | |
| | 51 | 30.00 | N | 176 | 36.00 | W | |
| | 51 | 36.00 | N | 176 | 36.00 | W | |
| | 51 | 36.00 | N | 176 | 0.00 | W | |
| | 51 | 42.00 | N | 176 | 0.00 | W | |
| | 51 | 42.00 | N | 175 | 36.00 | W | |
| | 51 | 48.00 | N | 175 | 36.00 | W | |
| | 51 | 48.00 | N | 175 | 18.00 | W | |
| | 51 | 51.00 | N | 175 | 18.00 | W | |
| | 51 | 51.00 | N | 175 | 0.00 | W | |
| | 51 | 57.00 | N | 175 | 0.00 | W | |
| | 51 | 57.00 | N | 175 | 18.00 | W | |
| | 52 | 0.00 | N | 175 | 18.00 | W | |
| | 52 | 0.00 | N | 175 | 30.00 | W | |
| | 52 | 3.00 | N | 175 | 30.00 | W | |
| | 52 | 3.00 | N | 175 | 36.00 | W | |
| Cape Adagdak | 52 | 6.00 | N | 176 | 12.44 | W | |
| | 52 | 6.00 | N | 176 | 30.00 | W | |
| | 52 | 3.00 | N | 176 | 30.00 | W | |
| | 52 | 3.00 | N | 176 | 42.00 | W | |
| | 52 | 0.00 | N | 176 | 42.00 | W | |
| | 52 | 0.00 | N | 176 | 46.64 | W | |
| | 51 | 57.92 | N | 176 | 46.51 | W | 1 |
| | 51 | 54.00 | N | 176 | 37.07 | W | |
| | 51 | 54.00 | N | 176 | 18.00 | W | |

| Name | Latitude | | | Longitude | | | Footnote |
|---|---|---|---|---|---|---|---|
| | 52 | 0.00 | N | 176 | 18.00 | W | |
| | 52 | 0.00 | N | 176 | 12.00 | W | |
| | 52 | 2.85 | N | 176 | 12.00 | W | 1 |
| | 52 | 4.69 | N | 176 | 12.44 | W | |
| Cape Kiguga/Round Head | 52 | 0.00 | N | 176 | 53.00 | W | |
| | 52 | 0.00 | N | 177 | 6.00 | W | |
| | 51 | 56.06 | N | 177 | 6.00 | W | 1 |
| | 51 | 54.00 | N | 177 | 2.84 | W | |
| | 51 | 54.00 | N | 176 | 54.00 | W | |
| | 51 | 48.79 | N | 176 | 54.00 | W | 1 |
| | 51 | 48.00 | N | 176 | 50.35 | W | |
| | 51 | 48.00 | N | 176 | 43.14 | W | 1 |
| | 51 | 55.69 | N | 176 | 48.59 | W | |
| | 51 | 55.69 | N | 176 | 53.00 | W | |
| Adak Strait South | 51 | 42.00 | N | 176 | 55.77 | W | |
| | 51 | 42.00 | N | 177 | 12.00 | W | |
| | 51 | 30.00 | N | 177 | 12.00 | W | |
| | 51 | 36.00 | N | 177 | 6.00 | W | |
| | 51 | 36.00 | N | 177 | 3.00 | W | |
| | 51 | 39.00 | N | 177 | 3.00 | W | |
| | 51 | 39.00 | N | 177 | 0.00 | W | |
| | 51 | 36.00 | N | 177 | 0.00 | W | |
| | 51 | 36.00 | N | 176 | 57.72 | W | 3 |
| Bay of Waterfalls | 51 | 38.62 | N | 176 | 54.00 | W | |
| | 51 | 36.00 | N | 176 | 54.00 | W | |
| | 51 | 36.00 | N | 176 | 55.99 | W | 3 |
| Tanaga/Kanaga North | 51 | 54.00 | N | 177 | 12.00 | W | |
| | 51 | 54.00 | N | 177 | 19.93 | W | |
| | 51 | 51.71 | N | 177 | 19.93 | W | |
| | 51 | 51.65 | N | 177 | 29.11 | W | |
| | 51 | 54.00 | N | 177 | 29.11 | W | |
| | 51 | 54.00 | N | 177 | 30.00 | W | |
| | 51 | 57.00 | N | 177 | 30.00 | W | |
| | 51 | 57.00 | N | 177 | 42.00 | W | |
| | 51 | 54.00 | N | 177 | 42.00 | W | |
| | 51 | 54.00 | N | 177 | 54.00 | W | |
| | 51 | 50.92 | N | 177 | 54.00 | W | 1 |
| | 51 | 48.00 | N | 177 | 46.44 | W | |
| | 51 | 48.00 | N | 177 | 42.00 | W | |
| | 51 | 42.59 | N | 177 | 42.00 | W | 1 |
| | 51 | 45.57 | N | 177 | 24.01 | W | |
| | 51 | 48.00 | N | 177 | 24.00 | W | |
| | 51 | 48.00 | N | 177 | 14.08 | W | 4 |
| Tanaga/Kanaga South | 51 | 43.78 | N | 177 | 24.04 | W | 1 |
| | 51 | 42.37 | N | 177 | 42.00 | W | |
| | 51 | 42.00 | N | 177 | 42.00 | W | |
| | 51 | 42.00 | N | 177 | 50.04 | W | 1 |
| | 51 | 40.91 | N | 177 | 54.00 | W | |
| | 51 | 36.00 | N | 177 | 54.00 | W | |
| | 51 | 36.00 | N | 178 | 0.00 | W | |
| | 51 | 38.62 | N | 178 | 0.00 | W | 1 |
| | 51 | 42.52 | N | 178 | 6.00 | W | |
| | 51 | 49.34 | N | 178 | 6.00 | W | 1 |
| | 51 | 51.35 | N | 178 | 12.00 | W | |
| | 51 | 48.00 | N | 178 | 12.00 | W | |
| | 51 | 48.00 | N | 178 | 30.00 | W | |
| | 51 | 42.00 | N | 178 | 30.00 | W | |
| | 51 | 42.00 | N | 178 | 36.00 | W | |

| Name | Latitude | | | Longitude | | | Footnote |
|---|---|---|---|---|---|---|---|
| | 51 | 36.26 | N | 178 | 36.00 | W | 1 |
| | 51 | 35.75 | N | 178 | 36.00 | W | |
| | 51 | 27.00 | N | 178 | 36.00 | W | |
| | 51 | 27.00 | N | 178 | 42.00 | W | |
| | 51 | 21.00 | N | 178 | 42.00 | W | |
| | 51 | 21.00 | N | 178 | 24.00 | W | |
| | 51 | 24.00 | N | 178 | 24.00 | W | |
| | 51 | 24.00 | N | 178 | 12.00 | W | |
| | 51 | 30.00 | N | 178 | 12.00 | W | |
| | 51 | 30.00 | N | 177 | 24.00 | W | |
| Amchitka Pass East | 51 | 42.00 | N | 178 | 48.00 | W | |
| | 51 | 42.00 | N | 179 | 18.00 | W | |
| | 51 | 45.00 | N | 179 | 18.00 | W | |
| | 51 | 45.00 | N | 179 | 36.00 | W | |
| | 51 | 42.00 | N | 179 | 36.00 | W | |
| | 51 | 42.00 | N | 179 | 39.00 | W | |
| | 51 | 30.00 | N | 179 | 39.00 | W | |
| | 51 | 30.00 | N | 179 | 36.00 | W | |
| | 51 | 18.00 | N | 179 | 36.00 | W | |
| | 51 | 18.00 | N | 179 | 24.00 | W | |
| | 51 | 30.00 | N | 179 | 24.00 | W | |
| | 51 | 30.00 | N | 179 | 0.00 | W | |
| | 51 | 25.82 | N | 179 | 0.00 | W | |
| | 51 | 25.85 | N | 178 | 59.00 | W | |
| | 51 | 24.00 | N | 178 | 58.97 | W | |
| | 51 | 24.00 | N | 178 | 54.00 | W | |
| | 51 | 30.00 | N | 178 | 54.00 | W | |
| | 51 | 30.00 | N | 178 | 48.00 | W | |
| | 51 | 32.69 | N | 178 | 48.00 | W | 1 |
| | 51 | 33.95 | N | 178 | 48.00 | W | |
| Amatignak I | 51 | 18.00 | N | 178 | 54.00 | W | |
| | 51 | 18.00 | N | 179 | 5.30 | W | 1 |
| | 51 | 18.00 | N | 179 | 6.75 | W | |
| | 51 | 18.00 | N | 179 | 12.00 | W | |
| | 51 | 6.00 | N | 179 | 12.00 | W | |
| | 51 | 6.00 | N | 179 | 0.00 | W | |
| | 51 | 12.00 | N | 179 | 0.00 | W | |
| | 51 | 12.00 | N | 178 | 54.00 | W | |
| Amchitka Pass Center | 51 | 30.00 | N | 179 | 48.00 | W | |
| | 51 | 30.00 | N | 180 | 0.00 | W | |
| | 51 | 24.00 | N | 180 | 0.00 | W | |
| | 51 | 24.00 | N | 179 | 48.00 | W | |
| Amchitka Pass West | 51 | 36.00 | N | 179 | 54.00 | E | |
| | 51 | 36.00 | N | 179 | 36.00 | E | |
| | 51 | 30.00 | N | 179 | 36.00 | E | |
| | 51 | 30.00 | N | 179 | 45.00 | E | |
| | 51 | 27.00 | N | 179 | 48.00 | E | |
| | 51 | 24.00 | N | 179 | 48.00 | E | |
| | 51 | 24.00 | N | 179 | 54.00 | E | |
| Petrel Bank | 52 | 51.00 | N | 179 | 12.00 | W | |
| | 52 | 51.00 | N | 179 | 24.00 | W | |
| | 52 | 48.00 | N | 179 | 24.00 | W | |
| | 52 | 48.00 | N | 179 | 30.00 | W | |
| | 52 | 42.00 | N | 179 | 30.00 | W | |
| | 52 | 42.00 | N | 179 | 36.00 | W | |
| | 52 | 36.00 | N | 179 | 36.00 | W | |
| | 52 | 36.00 | N | 179 | 48.00 | W | |
| | 52 | 30.00 | N | 179 | 48.00 | W | |

| Name | Latitude | | | Longitude | | | Footnote |
|---|---|---|---|---|---|---|---|
| | 52 | 30.00 | N | 179 | 42.00 | E | |
| | 52 | 24.00 | N | 179 | 42.00 | E | |
| | 52 | 24.00 | N | 179 | 36.00 | E | |
| | 52 | 12.00 | N | 179 | 36.00 | E | |
| | 52 | 12.00 | N | 179 | 36.00 | W | |
| | 52 | 24.00 | N | 179 | 36.00 | W | |
| | 52 | 24.00 | N | 179 | 30.00 | W | |
| | 52 | 30.00 | N | 179 | 30.00 | W | |
| | 52 | 30.00 | N | 179 | 24.00 | W | |
| | 52 | 36.00 | N | 179 | 24.00 | W | |
| | 52 | 36.00 | N | 179 | 18.00 | W | |
| | 52 | 42.00 | N | 179 | 18.00 | W | |
| | 52 | 42.00 | N | 179 | 12.00 | W | |
| Rat I/Amchitka I South | 51 | 21.00 | N | 179 | 36.00 | E | |
| | 51 | 21.00 | N | 179 | 18.00 | E | |
| | 51 | 18.00 | N | 179 | 18.00 | E | |
| | 51 | 18.00 | N | 179 | 12.00 | E | |
| | 51 | 23.77 | N | 179 | 12.00 | E | 1 |
| | 51 | 24.00 | N | 179 | 10.20 | E | |
| | 51 | 24.00 | N | 179 | 0.00 | E | |
| | 51 | 36.00 | N | 178 | 36.00 | E | |
| | 51 | 36.00 | N | 178 | 24.00 | E | |
| | 51 | 42.00 | N | 178 | 24.00 | E | |
| | 51 | 42.00 | N | 178 | 6.00 | E | |
| | 51 | 48.00 | N | 178 | 6.00 | E | |
| | 51 | 48.00 | N | 177 | 54.00 | E | |
| | 51 | 54.00 | N | 177 | 54.00 | E | |
| | 51 | 54.00 | N | 178 | 12.00 | E | |
| | 51 | 48.00 | N | 178 | 12.00 | E | |
| | 51 | 48.00 | N | 178 | 17.09 | E | 1 |
| | 51 | 48.00 | N | 178 | 20.60 | E | |
| | 51 | 48.00 | N | 178 | 24.00 | E | |
| | 52 | 6.00 | N | 178 | 24.00 | E | |
| | 52 | 6.00 | N | 178 | 12.00 | E | |
| | 52 | 0.00 | N | 178 | 12.00 | E | |
| | 52 | 0.00 | N | 178 | 11.01 | E | 1 |
| | 52 | 0.00 | N | 178 | 5.99 | E | |
| | 52 | 0.00 | N | 177 | 54.00 | E | |
| | 52 | 9.00 | N | 177 | 54.00 | E | |
| | 52 | 9.00 | N | 177 | 42.00 | E | |
| | 52 | 0.00 | N | 177 | 42.00 | E | |
| | 52 | 0.00 | N | 177 | 48.00 | E | |
| | 51 | 54.00 | N | 177 | 48.00 | E | |
| | 51 | 54.00 | N | 177 | 30.00 | E | |
| | 51 | 51.00 | N | 177 | 30.00 | E | |
| | 51 | 51.00 | N | 177 | 24.00 | E | |
| | 51 | 45.00 | N | 177 | 24.00 | E | |
| | 51 | 45.00 | N | 177 | 30.00 | E | |
| | 51 | 48.00 | N | 177 | 30.00 | E | |
| | 51 | 48.00 | N | 177 | 42.00 | E | |
| | 51 | 42.00 | N | 177 | 42.00 | E | |
| | 51 | 42.00 | N | 178 | 0.00 | E | |
| | 51 | 39.00 | N | 178 | 0.00 | E | |
| | 51 | 39.00 | N | 178 | 12.00 | E | |
| | 51 | 36.00 | N | 178 | 12.00 | E | |
| | 51 | 36.00 | N | 178 | 18.00 | E | |
| | 51 | 30.00 | N | 178 | 18.00 | E | |
| | 51 | 30.00 | N | 178 | 24.00 | E | |

| Name | Latitude | | | Longitude | | | Footnote |
|---|---|---|---|---|---|---|---|
| | 51 | 24.00 | N | 178 | 24.00 | E | |
| | 51 | 24.00 | N | 178 | 36.00 | E | |
| | 51 | 30.00 | N | 178 | 36.00 | E | |
| | 51 | 24.00 | N | 178 | 48.00 | E | |
| | 51 | 18.00 | N | 178 | 48.00 | E | |
| | 51 | 18.00 | N | 178 | 54.00 | E | |
| | 51 | 12.00 | N | 178 | 54.00 | E | |
| | 51 | 12.00 | N | 179 | 30.00 | E | |
| | 51 | 18.00 | N | 179 | 30.00 | E | |
| | 51 | 18.00 | N | 179 | 36.00 | E | |
| Amchitka I North | 51 | 42.00 | N | 179 | 12.00 | E | |
| | 51 | 42.00 | N | 178 | 57.00 | E | |
| | 51 | 36.00 | N | 178 | 56.99 | E | |
| | 51 | 36.00 | N | 179 | 0.00 | E | |
| | 51 | 33.62 | N | 179 | 0.00 | E | 2 |
| | 51 | 30.00 | N | 179 | 5.00 | E | |
| | 51 | 30.00 | N | 179 | 18.00 | E | |
| | 51 | 36.00 | N | 179 | 18.00 | E | |
| | 51 | 36.00 | N | 179 | 12.00 | E | |
| Pillar Rock | 52 | 9.00 | N | 177 | 30.00 | E | |
| | 52 | 9.00 | N | 177 | 18.00 | E | |
| | 52 | 6.00 | N | 177 | 18.00 | E | |
| | 52 | 6.00 | N | 177 | 30.00 | E | |
| Murray Canyon | 51 | 48.00 | N | 177 | 12.00 | E | |
| | 51 | 48.00 | N | 176 | 48.00 | E | |
| | 51 | 36.00 | N | 176 | 48.00 | E | |
| | 51 | 36.00 | N | 177 | 0.00 | E | |
| | 51 | 39.00 | N | 177 | 0.00 | E | |
| | 51 | 39.00 | N | 177 | 6.00 | E | |
| | 51 | 42.00 | N | 177 | 6.00 | E | |
| | 51 | 42.00 | N | 177 | 12.00 | E | |
| Buldir | 52 | 6.00 | N | 177 | 12.00 | E | |
| | 52 | 6.00 | N | 177 | 0.00 | E | |
| | 52 | 12.00 | N | 177 | 0.00 | E | |
| | 52 | 12.00 | N | 176 | 54.00 | E | |
| | 52 | 9.00 | N | 176 | 54.00 | E | |
| | 52 | 9.00 | N | 176 | 48.00 | E | |
| | 52 | 0.00 | N | 176 | 48.00 | E | |
| | 52 | 0.00 | N | 176 | 36.00 | E | |
| | 52 | 6.00 | N | 176 | 36.00 | E | |
| | 52 | 6.00 | N | 176 | 24.00 | E | |
| | 52 | 12.00 | N | 176 | 24.00 | E | |
| | 52 | 12.00 | N | 176 | 12.00 | E | |
| | 52 | 18.00 | N | 176 | 12.00 | E | |
| | 52 | 18.00 | N | 176 | 30.00 | E | |
| | 52 | 24.00 | N | 176 | 30.00 | E | |
| | 52 | 24.00 | N | 176 | 0.00 | E | |
| | 52 | 18.00 | N | 176 | 0.00 | E | |
| | 52 | 18.00 | N | 175 | 54.00 | E | |
| | 52 | 6.00 | N | 175 | 54.00 | E | |
| | 52 | 6.00 | N | 175 | 48.00 | E | |
| | 52 | 0.00 | N | 175 | 48.00 | E | |
| | 52 | 0.00 | N | 175 | 54.00 | E | |
| | 51 | 54.00 | N | 175 | 54.00 | E | |
| | 51 | 54.00 | N | 175 | 36.00 | E | |
| | 51 | 42.00 | N | 175 | 36.00 | E | |
| | 51 | 42.00 | N | 175 | 30.00 | E | |
| | 51 | 36.00 | N | 175 | 30.00 | E | |

| Name | Latitude | | | Longitude | | | Footnote |
|---|---|---|---|---|---|---|---|
| | 51 | 36.00 | N | 175 | 36.00 | E | |
| | 51 | 30.00 | N | 175 | 36.00 | E | |
| | 51 | 30.00 | N | 175 | 42.00 | E | |
| | 51 | 36.00 | N | 175 | 42.00 | E | |
| | 51 | 36.00 | N | 176 | 0.00 | E | |
| | 52 | 0.00 | N | 176 | 0.00 | E | |
| | 52 | 0.00 | N | 176 | 6.00 | E | |
| | 52 | 6.00 | N | 176 | 6.00 | E | |
| | 52 | 6.00 | N | 176 | 12.00 | E | |
| | 52 | 0.00 | N | 176 | 12.00 | E | |
| | 52 | 0.00 | N | 176 | 30.00 | E | |
| | 51 | 54.00 | N | 176 | 30.00 | E | |
| | 51 | 54.00 | N | 177 | 0.00 | E | |
| | 52 | 0.00 | N | 177 | 0.00 | E | |
| | 52 | 0.00 | N | 177 | 12.00 | E | |
| Buldir donut | 51 | 48.00 | N | 175 | 48.00 | E | 5 |
| | 51 | 48.00 | N | 175 | 42.00 | E | 5 |
| | 51 | 45.00 | N | 175 | 42.00 | E | 5 |
| | 51 | 45.00 | N | 175 | 48.00 | E | 5, 7 |
| Buldir Mound | 51 | 54.00 | N | 176 | 24.00 | E | |
| | 51 | 54.00 | N | 176 | 18.00 | E | |
| | 51 | 48.00 | N | 176 | 18.00 | E | |
| | 51 | 48.00 | N | 176 | 24.00 | E | |
| Buldir West | 52 | 30.00 | N | 175 | 48.00 | E | |
| | 52 | 30.00 | N | 175 | 36.00 | E | |
| | 52 | 36.00 | N | 175 | 36.00 | E | |
| | 52 | 36.00 | N | 175 | 24.00 | E | |
| | 52 | 24.00 | N | 175 | 24.00 | E | |
| | 52 | 24.00 | N | 175 | 30.00 | E | |
| | 52 | 18.00 | N | 175 | 30.00 | E | |
| | 52 | 18.00 | N | 175 | 36.00 | E | |
| | 52 | 24.00 | N | 175 | 36.00 | E | |
| | 52 | 24.00 | N | 175 | 48.00 | E | |
| Tahoma Canyon | 52 | 0.00 | N | 175 | 18.00 | E | |
| | 52 | 0.00 | N | 175 | 12.00 | E | |
| | 51 | 42.00 | N | 175 | 12.00 | E | |
| | 51 | 42.00 | N | 175 | 24.00 | E | |
| | 51 | 54.00 | N | 175 | 24.00 | E | |
| | 51 | 54.00 | N | 175 | 18.00 | E | |
| Walls Plateau | 52 | 24.00 | N | 175 | 24.00 | E | |
| | 52 | 24.00 | N | 175 | 12.00 | E | |
| | 52 | 18.00 | N | 175 | 12.00 | E | |
| | 52 | 18.00 | N | 175 | 0.00 | E | |
| | 52 | 12.00 | N | 175 | 0.00 | E | |
| | 52 | 12.00 | N | 174 | 42.00 | E | |
| | 52 | 6.00 | N | 174 | 42.00 | E | |
| | 52 | 6.00 | N | 174 | 36.00 | E | |
| | 52 | 0.00 | N | 174 | 36.00 | E | |
| | 52 | 0.00 | N | 174 | 42.00 | E | |
| | 51 | 54.00 | N | 174 | 42.00 | E | |
| | 51 | 54.00 | N | 174 | 48.00 | E | |
| | 52 | 0.00 | N | 174 | 48.00 | E | |
| | 52 | 0.00 | N | 174 | 54.00 | E | |
| | 52 | 6.00 | N | 174 | 54.00 | E | |
| | 52 | 6.00 | N | 175 | 18.00 | E | |
| | 52 | 12.00 | N | 175 | 24.00 | E | |
| Semichi I | 52 | 30.00 | N | 175 | 6.00 | E | |
| | 52 | 30.00 | N | 175 | 0.00 | E | |

| Name | Latitude | | | Longitude | | | Footnote |
|---|---|---|---|---|---|---|---|
| | 52 | 36.00 | N | 175 | 0.00 | E | |
| | 52 | 36.00 | N | 174 | 48.00 | E | |
| | 52 | 42.00 | N | 174 | 48.00 | E | |
| | 52 | 42.00 | N | 174 | 33.00 | E | |
| | 52 | 36.00 | N | 174 | 33.00 | E | |
| | 52 | 36.00 | N | 174 | 24.00 | E | |
| | 52 | 39.00 | N | 174 | 24.00 | E | |
| | 52 | 39.00 | N | 174 | 0.00 | E | |
| | 52 | 42.00 | N | 173 | 54.00 | E | |
| | 52 | 45.16 | N | 173 | 54.00 | E | 1 |
| | 52 | 46.35 | N | 173 | 54.00 | E | |
| | 52 | 54.00 | N | 173 | 54.00 | E | |
| | 52 | 54.00 | N | 173 | 30.00 | E | |
| | 52 | 48.00 | N | 173 | 30.00 | E | |
| | 52 | 48.00 | N | 173 | 36.00 | E | |
| | 52 | 40.00 | N | 173 | 36.00 | E | |
| | 52 | 40.00 | N | 173 | 25.00 | E | |
| | 52 | 30.00 | N | 173 | 25.00 | E | |
| | 52 | 33.00 | N | 173 | 40.00 | E | |
| | 52 | 33.00 | N | 173 | 54.00 | E | |
| | 52 | 18.00 | N | 173 | 54.00 | E | |
| | 52 | 18.00 | N | 174 | 30.00 | E | |
| | 52 | 30.00 | N | 174 | 30.00 | E | |
| | 52 | 30.00 | N | 174 | 48.00 | E | |
| | 52 | 24.00 | N | 174 | 48.00 | E | |
| | 52 | 24.00 | N | 175 | 6.00 | E | |
| Agattu South | 52 | 18.00 | N | 173 | 54.00 | E | |
| | 52 | 18.00 | N | 173 | 24.00 | E | |
| | 52 | 9.00 | N | 173 | 24.00 | E | |
| | 52 | 9.00 | N | 173 | 36.00 | E | |
| | 52 | 6.00 | N | 173 | 36.00 | E | |
| | 52 | 6.00 | N | 173 | 54.00 | E | |
| Attu I North | 53 | 3.00 | N | 173 | 24.00 | E | |
| | 53 | 3.00 | N | 173 | 6.00 | E | |
| | 53 | 0.00 | N | 173 | 6.00 | E | |
| | 53 | 0.00 | N | 173 | 24.00 | E | |
| Attu I West | 52 | 54.00 | N | 172 | 12.00 | E | |
| | 52 | 54.00 | N | 172 | 0.00 | E | |
| | 52 | 48.00 | N | 172 | 0.00 | E | |
| | 52 | 48.00 | N | 172 | 12.00 | E | |
| Stalemate Bank | 53 | 0.00 | N | 171 | 6.00 | E | |
| | 53 | 0.00 | N | 170 | 42.00 | E | |
| | 52 | 54.00 | N | 170 | 42.00 | E | |
| | 52 | 54.00 | N | 171 | 6.00 | E | |

Note: Unless otherwise footnoted, each area is delineated by connecting in order the coordinates listed by straight lines. Except for the Amlia North/Seguam donut and the Buldir donut, each area delineated in the table is open to nonpelagic trawl gear fishing. The remainder of the entire Aleutian Islands subarea and the areas delineated by the coordinates for the Amlia North/Seguam and Buldir donuts are closed to nonpelagic trawl gear fishing, as specified at § 679.22. Unless otherwise noted, the last set of coordinates for each area is connected to the first set of coordinates for the area by a straight line. The projected coordinate system is North American Datum 1983, Albers.

[1]The connection of these coordinates to the next set of coordinates is by a line extending in a clockwise direction from these coordinates along the shoreline at mean lower-low water to the next set of coordinates.
[2]The connection of these coordinates to the next set of coordinates is by a line extending in a counter clockwise direction from these coordinates along the shoreline at mean lower-low water to the next set of coordinates.
[3]The connection of these coordinates to the first set of coordinates for this area is by a line extending in a clockwise direction from these coordinates along the shoreline at mean lower-low water to the first set of coordinates.

[4]The connection of these coordinates to the first set of coordinates for this area is by a line extending in a counter clockwise direction from these coordinates along the shoreline at mean lower-low water to the first set of coordinates.
[5] The area specified by this set of coordinates is closed to fishing with non-pelagic trawl gear.
[6] This set of coordinates is connected to the first set of coordinates listed for the area by a straight line.
[7]The last coordinate for the donut is connected to the first set of coordinates for the donut by a straight line.

## Aleutian Islands Coral Habitat Protection Areas (AICHPAs)

The use of bottom contact gear is prohibited in the AICHPAs. The coordinates for the areas are listed in the table below. Note: Each area is delineated by connecting the coordinates in the order listed by straight lines. The last set of coordinates for each area is connected to the first set of coordinates for the area by a straight line. The projected coordinate system is North American Datum 1983, Albers.

| Area Number | Name | Latitude | | | Longitude | | |
|---|---|---|---|---|---|---|---|
| 1 | Great Sitkin Is | 52 | 9.56 | N | 176 | 6.14 | W |
| | | 52 | 9.56 | N | 176 | 12.44 | W |
| | | 52 | 4.69 | N | 176 | 12.44 | W |
| | | 52 | 6.59 | N | 176 | 6.12 | W |
| 2 | Cape Moffett Is | 52 | 0.11 | N | 176 | 46.65 | W |
| | | 52 | 0.10 | N | 176 | 53.00 | W |
| | | 51 | 55.69 | N | 176 | 53.00 | W |
| | | 51 | 55.69 | N | 176 | 48.59 | W |
| | | 51 | 57.96 | N | 176 | 46.52 | W |
| 3 | Adak Canyon | 51 | 39.00 | N | 177 | 0.00 | W |
| | | 51 | 39.00 | N | 177 | 3.00 | W |
| | | 51 | 30.00 | N | 177 | 3.00 | W |
| | | 51 | 30.00 | N | 177 | 0.00 | W |
| 4 | Bobrof Is | 51 | 57.35 | N | 177 | 19.94 | W |
| | | 51 | 57.36 | N | 177 | 29.11 | W |
| | | 51 | 51.65 | N | 177 | 29.11 | W |
| | | 51 | 51.71 | N | 177 | 19.93 | W |
| 5 | Ulak Is | 51 | 25.85 | N | 178 | 59.00 | W |
| | | 51 | 25.69 | N | 179 | 6.00 | W |
| | | 51 | 22.28 | N | 179 | 6.00 | W |
| | | 51 | 22.28 | N | 178 | 58.95 | W |
| 6 | Semisopochnoi Is | 51 | 53.10 | N | 179 | 53.11 | E |
| | | 51 | 53.10 | N | 179 | 46.55 | E |
| | | 51 | 48.84 | N | 179 | 46.55 | E |
| | | 51 | 48.89 | N | 179 | 53.11 | E |

## Bowers Ridge Habitat Conservation Zone (BRHCZ)

The use of mobile bottom contact gear is prohibited in the BRHCZ. The areas are described in the table below.

| Area number | Name | Latitude | | | Longitude | | |
|---|---|---|---|---|---|---|---|
| 1 | Bowers Ridge | 55 | 10.50 | N | 178 | 27.25 | E |
| | | 54 | 54.50 | N | 177 | 55.75 | E |
| | | 54 | 5.83 | N | 179 | 20.75 | E |
| | | 52 | 40.50 | N | 179 | 55.00 | W |
| | | 52 | 44.50 | N | 179 | 26.50 | W |
| | | 54 | 15.50 | N | 179 | 54.00 | W |
| 2 | Ulm Plateau | 55 | 5.00 | N | 177 | 15.00 | E |
| | | 55 | 5.00 | N | 175 | 60.00 | E |
| | | 54 | 34.00 | N | 175 | 60.00 | E |
| | | 54 | 34.00 | N | 177 | 15.00 | E |

Note: Each area is delineated by connecting the coordinates in the order listed by straight lines. The last set of coordinates for each area is connected to the first set of coordinates for the area by a straight line. The projected coordinate system is North American Datum 1983, Albers.

### Bering Sea Habitat Conservation Area

Nonpelagic trawl gear fishing is prohibited in Bering Sea Habitat Conservation Area. Coordinates for this habitat conservation area are listed in the table below. The area is delineated by connecting the coordinates in the order listed by straight lines. The last set of coordinates for each area is connected to the first set of coordinates for the area by a straight line. The projected coordinate system is North American Datum 1983, Albers.

| Latitude | | | Longitude | | |
|---|---|---|---|---|---|
| 179 | 19.95 | W | 59 | 25.15 | N |
| 177 | 51.76 | W | 58 | 28.85 | N |
| 175 | 36.52 | W | 58 | 11.78 | N |
| 174 | 32.36 | W | 58 | 8.37 | N |
| 174 | 26.33 | W | 57 | 31.31 | N |
| 174 | 0.82 | W | 56 | 52.83 | N |
| 173 | 0.71 | W | 56 | 24.05 | N |
| 170 | 40.32 | W | 56 | 1.97 | N |
| 168 | 56.63 | W | 55 | 19.30 | N |
| 168 | 0.08 | W | 54 | 5.95 | N |
| 170 | 0.00 | W | 53 | 18.24 | N |
| 170 | 0.00 | W | 55 | 0.00 | N |
| 178 | 46.69 | E | 55 | 0.00 | N |
| 178 | 27.25 | E | 55 | 10.50 | N |
| 178 | 6.48 | E | 55 | 0.00 | N |
| 177 | 15.00 | E | 55 | 0.00 | N |
| 177 | 15.00 | E | 55 | 5.00 | N |
| 176 | 0.00 | E | 55 | 5.00 | N |
| 176 | 0.00 | E | 55 | 0.00 | N |
| 172 | 6.35 | E | 55 | 0.00 | N |
| 173 | 59.70 | E | 56 | 16.96 | N |

### St. Matthew Island Habitat Conservation Area

Nonpelagic trawl gear fishing is prohibited in St. Matthew Island Habitat Conservation Area. Coordinates for this habitat conservation area are listed in the table below. The area is delineated by connecting the coordinates in the order listed by straight lines. The last set of coordinates for each area is connected to the first set of coordinates for the area by a straight line. The projected coordinate system is North American Datum 1983, Albers.

| Longitude | | | Latitude | | |
|---|---|---|---|---|---|
| 171 | 45.00 | W | 60 | 54.00 | N |
| 171 | 45.00 | W | 60 | 6.15 | N |
| 174 | 0.50 | W | 59 | 42.26 | N |
| 174 | 24.98 | W | 60 | 9.98 | N |
| 174 | 1.24 | W | 60 | 54.00 | N |

### St. Lawrence Island Habitat Conservation Area

Nonpelagic trawl gear fishing is prohibited in St. Lawrence Island Habitat Conservation Area. Coordinates for this habitat conservation area are listed in the table below. The area is delineated by connecting the coordinates in the order listed by straight lines. The last set of coordinates for each area is connected to the first set of coordinates for the area by a straight line. The projected coordinate system is North American Datum 1983, Albers.

| Longitude | | | Latitude | | |
|---|---|---|---|---|---|
| 168 | 24.00 | W | 64 | 0.00 | N |
| 168 | 24.00 | W | 62 | 42.00 | N |
| 172 | 24.00 | W | 62 | 42.00 | N |
| 172 | 24.00 | W | 63 | 57.03 | N |
| 172 | 17.42 | W | 64 | 0.01 | N |

## Nunivak Island, Etolin Strait, and Kuskokwim Bay Habitat Conservation Area

Nonpelagic trawl gear fishing is prohibited in Nunivak Island, Etolin Strait, and Kuskokwim Bay Habitat Conservation Area. Coordinates for this habitat conservation area are listed in the table below. The area is delineated by connecting the coordinates in the order listed by straight lines. The last set of coordinates for each area is connected to the first set of coordinates for the area by a straight line. The projected coordinate system is North American Datum 1983, Albers.

| Longitude | | | Latitude | | |
|---|---|---|---|---|---|
| 165 | 1.54 | W | 60 | 45.54 | N* |
| 162 | 7.01 | W | 58 | 38.27 | N |
| 162 | 10.51 | W | 58 | 38.35 | N |
| 162 | 34.31 | W | 58 | 38.36 | N |
| 162 | 34.32 | W | 58 | 39.16 | N |
| 162 | 34.23 | W | 58 | 40.48 | N |
| 162 | 34.09 | W | 58 | 41.79 | N |
| 162 | 33.91 | W | 58 | 43.08 | N |
| 162 | 33.63 | W | 58 | 44.41 | N |
| 162 | 33.32 | W | 58 | 45.62 | N |
| 162 | 32.93 | W | 58 | 46.80 | N |
| 162 | 32.44 | W | 58 | 48.11 | N |
| 162 | 31.95 | W | 58 | 49.22 | N |
| 162 | 31.33 | W | 58 | 50.43 | N |
| 162 | 30.83 | W | 58 | 51.42 | N |
| 162 | 30.57 | W | 58 | 51.97 | N |
| 163 | 17.72 | W | 59 | 20.16 | N |
| 164 | 11.01 | W | 59 | 34.15 | N |
| 164 | 42.00 | W | 59 | 41.80 | N |
| 165 | 0.00 | W | 59 | 42.60 | N |
| 165 | 1.45 | W | 59 | 37.39 | N |
| 167 | 40.20 | W | 59 | 24.47 | N |
| 168 | 0.00 | W | 59 | 49.13 | N |
| 167 | 59.98 | W | 60 | 45.55 | N |

* The boundary extends in a clockwise direction from this set of geographic coordinates along the shoreline at mean lower-low tide line to the next set of coordinates.

## Northern Bering Sea Research Area

Nonpelagic trawl gear fishing in the Northern Bering Sea Research Area is prohibited, except as allowed through exempted fishing permits under 50 CFR 679.6 and described in section 3.5.2.1.12. The area is delineated by connecting the coordinates in the order listed by straight lines. The last set of coordinates for each area is connected to the first set of coordinates for the area by a straight line. The projected coordinate system is North American Datum 1983, Albers.

| Longitude | | | Latitude | | |
|---|---|---|---|---|---|
| 168 | 7.41 | W | 65 | 37.91 | N* |
| 165 | 1.54 | W | 60 | 45.54 | N |
| 167 | 59.98 | W | 60 | 45.55 | N |
| 169 | 00.00 | W | 60 | 35.50 | N |
| 169 | 00.00 | W | 61 | 00.00 | N |
| 171 | 45.00 | W | 61 | 00.00 | N |
| 171 | 45.00 | W | 60 | 54.00 | N |
| 174 | 1.24 | W | 60 | 54.00 | N |
| 176 | 13.51 | W | 62 | 6.56 | N |
| 172 | 24.00 | W | 63 | 57.03 | N |
| 172 | 24.00 | W | 62 | 42.00 | N |
| 168 | 24.00 | W | 62 | 42.00 | N |
| 168 | 24.00 | W | 64 | 0.00 | N |
| 172 | 17.42 | W | 64 | 0.01 | N |
| 168 | 58.62 | W | 65 | 30.00 | N |
| 168 | 58.62 | W | 65 | 49.81 | N** |

* The boundary extends in a clockwise direction from this set of geographic coordinates along the shoreline at mean lower-low tide line to the next set of coordinates.

** Intersection of the 1990 United States/Russia Maritime Boundary Line and a line from Cape Prince of Wales to Cape Dezhneva (Russia) that defines the boundary between the Chukchi and Bering Seas.

## Modified Gear Trawl Zone

Owners and operators of vessels using nonpelagic trawl gear in the Modified Gear Trawl Zone must use modified nonpelagic trawl gear, regardless of target species, as described in Section 3.4.2 for the Bering Sea subarea flatfish fishery. The area is delineated by connecting the coordinates below, in the order listed, by straight lines. The last set of coordinates is connected to the first set of coordinates for the area by a straight line. The projected coordinate system is North American Datum 1983, Albers.

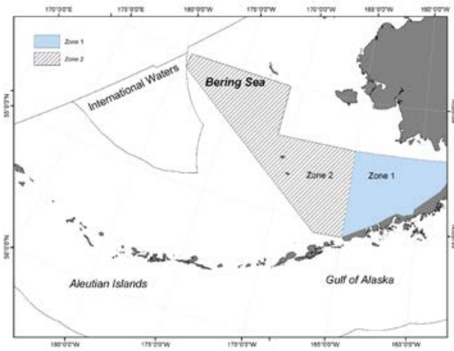
| Longitude | | | Latitude | | |
|---|---|---|---|---|---|
| 171 | 45.00 | W | 61 | 00.00 | N |
| 169 | 00.00 | W | 61 | 00.00 | N |
| 169 | 00.00 | W | 60 | 35.48 | N |
| 171 | 45.00 | W | 60 | 06.15 | N |

## B.3 PSC Limitation Zones

Specific areas of the management area are closed to some or all fishing during certain times of the year on attainment of a species-specific bycatch cap. These areas are described in Section 3.6.2.2 of the FMP.

### Zones 1 and 2

Zones 1 and 2 are closed to directed fishing when the crab bycatch caps are attained in specified fisheries.




Zone 1: area bounded by 165E W. longitude and 58E N. latitude extending east to the shore.

Zone 2: area bounded by 165E W. longitude, north to 58E N., then west to the intersection of 58E N. and 171E W. longitude, then north to 60E N., then west to 179E20' W. longitude, then south to 59E25' N. latitude, then diagonally extending on a straight line southeast to the intersection of 167E W. longitude and 54E30' N. latitude, and then extending eastward along 54E30' N. latitude to 165E W. longitude.

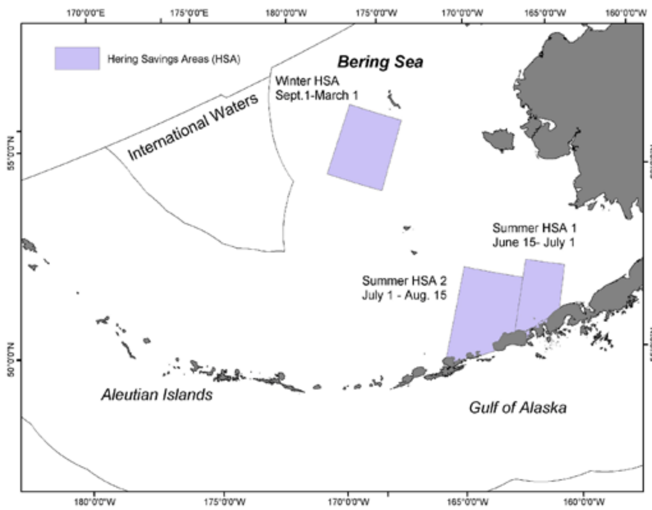
### Herring Savings Areas

The herring savings areas are all located within the Bering Sea subarea and are defined as follows:

Summer Herring Savings Area 1: area south of 57E N. latitude and between 162E W. and 164E W. longitude from 12:00 noon Alaska Local Time (ALT) June 15 through 12:00 noon ALT July 1 of a fishing year

Summer Herring Savings Area 2: area south of 56E30' N. latitude and between 164E W. and 167E W. longitude from 12:00 noon ALT July 1 through 12:00 noon ALT August 15 of a fishing year

Winter Herring Savings Area: area between 58E N. and 60E N. latitude and between 172E W. and 175E W. longitude from 12:00 noon ALT September 1 through 12:00 noon ALT March 1 of the succeeding fishing year




## Chum Salmon Savings Area

Upon the attainment of the “other salmon” catch limit, trawling is prohibited for the remainder of the period September 1 through October 14 within the area bounded by a straight line connecting the following pairs of coordinates in the order listed:

(56E00' N., 167E W.)

(56E00' N., 165E W.)

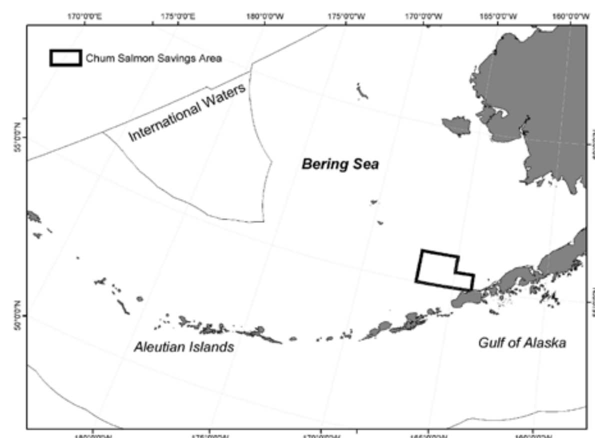
(55E30' N., 165E W.)

(55E30' N., 164E W.)

(55E00' N., 164E W.)

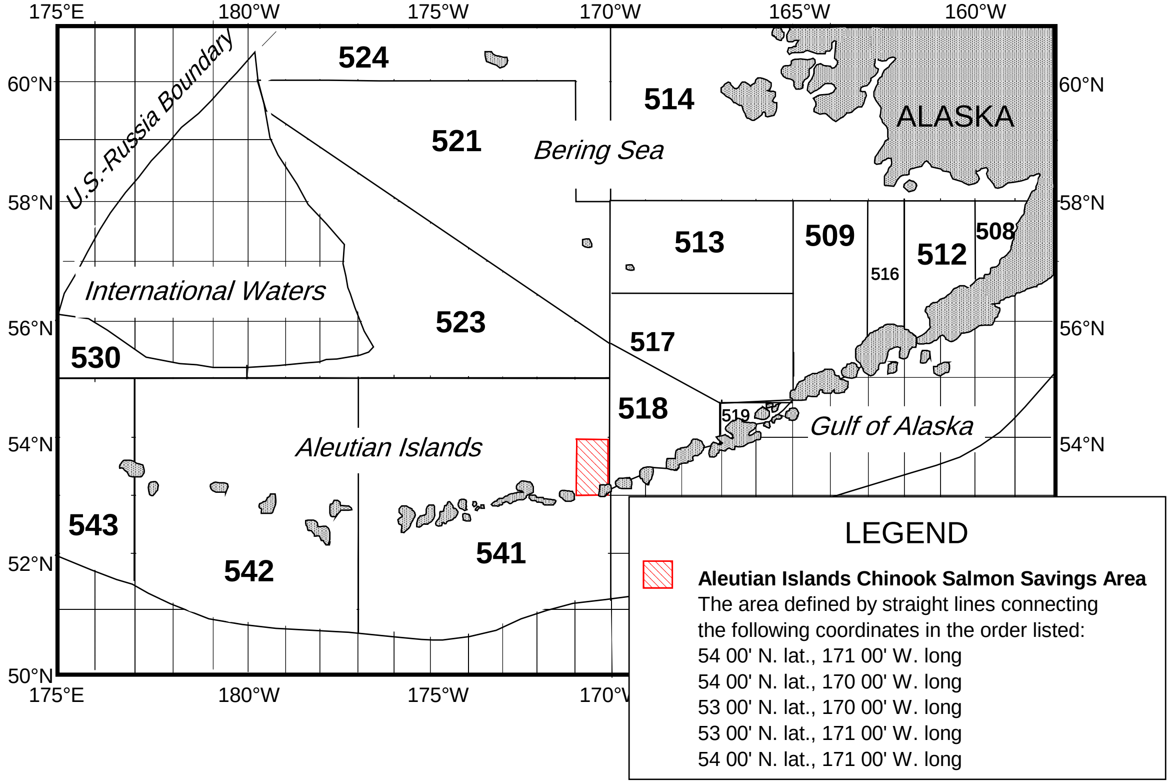
(55E00' N., 167E W.)

(56E00' N., 167E W.)




Trawling is also prohibited absolutely in the area from August 1 through August 31; see description in Section B.2 above.

## Aleutian Islands Chinook Salmon Savings Area




## *C. Opilio* Bycatch Limitation Zone (COBLZ)

Defined as that portion of the Bering Sea subarea north of 56□30' N. latitude and west of a line connecting the following coordinates in the order listed:

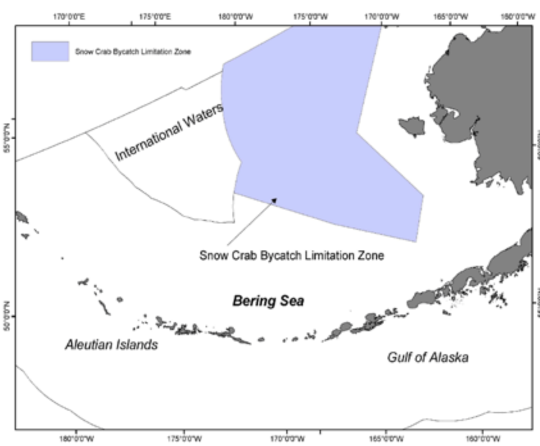
(56E30' N., 165E W.)

(58E00' N., 165E W.)

(59E30' N., 170E W.)

and north along 170E W. longitude to its intersection with the U.S.-Russia boundary.

Upon attainment of the COBLZ bycatch allowance of *C. opilio* crab specified for a particular fishery category, the COBLZ will be closed to directed fishing for each category for the remainder of the year or for the remainder of the season.



# Appendix C Summary of the American Fisheries Act and Subtitle II

## C.1 Summary of the American Fisheries Act (AFA) Management Measures

On October 21, 1998, the President signed into law the American Fisheries Act (AFA) that superseded the previous inshore/offshore management regime for Bering Sea and Aleutian Islands (BSAI) pollock adopted under Amendment 18 and extended under Amendments 23 and 51. With respect to the fisheries off Alaska, the AFA required several new management measures: 1) regulations that limit access into the fishing and processing sectors of the pollock fishery and that allocate pollock to such sectors, 2) regulations governing the formation and operation of fishery cooperatives in the pollock fishery, 3) regulations to protect other fisheries from spillover effects from the AFA, and 4) regulations governing catch measurement and monitoring in the pollock fishery.

The AFA, as enacted in 1998, is a complex piece of legislation with numerous provisions that affect the management of the groundfish and crab fisheries off Alaska. The AFA is divided into two subtitles. *Subtitle I – Fisheries Endorsements* includes nationwide United States (U.S.) ownership and vessel length restrictions for U.S. vessels with fisheries endorsements. These requirements are implemented by the Maritime Administration and the U.S. Coast Guard under the Department of Transportation and Department of Homeland Security, respectively. *Subtitle II – Bering Sea Pollock Fishery* contains measures related to the management of BSAI pollock fishery.

Since 1998, Congress has amended the AFA several times. Most notably, in 2004 certain provisions of the AFA regarding the Aleutian Islands directed pollock fishery were superseded by the Consolidated Appropriations Act of 2004, as further described in section 3.7.3 of the FMP, and in 2010, Congress amended the AFA to identify conditions under which the owner of an AFA vessel may rebuild or replace the vessel and conditions under which the owner of an AFA catcher vessel that is a member of an inshore cooperative may remove the vessel from the cooperative.

Key provisions of the AFA, as enacted in 1998, are listed below.

- A requirement that owners of all U.S. flagged fishing vessels comply with a 75 percent U.S. controlling interest standard.
- A prohibition on the entry of any new fishing vessels into U.S. waters that exceed 165 ft registered length, 750 gross registered tons, or 3,000 shaft horsepower.
- The buyout of nine pollock catcher/processors and the subsequent scrapping of eight of these vessels through a combination of $20 million in federal appropriations and $75 million in direct loan obligations.
- A new allocation scheme for BSAI pollock that allocates 10 percent of the BSAI pollock total allowable catch (TAC) to the Community Development Quota (CDQ) Program, and after allowance for incidental catch of pollock in other fisheries, allocates the remaining TAC as follows: 50 percent to vessels harvesting pollock for processing by inshore processors, 40 percent to vessels harvesting pollock for processing by catcher/processors, and 10 percent to vessels harvesting pollock for processing by motherships.

- A fee of six-tenths (0.6) of one cent for each pound round weight of pollock harvested by catcher vessels delivering to inshore processors for the purpose of repaying the $75 million direct loan obligation.
- A prohibition on entry of new vessels and processors into the BSAI pollock fishery. The AFA lists by name vessels and processors and/or provides qualifying criteria for those vessels and processors eligible to participate in the non-CDQ portion of the BSAI pollock fishery.
- An increase in observer coverage and scale requirements for AFA catcher/processors.
- New standards and limitations for the creation of fishery cooperatives in the catcher/ processor, mothership, and inshore industry sectors.
- A quasi-individual fishing quota program under which National Marine Fisheries Service grants individual allocations of the inshore BSAI pollock TAC to inshore catcher vessel cooperatives that form around a specific inshore processor and agree to deliver at least 90 percent of their pollock catch to that processor.
- The establishment of harvesting and processing restrictions (commonly known as “sideboards”) on fishermen and processors who have received exclusive harvesting or processing privileges under the AFA, to protect the interests of fishermen and processors who have not directly benefitted from the AFA.
- A 17.5 percent excessive share harvesting cap for BSAI pollock and a requirement that the Council develop excessive share caps for BSAI pollock processing and for the harvesting and processing of other groundfish.

Certain provisions of the AFA regarding the Aleutian Islands directed pollock fishery were superseded by the Consolidated Appropriations Act of 2004, as further described in section 3.7.3 of the FMP.

## C.2 Summary of Amendments to AFA in the Coast Guard Authorization Act of 2010

On October 15, 2010, the President signed into law the Coast Guard Authorization Act of 2010, Pub. L. 111-281. Title VI of the Act was entitled The Maritime Safety Act of 2010. Section 602 of Title VI, entitled “Vessel Size Limits,” amended section 208(g) of the AFA relating to the rebuilding and the replacement of AFA vessels and added section 210(b)(7) allowing for the removal from the AFA fishery of AFA catcher vessels that are members of an AFA inshore fishery cooperative.

Under the original AFA in section 208(g), an owner of an AFA vessel could only replace an AFA vessel if the AFA vessel was lost physically or was lost constructively, which means that the vessel was so damaged that the cost of repair was greater than the value of the vessel. If an owner lost a vessel, the owner could only replace the vessel with a vessel of the same length, weight, or horsepower, unless the AFA vessel was less than the statutory thresholds in 46 U.S.C. 12113 for a vessel to receive a federal fishery endorsement: 165 feet registered length, 750 gross registered tons, and 3,000 shaft horsepower engine(s). If the AFA vessel was less than any of those thresholds, the owner of a lost AFA vessel could replace the lost vessel with a vessel ten percent greater in length, tonnage, or horsepower, up to those thresholds in each category. For AFA catcher vessels that were members of an inshore fishery cooperative, the original AFA had no mechanism whereby the owner of a catcher vessel could remove that vessel and direct NMFS to assign the catch history of the removed vessel to other vessels in the inshore cooperative.

The key provisions of the AFA amendments in the Coast Guard Authorization Act of 2010 that NMFS will implement in Amendment 106 to this FMP are listed below:

- The owner of a vessel which is designated on an AFA vessel permit may replace or rebuild the AFA vessel to improve vessel safety or improve operational efficiency, including fuel efficiency.
- The AFA rebuilt and the AFA replacement vessel will be eligible to participate in the fisheries in the EEZ off Alaska in the same manner as the vessel before rebuilding or before replacing, except where the AFA amendments specifically changed a condition of participation.
- The AFA rebuilt and the AFA replacement vessel may exceed the maximum length overall (MLOA) on the LLP groundfish license that authorizes the vessel to conduct directed groundfish fishing for license limitation groundfish in the Bering Sea or the Aleutian Islands, while the AFA rebuilt or AFA replacement vessel is fishing pursuant to that LLP license.
- The AFA rebuilt and the AFA replacement vessel are subject to the MLOA requirement on the LLP groundfish license that authorizes the vessel to conduct directed fishing for license limitation groundfish in the Gulf of Alaska, while the AFA rebuilt or AFA replacement vessel is fishing pursuant to that LLP license.
- The AFA amendments prohibit AFA rebuilt catcher vessels and AFA replacement catcher vessels from harvesting fish in any fishery managed under the authority of any regional fishery management council with two exceptions: [1] an AFA rebuilt or AFA replacement catcher vessel may participate in the Pacific whiting fishery, which is managed under the authority of the Pacific Council; and [2] an AFA rebuilt or AFA replacement catcher vessel may participate in a fishery managed under the authority of the North Pacific Fishery Management Council in conformity with the requirements for participating in a Council-managed fishery. The original AFA already imposed this restriction on AFA catcher/processors and motherships.
- The owner of an AFA catcher vessel that is a member of an AFA inshore cooperative may remove the vessel from the AFA fishery and direct NMFS to assign the catch history of the removed vessel to any other vessel or vessels in the AFA cooperative to which the removed vessel belonged, provided that the vessel or vessels that are assigned the catch history remain in the cooperative for at least one year after NMFS assigns the catch history to them.
- If an owner of an AFA catcher vessel removes an AFA catcher vessel, and the removed vessel had an exemption from AFA sideboard limitations, the removal of the vessel permanently extinguishes the exemption from AFA sideboard limitations.
- A vessel that is replaced or removed would be permanently ineligible for any permits to participate in any fishery in the EEZ off Alaska unless the replaced or removed vessel reenters the directed pollock fishery as an AFA replacement vessel.

## C.3 American Fisheries Act: Subtitle II Bering Sea Pollock Fishery

***SEC. 205. DEFINITIONS.***

*As used in this subtitle –*

*(1) the term "Bering Sea and Aleutian Islands Management Area" has the same meaning as the meaning given for such term in part 679.2 of title 50, Code of Federal Regulations, as in effect on October 1, 1998;*

*(2) the term "catcher/processor" means a vessel that is used for harvesting fish and processing that fish;*

*(3) the term "catcher vessel" means a vessel that is used for harvesting fish and that does not process pollock onboard;*

*(4) the term "directed pollock fishery" means the fishery for the directed fishing allowances allocated under paragraphs (1), (2), and (3) of section 206(b);*

*(5) the term "harvest" means to commercially engage in the catching, taking, or harvesting of fish or any activity that can reasonably be expected to result in the catching, taking, or harvesting of fish;*

*(6) the term "inshore component" means the following categories that process groundfish harvested in the Bering Sea and Aleutian Islands Management Area:*

*(A) shoreside processors, including those eligible under section 208(f); and*

*(B) vessels less than 125 feet in length overall that process less than 126 metric tons per week in round-weight equivalents of an aggregate amount of pollock and Pacific cod;*

*(7) the term "Magnuson-Stevens Act" means the Magnuson-Stevens Fishery Conservation and Management Act (16 U.S.C. 1801 et seq.);*

*(8) the term "mothership" means a vessel that receives and processes fish from other vessels in the exclusive economic zone of the United States and is not used for, or equipped to be used for, harvesting fish;*

*(9) the term "North Pacific Council" means the North Pacific Fishery Management Council established under section 302(a)(1)(G) of the Magnuson-Stevens Act (16 U.S.C. 1852(a)(1)(G));*

*(10) the term "offshore component" means all vessels not included in the definition of inshore component that process groundfish harvested in the Bering Sea and Aleutian Islands Management Area;*

*(11) the term "Secretary" means the Secretary of Commerce; and*

*(12) the term "shoreside processor" means any person or vessel that receives unprocessed fish, except catcher/processors, motherships, buying stations, restaurants, or persons receiving fish for personal consumption or bait.*

***SEC. 206. ALLOCATIONS.***

*(a) POLLOCK COMMUNITY DEVELOPMENT QUOTA. Effective January 1,1999, 10 percent of the total allowable catch of pollock in the Bering Sea and Aleutian Islands Management Area shall be allocated as a directed fishing allowance to the western Alaska community development quota program established under section 305(i) of the Magnuson-Stevens Act (16 U.S.C. 1855(i)).*

*(b) INSHORE/OFFSHORE. Effective January 1, 1999, the remainder of the pollock total allowable catch in the Bering Sea and Aleutian Islands Management Area, after the subtraction of the allocation under subsection (a) and the subtraction of allowances for the incidental catch of pollock by vessels harvesting other groundfish species (including under the western Alaska community development quota program) shall be allocated as directed fishing allowances as follows –*

*(1) 50 percent to catcher vessels harvesting pollock for processing by the inshore component;*

*(2) 40 percent to catcher/processors and catcher vessels harvesting pollock for processing by catcher/processors in the offshore component; and*

*(3) 10 percent to catcher vessels harvesting pollock for processing by motherships in the offshore component.*

***SEC. 207. BUYOUT.***

*(a) FEDERAL LOAN. Under the authority of sections 1111 and 1112 of title XI of the Merchant Marine Act, 1936 (46 U.S.C. App. 1279f and 1279g) and notwithstanding the requirements of section 312 of the Magnuson-Stevens Act (16 U.S.C. 1861a), the Secretary shall, subject to the availability of appropriations for the cost of the direct loan, provide up to $75,000,000 through a direct loan obligation for the payments required under subsection (d).*

*(b) INSHORE FEE SYSTEM. Notwithstanding the requirements of section 304(d) or 312 of the Magnuson-Stevens Act (16 U.S.C. 1854(d) and 1861a), the Secretary shall establish a fee for the repayment of such loan obligations which –*

*(1) shall be six-tenths (0.6) of one cent for each pound round-weight of all pollock harvested from the directed fishing allowance under section 206(b)(1); and*

*(2) shall begin with such pollock harvested on or after January 1, 2000, and continue without interruption until such loan obligation is fully repaid; and*

*(3) shall be collected in accordance with section 312(d)(2)(C) of the Magnuson-Stevens Act (16 U.S.C. 1861a(d)(2)(C)) and in accordance with such other conditions as the Secretary establishes.*

*(c) FEDERAL APPROPRIATION. Under the authority of section 312(c)(1)(B) of the Magnuson-Stevens Act (16 U.S.C. 1861a(c)(1)(B)), there are authorized to be appropriated $20,000,000 for the payments required under subsection (d).*

*(d) PAYMENTS. Subject to the availability of appropriations for the cost of the direct loan under subsection (a) and funds under subsection (c), the Secretary shall pay by not later than December 31, 1998–*

*(1) up to $90,000,000 to the owner or owners of the catcher/processors listed in paragraphs (1) through (9) of section 209, in such manner as the owner or owners, with the concurrence of the Secretary, agree, except that –*

*(A) the portion of such payment with respect to the catcher/processor listed in paragraph (1) of section 209 shall be made only after the owner submits a written certification acceptable to the Secretary that neither the owner nor a purchaser from the owner intends to use such catcher/processor outside the exclusive economic zone of the United States to harvest any stock of fish (as such term is defined in section 3 of the Magnuson-Stevens Act (16 U.S.C. 1802)) that occurs within the exclusive economic zone of the United States; and*

*(B) the portion of such payment with respect to the catcher/processors listed in paragraphs (2) through (9) of section 209 shall be made only after the owner or owners of such catcher/processors submit a written certification acceptable to the Secretary that such catcher/processors will be scrapped by December 31, 2000 and will not, before that date, be used to harvest or process any fish; and*

*(2)(A) if a contract has been filed under section 210(a) by the catcher/processors listed in section 208(e), $5,000,000 to the owner or owners of the catcher/processors listed in paragraphs (10) through (14) of such section in such manner as the owner or owners, with the concurrence of the Secretary, agree; or*

*(B) if such a contract has not been filed by such date, $5,000,000 to the owners of the catcher vessels eligible under section 208(b) and the catcher/processors eligible under paragraphs (1) through (20) of section 208(e), divided based on the amount of the harvest of pollock in the directed pollock fishery by each such vessel in 1997 in such manner as the Secretary deems appropriate,*

*except that any such payments shall be reduced by any obligation to the federal government that has not been satisfied by such owner or owners of any such vessels.*

*(e) PENALTY. If the catcher/processor under paragraph (1) of section 209 is used outside the exclusive economic zone of the United States to harvest any stock of fish that occurs within the exclusive economic zone of the United States while the owner who received the payment under subsection (d)(1)(A) has an ownership interest in such vessel, or if the catcher/processors listed in paragraphs (2) through (9) of section 209 are determined by the Secretary not to have been scrapped by December 31, 2000 or to have been used in a manner inconsistent with subsection (d)(1)(B), the Secretary may suspend any or all of the federal permits which allow any vessels owned in whole or in part by the owner or owners who received payments under subsection (d)(1) to harvest or process fish within the exclusive economic zone of the United States until such time as the obligations of such owner or owners under subsection (d)(1) have been fulfilled to the satisfaction of the Secretary.*

*(f) PROGRAM DEFINED; MATURITY. For the purposes of section 1111 of the Merchant Marine Act, 1936 (46 U.S.C. App. 1279f), the fishing capacity reduction program in this subtitle shall be within the meaning of the term program as defined and used in such section. Notwithstanding section 1111(b)(4) of such Act (46 U.S.C. App. 1279f(b)(4)), the debt obligation under subsection (a) of this section may have a maturity not to exceed 30 years.*

*(g) FISHERY CAPACITY REDUCTION REGULATIONS. The Secretary of Commerce shall by not later than October 15, 1998 publish proposed regulations to implement subsections (b), (c), (d) and (e) of section 312 of the Magnuson-Stevens Act (16 U.S.C. 1861a) and sections 1111 and 1112 of title XI of the Merchant Marine Act, 1936 (46 U.S.C. App. 1279f and 1279g).*

***SEC. 208. ELIGIBLE VESSELS AND PROCESSORS.***

*(a) CATCHER VESSELS ONSHORE. Effective January 1, 2000, only catcher vessels which are –*

*(1) determined by the Secretary –*

*(A) to have delivered at least 250 metric tons of pollock; or*

*(B) to be less than 60 feet in length overall and to have delivered at least 40 metric tons of pollock,*

*for processing by the inshore component in the directed pollock fishery in any one of the years 1996 or 1997, or between January 1, 1998 and September 1, 1998;*

*(2) eligible to harvest pollock in the directed pollock fishery under the license limitation program recommended by the North Pacific Council and approved by the Secretary; and*

*(3) not listed in subsection (b),*

*shall be eligible to harvest the directed fishing allowance under section 206(b)(1) pursuant to a federal fishing permit.*

*(b) CATCHER VESSELS TO CATCHER/PROCESSORS. Effective January 1, 1999, only the following catcher vessels shall be eligible to harvest the directed fishing allowance under section 206(b)(2) pursuant to a federal fishing permit:*

*(1) AMERICAN CHALLENGER (United States official number 633219);*

*(2) FORUM STAR (United States official number 925863);*

*(3) MUIR MILACH (United States official number 611524);*

*(4) NEAHKAHNIE (United States official number 599534);*

*(5) OCEAN HARVESTER (United States official number 549892);*

*(6) SEA STORM (United States official number 628959);*

*(7) TRACY ANNE (United States official number 904859); and*

*(8) any catcher vessel –*

*(A) determined by the Secretary to have delivered at least 250 metric tons and at least 75 percent of the pollock it harvested in the directed pollock fishery in 1997 to catcher/processors for processing by the offshore component; and*

*(B) eligible to harvest pollock in the directed pollock fishery under the license limitation program recommended by the North Pacific Council and approved by the Secretary.*

*(c) CATCHERS VESSELS TO MOTHERSHIPS. Effective January 1, 2000, only the following catcher vessels shall be eligible to harvest the directed fishing allowance under section 206(b)(3) pursuant to a federal fishing permit:*

*(1) ALEUTIAN CHALLENGER (United States official number 603820);*

*(2) ALYESKA (United States official number 560237);*

*(3) AMBER DAWN (United States official number 529425);*

*(4) AMERICAN BEAUTY (United States official number 613847);*

*(5) CALIFORNIA HORIZON (United States official number 590758);*

*(6) MAR-GUN (United States official number 525608);*

*(7) MARGARET LYN (United States official number 615563);*

*(8) MARK I (United States official number 509552);*

*(9) MISTY DAWN (United States official number 926647);*

*(10) NORDIC FURY (United States official number 542651);*

*(11) OCEAN LEADER (United States official number 561518);*

*(12) OCEANIC (United States official number 602279);*

*(13) PACIFIC ALLIANCE (United States official number 612084);*

*(14) PACIFIC CHALLENGER (United States official number 618937);*

*(15) PACIFIC FURY (United States official number 561934);*

*(16) PAPADO II (United States official number 536161);*

*(17) TRAVELER (United States official number 929356);*

*(18) VESTERAALEN (United States official number 611642);*

*(19) WESTERN DAWN (United States official number 524423);*

*(20) any vessel –*

*(A) determined by the Secretary to have delivered at least 250 metric tons of pollock for processing by motherships in the offshore component of the directed pollock fishery in any one of the years 1996 or 1997, or between January 1, 1998 and September 1, 1998;*

*(B) eligible to harvest pollock in the directed pollock fishery under the license limitation program recommended by the North Pacific Council and approved by the Secretary; and*

*(C) not listed in subsection (b).*

*(d) MOTHERSHIPS. Effective January 1, 2000, only the following motherships shall be eligible to process the directed fishing allowance under section 206(b)(3) pursuant to a federal fishing permit:*

*(1) EXCELLENCE (United States official number 967502);*

*(2) GOLDEN ALASKA (United States official number 651041);*

*(3) OCEAN PHOENIX (United States official number 296779).*

*(e) CATCHER/PROCESSORS. Effective January 1, 1999, only the following catcher/processors shall be eligible to harvest the directed fishing allowance under section 206(b)(2) pursuant to a federal fishing permit:*

*(1) AMERICAN DYNASTY (United States official number 951307);*

*(2) KATIE ANN (United States official number 518441);*

*(3) AMERICAN TRIUMPH (United States official number 646737);*

*(4) NORTHERN EAGLE (United States official number 506694);*

*(5) NORTHERN HAWK (United States official number 643771);*

*(6) NORTHERN JAEGER (United States official number 521069);*

*(7) OCEAN ROVER (United States official number 552100);*

*(8) ALASKA OCEAN (United States official number 637856);*

*(9) ENDURANCE (United States official number 592206);*

*(10) AMERICAN ENTERPRISE (United States official number 594803);*

*(11) ISLAND ENTERPRISE (United States official number 610290);*

*(12) KODIAK ENTERPRISE (United States official number 579450);*

*(13) SEATTLE ENTERPRISE (United States official number 904767);*

*(14) US ENTERPRISE (United States official number 921112);*

*(15) ARCTIC STORM (United States official number 903511);*

*(16) ARCTIC FJORD (United States official number 940866);*

*(17) NORTHERN GLACIER (United States official number 663457);*

*(18) PACIFIC GLACIER (United States official number 933627);*

*(19) HIGHLAND LIGHT (United States official number 577044);*

*(20) STARBOUND (United States official number 944658); and*

*(21) any catcher/processor not listed in this subsection and determined by the Secretary to have harvested more than 2,000 metric tons of the pollock in the 1997 directed pollock fishery and determined to be eligible to harvest pollock in the directed pollock fishery under the license limitation program recommended by the North Pacific Council and approved by the Secretary, except that catcher/processors eligible under this paragraph shall be prohibited from harvesting in the aggregate a total of more than one-half (0.5) of a percent of the pollock apportioned for the directed pollock fishery under section 206(b)(2).*

*Notwithstanding section 213(a), failure to satisfy the requirements of section 4(a) of the Commercial Fishing Industry Vessel Anti-Reflagging Act of 1987 (Public Law 100-239; 46 U.S.C. 12108 note) shall not make a catcher/processor listed under this subsection ineligible for a fishery endorsement.*

*(f) SHORESIDE PROCESSORS. (1) Effective January 1, 2000 and except as provided in paragraph (2), the catcher vessels eligible under subsection (a) may deliver pollock harvested from the directed fishing allowance under section 206(b)(1) only to –*

*(A) shoreside processors (including vessels in a single geographic location in Alaska State waters) determined by the Secretary to have processed more than 2,000 metric tons round-weight of pollock in the inshore component of the directed pollock fishery during each of 1996 and 1997; and*

*(B) shoreside processors determined by the Secretary to have processed pollock in the inshore component of the directed pollock fishery in 1996 and 1997, but to have processed less than 2,000 metric tons round-weight of such pollock in each year, except that effective January 1, 2000, each such shoreside processor may not process more than 2,000 metric tons round-weight from such directed fishing allowance in any year;*

*(2) Upon recommendation by the North Pacific Council, the Secretary may approve measures to allow catcher vessels eligible under subsection (a) to deliver pollock harvested from the directed fishing allowance under section 206(b)(1) to shoreside processors not eligible under paragraph (1) if the total allowable catch for pollock in the Bering Sea and Aleutian Islands Management Area increases by more than 10 percent above the total allowable catch in such fishery in 1997, or in the event of the actual total loss or constructive total loss of a shoreside processor eligible under paragraph (1)(A).*

*(g) VESSEL REBUILDING AND REPLACEMENT.—*

*(1) IN GENERAL.—*

*(A) REBUILD OR REPLACE.—Notwithstanding any limitation to the contrary on replacing, rebuilding, or lengthening vessels or transferring permits or licenses to a replacement vessel contained in sections 679.2 and 679.4 of title 50, Code of Federal Regulations, as in effect on the date of enactment of the Coast Guard Authorization Act of 2010 and except as provided in paragraph (4), the owner of a vessel eligible under subsection (a), (b), (c), (d), or (e), in order to improve vessel safety and operational efficiencies (including fuel efficiency), may rebuild or replace that vessel (including fuel efficiency) with a vessel documented with a fishery endorsement under section 12113 of title 46, United States Code.*

*(B) SAME REQUIREMENTS.—The rebuilt or replacement vessel shall be eligible in the same manner and subject to the same restrictions and limitations under such subsection as the vessel being rebuilt or replaced.*

*(C) TRANSFER OF PERMITS AND LICENSES.—Each fishing permit and license held by the owner of a vessel or vessels to be rebuilt or replaced under subparagraph (A) shall be transferred to the rebuilt or replacement vessel or its owner, as necessary to permit such rebuilt or replacement vessel to operate in the same manner as the vessel prior to the rebuilding or the vessel it replaced, respectively.*

*(2) RECOMMENDATIONS OF NORTH PACIFIC FISHERY MANAGEMENT COUNCIL.—The North Pacific Fishery Management Council may recommend for approval by the Secretary such conservation and management measures, including size limits and measures to control fishing capacity, in accordance with the Magnuson-Stevens Act as it considers necessary to ensure that this subsection does not diminish the effectiveness of fishery management plans of the Bering Sea and Aleutian Islands Management Area or the Gulf of Alaska.*

*(3) SPECIAL RULE FOR REPLACEMENT OF CERTAIN VESSELS.—*

*(A) IN GENERAL.—Notwithstanding the requirements of subsections (b)(2), (c)(1), and (c)(2) of section 12113 of title 46, United States Code, a vessel that is eligible under subsection (a), (b), (c), or (e) and that qualifies to be documented with a fishery endorsement pursuant to section 213(g) may be replaced with a replacement vessel under paragraph (1) if the vessel that is replaced is validly documented with a fishery endorsement pursuant to section 213(g) before the replacement vessel is documented with a fishery endorsement under section 12113 of title 46, Unites States Code.*

*(B) APPLICABILITY.—A replacement vessel under subparagraph (A) and its owner and mortgagee are subject to the same limitations under section 213(g) that are applicable to the vessel that has been replaced and its owner and mortgagee.*

*(4) SPECIAL RULES FOR CERTAIN CATCHER VESSELS.—*

*(A) IN GENERAL.—A replacement for a covered vessel described in subparagraph (B) is prohibited from harvesting fish in any fishery (except for the Pacific whiting fishery) managed under the authority of any Regional Fishery Management Council (other than the North Pacific Fishery Management Council) established under section 302(a) of the Magnuson-Stevens Act.*

*(B) COVERED VESSELS.—A covered vessel referred to in subparagraph (A) is—*

*(i) a vessel eligible under subsection (a), (b), or (c) that is replaced under paragraph (1); or*

*(ii) a vessel eligible under subsection (a), (b), or (c) that is rebuilt to increase its registered length, gross tonnage, or shaft horsepower.*

*(5) LIMITATION ON FISHERY ENDORSEMENTS.—Any vessel that is replaced under this subsection shall thereafter not be eligible for a fishery endorsement under section 12113 of title 46, United States Code, unless that vessel is also a replacement vessel described in paragraph (1).*

*(6) GULF OF ALASKA LIMITATIONS.—Notwithstanding paragraph (1), the Secretary shall prohibit from participation in the groundfish fisheries of the Gulf of Alaska any vessel that is rebuilt or replaced under this subsection and that exceeds the maximum length overall specified on the license that authorizes fishing for groundfish pursuant to the license limitation program under part 679 of title 50, Code of Federal Regulations, as in effect on the date of enactment of the Coast Guard Authorization Act of 2010.*

*(7) AUTHORITY OF PACIFIC COUNCIL.—Nothing in this section shall be construed to diminish or otherwise affect the authority of the Pacific Council to recommend to the Secretary conservation and management measures to protect fisheries under its jurisdiction (including the Pacific whiting fishery) and participants in such fisheries from adverse impacts caused by this Act.*

*(h) ELIGIBILITY DURING IMPLEMENTATION. In the event the Secretary is unable to make a final determination about the eligibility of a vessel under subsection (b)(8) or subsection (e)(21) before January 1, 1999, or a vessel or shoreside processor under subsection (a), subsection (c)(21), or subsection (f) before January 1, 2000, such vessel or shoreside processor, upon the filing of an application for eligibility, shall be eligible to participate in the directed pollock fishery pending final determination by the Secretary with respect to such vessel or shoreside processor.*

*(i) ELIGIBILITY NOT A RIGHT. Eligibility under this section shall not be construed –*

*(1) to confer any right of compensation, monetary or otherwise, to the owner of any catcher vessel, catcher/processor, mothership, or shoreside processor if such eligibility is revoked or limited in any way, including through the revocation or limitation of a fishery endorsement or any federal permit or license;*

*(2) to create any right, title, or interest in or to any fish in any fishery; or*

*(3) to waive any provision of law otherwise applicable to such catcher vessel, catcher/processor, mothership, or shoreside processor.*

***SEC. 209. LIST OF INELIGIBLE VESSELS.***

*Effective December 31, 1998, the following vessels shall be permanently ineligible for fishery endorsements, and any claims (including relating to catch history) associated with such vessels that could qualify any owners of such vessels for any present or future limited access system permit in any fishery within the exclusive economic zone of the United States (including a vessel moratorium permit or license limitation program permit in fisheries under the authority of the North Pacific Council) are hereby extinguished:*

*(1) AMERICAN EMPRESS (United States official number 942347);*

*(2) PACIFIC SCOUT (United States official number 934772);*

*(3) PACIFIC EXPLOYER (United States official number 942592);*

*(4) PACIFIC NAVIGATOR (United States official number 592204);*

*(5) VICTORIA ANN (United States official number 592207);*

*(6) ELIZABETH ANN (United States official number 534721);*

*(7) CHRISTINA ANN (United States official number 653045);*

*(8) REBECCA ANN (United States official number 592205);*

*(9) BROWNS POINT (United States official number 587440).*

***SEC. 210. FISHERY COOPERATIVE LIMITATIONS.***

*(a) PUBLIC NOTICE. (1) Any contract implementing a fishery cooperative under section 1 of the Act of June 25, 1934 (15 U.S.C. 521) in the directed pollock fishery and any material modifications to any such contract shall be filed not less than 30 days prior to the start of fishing under the contract with the North Pacific Council and with the Secretary, together with a copy of a letter from a party to the contract requesting a business review letter on the fishery cooperative from the Department of Justice and any response to such request. Notwithstanding section 402 of the Magnuson-Stevens Act (16 U.S.C. 1881a) or any other provision of law, but taking into account the interest of parties to any such contract in protecting the confidentiality of proprietary information, the North Pacific Council and Secretary shall –*

*(A) make available to the public such information about the contract, contract modifications, or fishery cooperative the North Pacific Council and Secretary deem appropriate, which at a minimum shall include a list of the parties to the contract, a list of the vessels involved, and the amount of pollock and other fish to be harvested by each party to such contract; and*

*(B) make available to the public in such manner as the North Pacific Council and Secretary deem appropriate information about the harvest by vessels under a fishery cooperative of all species (including by catch) in the directed pollock fishery on a vessel-by-vessel basis.*

*(b) CATCHER VESSELS ONSHORE*

*(1) CATCHER VESSEL COOPERATIVES. Effective January 1, 2000, upon the filing of a contract implementing a fishery cooperative under subsection (a) which –*

*(A) is signed by the owners of 80 percent or more of the qualified catcher vessels that delivered pollock for processing by a shoreside processor in the directed pollock fishery in the year prior to the year in which the fishery cooperative will be in effect; and*

*(B) specifies, except as provided in paragraph (6), that such catcher vessels will deliver pollock in the directed pollock fishery only to such shoreside processor during the year in which the fishery cooperative will be in effect and that such shoreside processor has agreed to process such pollock,*

*the Secretary shall allow only such catcher vessels (and catcher vessels whose owners voluntarily participate pursuant to paragraph (2)) to harvest the aggregate percentage of the directed fishing allowance under section 206(b)(1) in the year in which the fishery cooperative will be in effect that is equivalent to the aggregate total amount of pollock harvested by such catcher vessels (and by such catcher vessels whose owners voluntarily participate pursuant to paragraph (2)) in the directed pollock fishery for processing by the inshore component during 1995, 1996, and 1997 relative to the aggregate total amount of pollock harvested in the directed pollock fishery for processing by the inshore component during such years and shall prevent such catcher vessels (and catcher vessels whose owners voluntarily participate pursuant to paragraph (2)) from harvesting in aggregate in excess of such percentage of such directed fishing allowance.*

*(2) VOLUNTARY PARTICIPATION. Any contract implementing a fishery cooperative under paragraph (1) must allow the owners of other qualified catcher vessels to enter into such contract after it is filed and before the calendar year in which fishing will begin under the same terms and conditions as the owners of the qualified catcher vessels who entered into such contract upon filing.*

*(3) QUALIFIED CATCHER VESSEL. For the purposes of this subsection, a catcher vessel shall be considered a qualified catcher vessel if, during the year prior to the year in which the fishery cooperative will be in effect, it delivered more pollock to the shoreside processor to which it will deliver pollock under the fishery cooperative in paragraph (1) than to any other shoreside processor.*

*(4) CONSIDERATION OF CERTAIN VESSELS. Any contract implementing a fishery cooperative under paragraph (1) which has been entered into by the owner of a qualified catcher vessel eligible under section 208(a) that harvested pollock for processing by catcher/processors or motherships in the directed pollock fishery during 1995, 1996, and 1997 shall, to the extent practicable, provide fair and equitable terms and conditions for the owner of such qualified catcher vessel.*

*(5) OPEN ACCESS. A catcher vessel eligible under section 208(a) the catch history of which has not been attributed to a fishery cooperative under paragraph (1) may be used to deliver pollock harvested by such vessel from the directed fishing allowance under section 206(b)(1) (other than pollock reserved under paragraph (1) for a fishery cooperative) to any of the shoreside processors eligible under section 208(f). A catcher vessel eligible under section 208(a) the catch history of which has been attributed to a fishery cooperative under paragraph (1) during any calendar year may not harvest any pollock apportioned under section 206(b)(1) in such calendar year other than the pollock reserved under paragraph (1) for such fishery cooperative.*

*(6) TRANSFER OF COOPERATIVE HARVEST. A contract implementing a fishery cooperative under paragraph (1) may, notwithstanding the other provisions of this subsection, provide for up to 10 percent of the pollock harvested under such cooperative to be processed by a shoreside processor eligible under section 208(f) other than the shoreside processor to which pollock will be delivered under paragraph (1).*

*(7) FISHERY COOPERATIVE EXIT PROVISIONS.—*

*(A) FISHING ALLOWANCE DETERMINATION.—For purposes of determining the aggregate percentage of directed fishing allowances under paragraph (1), when a catcher vessel is removed from the directed pollock fishery, the fishery allowance for pollock for the vessel being removed—*

*(i) shall be based on the catch history determination for the vessel made pursuant to section 679.62 of title 50, Code of Federal Regulations, as in effect on the date of enactment of the Coast Guard Authorization Act of 2010; and*

*(ii) shall be assigned, for all purposes under this title, in the manner specified by the owner of the vessel being removed to any other catcher vessel or among other catcher vessels participating in the fishery cooperative if such vessel or vessels remain in the fishery cooperative for at least one year after the date on which the vessel being removed leaves the direct pollock fishery.*

*(B) ELIGIBILITY FOR FISHERY ENDORSEMENT.—Except as provided in subparagraph (C), a vessel that is removed pursuant to this paragraph shall be permanently ineligible for a fishery endorsement, and any claim (including relating to catch history) associated with such vessel that could qualify any owner of such vessel for any permit to participate in any fishery within the exclusive economic zone of the United States shall be extinguished, unless such removed vessel is thereafter designated to replace a vessel to be removed pursuant to this paragraph.*

*(C) LIMITATIONS ON STATUTORY CONSTRUCTION.—Nothing in this paragraph shall be construed—*

*(i) to make the vessels AJ (United States official number 905625), DONA MARTITA (United States official number 651751), NORDIC EXPLORER (United States official number 678234), and PROVIDIAN (United States official number 1062183) ineligible for a fishery endorsement or any permit necessary to participate in any fishery under the authority of the New England Fishery Management Council or the Mid-Atlantic Fishery Management Council established, respectively, under subparagraphs (A) and (B) of section 302(a)(1) of the Magnuson-Stevens Act; or*

*(ii) to allow the vessels referred to in clause (i) to participate in any fishery under the authority of the Councils referred to in clause (i) in any manner that is not consistent with the fishery management plan for the fishery developed by the Councils under section 303 of the Magnuson-Stevens Act.*

*(c) CATCHER VESSELS TO CATCHER/PROCESSORS. Effective January 1, 1999, not less than 8.5 percent of the directed fishing allowance under section 206(b)(2) shall be available for harvest only by the catcher vessels eligible under section 208(b). The owners of such catcher vessels may participate in a fishery cooperative with the owners of the catcher/ processors eligible under paragraphs (1) through (20) of the section 208(e). The owners of such catcher vessels may participate in a fishery cooperative that will be in effect during 1999 only if the contract implementing such cooperative establishes penalties to prevent such vessels from exceeding in 1999 the traditional levels harvested by such vessels in all other fisheries in the exclusive economic zone of the United States.*

*(d) CATCHER VESSELS TO MOTHERSHIPS*

*(1) PROCESSING. Effective January 1, 2000, the authority in section 1 of the Act of June 25, 1934 (48 STAT. 1213 and 1214; 15 U.S.C. 521 et seq.) shall extend to processing by motherships eligible under section 208(d) solely for the purposes of forming or participating in a fishery cooperative in the directed pollock fishery upon the filing of a contract to implement a fishery cooperative under subsection (a) which has been entered into by the owners of 80 percent or more of the catcher vessels eligible under section 208(c) for the duration of such contract, provided that such owners agree to the terms of the fishery cooperative involving processing by the motherships.*

*(2) VOLUNTARY PARTICIPATION. Any contract implementing a fishery cooperative described in paragraph (1) must allow the owners of any other catcher vessels eligible under section 208(c) to enter such contract after it is filed and before the calendar year in which fishing will begin under the same terms and conditions as the owners of the catcher vessels who entered into such contract upon filing.*

*(e) EXCESSIVE SHARES.*

*(1) HARVESTING. No particular individual, corporation, or other entity may harvest, through a fishery cooperative or otherwise, a total of more than 17.5 percent of the pollock available to be harvested in the directed pollock fishery.*

*(2) PROCESSING. Under the authority of section 301(a)(4) of the Magnuson-Stevens Act (16 U.S.C. 1851(a)(4)), the North Pacific Council is directed to recommend for approval by the Secretary conservation and management measures to prevent any particular individual or entity from processing an excessive share of the pollock available to be harvested in the directed pollock fishery. In the event the North Pacific Council recommends and the Secretary approves an excessive processing share that is lower than 17.5 percent, any individual or entity that previously processed a percentage greater than such share shall be allowed to continue to process such percentage, except that their percentage may not exceed 17.5 percent (excluding pollock processed by catcher/processors that was harvested in the directed pollock fishery by catcher vessels eligible under section 208(b)) and shall be reduced if their percentage decreases, until their percentage is below such share. In recommending the excessive processing share, the North Pacific Council shall consider the need of catcher vessels in the directed pollock fishery to have competitive buyers for the pollock harvested by such vessels.*

*(3) REVIEW BY MARITIME ADMINISTRATION. At the request of the North Pacific Council or the Secretary, any individual or entity believed by such Council or the Secretary to have exceeded the percentage in either paragraph (1) or (2) shall submit such information to the Administrator of the Maritime Administration as the Administrator deems appropriate to allow the Administrator to determine whether such individual or entity has exceeded either such percentage. The Administrator shall make a finding as soon as practicable upon such request and shall submit such finding to the North Pacific Council and the Secretary. For the purposes of this subsection, any entity in which 10 percent or more of the interest is owned or controlled by another individual or entity shall be considered to be the same entity as the other individual or entity.*

*(f) LANDING TAX JURISDICTION. Any contract filed under subsection (a) shall include a contract clause under which the parties to the contract agree to make payments to the State of Alaska for any pollock harvested in the directed pollock fishery which is not landed in the State of Alaska, in amounts which would otherwise accrue had the pollock been landed in the State of Alaska subject to any landing taxes established under Alaska law. Failure to include such a contract clause or for such amounts to be paid shall result in a revocation of the authority to form fishery cooperatives under section 1 of the Act of June 25, 1934 (15 U.S.C. 521 et seq.).*

*(g) PENALTIES. The violation of any of the requirements of this subtitle or any regulation or permit issued pursuant to this subtitle shall be considered the commission of an act prohibited by section 307 of the Magnuson-Stevens Act (16 U.S.C. 1857), and sections 308, 309, 310, and 311 of such Act (16 U.S.C. 1858, 1859, 1860, and 1861) shall apply to any such violation in the same manner as to the commission of an act prohibited by section 307 of such Act (16 U.S.C. 1857). In addition to the civil penalties and permit sanctions applicable to prohibited acts under section 308 of such Act (16 U.S.C. 1858), any person who is found by the Secretary, after notice and an opportunity for a hearing in accordance with section 554 of title 5, United States Code, to have violated a requirement of this section shall be subject to the*

*forfeiture to the Secretary of Commerce of any fish harvested or processed during the commission of such act.*

### *SEC. 211. PROTECTIONS FOR OTHER FISHERIES; CONSERVATION MEASURES.*

*(a) GENERAL. The North Pacific Council shall recommend for approval by the Secretary such conservation and management measures as it determines necessary to protect other fisheries under its jurisdiction and the participants in those fisheries, including processors, from adverse impacts caused by this Act or fishery cooperatives in the directed pollock fishery.*

*(b) CATCHER/PROCESSOR RESTRICTIONS.*

*(1) GENERAL. The restrictions in this subsection shall take effect on January 1, 1999 and shall remain in effect thereafter except that they may be superseded (with the exception of paragraph (4)) by conservation and management measures recommended after the date of the enactment of this Act by the North Pacific Council and approved by the Secretary in accordance with the Magnuson-Stevens Act.*

*(2) BERING SEA FISHING. The catcher/processors eligible under paragraphs (1) through (20) of section 208(e) are hereby prohibited from, in the aggregate –*

*(A) exceeding the percentage of the harvest available in the offshore component of any Bering Sea and Aleutian Islands groundfish fishery (other than the pollock fishery) that is equivalent to the total harvest by such catcher/processors and the catcher/processors listed in section 209 in the fishery in 1995, 1996, and 1997 relative to the total amount available to be harvested by the offshore component in the fishery in 1995, 1996, and 1997;*

*(B) exceeding the percentage of the prohibited species available in the offshore component of any Bering Sea and Aleutian Islands groundfish fishery (other than the pollock fishery) that is equivalent to the total of the prohibited species harvested by such catcher/processors and the catcher/processors listed in section 209 in the fishery in 1995, 1996, and 1997 relative to the total amount of prohibited species available to be harvested by the offshore component in the fishery in 1995, 1996, and 1997.*

*(C) fishing for Atka mackerel in the eastern area of the Bering Sea and Aleutian Islands and from exceeding the following percentages of the directed harvest available in the Bering Sea and Aleutian Islands Atka mackerel fishery –*

*(i) 11.5 percent in the central area; and*

*(ii) 20 percent in the western area.*

*(3) BERING SEA PROCESSING. The catcher/processors eligible under paragraphs (1) through (20) of section 208(e) are hereby prohibited from –*

*(A) processing any of the directed fishing allowances under paragraphs (1) or (3) of section 206(b); and*

*(B) processing any species of crab harvested in the Bering Sea and Aleutian Islands Management Area.*

*(4) GULF OF ALASKA. The catcher/processors eligible under paragraphs (1) through (20) of section 208(e) are hereby prohibited from –*

*(A) harvesting any fish in the Gulf of Alaska;*

*(B) processing any groundfish harvested from the portion of the exclusive economic zone off Alaska known as area 630 under the fishery management plan for Gulf of Alaska groundfish; or*

*(C) processing any pollock in the Gulf of Alaska (other than as by catch in non-pollock groundfish fisheries) or processing, in the aggregate, a total of more than 10 percent of the cod harvested from areas 610, 620, and 640 of the Gulf of Alaska under the fishery management plan for Gulf of Alaska groundfish.*

*(5) FISHERIES OTHER THAN NORTH PACIFIC. The catcher/processors eligible under paragraphs (1) through (20) of section 208(e) and motherships eligible under section 208(d) are hereby prohibited from harvesting fish in any fishery under the authority of any regional fishery management council established under section 302(a) of the Magnuson-Stevens Act (16 U.S.C. 1852(a)) other than the North Pacific Council, except for the Pacific whiting fishery, and from processing fish in any fishery under the authority of any such regional fishery management council other than the North Pacific Council, except in the Pacific whiting fishery, unless the catcher/processor or mothership is authorized to harvest or process fish under a fishery management plan recommended by the regional fishery management council of jurisdiction and approved by the Secretary.*

*(6) OBSERVERS AND SCALES. The catcher/processors eligible under paragraphs (1) through (20) of section 208(e) shall –*

*(A) have two observers onboard at all times while groundfish is being harvested, processed, or received from another vessel in any fishery under the authority of the North Pacific Council; and*

*(B) weight its catch on a scale onboard approved by the National Marine Fisheries Service while harvesting groundfish in fisheries under the authority of the North Pacific Council.*

*This paragraph shall take effect on January 1, 1999 for catcher/processors eligible under paragraphs (1) through (20) of section 208(e) that will harvest pollock allocated under section 206(a) in 1999, and shall take effect on January 1, 2000 for all other catcher/processors eligible under such paragraphs of section 208(e).*

*(c) CATCHER VESSEL AND SHORESIDE PROCESSOR RESTRICTIONS.*

*(1) REQUIRED COUNCIL RECOMMENDATIONS. By not later than July 1, 1999, the North Pacific Council shall recommend for approval by the Secretary conservation and management measures to –*

*(A) prevent the catcher vessels eligible under subsections (a), (b), and (c) of section 208 from exceeding in the aggregate the traditional harvest levels of such vessels in other fisheries under the authority of the North Pacific Council as a result of fishery cooperatives in the directed pollock fisheries; and*

*(B) protect processors not eligible to participate in the directed pollock fishery from adverse effects as a result of this Act or fishery cooperatives in the directed pollock fishery.*

*If the North Pacific Council does not recommend such conservation and management measures by such date, or if the Secretary determines that such conservation and management measures recommended by the North Pacific Council are not adequate to fulfill the purposes of this paragraph, the Secretary may by regulation restrict or change the authority in section 210(b) to the extent the Secretary deems appropriate, including by preventing fishery cooperatives from being formed* *pursuant to such section and by providing greater flexibility with respect to the shoreside processor or shoreside processors to which catcher vessels in a fishery cooperative under section 210(b) may deliver pollock.*

*(2) BERING SEA CRAB AND GROUNDFISH.*

*(A) Effective January 1, 2000, the owners of the motherships eligible under section 208(d) and the shoreside processors eligible under section 208(f) that receive pollock from the directed pollock fishery under a fishery cooperative are hereby prohibited from processing, in the aggregate for each calendar year, more than the percentage of the total catch of each species of crab in directed fisheries under the jurisdiction of the North Pacific Council than facilities operated by such owners processed of each such species in the aggregate, on average, in 1995, 1996, and 1997. For the purposes of this subparagraph, the term facilities means any processing plant, catcher/processor, mothership, floating processor, or any other operation that processes fish. Any entity in which 10 percent or more of the interest is owned or controlled by another individual or entity shall be considered to be the same entity as the other individual or entity for the purposes of this subparagraph.*

*(B) Under the authority of section 301(a)(4) of the Magnuson-Stevens Act (16 U.S.C. 1851(a)(4)), the North Pacific Council is directed to recommend for approval by the Secretary conservation and management measures to prevent any particular individual or entity from harvesting or processing an excessive share of crab or of groundfish in fisheries in the Bering Sea and Aleutian Islands Management Area.*

*(C) The catcher vessels eligible under section 208(b) are hereby prohibited from participating in a directed fishery for any species of crab in the Bering Sea and Aleutian Islands Management Area unless the catcher vessel harvested crab in the directed fishery for that species of crab in such Area during 1997 and is eligible to harvest such crab in such directed fishery under the license limitation program recommended by the North Pacific Council and approved by the Secretary. The North Pacific Council is directed to recommend measures for approval by the Secretary to eliminate latent licenses under such program, and nothing in this subparagraph shall preclude the Council from recommending measures more restrictive than under this paragraph.*

*(3) FISHERIES OTHER THAN NORTH PACIFIC.*

*(A) By not later than July 1, 2000, the Pacific Fishery Management Council established under section 302(a)(1)(F) of the Magnuson-Stevens Act (16 U.S.C. 1852 (a)(1)(F)) shall recommended for approval by the Secretary conservation and management measures to protect fisheries under its jurisdiction and the participants in those fisheries from adverse impacts caused by this Act or by any fishery cooperatives in the directed pollock fishery.*

*(B) If the Pacific Council does not recommend such conservation and management measures by such date, or if the Secretary determines that such conservation and management measures recommended by the Pacific Council are not adequate to fulfill the purposes of this paragraph, the Secretary may by regulation implement adequate measures including, but not limited to, restrictions on vessels which harvest pollock under a fishery cooperative which will prevent such vessels from harvesting Pacific groundfish, and restrictions on the number of processors eligible to process Pacific groundfish.*

*(d) BYCATCH INFORMATION. Notwithstanding section 402 of the Magnuson-Stevens Act (16 U.S.C. 1881a), the North Pacific Council may recommend and the Secretary may approve, under such terms and*

*conditions as the North Pacific Council and Secretary deem appropriate, the public disclosure of any information from the groundfish fisheries under the authority of such Council that would be beneficial in the implementation of section 301(a)(9) or section 303(a)(11) of the Magnuson-Stevens Act (16 U.S.C. 1851(a)(9) and 1853(a)(11)).*

*(e) COMMUNITY DEVELOPMENT LOAN PROGRAM. Under the authority of title XI of the Merchant Marine Act, 1936 (46 U.S.C. App. 1271 et seq.), and subject to the availability of appropriations, the Secretary is authorized to provide direct loan obligations to communities eligible to participate in the western Alaska community development quota program established under section 304(i) of the Magnuson-Stevens Act (16 U.S.C. 1855(i)) for the purposes of purchasing all or part of an ownership interest in vessels and shoreside processors eligible under subsections (a), (b), (c), (d), (e), or (f) of section 208. Notwithstanding the eligibility criteria in section 208(a) and section 208(c), the LISA MARIE (United States official number 1038717) shall be eligible under such sections in the same manner as other vessels eligible under such sections.*

***SEC. 212. RESTRICTION ON FEDERAL LOANS.***

*Section 302(b) of the Fisheries Financing Act (46 U.S.C. 1274 note) is amended –*

*(1) by inserting "(1)" before "Until October 1, 2001" ; and*

*(2) by inserting at the end the following new paragraph:*

*"(2) No loans may be provided or guaranteed by the Federal Government for the construction or rebuilding of a vessel intended for use as a fishing vessel (as defined in section 2101 of title 46, United States Code), if such vessel will be greater than 165 feet in registered length, of more than 750 gross registered tons (as measured under chapter 145 of title 46) or 1,900 gross registered tons as measured under chapter 143 of that title, or have an engine or engines capable of producing a total of more than 3,000 shaft horsepower, after such construction or rebuilding is completed. This prohibition shall not apply to vessels to be used in the menhaden fishery or in tuna purse seine fisheries outside the exclusive economic zone of the United States or the area of the South Pacific Regional Fisheries Treaty.".*

***SEC. 213. DURATION.***

*(a) GENERAL. Except as otherwise provided in this title, the provisions of this title shall take effect upon the date of the enactment of this Act. There are authorized to be appropriated $6,700,000 per year to carry out the provisions of this Act through fiscal year 2004.*

*(b) EXISTING AUTHORITY. Except for the measures required by this subtitle, nothing in this subtitle shall be construed to limit the authority of the North Pacific Council or the Secretary under the Magnuson-Stevens Act.*

*(c) CHANGES TO FISHERY COOPERATIVE LIMITATIONS AND POLLOCK CDQ ALLOCATION. The North Pacific Council may recommend and the Secretary may approve conservation and management measures in accordance with the Magnuson-Stevens Act –*

*(1) that supersede the provisions of this subtitle, except for section 206 and 208, for conservation purposes or to mitigate adverse effects in fisheries or on owners of fewer than three vessels in the directed pollock fishery caused by this title or fishery cooperatives in the directed pollock fishery, provided such measures take into account all factors affecting the fisheries and are imposed fairly and equitably to the extent practicable among and within the sectors in the directed pollock fishery;*

*(2) that supersede the allocation in section 206(a) for any of the years 2002, 2003, and 2004, upon the finding by such Council that the western Alaska community development quota program for pollock has been adversely affected by the amendments in this subtitle; or*

*(3) that supersede the criteria required in paragraph (1) of section 210(b) to be used by the Secretary to set the percentage allowed to be harvested by catcher vessels pursuant to a fishery cooperative under such paragraph.*

*(d) REPORT TO CONGRESS. Not later than October 1, 2000, the North Pacific Council shall submit a report to the Secretary and to Congress on the implementation and effects of this Act, including the effects on fishery conservation and management, on bycatch levels, on fishing communities, on business and employment practices of participants in any fishery cooperatives, on the western Alaska community development quota program, on any fisheries outside of the authority of the North Pacific Council, and such other matters as the North Pacific Council deems appropriate.*

*(e) REPORT ON FILLET PRODUCTION. Not later than June 1, 2000, the General Accounting Office shall submit a report to the North Pacific Council, the Secretary, and the Congress on whether this Act has negatively affected the market for fillets and fillet blocks, including through the reduction in the supply of such fillets and fillet blocks. If the report determines that such market has been negatively affected, the North Pacific Council shall recommend measures for the Secretary's approval to mitigate any negative effects.*

*(f) SEVERABILITY. If any provision of this title, an amendment made by this title, or the application of such provision or amendment to any person or circumstance is held to be unconstitutional, the remainder of this title, the amendments made by this title, and the application of the provisions of such to any person or circumstance shall not be affected thereby.*

*(g) INTERNATIONAL AGREEMENTS. In the event that any provision of section 12102(c) or section 31322(a) of title 46, United States Code, as amended by this Act, is determined to be inconsistent with an existing international agreement relating to foreign investment to which the United States is a party with respect to the owner or mortgagee on October 1, 2001 of a vessel with a fishery endorsement, such provision shall not apply to that owner or mortgagee with respect to such vessel to the extent of any such inconsistency. The provisions of section 12102(c) and section 31322(a) of title 46, United States Code, as amended by this Act, shall apply to all subsequent owners and mortgagees of such vessel, and shall apply, notwithstanding the preceding sentence, to the owner on October 1, 2001 of such vessel if any ownership interest in that owner is transferred to or otherwise acquired by a foreign individual or entity after such date.*

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# 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 | | | | | | | Location | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Inner | Middle | Outer | Upper | | Intermediate | | Lower | Basin | | | | | | | | | | | | Pelagic | | |
| Species | Life Stage | Freshwater | Estuarine | Intertidal | Subtidal | 1-50m | 51-100m | 101-200m | 201-300m | 301-500m | 501-700m | 701-1000m | 1001-3000m | >3000m | Shallows | Island Pass | Bay/Fjord | Bank | Flat | Edge | Gully | Surafce | Near surface | Semi-demersal | Demersal | 1-200m (epi) | 201-1000m (meso) | >1000m (bathy) |
| **Walleye Pollock** | M | | | | | | 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 | | |
| | L | | | | | | x | x | | | | | | | | x | x | x | x | x | x | | x | x | x | x | | |
| | E | | | | | | x | x | x | 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 | | | x | x | | | |
| | LJ | | | | | 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 | | | |
| | L | | | | | x | x | x | | | | | | | x | x | x | x | x | x | x | | | | | x | | |
| | E | | | | | | | | | | | | | | | | | | | | | | | | x | | | |
| **Sablefish** | M | | | | | | | | x | x | x | x | x | | | | x | | | | x | | | | x | | | |
| | LJ | | | | | | | x | x | x | x | | | | | | x | | | | x | | | | x | | | |
| | EJ | | | | | x | x | x | | | | | | | | | x | | | | | | | | x | x | x | |
| | L | | | | | | x | x | x | x | x | x | x | x | | | | | | | | x | x | | | | | |
| | E | | | | | | | | x | x | x | x | x | x | | | | | | | | | | | | x | x | |
| **Yellowfin Sole** | M | | | | | x | x | | | | | | | | | | | | | | | | | | x | | | |
| | LJ | | | | | x | x | | | | | | | | | | | | | | | | | | x | | | |
| | EJ | | | | | x | | | | | | | | | | | | | | | | | | | x | | | |
| | L | | | | | x | x | | | | | | | | | | | | | | | | | | | x | | |
| | E | | | | | x | x | | | | | | | | | | | | | | | | | | | x | | |
| **Greenland Turbot** | M | | | | | | | x | x | x | x | | | | | | | | | | | | | | x | | | |
| | LJ | | | | | x | x | | | | | | | | | | | | | | | | | | x | | | |
| | EJ | | | | | | | | | | | | | | | | | | | | | | | | x | | | |
| | L | | | | | x | x | x | x | x | | | | | | | | | | | | | | | | x | | |
| | E | | | | | x | x | x | x | x | | | | | | | | | | | | | | | | x | | |
| **Arrowtooth Flounder** | M | | | | | x | x | x | x | x | x | | | | | | | | | | | | | | x | | | |
| | LJ | | | | | x | x | x | | | | | | | | | | | | | | | | | x | | | |
| | EJ | | | | | x | x | | | | | | | | | | | | | | | | | | x | | | |
| | L | | | | | x | x | x | x | x | | | | | | | | | | | | | | | | x | | |
| | E | | | | | x | x | x | x | x | | | | | | | | | | | | | | | x | | | |
| **Kamchatka Flounder** | M | | | | | | x | x | x | x | x | x | | | | | | | | | | | | | x | | | |
| | LJ | | | | | | x | x | x | x | | | | | | | | | | | | | | | x | | | |
| | EJ | | | | | | x | x | | | | | | | | | | | | | | | | | x | | | |
| | L | | | | | | x | x | x | x | | | | | | | | | | | | | | | | | x | |
| | E | | | | | | x | x | x | x | | | | | | | | | | | | | | | | | | |
| **Northern Rock Sole** | M | | | | | x | x | x | | | | | | | | | | | | | | | | | x | | | |
| | LJ | | | | | x | x | | | | | | | | | | | | | | | | | | x | | | |
| | EJ | | | | | x | | | | | | | | | | | | | | | | | | | x | | | |
| | L | | | | | x | x | x | | | | | | | | | | | | | | | | | | x | | |
| | E | | | | | x | x | x | | | | | | | | | | | | | | | | | x | | | |
| **Flathead Sole** | M | | | | | x | x | x | x | | | | | | | | | | | | | | | | x | | | |
| | LJ | | | | | x | x | x | | | | | | | | | | | | | | | | | x | | | |
| | EJ | | | | | x | x | | | | | | | | | | | | | | | | | | x | | | |
| | L | | | | | x | x | x | | | | | | | | | | | | | | | | | | x | | |
| | E | | | | | x | x | x | | | | | | | | | | | | | | | | | | x | | |

| BSAI Groundfish | | Physical Oceano-graphy | | | | | Substrate | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Species | Life Stage | Upwelling areas | Gyres | Thermo/pycnocline | Fronts | Edges (ice, bath) | Organic Debris | Mud | Sand | Gravel | Mud & sand | Mud & gravel | Sand & mud | Gravel & mud | Gravel & sand | Gravel & sand & mud | Gravel & mud & sand | Cobble | Rock |
| **Walleye Pollock** | M | 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 | |
| | L | x | x | x | x | x | | x | x | x | x | x | x | x | x | x | x | x | |
| | E | x | x | x | x | | | | | | | | | | | | | | |
| **Pacific Cod** | 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 | x | x | x | x | | |
| | L | | | | | | | | | | | | | | | | | | |
| | E | | | | | | | | | | | | | | | | | | |
| **Sablefish** | M | x | | | | | | x | x | x | | | | | | | | x | x |
| | LJ | x | | | | | | x | x | x | | | | | | | | x | x |
| | EJ | x | | | | | | | | | | | | | | | | | |
| | L | x | | | | | | | | | | | | | | | | | |
| | E | x | | | | | | | | | | | | | | | | | |
| **Yellowfin Sole** | M | | | | | | | x | x | | | | x | | | | | | |
| | LJ | | | | | | | x | x | | | | x | | | | | | |
| | EJ | | | | | | | x | x | | | | x | | | | | | |
| | L | | | | | | | | | | | | | | | | | | |
| | E | | | | | | | | | | | | | | | | | | |
| **Greenland Turbot** | M | | | | | | | x | x | x | | x | | | | | | | |
| | LJ | | | | | | | x | x | | | x | | | | | | | |
| | EJ | | | | | | | x | x | | | x | | | | | | | |
| | L | | | x | | | | | | | | | | | | | | | |
| | E | | | | | | | | | | | | | | | | | | |
| **Arrowtooth Flounder** | M | | | | | | | x | x | x | | | x | | | | | | |
| | LJ | | | | | | | x | x | x | | | x | | | | | | |
| | EJ | | | | | | | x | x | x | | | x | | | | | | |
| | L | | | x | | | | | | | | | | | | | | | |
| | E | | | | | | | | | | | | | | | | | | |
| **Kamchatka Flounder** | M | | | | | | | x | x | x | | | x | | | | | | |
| | LJ | | | | | | | x | x | x | | | x | | | | | | |
| | EJ | | | | | | | x | x | x | | | x | | | | | | |
| | L | | | | | | | | | | | | | | | | | | |
| | E | | | | | | | | | | | | | | | | | | |
| **Northern Rock Sole** | M | | | | | | | x | x | | | | x | | | | | | |
| | LJ | | | | | | | x | x | | | | x | | | | | | |
| | EJ | | | | | | | x | x | | | | x | | | | | | |
| | L | | | x | | | | | | | | | | | | | | | |
| | E | | | | | | | | | | | | | | | | | | |
| **Flathead Sole** | M | | | | | x | | x | x | x | | | x | | x | | | | |
| | LJ | | | | | | | x | x | x | | | x | | x | | | | |
| | EJ | | | | | | | | x | x | | | | | | | | | |
| | L | | | x | | | | | | | | | x | | | | | | |
| | E | | | | | | | | | | | | | | | | | | |

| 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 | | Intermediate | | Lower | Basin | | | | | | | | | | | | Pelagic | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Species | Life Stage | Freshwater | Estuarine | Intertidal | Subtidal | 1-50m | 51-100m | 101-200m | 201-300m | 301-500m | 501-700m | 701-1000m | 1001-3000m | >3000m | Shallows | Island Pass | Bay/Fjord | Bank | Flat | Edge | Gully | Surfce | 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 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 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 |  |  |  |  |  |  |  | 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 |  |  |  |  |  |  |  | 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 |  |  |  |  |  |  |  | x |  |  |  |  |  |  | x |  |  | x |  |  |  |  | 3-5 | >17 |  | M |
| | J |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | x | x |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 3-12 |  |  | J |
| | L |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | x | x |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 2-12 |  |  | L |
| | E |  |  |  |  | x | 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 | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Inner | Middle | Outer | Upper | | Intermediate | | Lower | Basin | | | | | | | |
| 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 |
| **Squids** | M | | | | 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 |
| | LJ | | | | | | | | | | | | | | | | | | | | |
| | EJ | | | | | | | | | | | | | | | | | | | | |
| | L | | | | | | | | | | | | | | | | | | | | |
| | E | | | | | | | | | | | | | | | | | | | | |
| **Sharks** | M | | | 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 |
| | LJ | | | | | | | | | | | | | | | | | | | | |
| | EJ | | | | | | | | | | | | | | | | | | | | |
| | L | | | | | | | | | | | | | | | | | | | | |
| | E | | | | | | | | | | | | | | | | | | | | |
| **Skates** | M | | | 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 | | | | |
| | LJ | | | | | | x | x | | | | | | | | | | | | | |
| | EJ | | | | | x | x | | | | | | | | | | | | | | |
| | L | x | x | | | x | x | | | | | | | | | | x | | | | |
| | E | x | | | | | | | | | | | | | | | | | | | |
| **Capelin** | M | | | | | | x | x | | | | | | | | | x | | | | |
| | LJ | | | | | | x | x | | | | | | | | | | | | | |
| | EJ | | | | | x | x | | | | | | | | | | | | | | |
| | L | | x | | | x | x | | | | | | | | | | x | | | | |
| | E | | | x | | | | | | | | | | | x | | x | | | | |
| **Sand Lance** | M | | | x | x | x | | | | | | | | | x | | x | | | | |
| | LJ | | | x | x | x | | | | | | | | | x | | x | | | | |
| | EJ | | x | | x | x | | | | | | | | | x | | x | | | | |
| | L | | x | | | x | | | | | | | | | x | | x | | | | |
| | E | | | x | | | | | | | | | | | | | x | | | | |

| BSAI Groundfish | | Location | | | | | | | Physical Oceanography | | | | | Substrate | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Pelagic | | | | | | | | | | | | | | | | | | | | |
| Species | Life Stage | Surfce | 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 |
| **Squids** | M | x | x | x | x | x | x | x | | | | | | | | | | | | | | | | | | |
| | LJ | | | | | | | | | | | | | | | | | | | | | | | | | |
| | EJ | | | | | | | | | | | | | | | | | | | | | | | | | |
| | L | | | | | | | | | | | | | | | | | | | | | | | | | |
| | E | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Octopuses** | M | | | | 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 |
| | LJ | | | | | | | | | | | | | | | | | | | | | | | | | |
| | EJ | | | | | | | | | | | | | | | | | | | | | | | | | |
| | L | | | | | | | | | | | | | | | | | | | | | | | | | |
| | E | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Sculpins** | M | | | x | x | | | | | | | | | | | | | | | | | | | | | |
| | LJ | | | | | | | | | | | | | | | | | | | | | | | | | |
| | EJ | | | | | | | | | | | | | | | | | | | | | | | | | |
| | L | | | | | | | | | | | | | | | | | | | | | | | | | |
| | E | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Skates** | M | | | x | x | | | | | | | | | | | | | | | | | | | | | |
| | LJ | | | | | | | | | | | | | | | | | | | | | | | | | |
| | EJ | | | | | | | | | | | | | | | | | | | | | | | | | |
| | L | | | | | | | | | | | | | | | | | | | | | | | | | |
| | E | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Eulachon** | M | | | | | x | | | x | | | x | x | | | | | | | | | | | | | |
| | LJ | | | | | x | | | x | | | x | x | | | | | | | | | | | | | |
| | EJ | | | | | x | | | x | | | x | | | | | | | | | | | | | | |
| | L | | x | | | | | | | | | | | | | | | | | | | | | | | |
| | E | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Capelin** | M | | | | | x | | | x | | | x | x | | | | | | | | | | | | | |
| | LJ | | | | | x | | | x | | | x | x | | | | | | | | | | | | | |
| | EJ | | | | | x | | | x | | | x | | | | | | | | | | | | | | |
| | L | | x | | | | | | | | | | | | | | | | | | | | | | | |
| | E | | | | | | | | | | | | | | | x | x | | | | | x | | | | |
| **Sand Lance** | M | x | x | x | x | x | | | | | | | | | | x | x | | | | | x | | | | |
| | LJ | x | x | x | x | x | | | | | | | | | | x | x | | | | | x | | | | |
| | EJ | x | x | | | x | | | | | | | | | | | | | | | | | | | | |
| | L | x | x | | | x | | | | | | | | | | | | | | | | | | | | |
| | E | | | | | | | | | | | | | | | | | | | | | | | | | |

| 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 |
| **Squids** | M | | | | | | | x | | | | | | | | | | | | | | | | | | | M |
| | LJ | | | | | | | | | | | | | | | | | | | | | | | | | | LJ |
| | EJ | | | | | | | | | | | | | | | | | | | | | | | | | | EJ |
| | L | | | | | | | | | | | | | | | | | | | | | | | | | | L |
| | E | | | | | | | | | | | | | | | | | | | | | | | | | | E |
| **Octopuses** | M | | | | | | | | | | | | | | | | | | | | | | | | | | M |
| | LJ | | | | | | | | | | | | | | | | | | | | | | | | | | LJ |
| | EJ | | | | | | | | | | | | | | | | | | | | | | | | | | EJ |
| | L | | | | | | | | | | | | | | | | | | | | | | | | | | L |
| | E | | | | | | | | | | | | | | | | | | | | | | | | | | E |
| **Sharks** | M | | | | | | | | | | | | | | | | | | | | | | | | | | M |
| | LJ | | | | | | | | | | | | | | | | | | | | | | | | | | LJ |
| | EJ | | | | | | | | | | | | | | | | | | | | | | | | | | EJ |
| | L | | | | | | | | | | | | | | | | | | | | | | | | | | L |
| | E | | | | | | | | | | | | | | | | | | | | | | | | | | E |
| **Sculpins** | M | | | | | | | x | | | | | | | | | | | | | | | | | | | M |
| | LJ | | | | | | | | | | | | | | | | | | | | | | | | | | LJ |
| | EJ | | | | | | | | | | | | | | | | | | | | | | | | | | EJ |
| | L | | | | | | | | | | | | | | | | | | | | | | | | | | L |
| | E | | | | | | | | | | | | | | | | | | | | | | | | | | E |
| **Skates** | M | | | | | | | | | | | | | | | | | | | | | | | | | | M |
| | LJ | | | | | | | | | | | | | | | | | | | | | | | | | | LJ |
| | EJ | | | | | | | | | | | | | | | | | | | | | | | | | | EJ |
| | L | | | | | | | | | | | | | | | | | | | | | | | | | | L |
| | E | | | | | | | | | | | | | | | | | | | | | | | | | | E |
| **Eulachon** | M | | | | | | | | | | | | | | | | | | | | | | | | | | M |
| | LJ | | | | | | | | | | | | | | | | | | | | | | | | | | LJ |
| | EJ | | | | | | | | | | | | | | | | | | | | | | | | | | EJ |
| | L | | | | | | | | | | | | | | | | | | | | | | | | | | L |
| | E | | | | | | | | | | | | | | | | | | | | | | | **4-8** | | | E |
| **Capelin** | M | | | | | | | | | | | | | | | | | | | | | | | **-2-3** | | | M |
| | LJ | | | | | | | | | | | | | | | | | | | | | | | | | | LJ |
| | EJ | | | | | | | | | | | | | | | | | | | | | | | | | | EJ |
| | L | | | | | | | | | | | | | | | | | | | | | | | | | | L |
| | E | | | | | | | | | | | | | | | | | | | | | | | **5-9** | | | E |
| **Sand Lance** | M | | | | | | | | | | | | | | | | | | | | | | | | | | M |
| | LJ | | | | | | | | | | | | | | | | | | | | | | | | | | LJ |
| | EJ | | | | | | | | | | | | | | | | | | | | | | | | | | EJ |
| | L | | | | | | | | | | | | | | | | | | | | | | | | | | L |
| | E | | | | | | | | | | | | | | | | | | | | | | | | | | E |

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

| BSAI Groundfish | | Reproductive Traits | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Age at Maturity | | | | Fertilization/ Egg Development | | | | | Spawning Behavior | | | | | | Spawning Season | | | | | | | | | | | |
| | | Female | | Male | | | | | | | | | | | | | | | | | | | | | | | | |
| Species | Life Stage | 50% | 100% | 50% | 100% | External | Internal | Oviparous | Aplacental | Viviparous | Batch Spawner | Broadcast Spawner | Egg Case Deposition | Nest Builder | Egg/Young Guarder | Egg/Young Bearer | January | February | March | April | May | June | July | August | September | October | November | December |
| **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.

**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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **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 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

**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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **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 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
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| | 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 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
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| | 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 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
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| | E | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Sculpins | M | | | | | | | | | | x | | x | | x | x | | x | x | x | x | x | | | | | | | | | |
| | LJ | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
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| Skates | M | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | LJ | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
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| | 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 | | | | | | | | | | | | | | | |
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## 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

A'mar, Z. T., Punt, A. E., and Dorn, M. W. 2009. The evaluation of two management strategies for the Gulf of Alaska walleye pollock fishery under climate change. – ICES Journal of Marine Science, 66: 000–000.

Aydin, K. Y., et al.A comparison of the Eastern Bering and western Bering Sea shelf and slope ecosystems through the use of mass-balance food web models. U.S. Department of Commerce, Seattle, WA. (NOAA Technical Memorandum NMFS-AFSC-130) 78p.

Bacheler, N.M., L. Ciannelli, K.M. Bailey, and J.T. Duffy-Anderson. 2010. Spatial and temporal patterns of walleye pollock (*Theragra chalcogramma*) spawning in the eastern Bering Sea inferred from egg and larval distributions. Fish. Oceanogr. 19:2. 107-120.

Bailey, K.M. 2000. Shifting control of recruitment of walleye pollock *Theragra chalcogramma* after a major climatic and ecosystem change. Mar. Ecol. Prog. Ser 198:215-224.

Bailey, K.M., P.J. Stabeno, and D.A. Powers. 1997. The role of larval retention and transport features in mortality and potential gene flow of walleye pollock. J. Fish. Biol. 51(Suppl. A):135-154.

Bailey, K.M., S.J. Picquelle, and S.M. Spring. 1996. Mortality of larval walleye pollock (*Theragra chalcogramma*) in the western Gulf of Alaska, 1988-91. Fish. Oceanogr. 5 (Suppl. 1):124-136.

Bailey, K.M., T.J. Quinn II, P. Bentzen, and W.S. Grant. 1999. Population structure and dynamics of walleye pollock, *Theragra chalcogramma*. Advances in Mar. Biol. 37: 179-255.

Bakkala, R.G., V.G. Wespestad and L.L. Low. 1987. Historical trends in abundance and current condition of walleye pollock in the eastern Bering Sea. Fish. Res.,5:199-215.

Barbeaux, S. J., and M. W. Dorn. 2003. Spatial and temporal analysis of eastern Bering Sea echo integration-trawl survey and catch data of walleye pollock, *Theragra chalcogramma*. NOAA Technical Memorandum NMFS-AFSC-136

Barbeaux, S. J., and D. Fraser. 2009. Aleutian Islands cooperative acoustic survey study for 2006. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-198, 91 p.

Barbeaux, S.J., Horne, J., Ianelli, J. 2014. A novel approach for estimating location and scale specific fishing exploitation rate of eastern Bering Sea walleye pollock (*Theragra chalcogramma*). Fish. Res. 153 p. 69 – 82.

Bates, R.D. 1987. Ichthyoplankton of the Gulf of Alaska near Kodiak Island, April-May 1984. NWAFC Proc. Rep. 87-11, 53 pp.

Bond, N.A., and J.E. Overland 2005. The importance of episodic weather events to the ecosystem of the Bering Sea shelf. Fisheries Oceanography, Vol. 14, Issue 2, pp. 97-111.

Brodeur, R.D. and M.T. Wilson. 1996. A review of the distribution, ecology and population dynamics of age-0 walleye pollock in the Gulf of Alaska. Fish. Oceanogr. 5 (Suppl. 1):148-166.

Brown, A.L. and K.M. Bailey. 1992. Otolith analysis of juvenile walleye pollock *Theragra chalcogramma* from the western Gulf of Alaska. Mar. Bio. 112:23-30.

Canino, M.F., P.T. O'Reilly, L. Hauser, and P. Bentzen. 2005. Genetic differentiation in walleye pollock (*Theragra chalcogramma*) in response to selection at the pantophysin (*Pan* I) locus. Can. J. Fish. Aquat. Sci. 62:2519-2529.

Coyle, K. O., Eisner, L. B., Mueter, F. J., Pinchuk, A. I., Janout, M. A., Cieciel, K. D., … Andrews, A. G. (2011). Climate change in the southeastern Bering Sea: Impacts on pollock stocks and implications for the oscillating control hypothesis. *Fisheries Oceanography*, *20*(2), 139–156. doi:10.1111/j.1365-2419.2011.00574.x

De Robertis, A., and K. Williams. 2008. Weight-length relationships in fisheries studies: the standard allometric model should be applied with caution. Trans. Am. Fish. Soc. 137:707-719.

De Robertis, A., McKelvey, D.R., and Ressler, P.H. 2010. Development and application of empirical multi-frequency methods for backscatter classification in the North Pacific. Can. J. Fish. Aquat. Sci. 67: 1459-1474.

De Robertis, A., Wilson, C. D., Williamson, N. J., Guttormsen, M. A., & Stienessen, S. (2010). Silent ships sometimes do encounter more fish. 1. Vessel comparisons during winter pollock surveys. *ICES Journal of Marine Science*, *67*(5), 985–995. doi:10.1093/icesjms/fsp299

Dorn, M., S. Barbeaux, M. Guttormsen, B. Megrey, A. Hollowed, E. Brown, and K. Spalinger. 2002. Assessment of Walleye Pollock in the Gulf of Alaska. In Stock assessment and fishery evaluation report for the groundfish resources of the Gulf of Alaska, 2002. North Pacific Fishery Management Council, Box 103136, Anchorage, AK 99510. 88p.

Grant, W.S. and F.M. Utter. 1980. Biochemical variation in walleye pollock *Theragra chalcogramma*: population structure in the southeastern Bering Sea and Gulf of Alaska. Can. J. Fish. Aquat. Sci. 37:1093-1100.

Grant, W. S., Spies, I., and Canino, M. F. 2010. Shifting-balance stock structure in North Pacific walleye pollock (*Gadus chalcogrammus*). – ICES Journal of Marine Science, 67:1686-1696.

Guttormsen , M. A., C. D. Wilson, and S. Stienessen. 2001. Echo integration-trawl survey results for walleye pollock in the Gulf of Alaska during 2001. In Stock Assessment and Fishery Evaluation Report for Gulf of Alaska. Prepared by the Gulf of Alaska Groundfish Plan Team, North Pacific Fishery Management Council, P.O. Box 103136, Anchorage, AK 99510. North Pacific Fisheries Management Council, Anchorage, AK.

Heintz, R. a., Siddon, E. C., Farley, E. V., & Napp, J. M. (2013). Correlation between recruitment and fall condition of age-0 pollock (Theragra chalcogramma) from the eastern Bering Sea under varying climate conditions. *Deep Sea Research Part II: Topical Studies in Oceanography*, *94*, 150–156. doi:10.1016/j.dsr2.2013.04.006

Hinckley, S. 1987. The reproductive biology of walleye pollock, *Theragra chalcogramma*, in the Bering Sea, with reference to spawning stock structure. Fish. Bull. 85:481-498.

Hinckley, S., Napp, J. M., Hermann, a. J., & Parada, C. (2009). Simulation of physically mediated variability in prey resources of a larval fish: a three-dimensional NPZ model. *Fisheries Oceanography*, *18*(4), 201–223. doi:10.1111/j.1365-2419.2009.00505.x

Hollowed, A.B., J.N. Ianelli, P. Livingston. 2000. Including predation mortality in stock assessments: a case study for Gulf of Alaska pollock. ICES J. Mar. Sci. 57:279-293.Hughes, S. E. and G. Hirschhorn. 1979. Biology of walleye pollock, *Theragra chalcogramma*, in Western Gulf of Alaska. Fish. Bull., U.S. 77:263-274.Ianelli, J.N. 2002. Bering Sea walleye pollock stock structure using morphometric methods. Tech. Report Hokkaido National Fisheries Research Inst. No. 5, 53-58.

Honkalehto, T, and A. McCarthy. 2015. Results of the Acoustic-Trawl Survey of Walleye Pollock (*Gaddus chalcogrammus*) on the U.S. and Russian Bering Sea Shelf in June - August 2014. AFSC Processed Rep. 2015-07, 62 p. Alaska Fish. Sci. Cent., NOAA, Natl. Mar. Fish. Serv., 7600 Sand Point Way NE, Seattle WA 98115. Available from: http://www.afsc.noaa.gov/Publications/ProcRpt/ PR2015-07.pdf

Hulson, P.-J.F., Miller, S.E., Ianelli, J.N., and Quinn, T.J., II. 2011. Including mark–recapture data into a spatial age-structured model: walleye pollock (*Theragra chalcogramma*) in the eastern Bering Sea. Can. J. Fish. Aquat. Sci. 68(9): 1625–1634. doi:10.1139/f2011-060.

Hulson, P. F., Quinn, T. J., Hanselman, D. H., Ianelli, J. N. (2013). Spatial modeling of Bering Sea walleye pollock with integrated age-structured assessment models in a changing environment. Canadian Journal of Fisheries & Aquatic Sciences, 70(9), 1402-1416. doi:10.1139/cjfas-2013-0020.

Ianelli, J. N., Hollowed, A. B., Haynie, A. C., Mueter, F. J., & Bond, N. A. (2011). Evaluating management strategies for eastern Bering Sea walleye pollock (Theragra chalcogramma) in a changing environment. *ICES Journal of Marine Science*, *68*(6), 1297–1304. doi:10.1093/icesjms/fsr010

Ianelli, J.N., S. Barbeaux, T. Honkalehto, G. Walters, and N. Williamson. 2002. Bering Sea-Aleutian Islands Walleye Pollock Assessment for 2003. In Stock assessment and fishery evaluation report for the groundfish resources of the Eastern Bering Sea and Aleutian Island Region, 2002. North Pacific Fishery Management Council, Box 103136, Anchorage, AK 99510. 88p.

Ianelli, J.N., T. Honkalehto, S. Barbeaux, S. Kotwicki, K. Aydin, andWilliamson, 2015. Assessment of the walleye pollock stock in the Eastern Bering Sea, pp. 51-156. *In* Stock assessment and fishery evaluation report for the groundfish resources of the Bering Sea/Aleutian Islands regions for 2015. North Pacific Fishery Management Council, Anchorage, AK. Available from http://www.afsc.noaa.gov/REFM/docs/2015/EBSpollock.pdf

Kendall, A.W., Jr. and S.J. Picquelle. 1990. Egg and larval distributions of walleye pollock *Theragra chalcogramma* in Shelikof Strait, Gulf of Alaska. U.S. Fish. Bull. 88(1):133-154.

Kim, S. and A.W. Kendall, Jr. 1989. Distribution and transport of larval walleye pollock (*Theragra chalcogramma*) in Shelikof Strait, Gulf of Alaska, in relation to water movement. Rapp. P.-v. Reun. Cons. int. Explor. Mer 191:127-136.

Kotenev B.N., and A.I. Glubokov. 2007. Walleye pollock *Theragra chalcogramma* from the Navarin region and adjacent waters of the Bering sea: ecology, biology and stock structure.– M.: VNIRO Publishing, 2007.

Kotwicki, S., T.W. Buckley, T. Honkalehto, and G. Walters. 2005. Variation in the distribution of walleye pollock (*Theragra chalcogramma*) with temperature and implications for seasonal migration. U.S. Fish. Bull. 103:574-587.

Kotwicki, S., A. DeRobertis, P vonSzalay, and R. Towler. 2009. The effect of light intensity on the availability of walleye pollock (Theragra chalcogramma) to bottom trawl and acoustic surveys. Can. J. Fish. Aquat. Sci. 66(6): 983–994

Kotwicki, S. and Lauth R.R. 2013. Detecting temporal trends and environmentally-driven changes in the spatial distribution of groundfishes and crabs on the eastern Bering Sea shelf. Deep-Sea Research Part II: Topical Studies in Oceanography. 94:231-243.

Kotwicki, S., Ianelli, J. N., & Punt, A. E. 2014. Correcting density-dependent effects in abundance estimates from bottom-trawl surveys. *ICES Journal of Marine Science*, *71*(5), 1107–1116.

Kotwicki, S. JN Ianelli, and André E. Punt. In press. Correcting density-dependent effects in abundance estimates from bottom trawl surveys. ICES Journal of Marine Science.

Lang, G.M., Livingston, P.A., Dodd, K.A., 2005. Groundfish food habits and predation on commercially important prey species in the eastern Bering Sea from 1997 through 2001. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-158, 230p. http://www.afsc.noaa.gov/Publications/AFSC-TM/NOAA-TM-AFSC-158.pdf

Lang, G. M., Brodeur, R. D., Napp, J. M., & Schabetsberger, R. (2000). Variation in groundfish predation on juvenile walleye pollock relative to hydrographic structure near the Pribilof Islands, Alaska. *ICES Journal of Marine Science, 57*(2), 265–271. doi:10.1006/jmsc.1999.0600

Livingston, P.A. 1991. Groundfish food habits and predation on commercially important prey species in the eastern Bering Sea from 1884-1986. U. S. Dept. Commerce, NOAA Tech Memo. NMFS F/NWC-207.

Meuter, F.J. and B.L. Norcross. 2002. Spatial and temporal patterns in the demersal fish community on the shelf and upper slope regions of the Gulf of Alaska. Fish. Bull. 100:559-581.

Mueter, F.J., C. Ladd, M.C. Palmer, and B.L. Norcross. 2006. Bottom-up and top-down controls of walleye pollock (*Theragra chalcogramma*) on the Eastern Bering Sea shelf. Progress in Oceanography, Volume 68, 2:152-183.

Moss, J.H., E.V. Farley, Jr., and A.M. Feldmann, J.N. Ianelli. 2009. Spatial Distribution, Energetic Status, and Food Habits of Eastern Bering Sea Age-0 Walleye Pollock. Transactions of the American Fisheries Society 138:497–505.

Mulligan, T.J., Chapman, R.W. and B.L. Brown. 1992. Mitochondrial DNA analysis of walleye pollock, *Theragra chalcogramma*, from the eastern Bering Sea and Shelikof Strait, Gulf of Alaska. Can. J. Fish. Aquat. Sci. 49:319-326.

Olsen, J.B., S.E. Merkouris, and J.E. Seeb. 2002. An examination of spatial and temporal genetic variation in walleye pollock (*Theragra chalcogramma*) using allozyme, mitochondrial DNA, and microsatellite data. Fish. Bull. 100:752-764.

Rugen, W.C. 1990. Spatial and temporal distribution of larval fish in the western Gulf of Alaska, with emphasis on the period of peak abundance of walleye pollock (*Theragra chalcogramma*) larvae. NWAFC Proc. Rep. 90-01, 162 pp.

Stram, D. L., and J. N. Ianelli. 2009. Eastern Bering Sea pollock trawl fisheries: variation in salmon bycatch over time and space. *In* C. C. Krueger and C. E. Zimmerman, editors. Pacific salmon: ecology and management of western Alaska's populations. American Fisheries Society, Symposium 70, Bethesda, Maryland.

Shima, M. 1996. A study of the interaction between walleye pollock and Steller sea lions in the Gulf of Alaska. Ph.D. dissertation, University of Washington, Seattle, WA 98195.

Siddon, E. C., Heintz, R. a., & Mueter, F. J. (2013). Conceptual model of energy allocation in walleye pollock (Theragra chalcogramma) from age-0 to age-1 in the southeastern Bering Sea. *Deep Sea Research Part II: Topical Studies in Oceanography*, *94*, 140–149. doi:10.1016/j.dsr2.2012.12.007

Smart, T. I., Siddon, E. C., & Duffy-Anderson, J. T. (2013). Vertical distributions of the early life stages of walleye pollock (Theragra chalcogramma) in the Southeastern Bering Sea. *Deep Sea Research Part II: Topical Studies in Oceanography*, *94*, 201–210. doi:10.1016/j.dsr2.03.030

Stabeno, P.J., J.D. Schumacher, K.M. Bailey, R.D. Brodeur, and E.D. Cokelet. 1996. Observed patches of walleye pollock eggs and larvae in Shelikof Strait, Alaska: their characteristics, formation and persistence. Fish. Oceanogr. 5 (Suppl. 1): 81-91.

Takahashi, Y, and Yamaguchi, H. 1972. Stock of the Alaska pollock in the eastern Bering Sea. Bull. Jpn. Soc. Sci. Fish. 38:418-419.

von Szalay PG, Somerton DA, Kotwicki S. 2007. Correlating trawl and acoustic data in the Eastern Bering Sea: A first step toward improving biomass estimates of walleye pollock (*Theragra chalcogramma*) and Pacific cod (*Gadus macrocephalus*)? Fisheries Research 86(1) 77-83.

Walline, P. D. 2007. Geostatistical simulations of eastern Bering Sea walleye pollock spatial distributions, to estimate sampling precision. ICES J. Mar. Sci. 64:559-569.

Wespestad V.G. and T.J. Quinn. II. 1997. Importance of cannibalism in the population dynamics of walleye pollock. In: Ecology of Juvenile Walleye Pollock, *Theragra chalcogramma*. NOAA Technical Report, NMFS 126.

Wespestad, V.G. 1993. The status of Bering Sea pollock and the effect of the “Donut Hole” fishery. Fisheries 18(3)18-25.

Wolotira, R.J., Jr., T.M. Sample, S.F. Noel, and C.R. Iten. 1993. Geographic and bathymetric distributions for many commercially important fishes and shellfishes off the west coast of North America, based on research survey and commercial catch data, 1912-84. U.S. Dep. Commerce, NOAA Tech. Memo. NMFS-AFSC-6, 184 pp.

## 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<br>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


Abookire, A.A., J.F. Piatt, and B.L. Norcross. 2001. Juvenile groundfish habitat in Kachemak Bay, Alaska, during late summer. Alaska Fishery Research Bulletin 8(1):45-56.

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

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

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

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

Bakkala, R.G.,Westrheim, S. Mishima, C. Zhang, and E. Brown. 1984. Distribution of Pacific cod (*Gadus macrocephalus*) in the North Pacific Ocean. Int. N. PacComm42:111-115.

Bian, X., X. Zhang, Y. Sakurai, X. Jin, T. Gao, R. Wan, and J. Yamamoto. 2014. Temperature-mediated survival, development and hatching variation of Pacific cod *Gadus macrocephalus* eggs. J.Biol. 84:85-105.

Bian, X., X. Zhang, Y. Sakurai, X. Jin, R. Wan, T. Gao, and J. Yamamoto. 2016. Interaction effects of incubation temperature and salinity on the early life stages of pacific cod Gadus macrocephalus. Deep-Sea Research II 124:117-128.

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

Conners, M.E., and P. Munro. 2008. Effects of commercial fishing on local abundance of Pacific cod (Gadus macrocephalus) in the Bering SeaBull. 106:281-292.

Doyle, M.J., S.J. Picquelle, K.L. Mier, M.C. Spillane, and N.A. Bond. 2009. Larval fish abundance and physical forcing in the Gulf of Alaska, 1981-2003. Prog. Oceanogr. 2009:163-187.

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

Farley, E.V. Jr., R.A. Heintz, A.G. Andrews, and T.P. Hurst. In press. Size, diet, and condition of age-0 Pacific cod (*Gadus macrocephalus*) during warm and cool climate states in the eastern Bering Sea. Deep-Sea Res. II.

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

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

Hurst, T.P., D.W. Cooper, J.T. Duffy-Anderson, and E.V. Farley. 2015. Contrasting coastal and shelf nursery habitats of Pacific cod in the southeastern Bering Sea. ICES J. Scie. 75:515-527.

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

Hurst, T.P., B.J. Laurel, and L. Ciannelli 2010. Ontogenetic patterns and temperature-dependent growth rates in the early life stages of Pacific cod (*Gadus macrocephalus*).108:382-392.

Hurst, T.P., J.H. Moss, and J.A. Miller. 2012. Distributional patterns of 0-group Pacific cod (*Gadus macrocephalus*) in the eastern Bering Sea under variable recruitment and thermal conditions. ICES J. Mar69:163-174.

Hurst, T.P., S.B. Munch, K.A. Lavelle. 2012. Thermal reaction norms for growth vary among cohorts of Pacific cod (*Gadus macrocephalus*). Mar. Biol. 159:2173-2183.

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

Laman, E.A., C.N. Rooper, S. Rooney, K. Turner, D. Cooper, and M. Zimmermann. In press. Model-based essential fish habitat definitions for eastern Bering Sea groundfish species. xxx.

Lang, G.M., P.A. Livingston, and K.A. Dodd. 2005. Groundfish food habits and predation on commercially important prey species in the eastern Bering Sea from 1997 through 2001. NOAA .

Laurel, B.J., L.A. Copeman, and C.C. Parrish. 2012. Role of temperature on lipid/fatty acid composition in Pacific cod (*Gadus macrocephalus*) eggs and unfed larvae. Mar. Biol. 159:2025-2034.

Laurel, B.J., T.P. Hurst, and L. Ciannelli. 2011. An experimental examination of temperature interactions in the match-mismatch hypothesis for Pacific cod larvae. Can. J. Fish. Aquat. Sci. 68:51-61.

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

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

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

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

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

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

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

Moss, J.H., M.F. Zaleski, R.A. Heintz. In press. Distribution, diet, and energetic condition of age-0 walleye pollock (Gadus chalcogrammus) and Pacific cod (*Gadus macrocephalus*) inhabiting the Gulf of Alaska. Deep-Sea Res. II.

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

National Oceanic and Atmospheric Administration (NOAA). 1990. West coast of North America--Coastal and ocean zones strategic assessment: Data Atlas. U.S. Dept. Commerce, NOAA, National Ocean Service and National Marine Fisheries Service.

Neidetcher, S.K., T.P. Hurst, L. Ciannelli, and E.A. Logerwell. 2014. Spawning phenology and geography of Aleutian Islands and eastern Bering Sea Pacific cod (*Gadus macrocephalus*). Deep-Sea Res. II 109:204-214.

Nichol, D.G., T. Honkalehto, and G.G. Thompson. Proximity of Pacific cod to the sea floor: Using archival tags to estimate fish availability to research bottom trawls. Fish. Res. 86:129-135.

Nichol, D.G., S. Kotwicki, and M. Zimmerman. 2013. Diel vertical migration of adult Pacific cod *Gadus macrocephalus* in Alaska. J. Fish Biol. 83:170-189.

Parker-Stetter, S.L., J.K. Horne, E.V. Farley, D.H. Barbee, A.G. Andrews III, L.B. Eisner, and J.M. Nomura. Summer distributions of forage fish in the eastern Bering Sea. Deep-Sea Res. II 94:211-230.

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

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

Poltev, Yu.N., and D.Yu. Stominok. 2008. Feeding habits of the Pacific cod Gadus macrocephalus in oceanic waters of the northern Kuril Islands and southeast Kamchatka. Russ. J. Mar. Biol. 34:316-324.

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

Sakurai, Y., and T. Hattori. 1996. Reproductive behavior of Pacific cod in captivity. Fish.Sci. 62:222-228.

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

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

Shimada, A.M., and D.K. Kimura. 1994. Seasonal movements of Pacific cod, *Gadus macrocephalus*, in the eastern Bering Sea and adjacent waters based on tag-recapture data. Fish. Bull. 92:800-816.

Spies, I. 2012. Landscape genetics reveals population subdivision in Bering Sea and Aleutian Islands Pacific cod. TSoci. 141:1557-1573.

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

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

Strasburger, W.W., N. Hillgruber, A.I. Pinchuk, and F.J. MueterFeeding ecology of age-0 walleye pollock (*Gadus chalcogrammus*) and Pacific cod (*Gadus macrocephalus*) in the southeastern Bering Sea. Deep-Sea Res. II 109:172-180.

Thompson, G.G., and W.A. Palsson. 2015. Assessment of the Pacific cod stock in the Aleutian Islands. In Plan Team for Groundfish Fisheries of the Bering Sea/Aleutian Islands (compiler), Stock assessment and fishery evaluation report for the groundfish resources of the Bering Sea/Aleutian Islands regions, p. 471-613. North Pacific Fishery Management Council, 605 W. 4th Avenue Suite 306, Anchorage, AK 99501.

Thompson, G.G. 2015. Assessment of the Pacific cod stock in the Eastern Bering Sea. *In* Plan Team for Groundfish Fisheries of the Bering Sea/Aleutian Islands (compiler), Stock assessment and fishery evaluation report for the groundfish resources of the Bering Sea/Aleutian Islands regions, p. 251-470. North Pacific Fishery Management Council, 605 W. 4th Avenue Suite 306, Anchorage, AK 99501.

Thomson, J.A. On the demersal quality of the fertilized eggs of Pacific cod, *Gadus macrocephalus* Tilesius. 1963. J. Fish. Res. Board Can. 20:1087-1088.

Turner, K., C.N. Rooper, S. Rooney, E. Laman, D. Cooper, and M. Zimmermann. In press. Model-based essential fish habitat definitions for Aleutian Islands groundfish species. NOAA Tech. Memo. NMFS-AFSC-xxx.

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

Yang, M.-S. 2004. Diet changes of Pacific cod (*Gadus macrocephalus*) in Pavlof Bay associated with climate changes in the Gulf of Alaska between 1980 and 1995. Fish. Bull. 102:400-405.

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

## D.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


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

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

Coutré, K. M., A.H. Beaudreau, and P.W. Malecha. 2015. Temporal Variation in Diet Composition and Use of Pulsed Resource Subsidies by Juvenile Sablefish. Transactions of the American Fisheries Society, 144(4), 807-819.

Fredin, R. A. 1987. History of regulation of Alaska groundfish fisheries. NWAFC Processed Report 87_07.

Gao, Y., S.H. Joner, R.A. Svec, and K.L. Weinberg. 2004. Stable isotopic comparison in otoliths of juvenile sablefish (Anoplopoma fimbria) from waters off the Washington and Oregon coast. Fisheries Research, 68(1), 351-360.

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

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

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

Hanselman, D.H., J. Heifetz, K.B. Echave, and S.C. Dressel. 2015. Move it or lose it: Movement and mortality of sablefish tagged in Alaska. Canadian Journal of Fish and Aquatic Sciences. http://www.nrcresearchpress.com/doi/abs/10.1139/cjfas-2014-0251

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

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

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

Laidig, T. E., P. B. Adams, and W. M. Samiere. 1997. Feeding habits of sablefish, *Anoplopoma fimbria*, off the coast of Oregon and California. *In* M. Saunders and M. Wilkins (eds.). Proceedings of the International Symposium on the Biology and Management of Sablefish. pp 65-80. NOAA Tech. Rep. 130. Mason, J.C. , R.J. Beamish, and G.A. McFralen. 1983. Sexual maturity, fecundity, spawning, and early life history of sablefish (Anoplopoma fimbria) off the Pacific coast of Canada. Can. J. Fish. Aquat. Sci. 40:2121-2134.

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

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

NOAA (National Oceanic and Atmospheric Administration). 1990. Sablefish, Anoplopoma fimbria. Pl 3.2.22. In: West Coast of North America Coastal and Ocean Zones Strategic Assessment Data Atlas. Invertebrate and Fish Volume. U.S. Dep. Commer. NOAA. OMA/NOS, Ocean Assessment Division, Strategic Assessment Branch.

Rodgveller, C.J., Stark, J.W., Echave, K.B. and Hulson, P.J.F., 2016. Age at maturity, skipped spawning, and fecundity of female sablefish (Anoplopoma fimbria) during the spawning season. Fishery Bulletin, 114(1).

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

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

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

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

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

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

Smith, G.B., G.E. Walters, P.A. Raymore, Jr., and W.A, Hischberger. 1984. Studies of the distribution and abundance of juvenile groundfish in the northwestern Gulf of Alaska, 1980-82: Part I, Three-year comparisons. NOAA Tech. Memo. NMFS F/NWC-59. 100p.Tanasichuk, R. W. 1997. Diet of sablefish, *Anoplopoma fimbria*, from the southwest coast of Vancouver Island. *In* M. Saunders and M. Wilkins (eds.). Proceedings of the International Symposium on the Biology and Management of Sablefish. pp 93-98. NOAA Tech. Rep. 130.

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

Umeda, Y., T. Sample, and R. G. Bakkala. 1983. Recruitment processes of sablefish in the EBS. In Proceedings of the International Sablefish Symposium March 1983, Anchorage, Alaska. Alaska Sea Grant Report 83-8.

Walters, G.E., G.B. Smith, P.A. Raymore, and W.A. Hirschberger. 1985. Studies of the distribution and abundance of juvenile groundfish in the northwestern Gulf of Alaska, 1980-82: Part II, Biological characteristics in the extended region. NOAA Tech. Memo. NMFS F/NWC-77. 95 p.

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

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

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

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

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

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

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

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

Yasumiishi, E., Shotwell, S.K., Hanselman, D.H., Orsi, J., and Ferguson, E. 2015. Using Salmon Survey and Commercial Fishery Data to Index Nearshore Rearing Conditions and Recruitment of Alaskan Sablefish. Marine and Coastal Fisheries: Dynamics, Management, and Ecosystem Science 7: 312-324.

# 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

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

<u>*Adults*</u>: 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<br>phyto/zoo plankton? | summer<br>autumn? | BAY, BCH ICS | P | | | |
| Early Juveniles | to 5.5 yrs | polychaete<br>bivalves<br>amphipods<br>echiurids | all year | BAY, ICS OCS | D | S, SM | | |
| Late Juveniles | 5.5 to 10 yrs | polychaete<br>bivalves<br>amphipods<br>echiurids | all year | BAY, ICS OCS | D | S, SM, MS | | |
| Adults | 10+ years | polychaete<br>bivalves<br>amphipods<br>echiurids | spawning/ feeding May–August<br>non-spawning Nov–April | BAY BCH ICS, MCS OCS | D | S, SM, MS, M | ice edge | |

## D.4.4 Literature


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

Bakkala, R.G., V.G. Wespestad, and L.L. Low. 1982. The yellowfin sole (*Limanda aspera*) resource of the eastern Bering Sea—Its current and future potential for commercial fisheries. U.S. Dep. Commer., NOAA Tech. Memo. NMFS F/NWC-33, 43 p.

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

Kashkina, A.A. 1965. Reproduction of yellowfin sole (*Limanda aspera*) and changes in its spawning stocks in the eastern Bering Sea. Tr. Vses. Nauchno-issled, Inst. Morsk. Rybn. Khoz. Okeanogr. 58 (Izv. Tikhookean. Nauchno-issled. Inst. Rbn. Khoz. Okeanogr. 53):191-199. [In Russ.] Transl. By Isr. Prog. Sci. Transl., 1968, p. 182-190. In P.A. Moiseev (Editor), Soviet fisheries investigations in the northeastern Pacific, Part IV. Avail. Natl. Tech. Inf. Serv., Springfield, VA., as TT67-51206.

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

Moles, A., and B. L. Norcross. 1995. Sediment preference in juvenile Pacific flatfishes. Netherlands J. Sea Res. 34(1-3):177-182 (1995).

Musienko, L.N. 1963. Ichthyoplankton of the Bering Sea (data of the Bering Sea expedition of 1958-59). Tr. Vses Nauchno-issled. Inst. Morsk. Rybn. Khoz. Okeanogr. 48 (Izv. Tikhookean. Nauchno-issled. Inst. Rybn. Khoz. Okeanogr. 50)239-269. [In Russ.] Transl. By Isr. Prog. Sci. Transl., 1968, p. 251-286. In P.A. Moiseev

(Editor), Soviet fisheries investigations in the northeastern Pacific, Part I. Avail. Natl. Tech. Inf. Serv., Springfield, VA, as TT67-51203.

Musienko, L.N. 1970. Reproduction and Development of Bering Sea. Tr. Vses Nauchno-issled. Inst. Morsk. Rybn. Khoz. Okeanogr. 70 (Izv. Tikhookean. Nauchno-issled. Inst. Rybn. Khoz. Okeanogr. 72)161-224. [In Russ.] Transl. By Isr. Prog. Sci. Transl., 1972, p. 161-224. In P.A. Moiseev (Editor), Soviet fisheries investigations in the northeastern Pacific, Part V. Avail. Natl. Tech. Inf. Serv., Springfield, VA., as TT71-50127.

Nichol, D.G. 1994. Maturation and Spawning of female yellowfin sole in the Eastern Bering Sea. Preceding of the International North Pacific Flatfish Symposium, Oct. 26-28, 1994, Anchorage, AK. Alaska Sea Grant Program.

TenBrink, T., and T. Wilderbuer. 2015. Updated maturity estimates for flatfishes (Pleuronectidae) in the Eastern Bering Sea, with implications for fisheries management. Mar. Coast. Fish. Dynam, Manage, Ecosys. Sci. DOI: 10.1080/19425120.2015.1091411.

Wakabayashi, K. 1986. Interspecific feeding relationships on the continental shelf of the eastern Bering Sea, with special reference to yellowfin sole. Int. N. Pac. Fish. Comm. Bull. 47:3-30.

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

Wilderbuer, T.K., G.E. Walters, and R.G. Bakkala. 1992. Yellowfin sole, Pleuronectes asper, of the Eastern Bering Sea: Biological Characteristics, History of Exploitation, and Management. Mar. Fish. Rev. 54(4) p 1-18.

Wilderbuer, T.K., D.G. Nichol, and J. Ianelli. 2010. Yellowfin sole. *In* Stock Assessment and Fishery Evaluation Report for Groundfish Resources of the Bering Sea/Aleutian Islands Regions. North Pacific Fishery Management Council, 605 W 4th Ave, Suite 306, Anchorage, Alaska 99501. Pp. 565-644.

Yeung, C, and M. Yang. 2014. Habitat and infauna prey availability for flatfishes in the northern Bering Sea. Polar. Biol (2014) 37:1669-1784.

Yeung, C, M. Yang, S. Jewett, A. Naidu. 2013. Polychaete assemblage as surrogate for prey availability in assessing southeastern Bering Sea flatfish habitat. J. Sea Res. 76(2013)211-221.

## 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<br>phyto/zoo plankton? | spring<br>summer | OCS, ICS MCS | P | | | |
| Juveniles | 1–5 yrs | euphausiids<br>polychaetes<br>small pollock | all year | ICS, MCS OCS, USP | D, SD | MS, M | | |
| Adults | 5+ years | pollock<br>small fish | spawning Nov–February | OCS, USP LSP | D, SD | MS, M | | |
| | | | non-spawning March–Oct | USP, LSP | | | | |

### D.5.4 Literature

Alton, M.S., R.G. Bakkala, G.E. Walters and P.T. Munro. 1988. Greenland turbot, *Reinhardtius hippoglossoides*, of the Eastern Bering Sea and Aleutian Islands. U.S. Dept. Commer., NOAA Tech. Rpt. NMFS 71, 31 pages.

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

Barber WE, Smith RL, Vallarino M, Meyer RM (1997) Demersal fish assemblages of the northeastern Chukchi Sea, Alaska. Fish Bull 95:195–209

Bulatov, O.A. 1983. Distribution of eggs and larvae of Greenland halibut, *Reinhardtius hippoglossoides*, (Pleuronectidae) in the eastern Bering Sea. J. Ichthyol. [Engl. Transl. Vopr. Ikhtiol.] 23(1):157-159.

Chiperzakl, D.B., F Aurette, and P Raddi. 1995. First Record of Greenland Halibut (*Reinhardtius hippoglossoides*) in the Beaufort Sea (Arctic Ocean). Arctic 48(4)368-371.

Chumakov, A.K. 1970. The Greenland halibut, *Reinhardtius hippoglossoides*, in the Iceland area-The halibut fisheries and tagging. Tr. Polyarn. Nauchno-Issled. Proektn. Inst. Morsk. Rybn. Khoz. 1970:909-912.

D'yakov, Yu. P. 1982. The fecundity of the Greenland halibut, *Reinhardtius hippoglossoides* (Pleuronectidae), from the Bering Sea. J. Ichthyol. [Engl. Trans. Vopr. Ikhtiol.] 22(5):59-64.

Filina, E. and K. Budnova. 2015. On the Finding of mature individuals of the Greenland halibut *Reinhardtius hippoglossoides* (Pleuronectidae) in the Kara Sea. Journal of Ichthyology. 55: 138–142.

Hognestad, P.T. 1969. Notes on Greenland halibut, *Reinhardtius hippoglossoides*, in the eastern Norwegian Sea. Fiskeridir. Skr. Ser. Havunders. 15(3):139-144.

Hubbs, C.L., and N.J. Wilimovsky. 1964. Distribution and synonymy in the Pacific Ocean and variation of the Greenland halibut, *Reinhardtius hippoglossoides* (Walbaum). J. Fish. Res. Board Can. 21:1129-1154.

Ianelli, J.N., T.K. Wilderbuer, and D. Nichol. 2010. Greenland turbot. *In* Stock Assessment and Fishery Evaluation Report for Groundfish Resources of the Bering Sea/Aleutian Islands Regions. North Pacific Fishery Management Council, 605 W 4th Ave, Suite 306, Anchorage, Alaska 99501.

Jensen, A.S. 1935. (*Reinhardtius hippoglossoides*) its development and migrations. K. dan. Vidensk. Selsk. Skr. 9 Rk., 6:1-32.

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

Mecklenburg , C. W., P. R. Moller, and D. Steinke. 2011. Biodiversity of arctic marine fishes: taxonomy and zoogeography. Marine Biodiversity 41: 109-140

Mikawa, M. 1963. Ecology of the lesser halibut, *Reinhardtius hippoglossoides matsuurae* Jordan and Snyder. Bull. Tohoku Reg. Fish. Res. Lab. 29:1-41.

Musienko, L.N. 1970. Reproduction and Development of Bering Sea. Tr. Vses Nauchno-issled. Inst. Morsk. Rybn. Khoz. Okeanogr. 70 (Izv. Tikhookean. Nauchno-issled. Inst. Rybn. Khoz. Okeanogr. 72)161-224. [In Russ.] Transl. By Isr. Prog. Sci. Transl., 1972, p. 161-224. In P. A. Moiseev (Editor), Soviet fisheries investigations in the northeastern Pacific, Part V. Avail. Natl. Tech. Inf. Serv., Springfield, VA., as TT71-50127.

Pertseva-Ostroumova, T.A. 1961. The reproduction and development of far eastern flounders. Izdatel'stvo Akad. Nauk. SSSR, 483 p. [Transl. By Fish. Res. Board Can., 1967, Transl. Ser. 856, 1003 p.]

Rand, K. M., and E. A. Logerwell, 2011: The first demersal trawl survey of benthic fish and invertebrates in the Beaufort Sea since the late 1970's. Polar Biol., 34, 475-488.

Shuntov, V.P. 1965. Distribution of the Greenland halibut and arrowtooth halibuts in the North Pacific. Tr. Vses. Nauchno-issled. Inst. Morsk. Rybn. Khoz. Okeanogr. 58 (Izv. Tikhookean. Nauchno-issled. Inst. Morsk. Rybn. Khoz. Okeanogr. 53):155-163. [Transl. In Soviet Fisheries Investigation in the Northeastern Pacific, Part IV, p. 147-156, by Israel Prog. Sci. Transl., 1972, avail. Natl. Tech. Inf. Serv., Springfield, VA as TT71-50127.]

Templeman, W. 1973. Distribution and abundance of the Greenland halibut, *Reinhardtius hippoglossoides* (Walbaum), in the Northwest Atlantic. Int. Comm. Northwest Atl. Fish. Res. Bull. 10:82-98.

# 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<br>phyto/zoo plankton? | spring summer? | BAY, ICS, MCS, OCS | P | | | |
| Early Juveniles | to 2 yrs | euphausiids<br>crustaceans<br>amphipods<br>pollock | all year | ICS, MCS | D | GMS | | |
| Late Juveniles | males 2–4 yrs<br>females 2–5 yrs | euphausiids<br>crustaceans<br>amphipods<br>pollock | all year | ICS, MCS, OCS, USP | D | GMS | | |
| Adults | males 4+ yrs<br>females 5+ yrs | pollock<br>misc. fish<br>Gadidae sp.<br>euphausiids | spawning Nov–March | MCS, OCS, USP | D | GMS | ice edge (EBS) | |
| | | | non-spawning April–Oct | | | | | |

## D.6.4 Literature


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

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

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

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

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

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

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

Stark, J. 2011. Female maturity, reproductive potential, relative distribution, and growth compared between arrowtooth flounder (*Atheresthes stomias*) and Kamchatka flounder (*A. evermanni*) indicating concerns for management. J. Appl. Ichthyol. 1-5.

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

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

Wilderbuer, T.K., D. Nichol, and K. Aydin. 2010. Arrowtooth flounder. *In* Stock Assessment and Fishery Evaluation Report for Groundfish Resources of the Bering Sea/Aleutian Islands Regions. North Pacific Fishery Management Council, 605 W 4th Ave, Suite 306, Anchorage, Alaska 99501. Pp. 697-762.

Zimmermann, Mark. 1997. Maturity and fecundity of arrowtooth flounder, *Atheresthes stomias*, from the Gulf of Alaska. Fish Bull. 95:598-611.

## 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<br>phyto/zoo plankton? | winter/spring | OCS, MCS, ICS | P | | | |
| Early Juveniles | to 3.5 yrs | polychaete<br>bivalves<br>amphipods<br>misc. crustaceans | all year | BAY, ICS | D | S<br>G | | |
| Late Juveniles | to 9 years | polychaete<br>bivalves<br>amphipods<br>misc. crustaceans | all year | BAY, ICS, MCS, OCS | D | S, SM,MS<br>G | | |
| Adults | 9+ years | polychaete<br>bivalves<br>amphipods<br>misc. crustaceans | feeding May–September | MCS, ICS | D | S,SM,M S,M<br>G | | |
| | | | spawning Dec.–April | OCS | | | ice edge | |

### D.7.4 Literature


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

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

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

Cooper, D., J. Duffy-Anderson, B. Norcross, B. Holladay and P. StabenoNursery areas of juvenile northern rock sole (Lepidopsetta polyxystra) in the eastern Bering Sea in relation to hydrography and thermal regimes. ICES J. Mar. Sci.;doi:10.1093/icesjms/fst210.

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

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

Lanksbury, J., J. Duffy-Anderson, M. Busby, P. Stabeno, and K. Meir. 2007. Distribution and transport patterns of northern rock sole larvae, Lepidopsetta polyxystra, in the Southeastern Bering Sea. Prog.Oceanog. 72.1 (2007): 39-62.

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

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

Norcross, B.L., B.A. Holladay, S. C. Dressel, and M. Frandsen. 1996 .Recruitment of juvenile flatfishes in Alaska: habitat preference near Kodiak Island. U. Alaska, Coastal Marine Institute, OCS study MMS 96-003. Vol. 1.

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

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

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

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

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

Wilderbuer, T.K. and D.G. Nichol. 2010. Northern Rock sole. *In* Stock Assessment and Fishery Evaluation Report for Groundfish Resources of the Bering Sea/Aleutian Islands Regions. North Pacific Fishery Management Council, 605 W 4th Ave, Suite 306, Anchorage, Alaska 99501. Pp. 781-868.

# 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 | MCS, OCS, ICS | D | S, M | ice edge | |
| | | | non-spawning May–December | | | | | |

## D.8.4 Literature


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

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

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

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

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

McConnaughey, R.A. and K.R. Smith. 2000. Associations between flatfish abundance and surficial sediments in the eastern Bering Sea. Can. J. Fish. Aquat. Sci. 57: 2410-2419.

McGilliard, C.R., Nichol, D., Palsson, W., and Stockhausen, W. 2014. 9. Assessment of the Flathead Sole-Bering Flounder Stock in the Bering Sea and Aleutian Islands. In Appendix A: Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Bering Sea/Aleutian Islands Region.1151-1258. North Pacific Fishery Management Council, 605 W 4$^{th}$ Ave.,Miller, B.S. 1969. Life history observations on normal and tumor bearing flathead sole in East Sound, Orcas Island (Washington). Ph.D. Thesis. Univ. Wash. 131 p.

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

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

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

Walters, G.E. and T.K. Wilderbuer 1996. Flathead sole. *In* Stock assessment and fishery evaluation Report for the groundfish resources of the Bering Sea/Aleutian Islands Regions. p 279-290. North Pacific Fishery Management Council, 605 West 4th Ave., Suite 306, Anchorage, AK 99501.

## 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

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

<u>*Adults*</u>: 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 | ICS, MCS | D | S, SM,MS, M | | |
| | | | non-spawning and feeding June–February | ICS, MCS | | | ice edge | |

## D.9.4 Literature

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

Bailey, K. Brown, E. S., Duffy-Anderson, J. 2003. Aspects of distribution, transport and recruitment of Alaska plaice (Pleurones quadrituberculatus) in the Gulf of Alaska and Eastern Bering Sea: comparison of larval and central populations. J. Sea.50 (2003) 87-95.

Duffy-Anderson, J., Doyle, M, J., Meier, K.L., Stabeno, P.J., Wilderbuer, T.K. 2010. Early life ecology of Alaska plaice (Pleuronectes quadrituberculatus) in the eastern Bering Sea: Seasonality, distribution and dispersal. J. Sea Res., 64,1-2:3-14.

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

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

Novikov, N.P. 1964. Basic elements of the biology of the Pacific Halibut (*Hippoglossus stenolepis* Schmidt) in the Bering Sea. Tr. Vses. Nauchno-issled. Inst. Morsk. Rybn. Khoz. Okeanogr. 49 (Izv. Tikhookean. Nauchno-isslled. Inst. Morsk. Rybn. Khoz. Okeanogr. 51):167-204. (Transl. In Soviet Fisheries Investigations in the Northeast Pacific, Part II, p.175-219, by Israel Program Sci. Transl., 1968, avail. Natl. Tech. Inf. Serv. Springfield, VA, as TT67-51204.)

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

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

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

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

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

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

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

## 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?<br>MCS, OCS | P | | | |
| Larvae | U | U<br>phyto/zoo plankton? | spring<br>summer | ICS?<br>MCS, OCS | P | | | |
| Juveniles | 2 years | polychaete<br>amphipods<br>euphausiids<br>Tanner crab | all year | MCS, ICS, OCS | D | G, S, M | | |
| Adults | 2+ years | polychaete<br>amphipods<br>euphausiids<br>Tanner crab | spawning<br>Feb–May | MCS, OCS<br>USP | D | G, S, M | | |
| | | | non-spawning<br>May–January | MCS, OCS, USP | | | | |

### D.10.4 Literature

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

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

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

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

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

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

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

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

Wilderbuer, T. K., D. G. Nichol and P. D. Spencer. 2010. Other flatfish. *In* Stock Assessment and Fishery Evaluation Report for the groundfish resources of the Eastern Bering Sea and Aleutian Islands. Compiled by the Plan Team for the fishery resources of the Bering Sea and Aleutian Islands. North Pacific Fisheries 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<br>summer | ICS?<br>MCS, OCS, UCS | P | | | |
| Larvae | up to 2 years | U<br>phyto/ zooplankton? | all year | ICS?<br>MCS, OCS, UCS | P | | | |
| Early Juveniles | to 3 years | polychaetes<br>amphipods<br>annelids | all year | MCS?<br>ICS? | D | S, M | | |
| Late Juveniles | 3–5 years | polychaetes<br>amphipods<br>annelids | all year | MCS?<br>ICS? | D | S, M | | |
| Adults | 5+ years | polychaetes<br>amphipods<br>annelids<br>molluscs | spawning Jan–August<br>non-spawning July–Jan | MCS, OCS, UCS | D | S, M | | |

## D.11.4 Literature

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

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

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

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

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

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

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

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

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

Turnock, B.J., T.K. Wilderbuer and E.S. Brown. 1996. Flatfish. In Stock assessment and fishery evaluation Report for the groundfish resources of the Gulf of Alaska. p 279-290. North Pacific Fishery Management Council, 605 West 4th Ave., Suite 306, Anchorage, AK 99501.

Wilderbuer, T. K., D. G. Nichol and P. D. Spencer. 2010. Other flatfish. *In* Stock Assessment and Fishery Evaluation Report for the groundfish resources of the Eastern Bering Sea and Aleutian Islands. Compiled by the Plan Team for the fishery resources of the Bering Sea and Aleutian Islands. North Pacific Fisheries Management Council, Anchorage, AK.

# 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 |

## D.12.4 Literature


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

Boldt, J.L. and C.N. Rooper. 2009. Abundance, condition, and diet of juvenile Pacific ocean perch (*Sebastes alutus*) in the Aleutian Islands. Fish Bull. 107:278-285.

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

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

Doyle, M.J. 1992. Patterns in distribution and abundance of ichthyoplankton off Washington, Oregon, and Northern California (1980-1987). U.S. Dep. Commer. NOAA NMFS AFSC Processed Rept. 92-14, 344 p.

Gillespie, G.E., R.D. Stanley, and B.M. Leaman. 1992. Early life history of rockfishes in British Columbia; preliminary results of the first year of investigation. Proc. 1992 W. Groundfish Conf. Alderbrook Inn Resort, Union, WA, Jan 27-30, 1992.

Gunderson, D.R. 1971. Reproductive patterns of Pacific ocean perch (*Sebatodes alutus*) off Washington and British Columbia and their relation to bathymetric distribution and seasonal abundance. J. Fish. Res. Bd. Can. 28: 417-425.

Gunderson, D.R., and M.O. Nelson. 1977. Preliminary report on an experimental rockfish survey conducted off Monterey, California and in Queen Charlotte Sound, British Columbia during August-September, 1976. Prepared for Feb. 15-16, 1977, Interagency Rockfish Survey Coordinating Committee Meeting, NWAFC, Seattle, WA. Unpubl. manuscr. 82 p.

Harrison, R.C. 1993. Data report: 1991 bottom trawl survey of the Aleutian Islands area. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-12. 144 p.

Heifetz, J., and D. Ackley. 1997. Bycatch in rockfish fisheries in the Gulf of Alaska. Unpubl. Manuscr. 20 p. (Available from NMFS Auke Bay Laboratory, 11305 Glacier Hwy., Juneau, AK 99801.

Heifetz, J., J.N. Ianelli, and D.M. Clausen. 1996. Slope rockfish. *In* Stock assessment and fishery evaluation report for the groundfish resources of the Gulf of Alaska, p.229-269. North Pacific Fishery Management Council, 605 W. 4th. Ave., Suite 306, Anchorage, AK 99501-2252.

Ito, D.H. 1982. A cohort analysis of Pacific ocean perch stocks from the Gulf of Alaska and Bering Sea regions. U.S. Dep. Commer., NWAFC Processed Rept. 82-15, 157 p.

Ito, D.H., and J.N. Ianelli. 1996. Pacific ocean perch. *In* Stock assessment and fishery evaluation report for the groundfish resources of the Bering Sea/Aleutian Islands regions, p.331-359. North Pacific Fishery Management Council, 605 W. 4th. Ave., Suite 306, Anchorage, AK 99501-2252.

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

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

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

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

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

Mattson, C.R., and B.L. Wing. 1978. Ichthyoplankton composition and plankton volumes from inland coastal waters of southeastern Alaska, April-November 1972. U.S. Dep. Commer., NOAA Tech. Rept. NMFS SSRF-723, 11 p.

Moser, H.G., 1996. SCORPAENIDAE: scorpionfishes and rockfishes. *In*: Moser, H.G., editor. The early stages of fishes in the California Current region, p. 733-795. CalCOFI Atlas No.33. 1505 p.

NOAA (National Oceanic and Atmospheric Administration). 1990. Pacific ocean perch, *Sebastes alutus*. *In*: West coast of North America coastal and ocean zones strategic assessment: data atlas. Invertebrate and fish volume, Plate 3.2.20. U.S. Dep. Commer. NOAA. OMA/NOS, Ocean Assessments Division, Strategic Assessment Branch.

Ronholt, L.L., K. Teshima, and D.W. Kessler. 1994. The groundfish resources of the Aleutian Islands region and southern Bering Sea 1980, 1983, and 1986. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-31. 351 p.

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

Rooper, C.N. and J. L. Boldt. 2005. Distribution of juvenile Pacific ocean perch *Sebastes alutus* in the Aleutian Islands in relation to benthic habitat. Alaska Fisheries Research Bulletin 11(2):102-112.

Rooper, C.N., J.L. Boldt, S Batten, and C. Gburski. 2012. Growth and production of Pacific ocean perch (*Sebastes alutus*) in nursery habitats in the Gulf of Alaska. Fish. Oceanog. 21:415-429.

Rooper, C.N. , J. L. Boldt, and M. Zimmermann. 2007. An assessment of juvenile Pacific Ocean perch (Sebastes alutus) habitat use in a deepwater nursery. Estuarine, Coastal and Shelf Science 75:371-380

Rooper, C.N., G.R. Hoff, and A. DeRobertis. 2010. Assessing habitat utilization and rockfish (*Sebastes* spp.) biomass on an isolated rocky ridge using acoustics and stereo image analysis. Can J. Fish. Aquat. Sci. 67:1658-1670. Seeb, L.W. 1993. Biochemical identification of larval rockfishes of the genus *Sebastes*. Final Report Contract #43ABNF001082. U.S. Dept. Commer. NOAA/NMFS NWAFC/RACE Division, Seattle, WA. 28 p.

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

Spencer, P.D., and J.N. Ianelli. 2014. Assessment of the Pacific ocean perch stock in the eastern Bering Sea and Aleutian Islands. *In* Stock assessment and fishery evaluation report for the groundfish resources of the Bering Sea/Aleutian Islands regions, pp. 1329-1394. North Pacific Fishery Management Council, 605 W. 4th Ave, suite 306. Anchorage, AK 99501.

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

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

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

Wing, B.L. 1985. Salmon stomach contents from the Alaska troll logbook program, 1977-84. U.S. Dep. Commer., NOAA Tech. Memo. NMFS F/NWC-91. 41 p.

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

Wolotira, R.J., Jr., T.M. Sample, S.F. Noel, and C.R. Iten. 1993. Geographic and bathymetric distributions for many commercially important fishes and shellfishes off the west coast of North America, based on research survey and commercial catch data, 1912-1984. U. S. Dep. Commer., NOAA Tech. Memo. NMFS - AFSC-6, 184 p.

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

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

Yang, M-S, K. Dodd, R. Hibpshman, and A. Whitehouse. 1996. Food Habits of Groundfishes in the Gulf of Alaska in 1999 and 2001. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-164, 199 p.

# D.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 |

## D.13.4 Literature


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

Harrison, R.C. 1993. Data report: 1991 bottom trawl survey of the Aleutian Islands area. U.S. Dep. Commerce, NOAA Tech. Memo. NMFS-AFSC-12. 144 p.

Heifetz, J., and D. Ackley. 1997. Bycatch in rockfish fisheries in the Gulf of Alaska. Unpubl. Manuscr. 20 p. (Available from NMFS Auke Bay Laboratory, 11305 Glacier Hwy., Juneau, AK 99801.)

Heifetz, J., J.N. Ianelli, and D.M. Clausen. 1996. Slope rockfish. *In* Stock assessment and fishery evaluation report for the groundfish resources of the Gulf of Alaska, p.229-269. North Pacific Fishery Management Council, 605 W. 4th. Ave., Suite 306, Anchorage, AK 99501-2252.

Jones, D.T, C.D. Wilson, A. De Robertis, C.N. Rooper, T.C. Weber, and J.L. Butler. 2012. Evaluation of rockfish abundance in untrawlable habitat: combining acoustic and complementary sampling tools. Fish Bull. 110:332-343.

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

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

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

Ronholt, L.L., K. Teshima, and D.W. Kessler. 1994. The groundfish resources of the Aleutian Islands region and southern Bering Sea 1980, 1983, and 1986. U.S. Dep. Commerce, NOAA Tech. Memo. NMFS-AFSC-31. 351 p.

Rooper, C.N., G.R. Hoff, and A. DeRobertis. 2010. Assessing habitat utilization and rockfish (*Sebastes* spp.) biomass on an isolated rocky ridge using acoustics and stereo image analysis. Can J. Fish. Aquat. Sci. 67:1658-1670.

Rooper, C.N. M.H. Martin., J.L. Butler, D.T Jones, and M Zimmerman. 2012. Estimating species and size composition of rockfishes to verify targets in acoustic surveys of untrawlable areas. Fish Bull. 110:317-331.

Spencer, P.D., and J.N. Ianelli. 2014. Assessment of the northern rockfish stock in the eastern Bering Sea and Aleutian Islands. *In* Stock assessment and fishery evaluation report for the groundfish resources of the Bering Sea/Aleutian Islands regions, pp. 1395-14514th Ave, suite 306. Anchorage, AK 99501

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

Westrheim, S.J., and H. Tsuyuki. 1971. Taxonomy, distribution, and biology of the northern rockfish, *Sebastes polyspinis*. J. Fish. Res. Bd. Can. 28: 1621-1627.

Yang, M-S, K. Dodd, R. Hibpshman, and A. Whitehouse. 1996. Food Habits of Groundfishes in the Gulf of Alaska in 1999 and 2001. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-164, 199 p.

## D.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

<u>Egg/Spawning</u>: 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 | Locatio n | 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 | |

## D.14.4 Literature

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

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

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

Gray, A.K., A.W. Kendall, B.L. Wing, M.G. Carls, J. Heifetz, Z. Li, and A.J. Gharrett. 2006. Identification and first documentation of larval rockfishes in Southeast Alaskan waters was possible using mitochondrial markers but not pigmentation patterns. Trans. Am. Fish. Soc. 135: 1-11.

Heifetz, J., J.N. Ianelli, and D.M. Clausen. 1996. Slope rockfish. *In* Stock assessment and fishery evaluation report for the 1997 Gulf of Alaska groundfish fishery, p. 230-270. North Pacific Fishery Management Council, 605 W. 4th Avenue, Suite 306, Anchorage, AK 99501.

Hutchinson, C.E. 2004. Using radioisotopes in the age determination of shortraker (*Sebastes borealis*) and canary (*Sebastes pinniger*) rockfish. Master's Thesis. Univ. Washington, Seattle. 84 p.

Kendall, A.W. 2003. Analysis of *Sebastes* larvae in the Gulf of Alaska based upon the AFSC ichthyoplankton database, and other sources of information. Unpublished manuscript, Alaska Fisheries Science Center, Seattle, WA.

Kramer, D.E., and V.M. O'Connell. 1986. Guide to northeast Pacific rockfishes, Genera *Sebastes* and *Sebastolobus*. Marine Advisory Bulletin No. 25: 1-78. Alaska Sea Grant College Program, University of Alaska.

Krieger, K. 1992. Shortraker rockfish, *Sebastes borealis*, observed from a manned submersible. Mar. Fish. Rev., 54(4): 34-37.

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

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

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

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

Sigler, M.F., and H.H. Zenger, Jr. 1994. Relative abundance of Gulf of Alaska sablefish and other groundfish based on the domestic longline survey, 1989. NOAA Tech. Memo. NMFS-AFSC-40.

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

Wolotira, R.J., Jr., T.M. Sample, S.F. Noel, and C.R. Iten. 1993. Geographic and bathymetric distributions for many commercially important fishes and shellfishes off the west coast of North America, based on research survey and commercial catch data, 1912-84. U.S. Dep. Commerce, NOAA Tech. Memo. NMFS-AFSC-6, 184 p.

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

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

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

## 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 | |

## D.15.4 Literature


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

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

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

Gray, A.K., A.W. Kendall, B.L. Wing, M.G. Carls, J. Heifetz, Z. Li, and A.J. Gharrett. 2006. Identification and first documentation of larval rockfishes in Southeast Alaskan waters was possible using mitochondrial markers but not pigmentation patterns. Trans. Am. Fish. Soc. 135: 1-11.

Heifetz, J., J.N. Ianelli, and D.M. Clausen. 1996. Slope rockfish. *In* Stock assessment and fishery evaluation report for the 1997 Gulf of Alaska groundfish fishery, p. 230-270. North Pacific Fishery Management Council, 605 W. 4th Avenue, Suite 306, Anchorage, AK 99501.

Kramer, D.E., and V.M. O'Connell. 1986. Guide to northeast Pacific rockfishes, Genera *Sebastes* and *Sebastolobus*. Marine Advisory Bulletin No. 25: 1-78. Alaska Sea Grant College Program, University of Alaska.

Krieger, K. 1992. Shortraker rockfish, *Sebastes borealis*, observed from a manned submersible. Mar. Fish. Rev., 54(4): 34-37.

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

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

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

Love, M.S., M. Yoklovich, and L. Thorsteinson. 2002. The rockfishes of the northeast Pacific. University of California Press, Berkeley. 405 p.

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

Orr, J.W. and S. Hawkins. 2008. Species of the rougheye rockfish complex: resurrection of *Sebastes melanostictus* (Matsubara 1934) and a redescription of *Sebastes aleutianus* (Jordan and Evermann, 1898) (Teleostei: Scorpaeniformes). Fish. Bull. 106(2):111-134

Sigler, M.F., and H.H. Zenger, Jr. 1994. Relative abundance of Gulf of Alaska sablefish and other groundfish based on the domestic longline survey, 1989. NOAA Tech. Memo. NMFS-AFSC-40.

Wolotira, R.J., Jr., T.M. Sample, S.F. Noel, and C.R. Iten. 1993. Geographic and bathymetric distributions for many commercially important fishes and shellfishes off the west coast of North America, based on research survey and commercial catch data, 1912-84. U.S. Dep. Commerce, NOAA Tech. Memo. NMFS-AFSC-6, 184 p.

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

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

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

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

## 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 |

## D.16.4 Literature


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

Clausen, D.M., and J. Heifetz. 1996. Pelagic shelf rockfish. *In* Stock assessment and fishery evaluation report for the groundfish resources of the Gulf of Alaska, p.271-288. North Pacific Fishery Management Council, 605 W. 4th. Ave., Suite 306, Anchorage, AK 99501-2252.

Harrison, R.C. 1993. Data report: 1991 bottom trawl survey of the Aleutian Islands area. U.S. Dep. Commerce, NOAA Tech. Memo. NMFS-AFSC-12. 144 p.

Heifetz, J., and D. Ackley. 1997. Bycatch in rockfish fisheries in the Gulf of Alaska. Unpubl. Manuscr. 20 p. (Available from NMFS Auke Bay Laboratory, 11305 Glacier Hwy., Juneau, AK 99801.

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

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

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

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

Reuter, R.F. 1999. Describing Dusky rockfish (*Sebastes ciliatus*) habitat in the Gulf of Alaska using Historical data. M.S. thesis. California State University, Hayward 83 p.

Reuter, R.F. and P.D. Spencer. 2002. Other rockfish. In Stock assessment and fishery evaluation report for the groundfish resources of the Bering Sea and Aleutian Islands, p. 579-608.

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

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

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

## D.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<br>shrimp, amphipods, mysids, euphausiids? | U | MCS, OCS, USP | D | M, S, R, SM, CB, MS, G | U | |
| Adults | U | shrimp<br>fish (cottids), small crabs | year-round? | MCS, OCS, USP, LSP | D | M, S, R, SM, CB, MS, G | U | |

## D.17.4 Literature


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

Aton, M. 1981. Gulf of Alaska bottomfish and shellfish resources. U.S. Dep. Commerce Tech. Memo. NMFS F/NWC-10, 51 p.

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

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

Heifetz, J., J.N. Ianelli, and D.M. Clausen. 1996. Slope rockfish. *In* Stock assessment and fishery evaluation report for the groundfish resources of the Gulf of Alaska, p. 230-270. North Pacific Fishery Management Council, 605 West 4th Avenue, Suite 306, Anchorage, AK 99501.

Ianelli, J.N., D.H. Ito, and M. Martin. 1996. Thornyheads (*Sebastolobus sp*.). *In* Stock Assessment and fishery evaluation report for the groundfish resources of the Gulf of Alaska, p. 303-330. North Pacific Fishery Management Council, 605 West 4th Avenue, Suite 306, Anchorage, AK 99501.

Jacobson, L.D. 1993. Thornyheads. *In* Status of living marine resources off the Pacific coast of the United States for 1993. U.S. Dep. Commerce, NOAA Tech. Memo. NMFS-AFSC-26, 35-37 p.

Kramer, D.E., and V.M. O'Connell. 1986. Guide to northeast Pacific rockfishes, Genera *Sebastes* and *Sebastolobus*. Marine Advisory Bulletin No. 25: 1-78. Alaska Sea Grant College Program, University of Alaska.

Low, L.L. 1994. Thornyheads. *In* Status of living marine resources off Alaska, 1993. U.S. Dep. Commerce, NOAA Tech. Memo. NMFS-AFSC-27, 56-57 p.

Miller, P.P. 1985. Life history study of the shortspine thornyhead, *Sebastolobus alascanus*, at Cape Ommaney, south-eastern Alaska. M.S. Thesis, Univ. Alaska, Fairbanks, AK, 61p.

Moser, H.G. 1974. Development and distribution of larvae and juveniles of *Sebastolobus* (Pisces: family Scorpaenidae). Fish. Bull. 72: 865-884.

Pearcy, W.G. 1962. Egg masses and early developmental stages of the scorpaenid fish, *Sebastolobus*. J. Fish. Res. Board Can.19: 1169-1173.

Sigler, M.F., and H.H. Zenger, Jr. 1994. Relative abundance of Gulf of Alaska sablefish and other groundfish based on the domestic longline survey, 1989. NOAA Tech. Memo. NMFS-AFSC-40.

Wolotira, R.J., Jr., T.M. Sample, S.F. Noel, and C.R. Iten. 1993. Geographic and bathymetric distributions for many commercially important fishes and shellfishes off the west coast of North America, based on research survey and commercial catch data, 1912-84. U.S. Dep. Commerce, NOAA Tech. Memo. NMFS-AFSC-6, 184 p.

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

Yang, M-S. 2003. Food Habits of the Important Groundfishes in the Aleutian Islands in 1994 and 1997. AFSC processed report 2003-07.

## 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

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

<u>Larvae/Juveniles</u>: 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.

<u>Adults</u>: 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<br>optimum 3.9–10.5 °C |
| Larvae | up to 6 mos | U<br>copepods? | fall–winter | U | U, N? | U | U | 2–12 °C optimum 5–7 °C |
| Juveniles | ½–2 yrs of age | U<br>copepods & euphausiids? | all year | U | N | U | U | 3–5 °C |
| Adults | 3+ yrs of age | copepods<br>euphausiids<br>meso-pelagic fish (myctophids) | spawning (June–Oct) | ICS and MCS, IP | D (males) SD females | G, R, CB, K | F, E | 3–5 °C all stages >17 ppt only |
| | | | non-spawning (Nov–May) | MCS and OCS, IP | SD/D all sexes | | | |
| | | | tidal/diurnal, year-round? | ICS, MCS, OCS, IP | D when currents high/day<br><br>SD slack tides/night | | | |

## D.18.4 Literature


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

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

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

Byrd, G.V., J.C. Williams, and R. Walder. 1992. Status and biology of the tufted puffin in the Aleutian Islands, Alaska, after a ban on salmon driftnets. U.S. Fish and Wildlife Service, Alaska Maritime National Wildlife Refuge, Aleutian Islands Unit, PSC 486, Box 5251, FPO AP 96506-5251, Adak, Alaska.

Canino, M.F, I.B. Spies, M.M. Hollowed, and J.L. GuthridgeMating behavior of Atka mackerel inferred from genetic analysis of egg masses in the wild and in captivity. Marine and Coastal Fisheries.

Cooper, D. W.,F. McDermott and J. N. Ianelli. 2010. Spatial and temporal variability in Atka mackerel female maturity at length and age. Marine and Coastal Fisheries, 2:329-338. http://www.tandfonline.com/doi/abs/10.1577/C09-45.1

Cooper, D., and S. McDermott. 2008. Variation in Atka mackerel, *Pleurogrammus monopterygius*, spatial and temporal distribution by maturity stage. Pages 11-42 *in* S. F. McDermott, M. Canino, N. Hillgruber, D. W. Cooper, I. Spies, J. Guthridge, J. N. Ianelli, P. Woods. 2008. Atka mackerel *Pleurogrammus monopterygius* reproductive ecology in Alaska. North Pacific Research Board Final report, 163p.

Doyle, M.J., W.C. Rugen, and R.D. Brodeur. 1995. Neustonic ichthyoplankton in the western Gulf of Alaska during spring. Fishery Bulletin 93: 231-253.

Dragoo, D.E., G.V. Byrd, and D.B. Irons. 2001. Breeding status, population trends, and diets of seabirds in Alaska, 2000. U.S. Fish and Wildl. Serv. Report AMNWR 01/07.

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

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

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

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

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

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

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

Hunt, G.L. Jr., H. Kato, and S.M. McKinnell [eds.] 2000. Predation by marine birds and mammals in the subarctic north Pacific Ocean. North Pacific Marine Science Organization (PICES) Scientific Report #25. 165 p.

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

Kendall, A.W., Jr., and J.R. Dunn. 1985. Ichthyoplankton of the continental shelf near Kodiak Island, Alaska. U.S. Dep. Commerc., NOAA Tech. Rept NMFS 20, 89 p.

Kendall, A.W., Jr., J.R. Dunn, and R.J. Wolotira, Jr. 1980. Zooplankton, including ichthyoplankton and decapod larvae, of the Kodiak shelf. NWAFC Processed Rept. 80-8, AFSC-NMFS, 7600 Sand Point Way, NE, Seattle, WA 98115. 393 p.

Lauth, R. R., J. Guthridge, D. Nichol, S. W. Mcentire, and N. Hillgruber. 2007a. Timing and duration of mating and brooding periods of Atka mackerel (*Pleurogrammus monopterygius*) in the North Pacific Ocean. Fish. Bull., U.S. 105:560-570. http://fishbull.noaa.gov/1054/lauth.pdf

Lauth, R. R., S. W. Mcentire, and H. H. Zenger, Jr. 2007b. Geographic distribution, depth range, and description of Atka mackerel *Pleurogrammus monopterygius* nesting habitat in Alaska. Alaska Fish. Res. Bull. 12:165-186. http://www.adfg.state.ak.us/pubs/afrb/vol12_n2/lautv12n2.pdf

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

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

Lowe, S., J. Ianelli, M. Wilkins, K. Aydin, R. Lauth, and I. Spies. 2007. Appendix B *In* Stock assessment of Aleutian Islands Atka mackerel. *In* Stock Assessment and Evaluation Report for the Groundfish Resources of the Bering Sea/Aleutian Islands Regions. North Pacific Fisheries Management Council, P.O. Box 103136, Anchorage, Alaska, 99510. http://www.afsc.noaa.gov/refm/docs/2007/BSAIatka.pdf

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

Materese, A.C., D. M. Blood, S. J. Piquelle, and J. L. Benson. 2003. Atlas of abundance and distribution patterns of ichthyoplankton from the Northeast Pacific Ocean and Bering Sea ecosystems based on research conducted by the Alaska Fisheries Science Center (1972-1996). U.S. Dep. Commer., NOAA Professional Paper, NMFS-1, 281 p.

McDermott, S.F. 2003. Improving abundance estimation of a patchily distributed fish, Atka mackerel (*Pleurogrammus monopterygius*). Dissertation, University of Washington, 150 p.

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

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

McDermott,K. Rand, M. Levine,Ianelli, and E. Small-scale Atka mackerel population abundance and movement in the central Aleutian Islands, an area of continuing Steller sea lion decline. North Pacific Research Board Final Report:109.

Mel'nikov, I.V. and A. YA. Efimkin. 2003. the young of the northern Atka mackerel *Pleurogrammus monopterygius* in the epipelagic zone over deep-sea areas of the northern Pacific Ocean. J. Ichthyol. 43: 424-437.

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

Morris, B.F. 1981. An assessment of the living marine resources of the central Bering Sea and potential resource use conflicts between commercial fisheries and Petroleum development in the Navarin Basin, Proposed sale No. 83. Anchorage, AK: USDOC, NOAA, NMFS, Environmental Assessment Division.

Musienko, L.N. 1970. Razmnozheine I razvitie ryb Beringova morya (Reproduction and development of Bering Sea fishes). Tr. Vses. Nauchno-issled. Inst. Morsk. Rybn. Koz. Okeanogr. 70: 161-224 In P.A. Moiseev (ed.), Soviet fisheries investigations in the northeastern Pacific, Pt. 5, Avail. Natl. Tech. Info. Serv., Springfield, VA as TT 74-50127.

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

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

Orlov, A.M. 1996. The role of mesopelagic fishes in feeding of Atka mackerel in areas of the North Kuril islands. Publ. Abstract in Role of forage fishes in marine ecosystems. Symposium held Nov 1996, AK Sea Grant, U. Alaska, Fairbanks.

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

Rand, K. M., D. A. Beauchamp, and S. A. LoweLongitudinal growth differences and the influence of diet quality on Atka mackerel of the Aleutian Islands, Alaska: using a bioenergetics model to explore underlying mechanisms. Marine and Coastal Fisheries 2:362-374.

Rugen, W.C. 1990. Spatial and temporal distribution of larval fish in the western Gulf of Alaska, with emphasis on the period of peak abundance of walleye pollock (*Theragra chalcogramma*) larvae. NWAFC Processed Rept 90-01, AFSC-NMFS, 7600 Sand Point Way, NE, Seattle, WA 98115. 162 p.

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

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

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

Springer, A.M., J.F. Piatt, V.P. Shuntov, G.B. Van Vliet, V.L. Vladimirov, A.E. Kuzin, A.S. Perlov. 1999. Prog. in Oceanogr. 43(1999)443-487.

Stone, R.P. 2006. Coral habitat in the Aleutian Islands of Alaska: depth distribution, fine-scale species associations, and fisheries interactions. Coral Reefs 25:229-238.Waldron, K.D. 1978. Ichthyoplankton of the eastern Bering Sea, 11 February-16 March 1978. REFM Report, AFSC, NMFS, 7600 Sand Point Way, NE, Seattle, WA 98115. 33 p.

Wolotira, R.J., Jr., T.M. Sample, S.F. Noel, and C.R. Iten. 1993. Geographic and bathymetric distributions for many commercially important fishes and shellfishes off the west coast of North America, based on research survey and commercial catch data, 1912-84. U.S. Dep. Commerce, NOAA Tech. Memo. NMFS-AFSC-6, 184 p.

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

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

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

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

## 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 | OS, USP, LSP, BSN | SP | U | UP, F? | euhaline waters, 2–4 °C |
| | | | winter | OS, USP, LSP, BSN | SP | U | UP, F? | |

### D.19.4 Literature


Arkhipkin, A.I., V.A. Bizikov, V.V. Krylov, and K.N. Nesis. 1996. Distribution, stock structure, and growth of the squid *Berryteuthis magister* (Berry, 1913) (Cephalopoda, Gonatidae) during summer and fall in the western Bering Sea. Fish. Bull. 94: 1-30.

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

Byrd, G.V., J.C. Williams, and R. Walder. 1992. Status and biology of the tufted puffin in the Aleutian Islands, Alaska, after a ban on salmon driftnets. U. S. Fish and Wildlife Service, Alaska Maritime National Wildlife Refuge, Aleutian Islands Unit, PSC 486, Box 5251, FPO AP 96506-5251, Adak, Alaska.

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

Hatch, S.A., G.V. Byrd, D.B. Irons, and G.L. Hunt, Jr. 1990. Status and ecology of kittiwakes in the North Pacific. Proc. Pacific Seabird Group Symposium, Victoria, B.C., 21-25 February 1990.

Jorgensen, E.M. 2009. Field guide to squids and octopods of the eastern North Pacific and Bering Sea. Alaska Sea Grant College Program, University of Alaska Fairbanks, Fairbanks, Alaska. 94 p.

Livingston, P.A., and B.J. Goiney, Jr. 1983. Food habits literature of North Pacific marine fishes: a review and selected bibliography. U.S. Dep. Commerce, NOAA Tech. Memo. NMFS F/NWC-54, 81 p.

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

Ormseth, O.A. 2014. Assessment of the squid stock complex in the Bering Sea and Aleutian Islands. *In* Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Bering Sea/Aleutian Islands Regions. North Pacific Fishery Management Council, 605 West 4th Avenue, Suite 306, Anchorage, AK 99501.

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

Sobolevsky, Ye. I. 1996. Species composition and distribution of squids in the western Bering Sea. Pp. 135-141 *In* O.A. Mathisen and K.O. Coyle (eds.), Ecology of the Bering Sea: a review of Russian literature. Alaska Sea Grant Rept 96-01, U. Alaska, Fairbanks, AK 99775.

Springer, A. 1993. Report of the seabird working group. pp. 14-29 *In* Is it food? Addressing marine mammal and seabird declines: a workshop summary. Alaska Sea Grant Report 93-01, Univ. Alaska, Fairbanks, AK, 99775.

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

## D.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 | Oceano-graphic Feature s | Other |
|---|---|---|---|---|---|---|---|---|
| Eggs | U (1–2 months?) | NA | spring–summer? | U, ICS, MCS | P*,D | R, G? | U | euhalin e waters |
| Young juveniles | U | zooplankton | summer–fall? | U, ICS, MCS, OCS, USP | D, SD | U | U | euhalin e 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 | euhalin e waters |

## D.20.4 Literature


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

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

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

Bowers, F.R., M. Schwenzfeier, K Herring, M Salmon, K Milani, J. Shaishnikoff, H. Barnhart, J. Alas, R. Burt, B. Baechler, and A. Buettner. 2010. Annual management report of the commercial and subsistence shellfish fisheries of the Aleutian Islands, Bering Sea, and the westward region’s shellfish observer program, 2008/09. ADF&G Fishery Management Report No 10-24.

Boyle, P. and P. RodhouseCephalopods: Ecology and Fisheries. Blackwell Publishing, Oxford, UK.

Brewer, R.S. and B.L. Norcross. Long-term retention of internal elastomer tags in a wild population of North Pacific giant octopus (Enteroctopus dofleini), Fisheries Research 134-136: 17-20.

Brewer, R.S. and B.L. Norcross. 2013. Seasonal changes in the sexual maturity and body condition of the North Pacific giant octopus (Enteroctopus dofleini).

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

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

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

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

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

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

Conners, M.E., C. Conrath, and K. Aydin 2014. Octopus Complex in the Bering Sea and Aleutian Islands. In: Stock assessment and fishery evaluation report for the groundfish resources of the Bering Sea/Aleutian Islands regions. North Pac. Mgmt. Council, Anchorage, AK,

Conners, M. E., C. L. Conrath, and R. Brewer. 2012. Field studies in support of stock assessment for the giant Pacific octopus Enteroctopus dofleini. NPRB Project 906 Final Report. North Pacific Research Board, Anchorage, AK.

Conrath, C. and M. E. Conners. 2014, Aspects of the reproductive biology of the giant Pacific octopus, Enteroctopus dofleini, in the Gulf of Alaska. Fishery Bulletin 112(4):253-260.

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

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

Gabe, S.H. 1975. Reproduction in the Giant Octopus of the North Pacific, Octopus dofleini martini. Veliger 18 (2): 146-150.

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

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

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

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

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

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

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

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

Kubodera, T. 1991. Distribution and abundance of the early life stages of octopus, Octopus dofleini Wulker, 1910 in the North Pacific. 49(1-2) 235-243.

Laptikhovsky, V.V. 1999. Fecundity and reproductive strategy of three species of octopods from the Northwest Bering Sea. Russian Journal of Marine Biology 25: 342-346.

Laptikhovsky, V. Fecundity, egg masses and hatchlings of Benthoctopus spp. (Octopodidae) in Falkland waters. J.Biol. Ass. U.K. 81: 267-270.

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

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

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

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

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

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

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

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

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

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

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

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

Robinson, S.M.C. 1983.Growth of the Giant Pacific octopus, Octopus dofleini martini on the west coast of British Columbia. MSc thesis, Simon Fraser University.

Robinson, S.M.C. and E.B. Hartwick. 1986. Analysis of growth based on tag-recapture of the Giant Pacific octopus Octopus dofleini martini. Journal of Zoology 209: 559-572.

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

Sagalkin, N.H. and K Spalinger. Annual management report of the commercial and subsistence shellfish fisheries in the Kodiak, Chignik, and Alaska Peninsula areas, 2010. ADF&G Fishery Management Report No. 11-43.

Sato, K. 1996. Survey of sexual maturation in Octopus dofleini in the coastal waters off Cape Shiriya, Shimokita Peninsula, Aomori Prefecture. Nippon Suisan Gakkaishi 62(3): 355-360.

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

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

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

Toussaint, R.K., D. Scheel, G.K. Sage, and S.L. Talbot. 2012. Nuclear and mitochondrial markers reveal evidence for genetically segregated cryptic speciation in giant Pacific octopuses from Prince William Sound, Alaska. Conservation Genetics. Online First: DOI 10.1007/s10592-012-0392-4.

Villanueva, R. 1992. Continuous spawning in the cirrate octopods Opisthoteuthis agassizii and O. vossi: features of sexual maturation defining a reproductive strategy in cephalopods. Marine Biology 114: 265-275.

Voight, J.R. 2004. Hatchlings of the deep-sea Graneledone boreopacifica are the largest and most advanced known. Journal of Molluscan Studies 70: 400-402.

Voight, J.R. and K.A. Feldheim. 2009. Microsatellite inheritance and multiple paternity in the deep-sea octopus, Graneledone boreopacifica (Mollusca: Cephalopoda). Invertebrate Biology 128:26-30.

Voight, J. R. and A. J. Grehan. 2000. Egg brooding by deep-sea octopuses in the North Pacific Ocean. Biological Bulletin 198: 94–100.

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

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

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

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

Young, R.E. 2008. Japetella diaphana (Hoyle 1885). Version 28 April 2008 (under construction). http://tolweb.org/Japetella_diaphana/20224/2008.04.28 in the Tree of Life Web Project, http://tolweb.org/

Young, R.E., and M. Vecchione. 1999. Morphological observations on a hatchling and a paralarva of the vampire squid, *Vampyroteuthis infernalis* Chun (Mollusca: Cephalopoda). Proceedings of the Biological Society of Washington 112:661-666.

## 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 |

## D.21.4 Literature

Alverson, Dand M. E. Stansby. 1963. The spiny dogfish (*Squalus acanthias*) in the northeastern Pacific. USFWS Spec Sci Rep-Fisheries. 447:25p.

Beamish, R. J., G. A. McFarlane, K. R. Weir, M. S. Smith, J.Scarsbrook, A. J. Cass and C. C. Wood. 1982. Observations on the biology of Pacific hake, walleye pollock and spiny dogfish in the Strait of Georgia, Juan de Fuca Strait and off the west coast of Vancouver Island and United States, July 13-24, 1976. Can MS Rep Fish Aquat Sci. 1651:150p.

Beamish, R.J., and G.A. McFarlane. 1985. Annulus development on the second dorsal spine of the spiny dogfish (*Squalus acanthias*) and its validity for age determination. JAquat. Sci. 42:1799-1805.

Benz, G. W., R. Hocking, A. Kowunna Sr., S. A. Bullard, J.C. George. 2004. A second species of Arctic shark: Pacific sleeper shark *Somniosus pacificus* from Point Hope, Alaska. Polar Biol. 27:250-252.

Bonham, K. 1954. Food of the dogfish *Squalus acanthias*. Fish Res Paper. 1:25-36.

Bright, D.B. 1959. The occurance and food of the sleeper shark, *Sominus pacificus*, in a central Alaskan Bay. Copeia 1959. 76-77.

Campana, S. E., C. Jones, G. A. McFarlane, and S. Myklevoll. 2006. Bomb dating and age validation using the spines of spiny dogfish (*Squalus acanthias*). Environ Biol Fish. 77:327-336.

Conrath, C.L., C.A. Tribuzio, and K.J. Goldman. 2014. Notes on the reproductive biology of female salmon sharks in the eastern North Pacific Ocean. Transactions of the American Fisheries Society. 143:363-368.

Cortes, E. 1999. Standardized diet compositions and trophic levels of sharks. J Mar Sci. 56:707-717.

Cortes, E. 2007. Chondrichthyan demographic modelling: an essay on its use, abuse and future. *Marine and Freshwater Research* **58**, 4-6.

Courtney, D. L. and R. FoyPacific sleeper shark *Somniosus pacificus* trophic ecology in the eastern North Pacific Ocean inferred from nitrogen and carbon stable-isotope ratios and diet. Journal of Fish Biology. 80:1508-1545.

Ebert, D.A., L.J.V. Compagno, and L.J. Natanson. 1987. Biological notes on the Pacific sleeper shark, *Somniosus pacificus (*Chondrichthyes: Squalidae). Calif. Fish and Game 73(2); 117-123.

Ebert, D.A., T.W. White, K.J. Goldman, L.J.V. Compagno, T.S. Daly-Engel and R.D. WardResurrection and redescriptions of *Squalus suckleyi* (Girard, 1854) from the North Pacfici, with comments on the *Squalus acanthias* subgroup (Squaliformes: Squalidae). Zootaxa. 2612:22-40.

Gilmore, R.G. 1993. Reproductive biology of lamnoid sharks. Env. Fish. 38:95-114.

Girard, C.F. 1854. Characterstics of some cartilaginous fishes of the Pacific coast of North America. Proceedings of the Natural Sciences of Philadephia. 7:196-197.

Goldman, K.J., S.D. Anderson, R.J. Latour and J.A. MusickHomeothermy in adult salmon sharks, *Lamna ditropis*. Env. Biol. Fish. December 2004.

Goldman, K.J. and J.A. Musick. 2006. Growth and maturity of salmon sharks in the eastern and western North Pacific, with comments on back-calculation methods. Fish. Bull 104:278-292.

Gotshall, D. W., and T. Jow. 1965. Sleeper sharks (*Somniosus pacificus*) off Trinidad, California, with life history notes. California Fish and Game 51:294 –298.

Hart, JL. 1973. Pacific fishes of Canada. Fisheries Research Board of Canada (Bull. 180), Ottawa, Canada. 749 pp.

Hulbert, L., A. M. Aires-Da-Silva, V. F. Gallucci, and J. S. Rice. 2005. Seasonal foraging behavior and migratory patterns of female *lamna ditropis* tagged in Prince William Sound, Alaska. J. Fish Biol. 67:490-509.

Hulbert, L., M. Sigler, and C. R. Lunsford. 2006. Depth and movement behavior of the Pacific sleeper shark in the north-east Pacific Ocean. J. of Fish Biol. 69:406-425.

Hulson, P-J.F., C.A. Tribuzio, K. Coutre. In review. The use of satellite tags to inform the stock assessment of a data poor species: Spiny Dogfish in the Gulf of Alaska. Proceedings of the 2015 Lowell Wakefield Symposium.

Ketchen, K. S. 1972. Size at maturity, fecundity, and embryonic growth of the spiny dogfish (*Squalus acanthias*) in British Columbia waters. J Fish Res Bd Canada. 29:1717-1723.

McFarlane. G.A., and J.R. King.Migration patterns of spiny dogfish (*Squalus acanthias*) in the North Pacific Ocean. Fishery Bulletin. 101:358-367.

Nagasawa, K. 1998. Predation by salmon sharks (*Lamna ditropis*) on Pacific salmon (*Oncorhynchus spp.*) in the North Pacific Ocean. Bulletin of the North Pacific Anadromous Fish Commission, No. 1:419-433.

Orlov, A.M. 1999. Capture of especially large sleeper shark *Somniosus pacificus* (Squalidae) with some notes on its ecology in Northwestern Pacific. Jornal of Ichthyology. 39: 548-553.

Orlov, A.M., and S.I. Moiseev. Some biological features of Pacific sleeper shark, *Somniosus pacificus* (Bigelow et Schroeder 1944) (Squalidae) in the Northwestern Pacific Ocean. Oceanological Studies. 28: 3-16.

Sano, O.The investigation of salmon sharks as a predator on salmon in the North Pacific, 1960. Bulletin of the Hokkaido Regional Fisheries Research Laboratory, Fisheries Agency 24:148–162 (in Japanese).

Saunders, M.W. and G.A. McFarlane. 1993. Age and length at maturity of the female spiny dogfish (*Squalus acanthias*) in the Strait of Georgia, British Columbia, Canada. Environ Biol Fish 38:49-57.

Schauffler, L. R. Heintz, M. Sigler and L. Hulbert. 2005. Fatty acid composition of sleeper shark (*Somniosus pacificus*) liver and muscle reveals nutritional dependence on planktivores. ICES CM 2005/N:05.

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

Tanaka, S. 1980. Biological investigation of *Lamna ditropis* in the north-western waters of the North Pacific. *In* Report of investigation on sharks as a new marine resource (1979). Published by: Japan Marine Fishery Resource Research Center, Tokyo [English abstract, translation by Nakaya].

Taylor, I.G., G.R. Lippert, V.F. Gallucci and G.G. BargmannMovement patterns of spiny dogfish from historical tagging experiments in Washington State. In ' Biology and Management of Dogfish Sharks'. (Eds. V. F. Gallucci, G. A. McFarlane, and G. Bargmann) pp. 67 – 76. (American Fisheries Society: Bethesda, MD)

Tribuzio, C. A., Gallucci, V. F., and Bargmann, G. G. 2009. A survey of demographics and reproductive biology of spiny dogfish (*Squalus acanthias*) in Puget Sound, WA. In ' Biology and Management of Dogfish Sharks'. (Eds. V. F. Gallucci, G. A. McFarlane, and G. Bargmann) pp. 181-194. (American Fisheries Society: Bethesda, MD)

Tribuzio, C.A., K. Echave, C. Rodgveller, and PJ. Hulson. 2014. Assessment of the shark stock complex in the Bering Sea and Aleutian Islands. *In* Stock Assessment and Fishery Evaluation Report for the groundfish resources of the Eastern Bering Sea and Aleutian Islands. North Pacific Fishery Management Council, 605 W. 4th Ave., Suite 306, Anchorage, AK 99501. Pgs. 1825-1884.

Tribuzio, C.A., C. Rodgveller, K. Echave and PJ. Hulson. 2015. Assessment of the shark stock complex in the Gulf of Alaska. *In* Stock Assessment and Fishery Evaluation Report for the groundfish resources of the Gulf of Alaska. North Pacific Fishery Management Council, 605 W. 4th Ave., Suite 306, Anchorage, AK 99501. Pgs. 1569-1642.

Tribuzio, C.A., G.H. Kruse and J.T. Fujioka. 2010. Age and growth of spiny dogfish (*Squalus acanthias*) in the Gulf of Alaska: Analysis of alternative growth models. Fishery Bulletin. 102:119-135.

Tribuzio, C.A. and G. H. Kruse. 2012. Life history characteristics of a lightly exploited stock of *Squalus suckleyi*. Journal of Fish Biology. 80:1159-1180.

Weng, K.C., A. Landiera, P.C. Castilho, D.B. Holts, R.J. Schallert, J.M. Morrissette, K.J. Goldman, and B.A. Block. 2005. Warm sharks in polar seas: satellite tracking from the dorsal fins of salmon sharks. Science 310:104-106.

White W.T., P.R. Last, J.D. Stevens, G.K. Yearsley, Fahmi and Dharmadi. 2006 Economically important sharks and rays of Indonesia Australian Centre for International Agricultural Research, Canberra, Australia.

Wood, C. C., Ketchen, K. S., and Beamish, R. J. (1979). Population dynamics of spiny dogfish (*Squalus acanthias*) in British Columbia waters. *Journal of the Fisheries Research Board of Canada* 36, 647-656.

Yang, M., and B.N. Page.Diet of Pacific sleeper shark, *Somniosus pacificus*, in the Gulf of Alaska. Fish. Bull. 97: 406-4-9.

Yano, K., J.D. Stevens, and L.J.V. Compagno.Distribution, reproduction and feeding of the Greenland shark *Somniosus (Somniosus) microcephalus*, with notes on two other sleeper sharks, *Somniosus (Somniosus) pacificus* and *Somniosus (Somniosus) antarticus.* J. Fish. Biol. 70: 374-390.

## D.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


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

Doyle, M.J., W.C. Rugen, and R.D. Brodeur. 1995. Neustonic ichthyoplankton in the western Gulf of Alaska during spring. Fishery Bulletin 93: 231-253.

Eschmyer, W.N., and E.S. Herald. 1983. A field guide to Pacific coast fishes, North America. Houghton Mifflin Co., Boston. 336 p.

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

Hart, J.L. 1973. Pacific fishes of Canada. Fisheries Res. Bd. Canada Bull. 180. Ottawa. 740 p.

Kendall, A.W., Jr., and J.R. Dunn. 1985. Ichthyoplankton of the continental shelf near Kodiak Island, Alaska. U.S. Dep. Commerce, NOAA Tech. Rept NMFS 20, 89 p.

Kendall, A.W., Jr., J.R. Dunn, and R.J. Wolotira, Jr. 1980. Zooplankton, including ichthyoplankton and decapod larvae, of the Kodiak shelf. NWAFC Processed Rept. 80-8, AFSC-NMFS, 7600 Sand Point Way, NE, Seattle, WA 98115. 393 p.

Ormseth, O.A. and T. TenBrink. 2010. Bering Sea and Aleutian Islands Sculpins. *In* Stock Assessments and Fishery Evaluation Report of the Bering Sea/Aleutian Islands Regions. North Pacific Fishery Management Council, Anchorage, AK.

Rugen, W.C. 1990. Spatial and temporal distribution of larval fish in the western Gulf of Alaska, with emphasis on the period of peak abundance of walleye pollock (*Theragra chalcogramma*) larvae. NWAFC Processed Rept 90-01, AFSC-NMFS, 7600 Sand Point Way, NE, Seattle, WA 98115. 162 p.

Waldron, K.D. 1978. Ichthyoplankton of the eastern Bering Sea, 11 February-16 March 1978. REFM Report, AFSC, NMFS, 7600 Sand Point Way, NE, Seattle, WA 98115. 33 p.

Waldron, K.D., and B.M. Vinter. 1978. Ichthyoplankton of the eastern Bering Sea. Final Report (RU 380), Environmental Assessment of the Alaskan continental shelf, REFM, AFSC, NMFS, 7600 Sand Point Way, NE, Seattle, WA 98115. 88 p.

## 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

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

<u>*Juveniles and Adults*</u>: 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 | Oceano-graphic 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 | |

### D.23.4 Literature


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

Eschmyer, W.N., and E.S. Herald. 1983. A field guide to Pacific coast fishes, North America. Houghton Mifflin Co., Boston. 336 p.

Hart, J.L. 1973. Pacific fishes of Canada. Fisheries Res. Bd. Canada Bull. 180. Ottawa. 740 p.

Hoff, G.R. 2006. Investigations of a skate nursery area in the eastern Bering Sea. Final report to the NPRB, project 415. March 7, 2006.

Hoff, G.R. 2007. Reproduction of the Alaska skate (*Bathyraja parmifera*) with regard to nursery sites, embryo development and predation. Ph.D. dissertation, University of Washington, Seattle.

Hoff, G. R. 2008. A nursery site of the Alaska skate (*Bathyraja parmifera*) in the eastern Bering Sea. Fish. Bull., U.S. 106:233-244.

Ormseth, O.A. 2014. Assessment of the skate stock complex in the Bering Sea and Aleutian Islands. *In* Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Bering Sea/Aleutian Islands Regions. North Pacific Fishery Management Council, 605 West 4th Avenue, Suite 306, Anchorage, AK 99501.

Stevenson, D. E., J. W. Orr, G. R. Hoff, and J. D. McEachran. 2008. Emerging patterns of species richness, diversity, population density, and distribution in the skates (Rajidae) of Alaska. Fish. Bull., U.S. 106:24-39.

Teshima, K., and T.K. Wilderbuer. 1990. Distribution and abundance of skates in the eastern Bering Sea, Aleutian Islands region, and the Gulf of Alaska. Pp. 257-267 *in* H.L. Pratt, Jr., S.H. Gruber, and T. Taniuchi (eds.), Elasmobranchs as living resources: advances in the biology, ecology, systematics and the status of the fisheries. U.S. Dep. Commerce, NOAA Technical Report 90.


## D.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) | BCH (to 10 m) | D, SD | S, CB, G | | |
| | | | non-spawning (Sep–Apr) | ICS, MCS, OCS | P | NA? | F ice edge in winter | -2 – 3°C peak distributions in EBS? |

## D.24.4 Literature

Allen, M.J. 1987. Demersal fish predators of pelagic forage fishes in the southeastern Bering Sea. Pp. 29-32 In Forage fishes of the southeastern Bering Sea. Proceedings of a Conference, November 1986, Anchorage, AK. U.S. Dept Interior, Minerals Management Service, OCS Study MMS 87-0017.

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

Crawford, T.W. 1981. Vertebrate prey of *Phocoenoides dalli* (Dall's porpoise), associated with the Japanese high seas salmon fishery in the North Pacific Ocean. M.S. Thesis, Univ. Washington, Seattle, 72 p.

Doyle, M.J., W.C. Rugen, and R.D. Brodeur. 1995. Neustonic ichthyoplankton in the western Gulf of Alaska during spring. Fishery Bulletin 93: 231-253.

Eschmyer, W.N., and E.S. Herald. 1983. A field guide to Pacific coast fishes, North America. Houghton Mifflin Co., Boston. 336 p.

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

Fritz, L.W., V.G. Wespestad, and J.S. Collie. 1993. Distribution and abundance trends of forage fishes in the Bering Sea and Gulf of Alaska. Pp. 30-44 In Is It Food: Addressing marine mammal and seabird declines. Workshop Summary. Alaska Sea Grant College Program Rept. No. AK-SG-93-01, Univ. Alaska, Fairbanks, AK 99775-5040.

Frost, K.J. and L. Lowry. 1987. Marine mammals and forage fishes in the southeastern Bering Sea. Pp. 11-18 In Forage fishes of the southeastern Bering Sea. Proceedings of a Conference, November 1986, Anchorage, AK. U.S. Dept Interior, Minerals Management Service, OCS Study MMS 87-0017.

Hart, J.L. 1973. Pacific fishes of Canada. Fisheries Res. Bd. Canada Bull. 180. Ottawa. 740 p.

Hunt, G.L., Jr., B. Burgeson, and G.A. Sanger. 1981a. Feeding ecology of seabirds of the eastern Bering Sea. Pp 629-647 In D.W. Hood and J.A. Calder (eds.), The Eastern Bering Sea Shelf: Oceanography and Resources, Vol.

II. U.S. Dept. Commerce, NOAA, OCSEAP, Office of Marine Pollution Assessment, Univ. WA Press, Seattle, WA.

Hunt, G.L., Jr., Z. Eppley, B. Burgeson, and R. Squibb. 1981b. Reproductive ecology, foods and foraging areas of seabirds nesting on the Pribilof Islands, 1975-79. Environmental Assessment of the Alaskan Continental Shelf, Final Reports of Principal Investigators, RU-83, U.S. Dept. Commerce, NOAA, OCSEAP, Boulder, CO.

Kawakami, T. 1980. A review of sperm whale food. Sci. Rep. Whales Res. Inst. Tokyo 32: 199-218.

Kendall, A.W., Jr., and J.R. Dunn. 1985. Ichthyoplankton of the continental shelf near Kodiak Island, Alaska. U.S. Dep. Commerce, NOAA Tech. Rept NMFS 20, 89 p.

Kendall, A.W., Jr., J.R. Dunn, and R.J. Wolotira, Jr. 1980. Zooplankton, including ichthyoplankton and decapod larvae, of the Kodiak shelf. NWAFC Processed Rept. 80-8, AFSC-NMFS, 7600 Sand Point Way, NE, Seattle, WA 98115. 393 p.

Morris, B.F., M.S. Alton, and H.W. Braham. 1983. Living marine resources of the Gulf of Alaska: a resource assessment for the Gulf of Alaska/Cook Inlet Proposed Oil and Gas Lease Sale 88. U.S. Dept. Commerce, NOAA, NMFS.

Murphy, E.C., R.H. Day, K.L. Oakley, A.A. Hoover. 1984. Dietary changes and poor reproductive performances in glaucous-winged gulls. Auk 101: 532-541.

Naumenko, E.A. 1996. Distribution, biological condition, and abundance of capelin (*Mallotus villosus socialsis*) in the Bering Sea. Pp. 237-256 In O.A. Mathisen and K.O. Coyle (eds.), Ecology of the Bering Sea: a review of Russian literature. Alaska Sea Grant Report No. 96-01, Alaska Sea Grant College Program, U. Alaska, Fairbanks, AK 99775-5040. 306 p.

Ormseth, O.A., Conners, L., Guttormsen M., and J. Vollenweider. 2008. Forage fishes in the Gulf of Alaska. In: Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Gulf of Alaska Region. North Pacific Fishery Management Council, 605 W. 4th Ave., Suite 306, Anchorage, AK 99501.

Ormseth, O.A. 2015. Status of forage species in the Bering Sea and Aleutian Islands region. In: Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Bering Sea and Aleutians Islands.

Pahlke, K.A. 1985. Preliminary studies of capelin *Mallotus villosus* in Alaska waters. Alaska Dept. Fish Game, Info. Leaf. 250, 64 p.

Perez, M.A. and M.A. Bigg. 1986. Diet of northern fur seals, *Callorhinus ursinus*, off western North America. Fish. Bull., U.S. 84: 957-971.

Pitcher, K.W. 1980. Food of the harbor seal, *Phoca vitulina richardsi*, in the Gulf of Alaska. Fish. Bull., U.S. 78: 544-549.

Rugen, W.C. 1990. Spatial and temporal distribution of larval fish in the western Gulf of Alaska, with emphasis on the period of peak abundance of walleye pollock (*Theragra chalcogramma*) larvae. NWAFC Processed Rept 90-01, AFSC-NMFS, 7600 Sand Point Way, NE, Seattle, WA 98115. 162 p.

Sigler, M. *et al*. 2006. Survey strategies for assessment of Bering Sea forage species. NPRB final report, project 401.

Waldron, K.D. 1978. Ichthyoplankton of the eastern Bering Sea, 11 February-16 March 1978. REFM Report, AFSC, NMFS, 7600 Sand Point Way, NE, Seattle, WA 98115. 33 p.

Waldron, K.D., and B.M. Vinter. 1978. Ichthyoplankton of the eastern Bering Sea. Final Report (RU 380), Environmental Assessment of the Alaskan continental shelf, REFM, AFSC, NMFS, 7600 Sand Point Way, NE, Seattle, WA 98115. 88 p.

Wespestad, V.G. 1987. Population dynamics of Pacific herring (*Clupea palasii*), capelin (*Mallotus villosus*), and other coastal pelagic fishes in the eastern Bering Sea. Pp. 55-60 In Forage fishes of the southeastern Bering Sea. Proceedings of a Conference, November 1986, Anchorage, AK. U.S. Dept Interior, Minerals Management Service, OCS Study MMS 87-0017.

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

Yang, M.-S., K. Aydin, A. Greig,Lang, P. LivingstonHistorical review of capelin (*Mallotus villosus*) consumption in the Gulf of Alaska and eastern Bering SeaCommer.,155, 89 p.

# 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<br>phytoplankton<br>mysids, larvae | summer /fall | ICS ? | P? | U, NA? | U | |
| Juveniles | 2.5+ yrs<br>up to age 3 | copepods<br>euphausiids | all year | MCS, OCS, USP | P | U, NA? | U<br>F? | |
| Adults | 3 yrs<br>ages 3–5+ | | spawning (May–June) | rivers, FW | D | S (CB?) | | |
| | | copepods<br>euphausiids | non-spawning (July–Apr) | MCS, OCS, USP | P | NA? | F? | |

## D.25.4 Literature

Allen, M.J. 1987. Demersal fish predators of pelagic forage fishes in the southeastern Bering Sea. Pp. 29-32 In Forage fishes of the southeastern Bering Sea. Proceedings of a Conference, November 1986, Anchorage, AK. U.S. Dept Interior, Minerals Management Service, OCS Study MMS 87-0017.

Crawford, T.W. 1981. Vertebrate prey of *Phocoenoides dalli* (Dall's porpoise), associated with the Japanese hign seas salmon fishery in the North Pacific Ocean. M.S. Thesis, Univ. Washington, Seattle, 72 p.

Fritz, L.W., V.G. Wespestad, and J.S. Collie. 1993. Distribution and abundance trends of forage fishes in the Bering Sea and Gulf of Alaska. Pp. 30-44 In Is It Food: Addressing marine mammal and seabird declines. Workshop Summary. Alaska Sea Grant College Program Rept. No. AK-SG-93-01, Univ. Alaska, Fairbanks, AK 99775-5040.

Frost, K.J. and L. Lowry. 1987. Marine mammals and forage fishes in the southeastern Bering Sea. Pp. 11-18 In Forage fishes of the southeastern Bering Sea. Proceedings of a Conference, November 1986, Anchorage, AK. U.S. Dept Interior, Minerals Management Service, OCS Study MMS 87-0017.

Hart, J.L. 1973. Pacific fishes of Canada. Fisheries Res. Bd. Canada Bull. 180. Ottawa. 740 p.

Hunt, G.L., Jr., B. Burgeson, and G.A. Sanger. 1981a. Feeding ecology of seabirds of the eastern Bering Sea. Pp 629-647 In D.W. Hood and J.A. Calder (eds.), The Eastern Bering Sea Shelf: Oceanography and Resources, Vol. II. U.S. Dept. Commerce, NOAA, OCSEAP, Office of Marine Pollution Assessment, Univ. WA Press, Seattle, WA.

Hunt, G.L., Jr., Z. Eppley, B. Burgeson, and R. Squibb. 1981b. Reproductive ecology, foods and foraging areas of seabirds nesting on the Pribilof Islands, 1975-79. Environmental Assessment of the Alaskan Continental Shelf, Final Reports of Principal Investigators, RU-83, U.S. Dept. Commerce, NOAA, OCSEAP, Boulder, CO.

Kawakami, T. 1980. A review of sperm whale food. Sci. Rep. Whales Res. Inst. Tokyo 32: 199-218.

Morris, B.F., M.S. Alton, and H.W. Braham. 1983. Living marine resources of the Gulf of Alaska: a resource assessment for the Gulf of Alaska/Cook Inlet Proposed Oil and Gas Lease Sale 88. U.S. Dept. Commerce, NOAA, NMFS.

Ormseth, O.A., Conners, L., Guttormsen M., andVollenweider. 2008. Forage fishes in the Gulf of Alaska. In: Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Gulf of Alaska Region

Ormseth, O.A. 2015. Status of forage species in the Bering Sea and Aleutian Islands region. In: Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Bering Sea and Aleutians Islands. North Pacific Fishery Management Council, 605 W. 4th Ave., Suite 306, Anchorage, AK 99501.

Perez, M.A. and M.A. Bigg. 1986. Diet of northern fur seals, *Callorhinus ursinus*, off western North America. Fish. Bull., U.S. 84: 957-971.

Pitcher, K.W. 1980. Food of the harbor seal, *Phoca vitulina richardsi*, in the Gulf of Alaska. Fish. Bull., U.S. 78: 544-549.

Sanger, G.A. 1983. Diets and food web relationships of seabirds in the Gulf of Alaska and adjacent marine regions. Outer Continental Shelf Environmental Assessment Program, Final Reports of Principal Investigators 45: 631-771.

Wespestad, V.G. 1987. Population dynamics of Pacific herring (*Clupea palasii*), capelin (*Mallotus villosus*), and other coastal pelagic fishes in the eastern Bering Sea. Pp. 55-60 In Forage fishes of the southeastern Bering Sea. Proceedings of a Conference, November 1986, Anchorage, AK. U.S. Dept Interior, Minerals Management Service, OCS Study MMS 87-0017.

Yang, M.S. 1993. Food habits of the commercially important groundfishes in the Gulf of Alaska in 1990. U.S. Dept. Commerce, NOAA Tech. Memo. NMFS-AFSC-22. 150 pp.December 11, 2006

## 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


Bakkala, R. G., W. A. Karp, G. F. Walters, T. Sasaki, M. T. Wilson, T. M. Sample, A. M. Shimada, D. Adams, and C. E. Armistead. 1992. Distribution, abundance, and biological characteristics of groundfish in the eastern Bering Sea based on results of U.S.-Japan bottom trawl and midwater surveys during June-September 1988. NOAA Tech. Memo. NMFS F/NWC-213, 362 p.

Britt, L. L., and M. H. Martin. 2001. Data report: 1999 Gulf of Alaska bottom trawl survey. Memo. NMFS-AFSC-121, 249 p.

Burton, E. J. 1999. Radiometric age determination of the giant grenadier (*Albatrossia pectoralis*) using $^{210}$Pb:$^{226}$Ra disequilibria. Master’s thesis, San Francisco State University, 91 p.

Busby, M. S. 2005. An unusual macrourid larva (Gadiformes) from San Juan Island, Washington, USA. 52: 86-89.

Clausen, D. M., andJ 2012. Assessment of grenadiers in the Gulf of Alaska, eastern Bering Sea, and Aleutian Islands. In Stock assessment and fishery evaluation report for the groundfish resources of the Gulf of Alaska and Bering Sea/Aleutian Islands regions, Appendix 1. North Pacific Fishery Management Council, 605 W 4th Ave., Suite 306, Anchorage AK 99501.

Drazen, J. C., T. W. Buckley, and G. R. Hoff. 2001. The feeding habits of slope dwelling macrourid fishes in the eastern North Pacific. I 48:909-935.

Drazen, J. C. 2008. Energetics of grenadier fishes. *In* A. M. Orlov and T. Iwamoto (Editors), Grenadiers of the world oceans: biology, stock assessment, and fisheries, p. 203-223. Amer. Fish. Soc Sympos. 63. (Published by Amer. Fish. Soc., Bethesda, MD).

Eschmeyer, W. N., E.Herald, and H. Hammann. 1983. A field guide to Pacific coast fishes of North America. Houghton Mifflin Co., Boston, 336 p.

Goddard, P., andZimmermann. 1993. Distribution, abundance, and biological characteristics of groundfish in the eastern Bering Sea based on results of U.S. bottom trawl surveys during June-September 1991. AFSC Processed 93-15, 338 p. (Available from National Marine Fisheries Service, Alaska Fisheries Science Center, 7600 Sand Point Way NE, Seattle WA 98115).

Hoff, G. R., and LBritt. 2011. Results of the 2010 eastern Bering Sea upper continental slope survey of groundfish and invertebrate resources, 300 p.

Iwamoto, T., and D. L. Stein. 1974. A systematic review of the rattail fishes (Macrouridae: Gadiformes) from Oregon and adjacent waters. Occasional Papers of the California Academy of Sciences No. 111, 79 p.

Lunsford, C. and C. J. Rodgveller. 2014. F/V *Ocean Prowler* cruise report OP-13-01, longline survey of the Gulf of Alaska and eastern Bering Sea, May 26-August 28, 2013. Alaska Fisheries Science Center, Auke Bay Laboratories, 17109 Point Lena Loop Rd., Juneau, AK 99801.

Lunsford, C., C. J. Rodgveller, and P. Malecha. 2014. F/V *Alaskan Leader* cruise report AL-14-01, longline survey of the Gulf of Alaska and eastern Aleutain Islands, May 25-August 28, 2014. Alaska Fisheries Science Center, Auke Bay Laboratories, 17109 Point Lena Loop Rd., Juneau, AK 99801.

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

Orlov, A. M., and S. 1999. Some biological features of Pacific sleeper shark, *Somniosus pacificus* (Bigelow *et* Schroeder 1944) (Squalidae), in the northwestern Pacific Ocean. Polish Academy of Sciences, National Scientific Committee on Oceanic Research, Institute of Oceanography, University of Gdansk. Oceanological Studies FVIII No. 1-2: 3-16.

Rodgveller, C. J., D. M. Clausen, J. J. Nagler, and C. Hutchinson. Reproductive characteristics and mortality of female giant grenadiers in the northern Pacific Ocean.Coast. Fish.: Dynamics, Management, and Ecosystem Sci. 2:73-82.

Ronholt, L. L., K. Teshima, and D. W. Kessler. The groundfish resources of the Aleutian Islands region and southern Bering Sea 1980, 1983, and 1986. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-31, 351 p.

Sasaki, T., and K. Teshima. 1988. Data report on abundance indices of flatfishes, rockfishes, shortspine thornyhead, and grenadiers based on the results from Japan-U.S. joint longline surveys, 1979-87. (Document submitted to the Annual Meeting of the International North Pacific Fisheries Commission, Tokyo, Japan, 1988 October.) 31 p. Fisheries Agency of Japan, Far Seas Fisheries Research Laboratory, 5-7-1 Orido, Shimizu, Japan 424.

Tuponogov, V. N. 1997. Seasonal migrations of the grenadier *Coryphaenoides pectoralis* in the Sea of

Okhotsk and contiguous waters. J. Mar. Bio. 23(6):314-321.

Walker, W. A., J. G. Mead, andL. Brownell, Jr. 2002. Diets of Baird's beaked whales, *Berardius bairdii*, in the southern Sea of Okhotsk and off the Pacific coast of Honshu, Japan. Marine Mammal Science 18(4): 902-919.

Yang, M-S. 2003. Food habits of the important groundfishes in the Aleutian Islands in 1994 and 1997. AFSC Processed Rep. 2003-07, 233 p. (Available from National Marine Fisheries Service, Alaska Fisheries Science Center, 7600 Sand Point Way NE, Seattle WA 98115).

Yang, M-S., K. Dodd, R. Hibpshman, and A. Whitehouse. 2006. Food habits of groundfishes in the Gulf of Alaska in 1999 and 2001. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-AFSC-1

# 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):

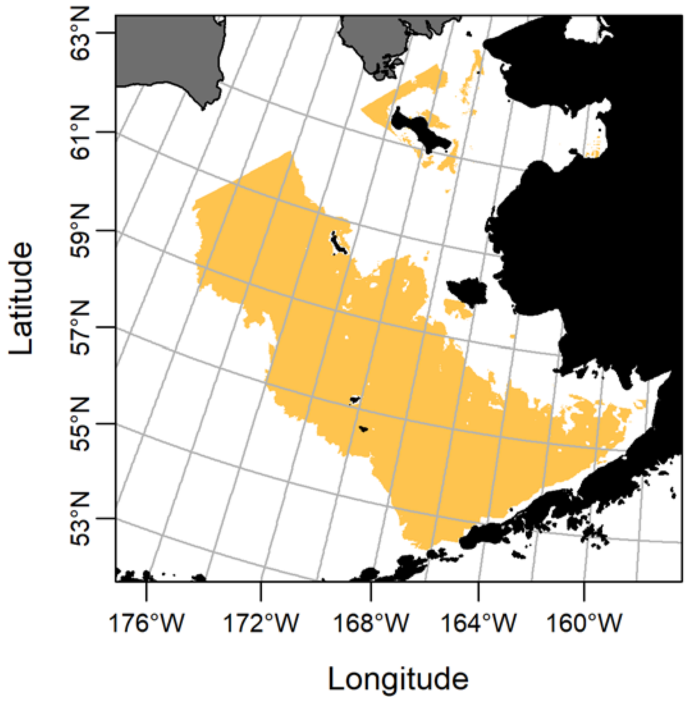


**Figure E-1 EFH distribution of EBS Walleye Pollock adult, fall.**

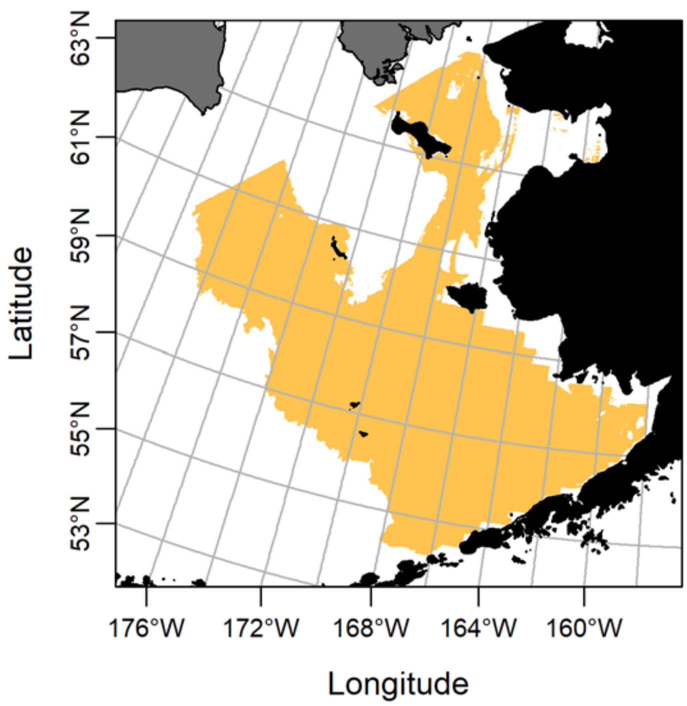


**Figure E-2 EFH distribution of EBS Walleye pollock adult, spring.**

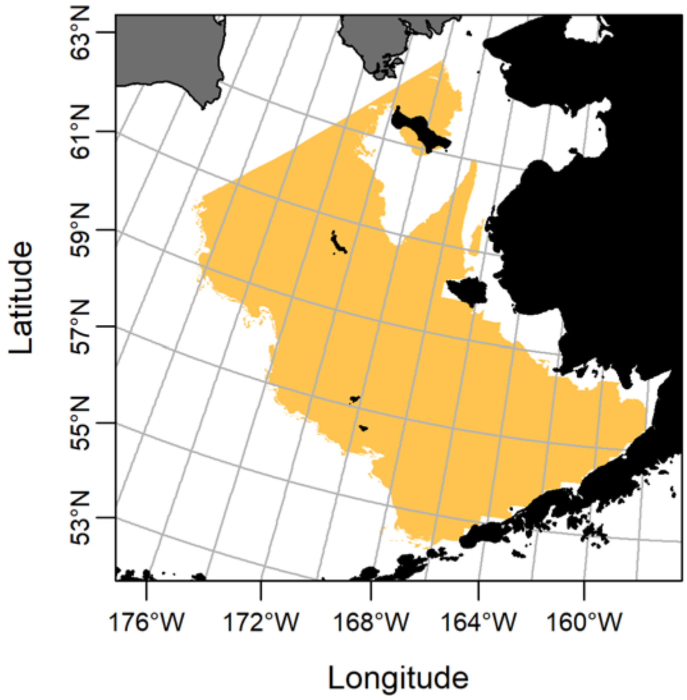

**Figure E-3 EFH distribution of EBS Walleye pollock adult, summer**

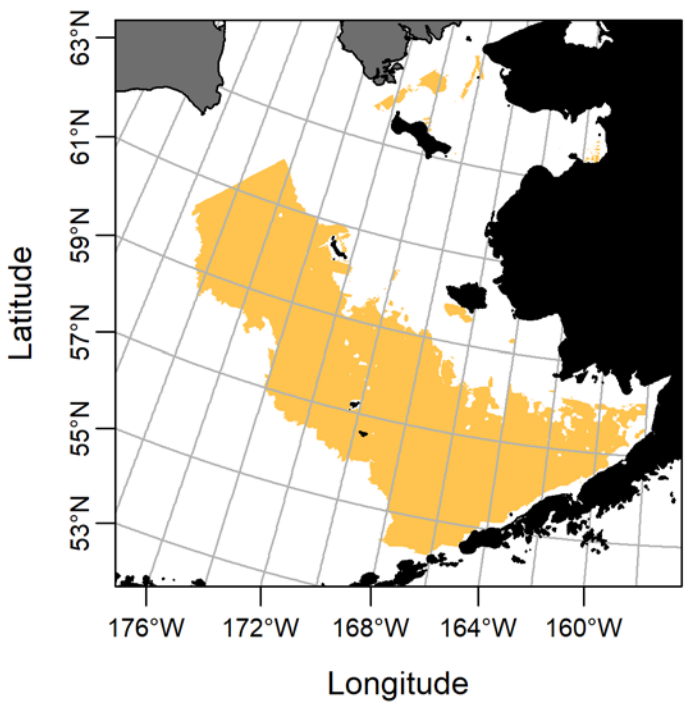

**Figure E-4 EFH distribution of EBS Walleye pollock adult, winter.**

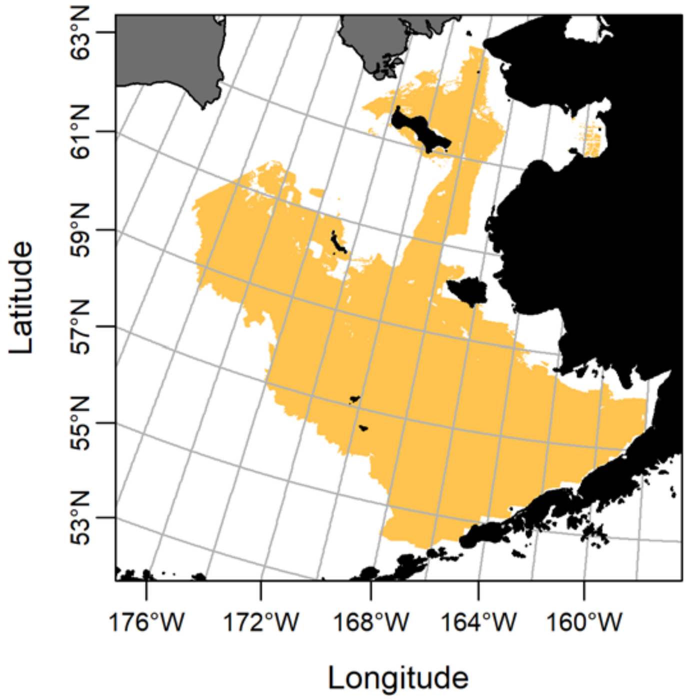

**Figure E-5 EFH distribution of EBS Walleye pollock eggs, summer.**

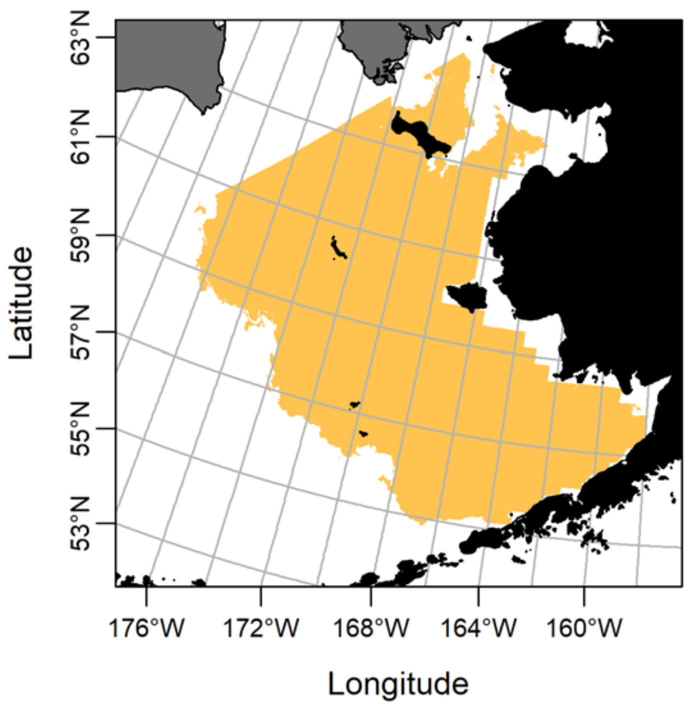

**Figure E-6 EFH distribution of EBS Walleye pollock juvenile, summer.**

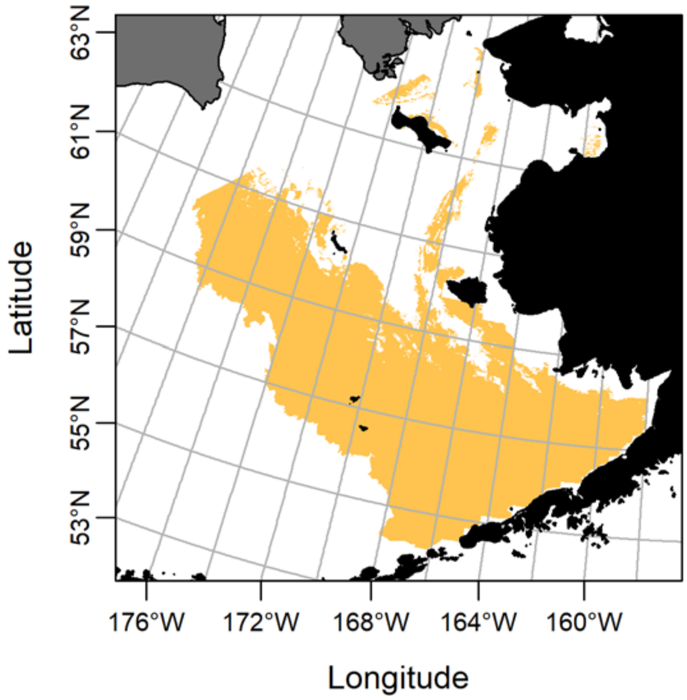

Figure E-7 EFH distribution of EBS Walleye pollock larvae, summer.

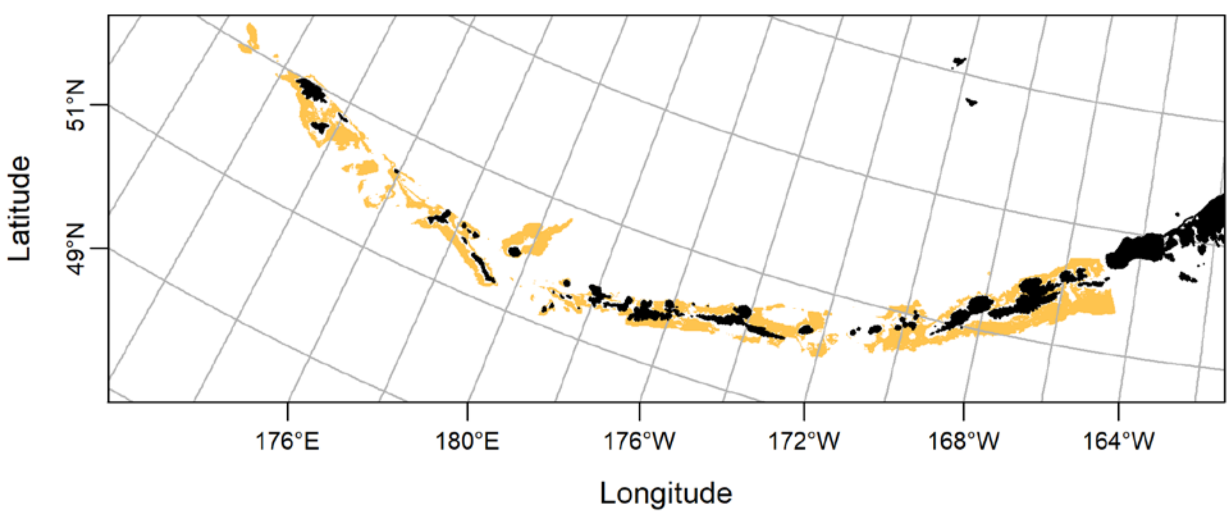

Figure E-8 EFH distribution of AI Walleye pollock adult, fall.

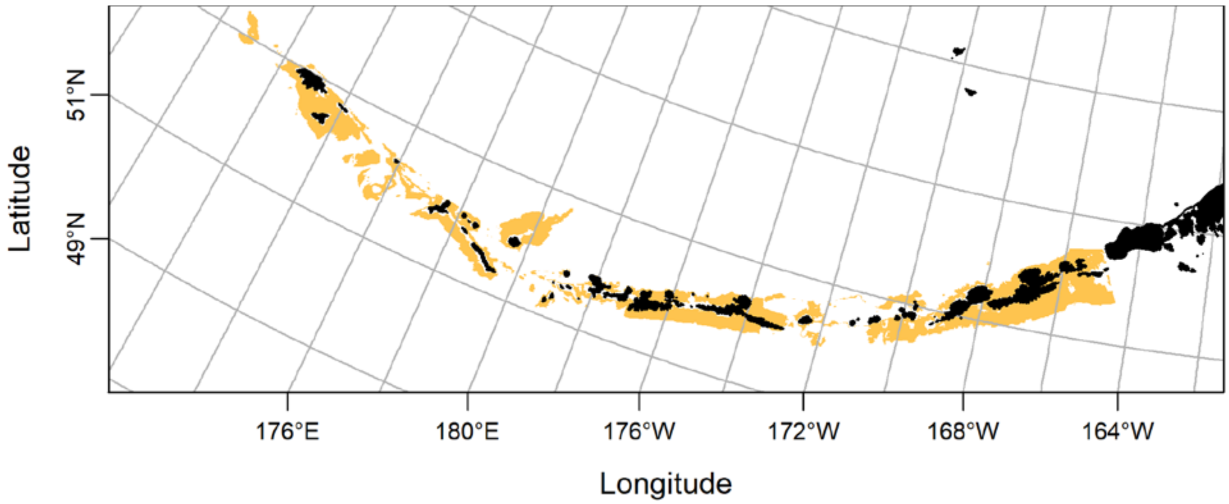


**Figure E-9 EFH distribution of AI Walleye pollock adult, spring.**

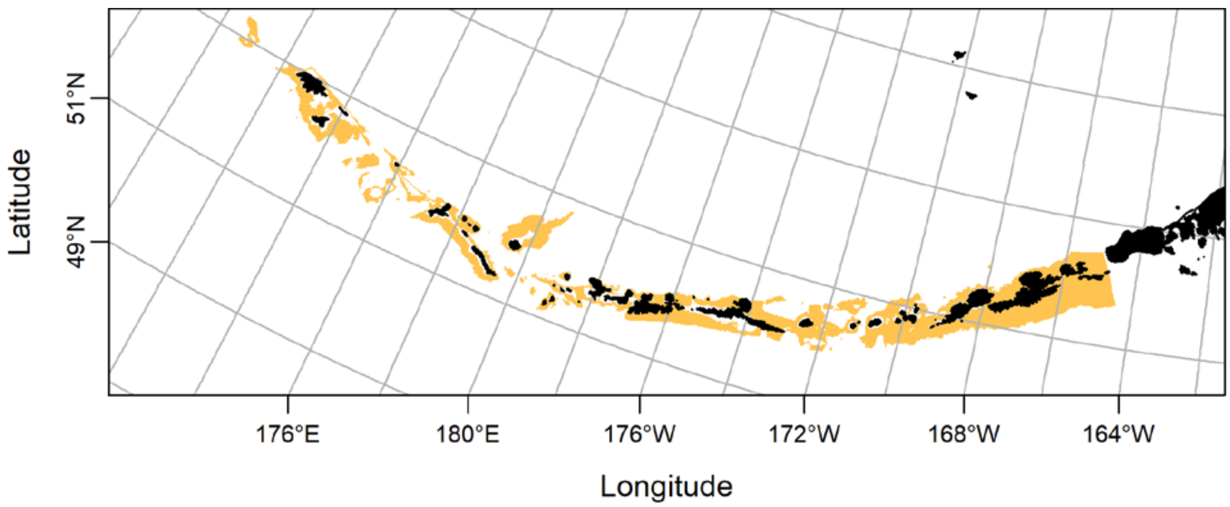


**Figure E-10 EFH distribution of AI Walleye pollock adult, summer.**

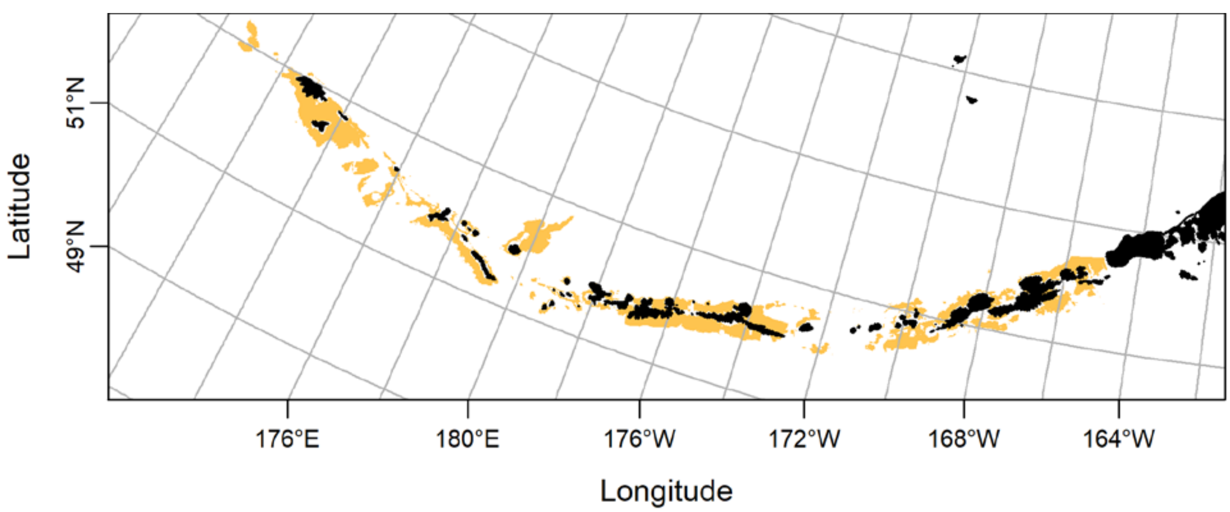


**Figure E-11 EFH distribution of AI Walleye pollock adult, winter.**

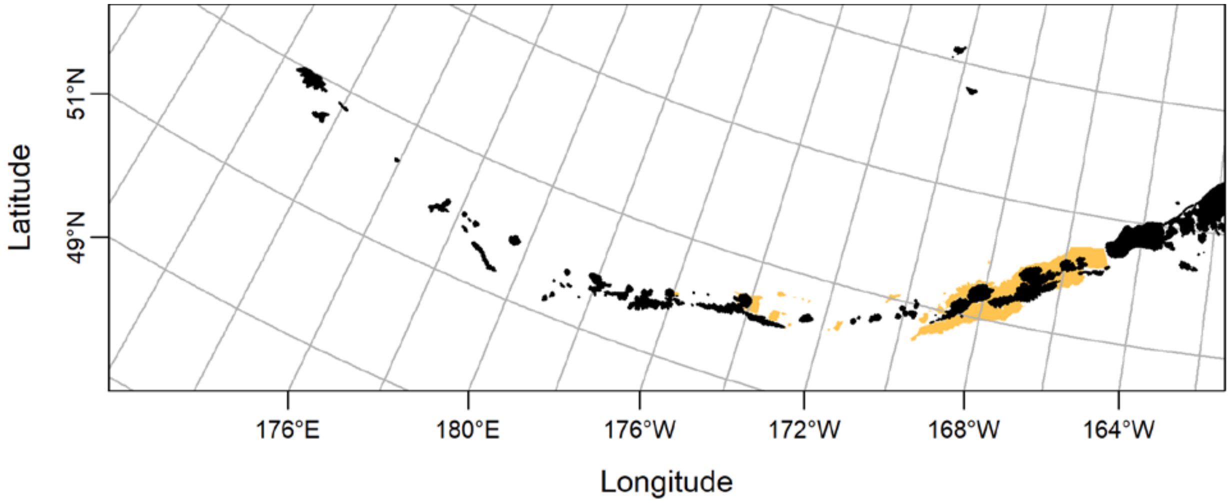


**Figure E-12 EFH distribution of AI Walleye pollock egg, summer.**

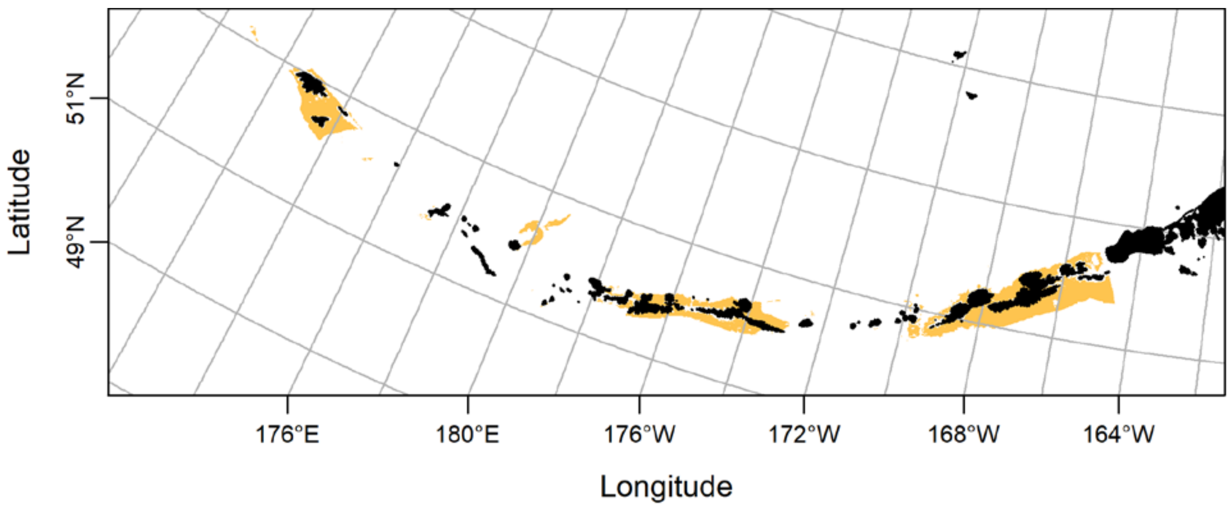


**Figure E-13 EFH distribution of AI Walleye pollock juvenile, summer.**

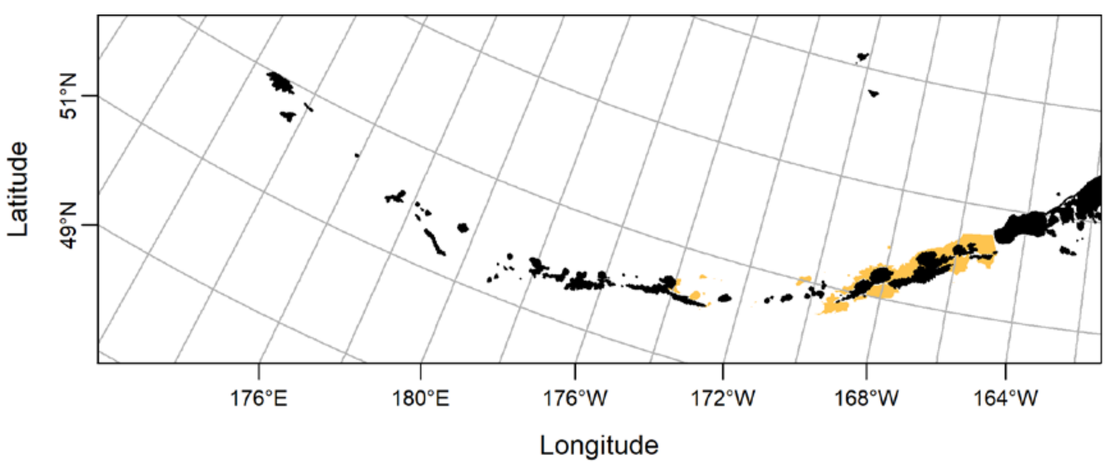


**Figure E-14 EFH distribution of AI Walleye pollock larvae, summer.**

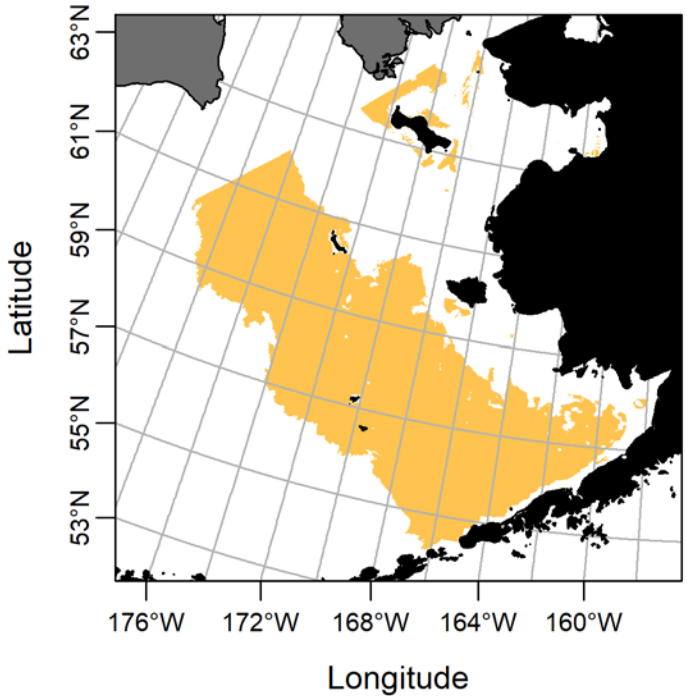


**Figure E-15 EFH distribution of EBS Pacific cod adult, fall.**

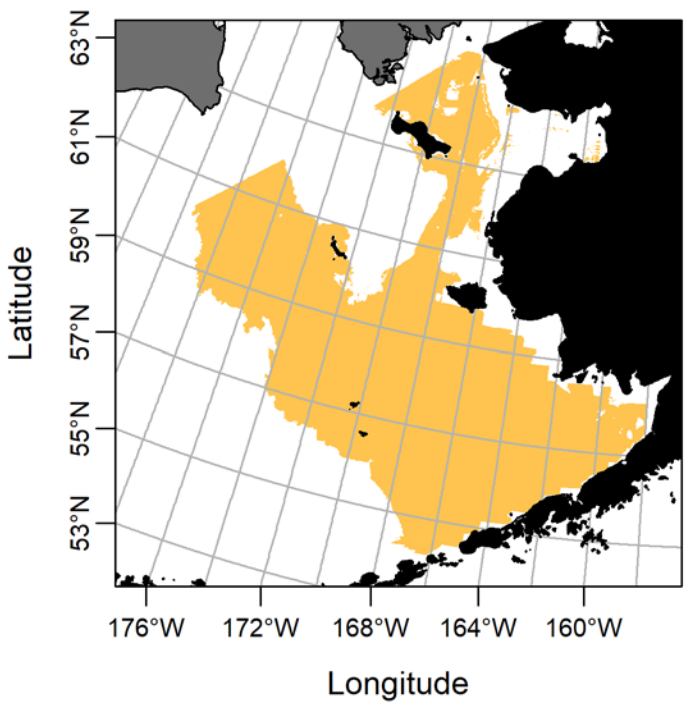


**Figure E-16 EFH distribution of EBS Pacific cod adult, spring.**

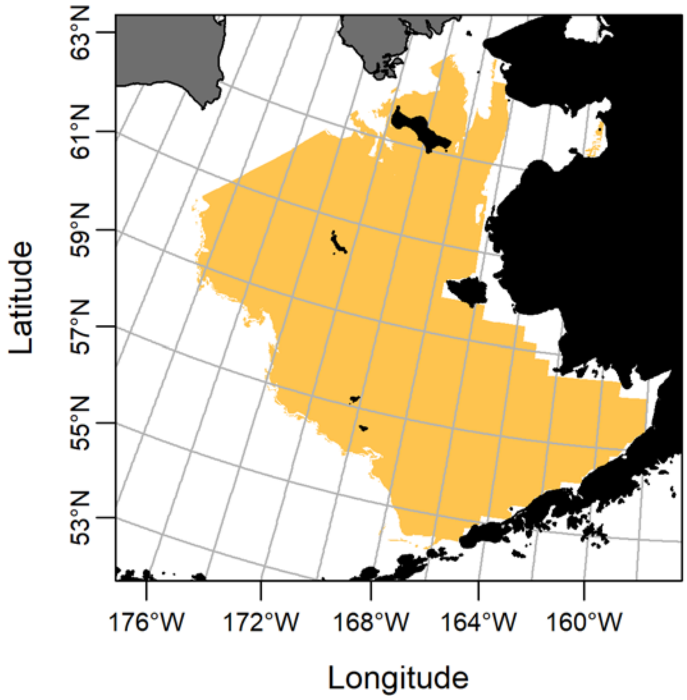


**Figure E-17 EFH distribution of EBS Pacific cod adult, summer.**

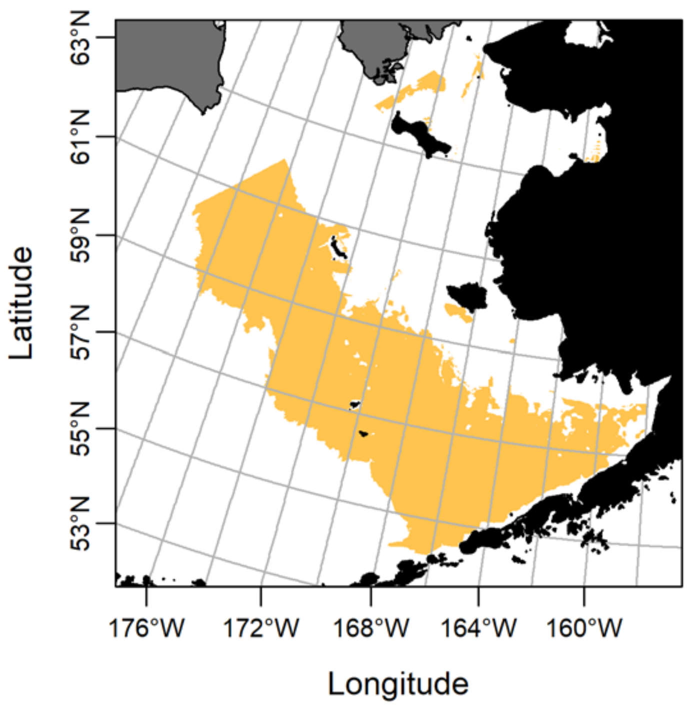


**Figure E-18 EFH distribution of EBS Pacific cod adult, winter.**

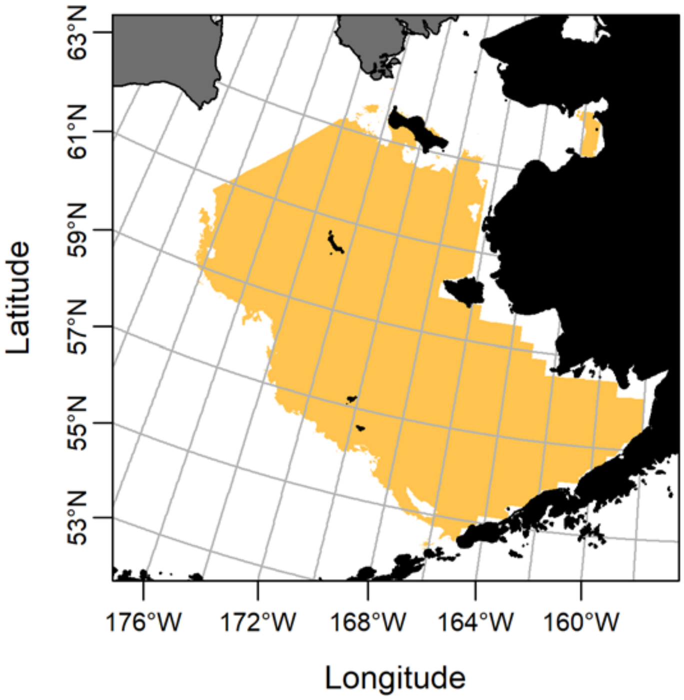


**Figure E-19 EFH distribution of EBS Pacific cod juvenile, summer.**

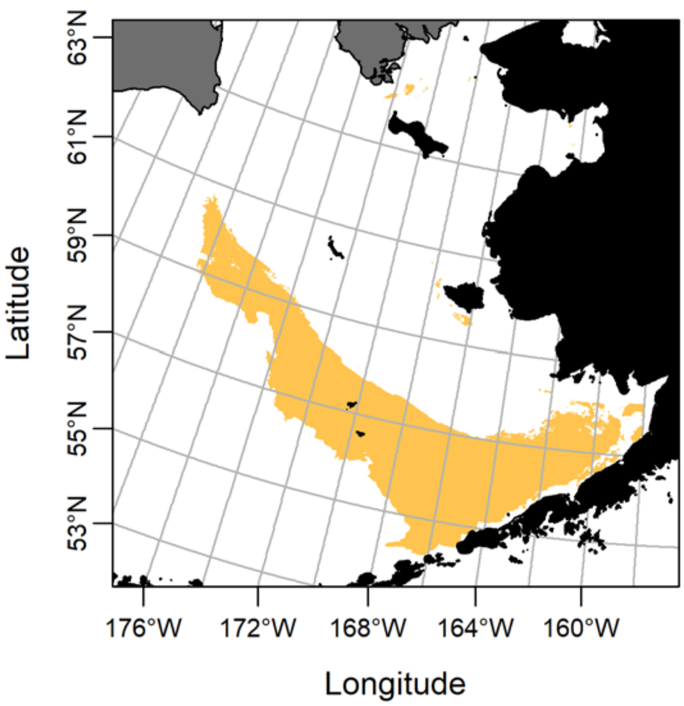


**Figure E-20 EFH distribution of EBS Pacific cod larvae, summer.**

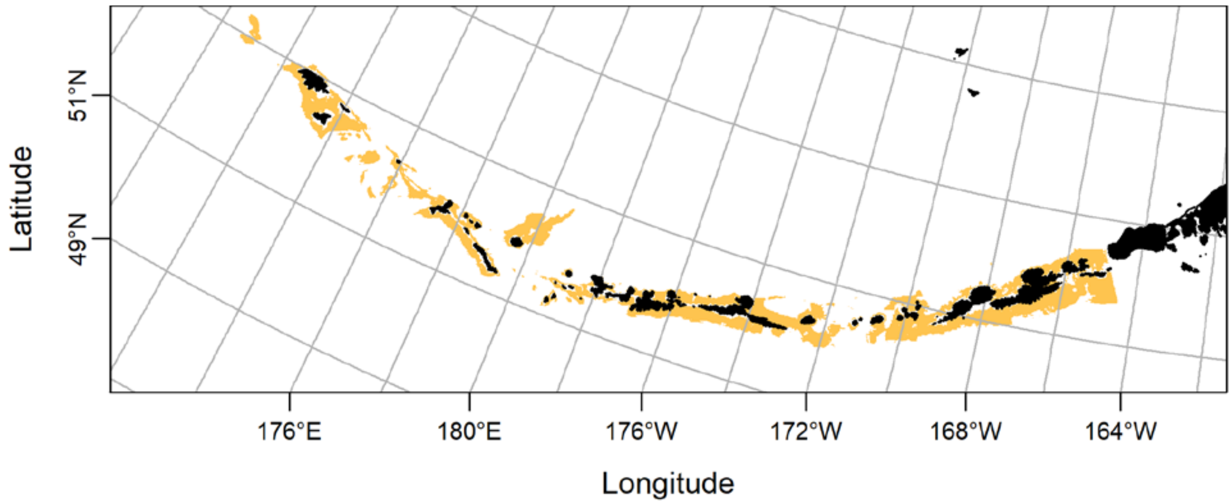


**Figure E-21 EFH distribution of AI Pacific cod adult, fall.**

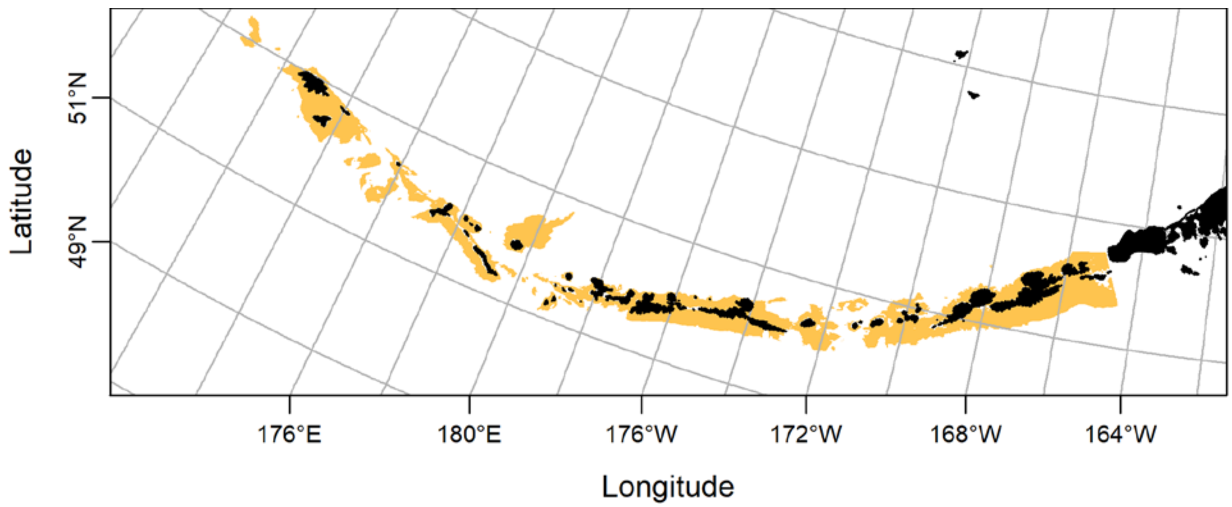


**Figure E-22 EFH distribution of AI Pacific cod adult, spring.**

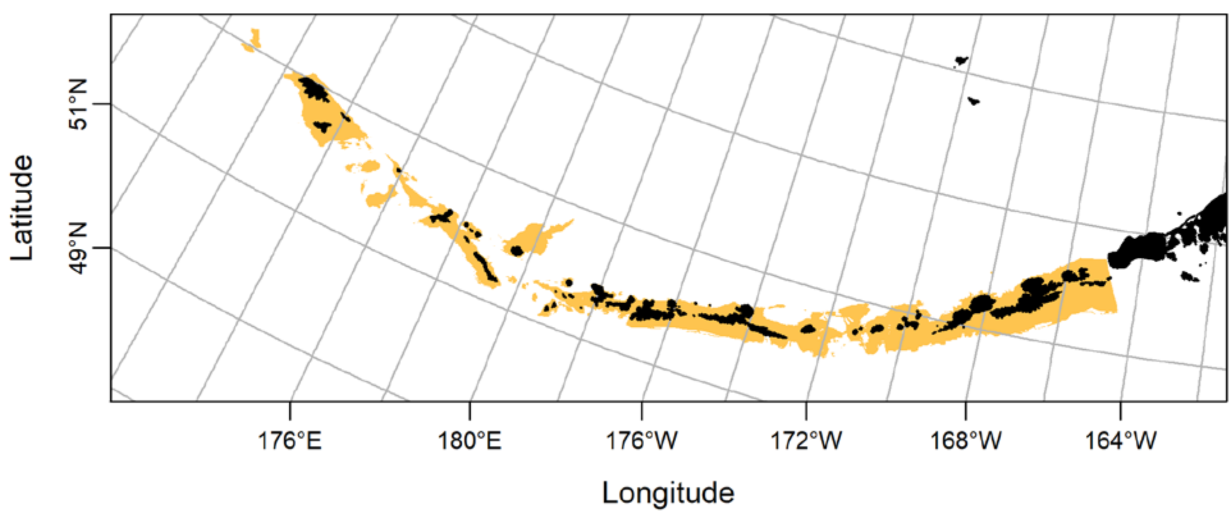


**Figure E-23 EFH distribution of AI Pacific cod adult, summer.**

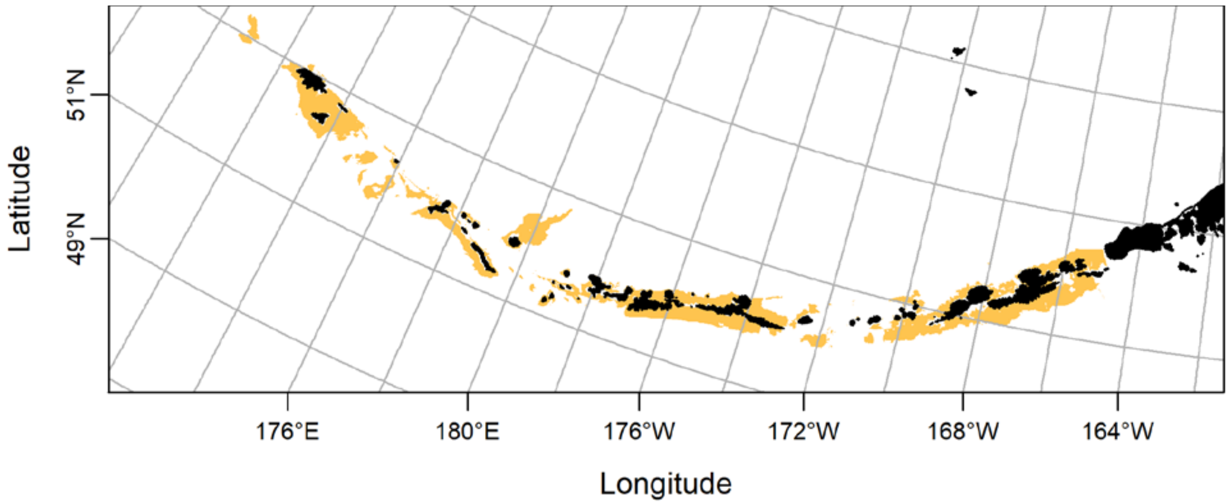


**Figure E-24 EFH distribution of AI Pacific cod adult, winter.**

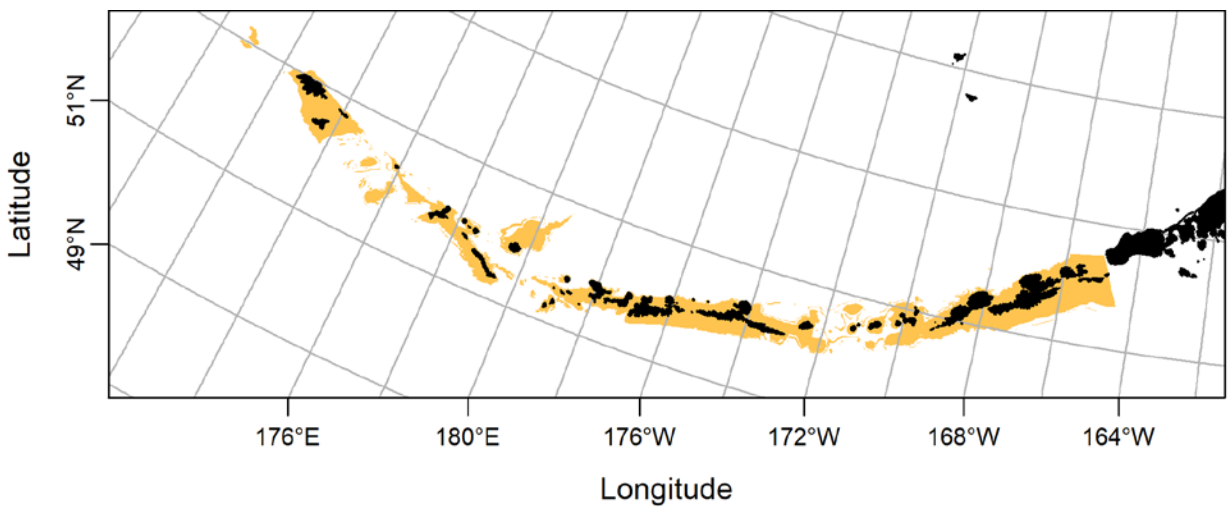


**Figure E-25 EFH distribution of AI Pacific cod juvenile, summer.**

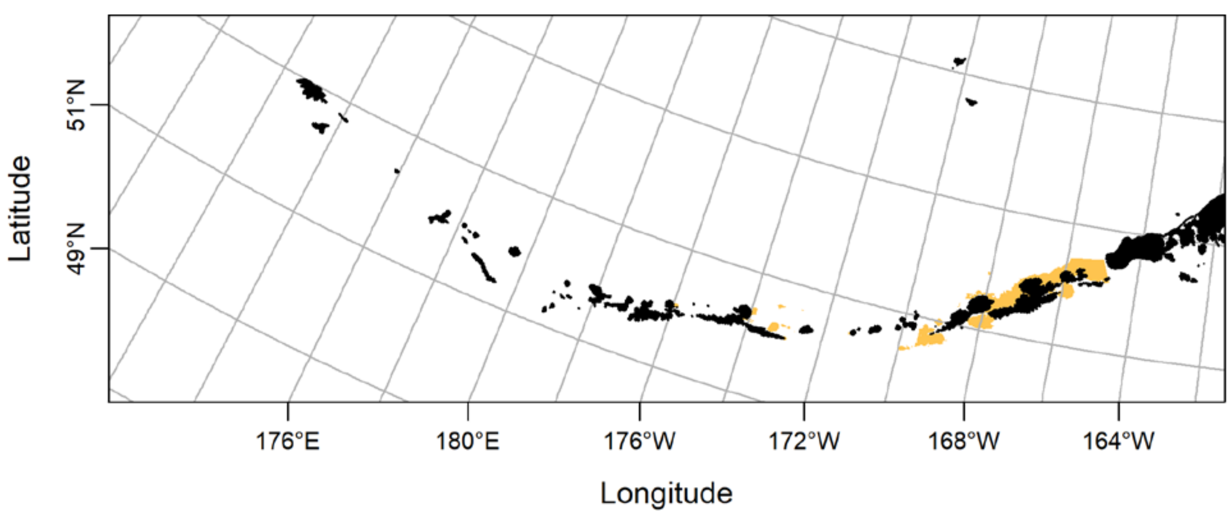


**Figure E-26 EFH distribution of AI Pacific cod larvae, summer.**

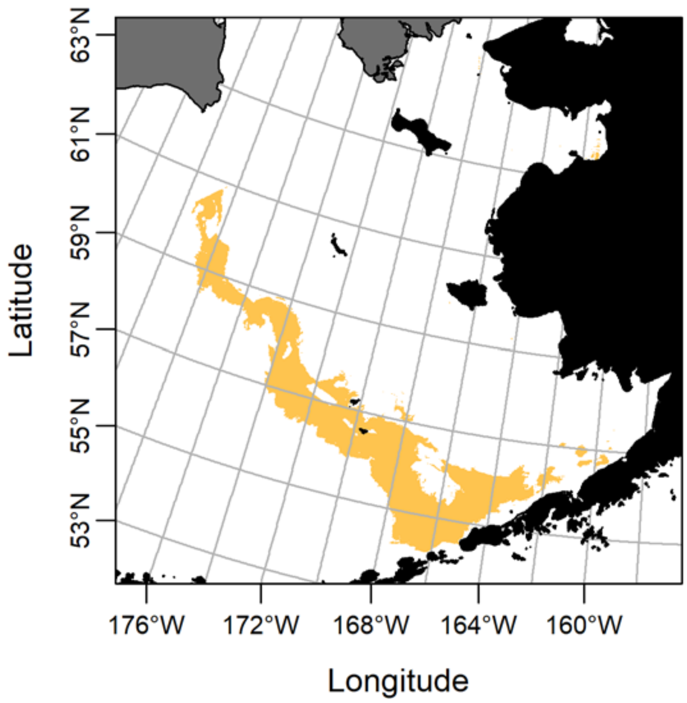


**Figure E-27 EFH distribution of EBS Sablefish adult, fall.**

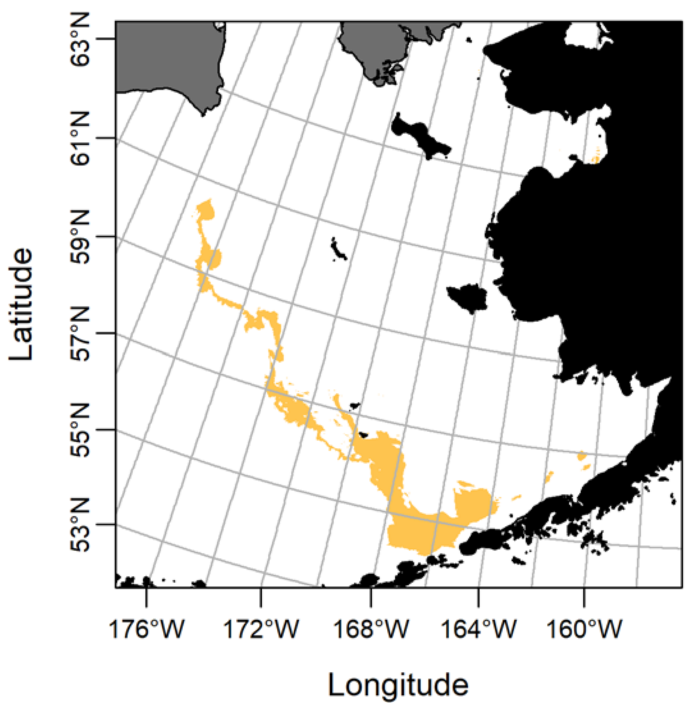


**Figure E-28 EFH distribution of EBS Sablefish adult, spring.**

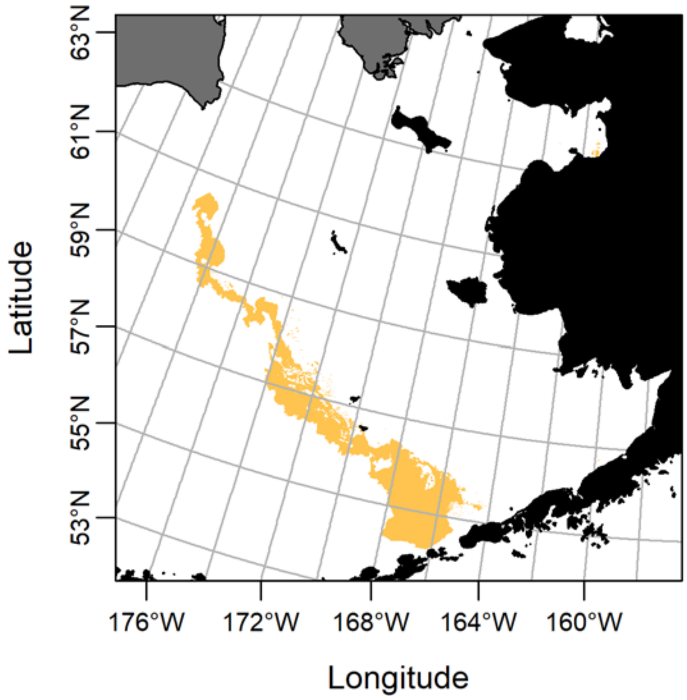


**Figure E-29 EFH distribution of EBS Sablefish adult, summer.**

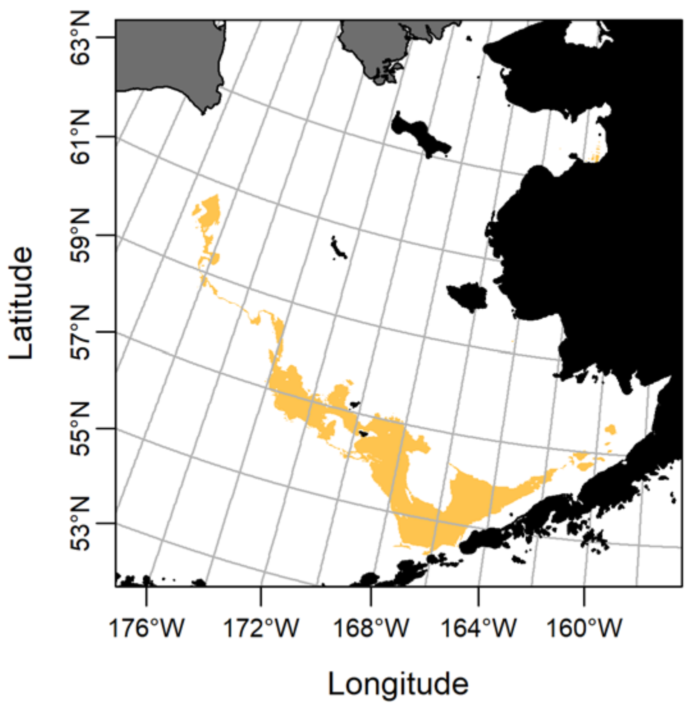


**Figure E-30 EFH distribution of EBS Sablefish adult, winter.**

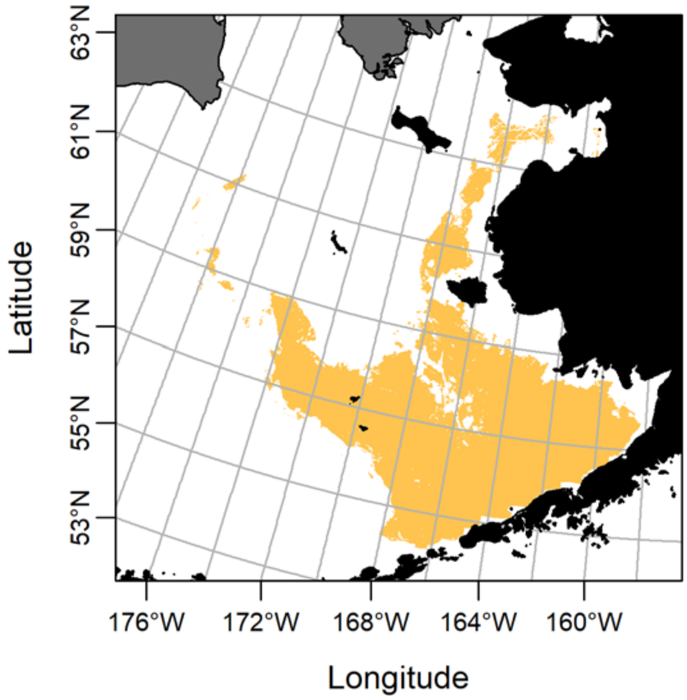


**Figure E-31 EFH distribution of EBS Sablefish juvenile, summer.**

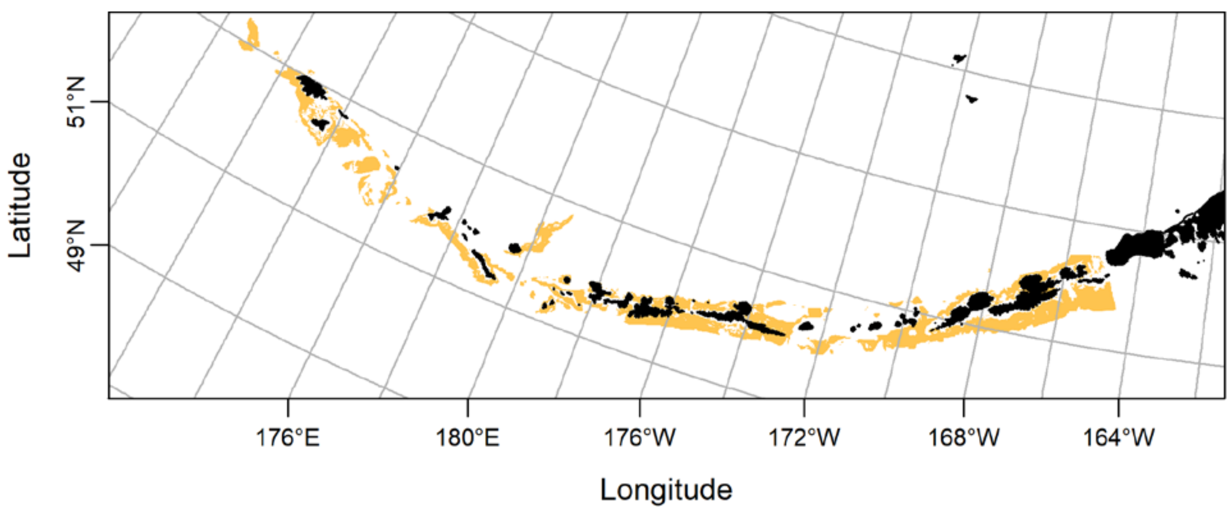


**Figure E-32 EFH distribution of AI Sablefish adult, fall.**

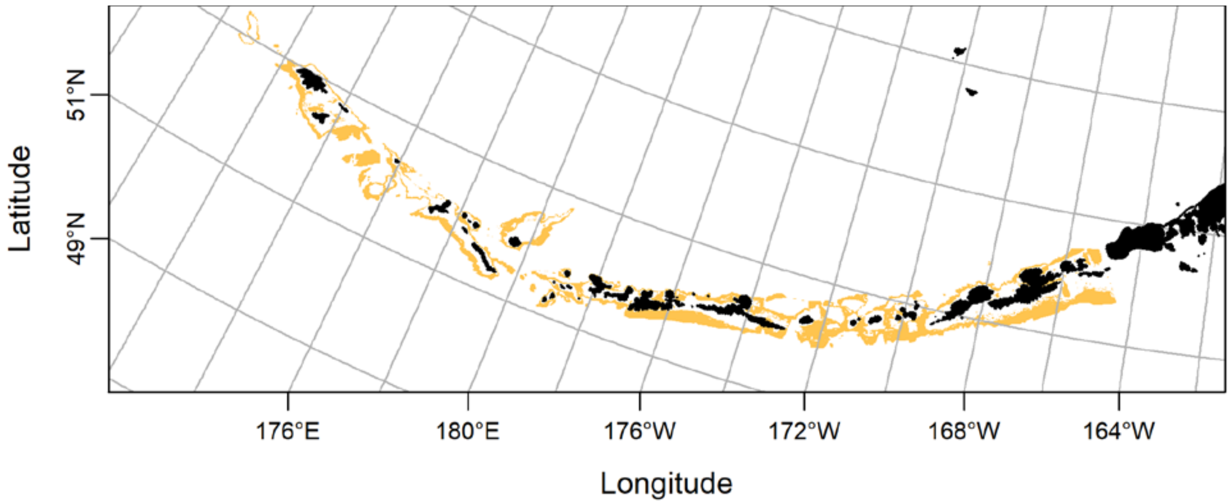


**Figure E-33 EFH distribution of AI Sablefish adult, spring.**

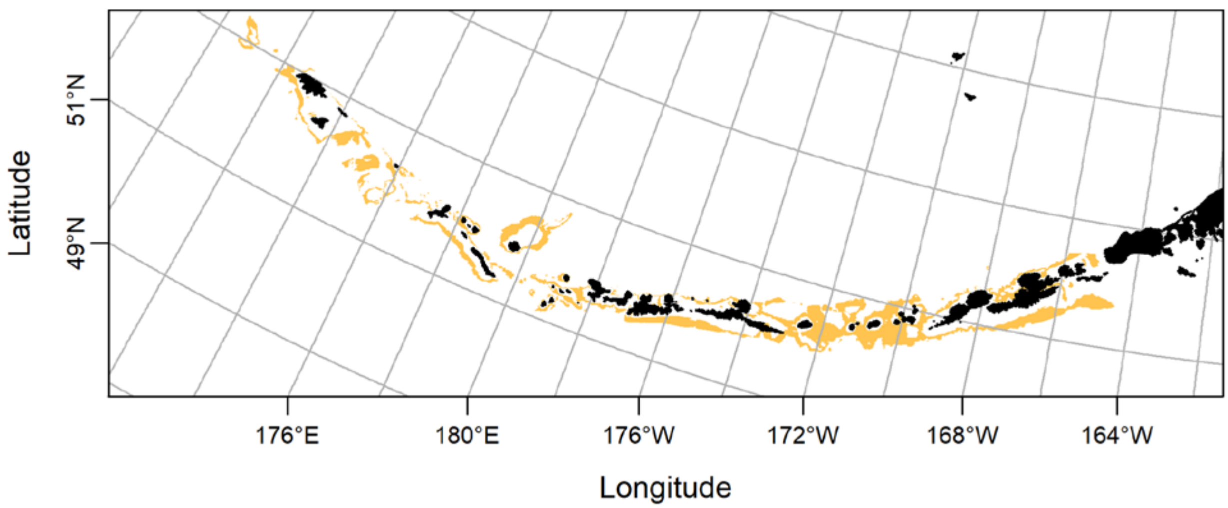


**Figure E-34 EFH distribution of AI Sablefish adult, summer.**

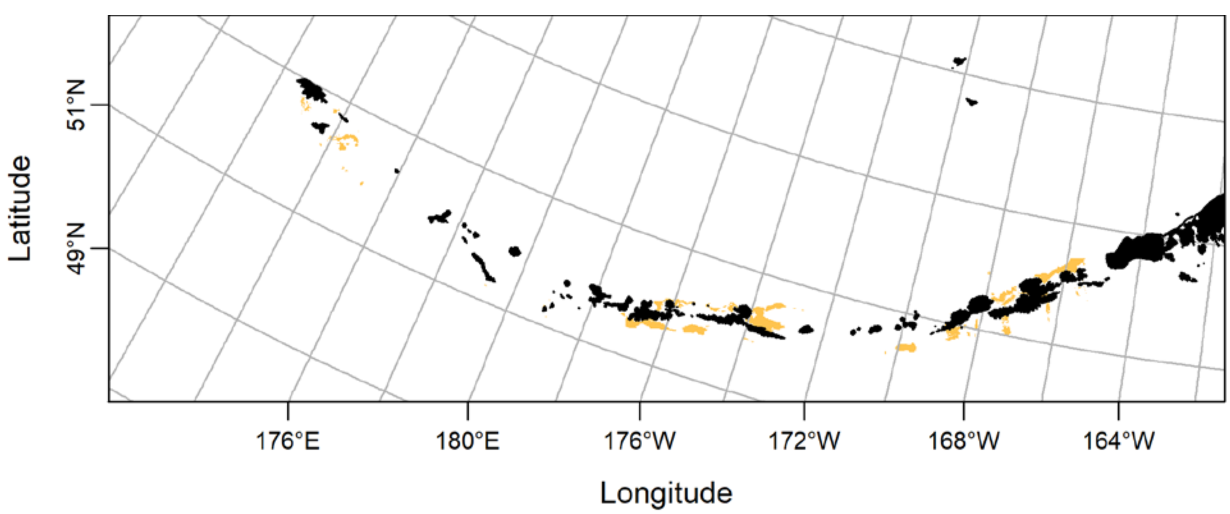


**Figure E-35 EFH distribution of AI Sablefish adult, winter.**

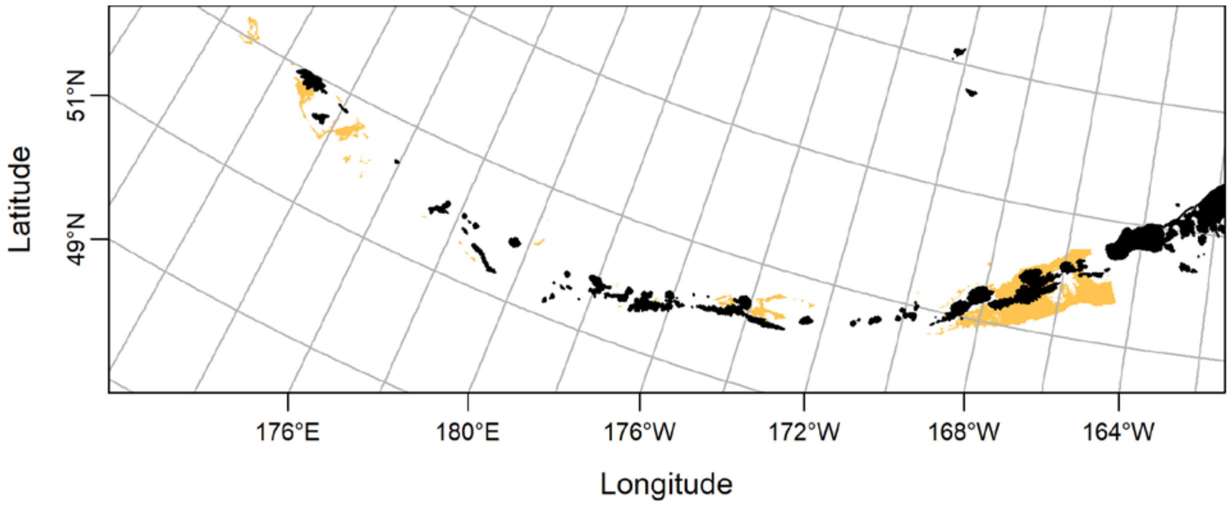


**Figure E-36 EFH distribution of AI Sablefish juvenile, summer.**

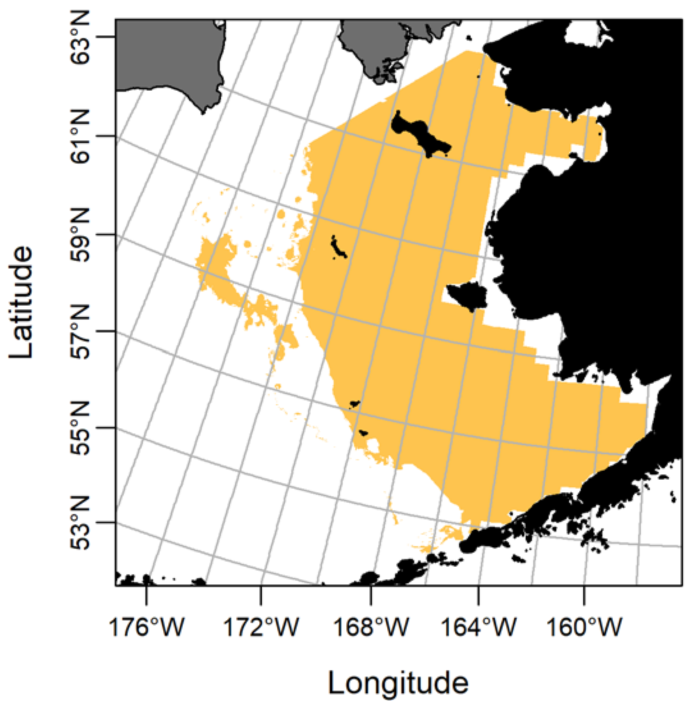


**Figure E-37 EFH distribution of EBS Yellowfin sole juvenile, summer.**

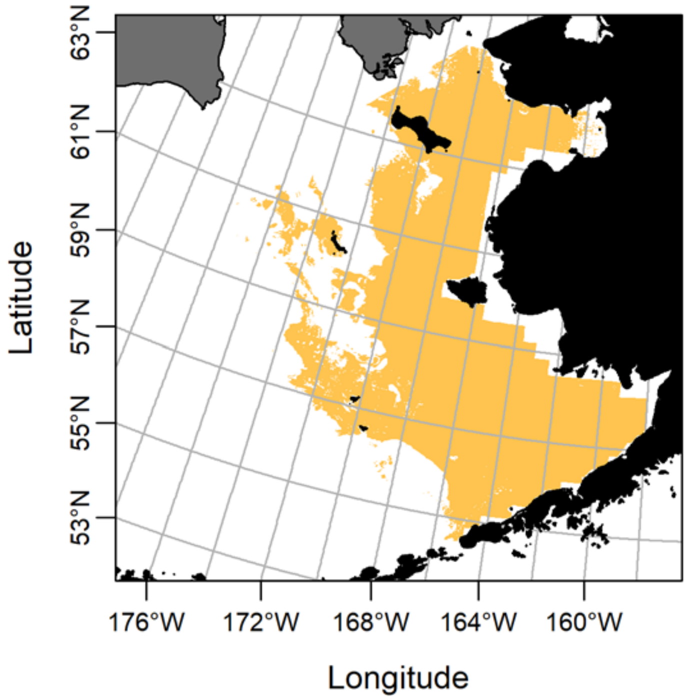


**Figure E-38 EFH distribution of EBS Yellowfin sole larvae, summer.**

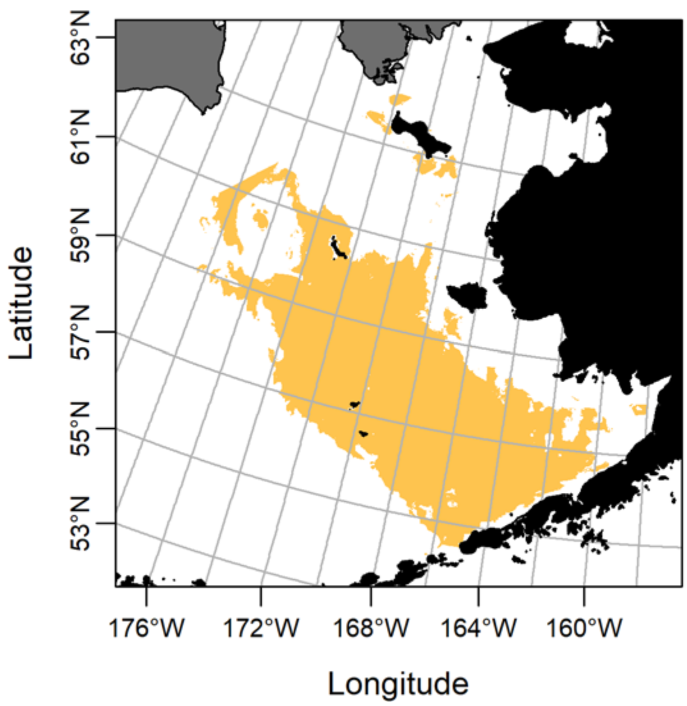


**Figure E-39 EFH distribution of EBS Yellowfin sole adult, fall.**

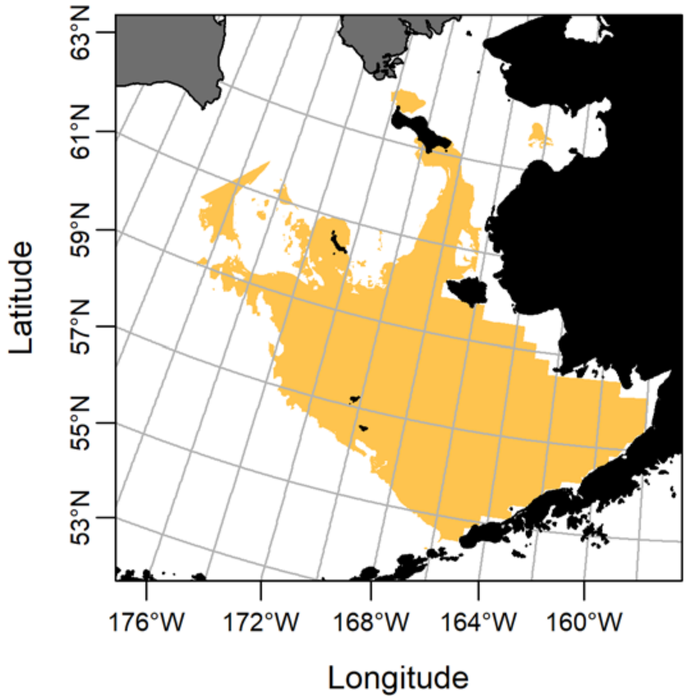


**Figure E-40 EFH distribution of EBS Yellowfin sole adult, spring.**

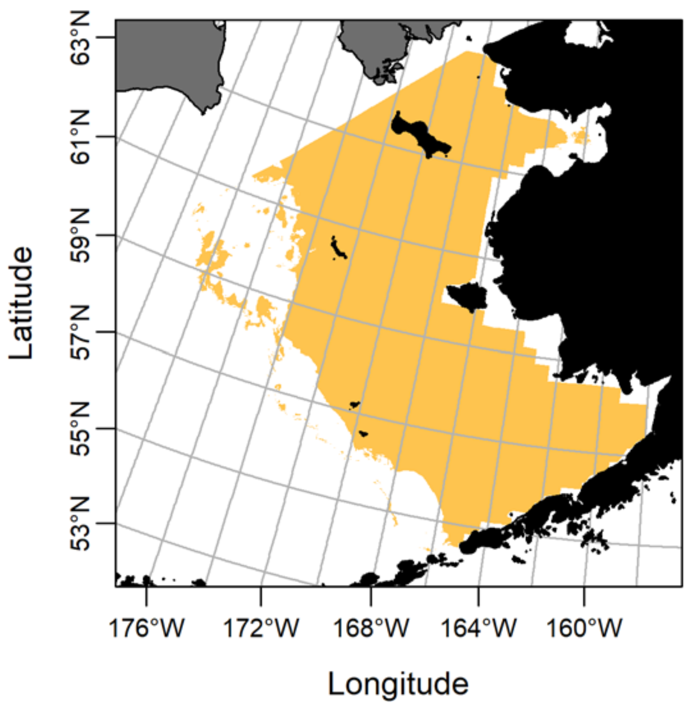


**Figure E-41 EFH distribution of EBS Yellowfin sole adult, summer.**

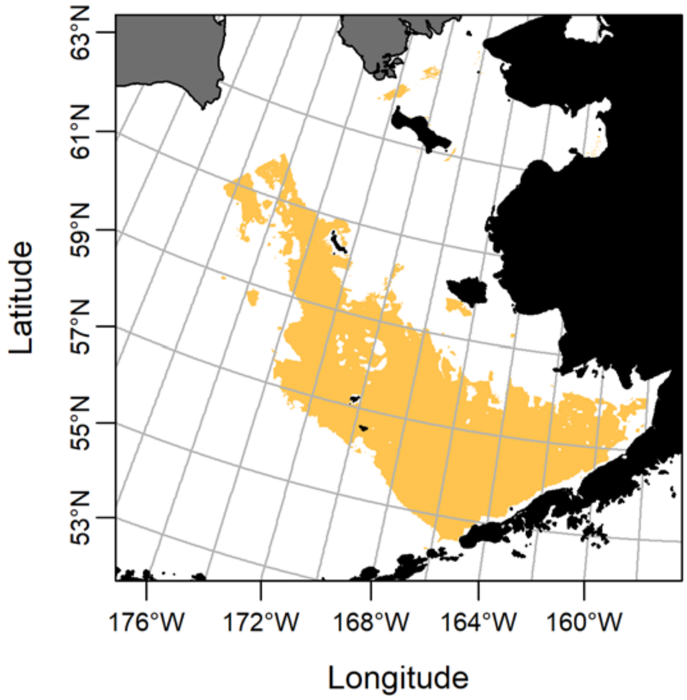


**Figure E-42 EFH distribution of EBS Yellowfin sole adult, winter.**

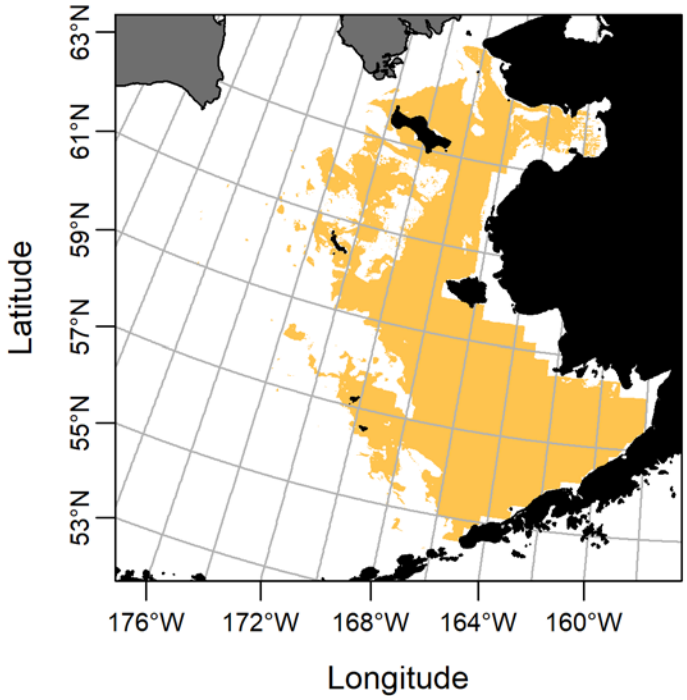


**Figure E-43 EFH distribution of EBS Yellowfin sole egg, summer.**

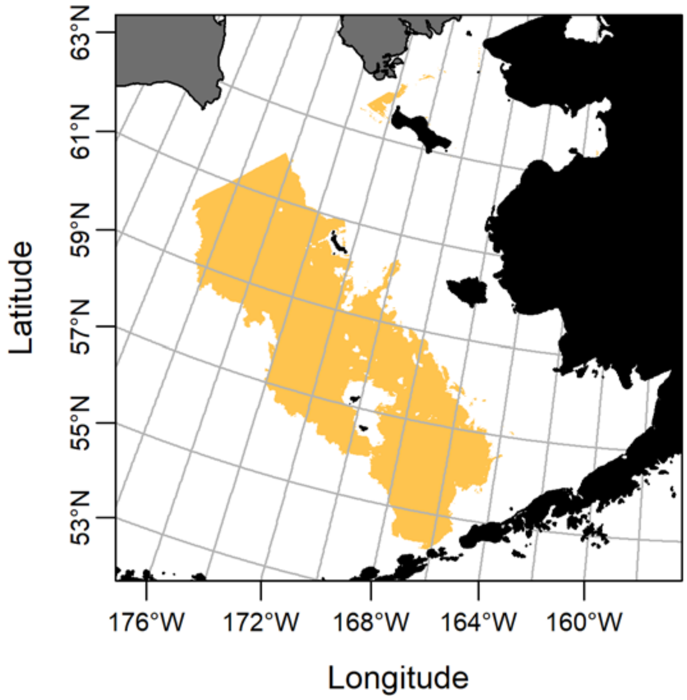


**Figure E-44 EFH distribution of EBS Greenland turbot adult, fall.**

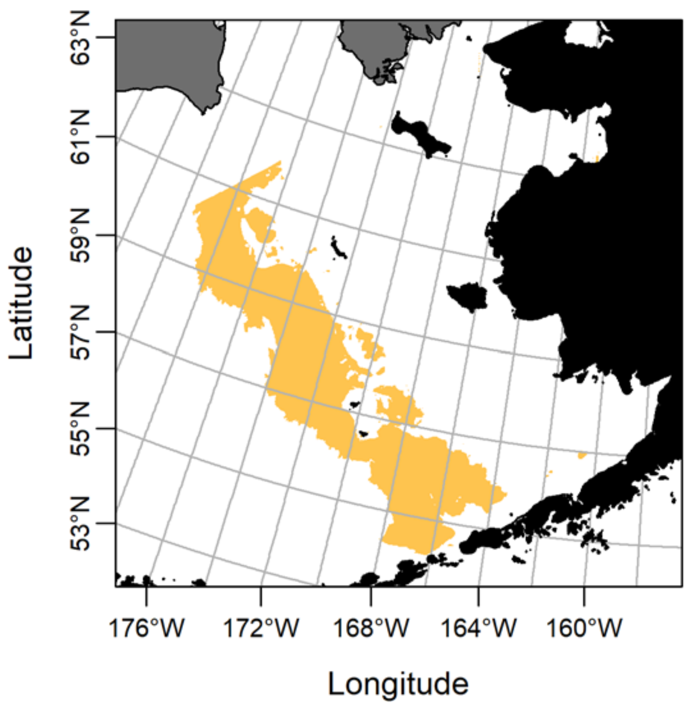


**Figure E-45 EFH distribution of EBS Greenland turbot adult, spring.**

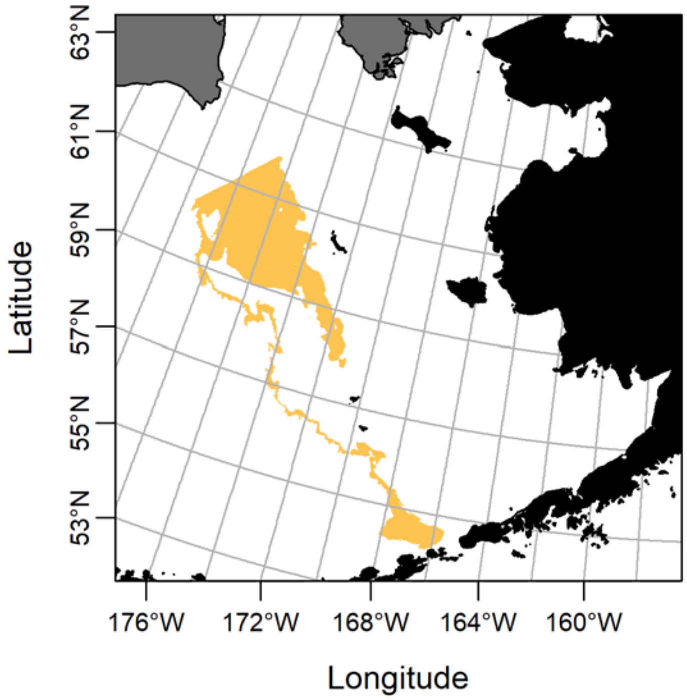


**Figure E-46 EFH distribution of EBS Greenland turbot adult, summer.**

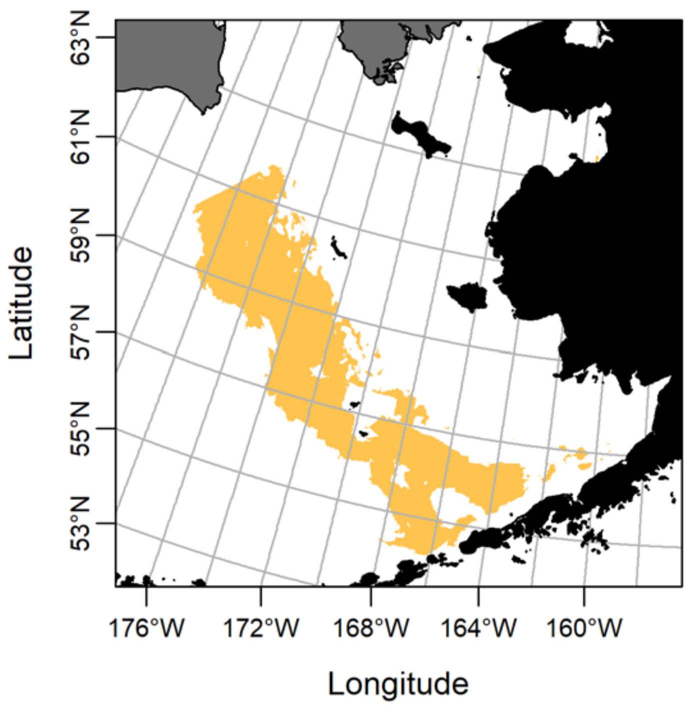


**Figure E-47 EFH distribution of EBS Greenland turbot adult, winter.**

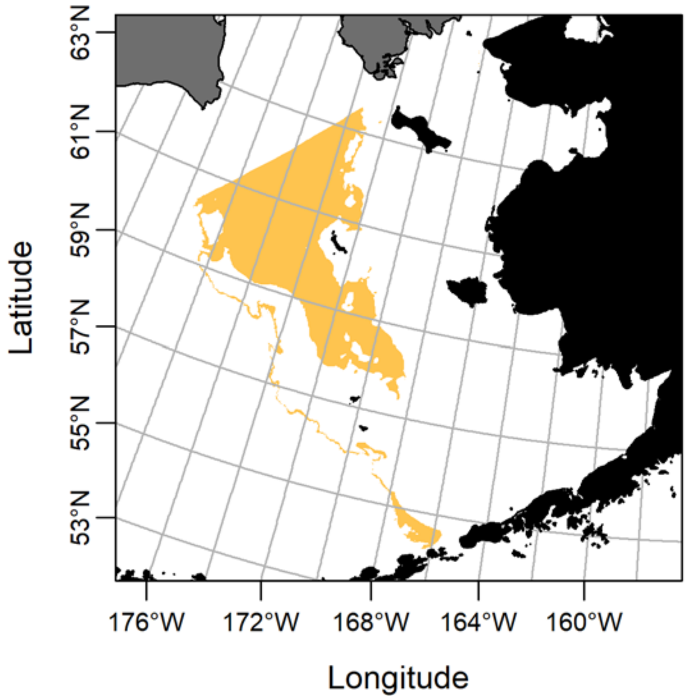


**Figure E-48 EFH distribution of EBS Greenland turbot, juvenile, summer.**

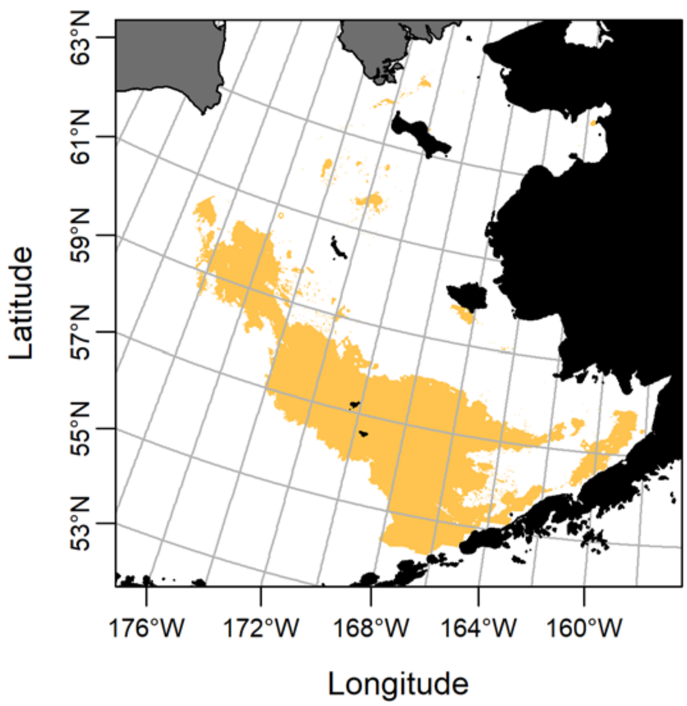


**Figure E-49 EFH distribution of EBS Greenland turbot larvae, summer.**

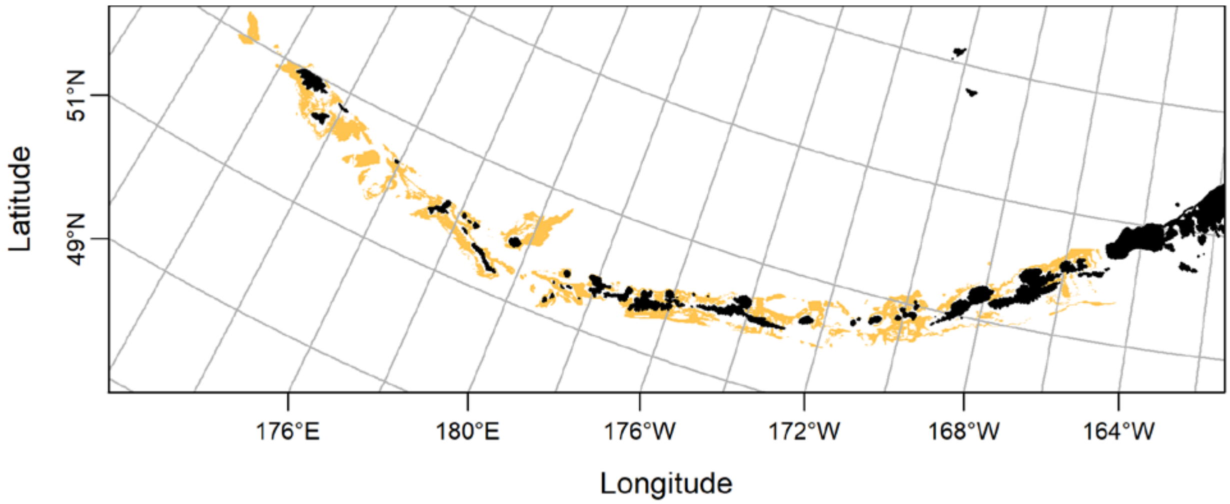


**Figure E-50 EFH distribution of AI Greenland turbot adult, fall.**

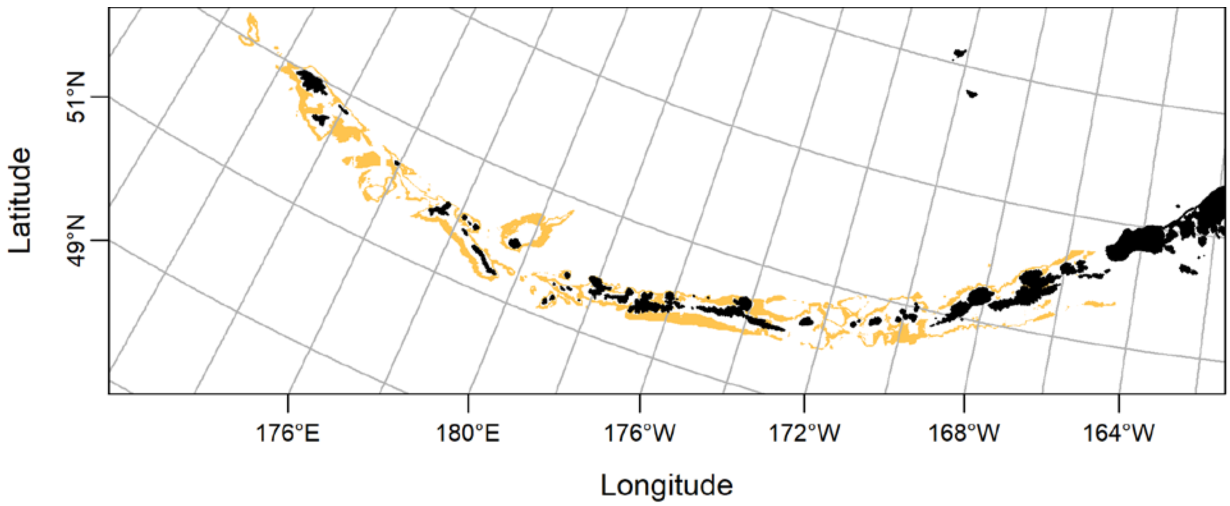


**Figure E-51 EFH distribution of AI Greenland turbot adult, spring.**

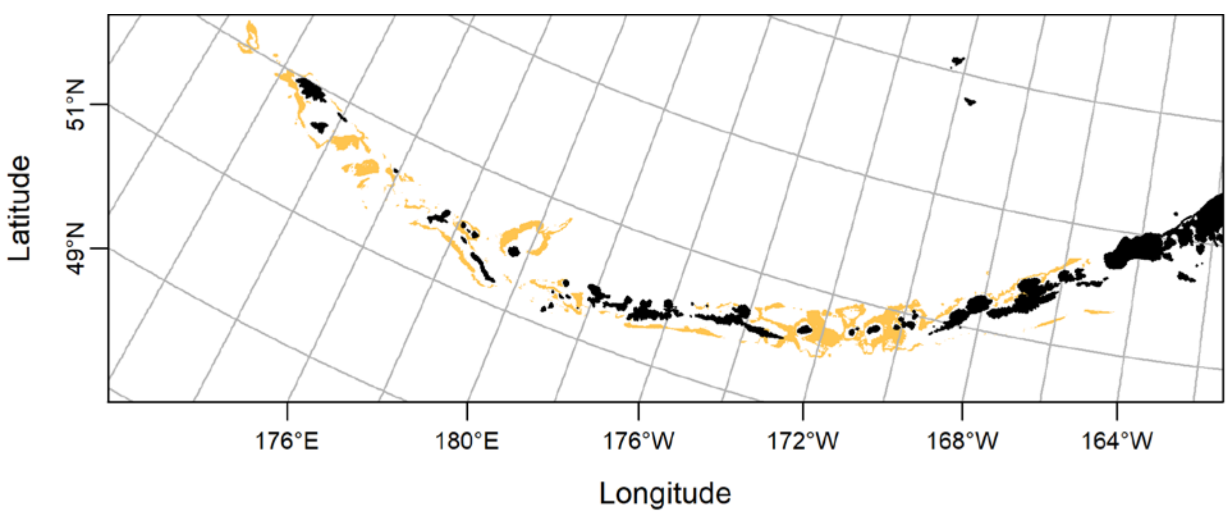


**Figure E-52 EFH distribution of AI Greenland turbot adult, summer.**

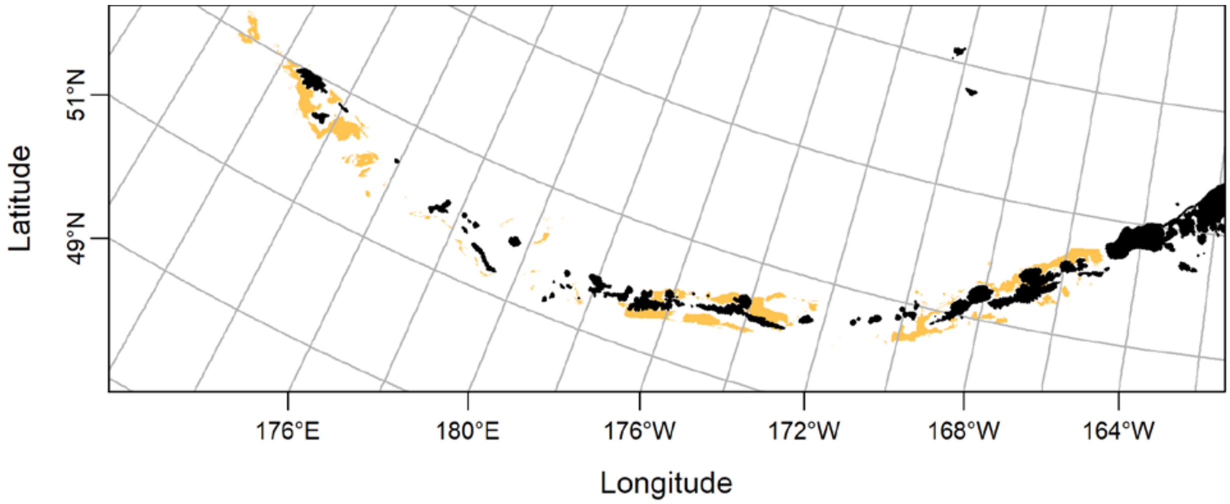


**Figure E-53 EFH distribution of AI Greenland turbot adult, winter.**

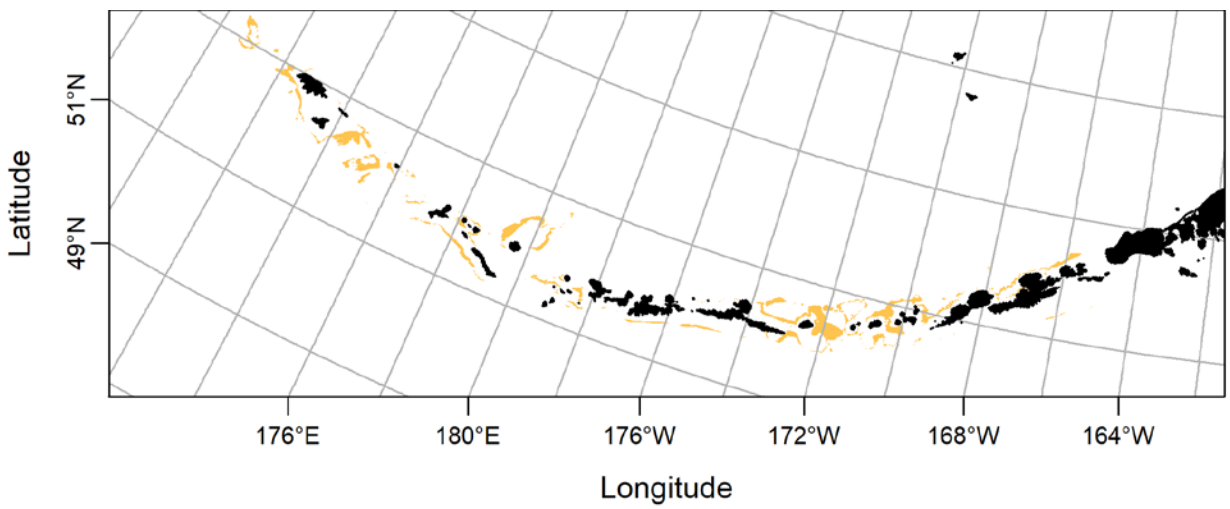


**Figure E-54 EFH distribution of AI Greenland turbot juvenile, summer.**

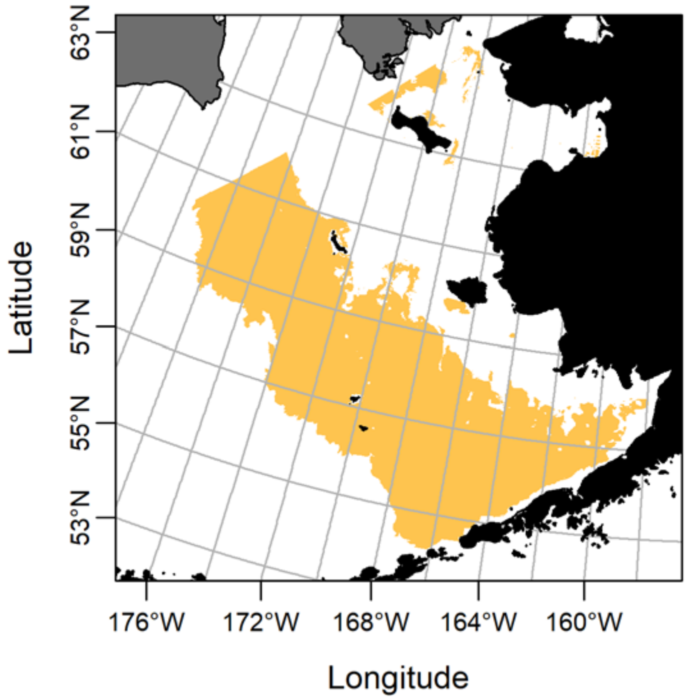


**Figure E-55 EFH distribution of EBS Arrowtooth flounder adult, fall.**

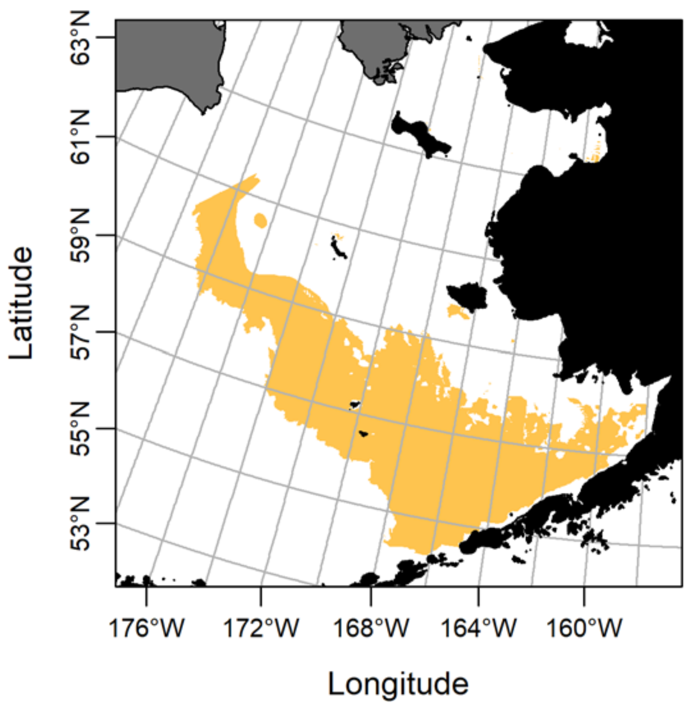


**Figure E-56 EFH distribution of EBS Arrowtooth flounder adult, spring.**

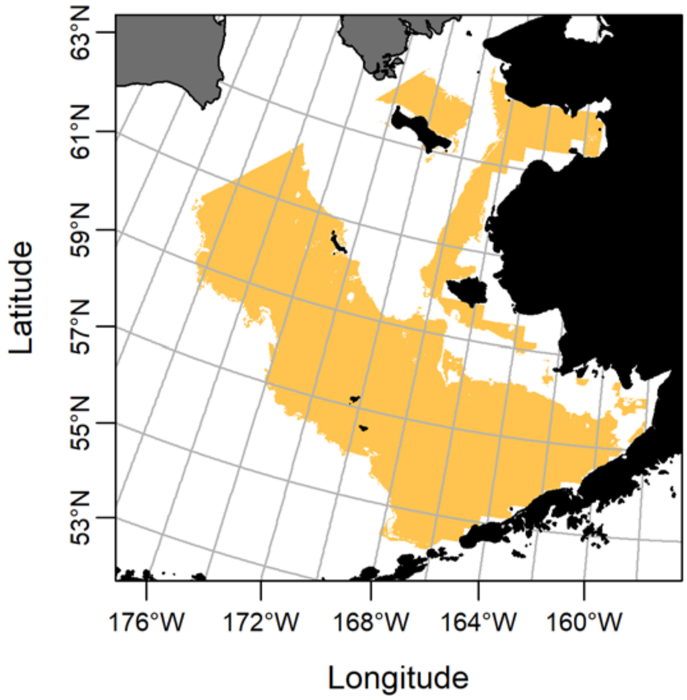


**Figure E-57 EFH distribution of EBS Arrowtooth flounder adult, summer.**

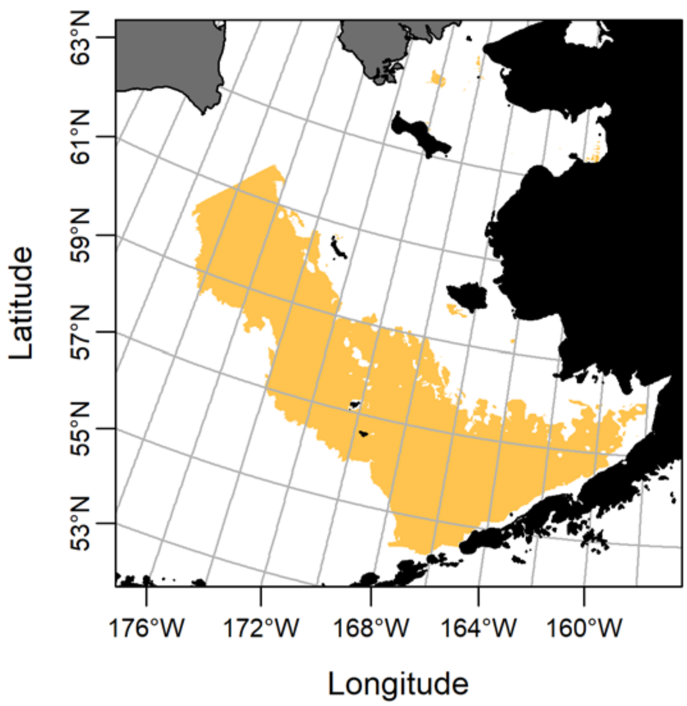


**Figure E-58 EFH distribution of EBS Arrowtooth flounder adult, winter.**

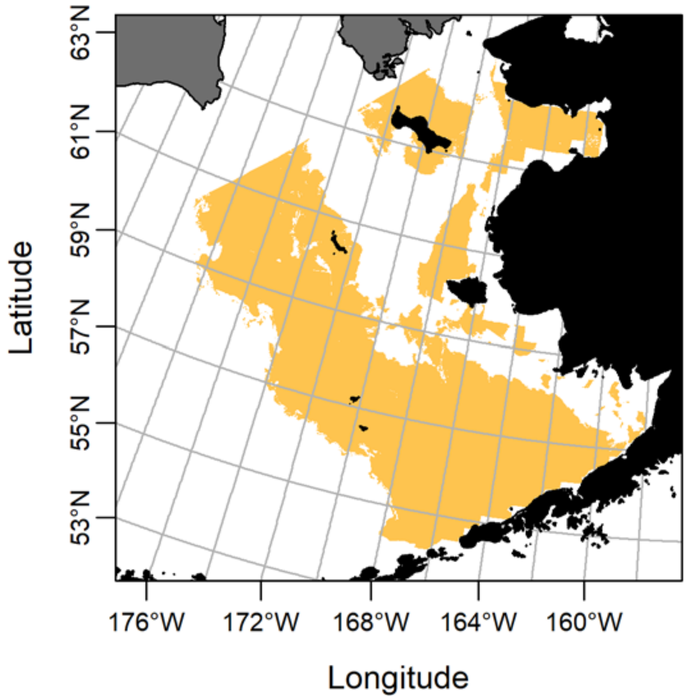


**Figure E-59 EFH distribution of EBS Arrowtooth flounder juvenile, summer.**

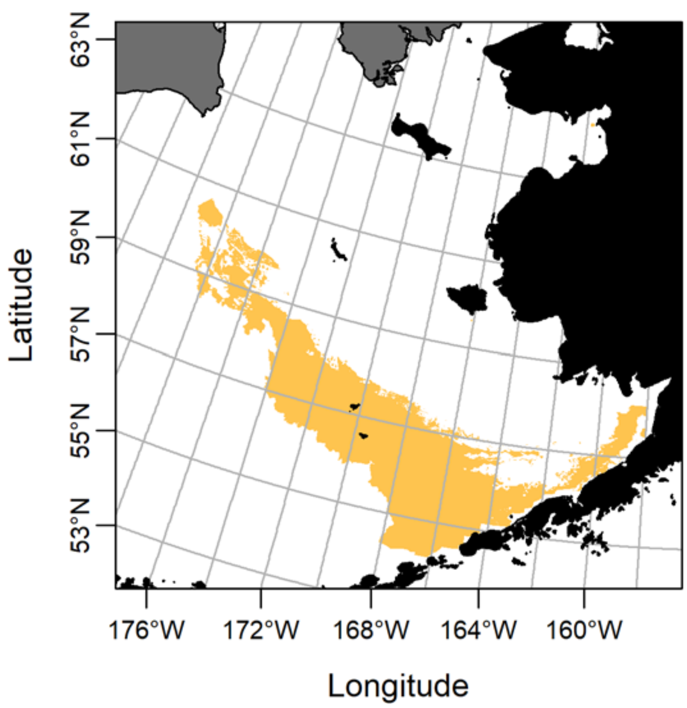


**Figure E-60 EFH distribution of EBS Arrowtooth flounder larvae, summer.**

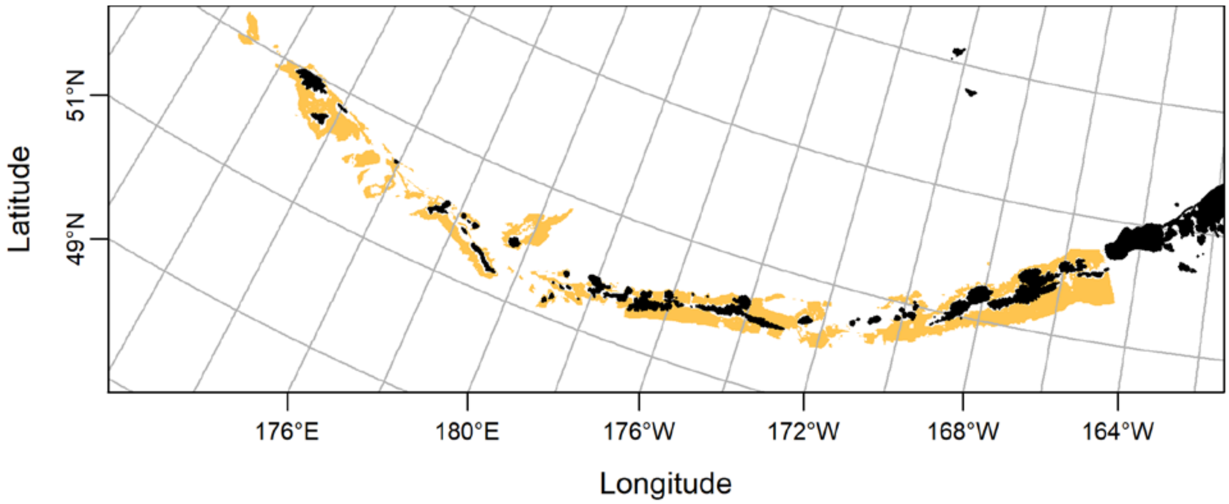


**Figure E-61 EFH distribution of AI Arrowtooth flounder adult, fall.**

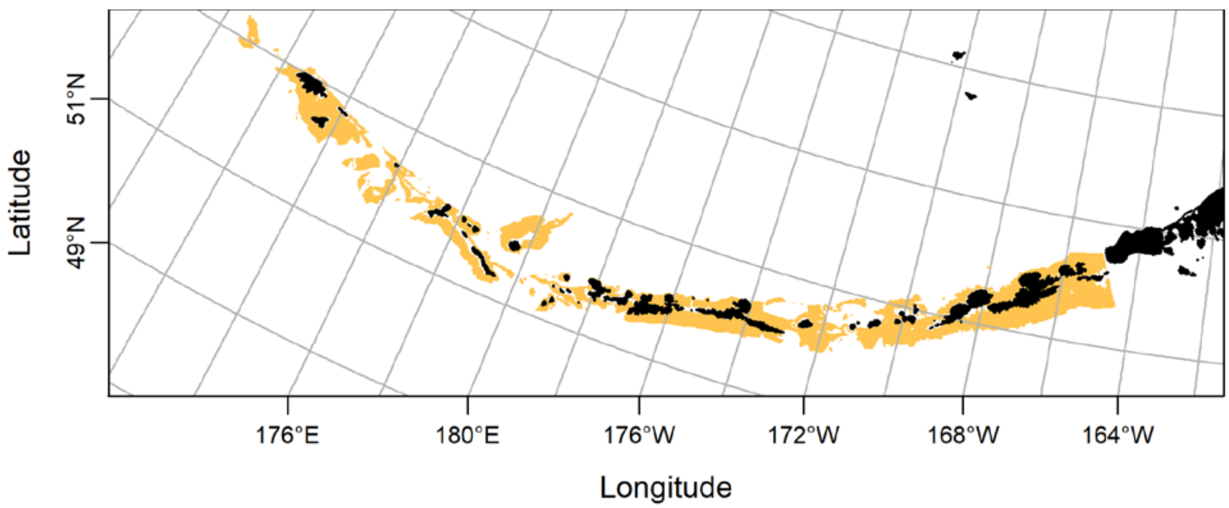


**Figure E-62 EFH distribution of AI Arrowtooth flounder adult, spring.**

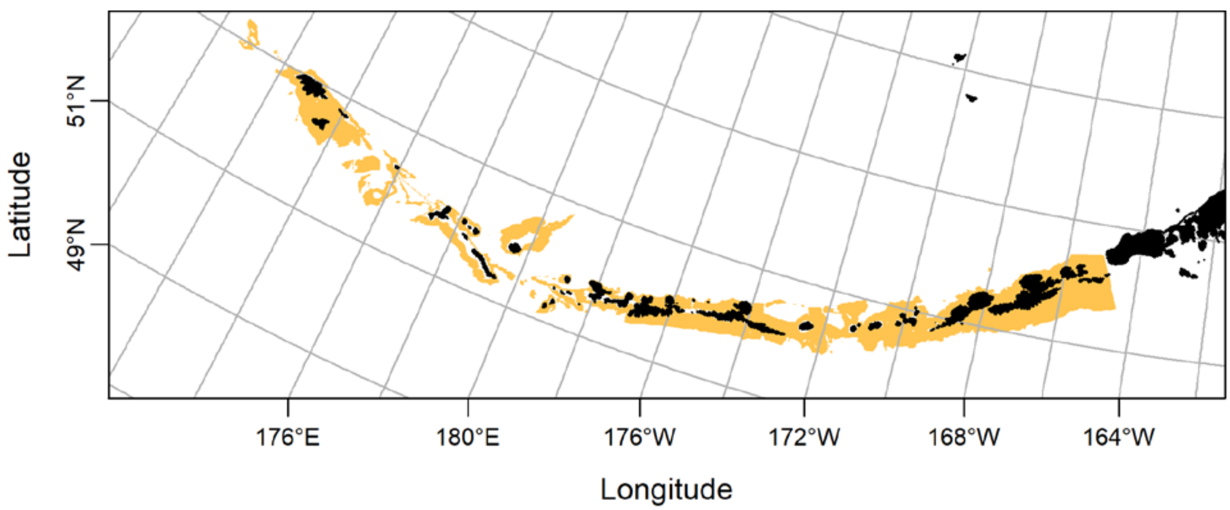


**Figure E-63 EFH distribution of AI Arrowtooth flounder adult, summer.**

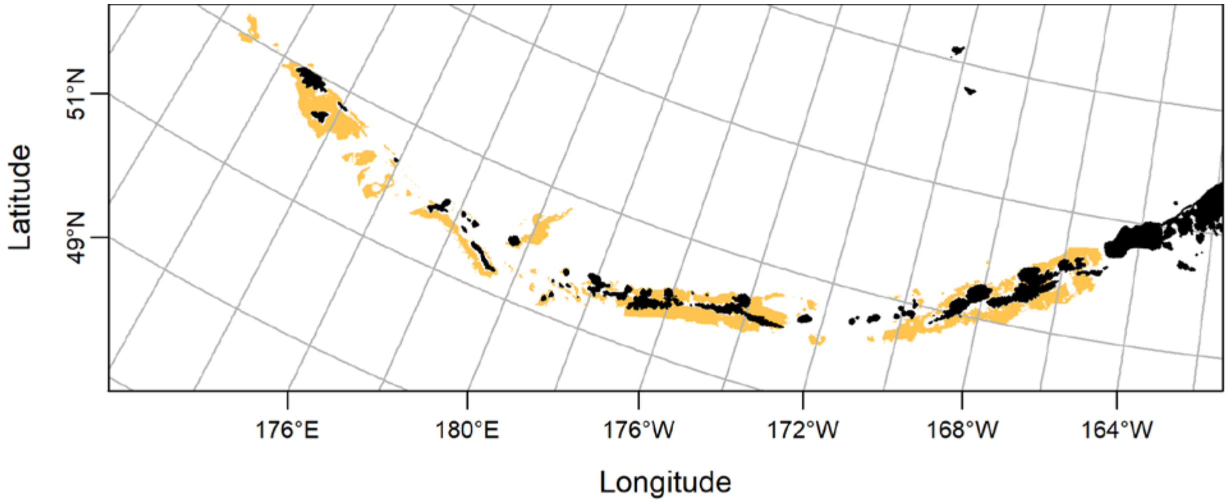


**Figure E-64 EFH distribution of AI Arrowtooth flounder adult, winter.**

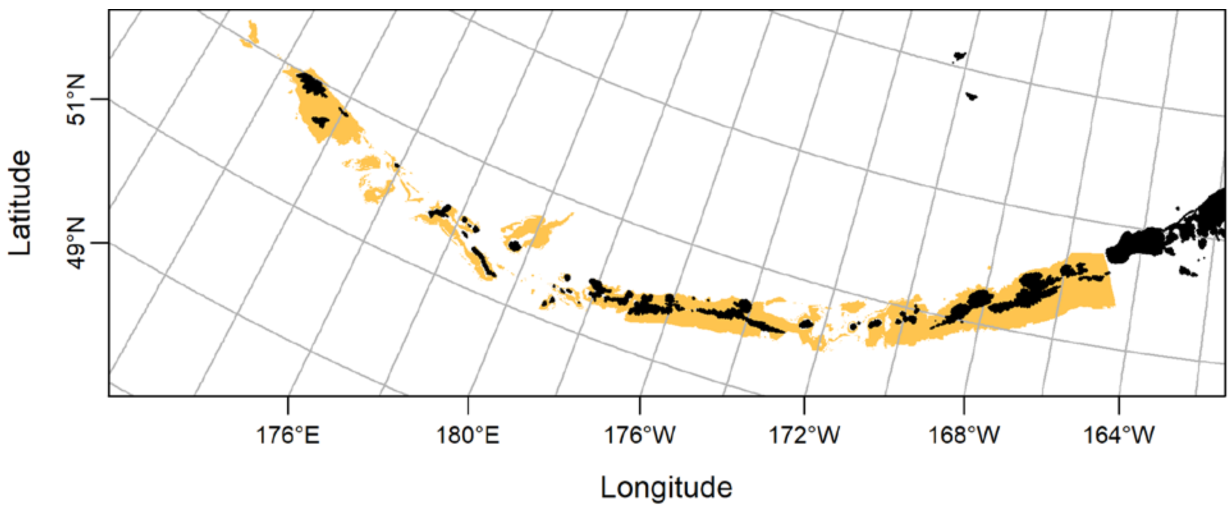


**Figure E-65 EFH distribution of AI Arrowtooth flounder juvenile, summer.**

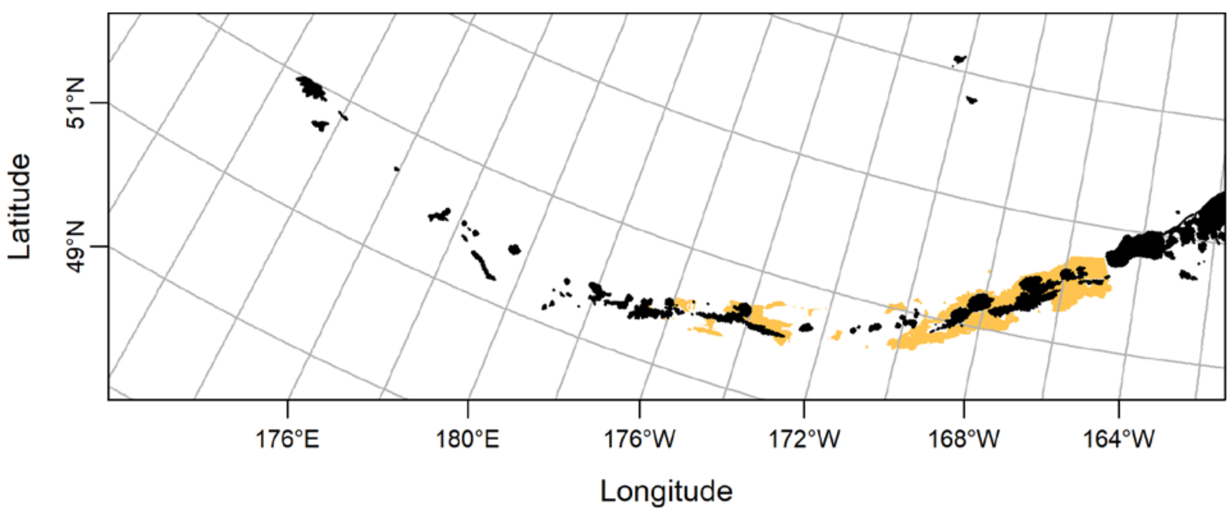


**Figure E-66 EFH distribution of AI Arrowtooth flounder larvae, summer.**

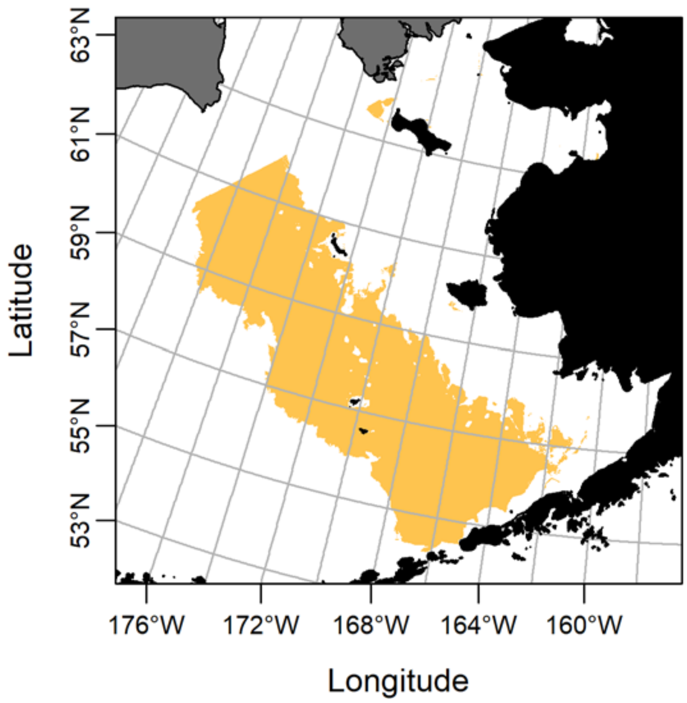


**Figure E-67 EFH distribution of EBS Kamchatka flounder adult, fall.**

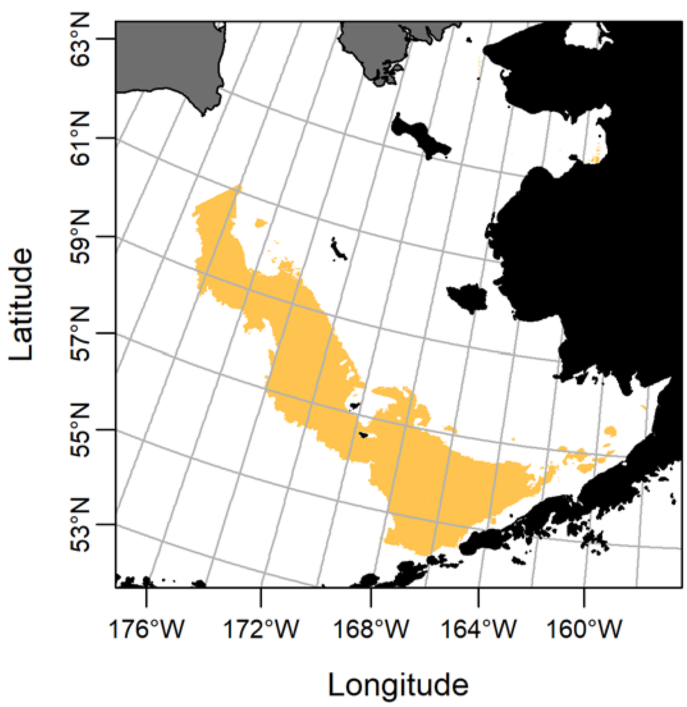


**Figure E-68 EFH distribution of EBS Kamchatka flounder adult, spring.**

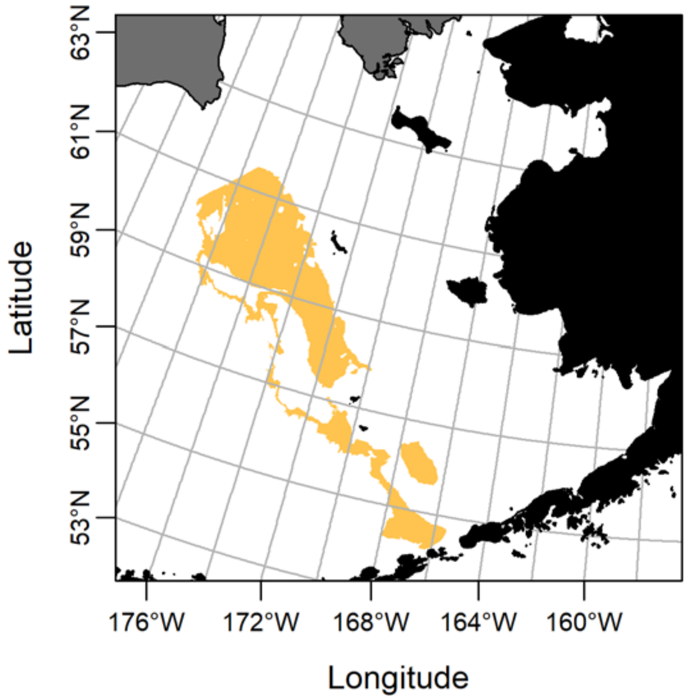


**Figure E-69 EFH distribution of EBS Kamchatka flounder adult, summer.**

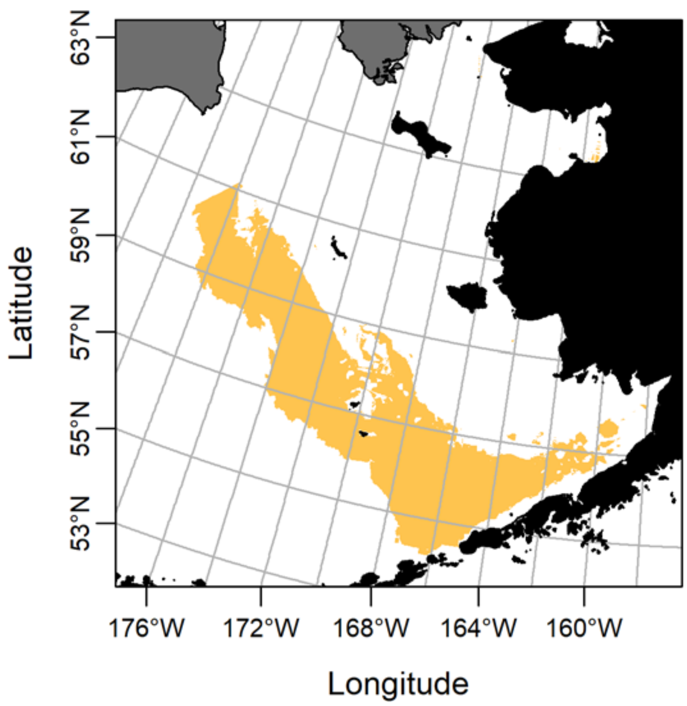


**Figure E-70 EFH distribution of EBS Kamchatka flounder adult, winter.**

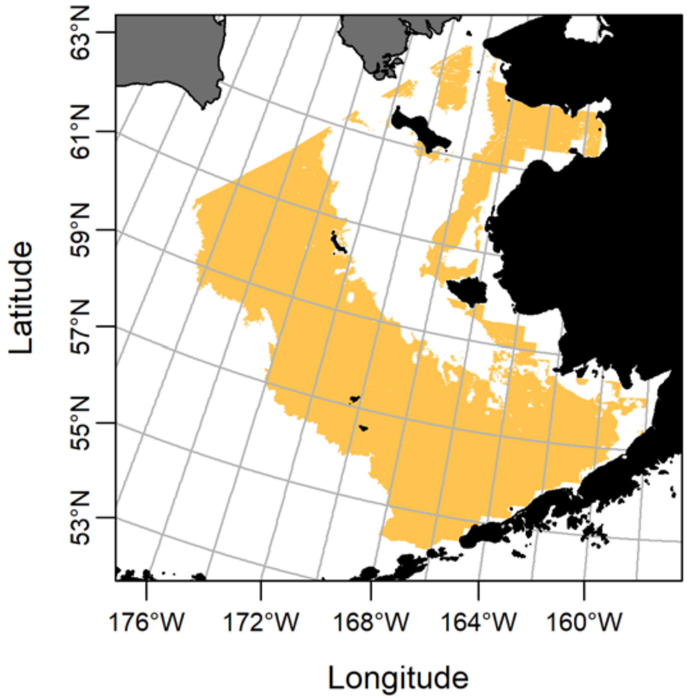


**Figure E-71 EFH distribution of EBS Kamchatka flounder juvenile, summer.**

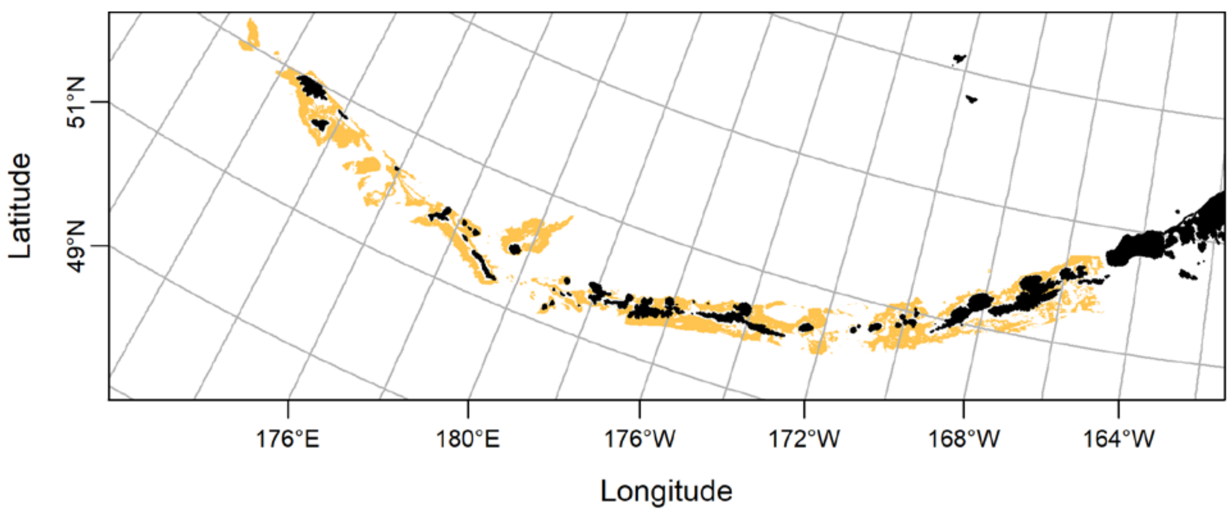


**Figure E-72 EFH distribution of AI Kamchatka flounder adult, fall.**

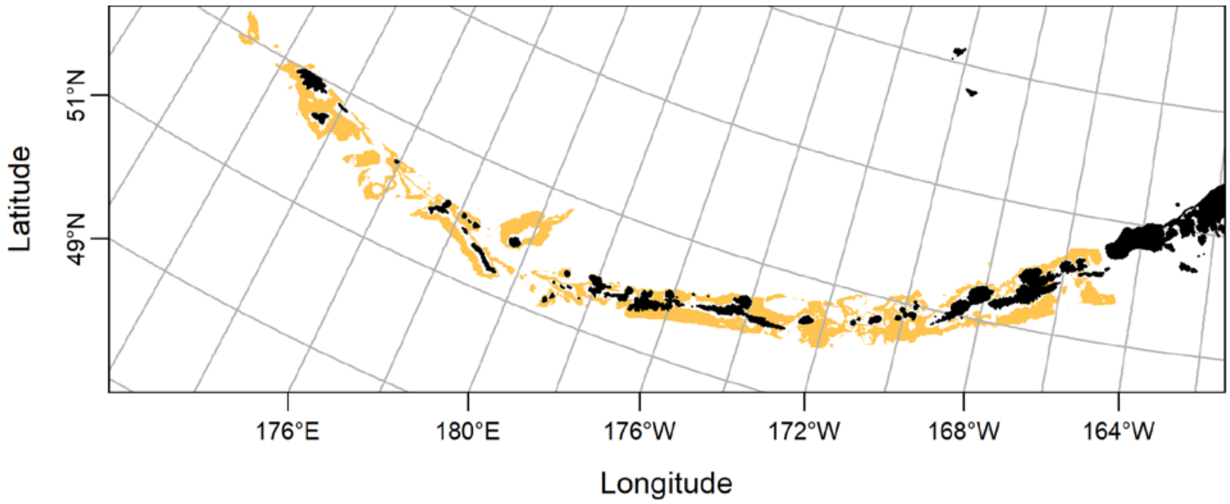


**Figure E-73 EFH distribution of AI Kamchatka flounder adult, spring.**

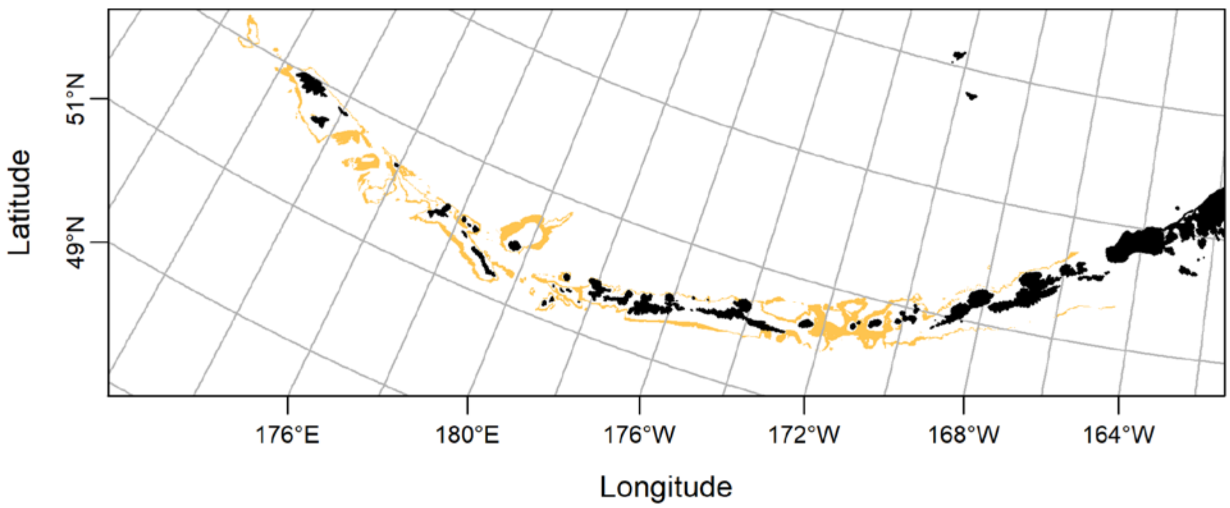


**Figure E-74 EFH distribution of AI Kamchatka flounder adult, summer.**

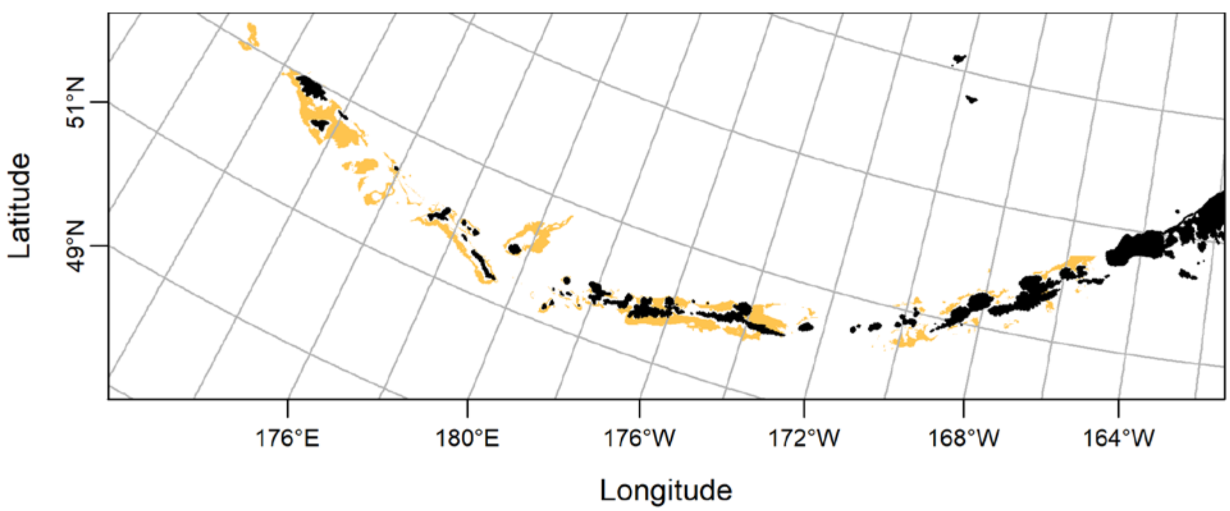


**Figure E-75 EFH distribution of AI Kamchatka flounder adult, winter.**

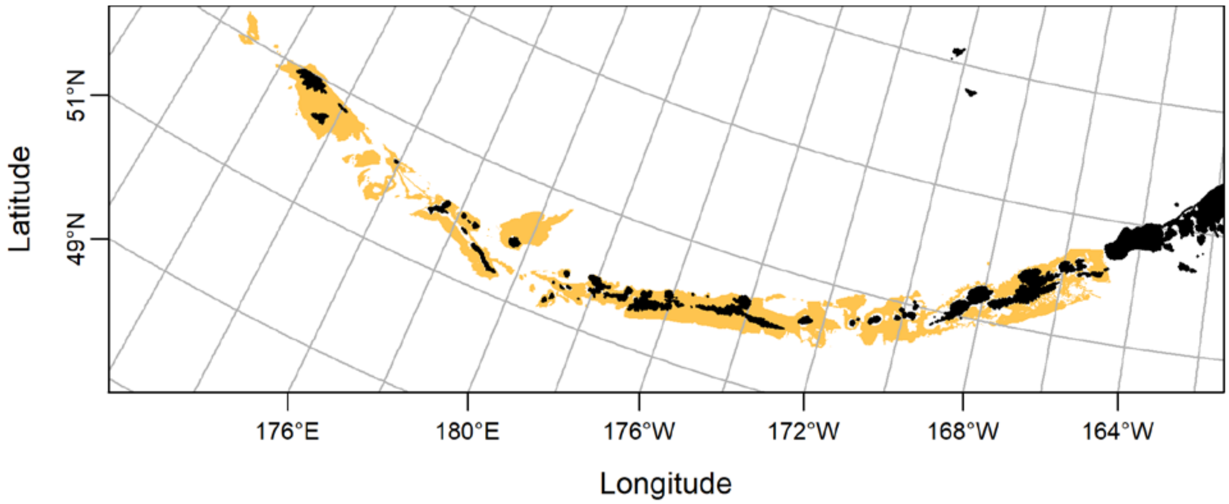


**Figure E-76 EFH distribution of AI Kamchatka flounder juvenile, summer.**

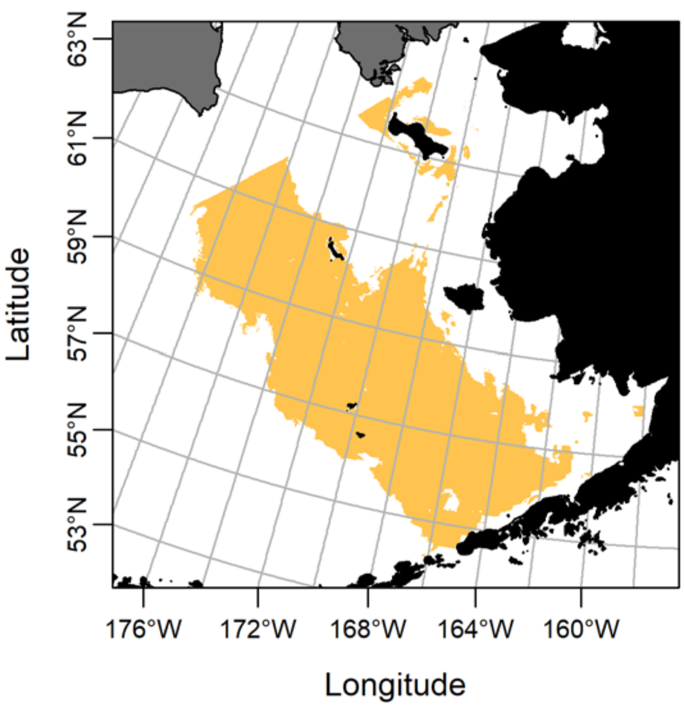


**Figure E-77 EFH distribution of EBS Northern rock sole adult, fall.**

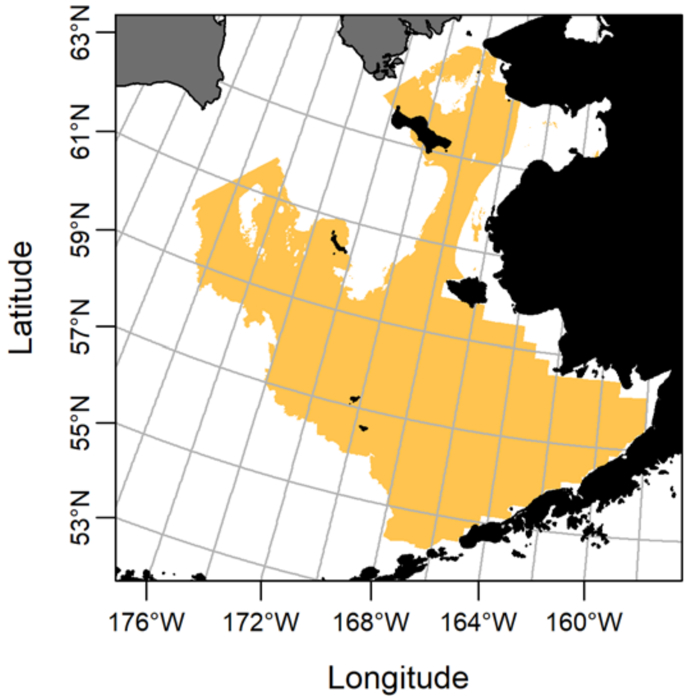


**Figure E-78 EFH distribution of EBS Northern rock sole adult, spring.**

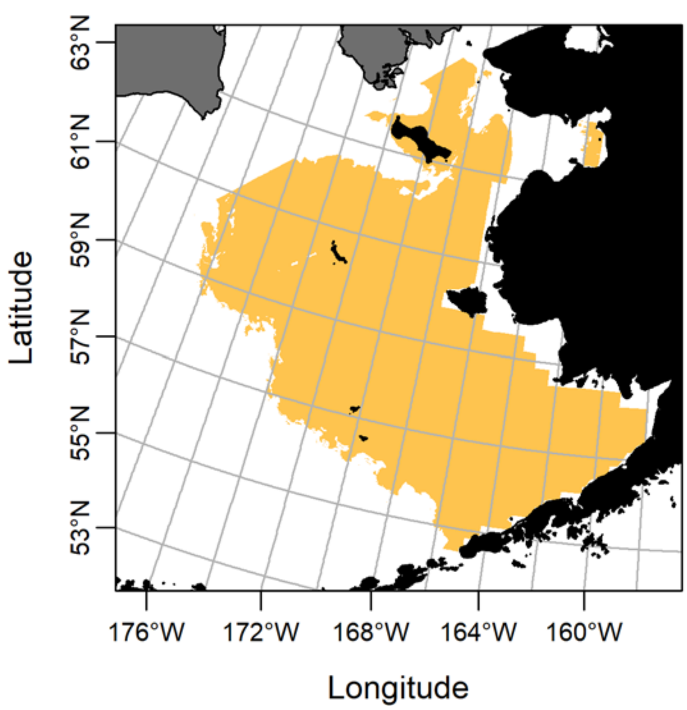


**Figure E-79 EFH distribution of EBS Northern rock sole adult, summer.**

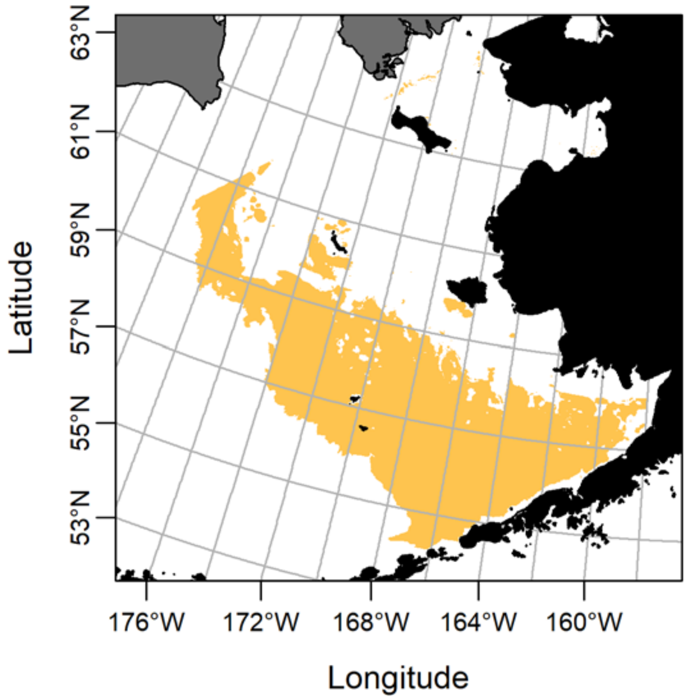


**Figure E-80 EFH distribution of EBS Northern rock sole adult, winter.**

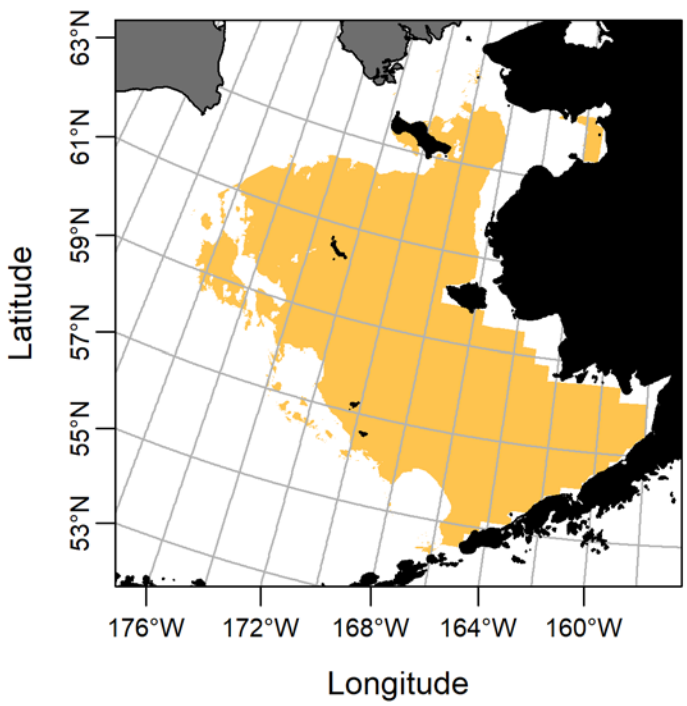


**Figure E-81 EFH distribution of EBS Northern rock sole juvenile, summer.**

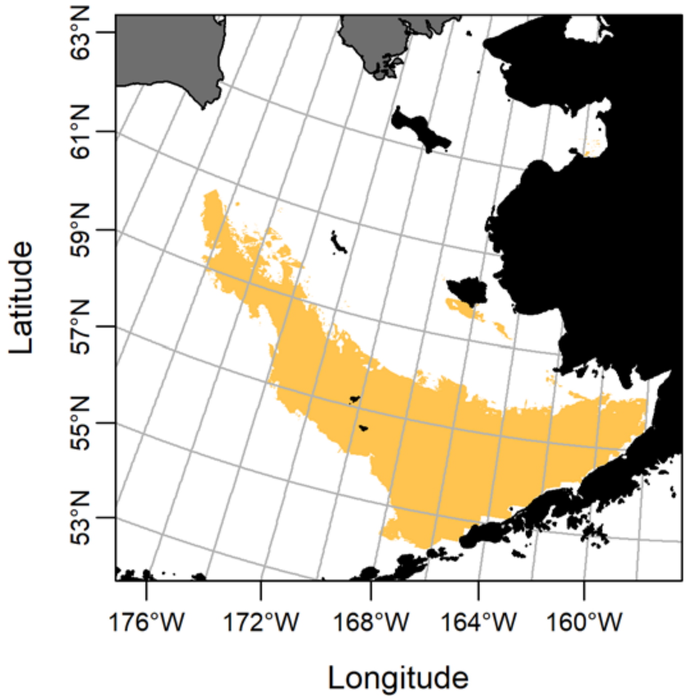


**Figure E-82 EFH distribution of EBS Northern rock sole larvae, summer.**

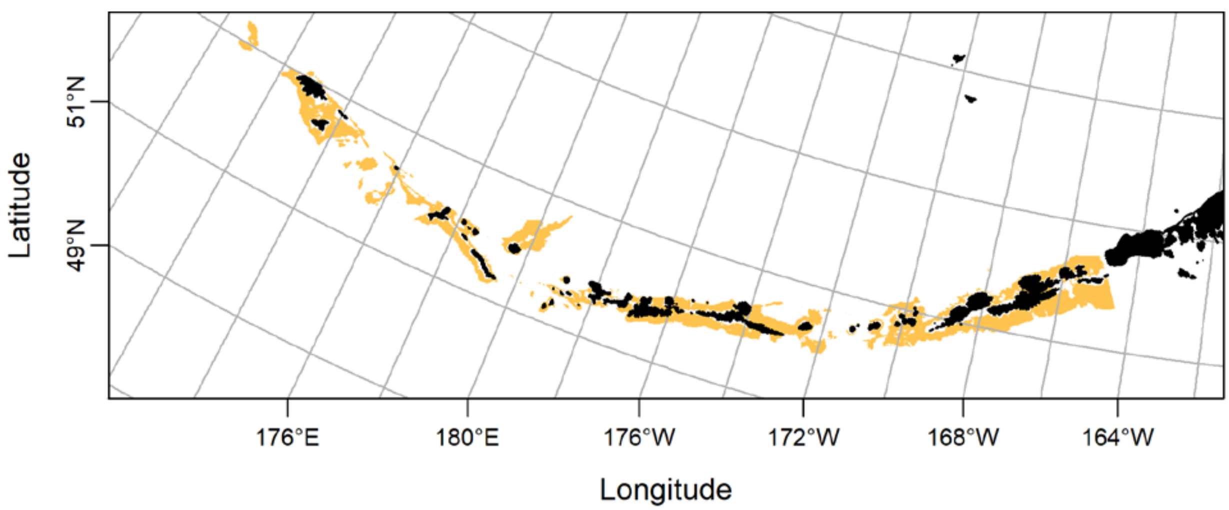


**Figure E-83 EFH distribution of AI Northern rock sole adult, fall.**

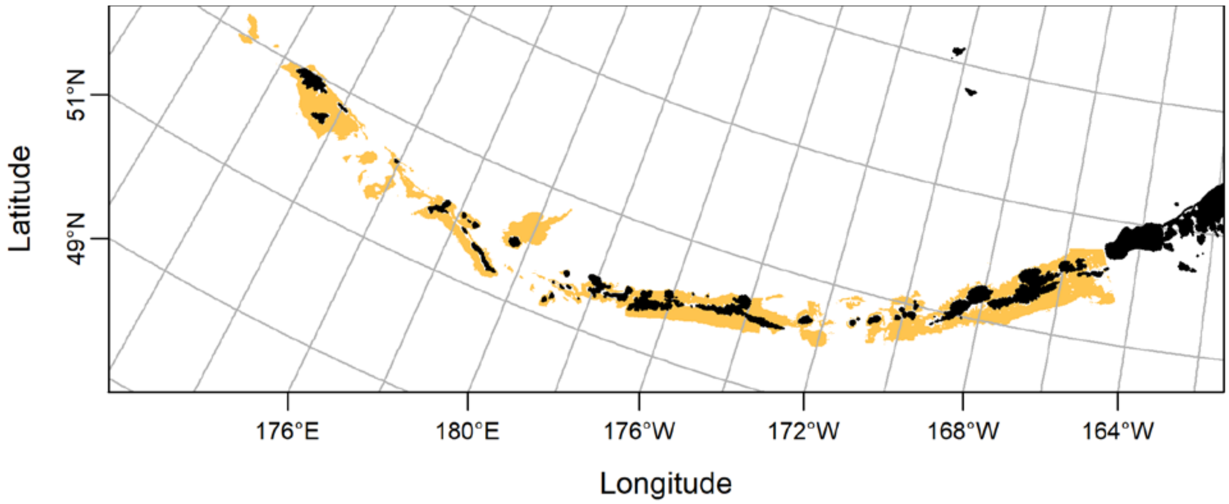


**Figure E-84 EFH distribution of AI Northern rock sole adult, spring.**

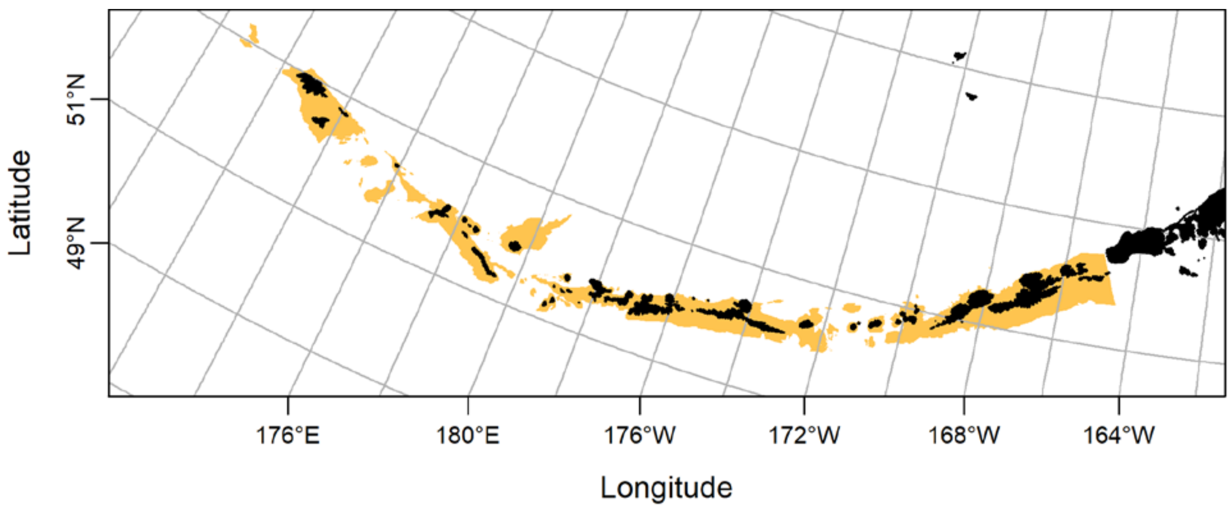


**Figure E-85 EFH distribution of AI Northern rock sole adult, summer.**

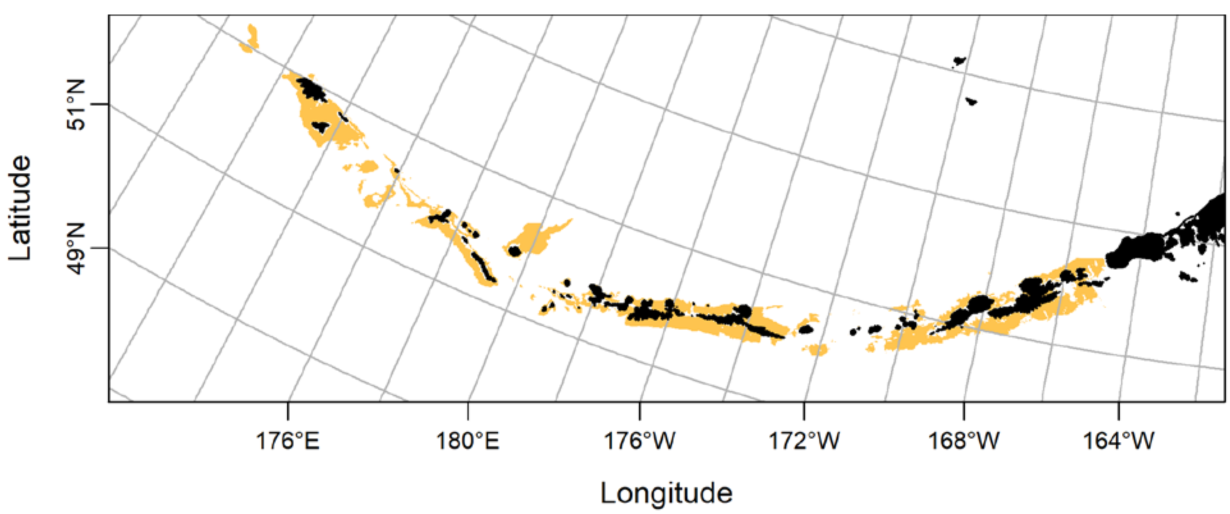


**Figure E-86 EFH distribution of AI Northern rock sole adult, winter.**

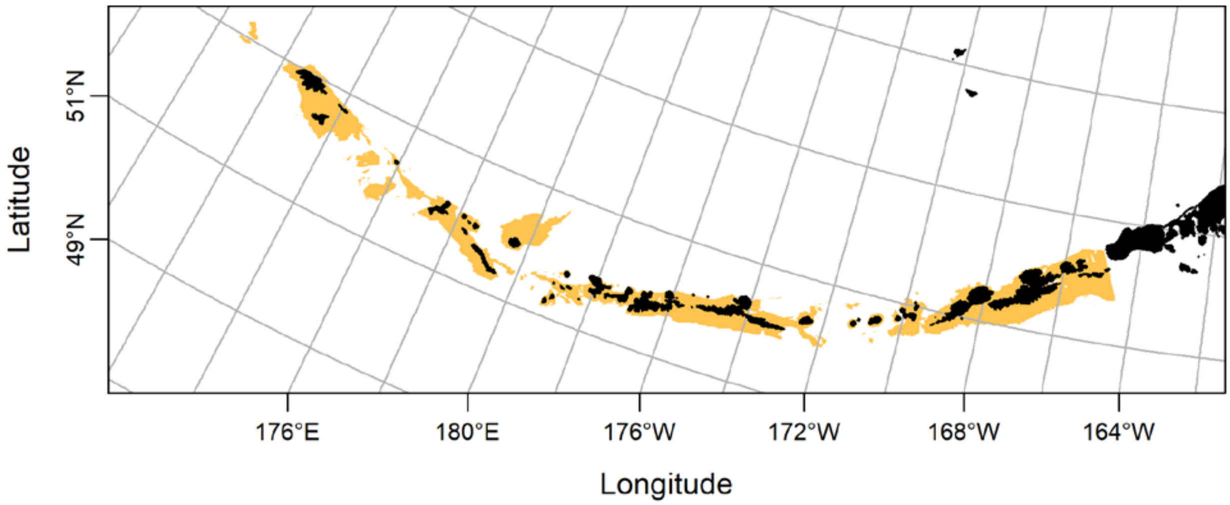


**Figure E-87 EFH distribution of AI Northern rock sole juvenile, summer.**

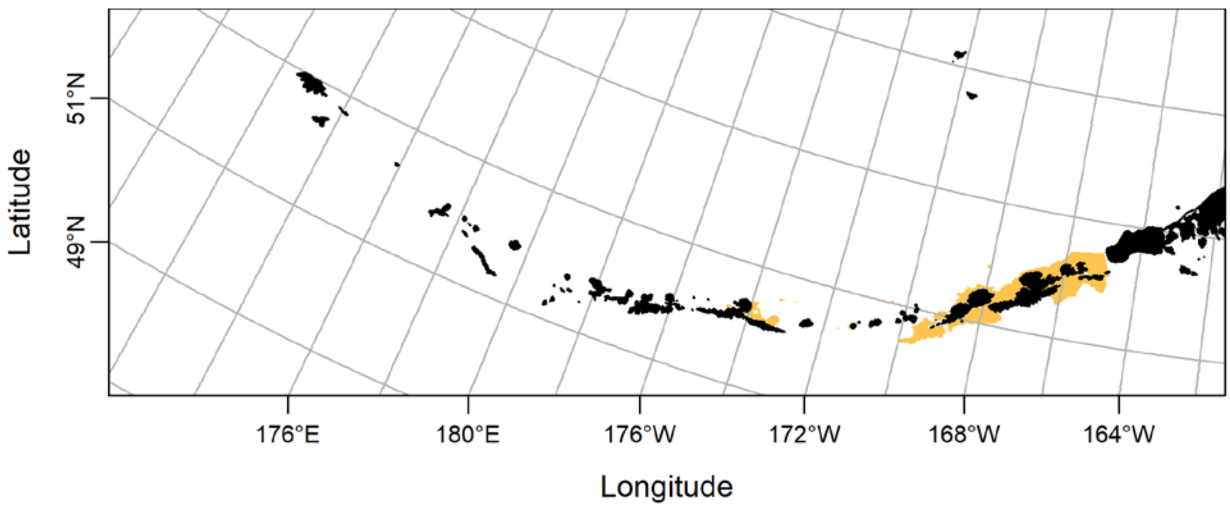


**Figure E-88 EFH distribution of AI Northern rock sole larvae, summer.**

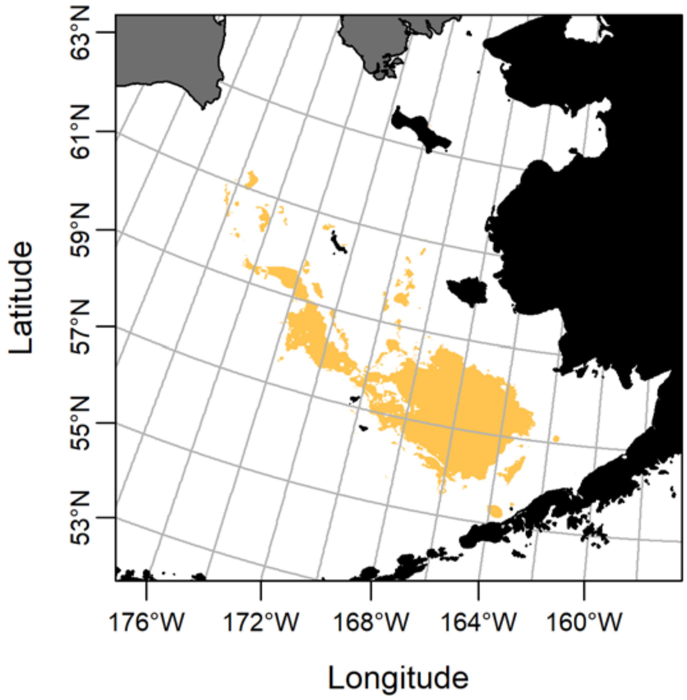

**Figure E-89 EFH distribution of EBS Alaska plaice adult, fall.**

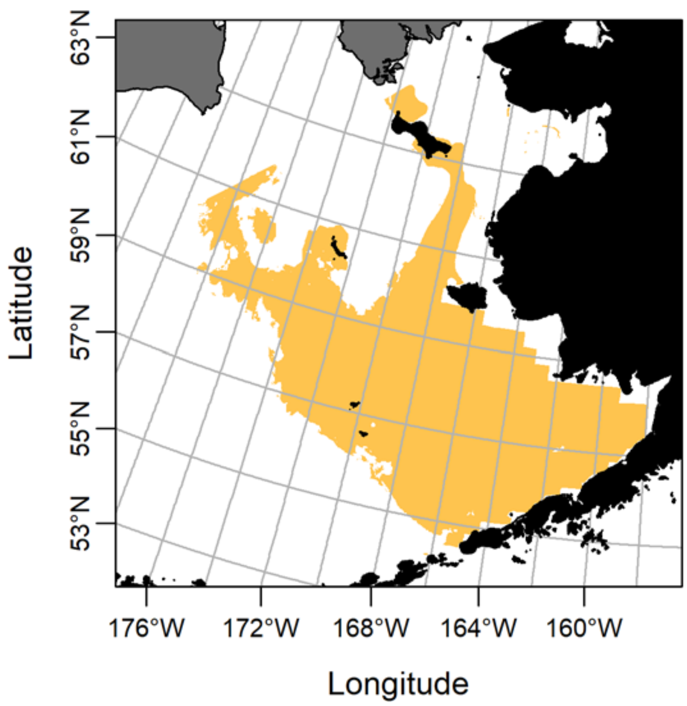

**Figure E-90 EFH distribution of EBS Alaska plaice adult, spring.**

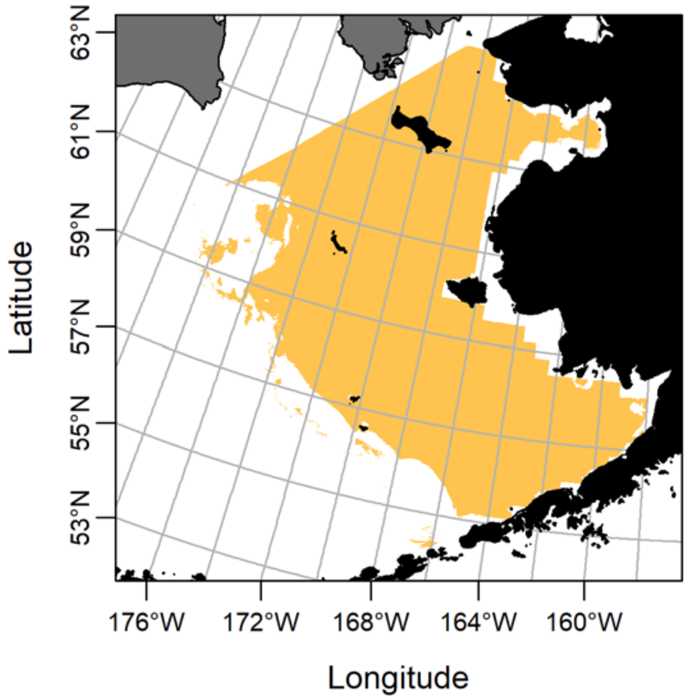


**Figure E-91 EFH distribution of EBS Alaska plaice adult, summer.**

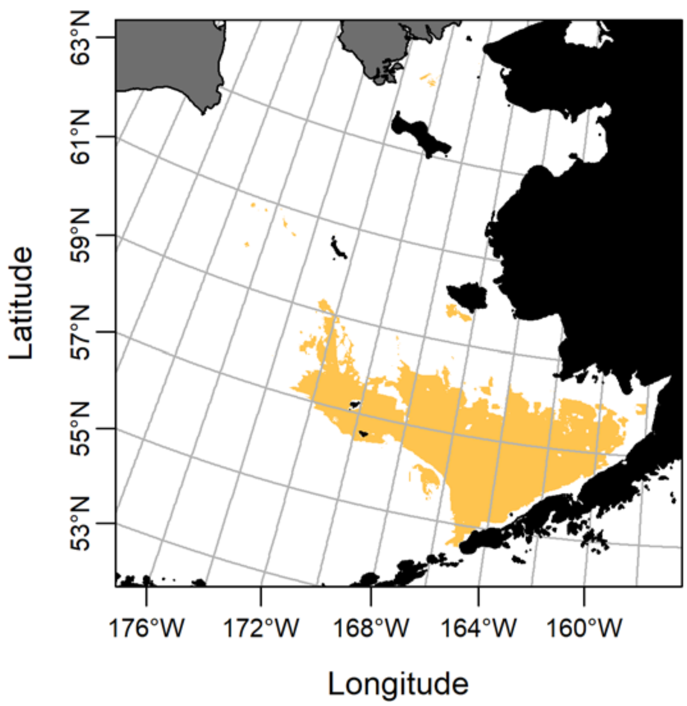


**Figure E-92 EFH distribution of EBS Alaska plaice adult, winter.**

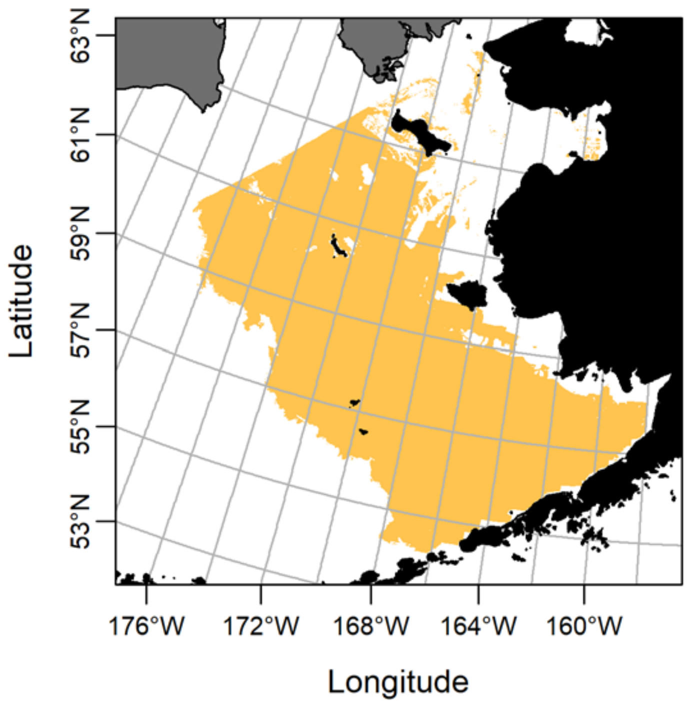


**Figure E-93 EFH distribution of EBS Alaska plaice egg, summer.**

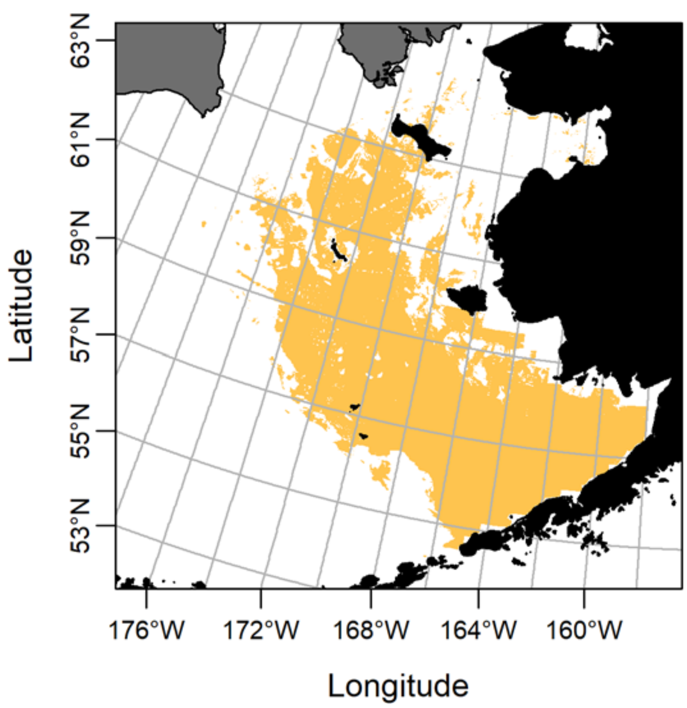


**Figure E-94 EFH distribution of EBS Alaska plaice larvae, summer.**

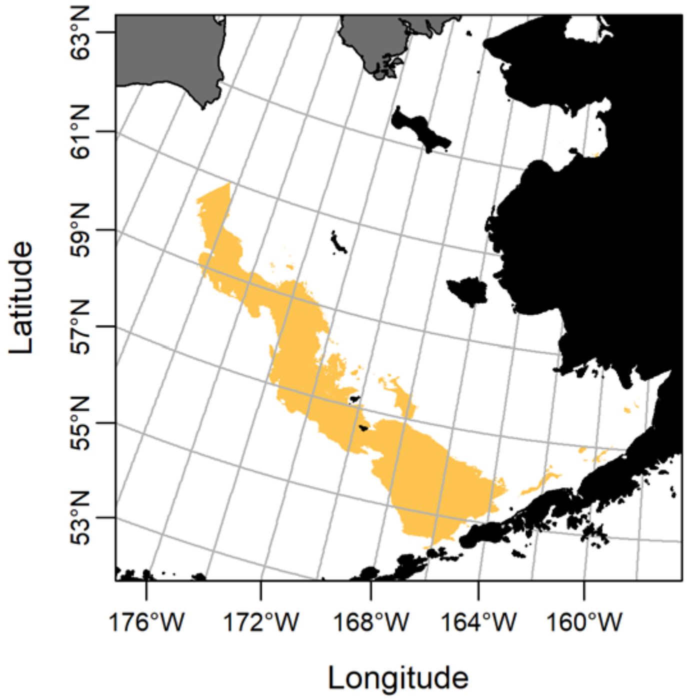


**Figure E-95 EFH distribution of EBS Rex sole adult, fall.**

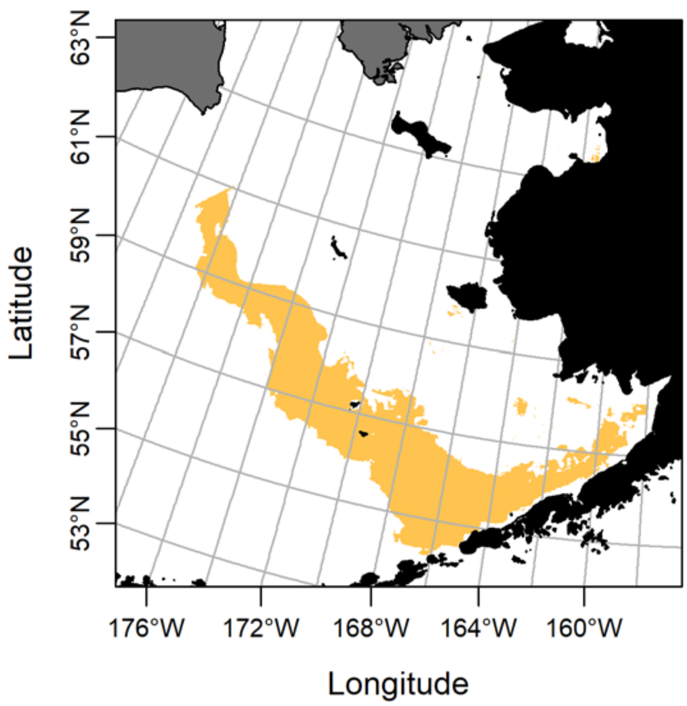


**Figure E-96 EFH distribution of EBS Rex sole adult, spring.**

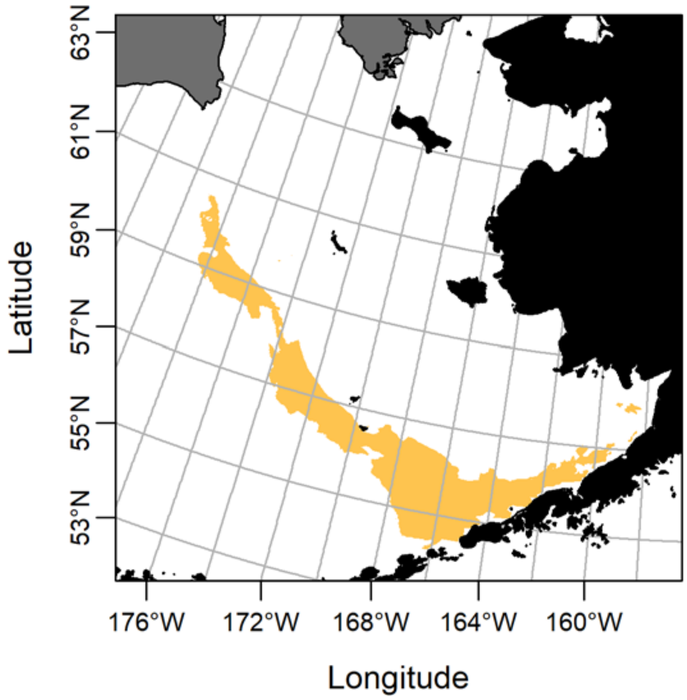


**Figure E-97 EFH distribution of EBS Rex sole adult, summer.**

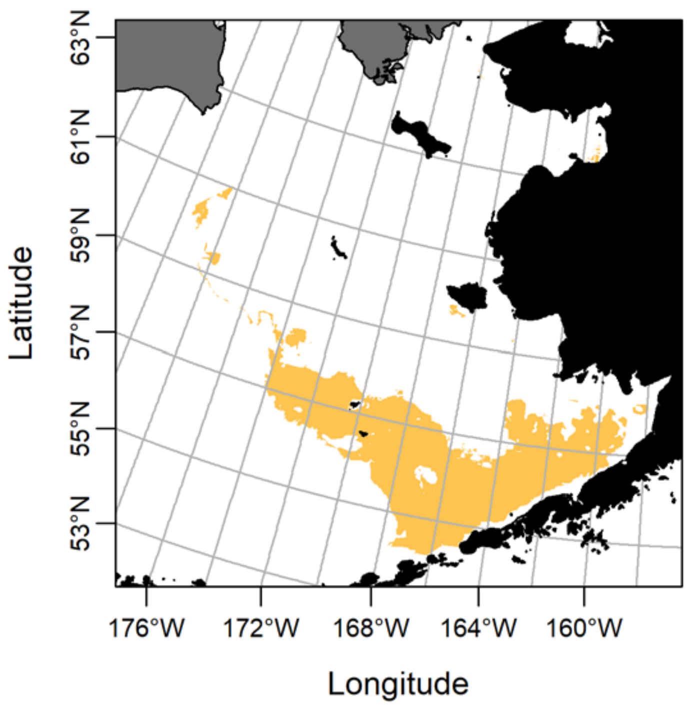


**Figure E-98 EFH distribution of EBS Rex sole adult, winter.**

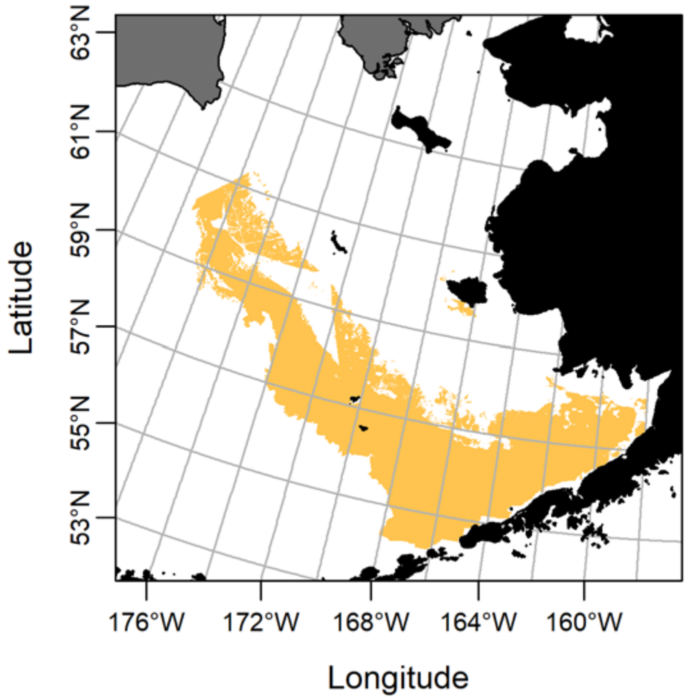


**Figure E-99 EFH distribution of EBS Rex sole egg, summer.**

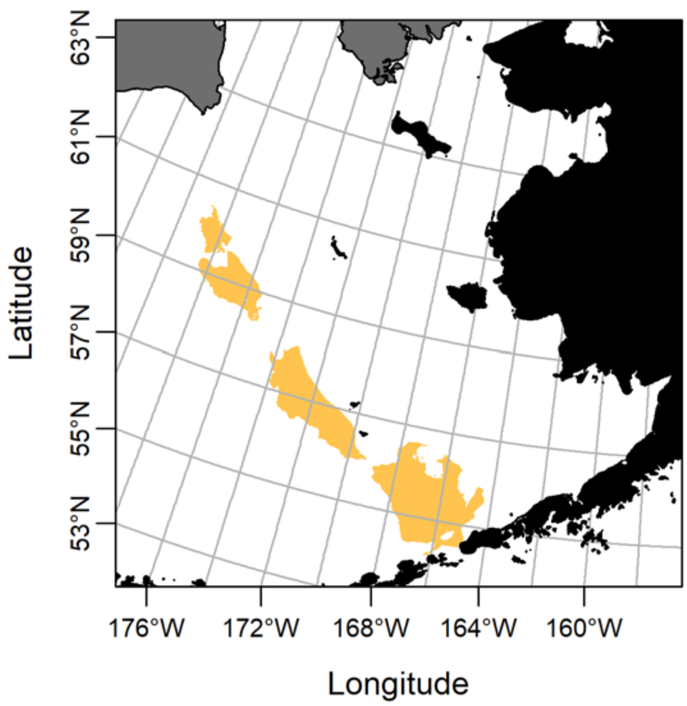


**Figure E-100 EFH distribution of EBS Rex sole juvenile, summer.**

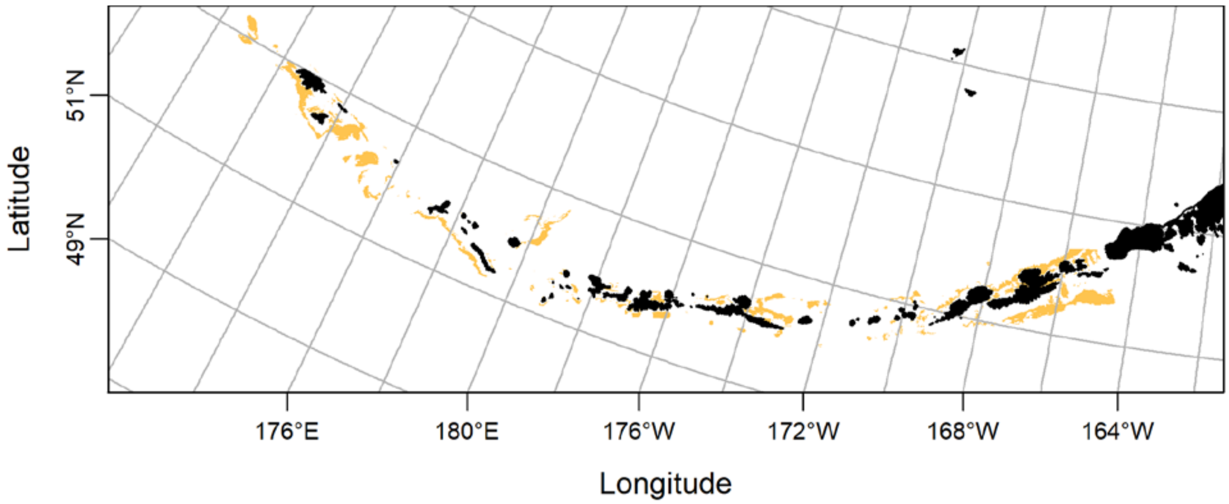


**Figure E-101 EFH distribution of AI Rex sole adult, fall.**

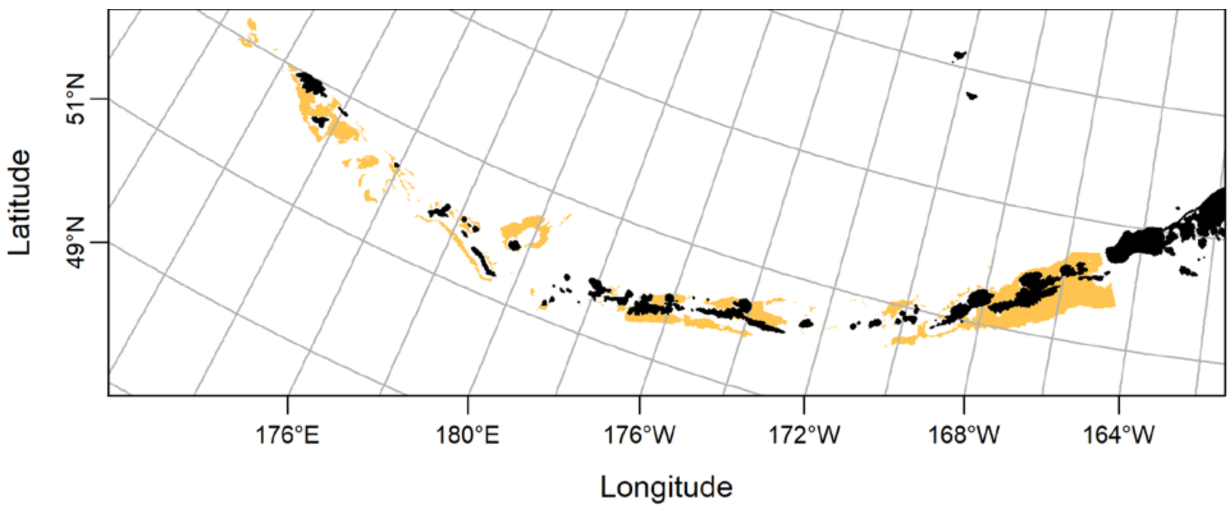


**Figure E-102 EFH distribution of AI Rex sole adult, spring.**

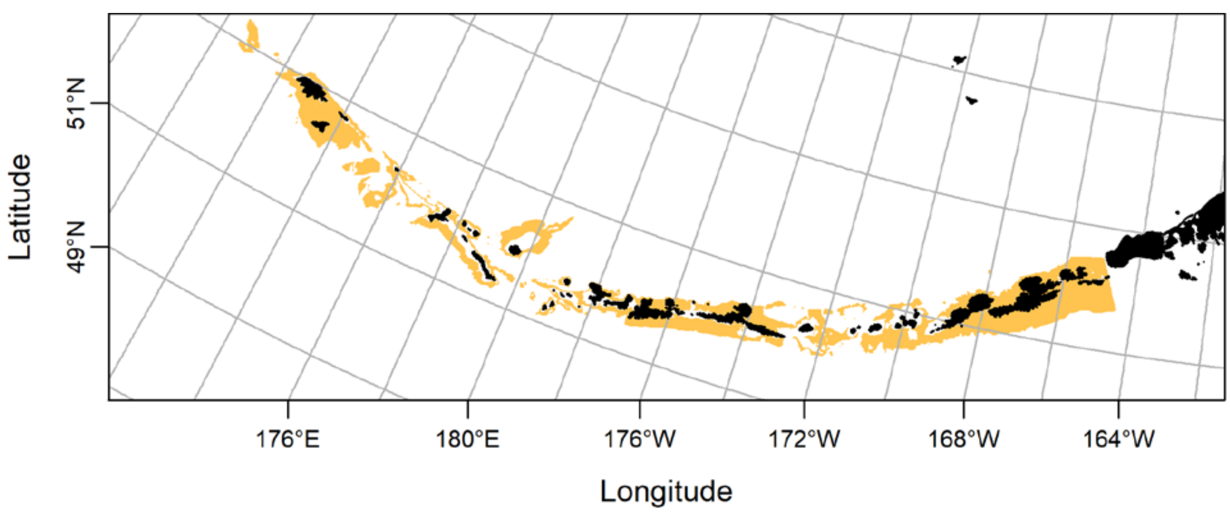


**Figure E-103 EFH distribution of AI Rex sole adult, summer.**

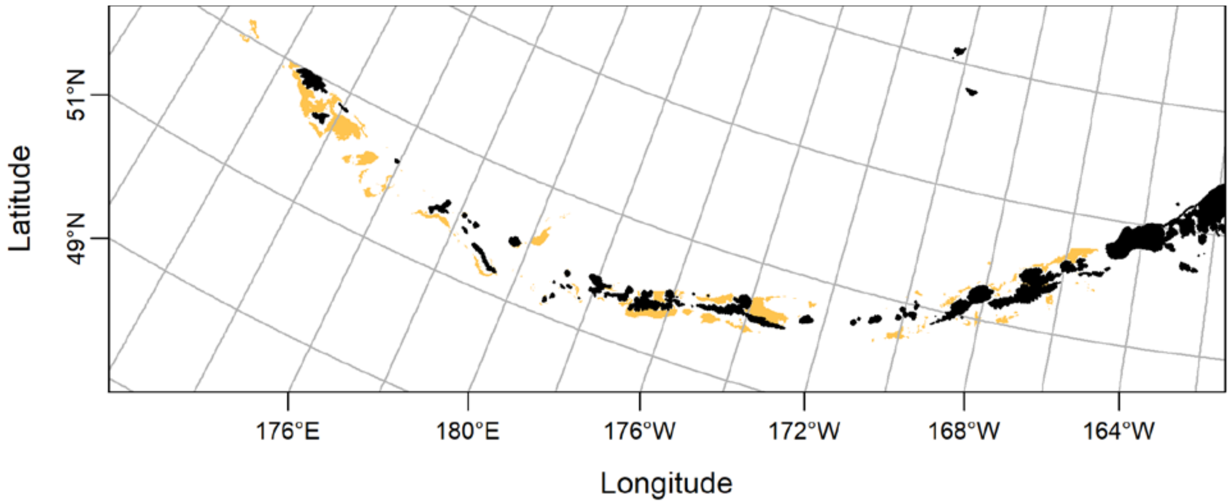


**Figure E-104 EFH distribution of AI Rex sole adult, winter.**

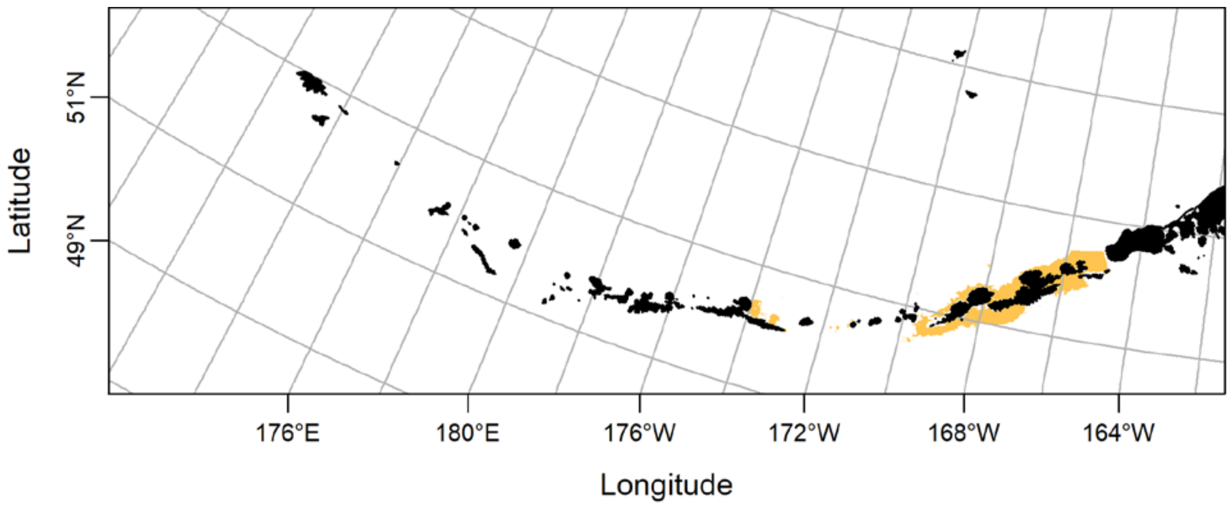


**Figure E-105 EFH distribution of AI Rex sole egg, summer.**

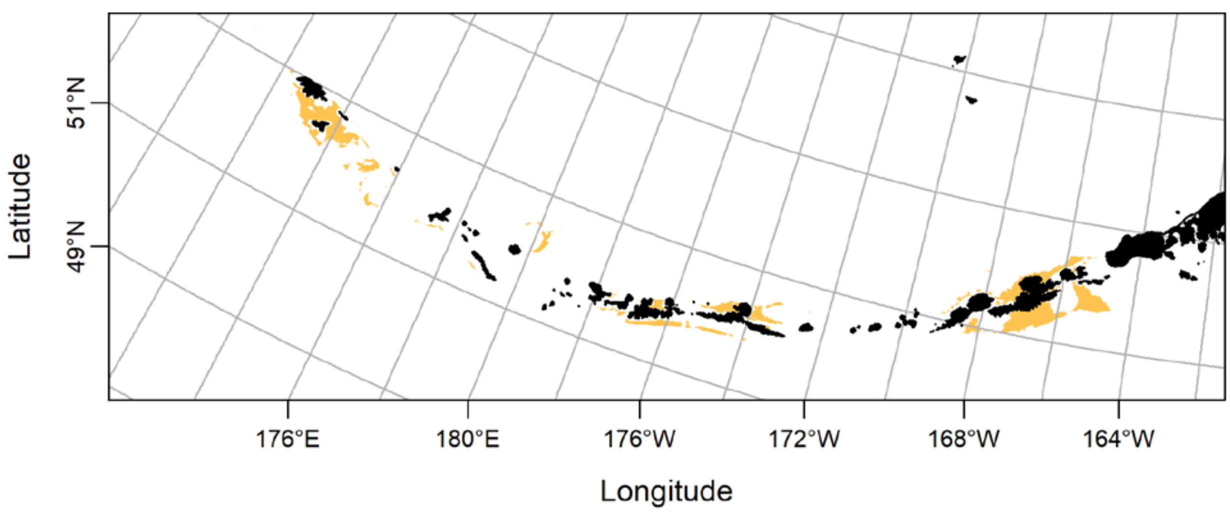


**Figure E-106 EFH distribution of AI Rex sole juvenile, summer.**

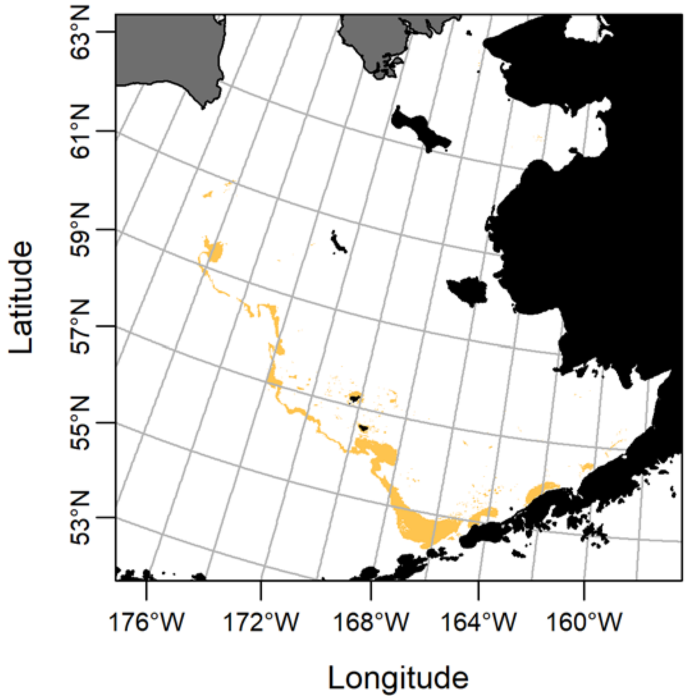


**Figure E-107 EFH distribution of EBS Dover sole adult, spring.**

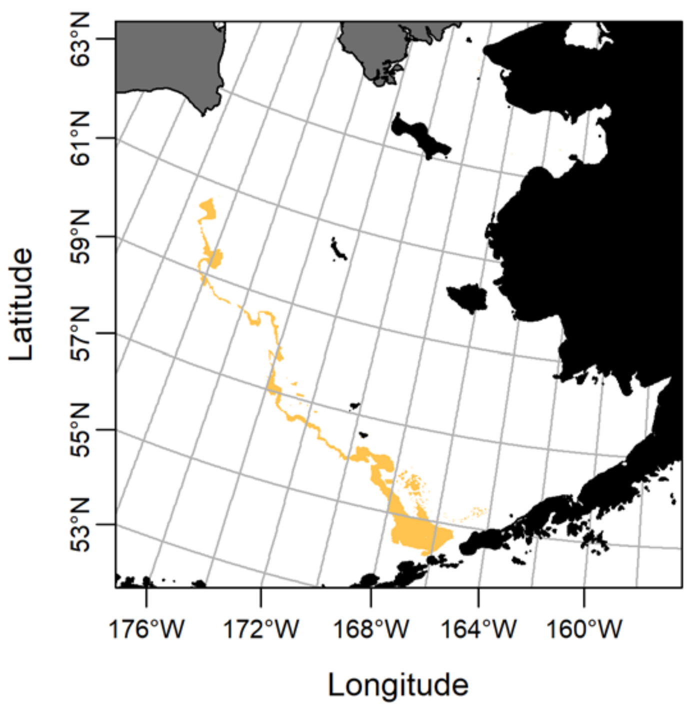


**Figure E-108 EFH distribution of EBS Dover sole adult, summer.**

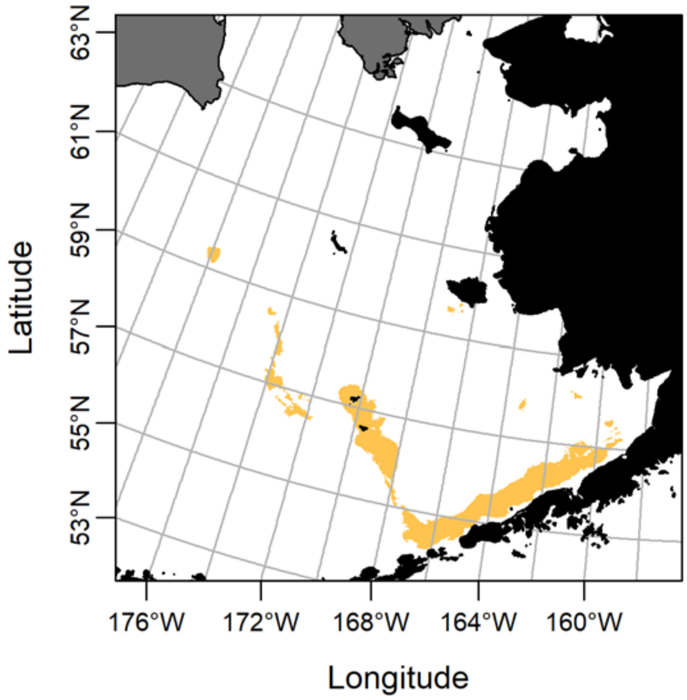


**Figure E-109 EFH distribution of EBS Dover sole adult, winter.**

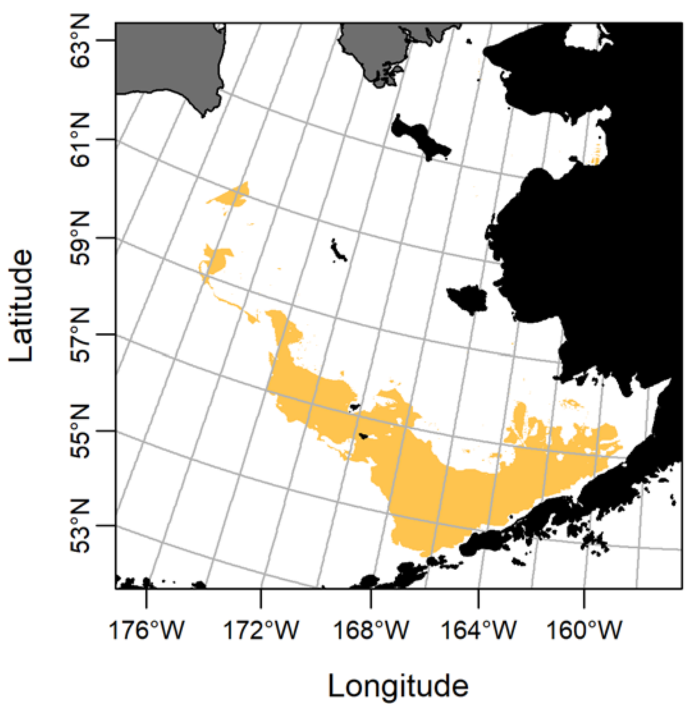


**Figure E-110 EFH distribution of EBS Dover sole juvenile, summer.**

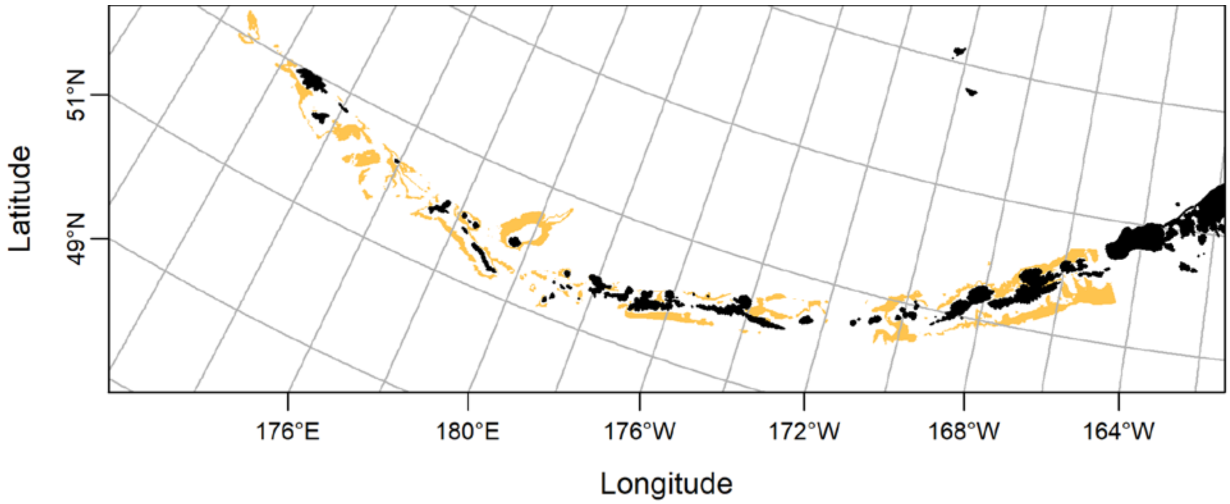


**Figure E-111 EFH distribution of AI Dover sole adult, spring.**

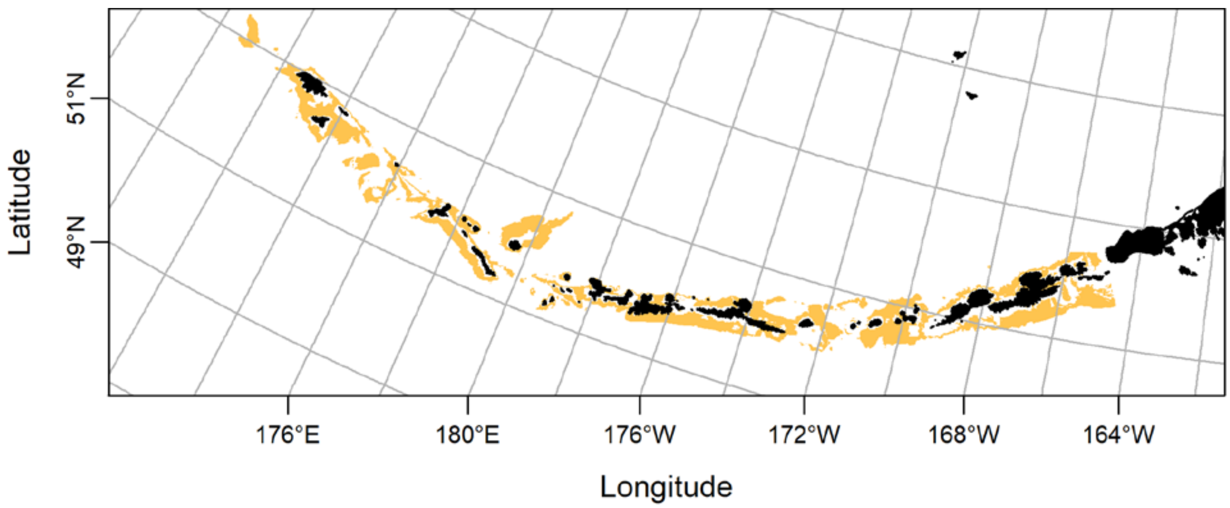


**Figure E-112 EFH distribution of AI Dover sole adult, summer.**

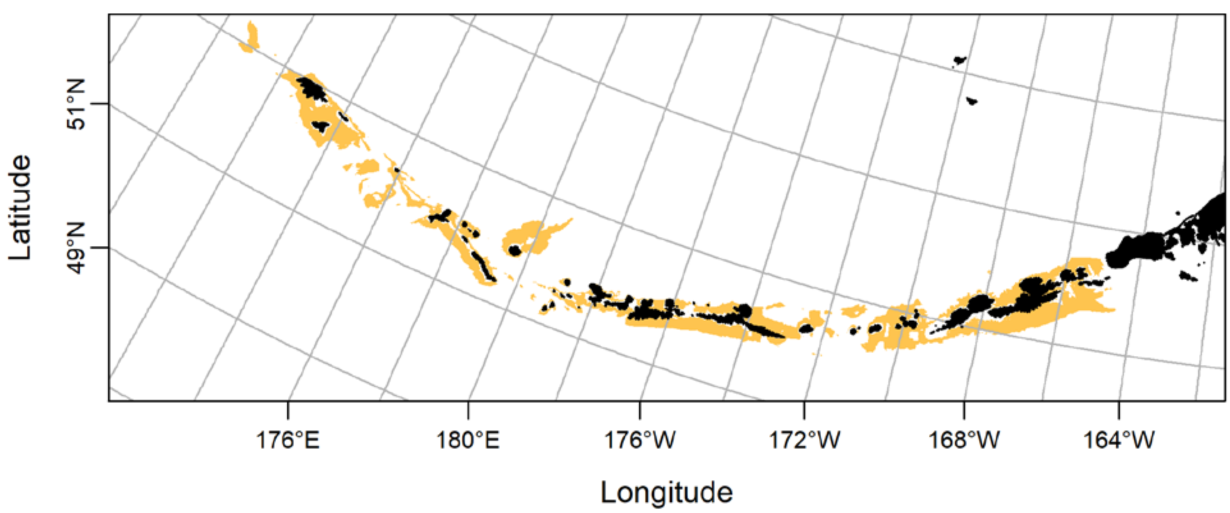


**Figure E-113 EFH distribution of AI Dover sole juvenile, summer.**

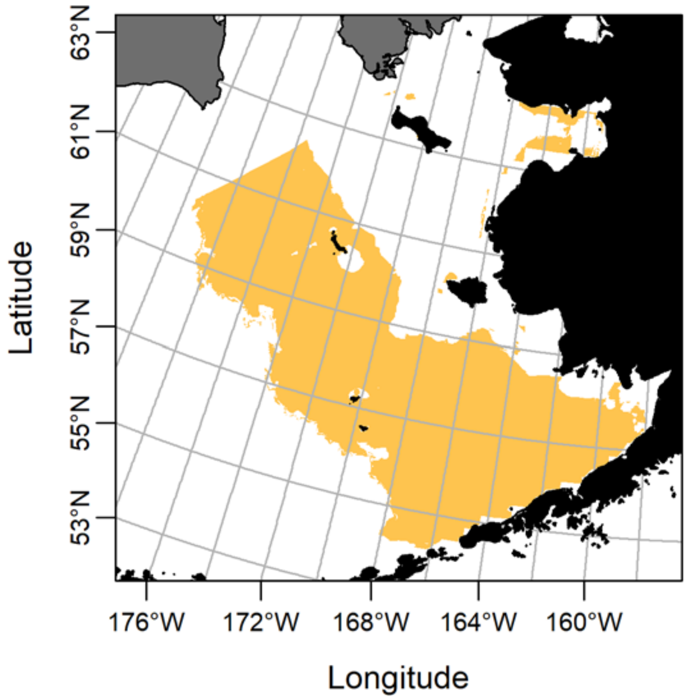


**Figure E-114 EFH distribution of EBS Flathead sole juvenile, summer.**

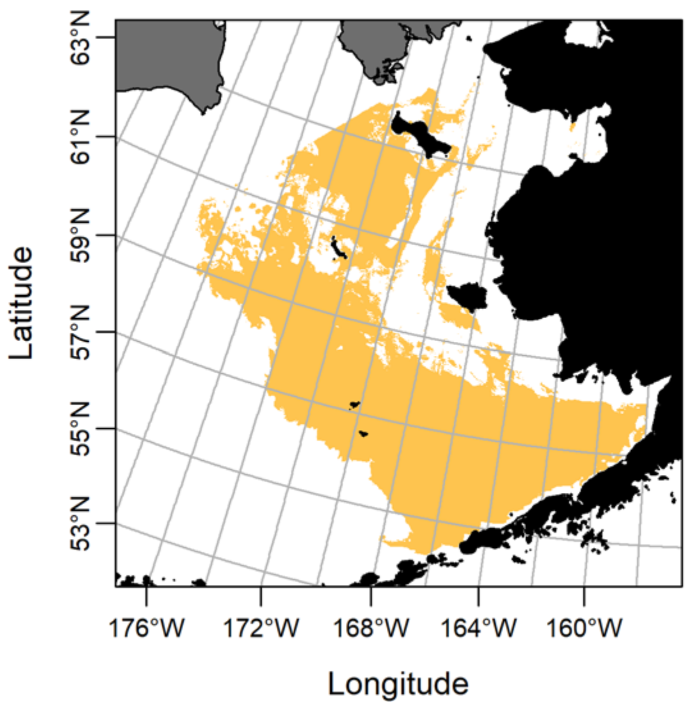


**Figure E-115 EFH distribution of EBS Flathead sole larvae, summer.**

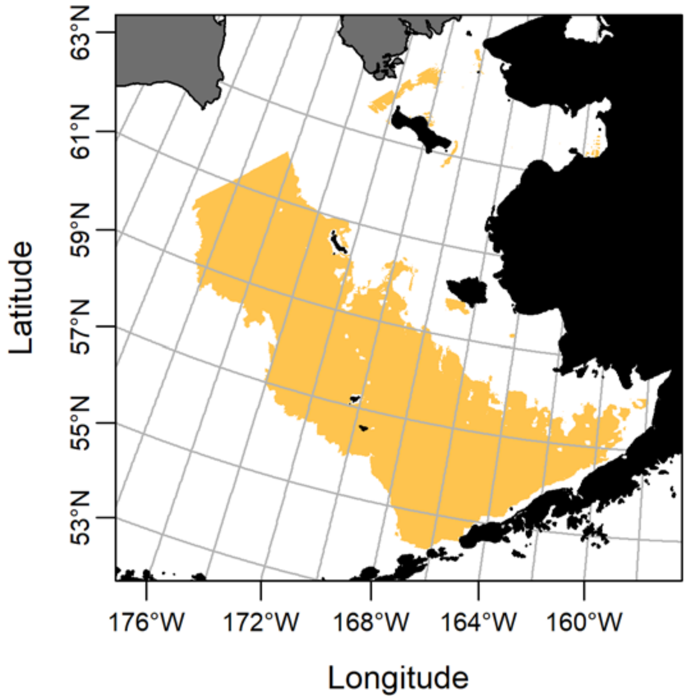


**Figure E-116 EFH distribution of EBS Flathead sole adult, fall.**

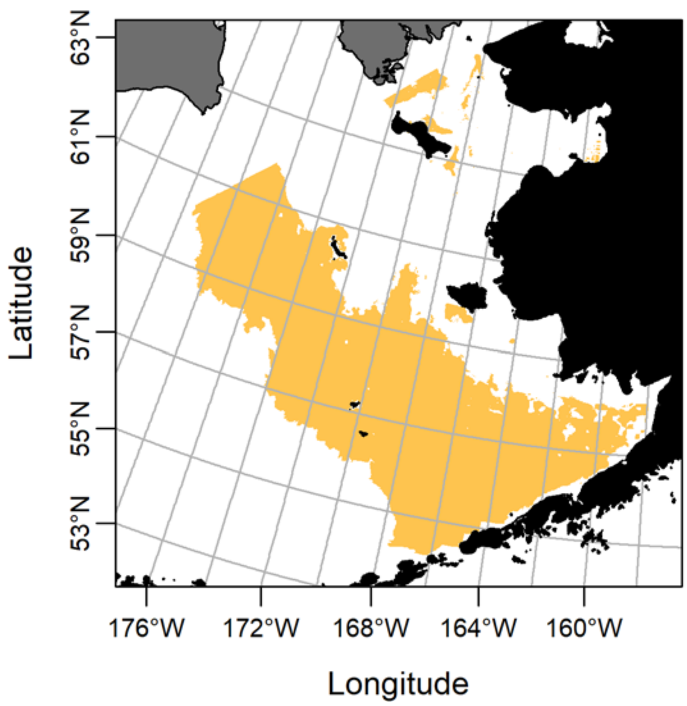


**Figure E-117 EFH distribution of EBS Flathead sole adult, spring.**

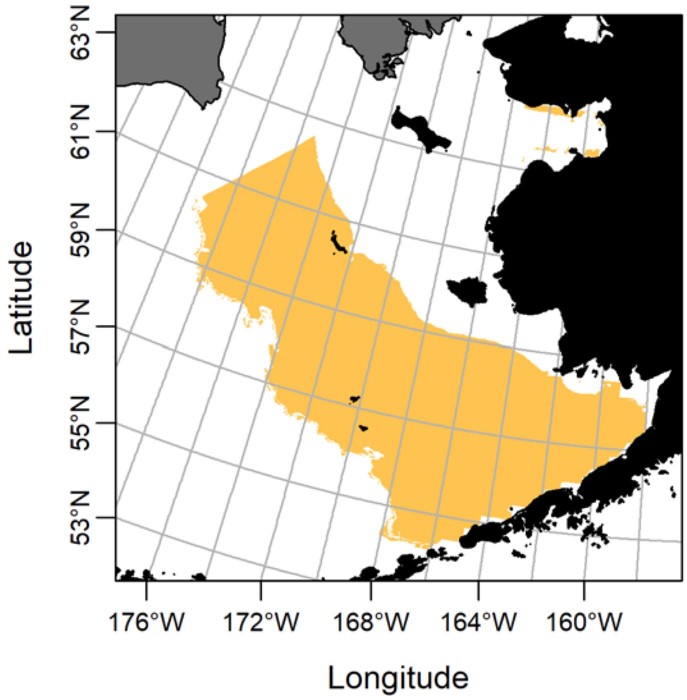


**Figure E-118 EFH distribution of EBS Flathead sole adult, summer.**

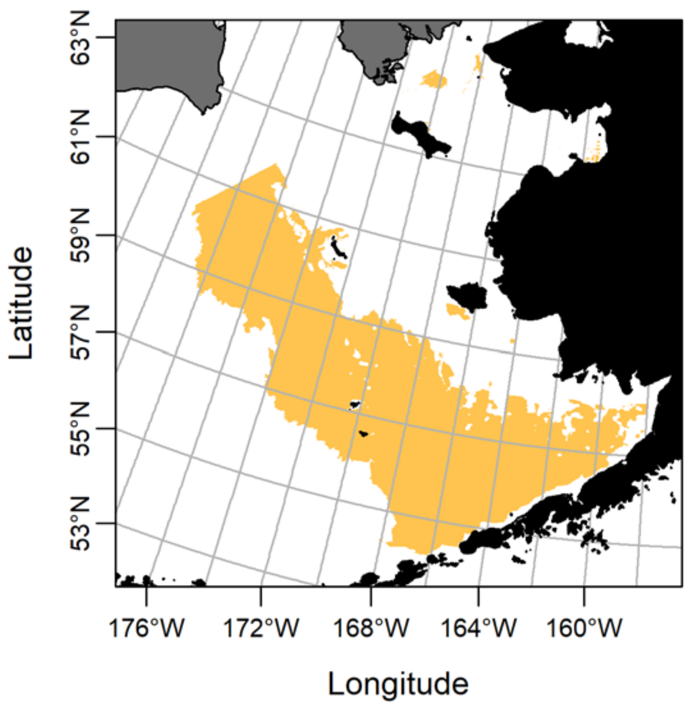


**Figure E-119 EFH distribution of EBS Flathead sole adult, winter.**

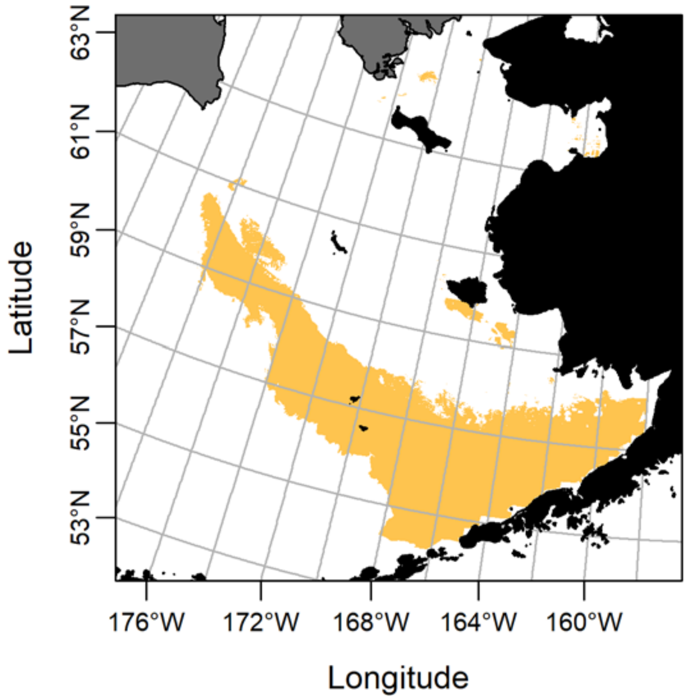


**Figure E-120 EFH distribution of EBS Flathead sole egg, summer.**

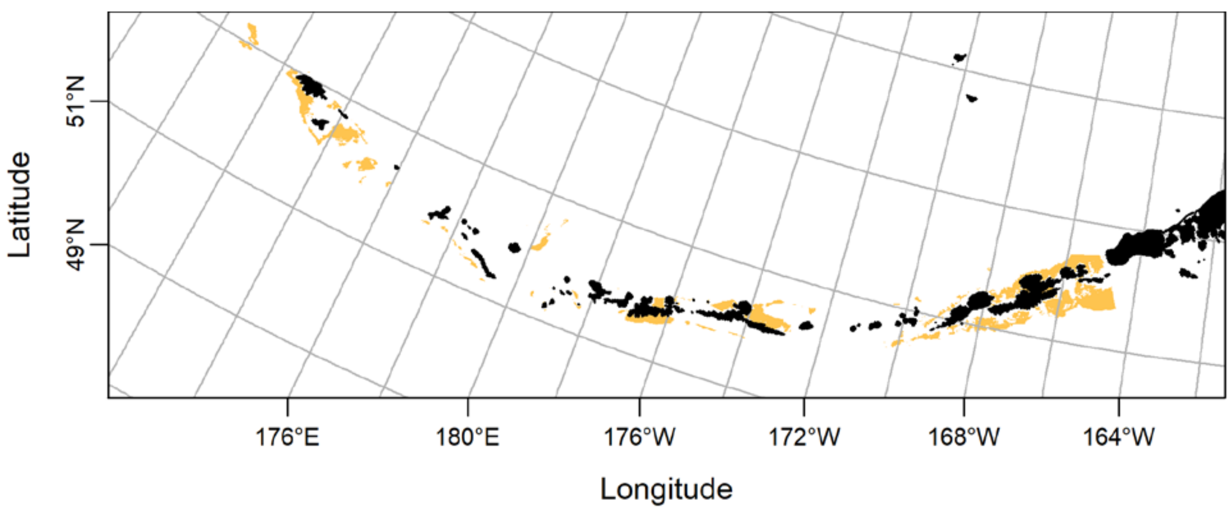


**Figure E-121 EFH distribution of AI Flathead sole adult, fall.**

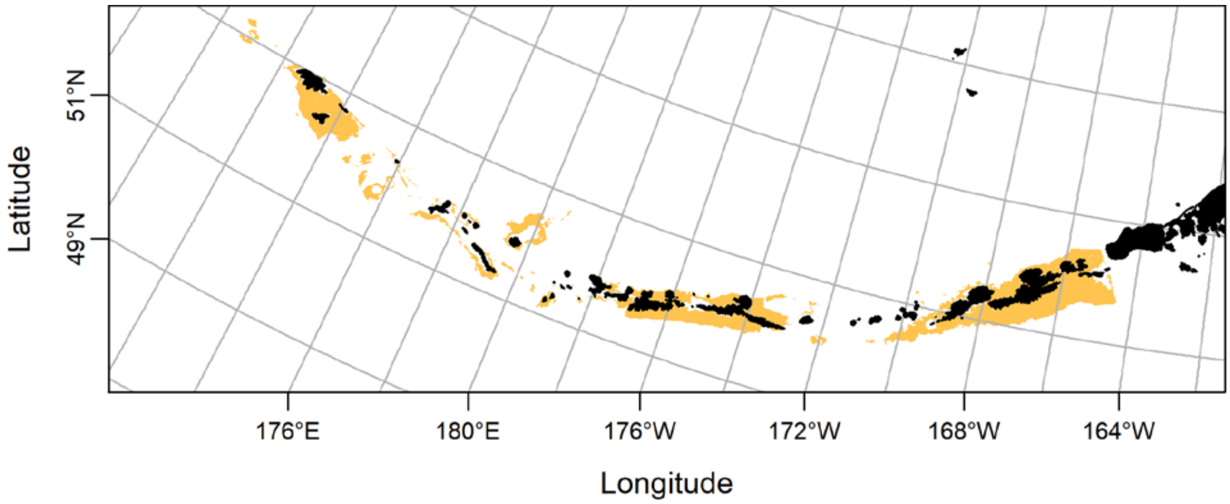


**Figure E-122 EFH distribution of AI Flathead sole adult, spring.**

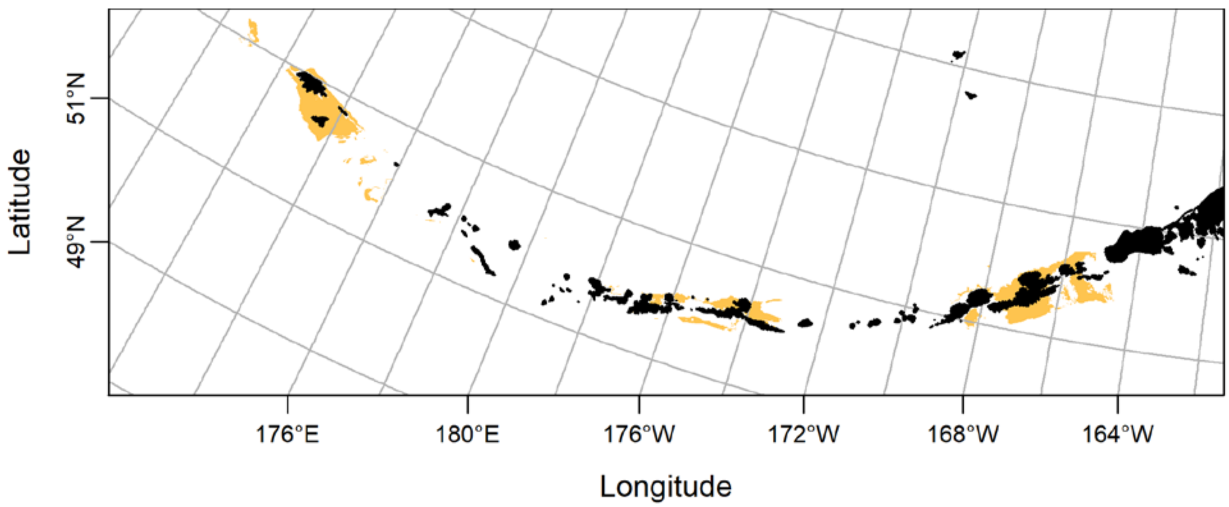


**Figure E-123 EFH distribution of AI Flathead sole adult, summer.**

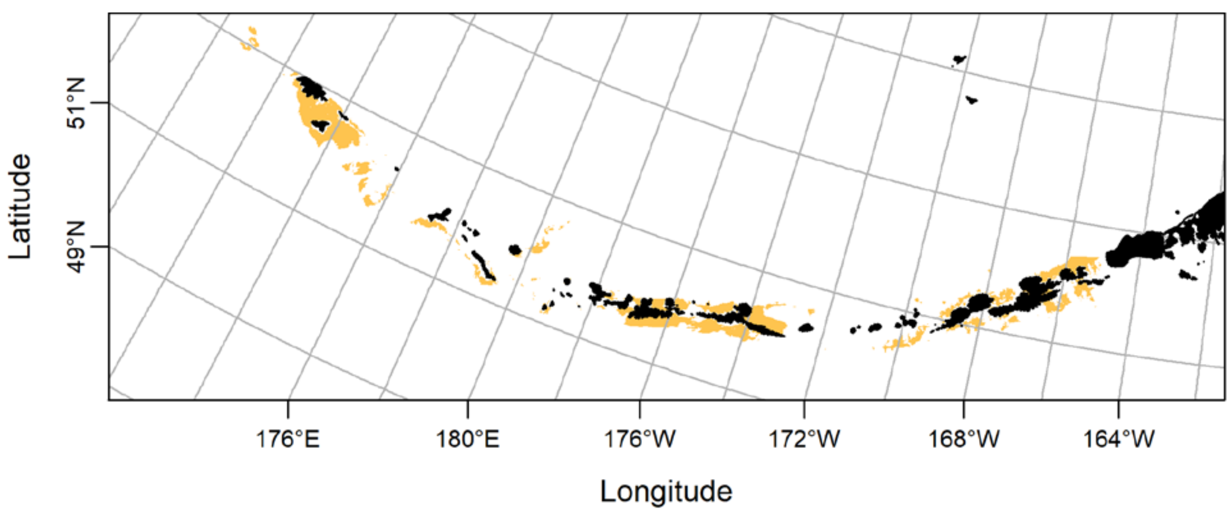


**Figure E-124 EFH distribution of AI Flathead sole adult, winter.**

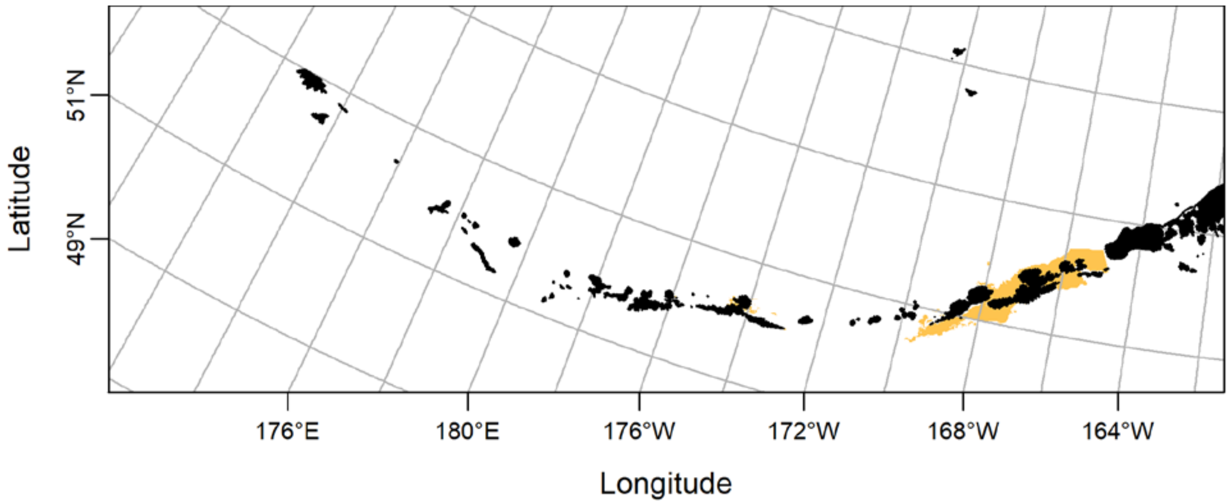


**Figure E-125 EFH distribution of AI Flathead sole egg, summer.**

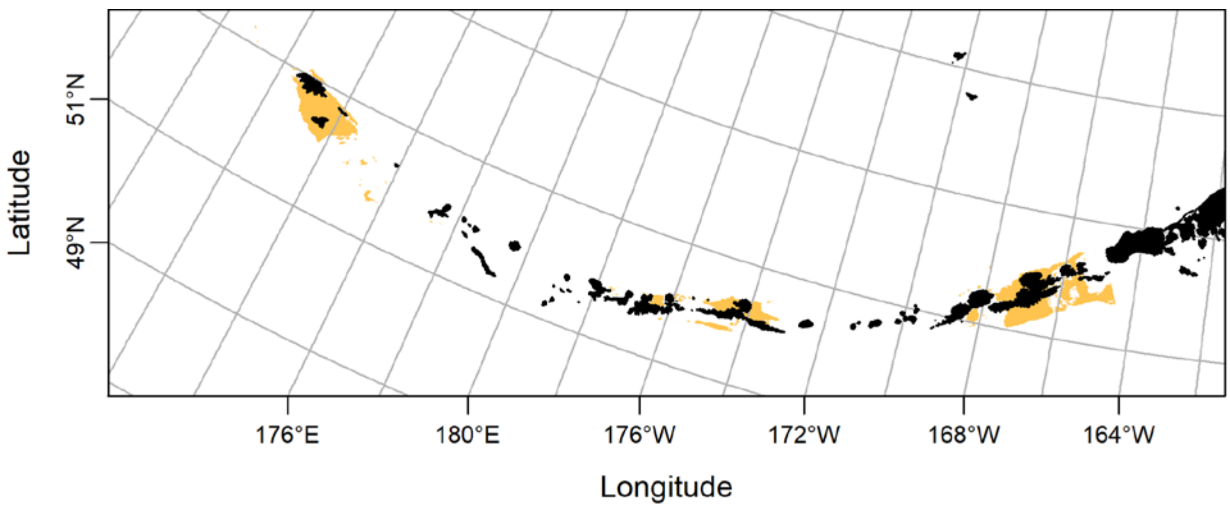


**Figure E-126 EFH distribution of AI Flathead sole juvenile, summer.**

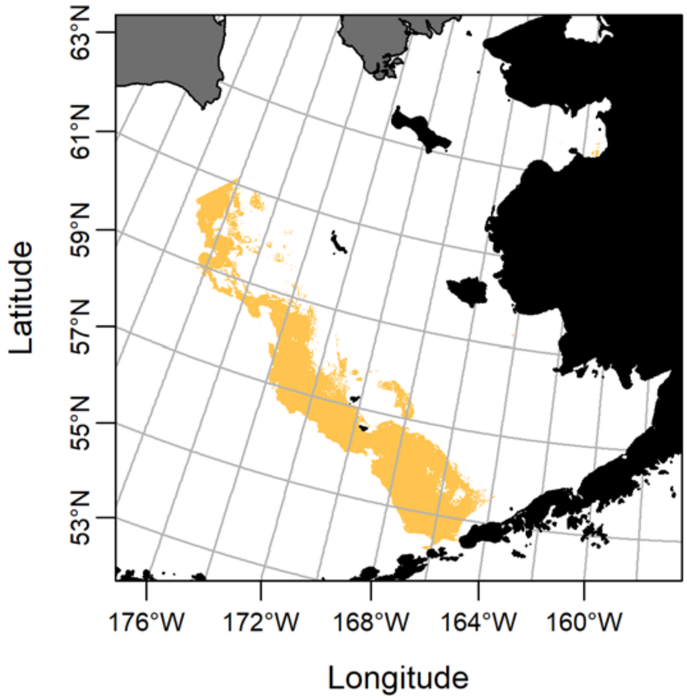


**Figure E-127 EFH distribution of EBS Pacific ocean perch adult, fall.**

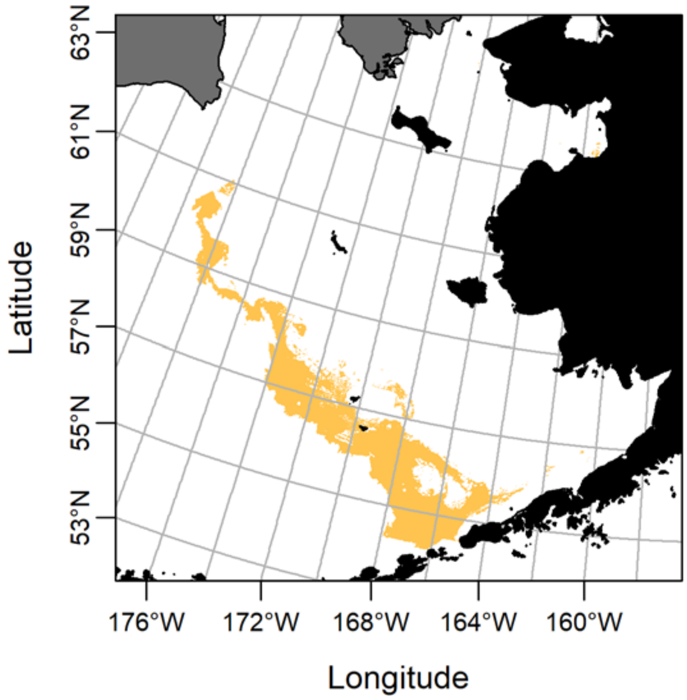


**Figure E-128 EFH distribution of EBS Pacific ocean perch adult, spring.**

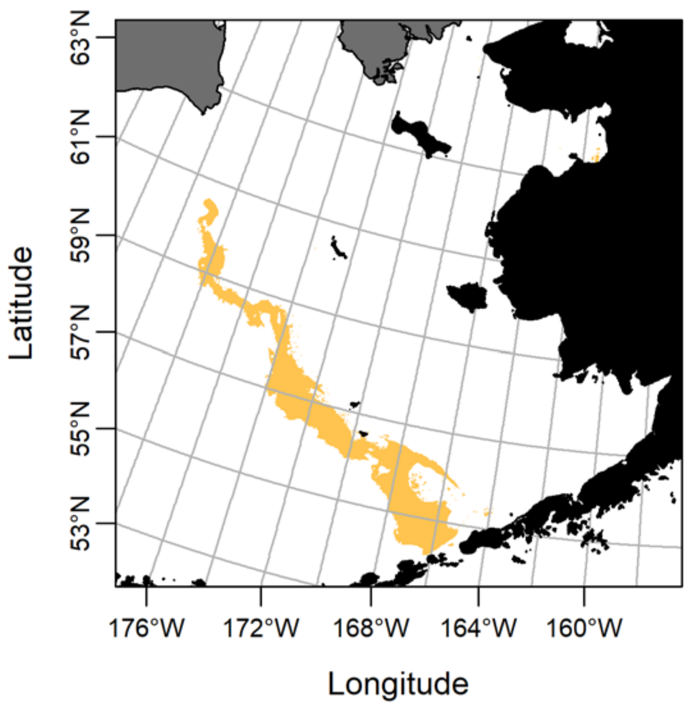


**Figure E-129 EFH distribution of EBS Pacific ocean perch adult, summer.**

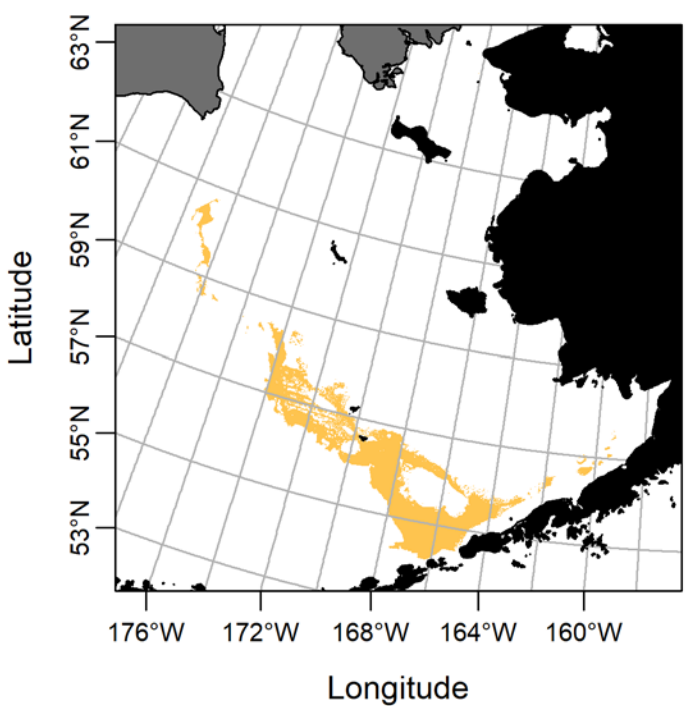


**Figure E-130 EFH distribution of EBS Pacific ocean perch adult, winter.**

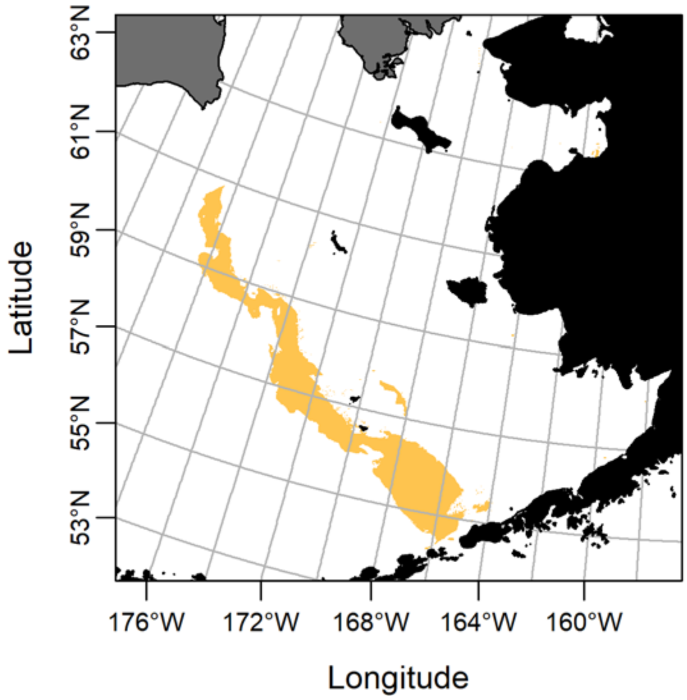


**Figure E-131 EFH distribution of EBS Pacific ocean perch juvenile, summer.**

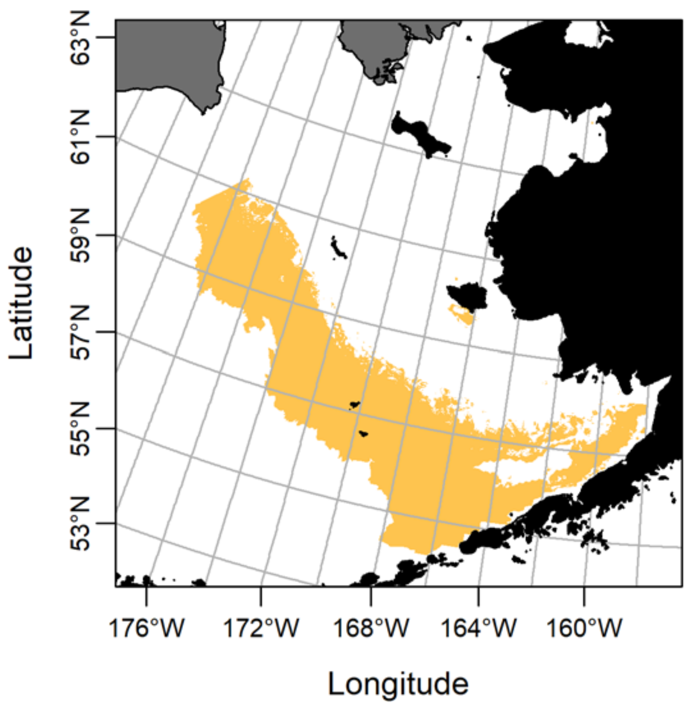


**Figure E-132 EFH distribution of EBS Pacific ocean perch larvae, summer.**

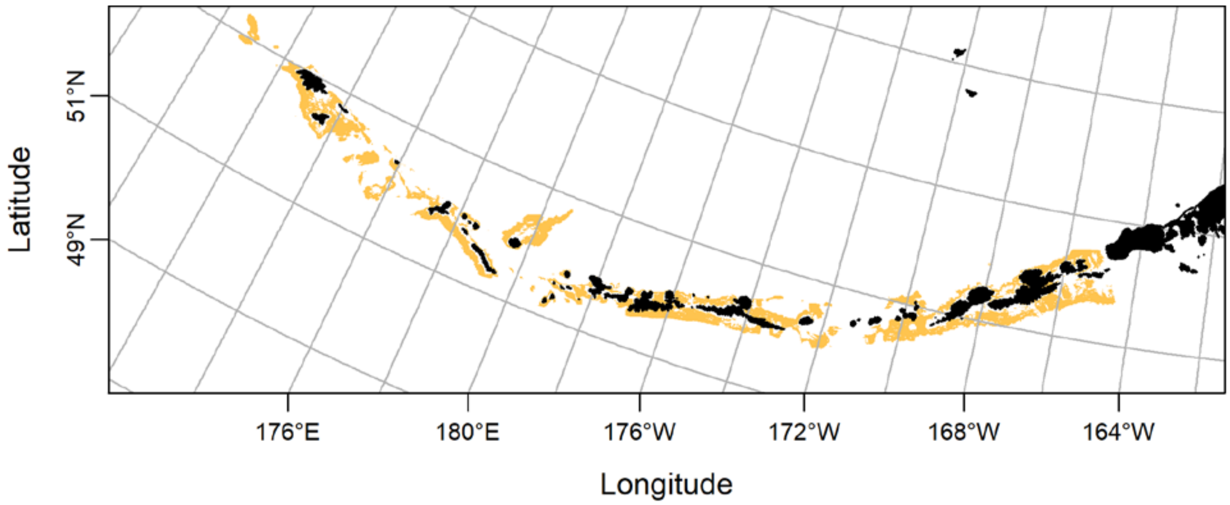


**Figure E-133 EFH distribution of AI Pacific ocean perch adult, fall.**

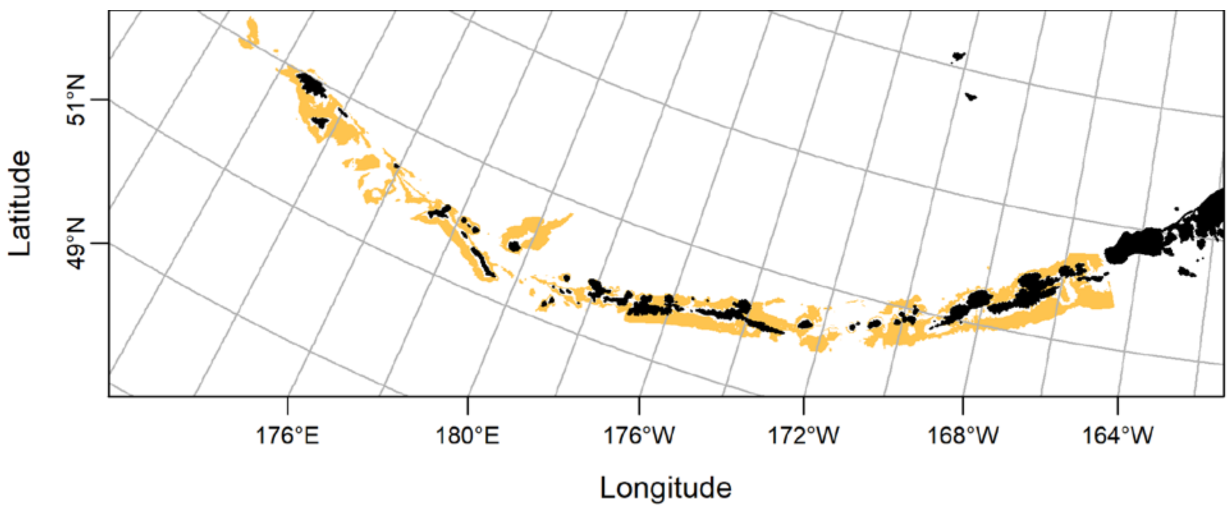


**Figure E-134 EFH distribution of AI Pacific ocean perch adult, spring.**

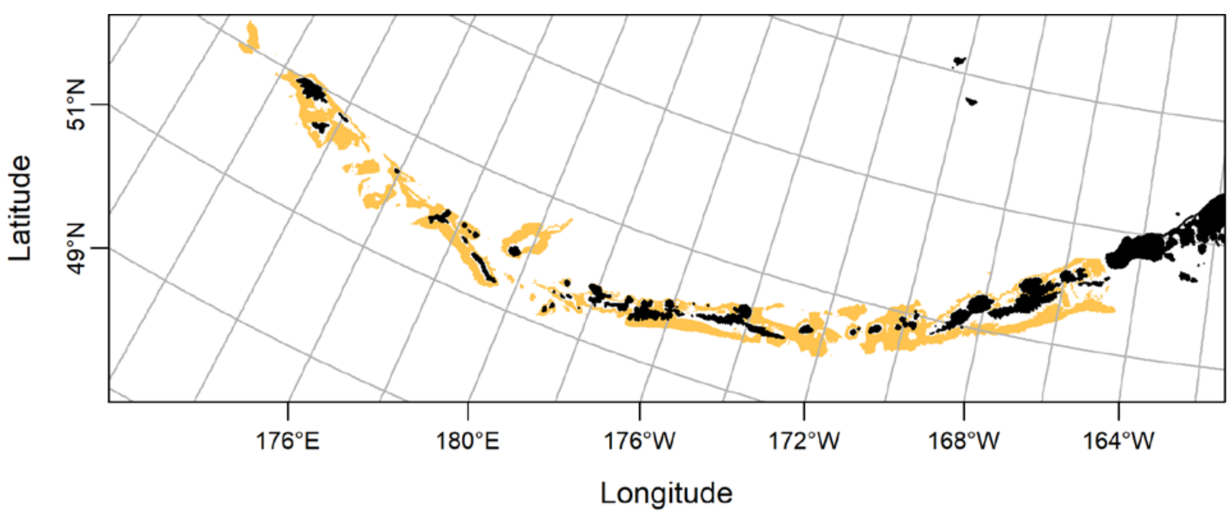


**Figure E-135 EFH distribution of AI Pacific ocean perch adult, summer.**

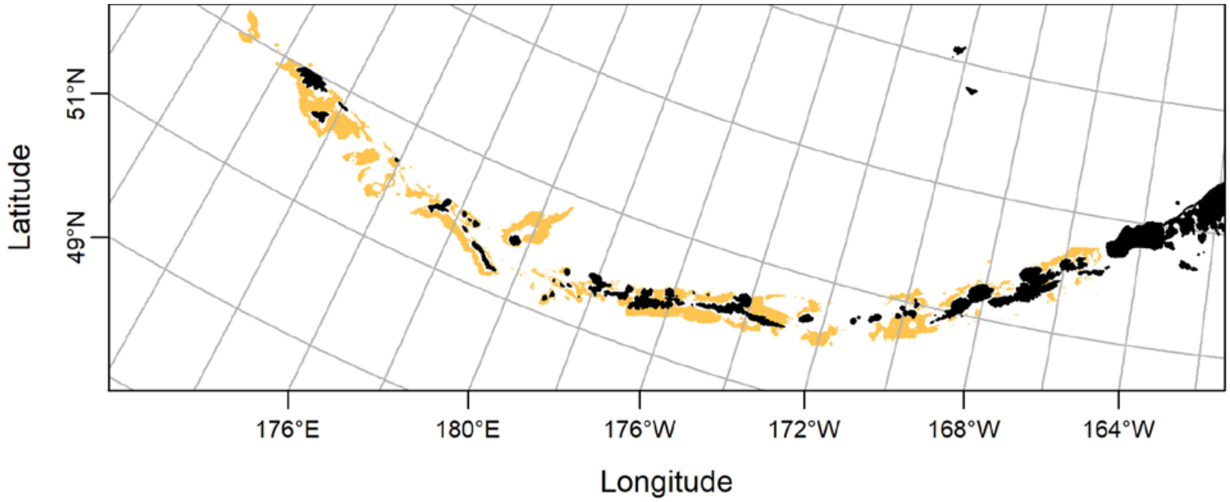


**Figure E-136 EFH distribution of AI Pacific ocean perch adult, winter.**

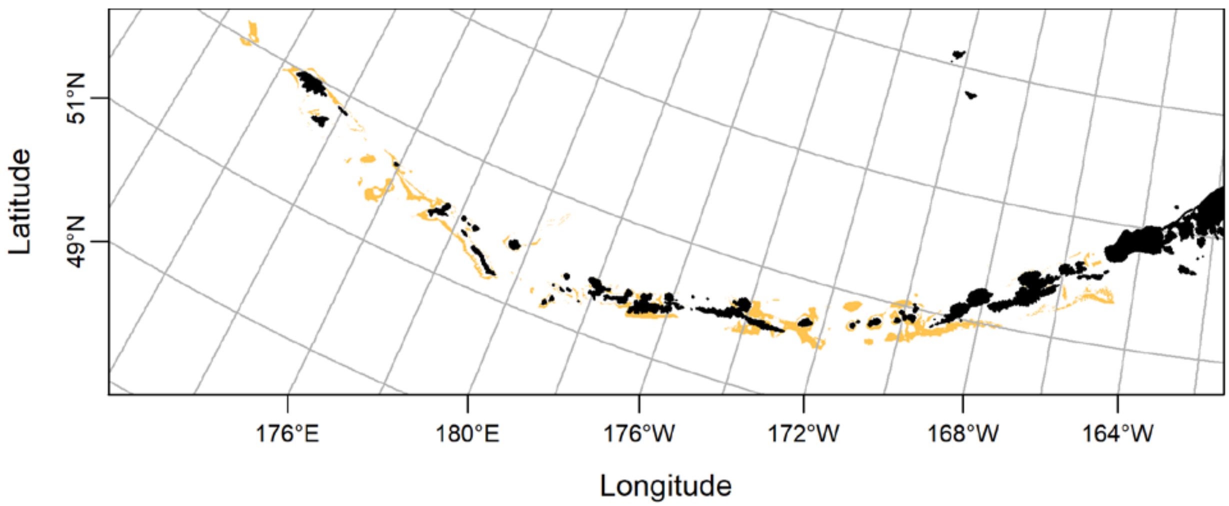


**Figure E-137 EFH distribution of AI Pacific ocean perch juvenile, summer.**

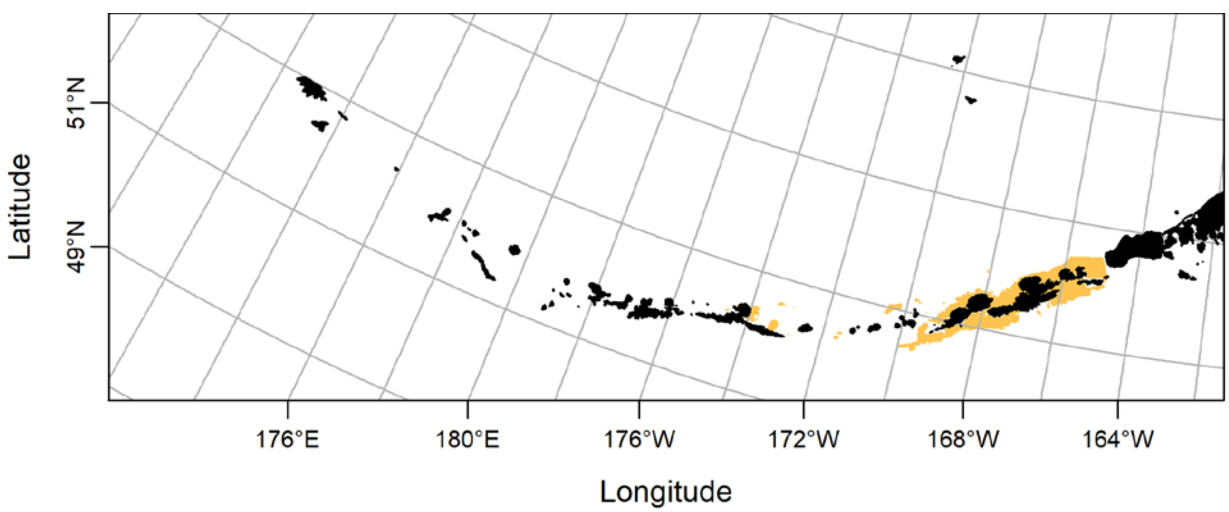

**Figure E-138 EFH distribution of AI Pacific ocean perch larvae, summer.**

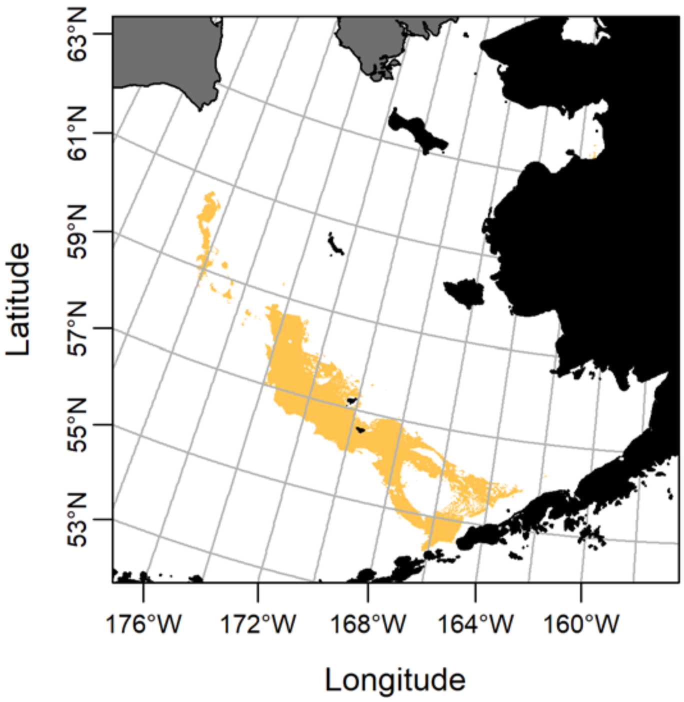


**Figure E-139 EFH distribution of EBS Northern rockfish adult, spring.**

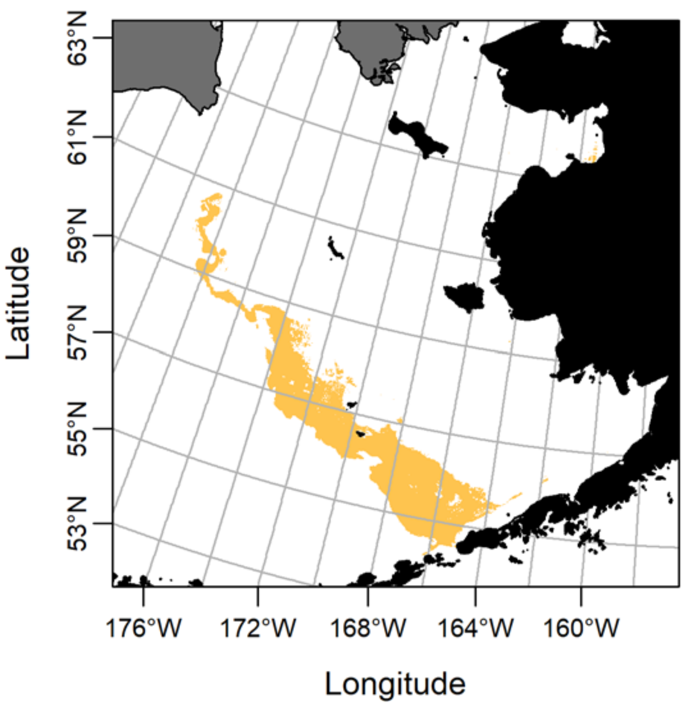


**Figure E-140 EFH distribution of EBS Northern rockfish adult, fall.**

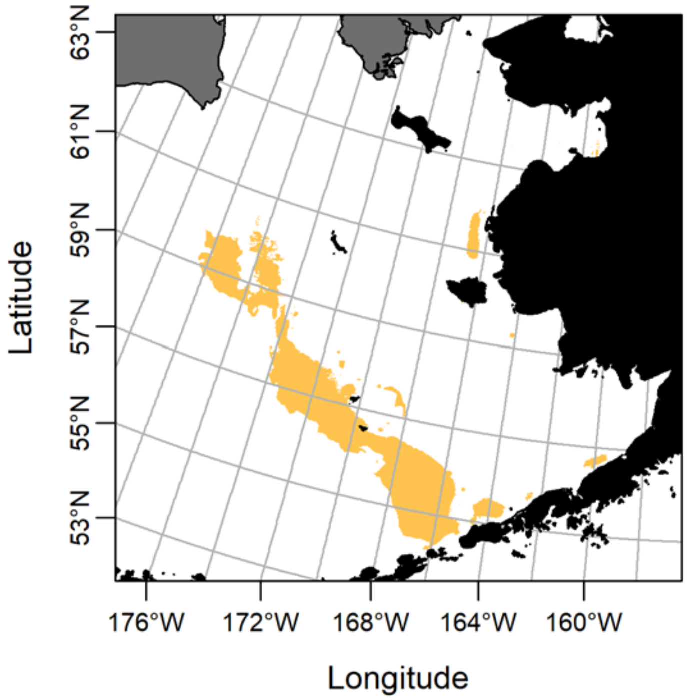

**Figure E-141 EFH distribution of EBS Northern rockfish adult, summer.**

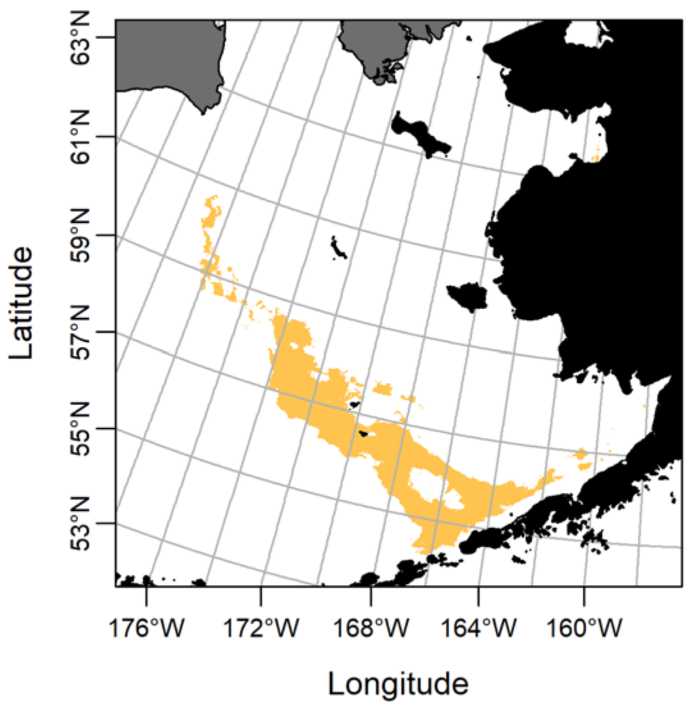

**Figure E-142 EFH distribution of EBS Northern rockfish adult, winter.**

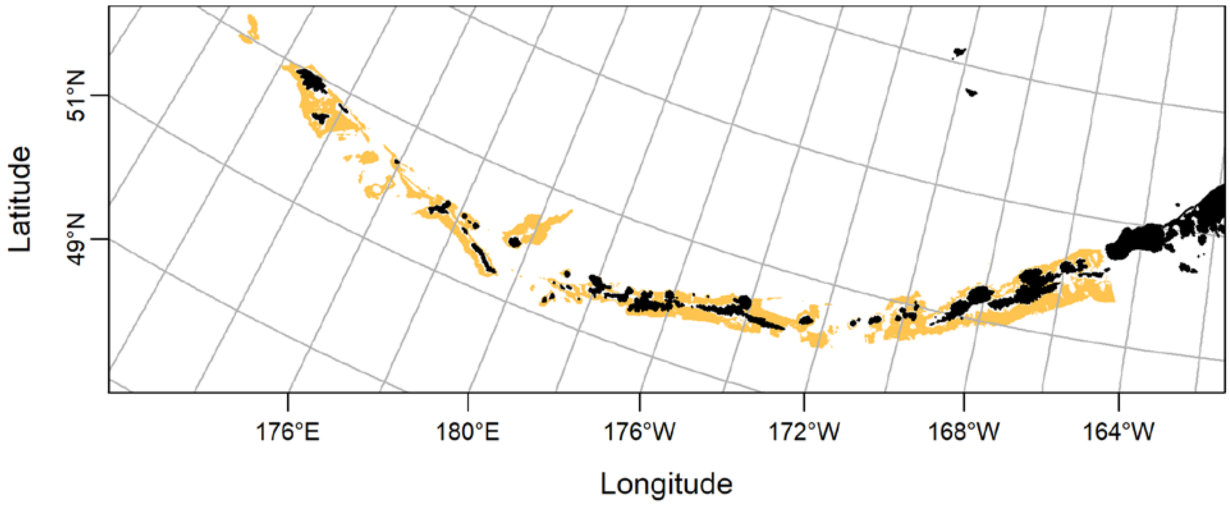


**Figure E-143 EFH distribution of AI Northern rockfish adult, fall.**

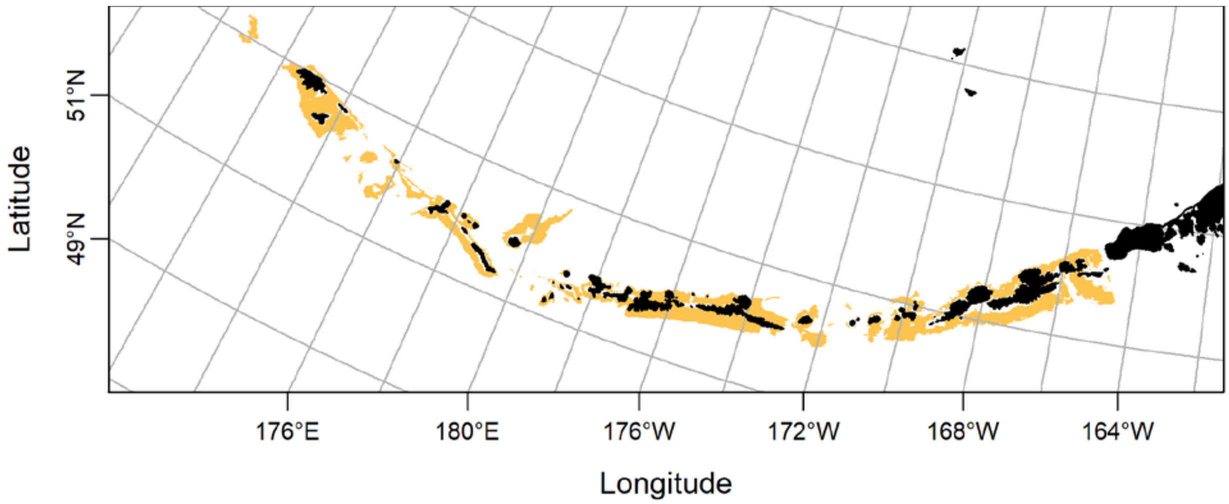


**Figure E-144 EFH distribution of AI Northern rockfish adult, spring.**

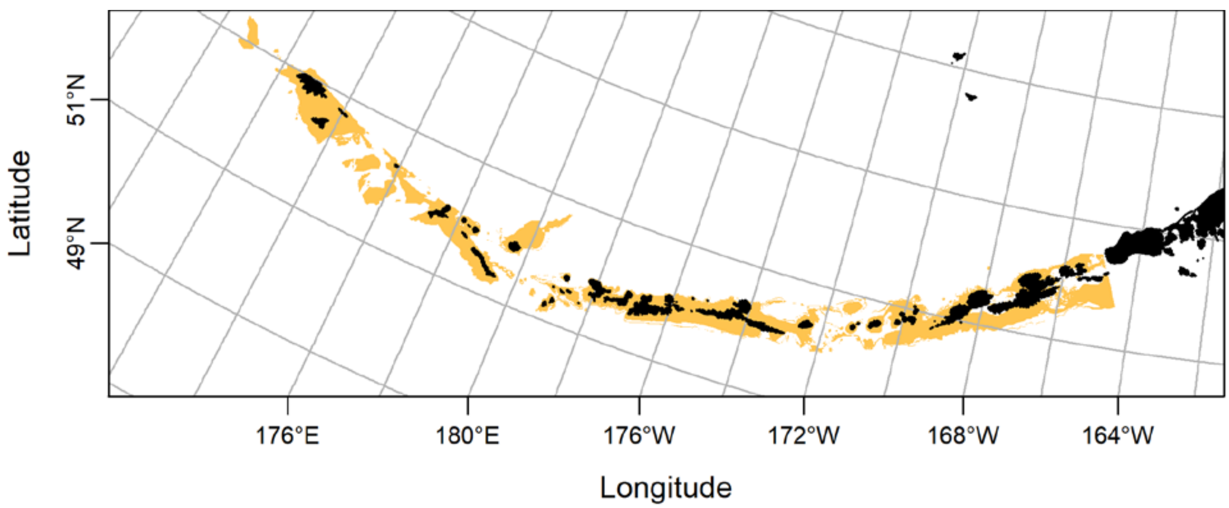


**Figure E-145 EFH distribution of AI Northern rockfish adult, summer.**

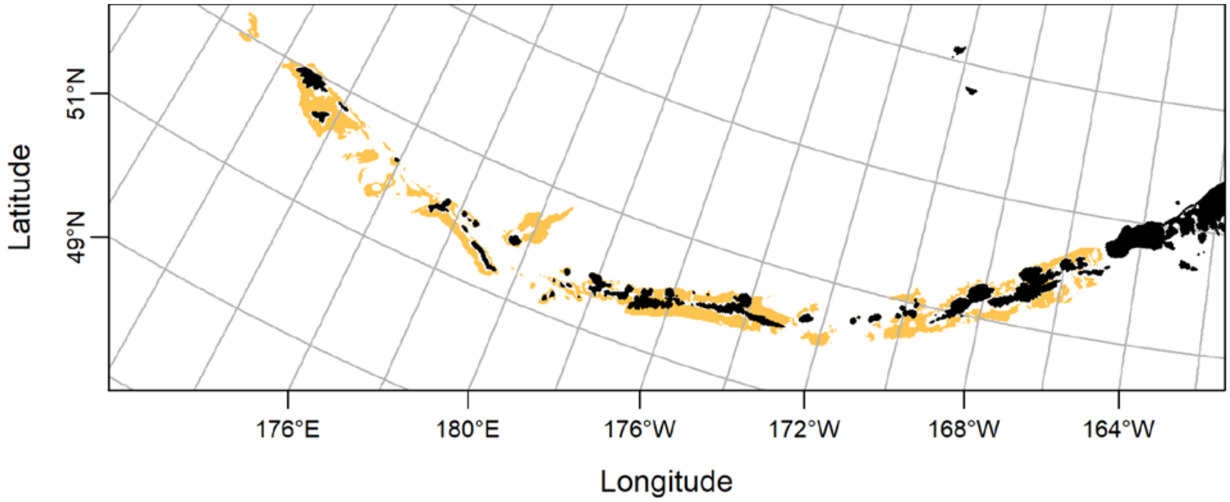


**Figure E-146 EFH distribution of AI Northern rockfish adult, winter.**

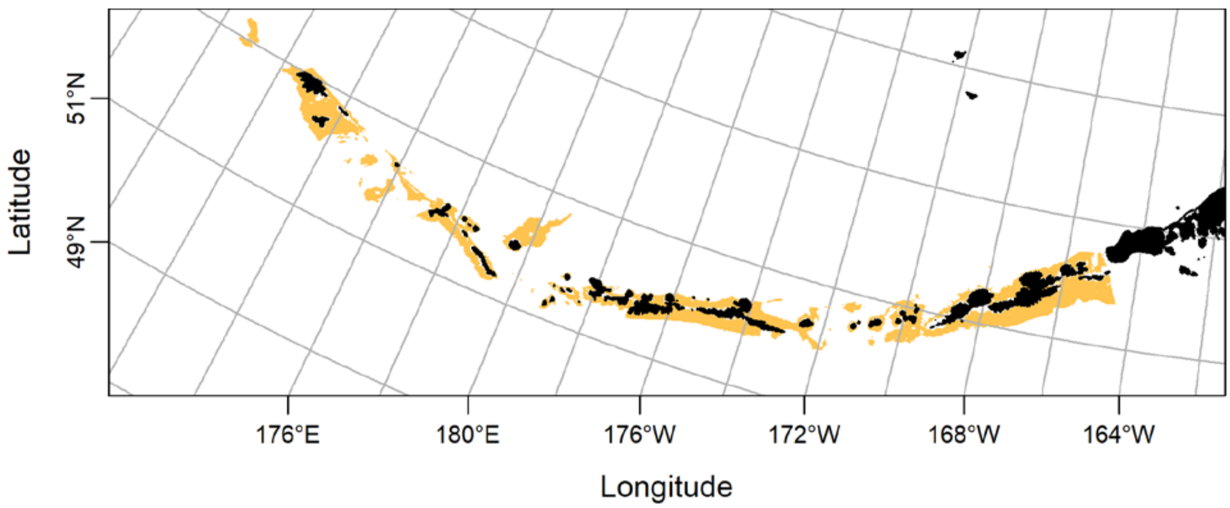


**Figure E-147 EFH distribution of AI Northern rockfish juvenile, summer.**

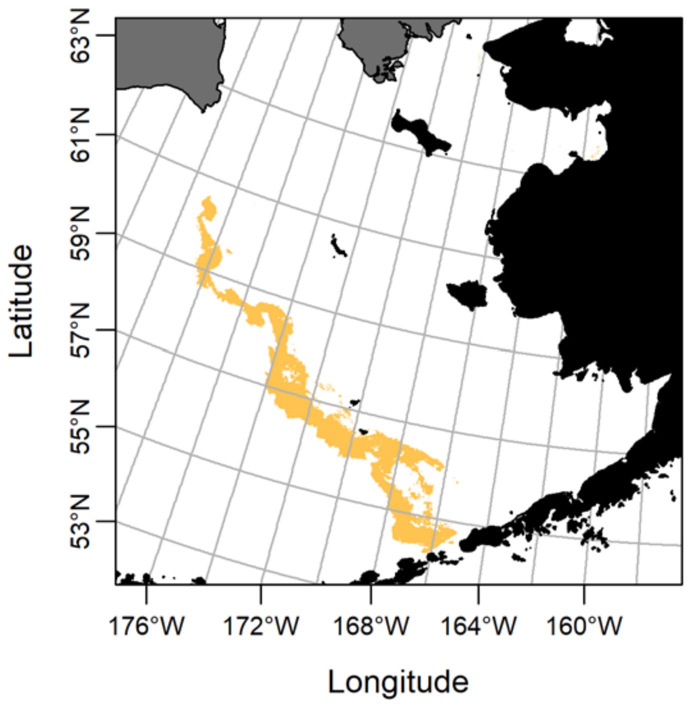


**Figure E-148 EFH distribution of EBS Shortraker rockfish adult, fall.**

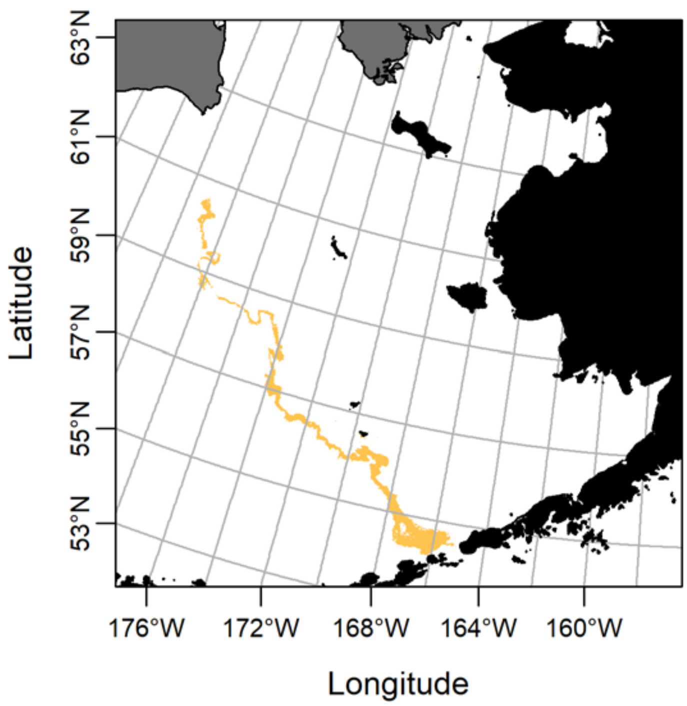


**Figure E-149 EFH distribution of EBS Shortraker rockfish adult, spring.**

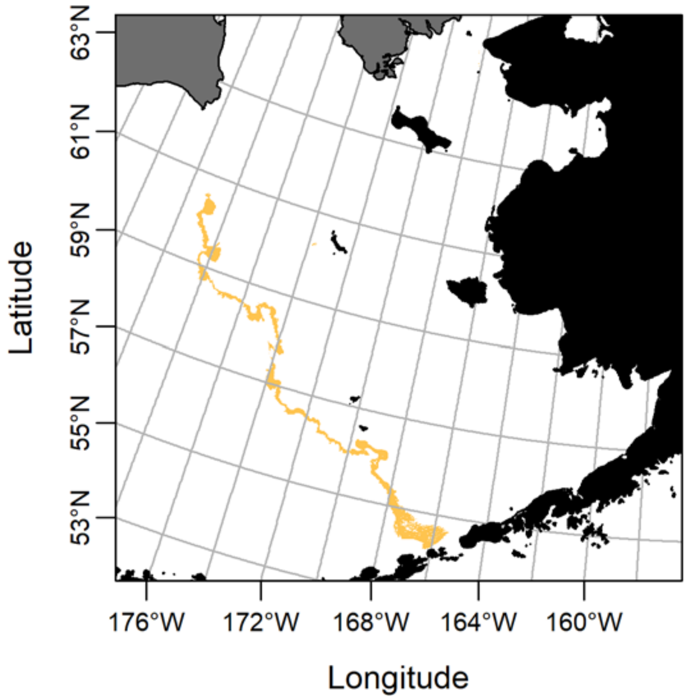


**Figure E-150 EFH distribution of EBS Shortraker rockfish adult, summer.**

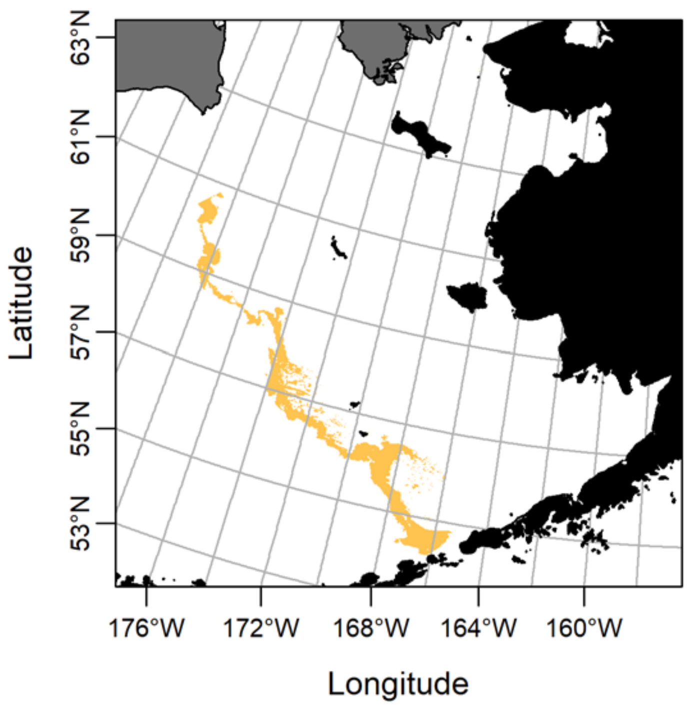


**Figure E-151 EFH distribution of EBS Shortraker rockfish adult, winter.**

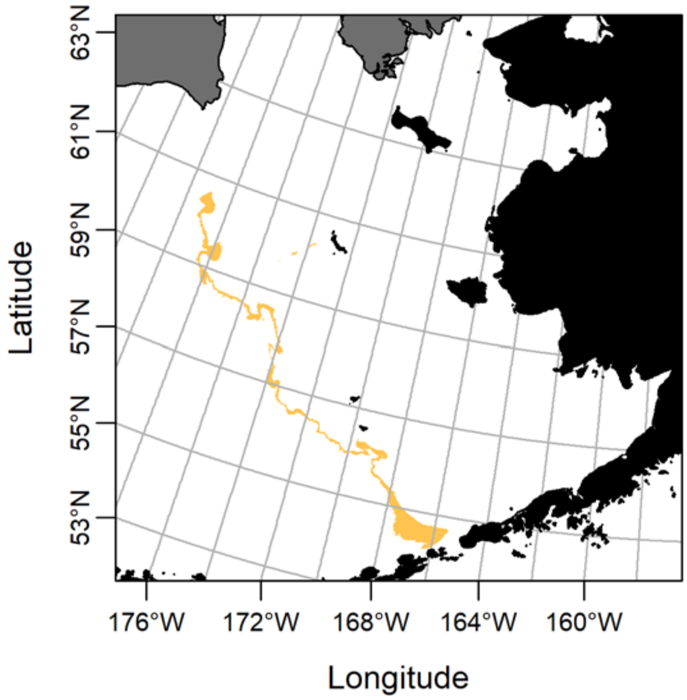


**Figure E-152 EFH distribution of EBS Shortraker rockfish juvenile, summer.**

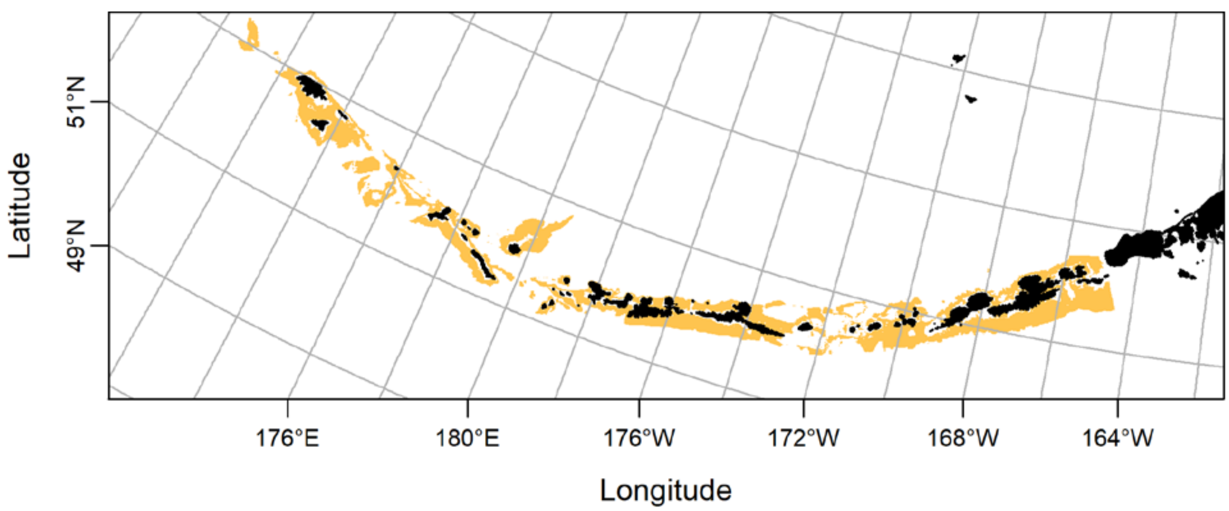


**Figure E-153 EFH distribution of AI Shortraker rockfish adult, fall.**

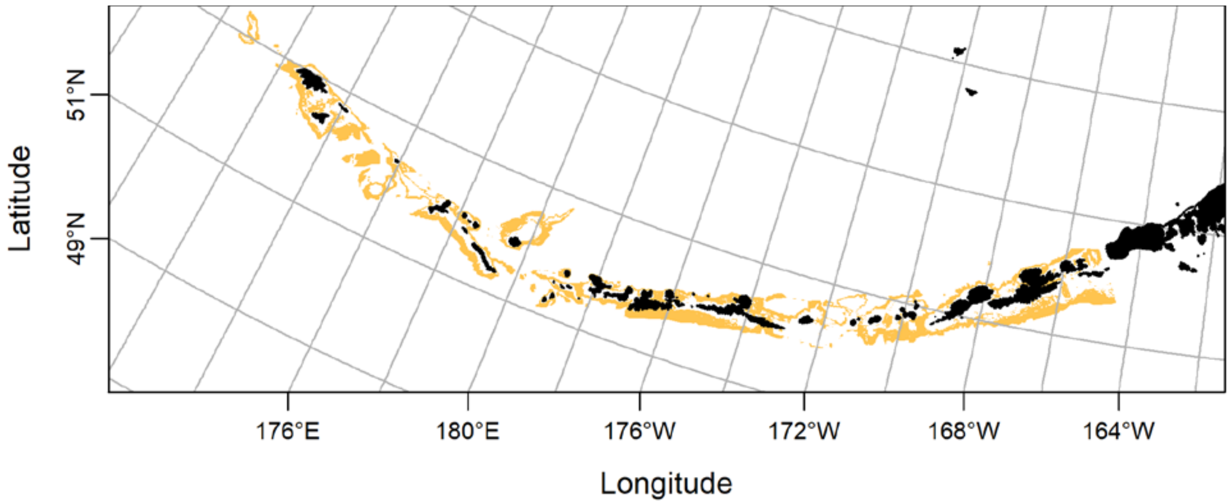


**Figure E-154 EFH distribution of AI Shortraker rockfish adult, spring.**

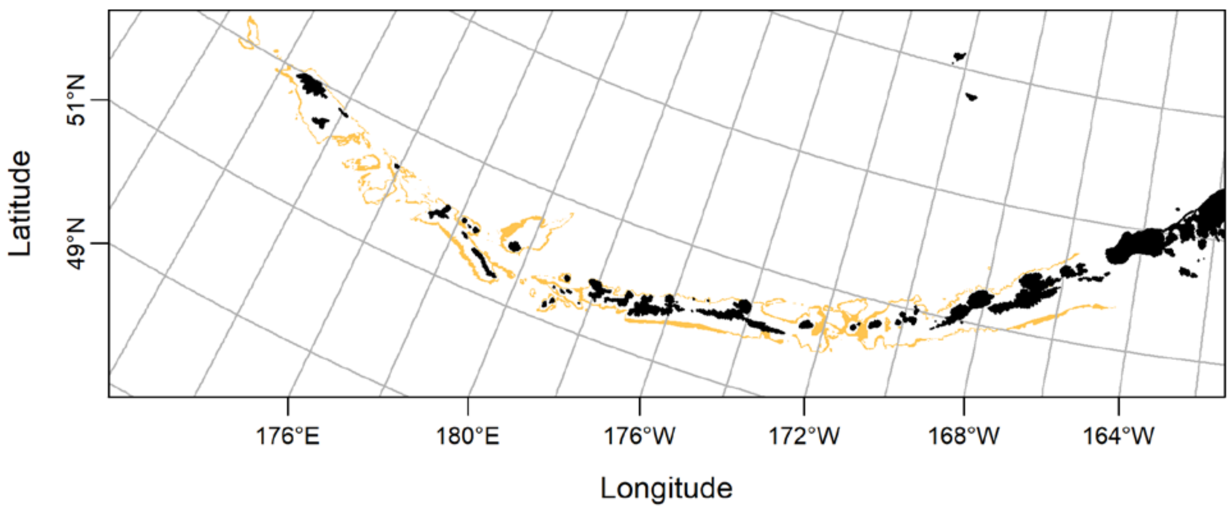


**Figure E-155 EFH distribution of AI Shortraker rockfish adult, summer.**

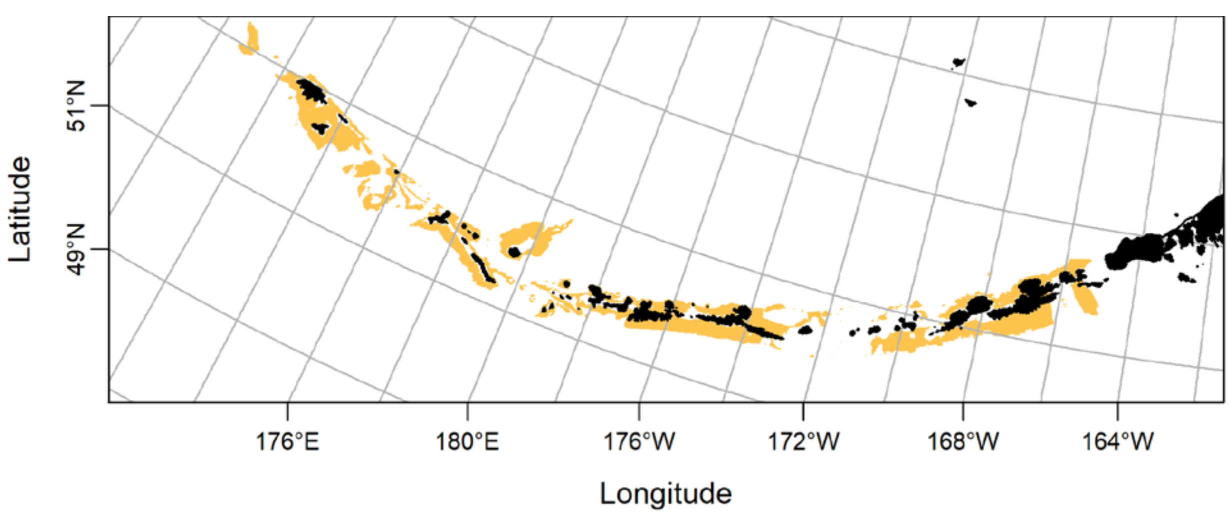


**Figure E-156 EFH distribution of AI Shortraker rockfish adult, winter.**

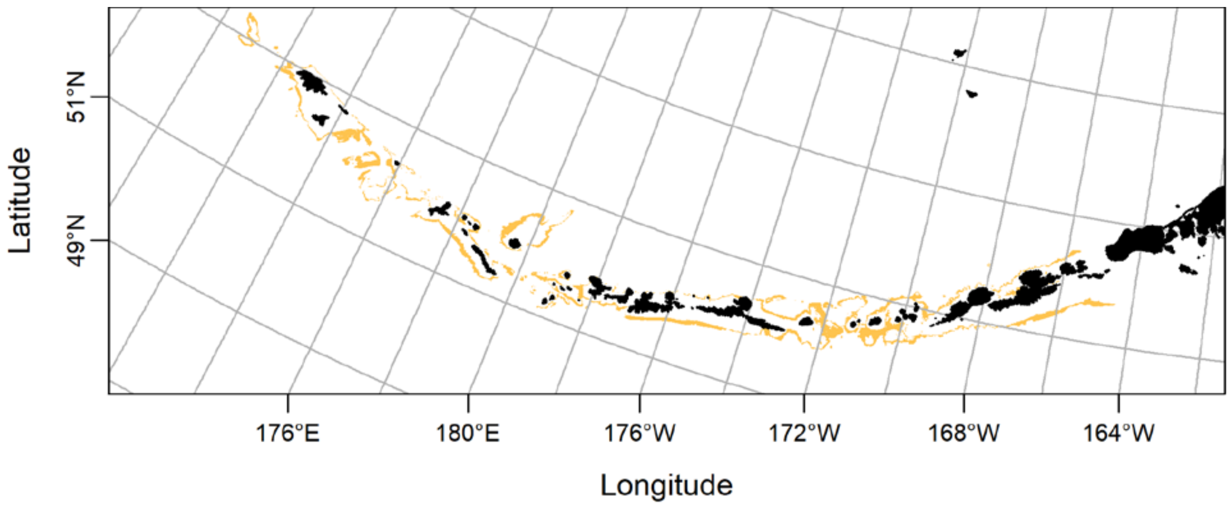


**Figure E-157 EFH distribution of AI Shortraker rockfish juvenile, summer.**

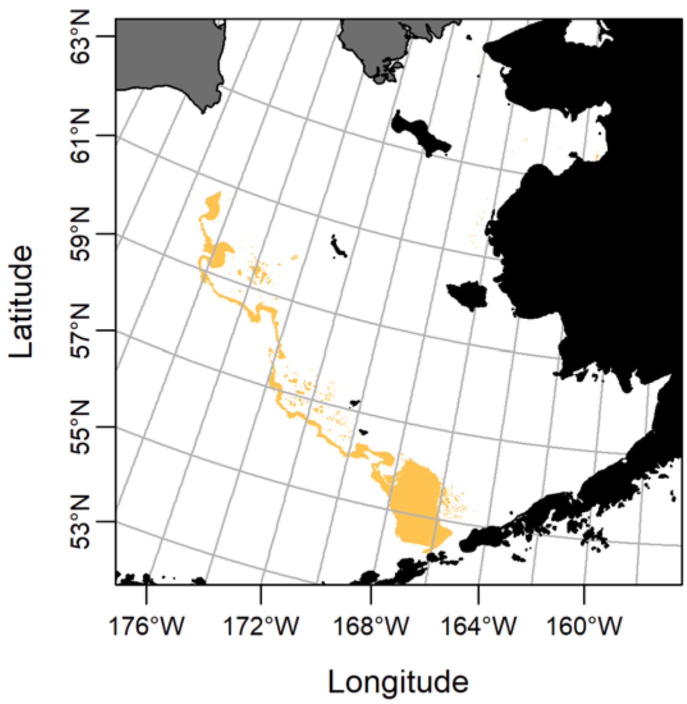


**Figure E-158 EFH distribution of EBS Blackspotted rockfish juvenile, summer.**

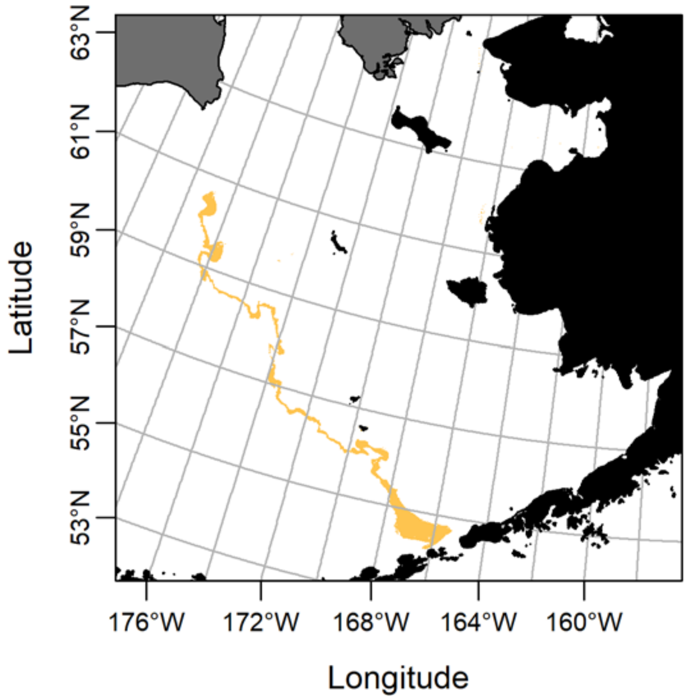


**Figure E-159 EFH distribution of EBS Blackspotted rockfish adult, summer.**

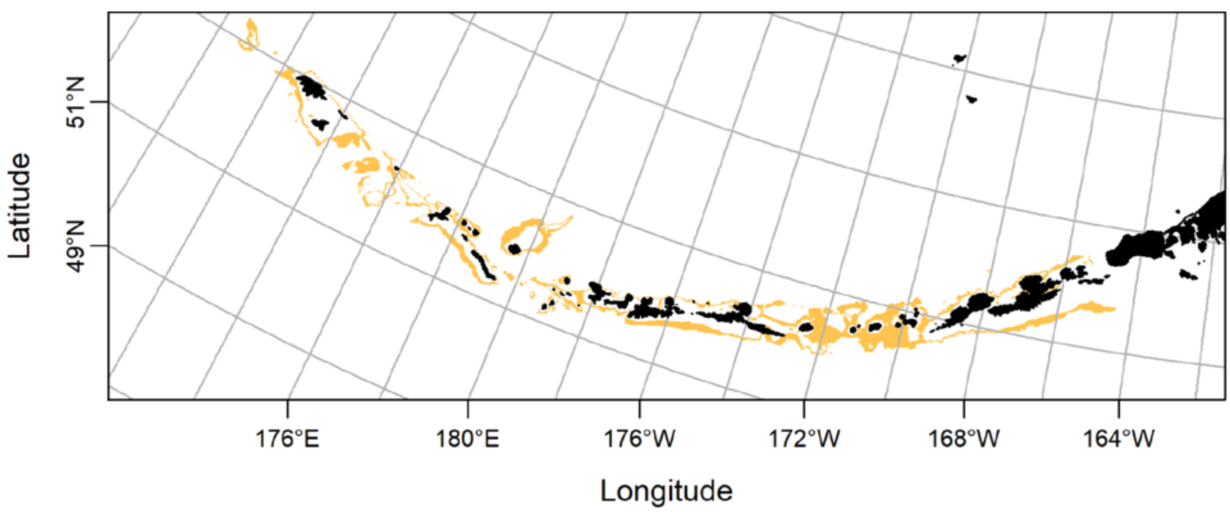


**Figure E-160 EFH distribution of AI Blackspotted rockfish adult, summer.**

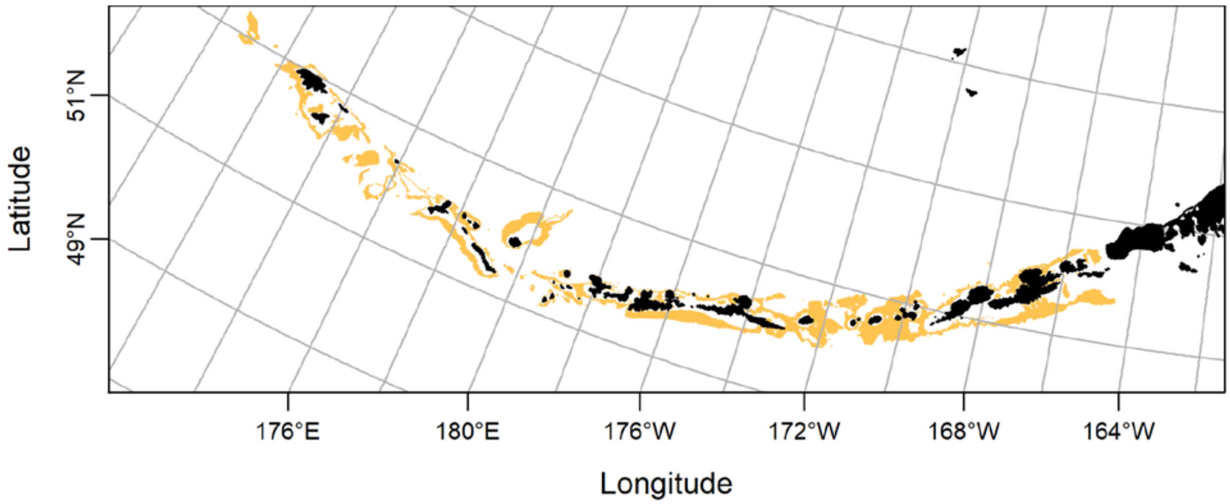


**Figure E-161 EFH distribution of AI Blackspotted rockfish juvenile, summer.**

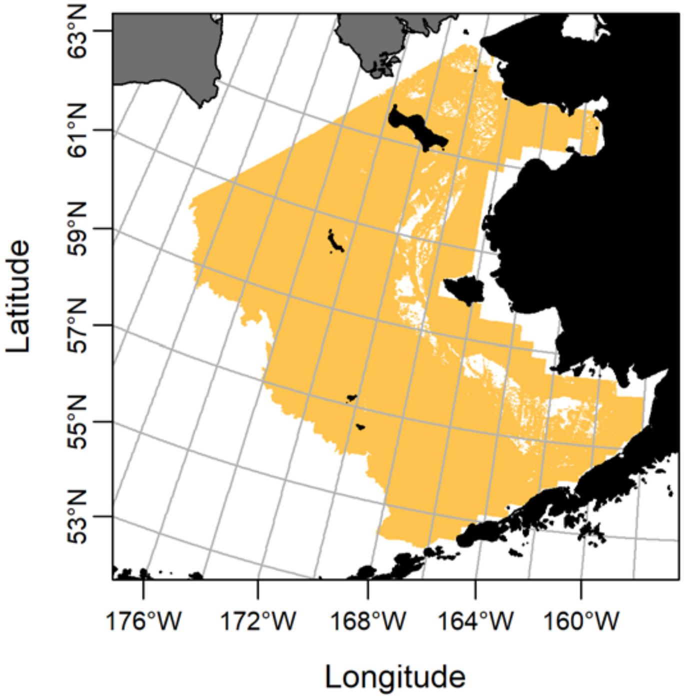


**Figure E-162 EFH distribution of EBS Rougheye rockfish adult, fall.**

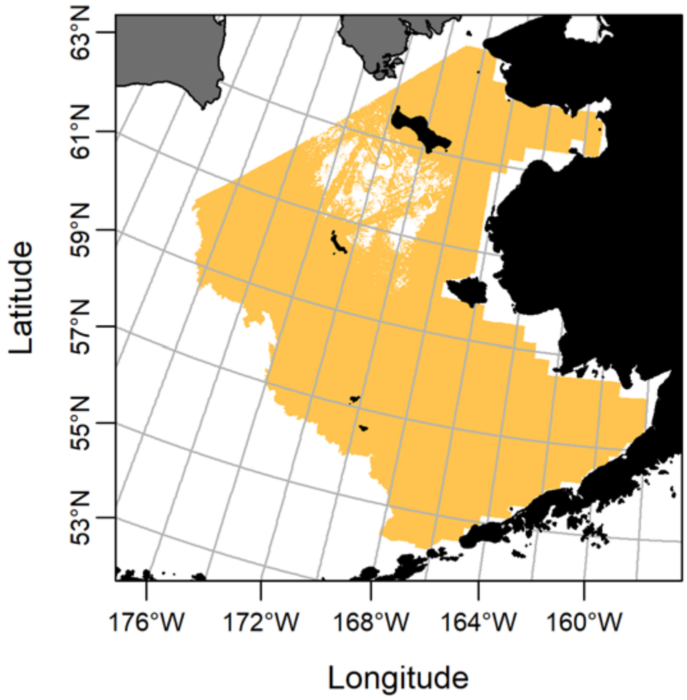


**Figure E-163 EFH distribution of EBS Rougheye rockfish adult, spring.**

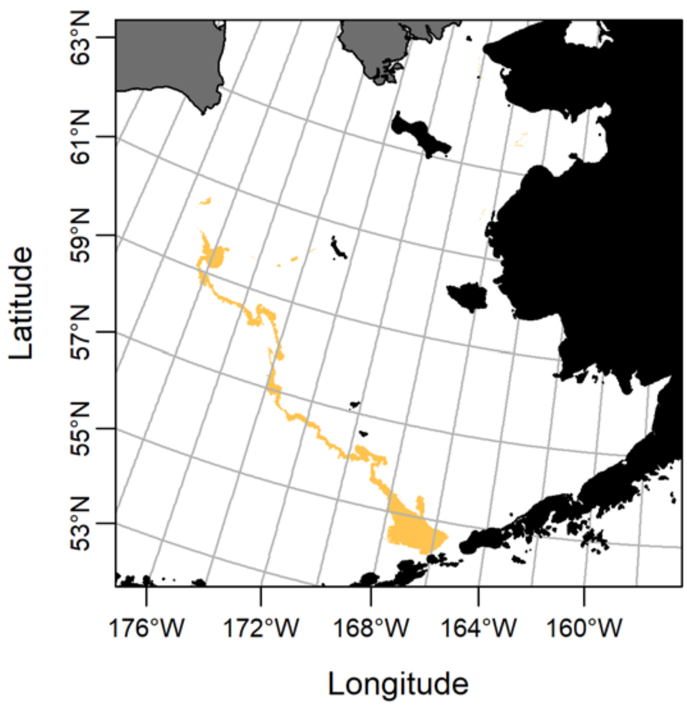


**Figure E-164 EFH distribution of EBS Rougheye rockfish adult, summer.**

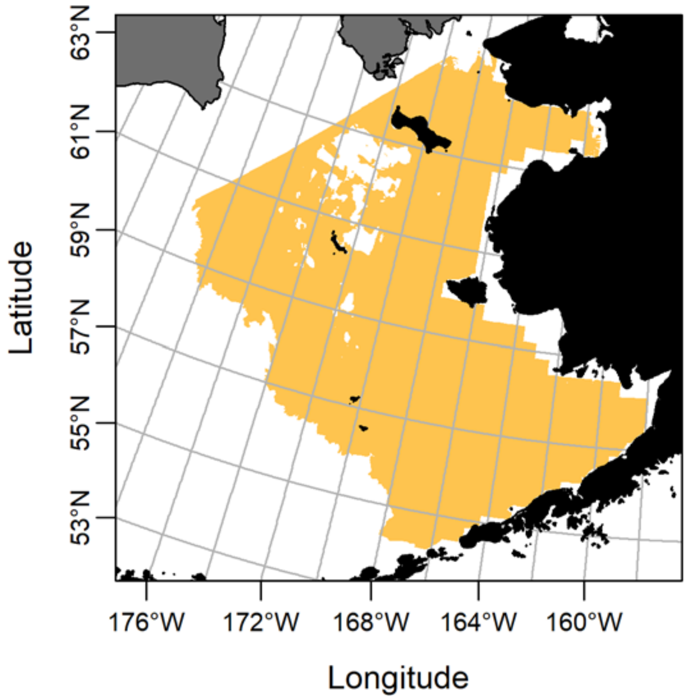


**Figure E-165 EFH distribution of EBS Rougheye rockfish adult, winter.**

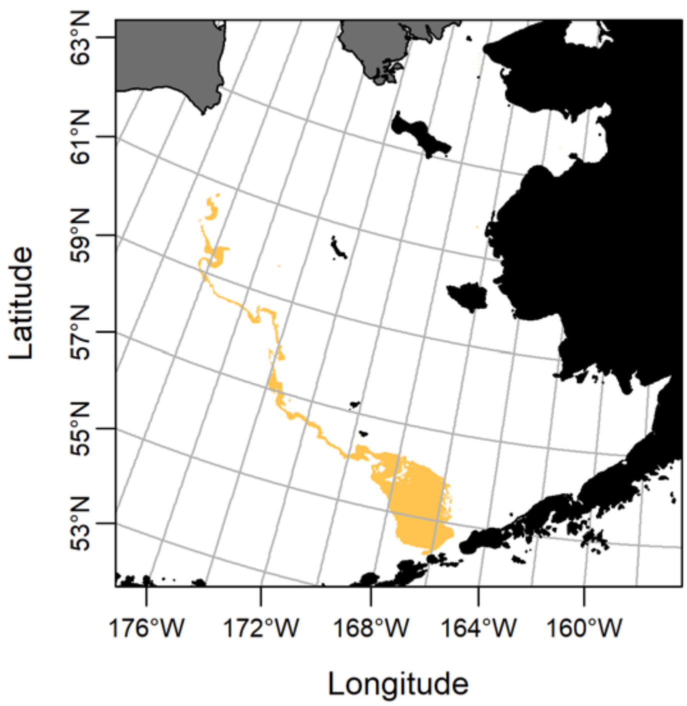


**Figure E-166 EFH distribution of EBS Rougheye rockfish juvenile, summer.**

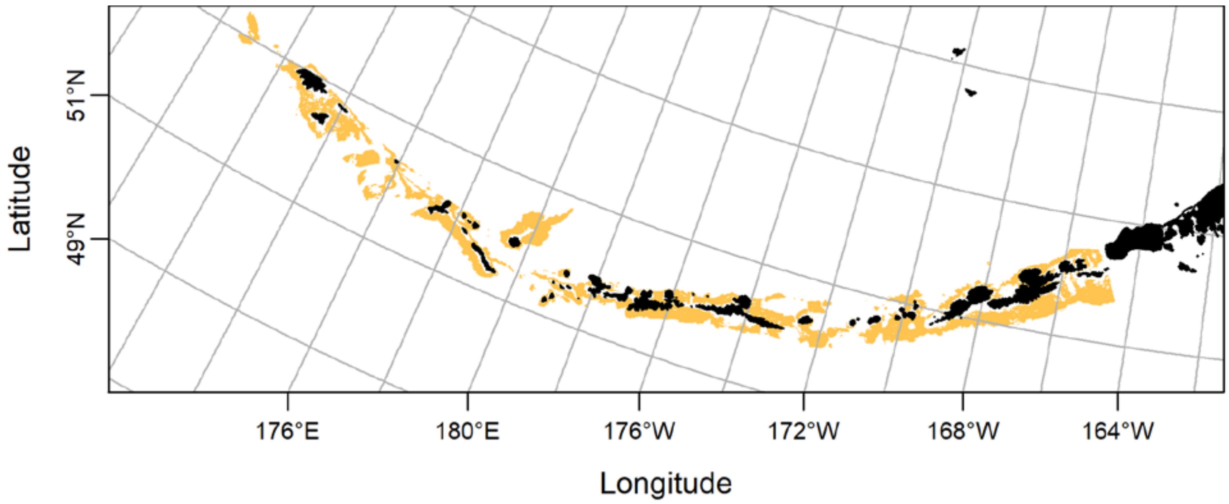


**Figure E-167 EFH distribution of AI Rougheye rockfish adult, fall.**

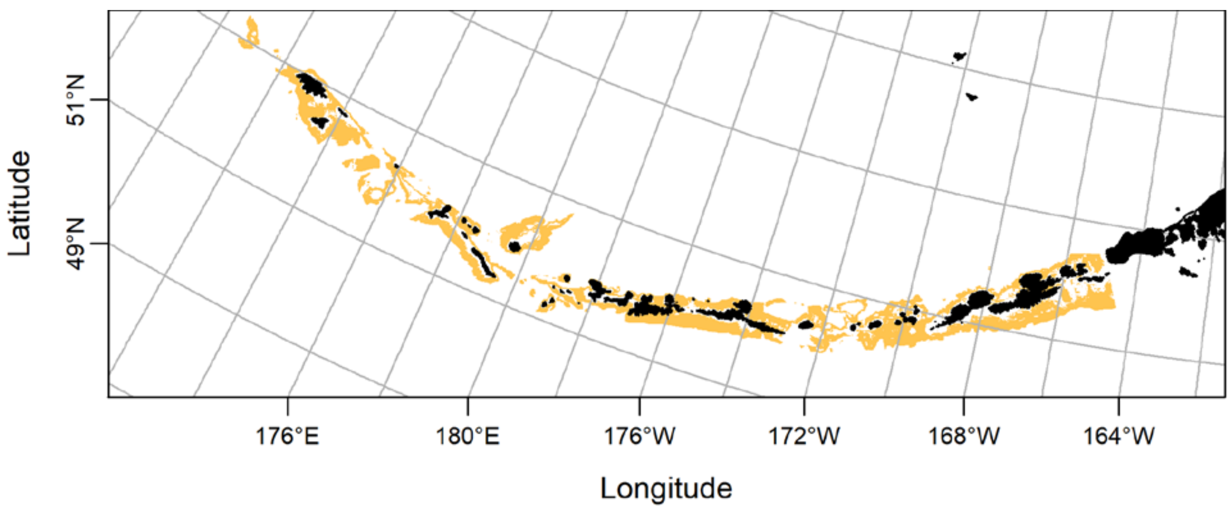


**Figure E-168 EFH distribution of AI Rougheye rockfish adult, spring.**

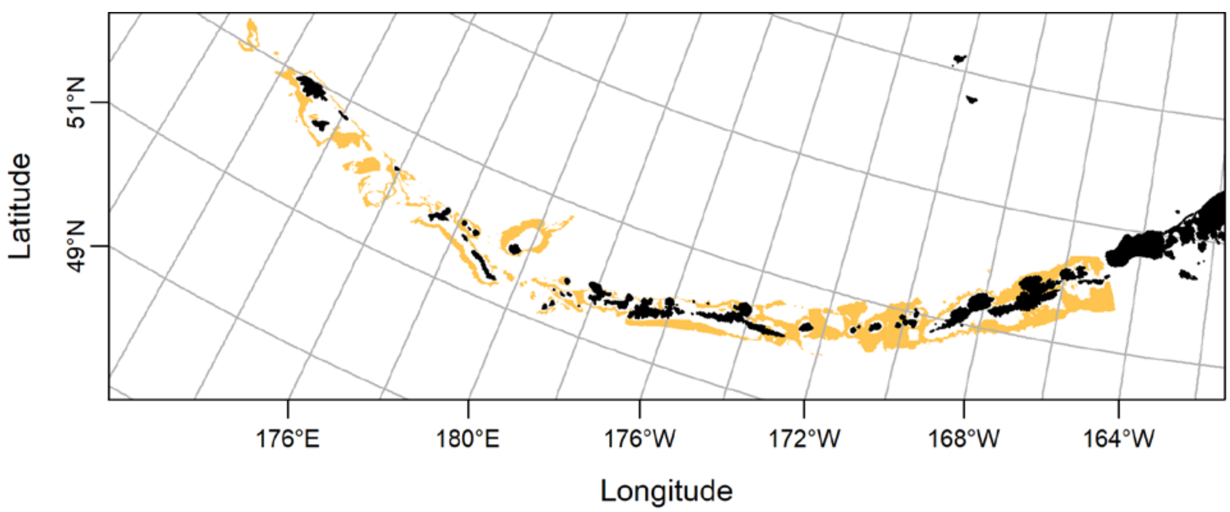


**Figure E-169 EFH distribution of AI Rougheye rockfish adult, summer.**

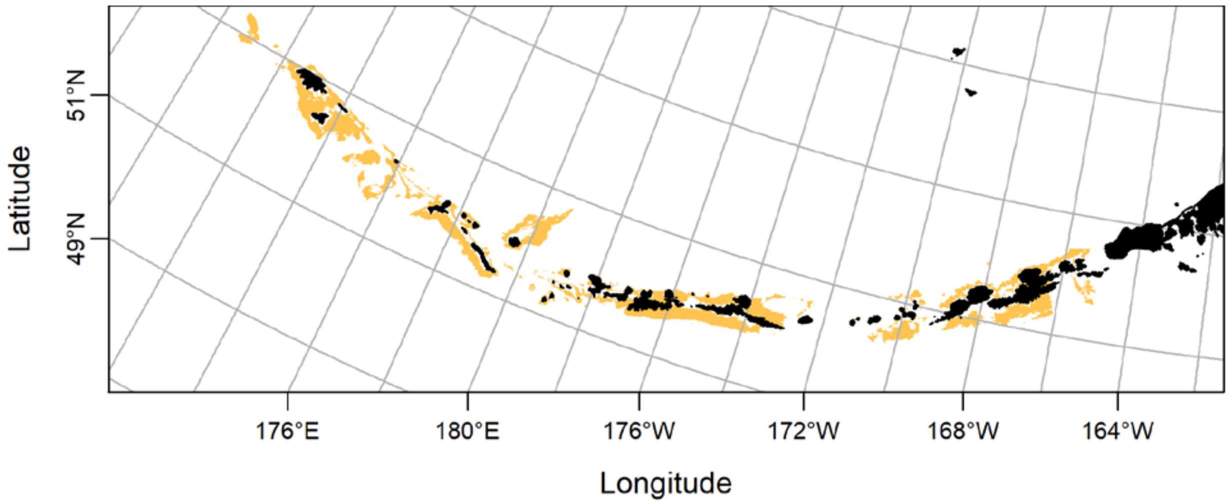


**Figure E-170 EFH distribution of Rougheye rockfish adult, winter.**

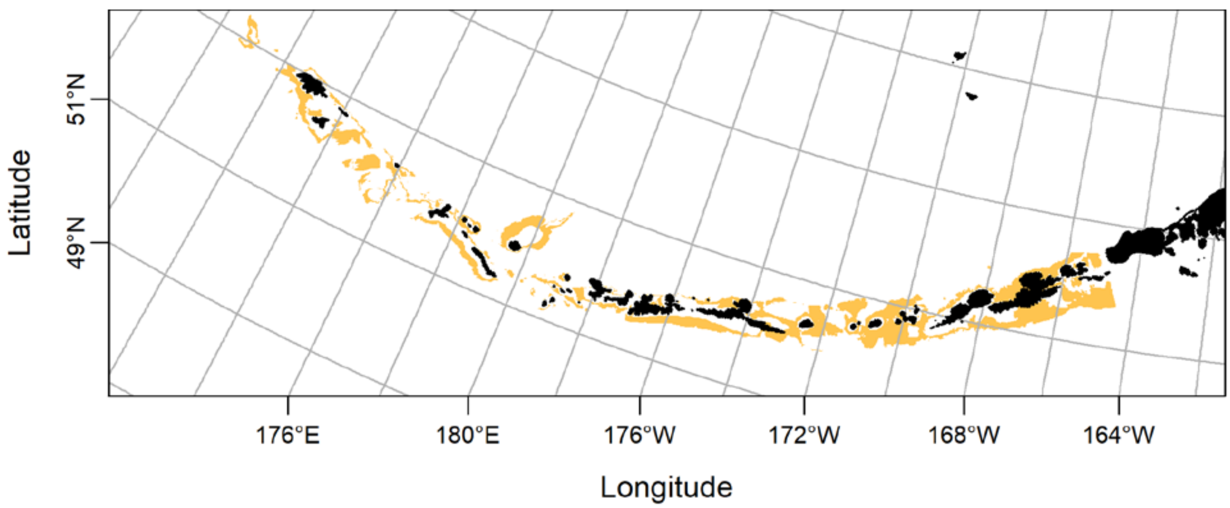


**Figure E-171 EFH distribution of AI Rougheye rockfish juvenile, summer.**

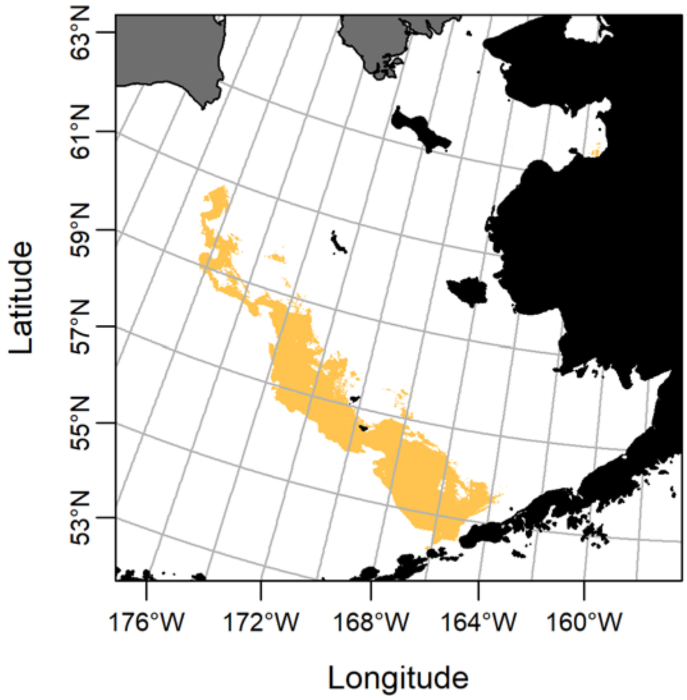

**Figure E-172 EFH distribution of EBS Dusky rockfish adult, fall.**

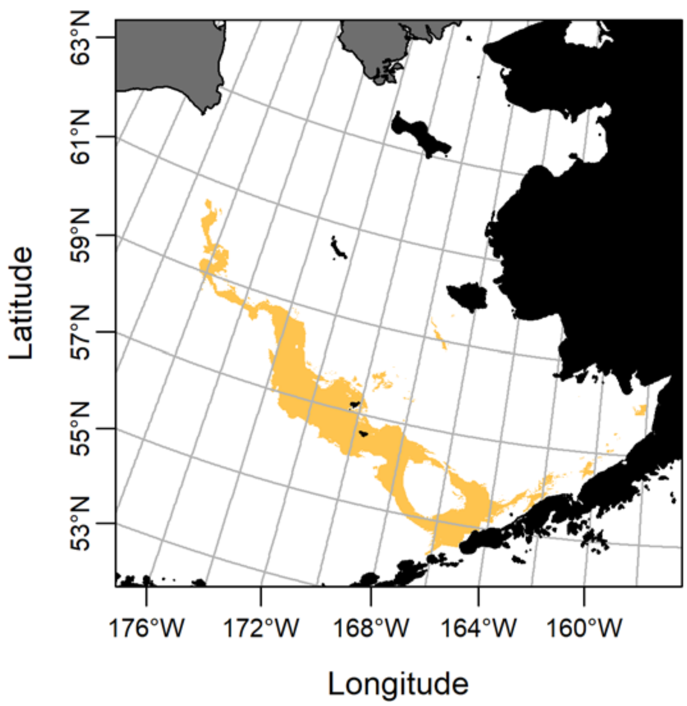

**Figure E-173 EFH distribution of EBS Dusky rockfish adult, spring.**

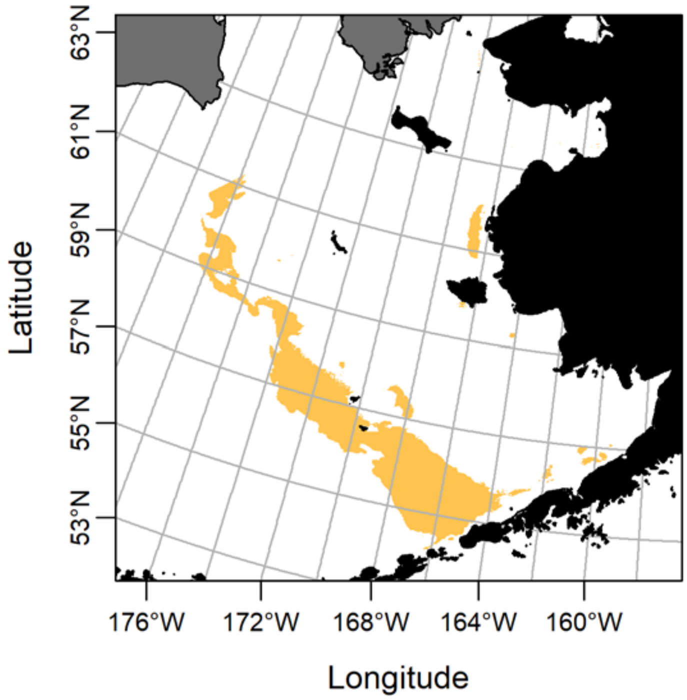


**Figure E-174 EFH distribution of EBS Dusky rockfish adult, summer.**

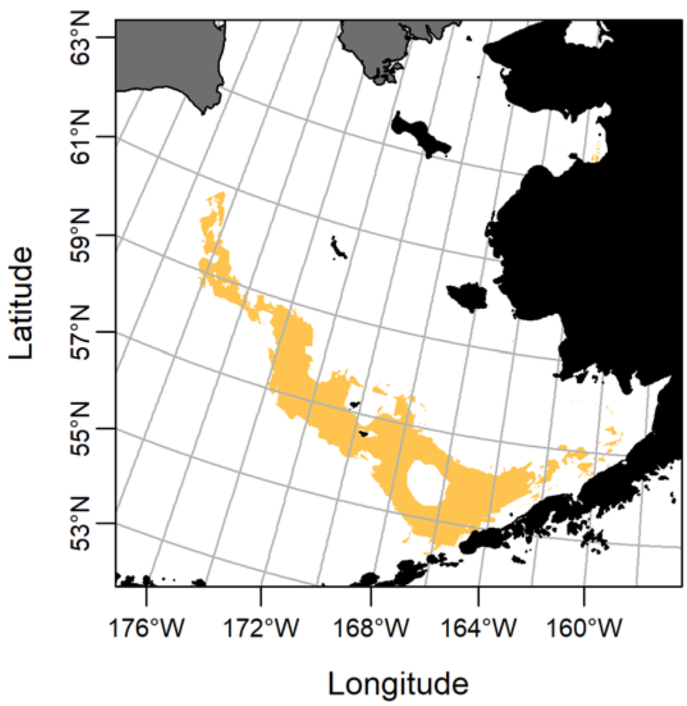


**Figure E-175 EFH distribution of EBS Dusky rockfish adult, winter.**

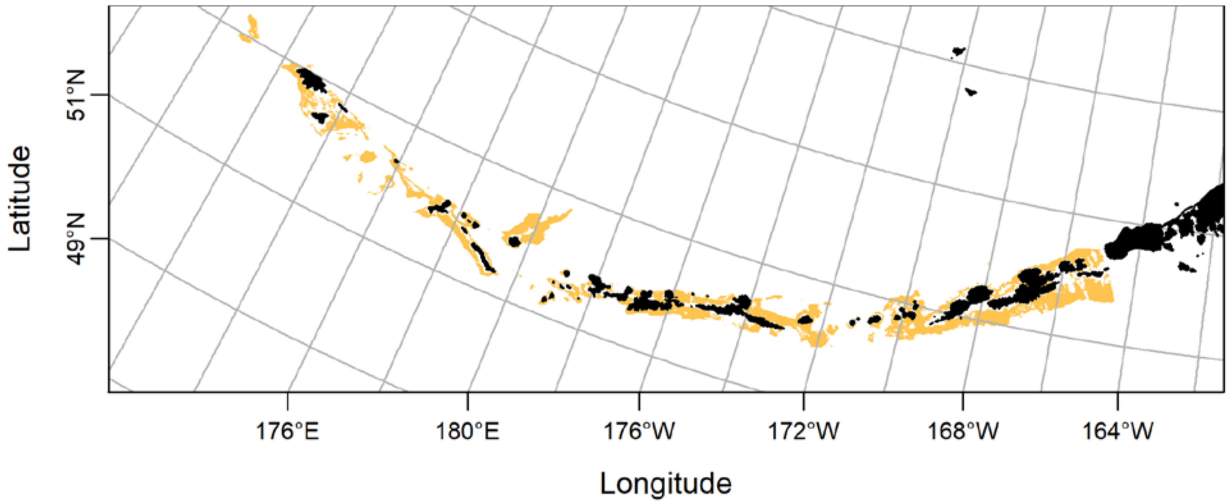


**Figure E-176 EFH distribution of AI Dusky rockfish adult, fall.**

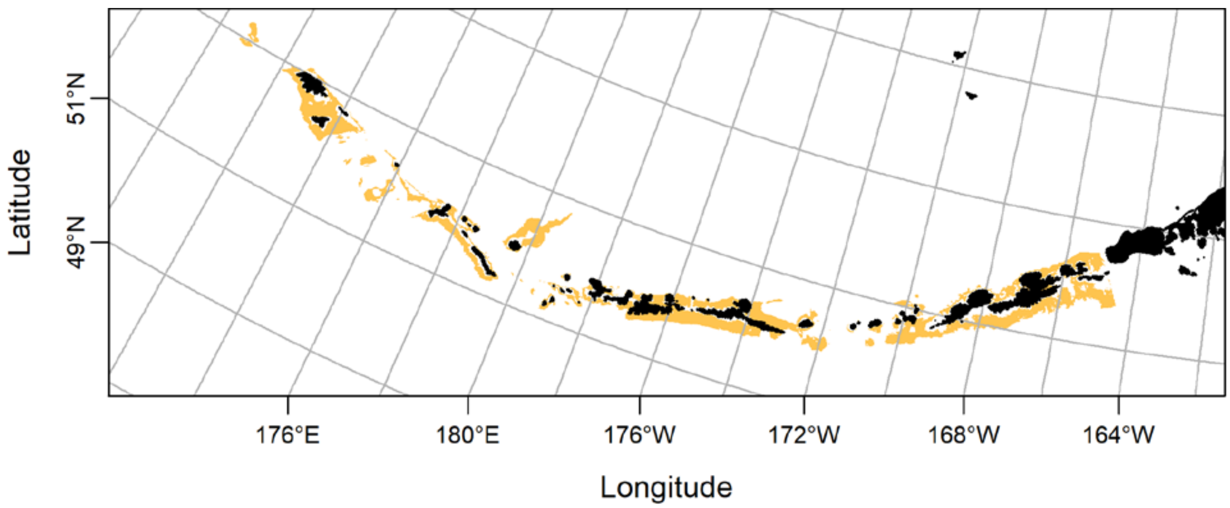


**Figure E-177 EFH distribution of AI Dusky rockfish adult, spring.**

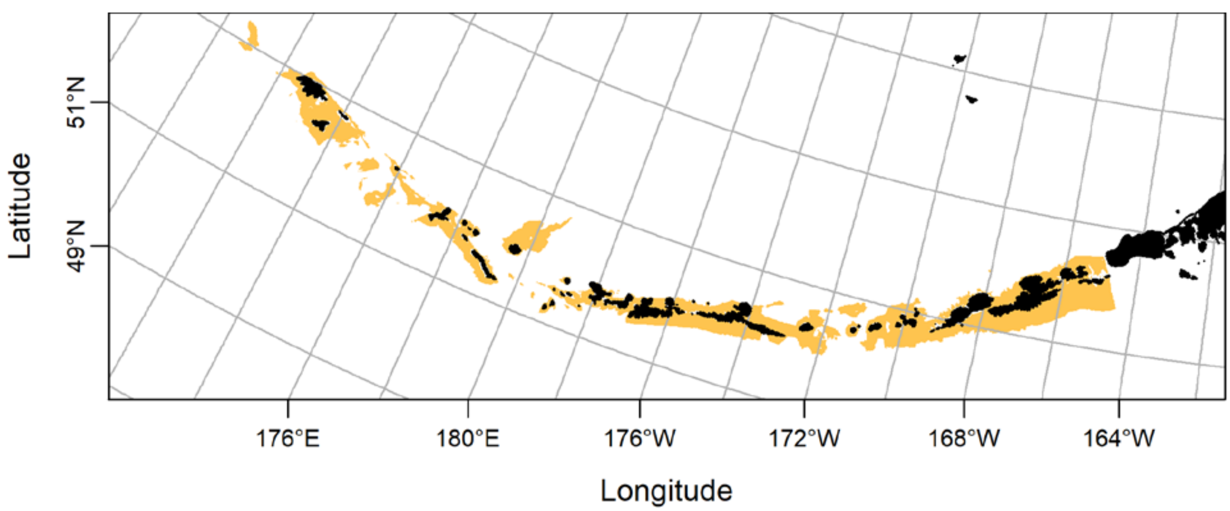


**Figure E-178 EFH distribution of AI Dusky rockfish adult, summer.**

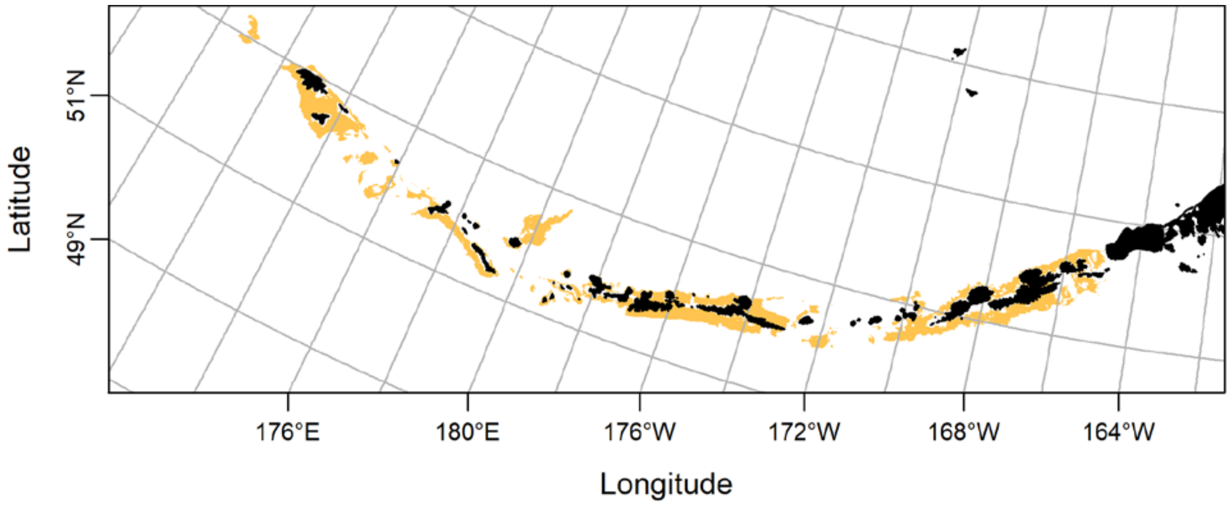


**Figure E-179 EFH distribution of AI Dusky rockfish adult, winter.**

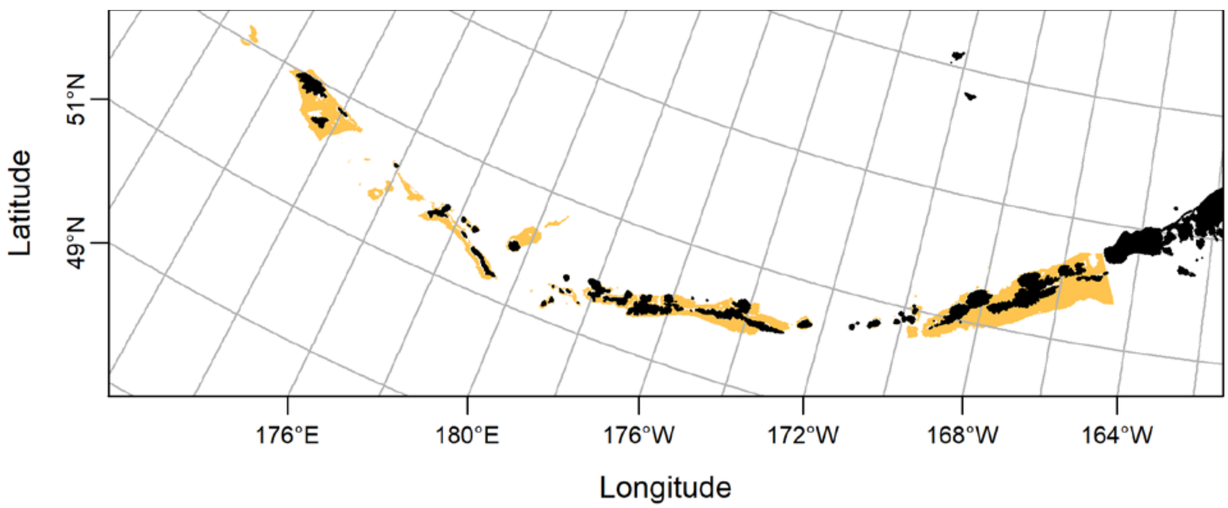


**Figure E-180 EFH distribution of AI Dusky rockfish juvenile, summer.**

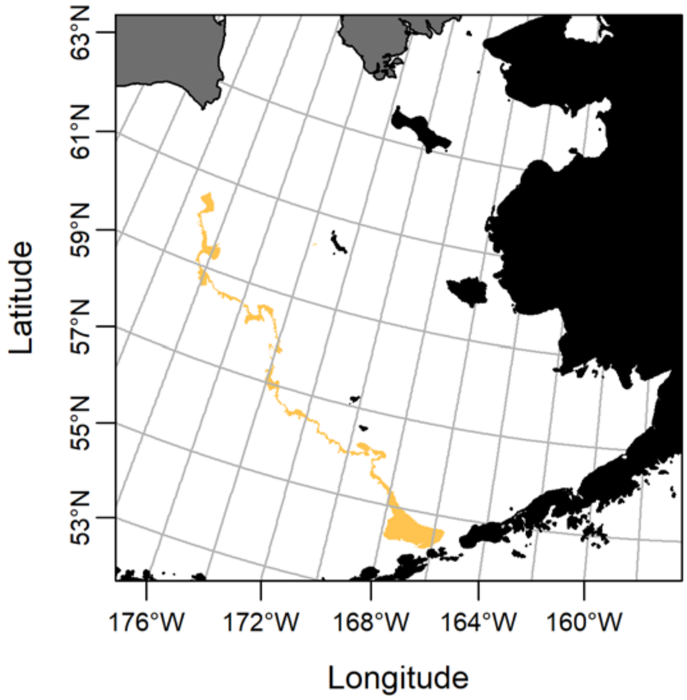


**Figure E-181 EFH distribution of EBS Shortspine thornyhead rockfish juvenile, summer.**

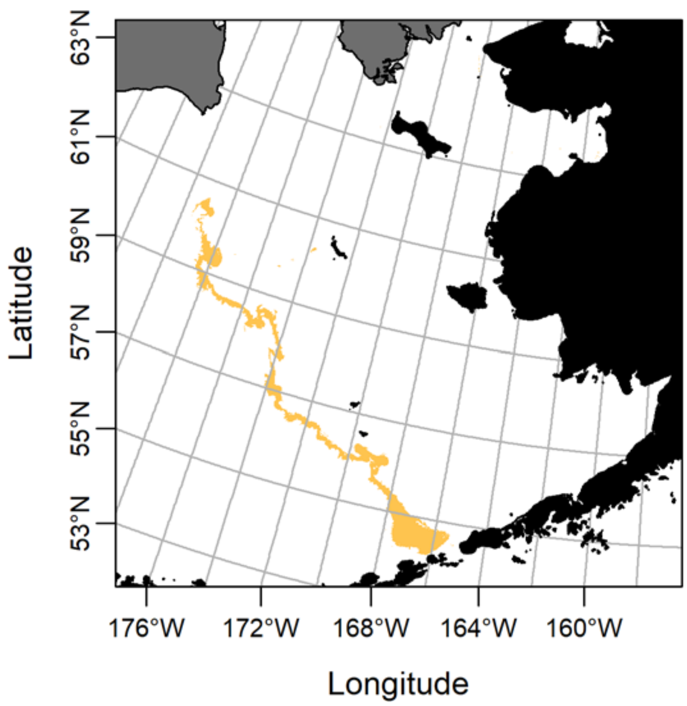


**Figure E-182 EFH distribution of EBS Shortspine thornyhead rockfish adult, fall.**

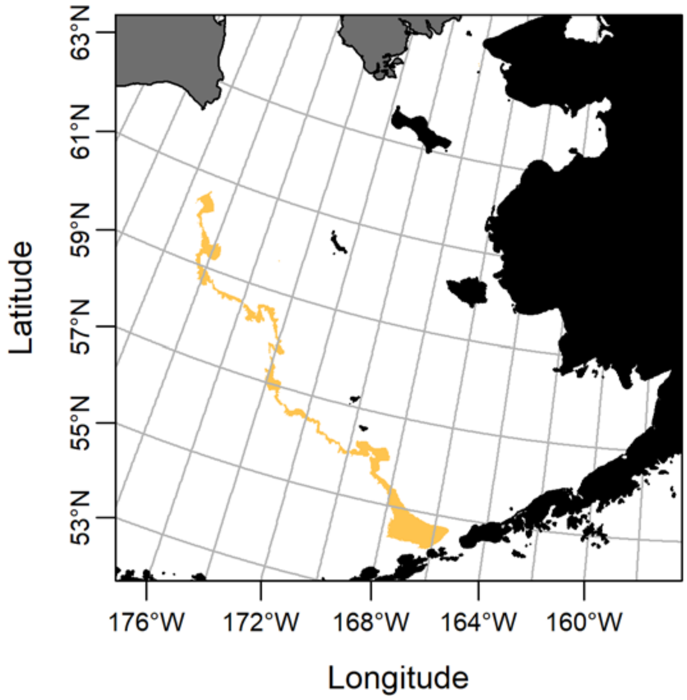


**Figure E-183 EFH distribution of EBS Shortspine thornyhead rockfish adult, spring.**

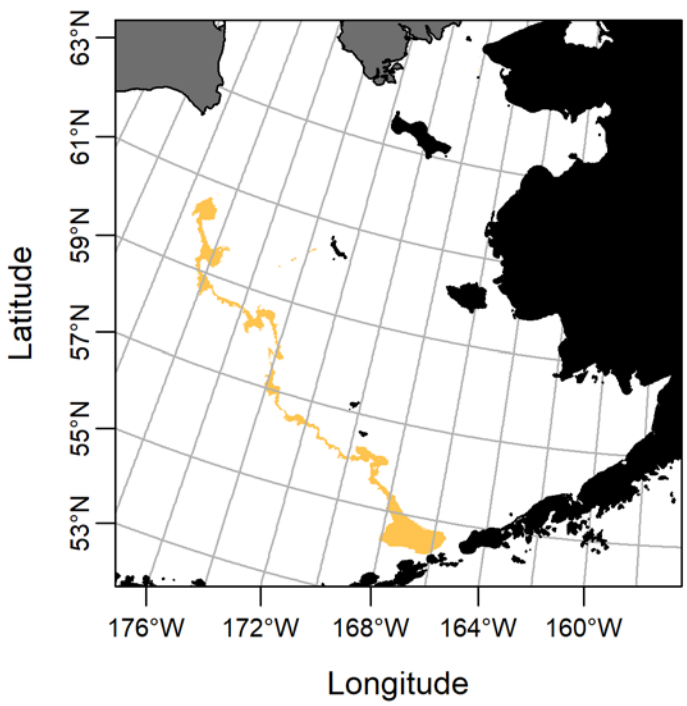


**Figure E-184 EFH distribution of EBS Shortspine thornyhead rockfish adult, summer.**

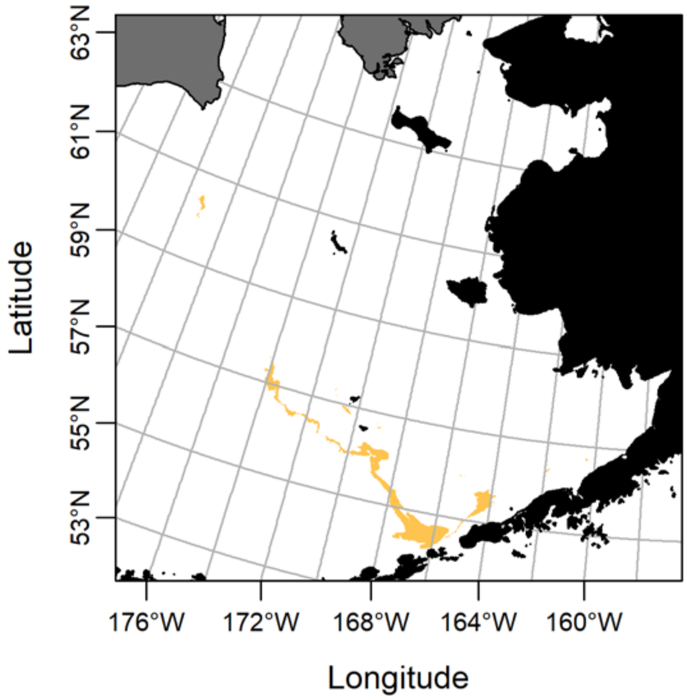


**Figure E-185 EFH distribution of EBS Shortspine thornyhead rockfish adult, winter.**

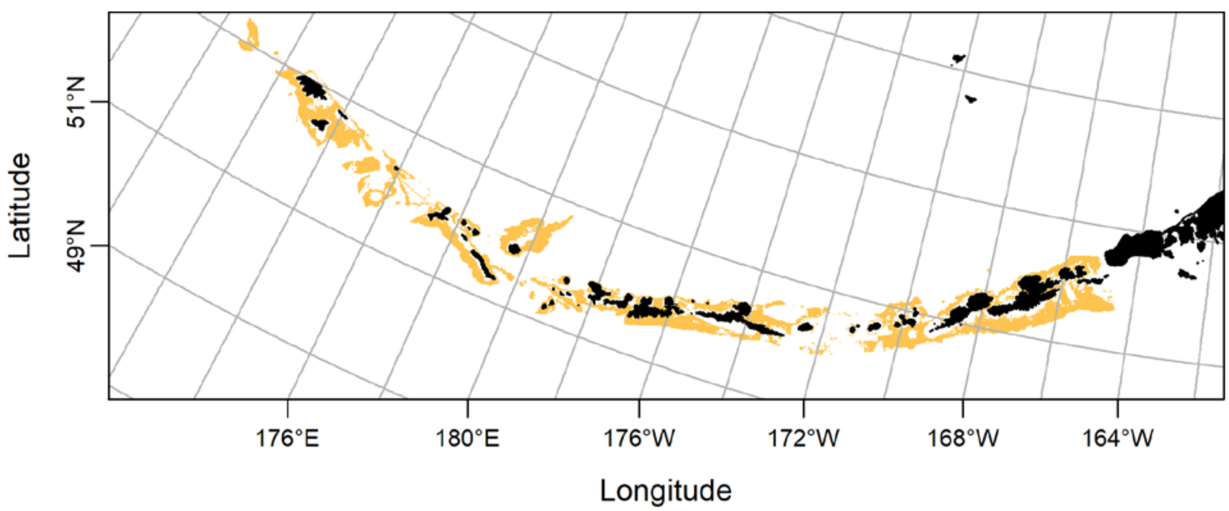


**Figure E-186 EFH distribution of AI Shortspine thornyhead rockfish adult, fall.**

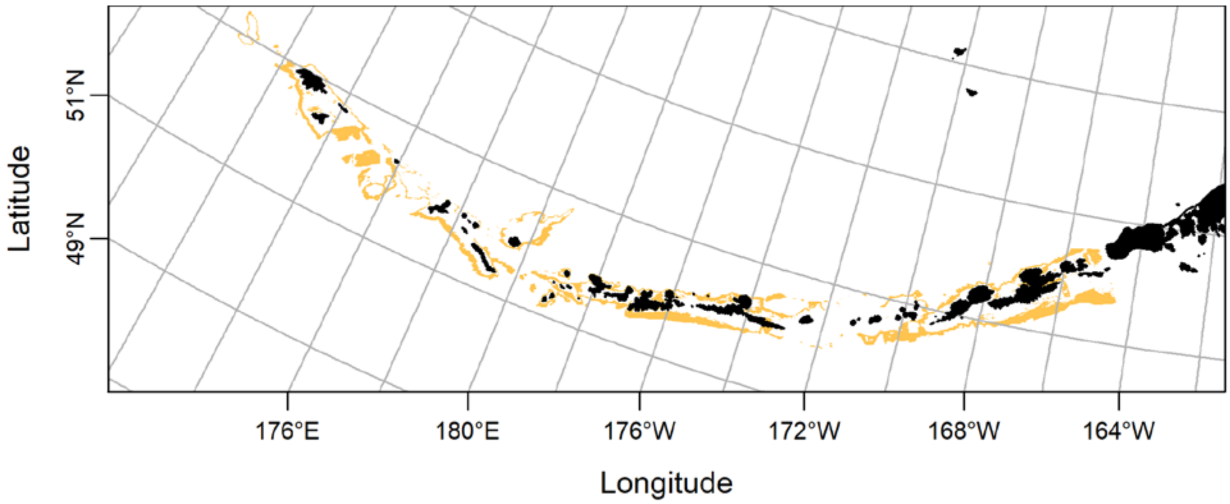


**Figure E-187 EFH distribution of AI Shortspine thornyhead rockfish adult, spring.**

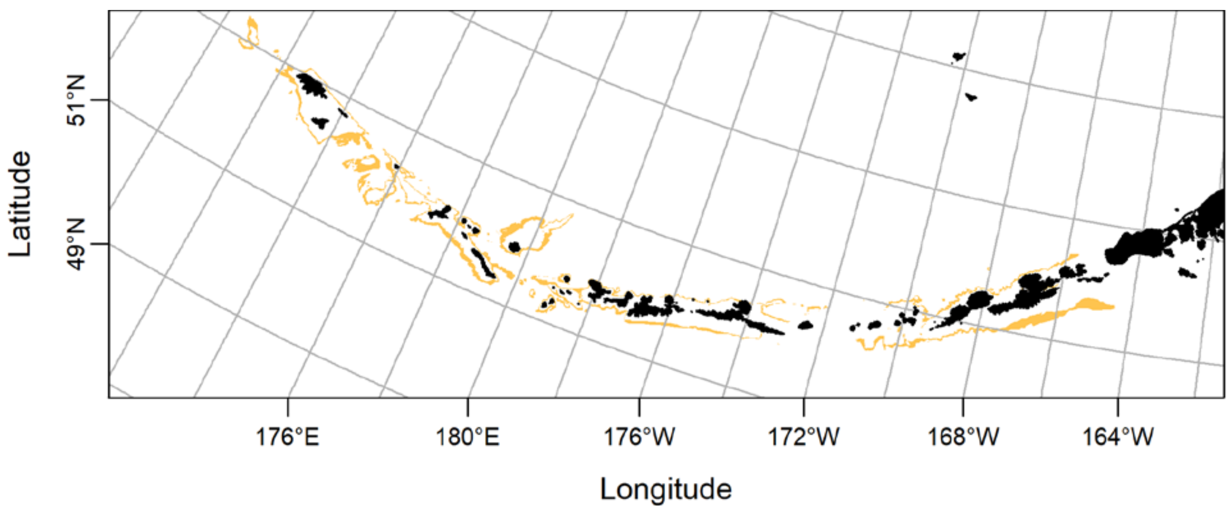


**Figure E-188 EFH distribution of AI Shortspine thornyhead rockfish adult, summer.**

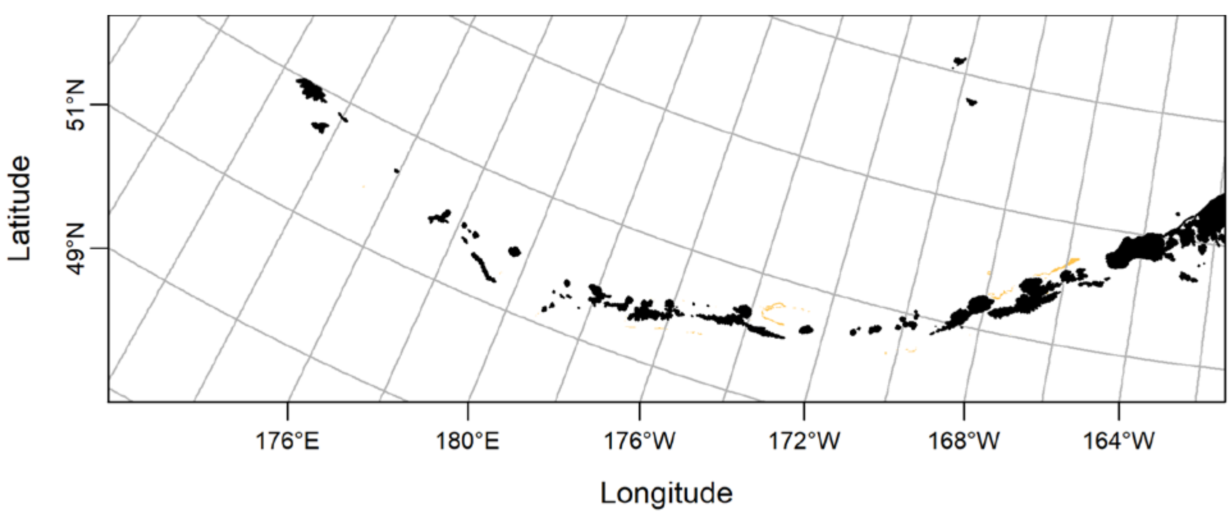


**Figure E-189 EFH distribution of AI Shortspine thornyhead rockfish adult, winter.**

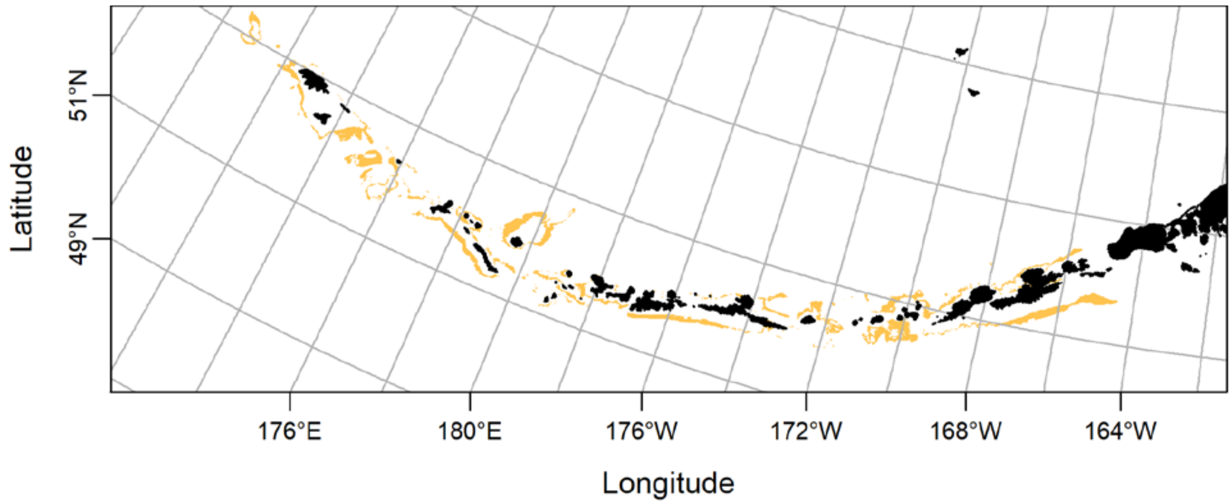


**Figure E-190 EFH distribution of AI Shortspine thornyhead rockfish juvenile, summer.**

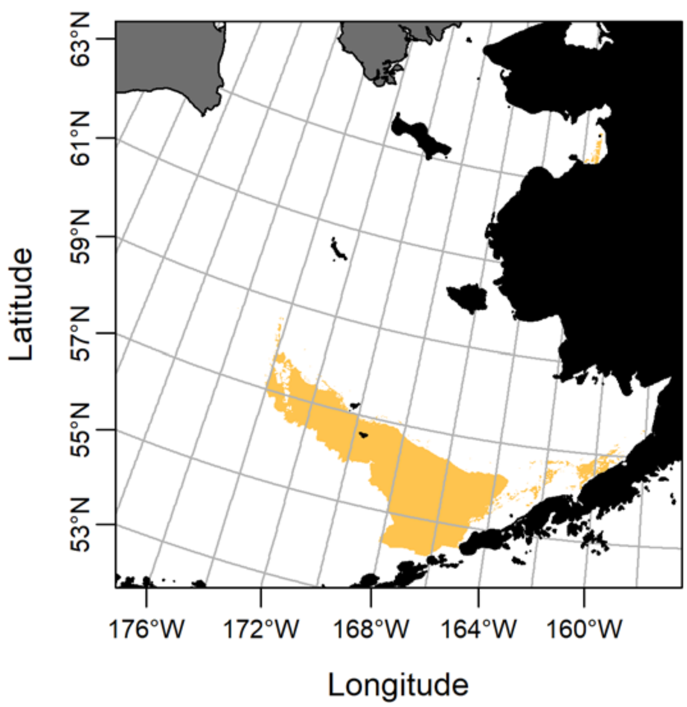


**Figure E-191 EFH distribution of EBS Atka mackerel larvae, summer.**

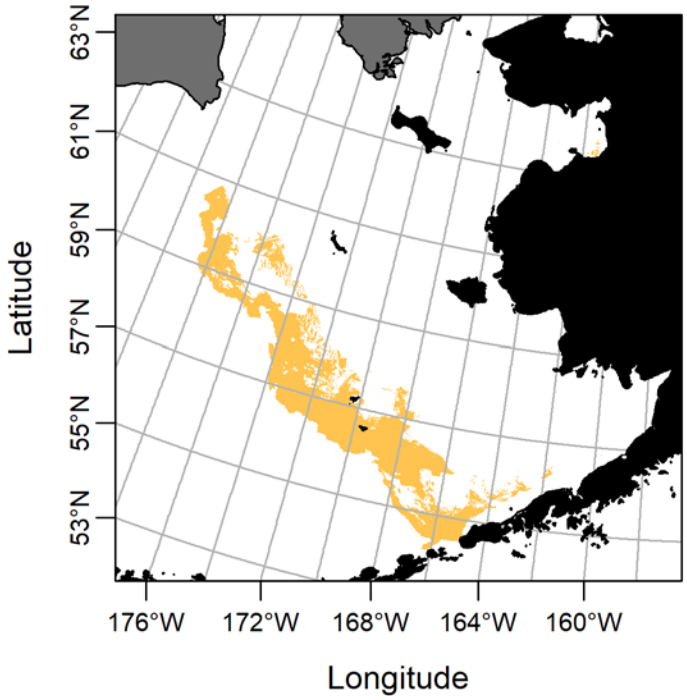


**Figure E-192 EFH distribution of EBS Atka mackerel adult, fall.**

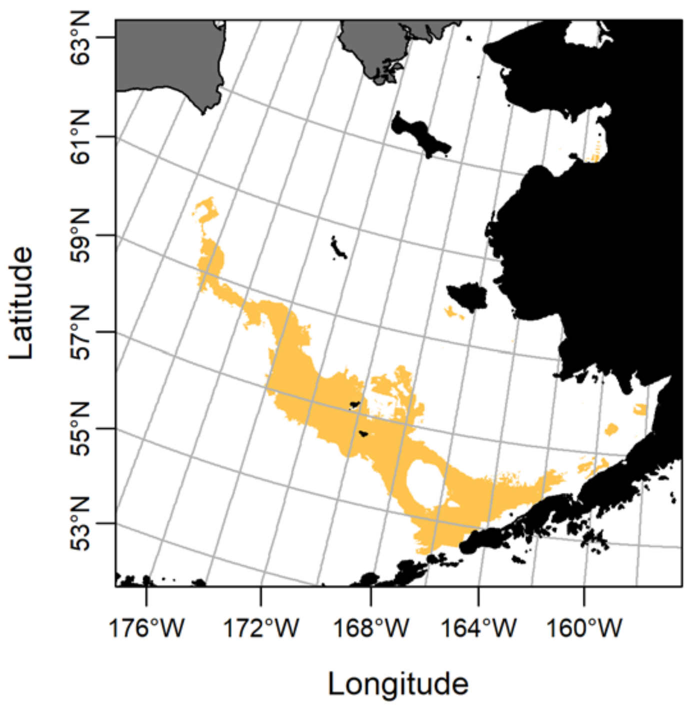


**Figure E-193 EFH distribution of EBS Atka mackerel adult, spring.**

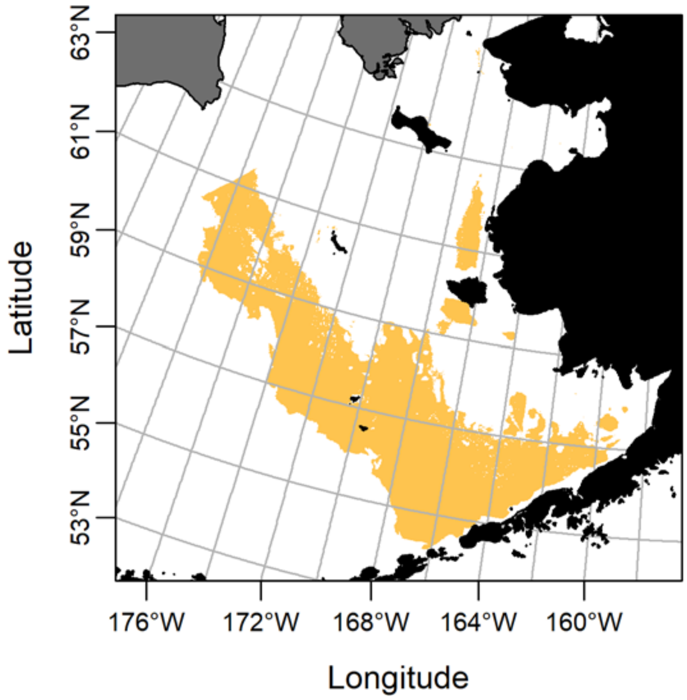

**Figure E-194 EFH distribution of EBS Atka mackerel adult, summer.**

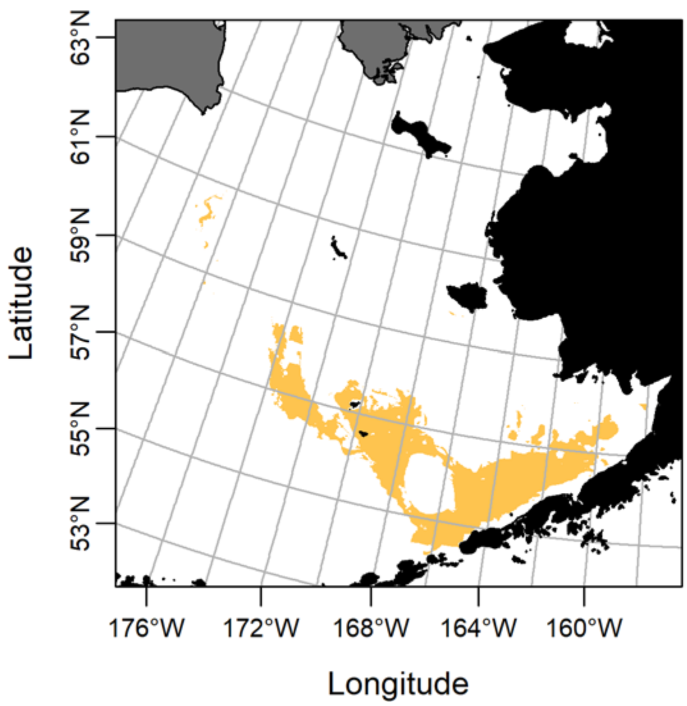

**Figure E-195 EFH distribution of EBS Atka mackerel adult, winter.**

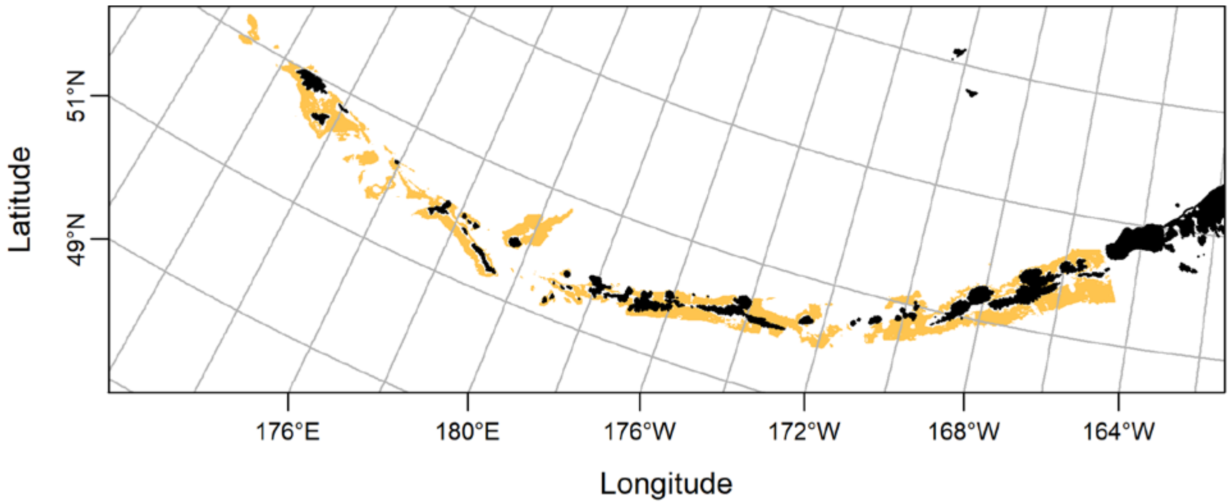


**Figure E-196 EFH distribution of AI Atka mackerel adult, fall.**

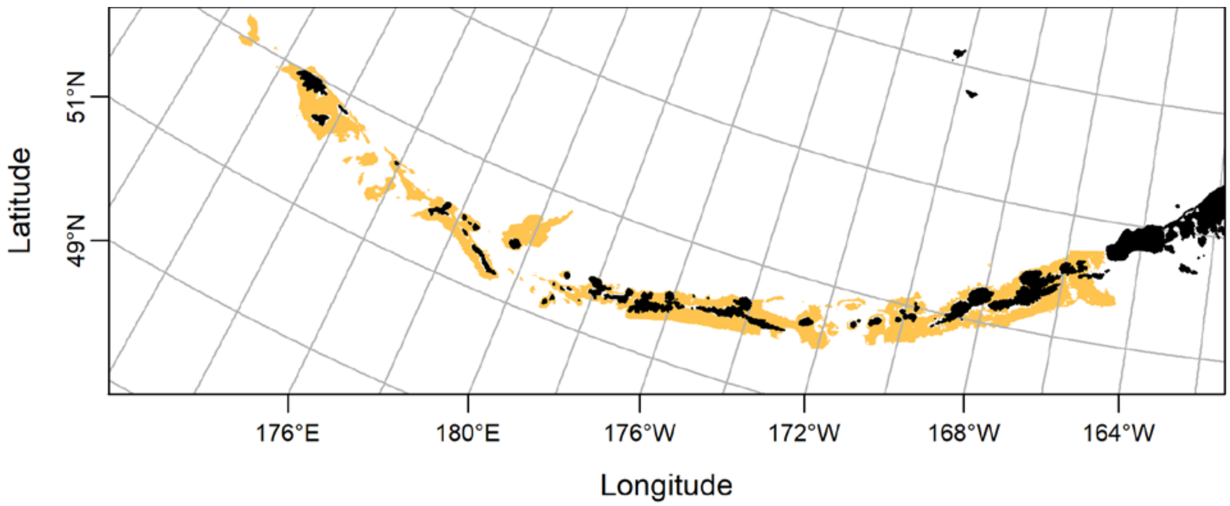


**Figure E-197 EFH distribution of AI Atka mackerel adult, spring.**

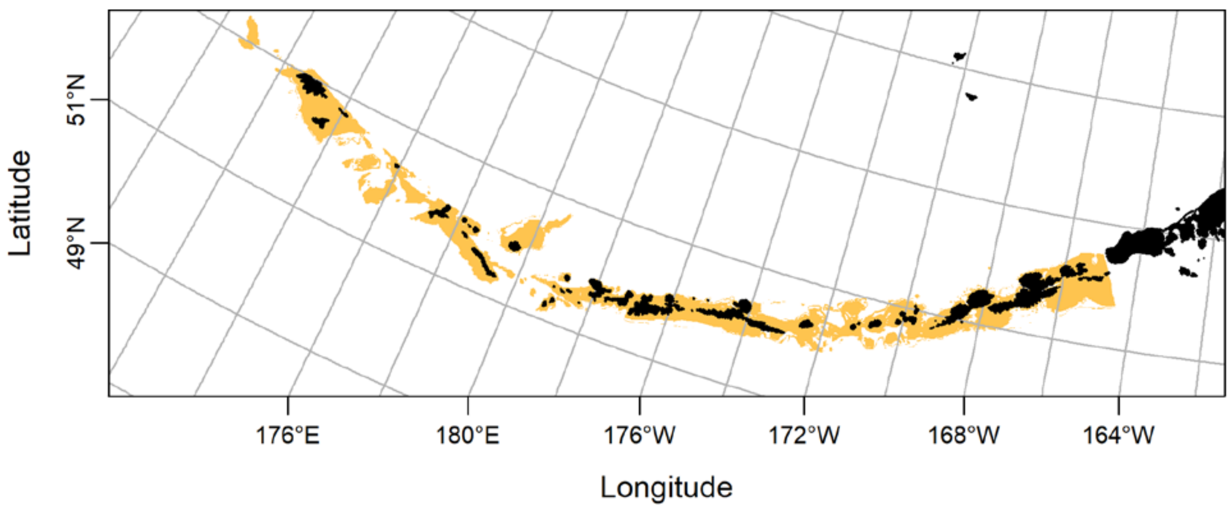


**Figure E-198 EFH distribution of AI Atka mackerel adult, summer.**

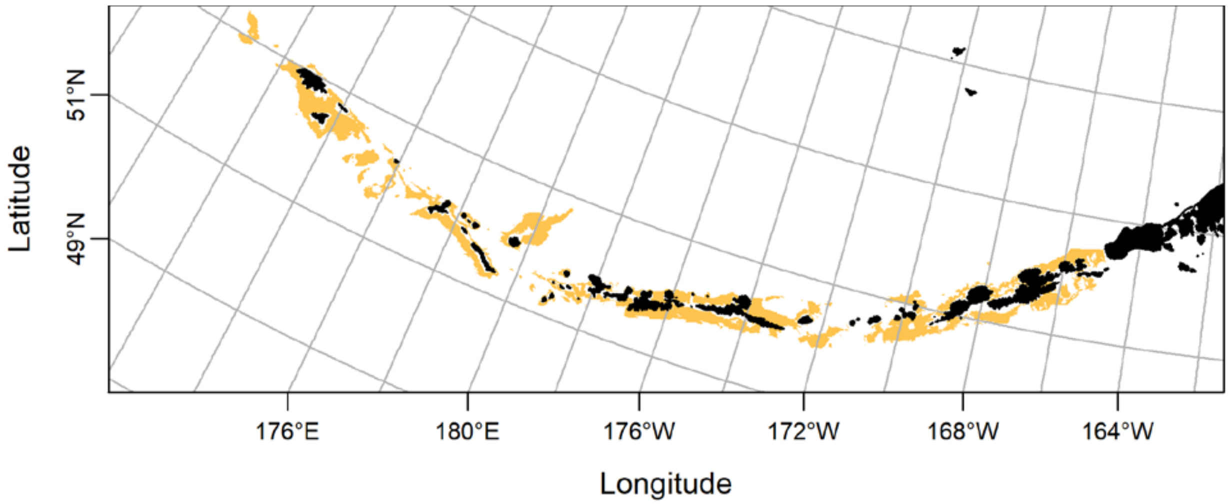


**Figure E-199 EFH distribution of AI Atka mackerel adult, winter.**

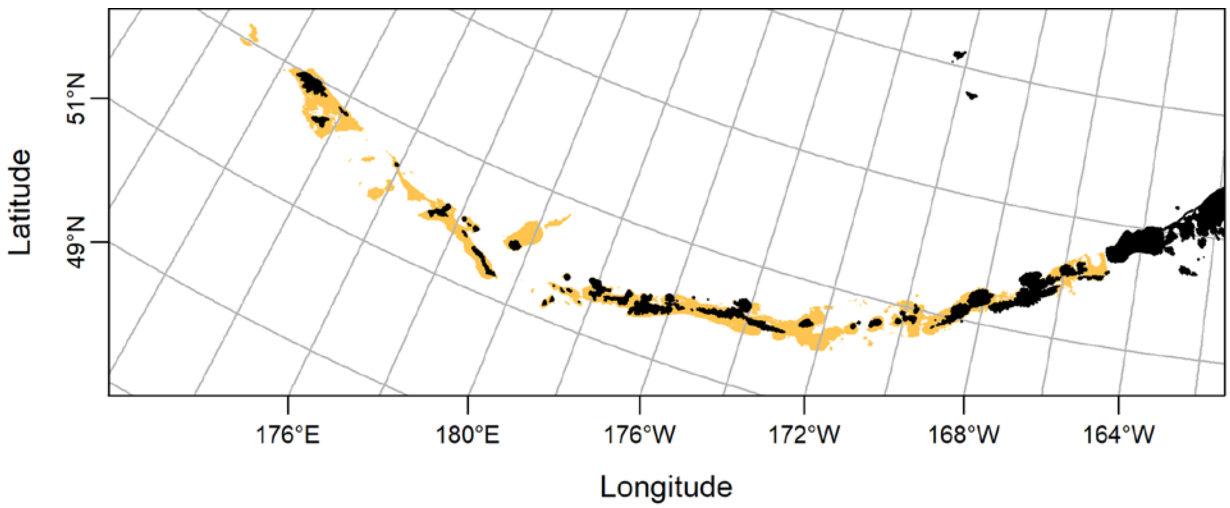


**Figure E-200 EFH distribution of AI Atka mackerel egg, summer.**

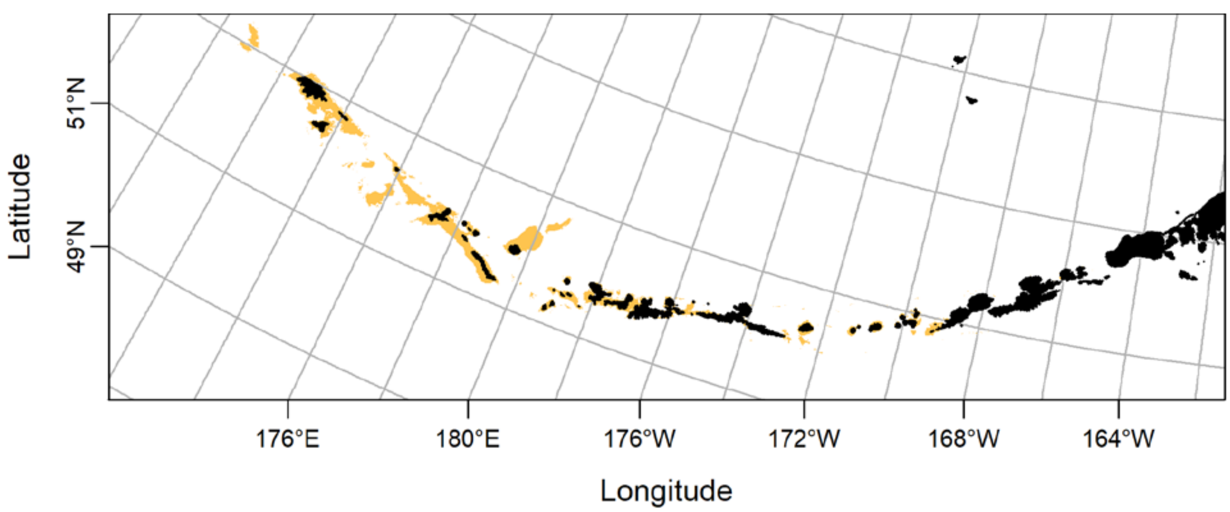


**Figure E-201 EFH distribution of AI Atka mackerel juvenile, summer.**

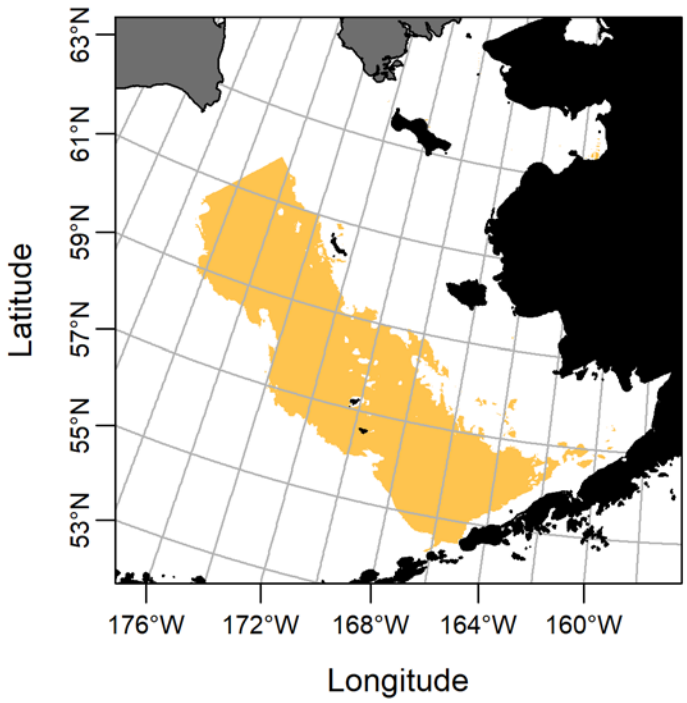


**Figure E-202 EFH distribution of EBS Bigmouth sculpin adult, fall.**

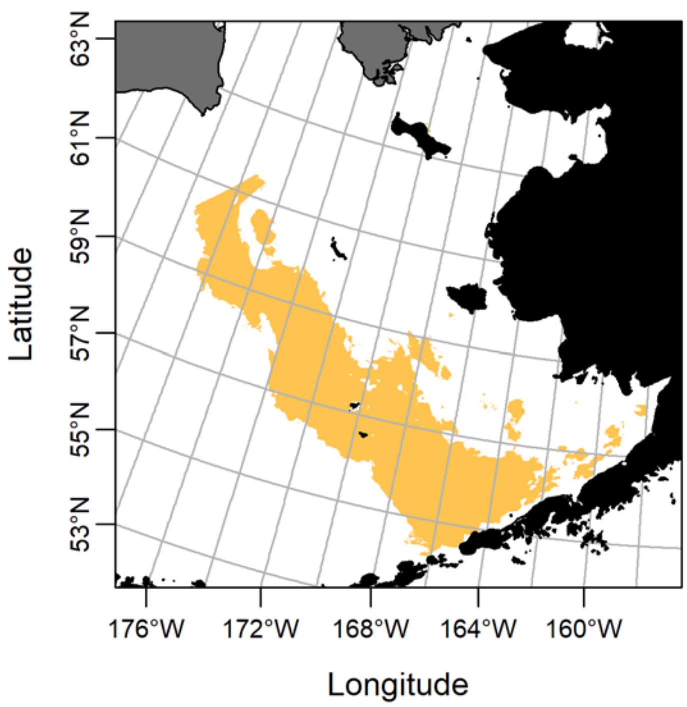


**Figure E-203 EFH distribution of EBS Bigmouth sculpin adult, spring.**

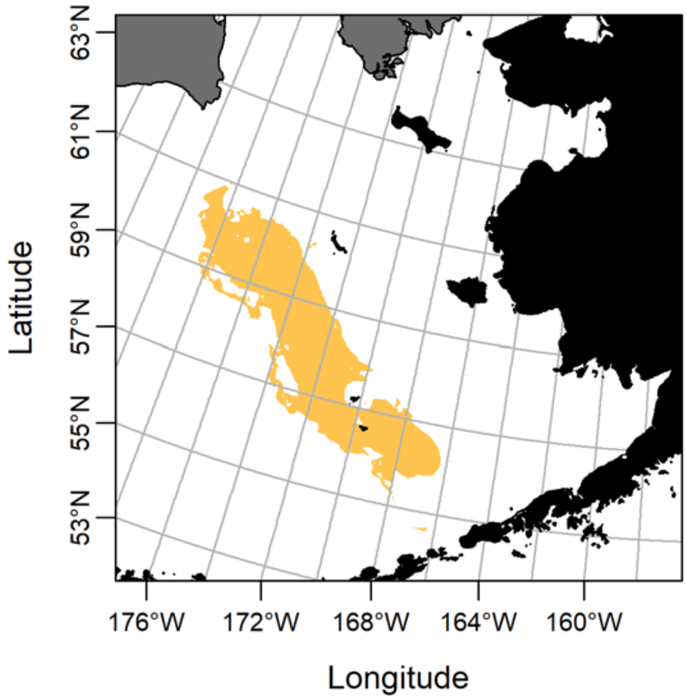


**Figure E-204 EFH distribution of EBS Bigmouth sculpin adult, summer.**

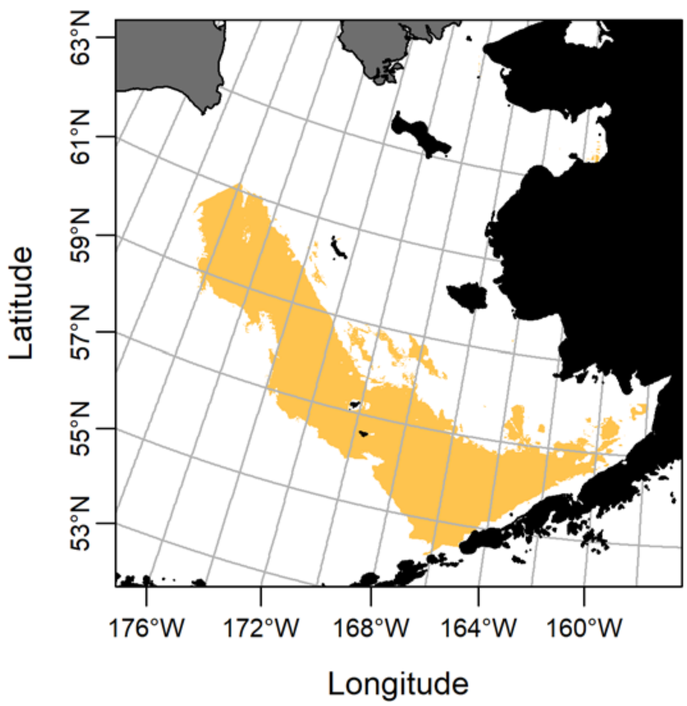


**Figure E-205 EFH distribution of EBS Bigmouth sculpin adult, winter.**

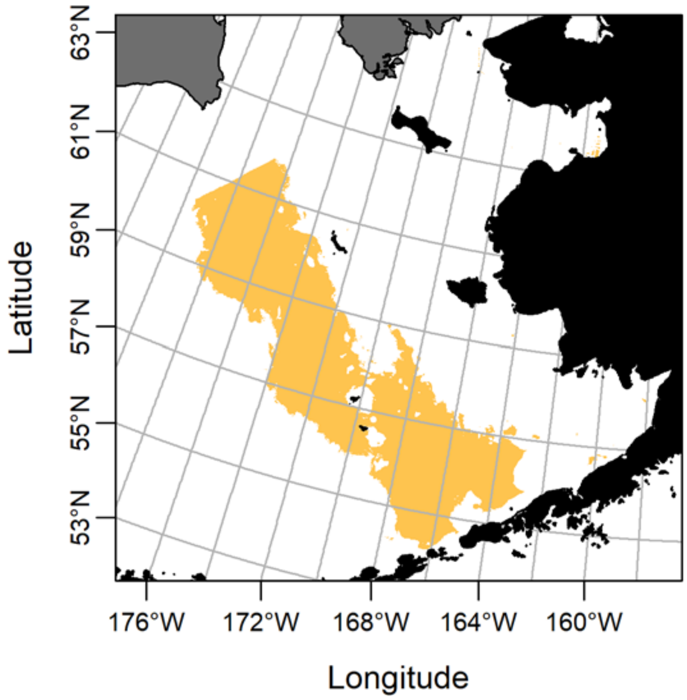


**Figure E-206 EFH distribution of EBS Bigmouth sculpin juvenile, summer.**

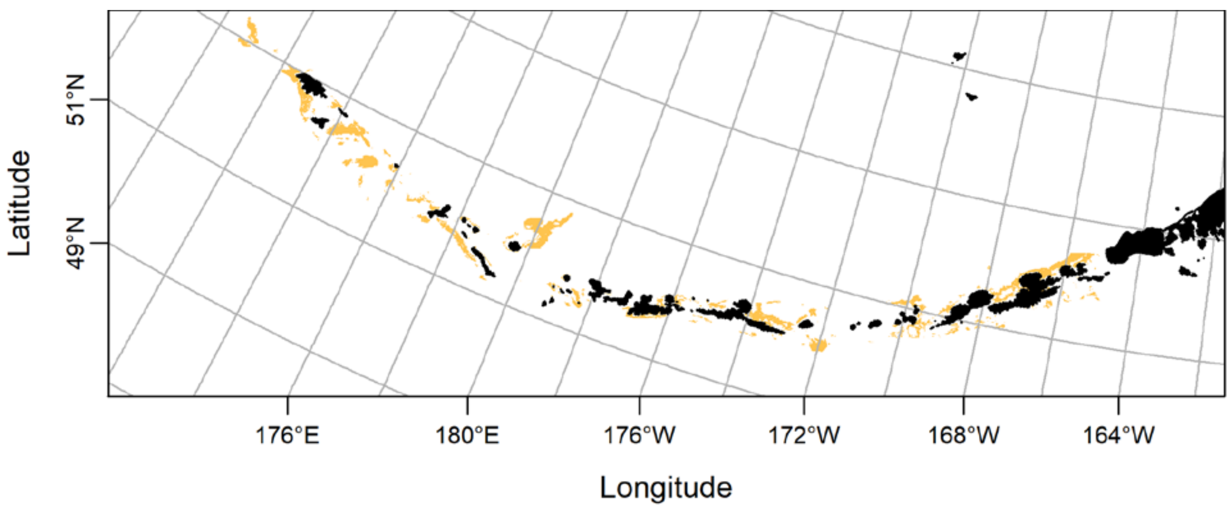


**Figure E-207 EFH distribution of AI Bigmouth sculpin adult, fall.**

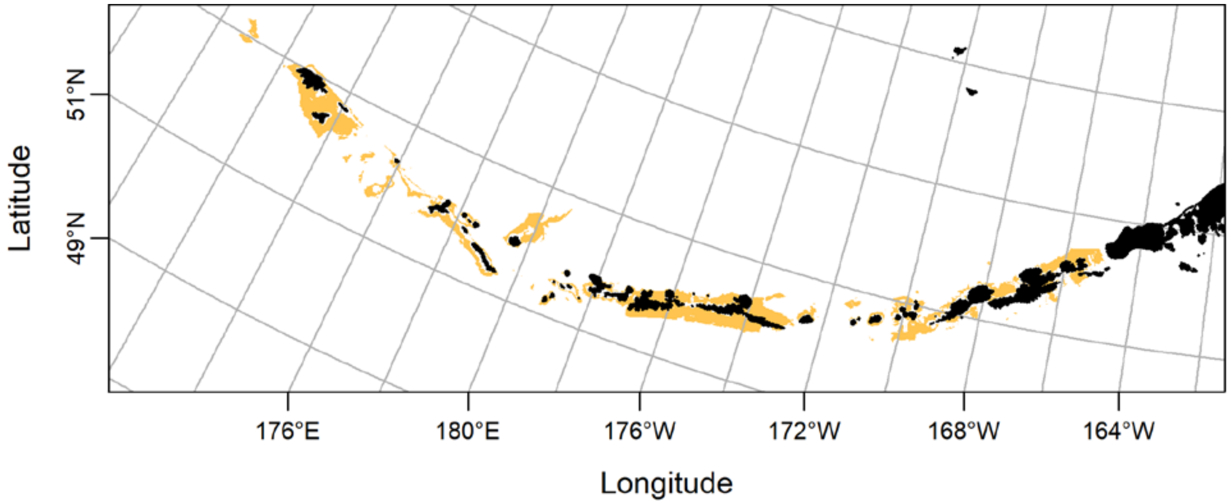


**Figure E-208 EFH distribution of AI Bigmouth sculpin adult, spring.**

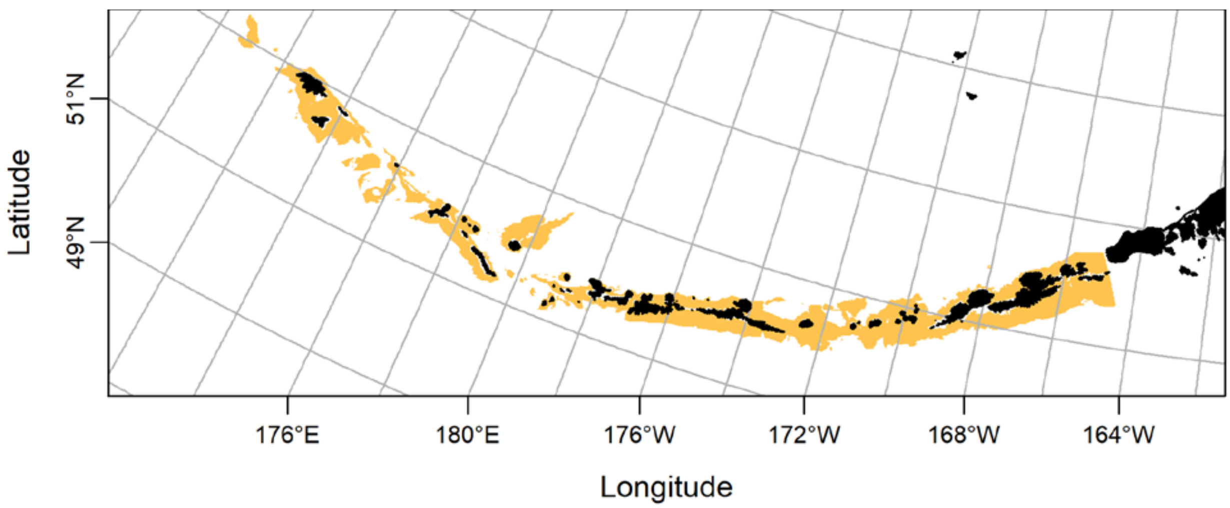


**Figure E-209 EFH distribution of AI Bigmouth sculpin adult, summer.**

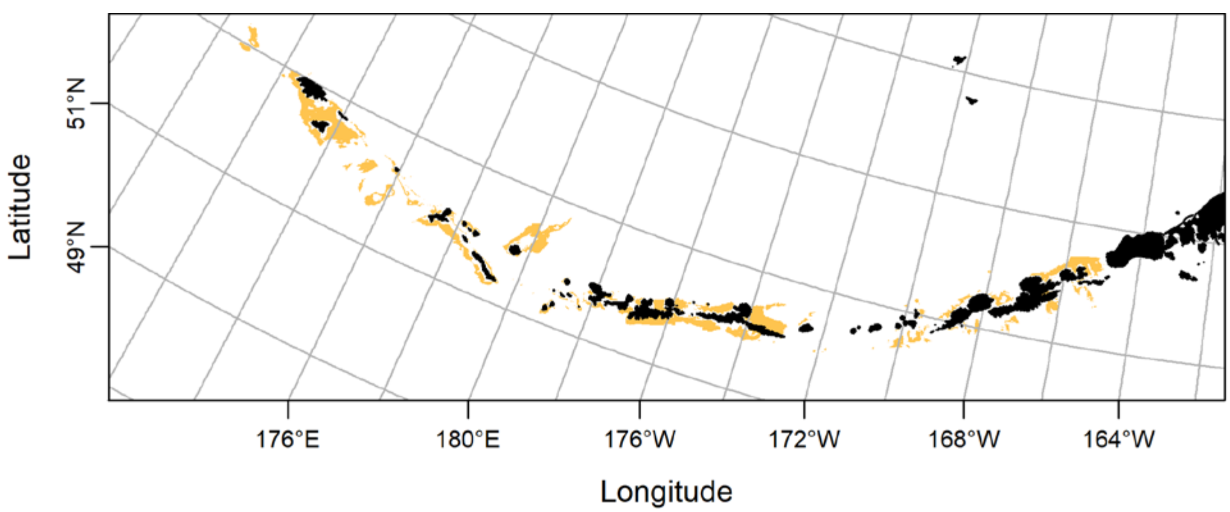


**Figure E-210 EFH distribution of AI Bigmouth sculpin adult, winter.**

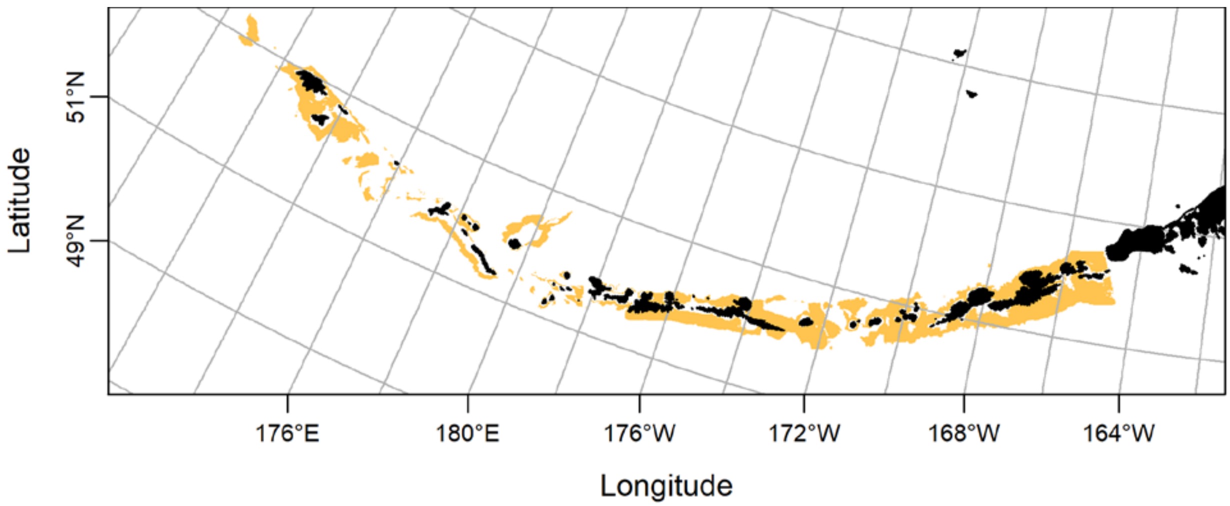


**Figure E-211 EFH distribution of AI Bigmouth sculpin juvenile, summer.**

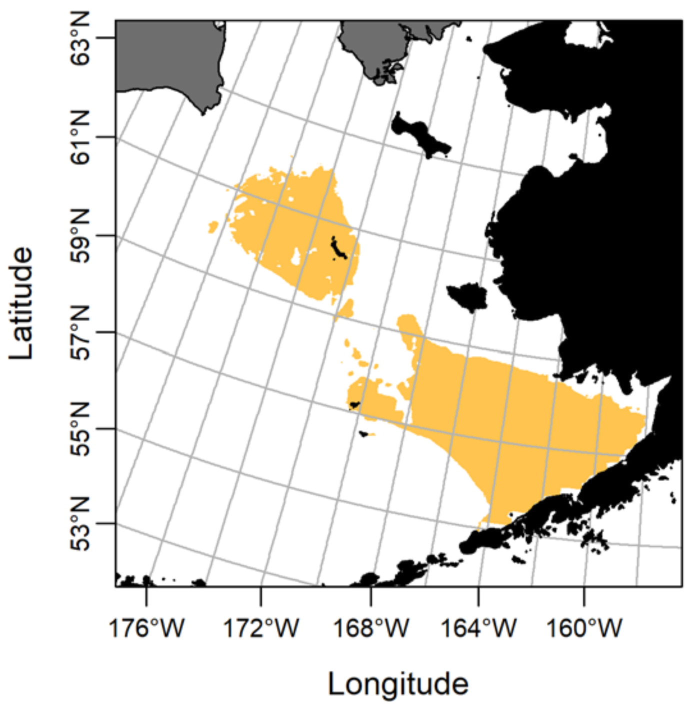


**Figure E-212 EFH distribution of EBS Great sculpin juvenile, summer.**

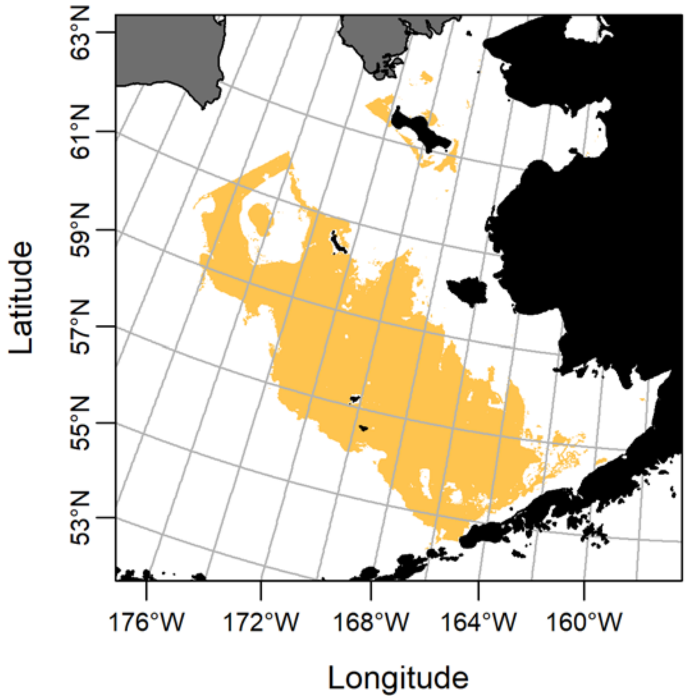

**Figure E-213 EFH distribution of EBS Great sculpin adult, fall.**

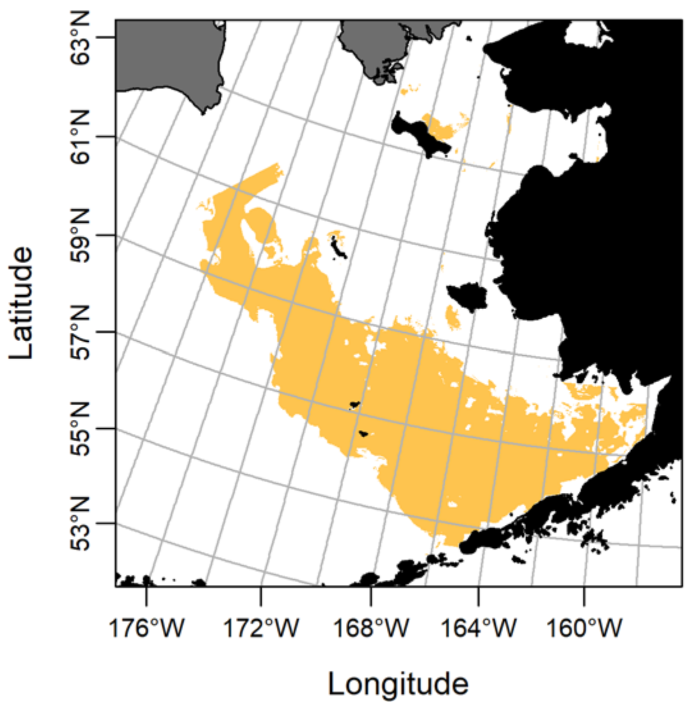

**Figure E-214 EFH distribution of EBS Great sculpin adult, spring.**

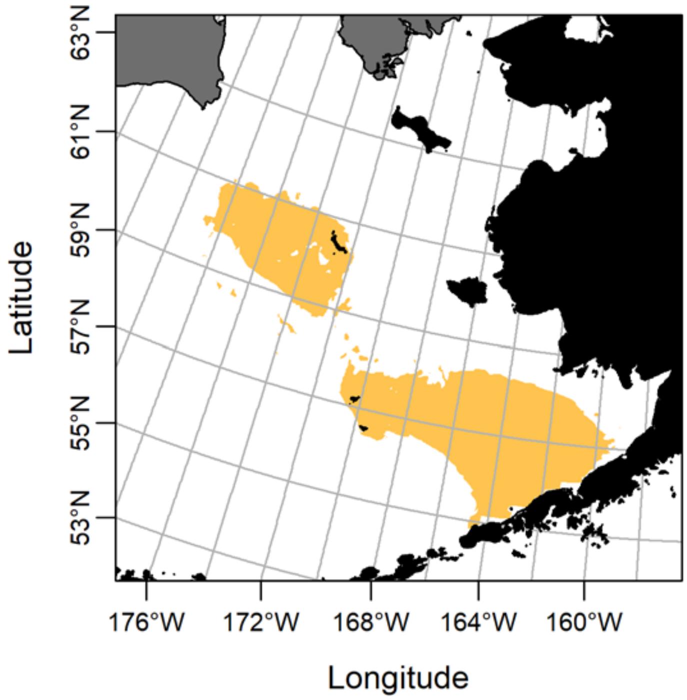


**Figure E-215 EFH distribution of EBS Great sculpin adult, summer.**

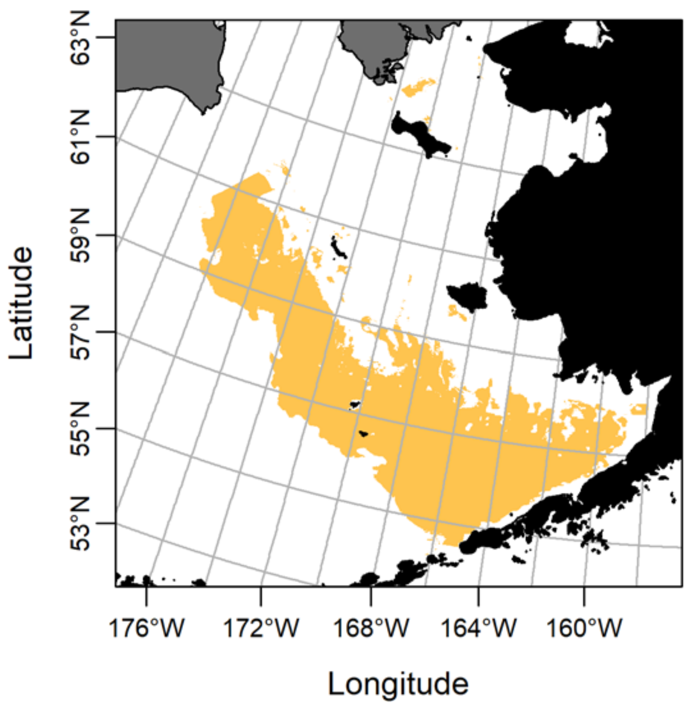


**Figure E-216 EFH distribution of EBS Great sculpin adult, winter.**

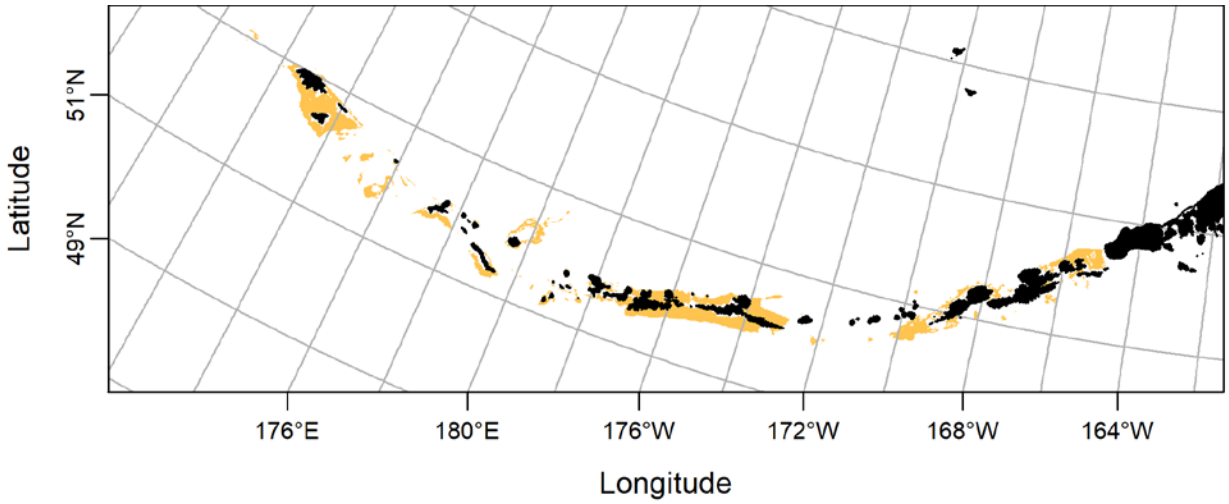


**Figure E-217 EFH distribution of AI Great sculpin adult, spring.**

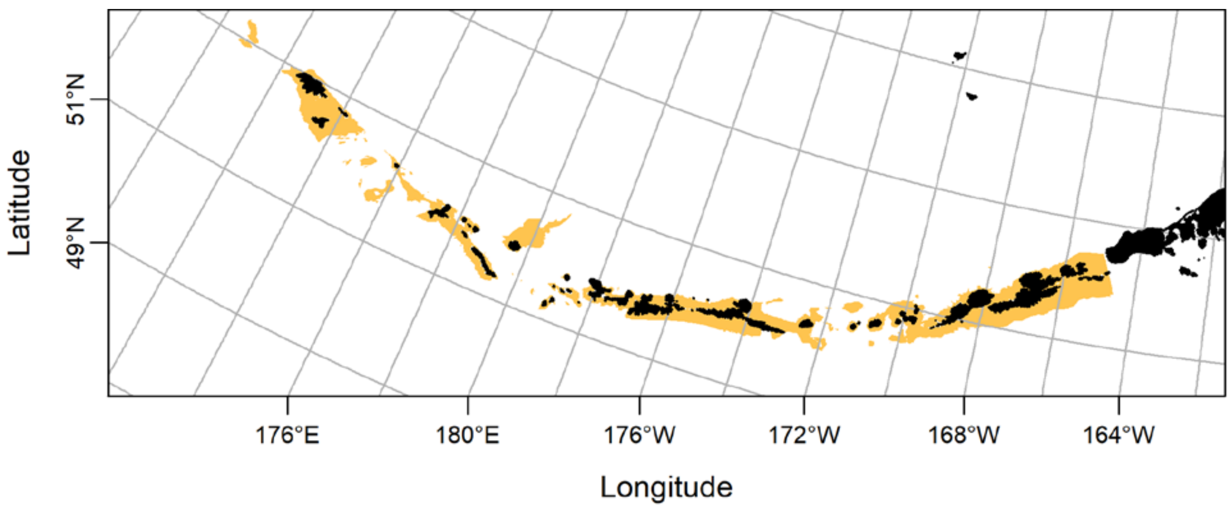


**Figure E-218 EFH distribution of AI Great sculpin adult, summer.**

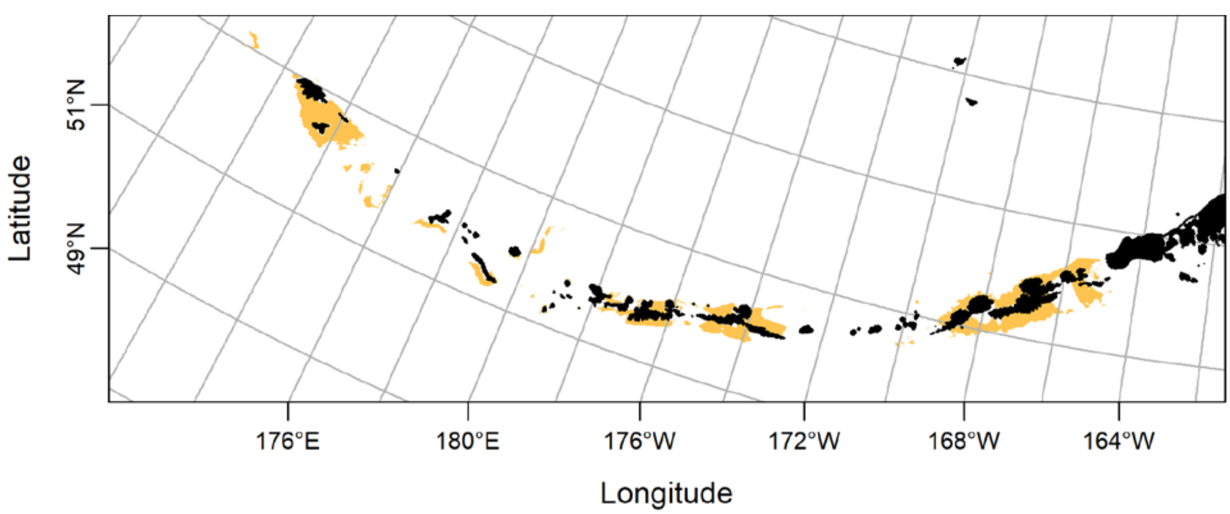


**Figure E-219 EFH distribution of AI Great sculpin adult, winter.**

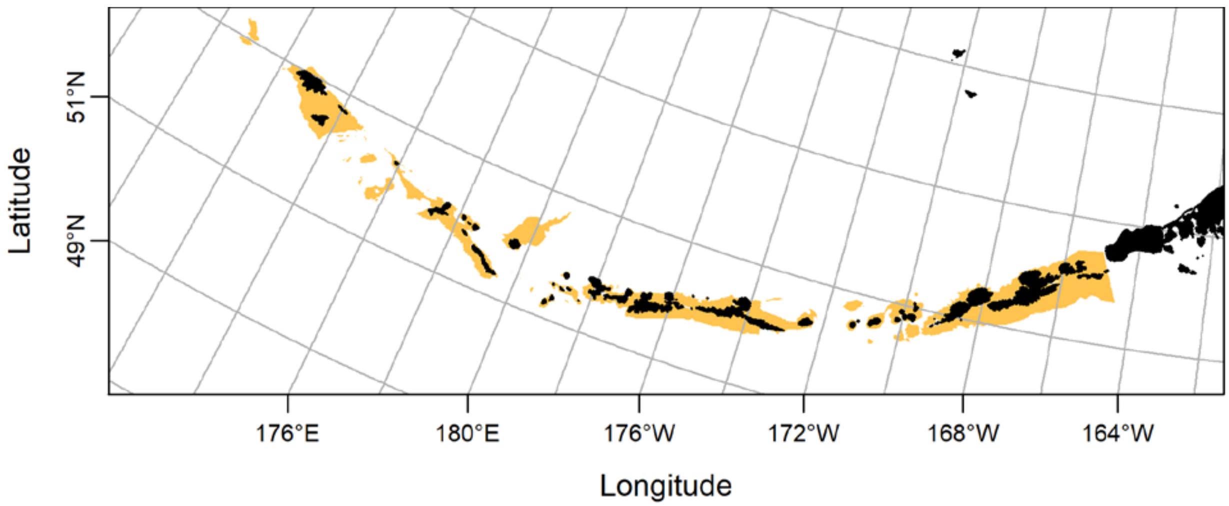


**Figure E-220 EFH distribution of AI Great sculpin juvenile, summer.**

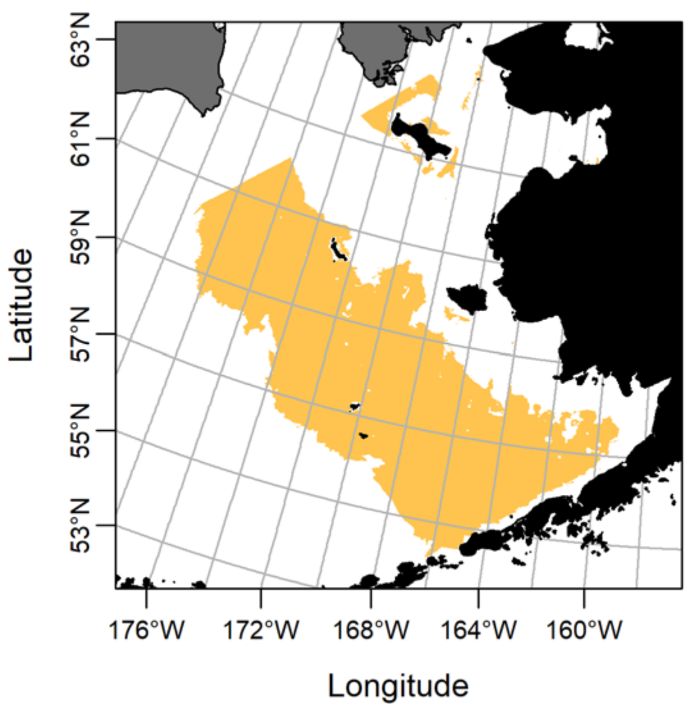


**Figure E-221 EFH distribution of EFH distribution of EBS Alaska skate adult, fall.**

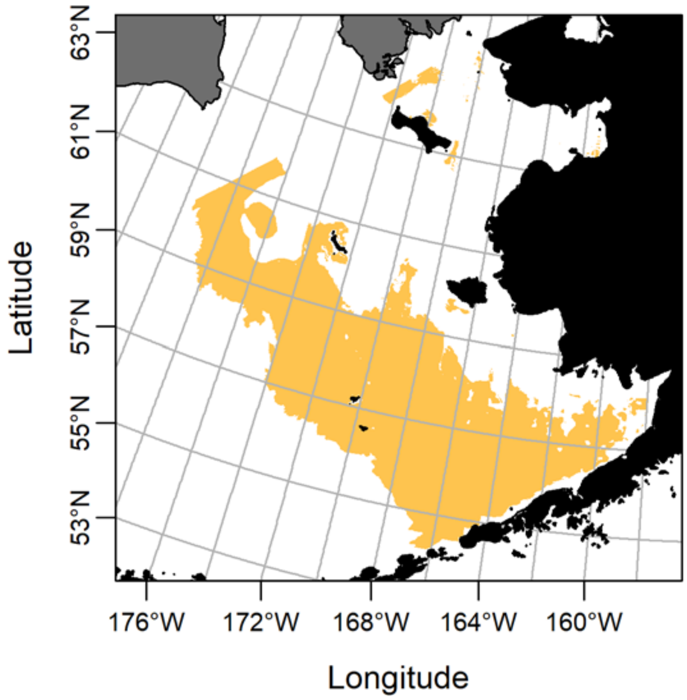


**Figure E-222 EFH distribution of EBS Alaska skate adult, spring.**

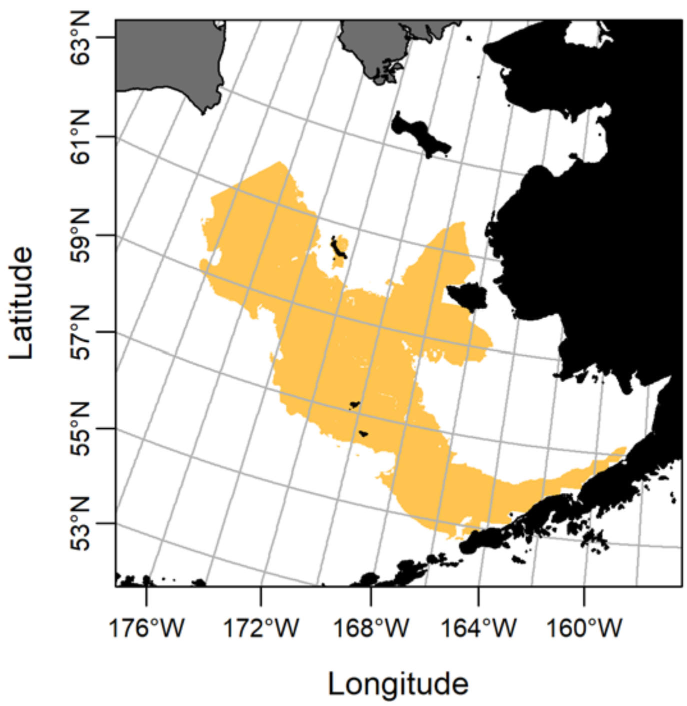


**Figure E-223 EFH distribution of EBS Alaska skate adult, summer.**

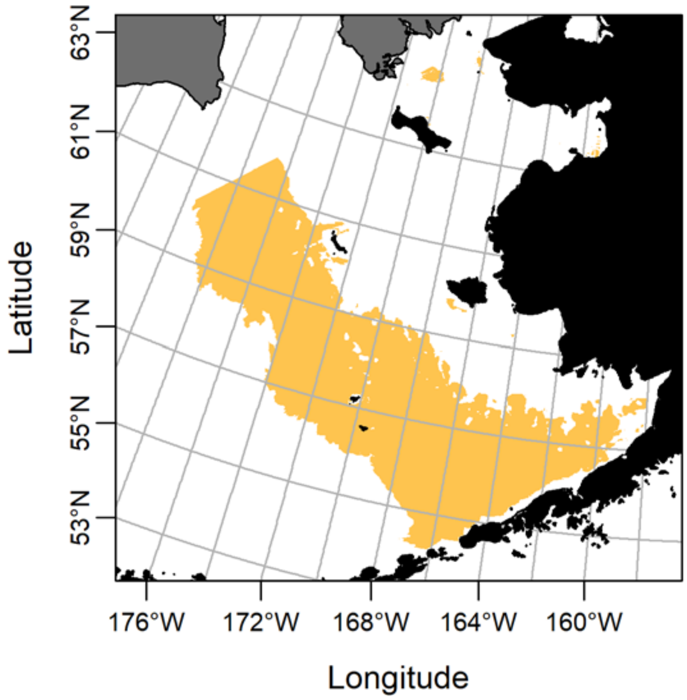


**Figure E-224 EFH distribution of EBS Alaska skate adult, winter.**

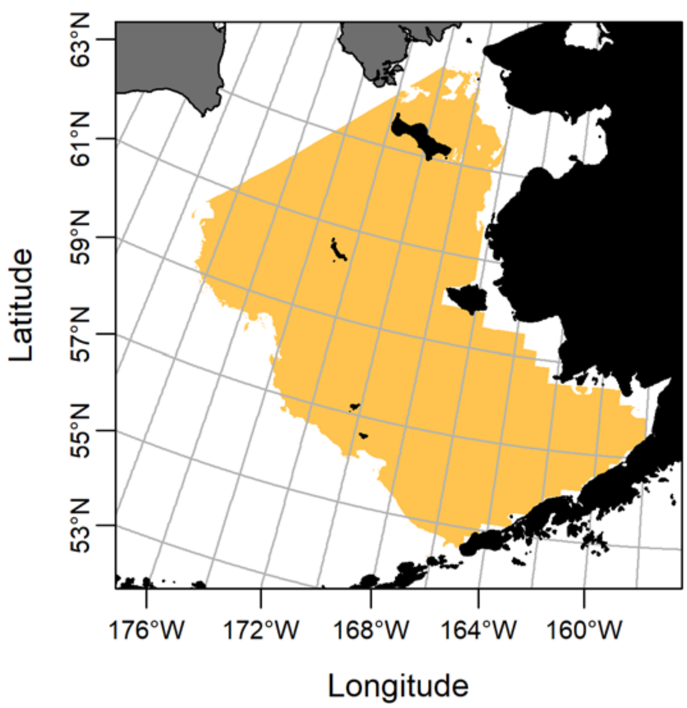


**Figure E-225 EFH distribution of EBS Alaska skate juvenile, summer.**

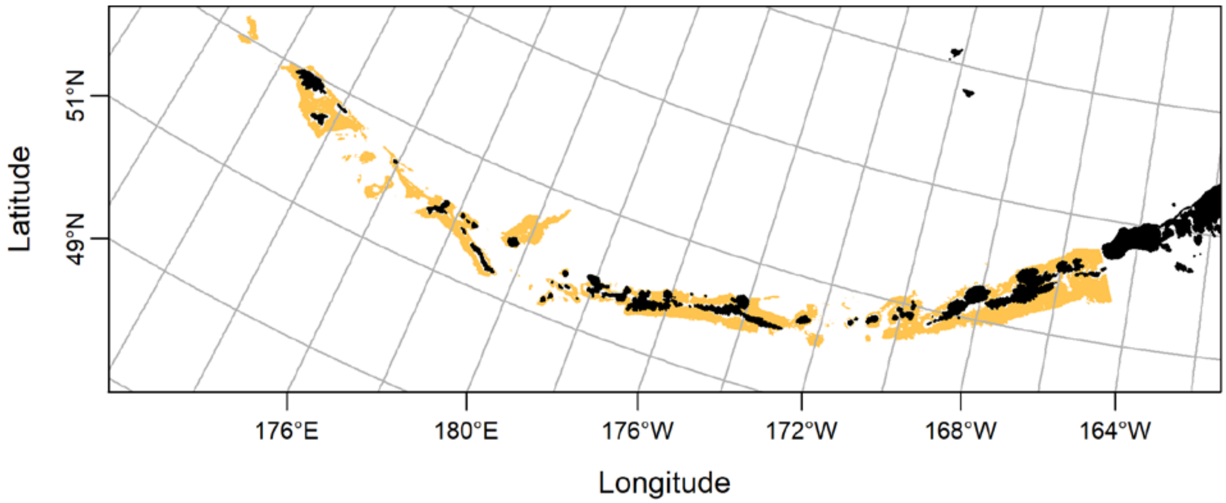


**Figure E-226 EFH distribution of AI Alaska skate adult, fall.**

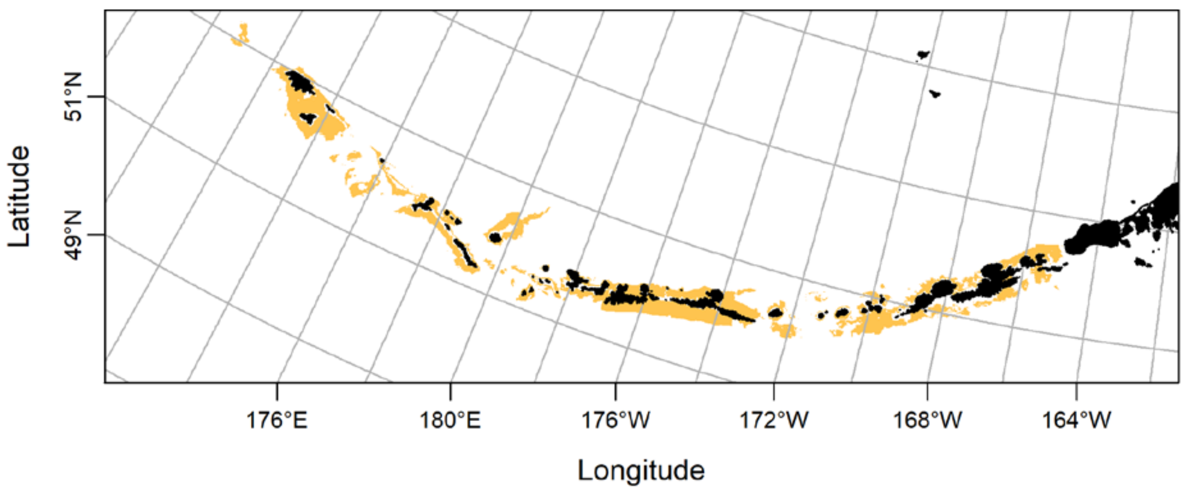


**Figure E-227 EFH distribution of AI Alaska skate adult, spring.**

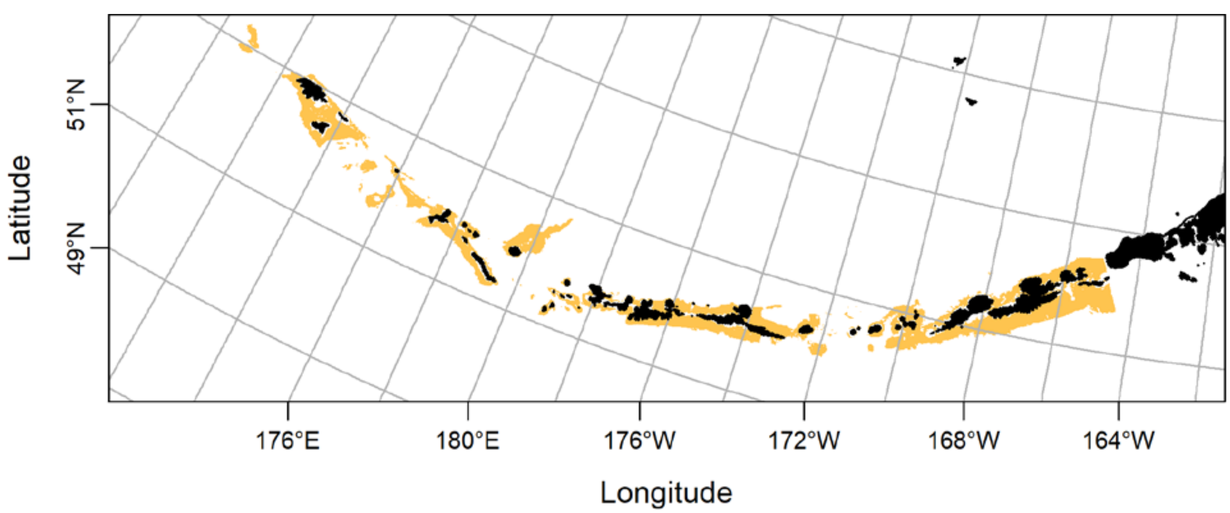


**Figure E-228 EFH distribution of AI Alaska skate adult, fall.**

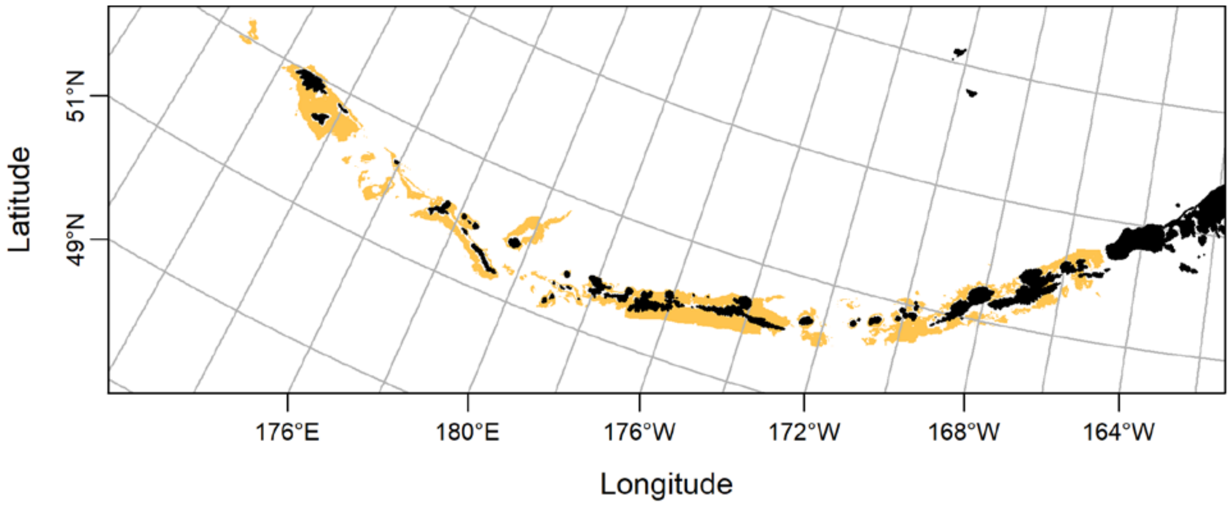


**Figure E-229 EFH distribution of AI Alaska skate adult, spring.**

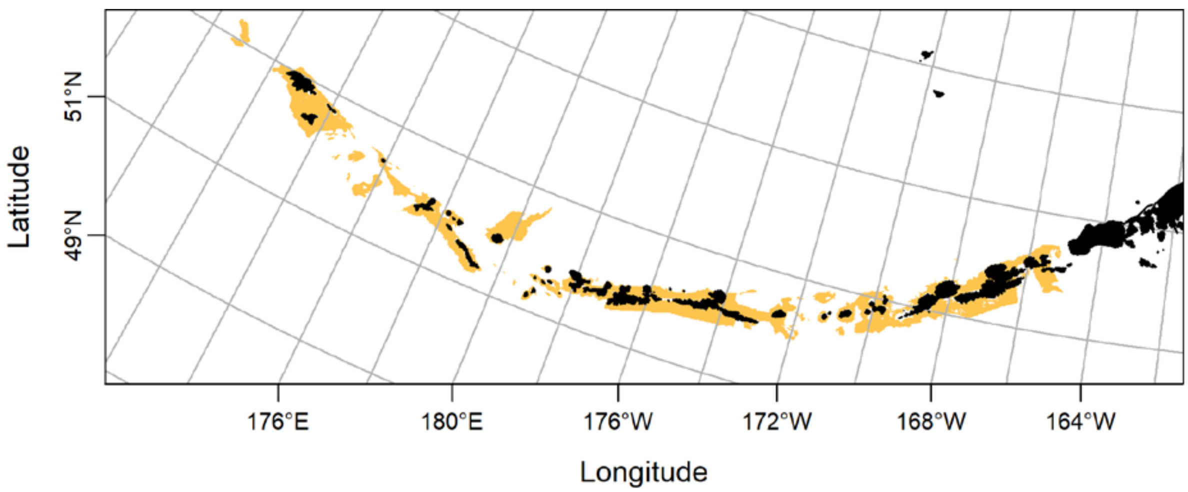


**Figure E-230 EFH distribution of AI Alaska skate adult, summer.**

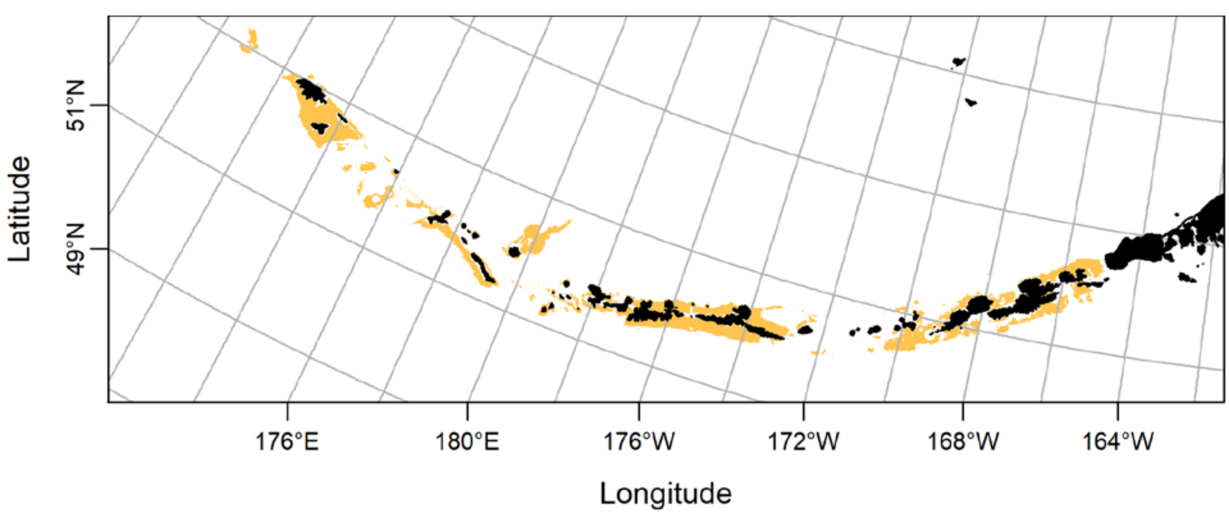


**Figure E-231 EFH distribution of AI Alaska skate adult, winter.**

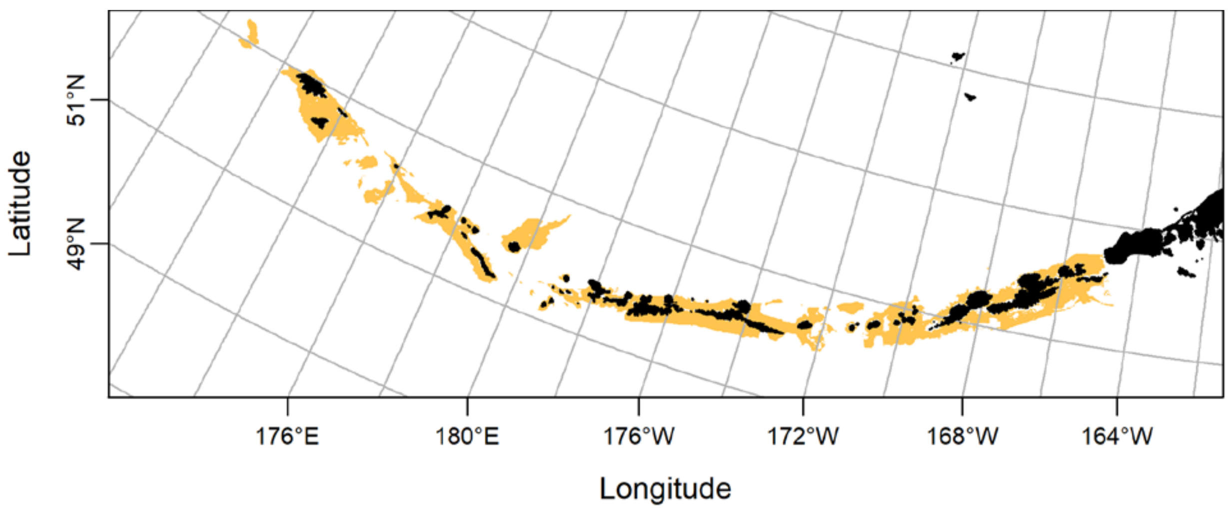


**Figure E-232 EFH distribution of AI Alaska skate juvenile, summer.**

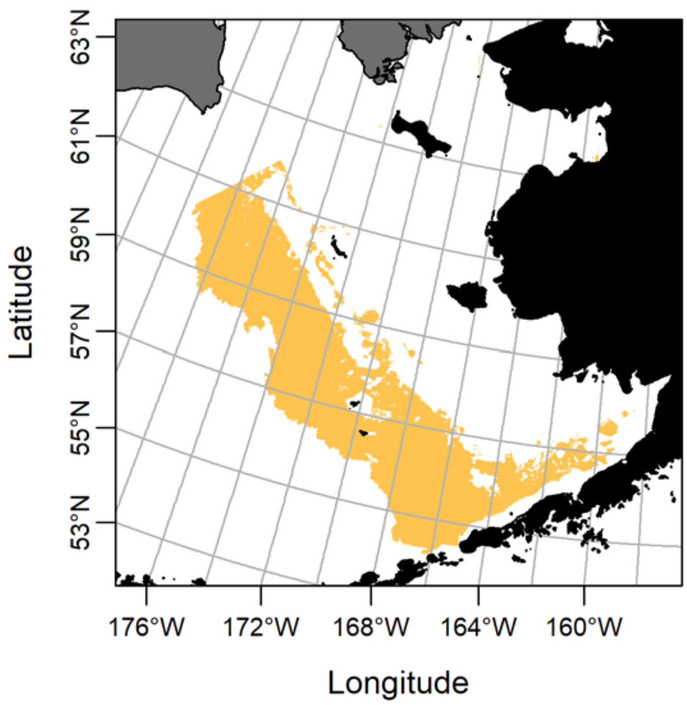


**Figure E-233 EFH distribution of EBS Aleutian skate adult, fall.**

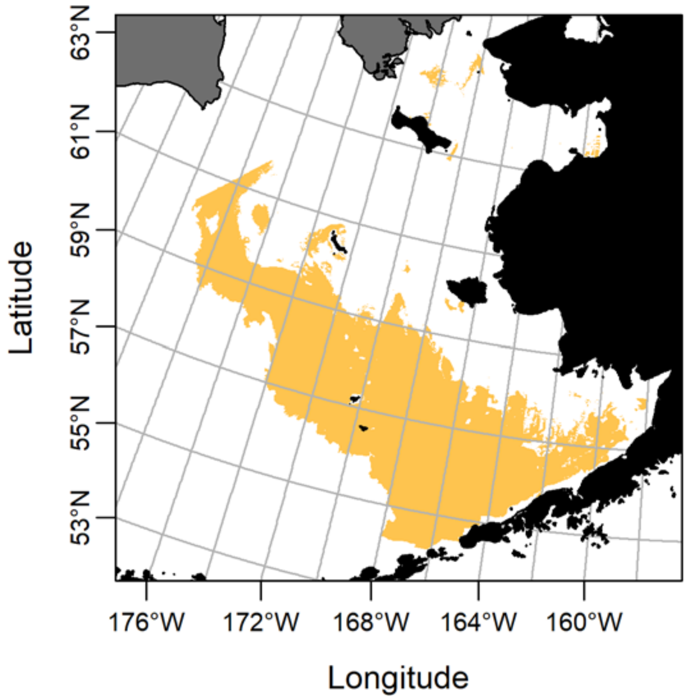


**Figure E-234 EFH distribution of EBS Aleutian skate adult, spring.**

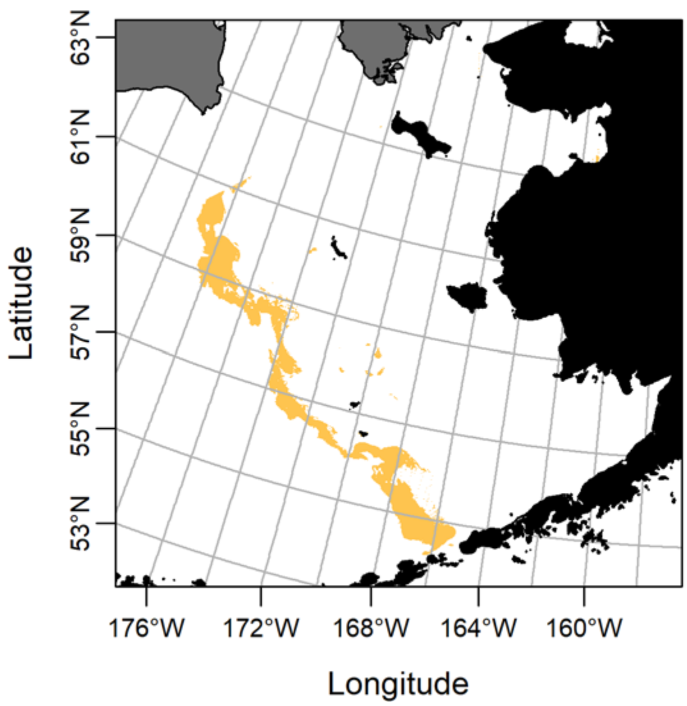


**Figure E-235 EFH distribution of EBS Aleutian skate adult, summer.**

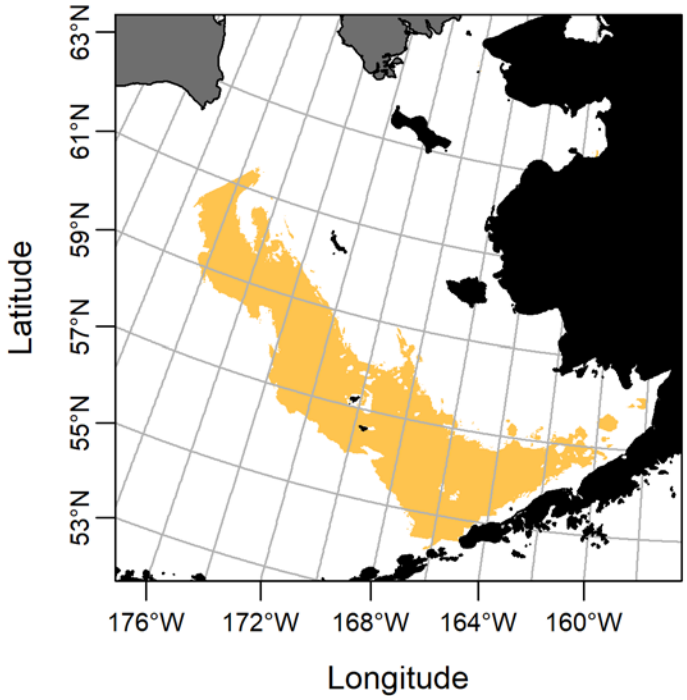


**Figure E-236 EFH distribution of EBS Aleutian skate adult, winter.**

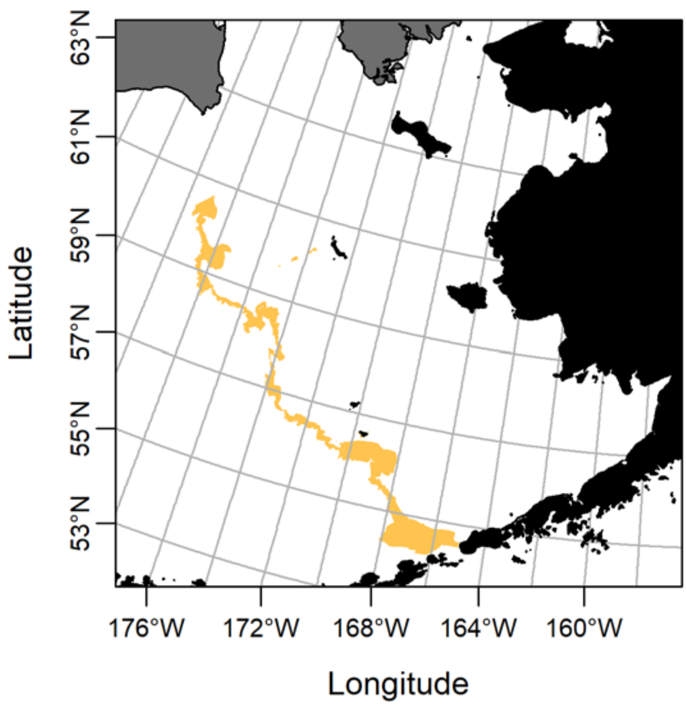


**Figure E-237 EFH distribution of Aleutian skate juvenile, summer.**

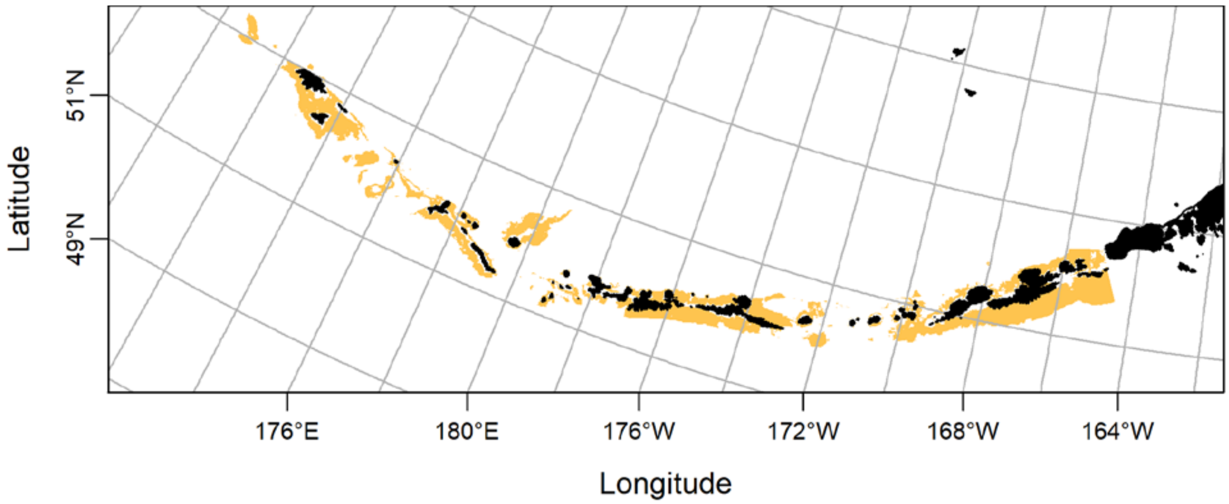


**Figure E-238 EFH distribution of AI Aleutian skate adult, fall.**

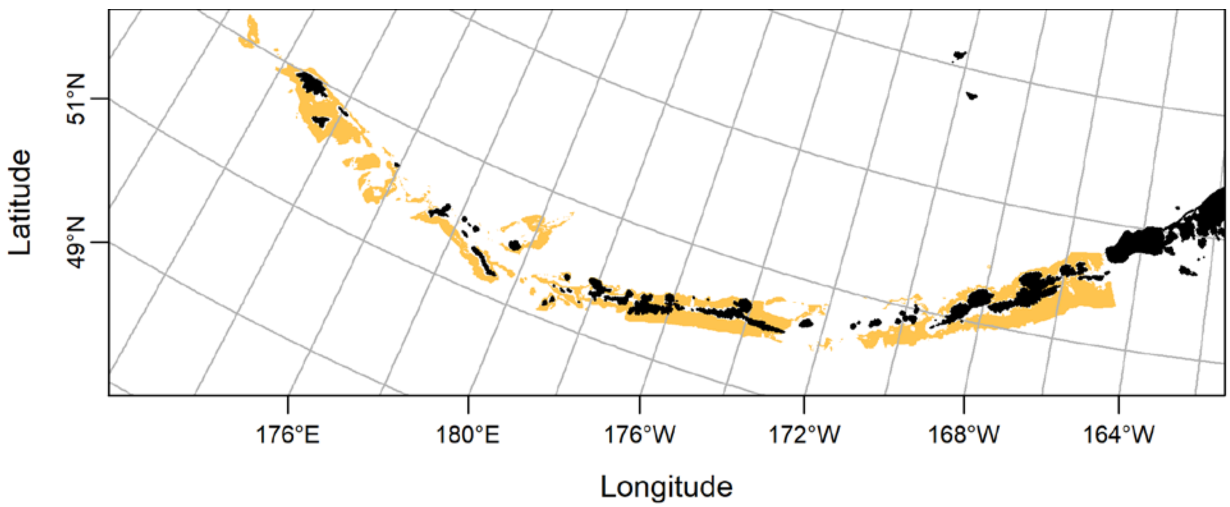


**Figure E-239 EFH distribution of AI Aleutian skate adult, spring.**

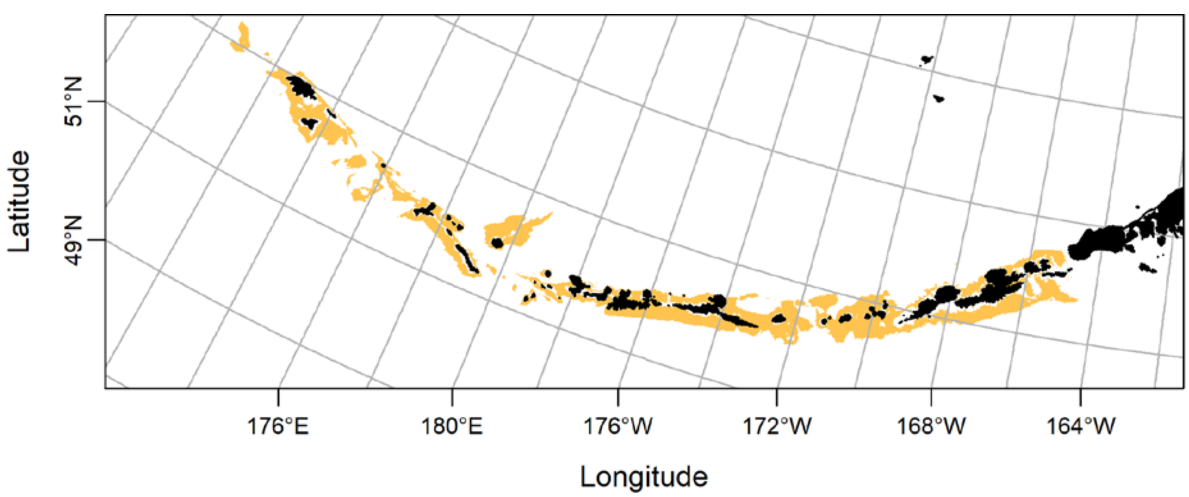


**Figure E-240 EFH distribution of AI Aleutian skate adult, summer.**

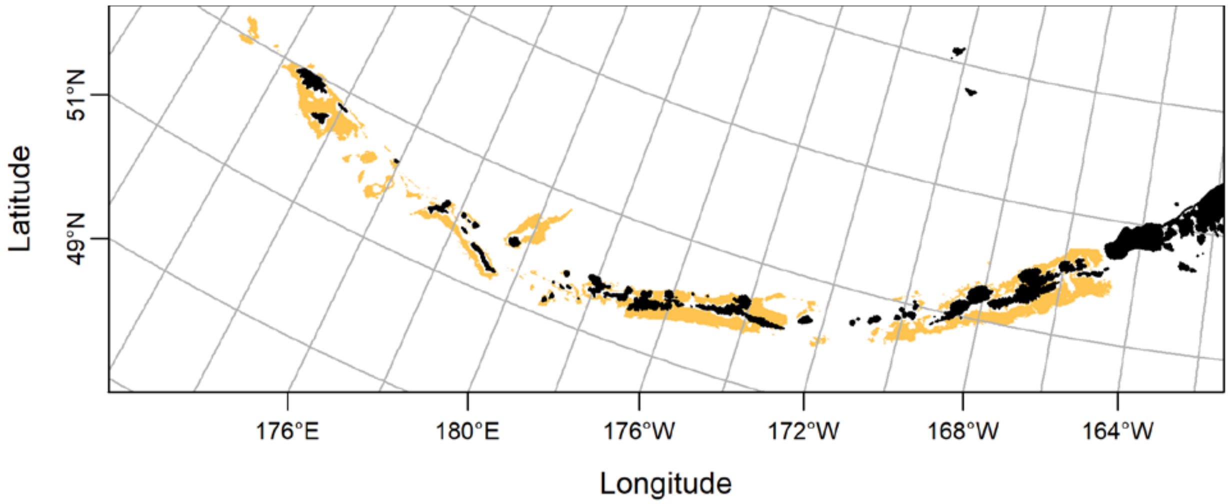


**Figure E-241 EFH distribution of AI Aleutian skate adult, winter.**

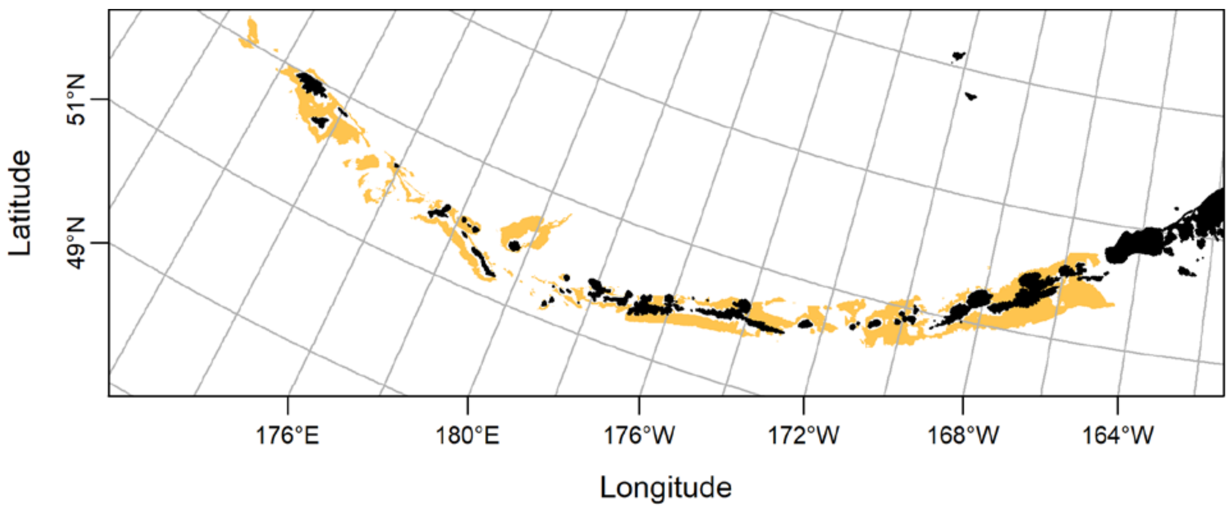


**Figure E-242 EFH distribution of AI Aleutian skate juvenile, summer.**

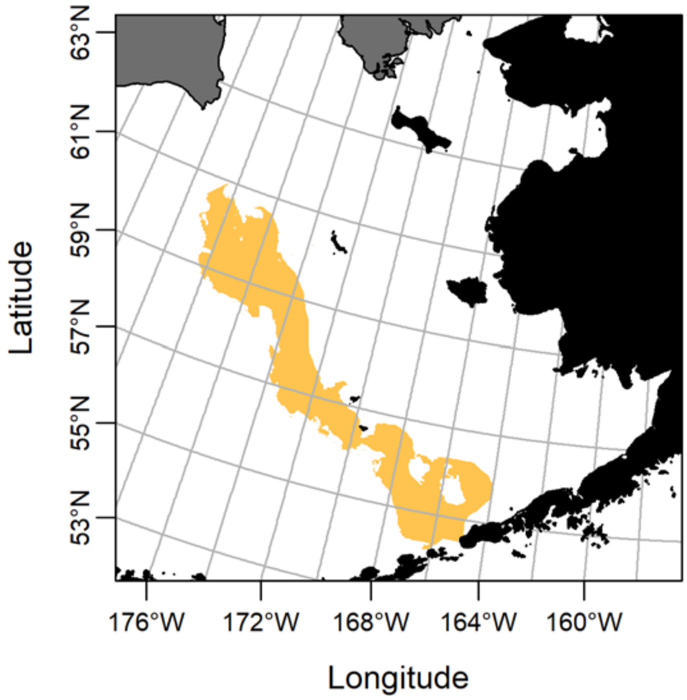


**Figure E-243 EFH distribution of EBS Bering skate adult, summer.**

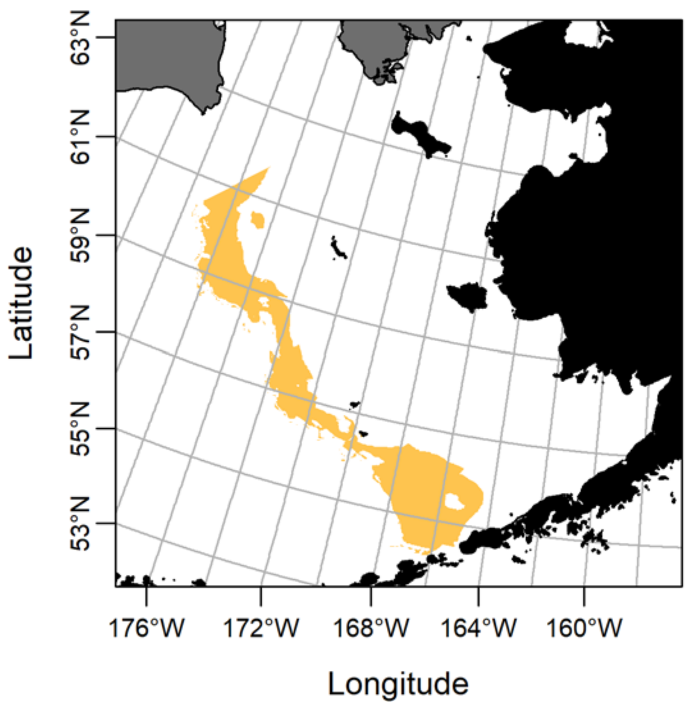


**Figure E-244 EFH distribution of EBS Bering skate juvenile, summer.**

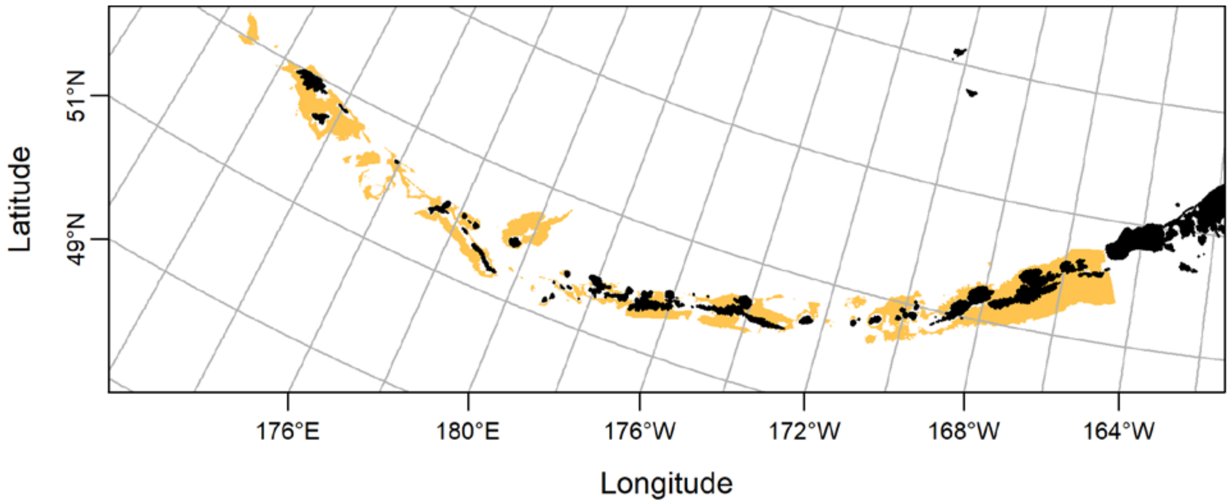


**Figure E-245 EFH distribution of AI Bering skate adult, summer.**

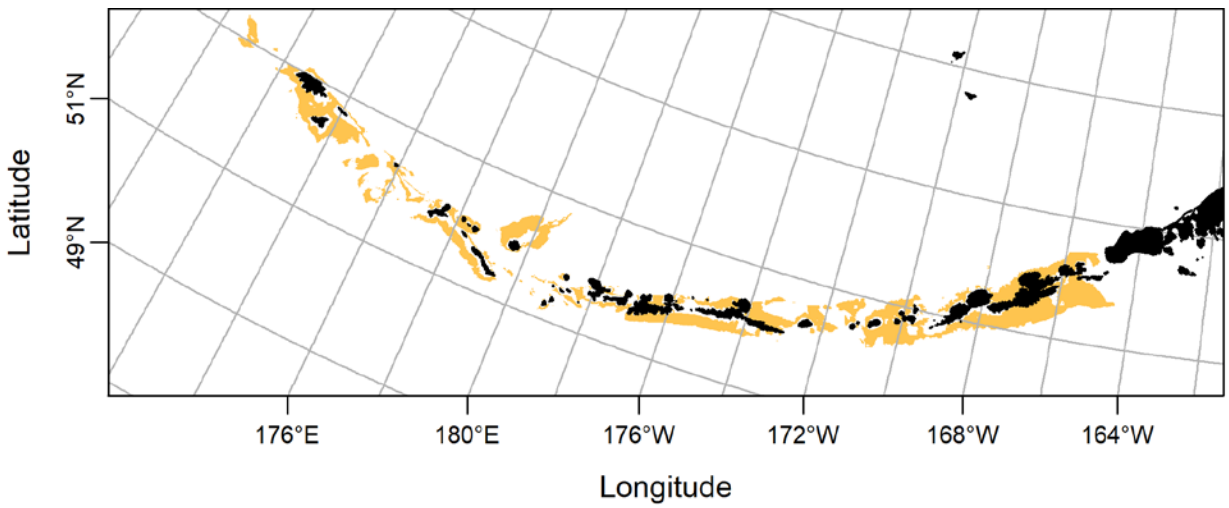


**Figure E-246 EFH distribution of AI Bering skate juvenile, summer.**

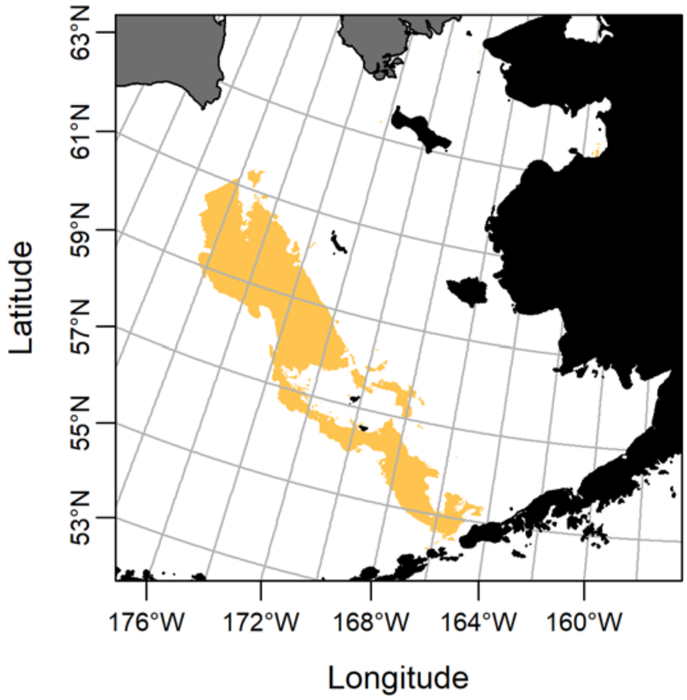


**Figure E-247 EFH distribution of EBS Mud skate adult, fall.**

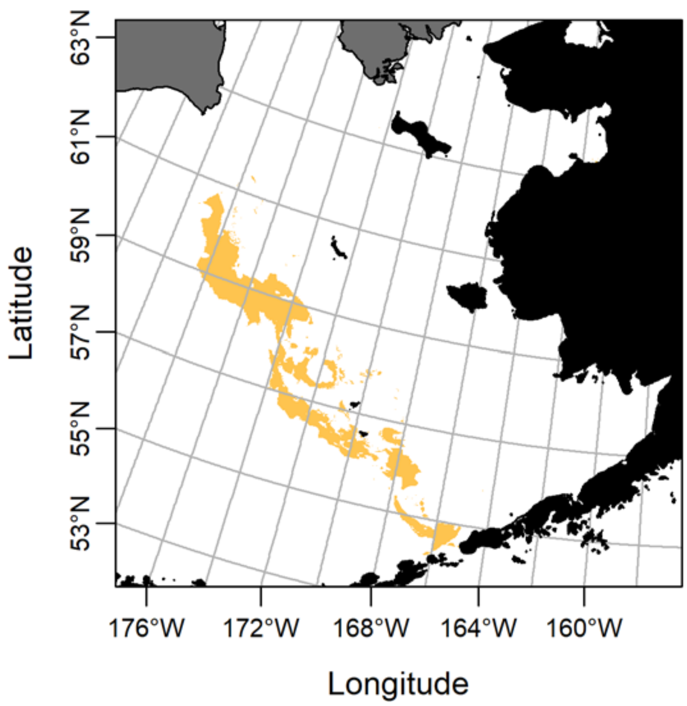


**Figure E-248 EFH distribution of EBS Mud skate adult, spring.**

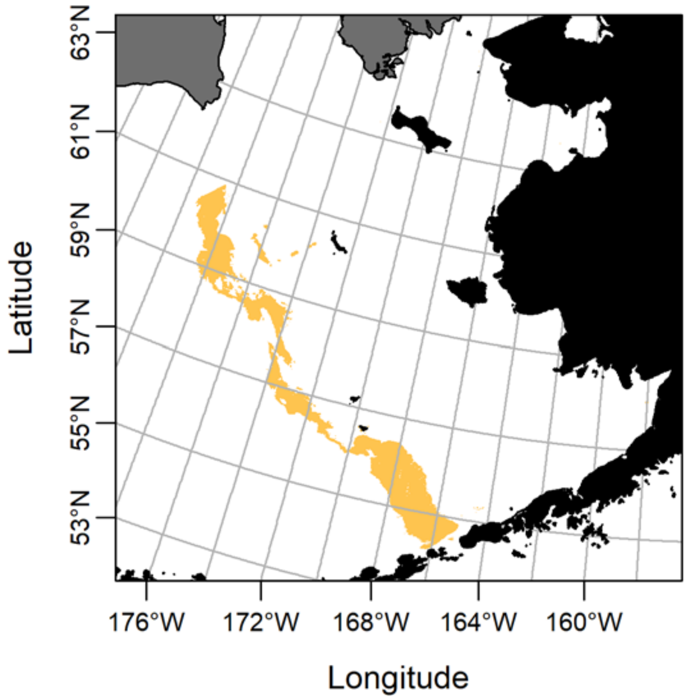


**Figure E-249 EFH distribution of EBS Mud skate adult, summer.**

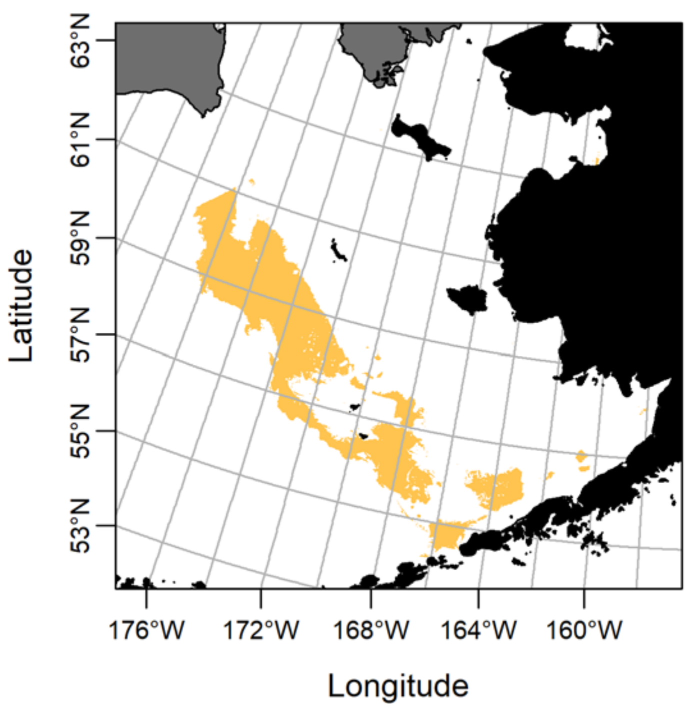


**Figure E-250 EFH distribution of EBS Mud skate adult, winter.**

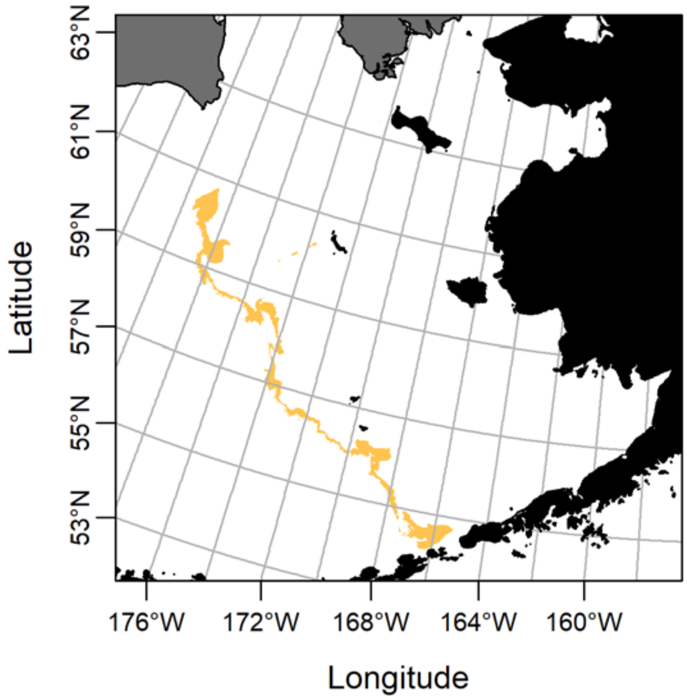


Figure E-251 EFH distribution of EBS Mud skate juvenile, summer.

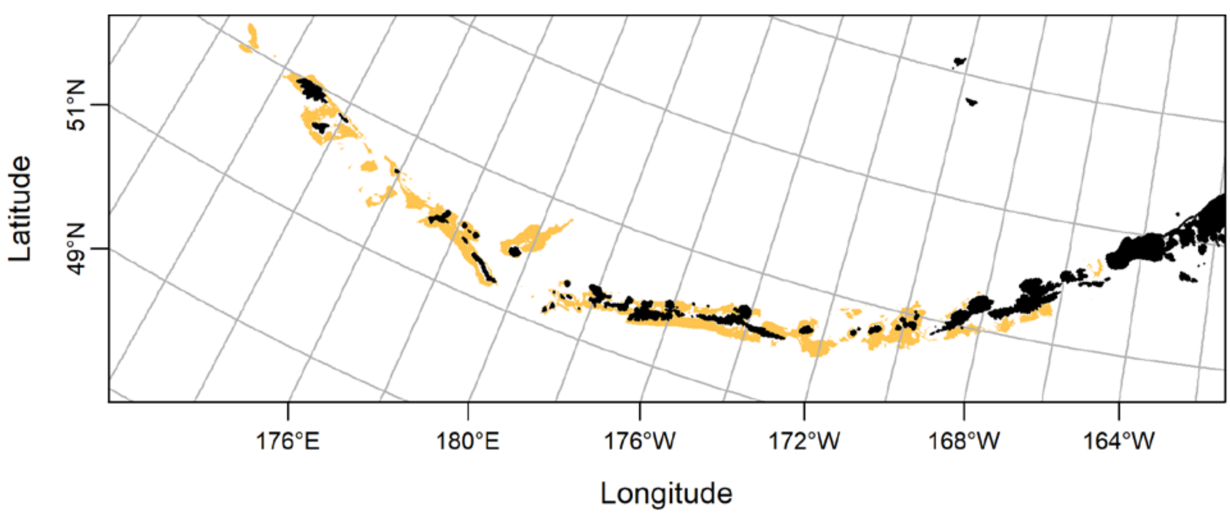


Figure E-252 EFH distribution of AI Mud skate adult, fall.

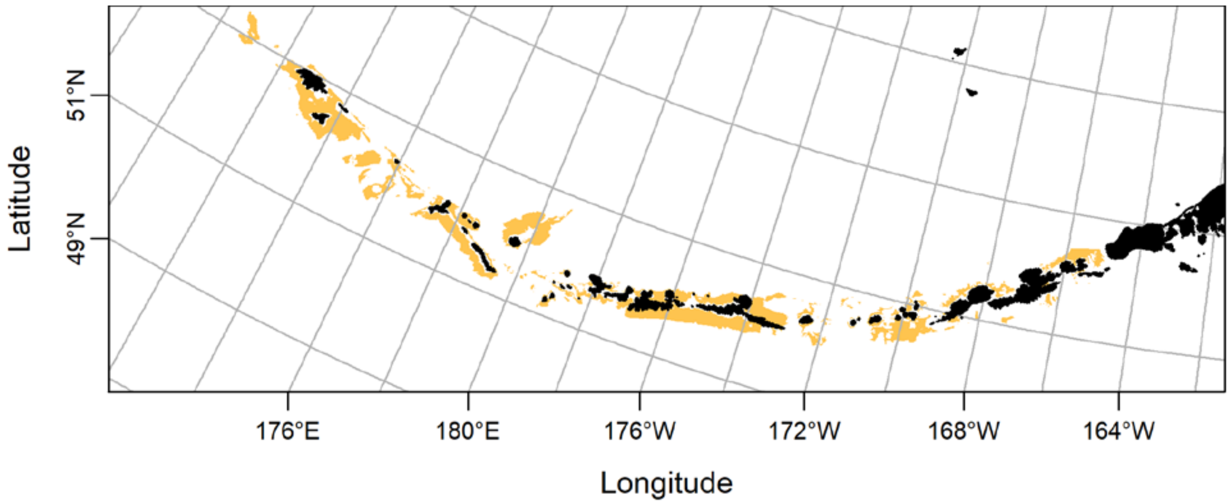


**Figure E-253 EFH distribution of AI Mud skate adult, spring.**

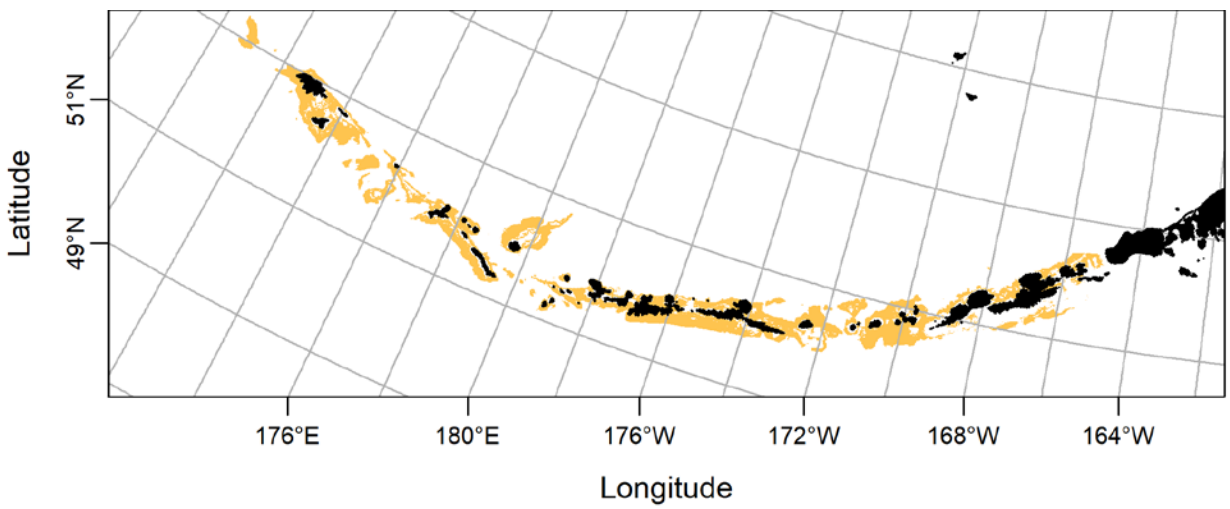


**Figure E-254 EFH distribution of AI Mud skate adult, summer.**

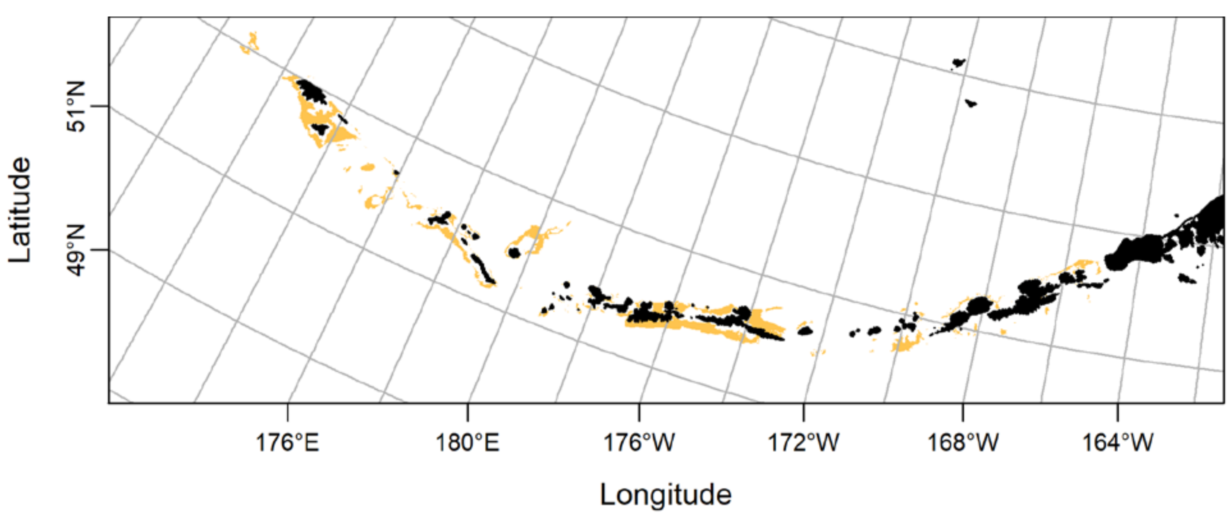


**Figure E-255 EFH distribution of AI Mud skate adult, winter.**

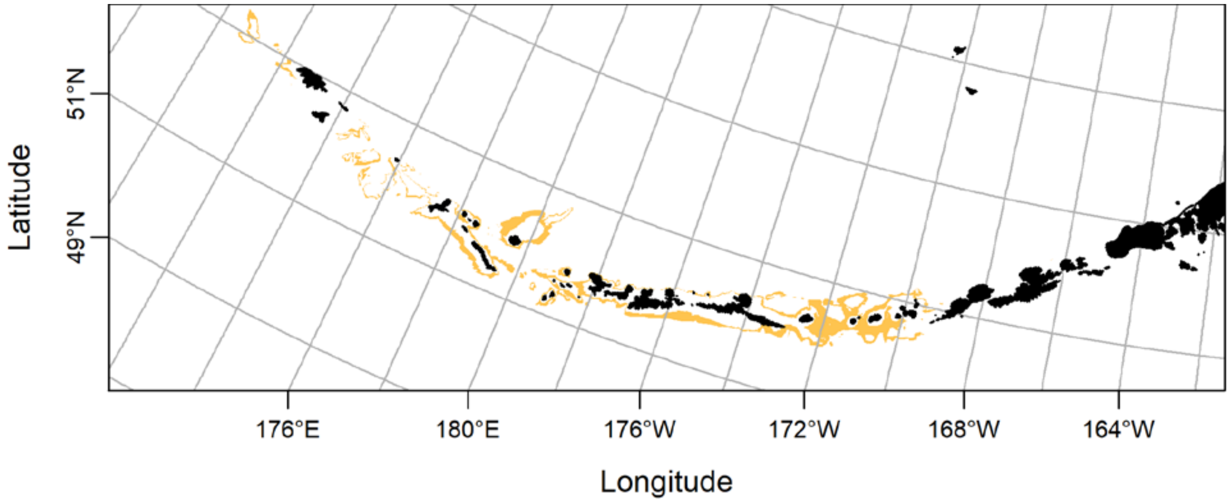


**Figure E-256 EFH distribution of AI Mud skate juvenile, summer.**

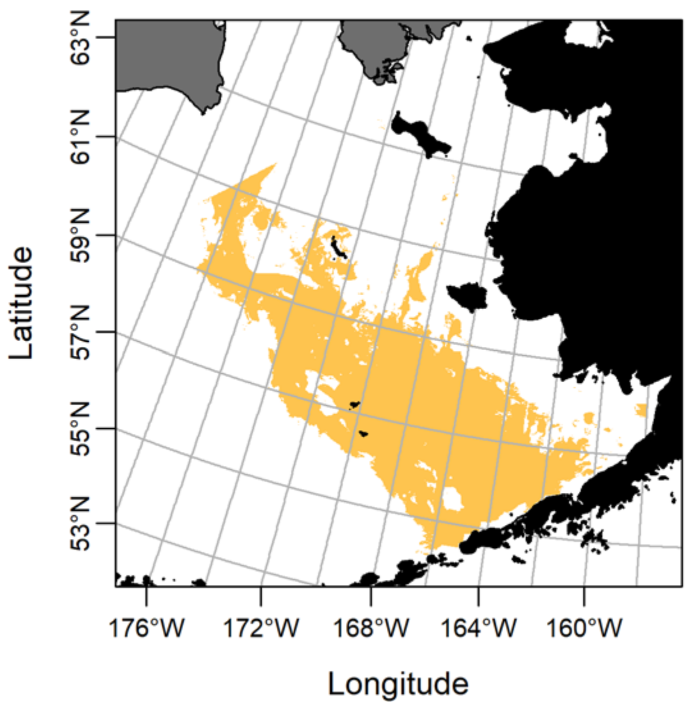


**Figure E-257 EFH distribution of EBS Southern rock sole adult, fall.**

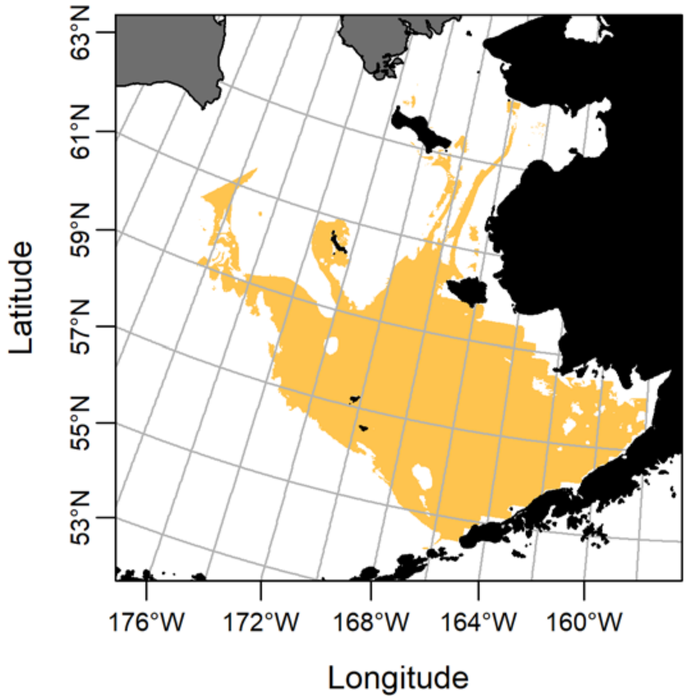


**Figure E-258 EFH distribution of EBS Southern rock sole adult, spring.**

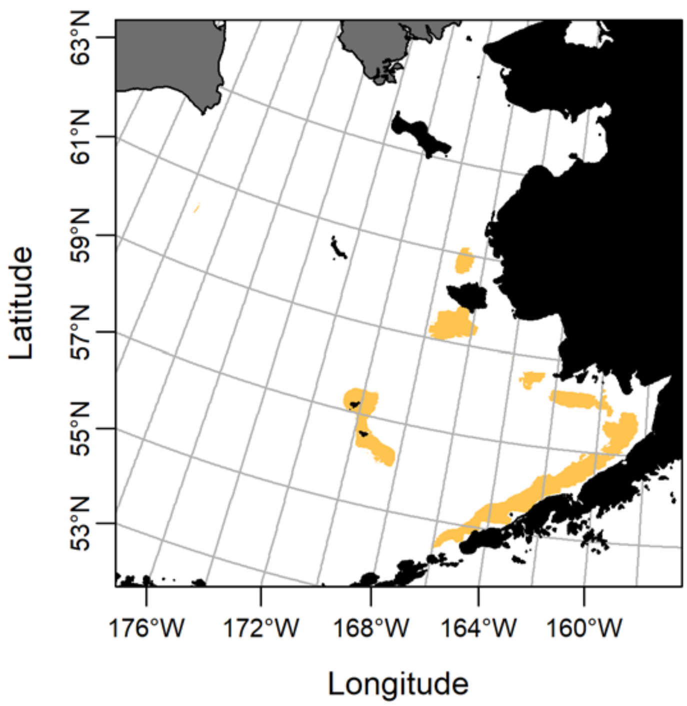


**Figure E-259 EFH distribution of EBS Southern rock sole adult, summer.**

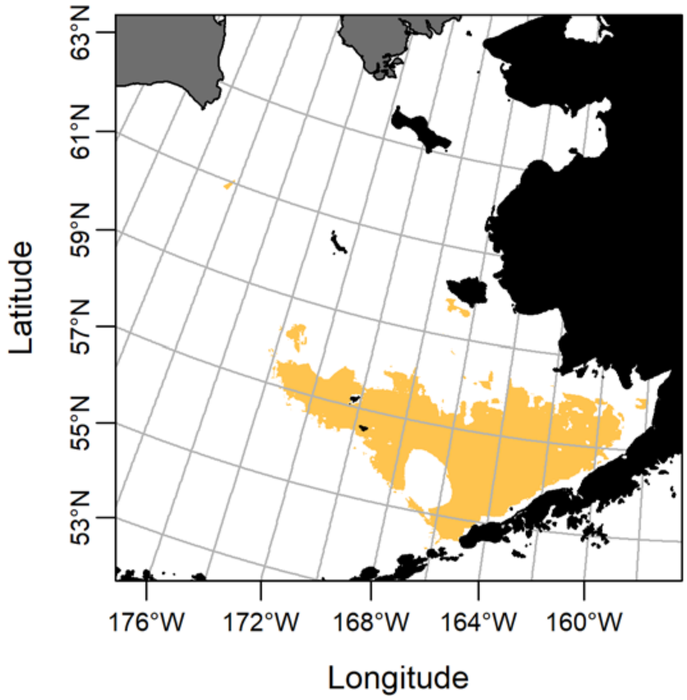


**Figure E-260 EFH distribution of EBS Southern rock sole adult, winter.**

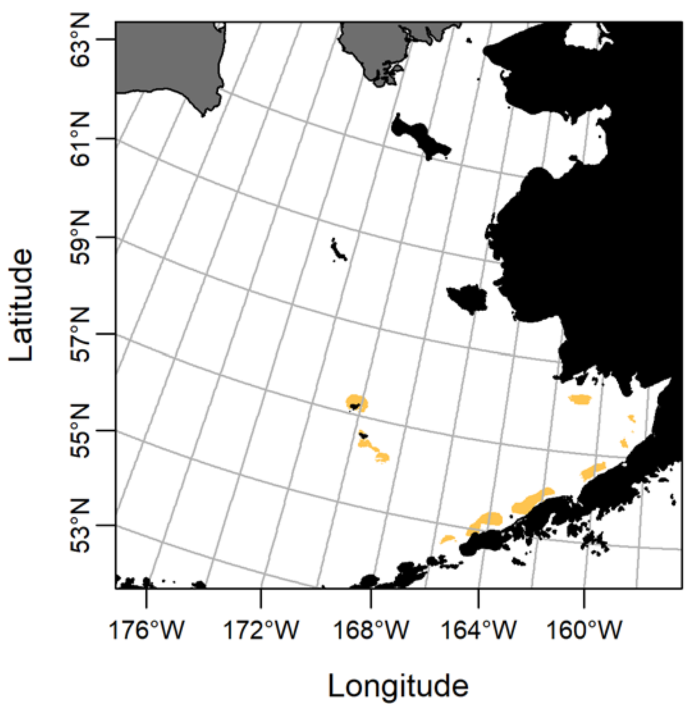


**Figure E-261 EFH distribution of EBS Southern rock sole juvenile, summer.**

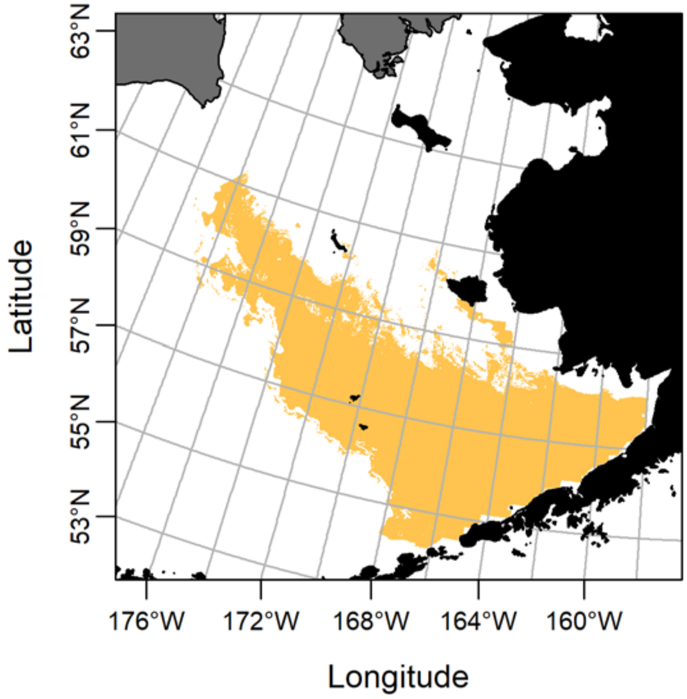


**Figure E-262 EFH distribution of EBS Southern rock sole larvae, summer.**

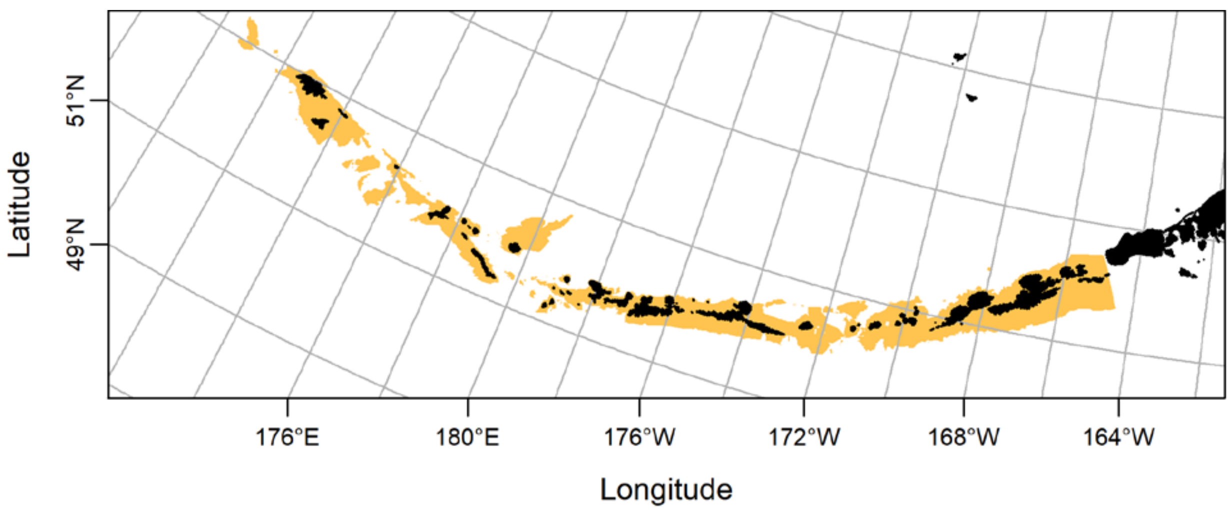


**Figure E-263 EFH distribution of AI Southern rock sole adult, sole.**

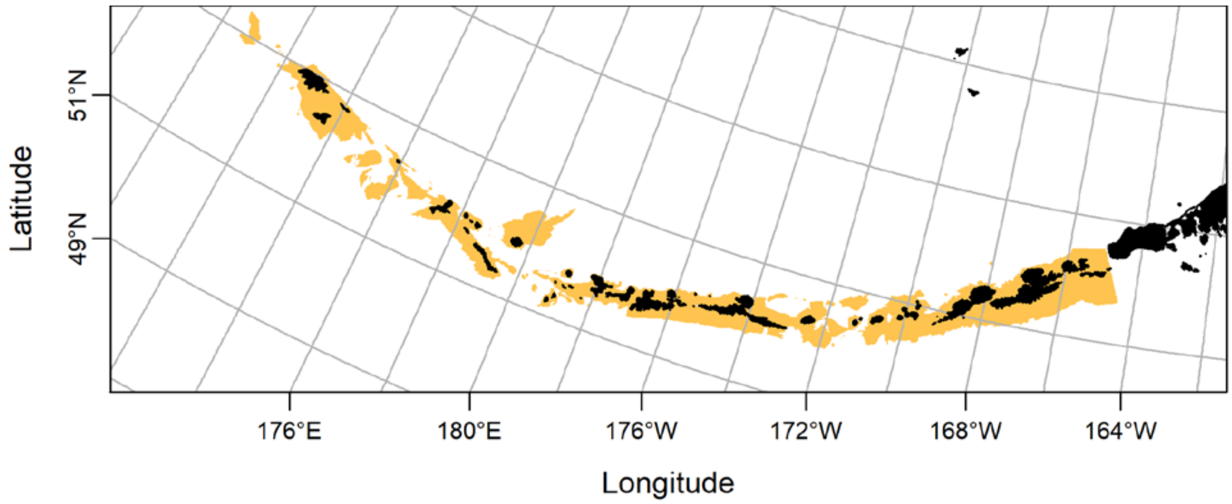


**Figure E-264 EFH distribution of AI Southern rock sole adult, spring.**

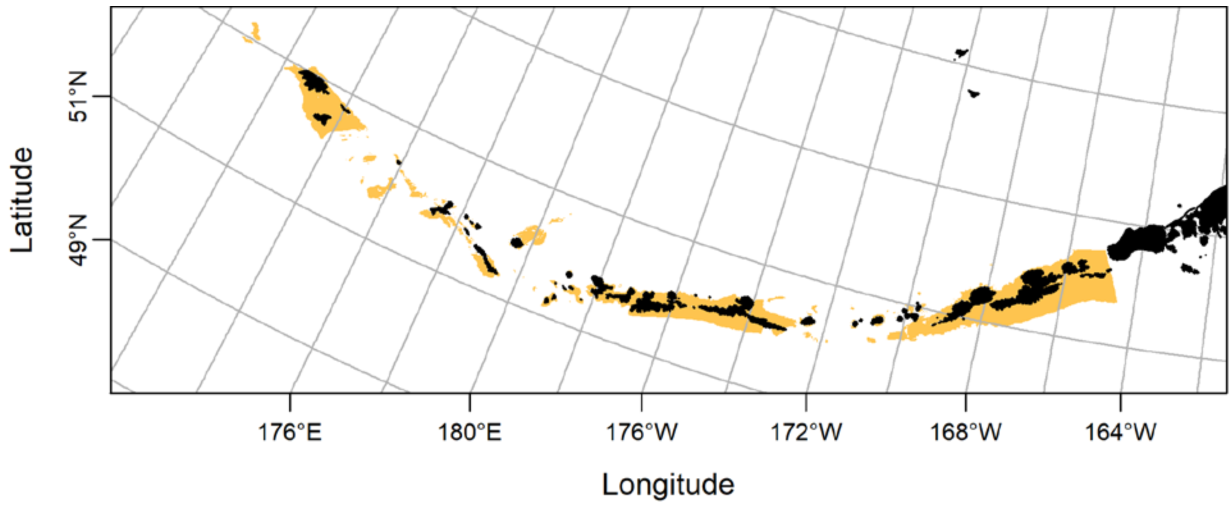


**Figure E-265 EFH distribution of AI Southern rock sole adult, summer.**

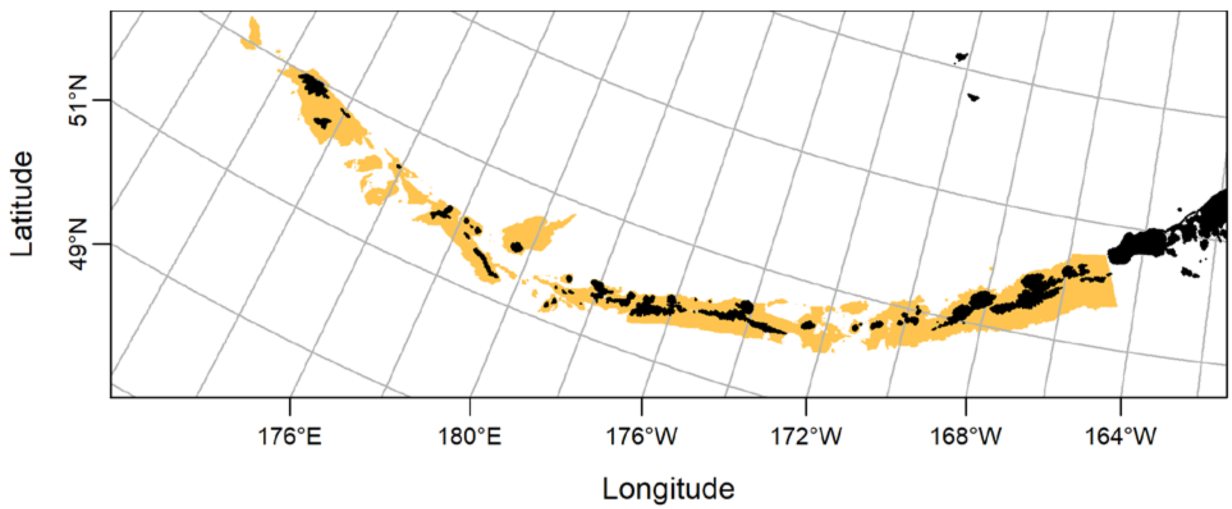


**Figure E-266 EFH distribution of AI Southern rock sole adult, winter.**

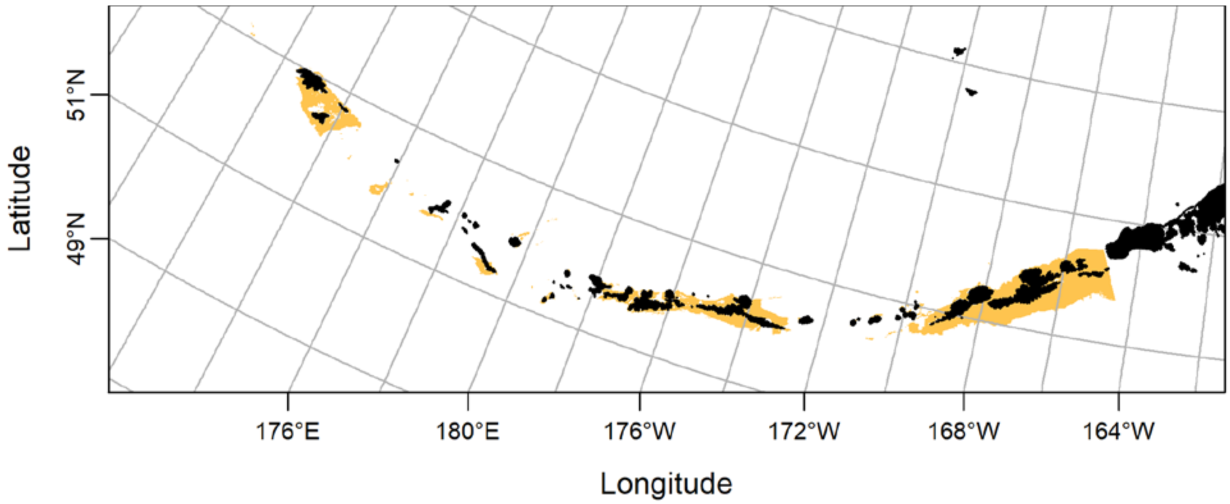


**Figure E-267 EFH distribution of AI Southern rock sole juvenile, summer.**

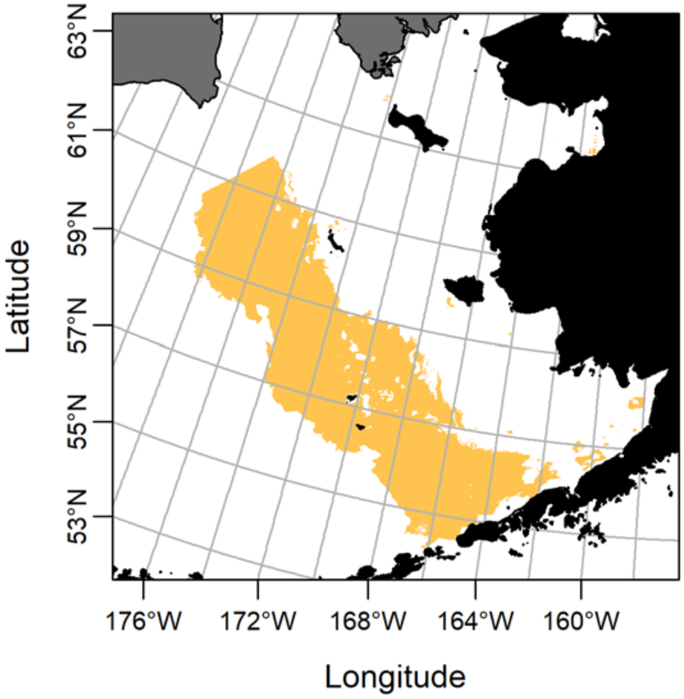


**Figure E-268 EFH distribution of EBS Octopus adult, fall.**

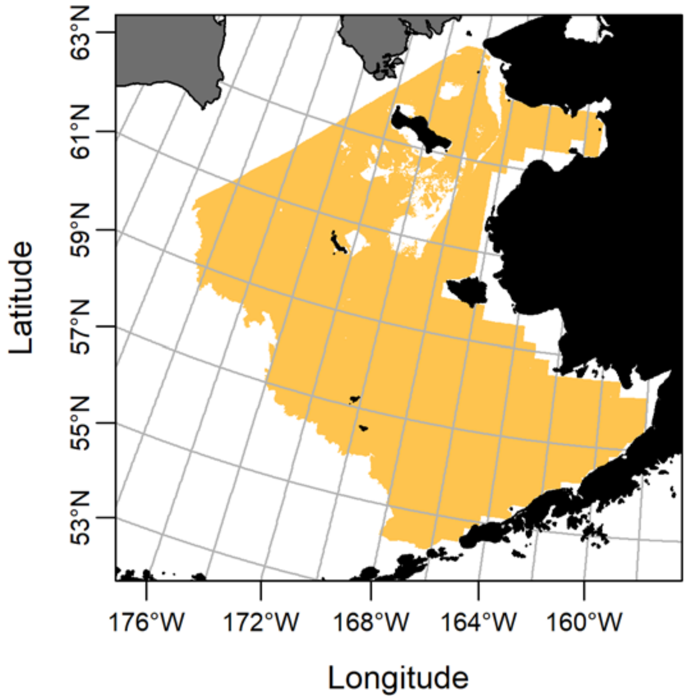

**Figure E-269 EFH distribution of EBS Octopus adult, spring.**

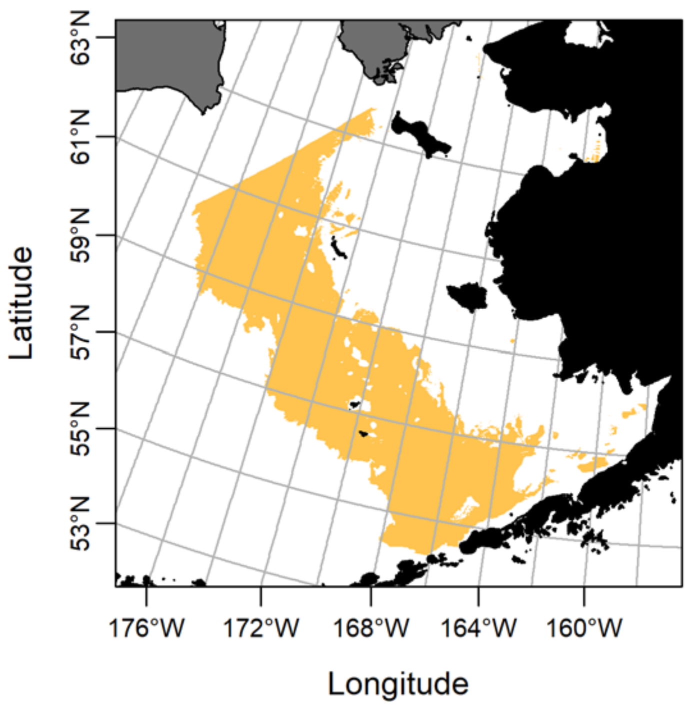

**Figure E-270 EFH distribution of EBS Octopus adult, summer.**

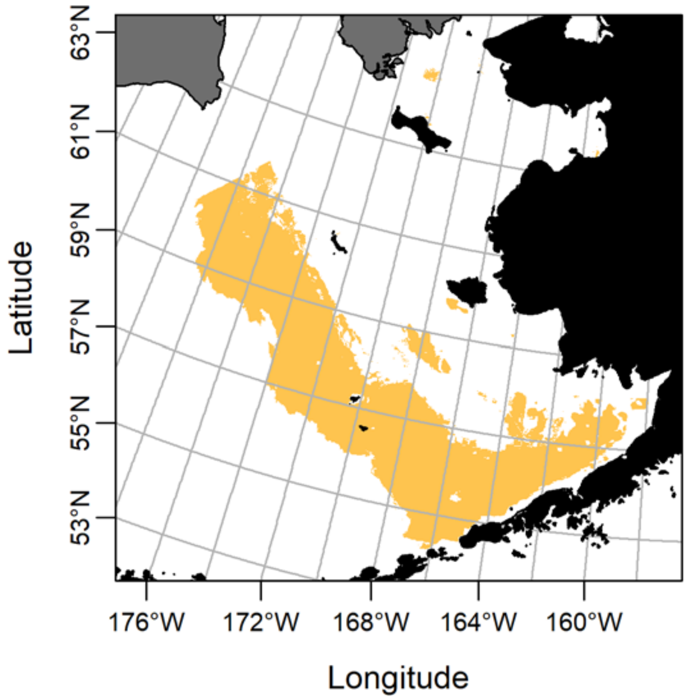


**Figure E-271 EFH distribution of EBS Octopus adult, winter.**

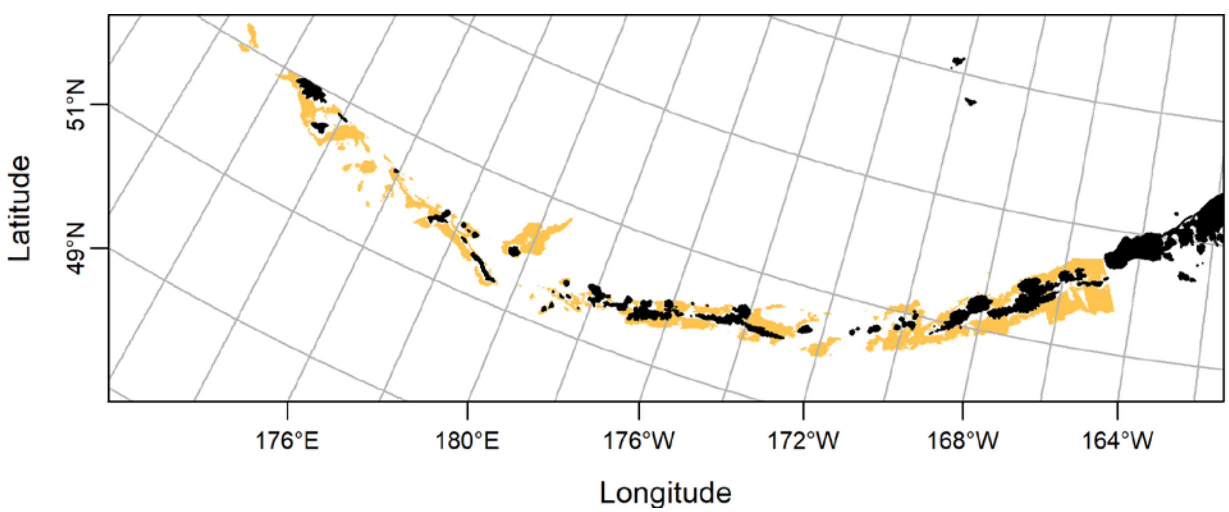


**Figure E-272 EFH distribution of AI Octopus adult, fall.**

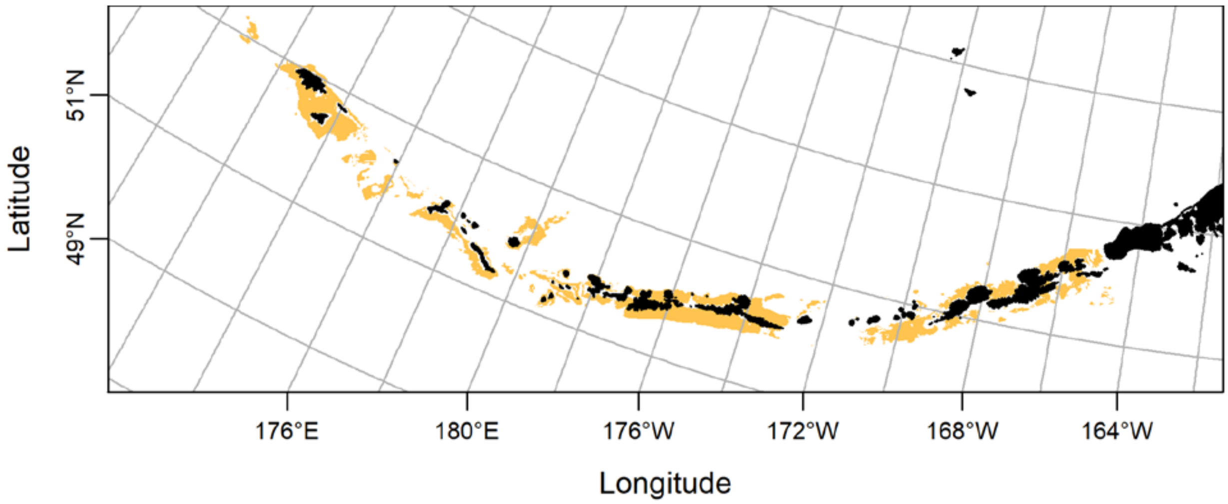


**Figure E-273 EFH distribution of AI Octopus adult, spring.**

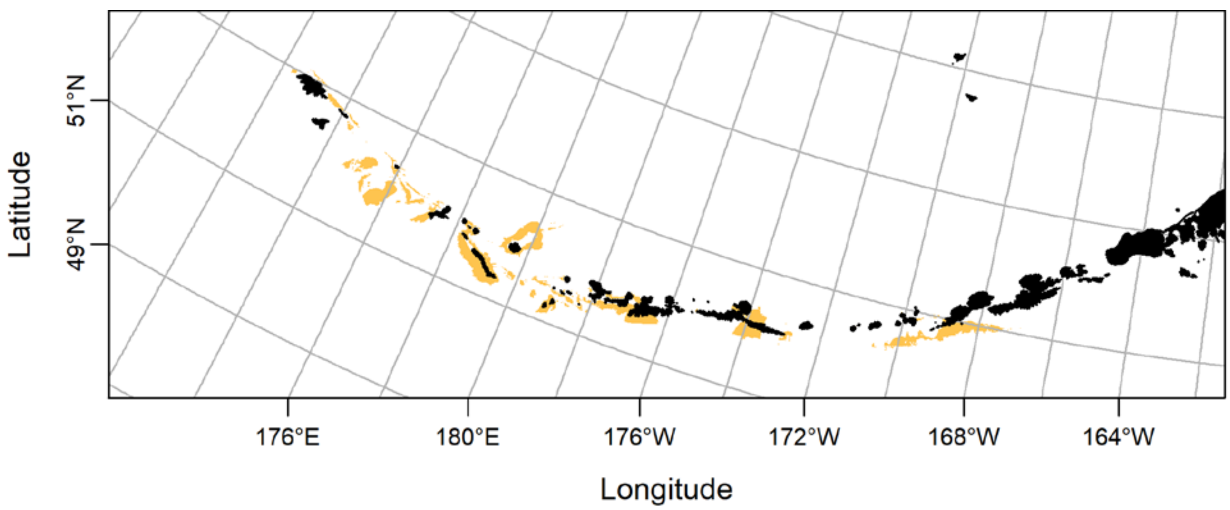


**Figure E-274 EFH distribution of AI Octopus adult, summer.**

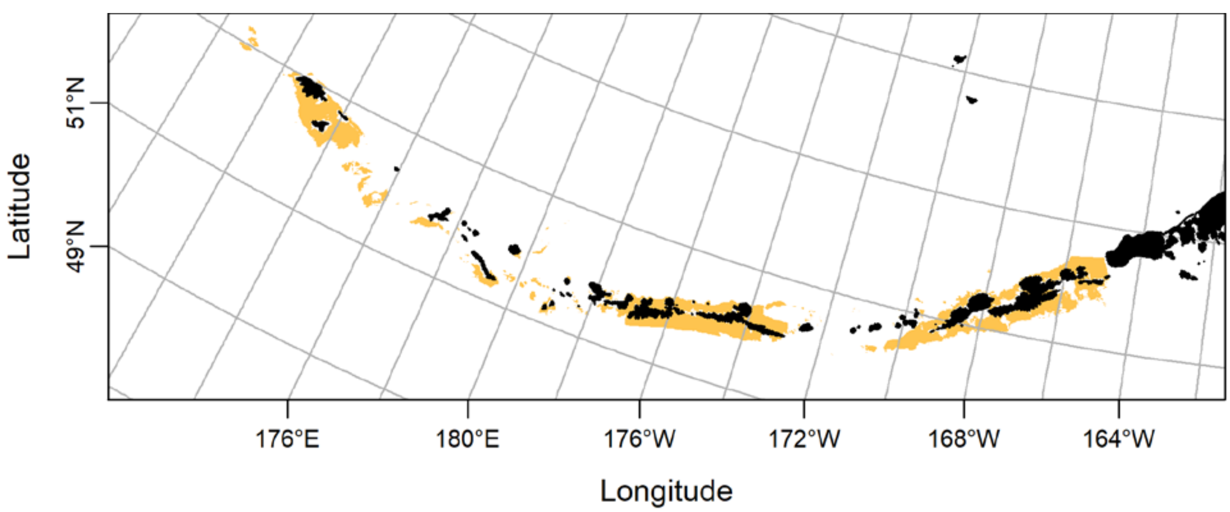


**Figure E-275 EFH distribution of AI Octopus adult, winter.**

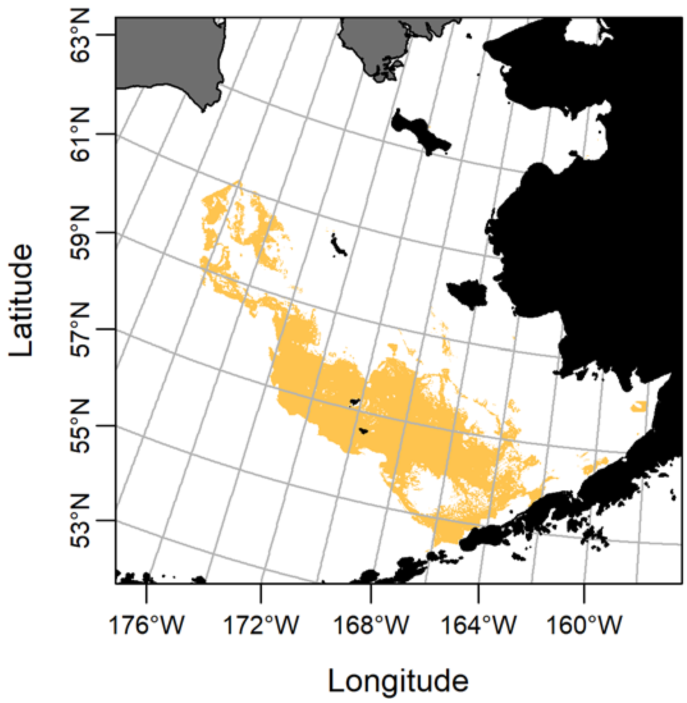


**Figure E-276 EFH distribution of EBS Yellow Irish lord adult, fall.**

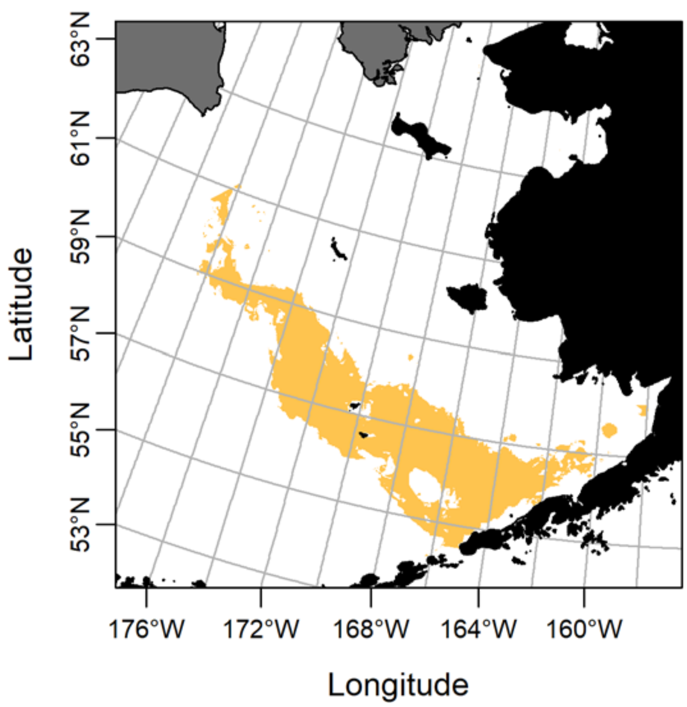


**Figure E-277 EFH distribution of EBS Yellow Irish lord adult, spring.**

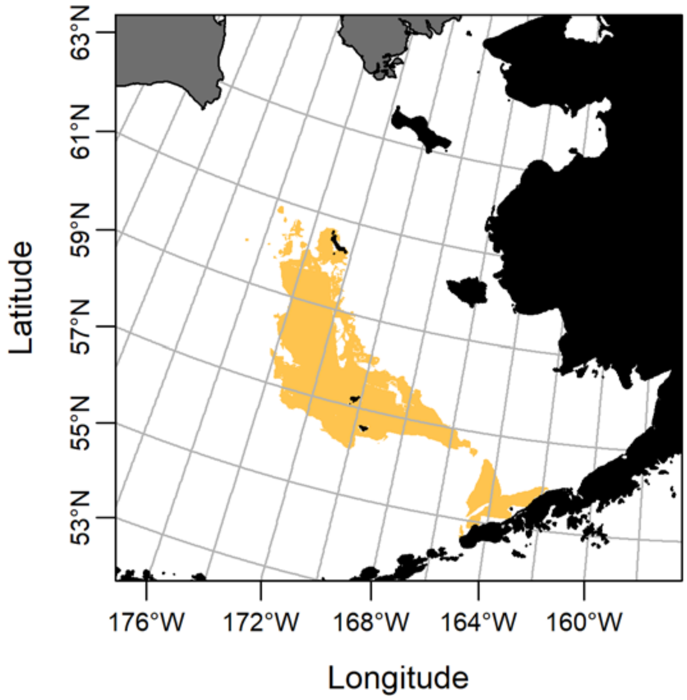


**Figure E-278 EFH distribution of EBS Yellow Irish lord adult, summer**

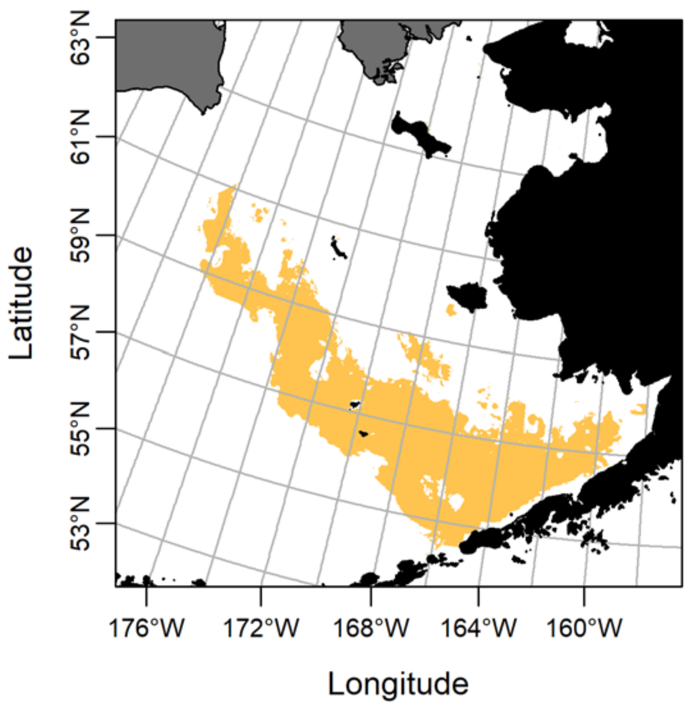


**Figure E-279 EFH distribution of EBS Yellow Irish lord adult, winter.**

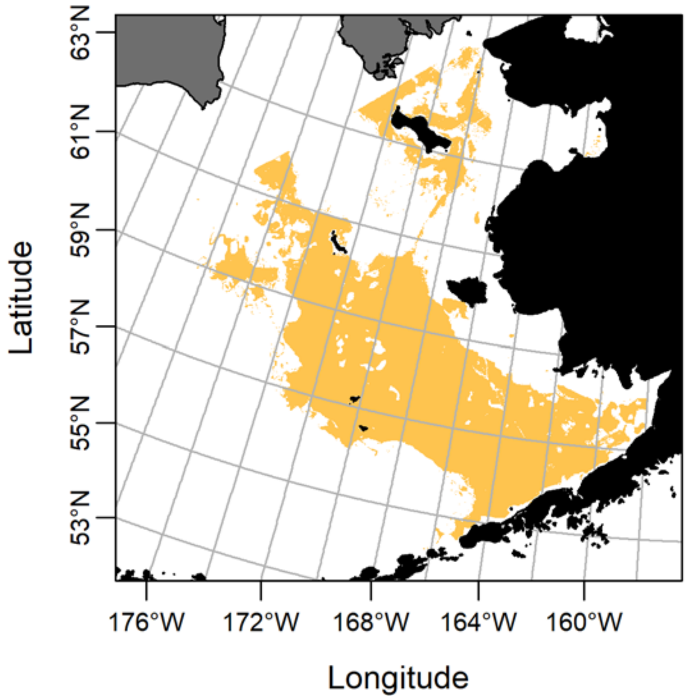


**Figure E-280 EFH distribution of EBS Yellow Irish lord juvenile, summer.**

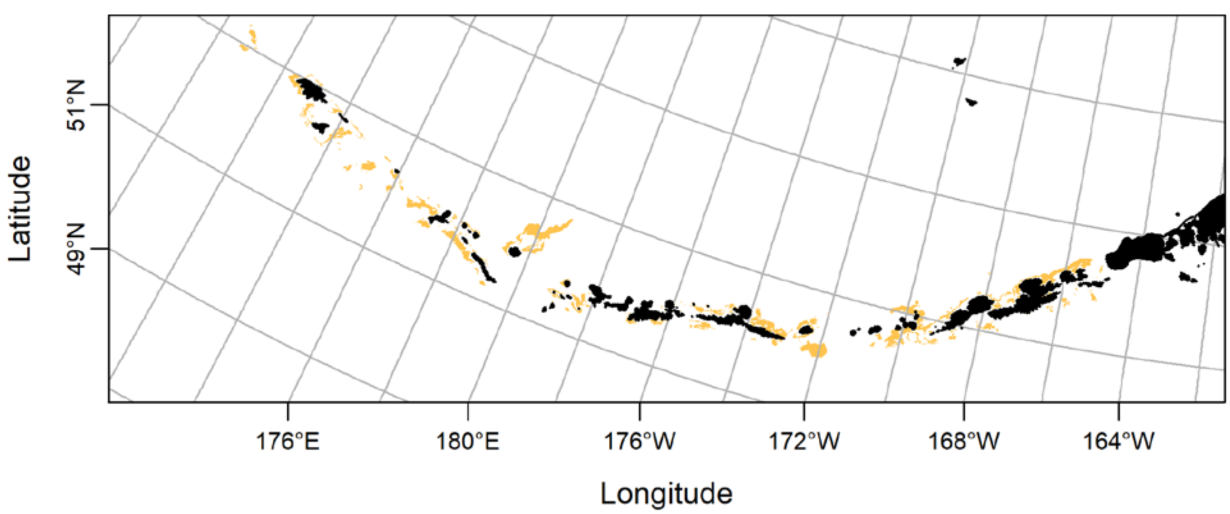


**Figure E-281 EFH distribution of AI Yellow Irish lord adult, fall.**

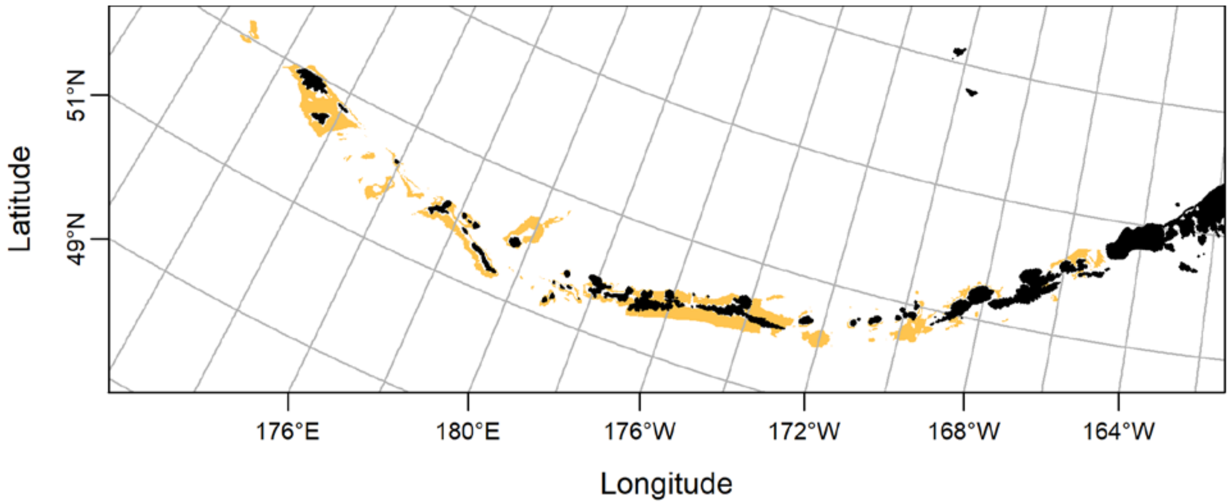


**Figure E-282 EFH distribution of AI Yellow Irish lord adult, spring.**

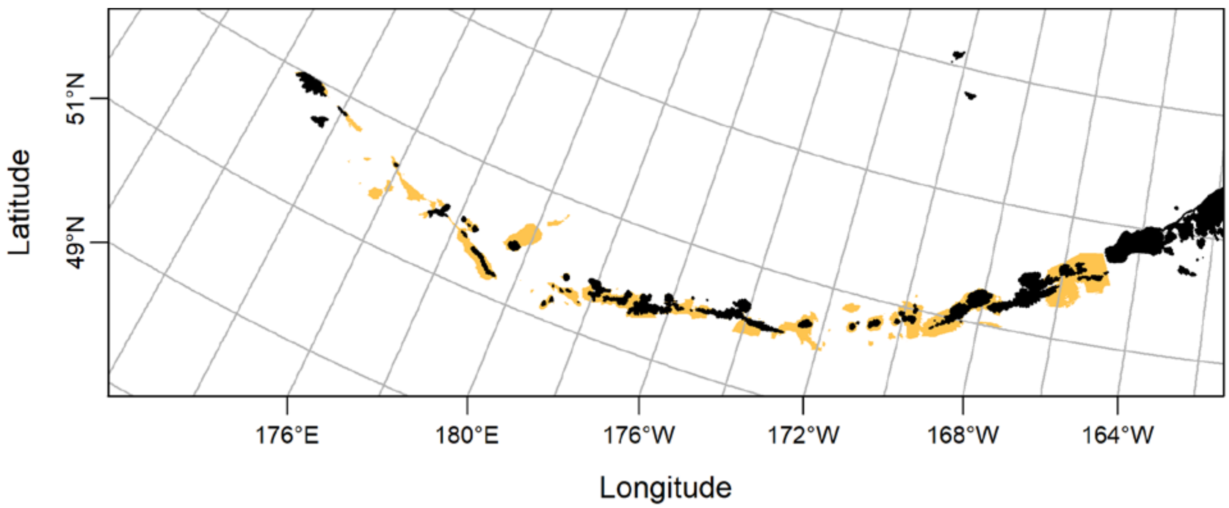


**Figure E-283 EFH distribution of AI Yellow Irish lord adult, summer.**

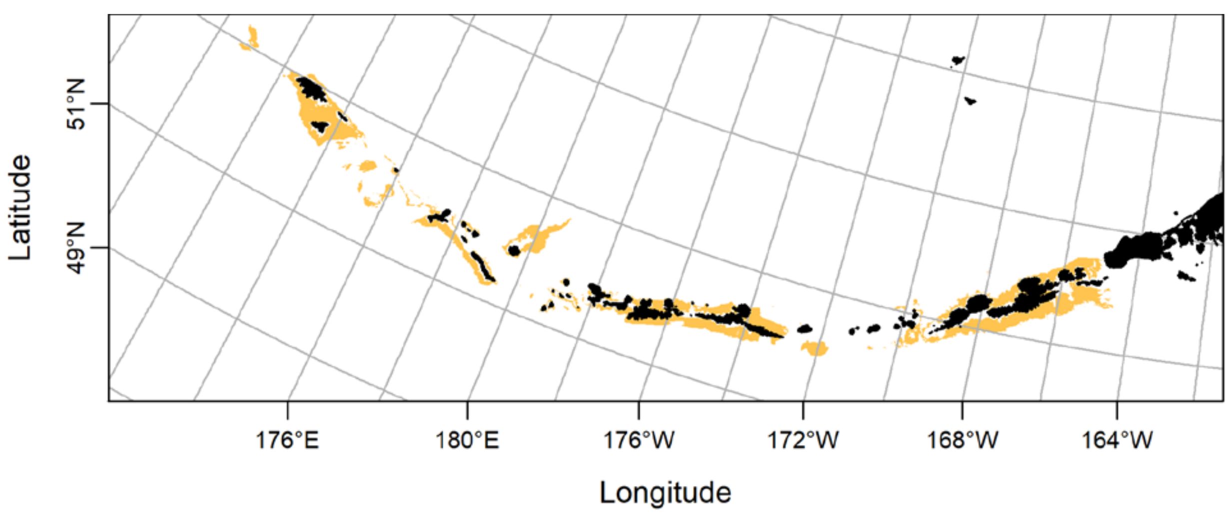


**Figure E-284 EFH distribution of AI Yellow Irish lord adult, winter.**

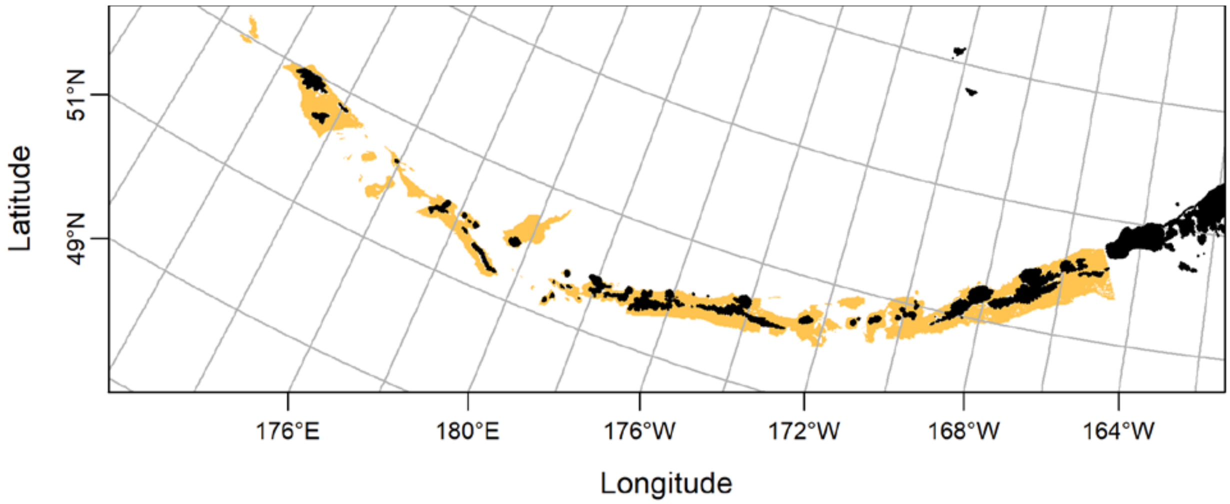


**Figure E-285 EFH distribution of AI Yellow Irish lord juvenile, summer.**

# Appendix F Adverse Effects on Essential Fish Habitat

# 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.

##### F.1.1.1.1 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.

#### F.1.1.1.2 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.

#### F.1.1.1.3 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).

### F.1.1.1.4 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.

#### F.1.1.1.5 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.

#### F.1.1.1.6 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.

#### F.1.1.1.7 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 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.

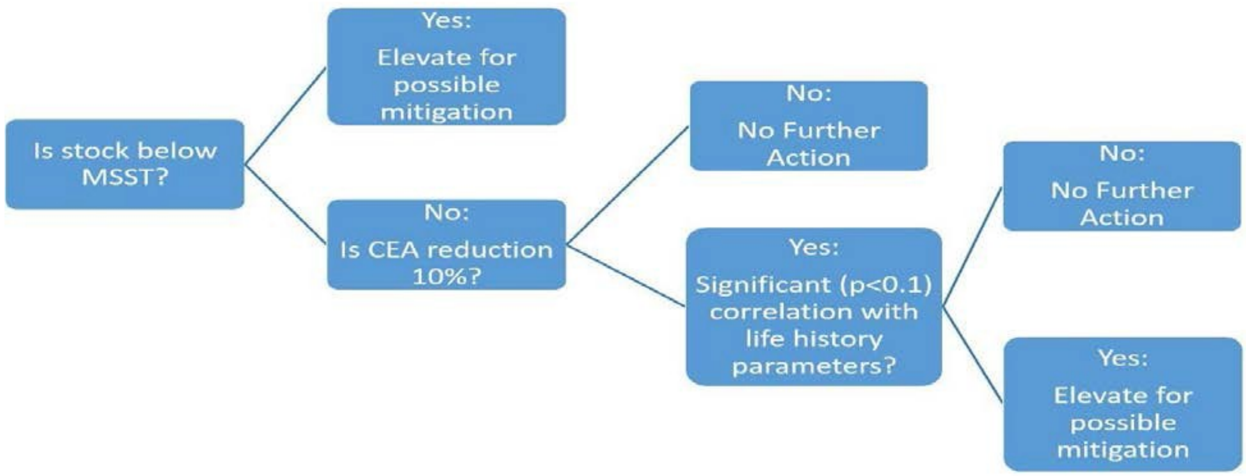


Figure F-1 Three-tiered method to evaluate effects of fishing on Essential Fish Habitat in Alaska.

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.

### F.1.9 References

AFSC. 2006. Essential Fish Habitat Research Implementation Plan for Alaska for FY 2007 – 2011. U.S. Dep. Commer., NOAA Alaska Fisheries Science Center. 13 p.

Bergman, M.J.N. and J.W. van Santbrink. 2000. Mortality in megafaunal benthic populations caused by trawl fisheries on the Dutch continental shelf in the North Sea in 1994 ICES Journal of Marine Science 57:1,321-1,331.

Brown, E. 2003. Effects of commercial otter trawling on EFH of the southeastern BS shelf. Master's Thesis, University of Washington.

Brylinsky, M., J. Gibson, and D.C. Gordon, Jr. 1994. Impacts of flounder trawls on the intertidal habitat and community of the Minas Basin, Bay of Fundy. Canadian Journal of Fisheries and Aquatic Sciences. 51(3):650-661.

Clark, M.R. and R. O'Driscoll. 2003. Deepwater fisheries and their impact on seamount habitat in New Zealand. Journal of Northwest Atlantic Fishery Science 31: 441-458.

Cragg, J. G. 1971. Some statistical models for limited dependent variables with application to the demand for durable goods. Econometrica 39: 829–844.

DeLong, A.K. and J.S. Collie. 2004. Defining Essential Fish Habitat: A Model-Based Approach. Rhode Island Sea Grant, Narragansett, R.I. 4pp.

Elith, J. Phillips, S.J., Hastie, T., Dudik, M., Chee, Y.E., and Yates, C.J. 2011. A statistical explanation of MaxEnt for ecologists. Biodiversity Research 17:43-57.

Eno, N., D.S. Macdonald, J.A. Kinnear, S. Amos, C.J. Chapman, R.A. Clark, F.S. Bunker, and C. Munro. 2001. Effects of crustacean traps on benthic fauna. ICES Journal of Marine Science. 58(1):11-20.

Fisheries Leadership and Sustainability Forum. 2016. Regional EFH Profile: North Pacific. National Essential Fish Habitat Summit, 2016. 4 p.

Fossa, J.H., P.B. Mortensen, and D.M. Furevik. 2002. The deep-water coral *Lophelia pertusa* in Norwegian waters distribution and fishery impacts. Hydrobiologia 471: 1-12.

Freese, J.L. 2001. Trawl induced damage to sponges observed from a research submersible. Marine Fisheries Review 63(3) 7-13.

Fujioka, J.T. 2006. A model for evaluating fishing impacts on habitat and comparing fishing closure strategies. Can. J. Fish. Aquat. Sci. 63:2330-2342.

Grabowski, J.H., Bachman, M., Demarest, C., Eayrs, S., Harris, B.P., Malkoski, V., Packer, D., Stevenson, D. 2014. Assessing the vulnerability of marine benthos to fishing gear impacts. Reviews in Fisheries Science and Aquaculture 22: 142-155.

Gilkinson, K., M. Paulin, S. Hurley, and P. Schwinghamer. 1998. Impacts of trawl door scouring on infaunal bivalves: results of a physical trawl door model/dense sand interaction Journal of Experimental Marine Biology and Ecology 224(2):291-312.

Heifetz J, Stone, R.P., Shotwell, S.K., 2009. Damage and disturbance to coral and sponge habitat of the Aleutian Archipelago. Mar Ecol Prog Ser 397:295-303.

Henry, LA., Kenchington, E.L.R., Kenchington, T.J., MacIsaac, K.G., Bourbonnais- Boyce, C., Gordon Jr., D.C. 2006. Impacts of otter trawling on colonial epifaunal assemblages on a cobble bottom ecosystem on Western Bank (northwest Atlantic). Mar. Ecol. Prog. Ser. 306: 63-78.

Hiddink, J.G., Jennings, S., Kaiser, M.J., Queiros, A.M., Duplisea, D.E., Piet, G.J. 2006. Cumulative impacts of seabed trawl disturbance on benthic biomass, production, and species richness in different habitats. Can. J. Fish. Aquat. Sci. 63:721-736.

Hiddink, J.G., Jennings, S., and Kaiser, M.J. 2007. Assessing and predicting the relative ecological impacts of disturbance on habitats with different sensitivities. Journal of Applied Ecology. 44:405-413.

Kaiser, M.J., Clarke, K.R., Hinz, H., Austen, M.C.V., Somerfield, P.J. & Karakassis, I. 2006. Global analysis and prediction of the response of benthic biota to fishing. Mar. Ecol. Prog. Ser. 311:1– 14.

Kenchington, E.L.R., J. Prena, K.D. Gilkinson, D.C. Gordon, K. MacIsaac, C. Bourbonnais, P.J. Schwinghamer, T.W. Rowell, D.L McKeown, and W.P. Vass. 2001. Effects of experimental otter trawling on the macrofauna of a sandy bottom ecosystem on the Grand Banks of Newfoundland. Canadian Journal of Fisheries and Aquatic Sciences. 58(6):1043-1057.

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

Krieger, K. 1993. Distribution and abundance of rockfish determined from a submersible and by bottom trawling. Fishery Bulletin 91(1):87-96.

Krieger, K. 1992. Shortraker rockfish, Sebastes borealis, observed from a manned submersible. Marine Fisheries Review. 54(4):34-37.

Laman, E.A., C.N. Rooper, S. Rooney, K. Turner, D. Cooper, and M. Zimmerman. In Press. Model- based Essential Fish Habitat Definitions for Eastern Bering Sea Groundfish Species. U.S. Dep.Commer., NOAA Tech Memo. NMFS-AFSC-XXXX, XXp.

Laurel, B.J., M. Spencer, P. Iseri, and L.A. Copeman. 2015. Temperature-dependent growth and behavior of juvenile Arctic cod (Boreogadus saida) and co-occurring North Pacific gadids. Polar Biology, pp.1-9. DOI 10.1007/s00300-015-1761-5.

Limpinsel, D.E., Eagleton, M.P., and Hanson, J.L., 2017. Impacts to Essential Fish Habitat from Non-Fishing Activities in Alaska. EFH 5 Year Review: 2010 through 2015. U.S. Dep. Commer., NOAA Tech memo. NMFS-F/AKR-14, 229.p.

Løkkeborg, S. Impacts of trawling and scallop dredging on benthic habitats and communities. FAO Fisheries Technical Paper. No. 472. Rome, FAO. 2005. 58p. Malecha, P.W., and Stone, R.P., 2009. Response of the sea whip Halipteris willemoesi to simulated trawl disturbance and its vulnerability to subsequent predation. Mar. Ecol. Prog. Ser. 388:197–206.

Lozier, J.D., Aniello, P. and Hickerson, M.J. 2009. Predicting the distribution of Sasquatch in western North America: anything goes with ecological niche modeling. J. Biogeogr. 36:1623-1627.

McConnaughey, R.A., K.L. Mier, and C.B. Dew. 2000. An examination of chronic trawling effects on soft-bottom benthos of the EBS. ICES Journal of Marine Sciences. 57(5):1377-1388.

McConnaughey, R.A., Syrjala, S.E., Dew, C.B., 2005. Effects of Chronic Bottom Trawling on the Size Structure of Soft-Bottom Benthic Invertebrates. Pages 425-427 in P.W. Barnes and J.P. Thomas, editors. Benthic habitats and the effects of fishing. American Fisheries Society, Symposium 41, Bethesda, Maryland.

Moran, M.J. and P.C. Stephenson. 2000. Effects of otter trawling on macrobenthos and management of demersal scalefish fisheries on the continental shelf of north-western Australia. 2000. ICES Journal of Marine Science. 57(3):510-516.

National Marine Fisheries Service (NMFS). 2005. Environmental Impact Statement for Essential Fish Habitat Identification and Conservation in Alaska. April 2005. DOC, NOAA, National Marine Fisheries Service, Alaska Region, P. O. Box 21668, Juneau, Alaska 99802-1668.

Phillips, S.J., Anderson, R.P. and Schapire, R.E., 2006. Maximum entropy modeling of species geographic distributions. Ecological modelling, 190(3), pp.231-259.

Pitcher C.R., Austin M., Burridge C.Y., Bustamante R.H., Cheers S.J., Ellis N., Jones P.N., Koutsoukos A.G., Moeseneder C.H., Smith G.P., Venables W., Wassenberg T.J., 2008. Recovery of Seabed Habitat from the Impact of Prawn Trawling in the Far Northern Section of the Great Barrier Reef Marine Park. CSIRO Final Report to GBRMPA, pp. 189

Pitcher, C.R., Burridge, C.Y., Wassenberg, T.J., Hill, B.J., Poiner, I.R. 2009. A large scale BACI experiment to test the effects of prawn trawling on seabed biota in a closed area of the Great Barrier Reef Marine Park, Australia. Fisheries Research. 99:168-183.

Prena, J., P. Schwinghamer, T.W. Rowell, D.C. Jr Gordon, K.D. Gilkinson, W.P. Vass, and D.L McKeown. 1999. Experimental otter trawling on a sandy bottom ecosystem of the Grand Banks of Newfoundland: Analysis of trawl bycatch and effects on epifauna. Marine Ecology Progress Series. 181:107-124.

Rooney, S., K. Turner, E.A. Laman, C.N. Rooper, D. Cooper, and M. Zimmerman. In Press. Model-based Essential Fish Habitat Definitions for Federally Managed Species in United States Waters of Gulf of Alaska. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-XXX, XXX p.

Rooper, C.N., M. Zimmermann, M. Prescott, A. Hermann. 2014. Predictive models of coral and sponge distribution, abundance and diversity in bottom trawl surveys of the Aleutian Islands, Alaska. Mar. Ecol. Prog. Ser. 503:157-176.

Rooper, C.N., Sigler, M.F., Goddard, P., Malecha, P., Towler, R., Williams, K., Wilborn, R. and Zimmermann, M., 2016. Validation and improvement of species distribution models for structure-forming invertebrates in the eastern Bering Sea with an independent survey. Marine Ecology Progress Series, 551, pp.117-130.

Rooper, CN, Laman E, Turner, K, Rooney, S, Cooper, D, Zimmermann, M. In Press. Model-based Essential Fish Habitat Definitions for Aleutian Islands Groundfish Species. U.S. Dp. Commer., NOAA Tech. Memo. NMFS-AFSC-XXX, XXX p.

Sagarese, S.R, Frisk, M.G., Cerrato, R.M., Sosebee, K.A., Musick, J.A., and Rago, P.J. 2014. Application of generalized additive models to examine ontogenetic and seasonal distributions of spiny dogfish (Squalis acanthias) in the Northeast (US) shelf large marine ecosystem. Can. J. Fish. Aquat. Sci. 71:847-877.

Schwinghamer, P., D.C. Gordon, Jr., T.W. Rowell, J.P. Prena, D.L McKeown, G. Sonnichsen, and J.Y. Guignes. 1998. Effects of experimental otter trawling on surficial sediment properties of a sandy-bottom ecosystem on the Grand Banks of Newfoundland. Conservation Biology 12: 1215-1222.

Sigler, M. F., M. F. Cameron, M. P. Eagleton,C. H. Faunce, J. Heifetz, T. E. Helser, B. J. Laurel, M. R. Lindeberg, R. A. McConnaughey, C. H. Ryer, and T. K. Wilderbuer. 2012. Alaska Essential Fish Habitat Research Plan: A research plan for the National Marine Fisheries Service's Alaska Fisheries Science Center and Alaska Regional Office. AFSC Processed Rep. 2012-06, 21 p.Alaska Fish. Sci. Cent., NOAA, Natl. Mar. Fish. Serv., 17109 Pt. Lena Loop Road, Juneau, AK 99801.

Sigler M.F., C. N. Rooper, G. R. Hoff, R. P. Stone, R. A. McConnaughey, and T. K. Wilderbuer. 2015. Faunal features of submarine canyons on the eastern Bering Sea slope. Mar Ecol Prog Ser 526: 21−40.

Sigler, M. F., M. P. Eagleton, T. E. Helser, J. V. Olson, J. L. Pirtle, C. N. Rooper, S. C. Simpson, and R.Smith, C.J., K.N. Papadopoulou, S. Diliberto. 2000. Impact of otter trawling on eastern Mediterranean commercial trawl fishing ground. ICES Journal of Marine Science 55:1340-1351. (B-16).

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.

Stone, P. 2017. Alaska Essential Fish Habitat Research Plan: A research plan for the National Marine Fisheries Service's Alaska Fisheries Science Center and Alaska Regional Office. AFSC Processed Report 2015-05, 22 p. Alaska Fish. Sci. Cent., NOAA, Natl. Mar. Fish. Serv., 7600 Sand Point Way NE, Seattle WA 98115.

Stone, R.P. 2006. Coral habitat in the Aleutian Islands of Alaska: depth distribution, fine-scale species associations, and fisheries interactions. Coral Reefs Vol. 25, No. 2, pp. 229-238.

Stone, R.P. 2014. The ecology of deep-sea coral and sponge habitats of the central Aleutian Islands of Alaska. NOAA Professional paper NMFS 16, 52p. doi:10.7755/PP.16

Van Dolah, R.F., P.H. Wendt, and N. Nicholson. 1987. Effects of a research trawl on a hard-bottom assemblage of sponges and corals. Fisheries Research 5: 39-54.

von Szalay, P. G. and N. W. Raring. 2016. Data report: 2015 Gulf of Alaska bottom trawl survey. U. S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-325, 249 p.

Zador, S. (ed). 2017. Ecosystem Considerations 2016 Status of Alaska’s Marine Ecosystems. NOAA, AFSC, REFM. Seattle, WA.

## F.2 Non-fishing Impacts 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 4 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.

# Appendix G Fishery Impact Statement

The Magnuson-Stevens Fishery and Conservation Management Act requires that a fishery management plan (FMP) include a fishery impact statement that assesses, specifies, and describes the likely effects of the FMP measures on participants in the fisheries and fishing communities affected by the FMP. A detailed analysis of the effects of the FMP on the human environment, including fishery participants and fishing communities, was conducted in the *Alaska Groundfish Fisheries Programmatic Supplemental Environmental Impact Statement* (NMFS 2004). The following is a brief summary from this analysis.

The FMP has instituted privilege-based management programs in the some groundfish fisheries, and fishery managers, under the guidance of the FMP management policy, are moving towards extending privilege-based allocations to other groundfish fisheries.

1. The FMP promotes increased social and economic benefits through the promotion of privilege-based allocations to individuals, sectors and communities. For this reason, it is likely to increase the commercial value generated from the groundfish fisheries.
2. As the race-for-fish is eliminated, the FMP could result in positive effects in terms of producer net revenue, consumer benefits, and participant health and safety.
3. The elimination of the race-for-fish will likely result in a decrease in overall participation levels. In the long-run, communities are likely to see fewer persons employed in jobs related to the fishing industry (fishing, processing, or support sectors), but the jobs that remain could be more stable and provide higher pay.
4. The FMP's promotion of privilege-based allocations is also expected to increase consumer benefits and health and safety of participants.

The FMP has adopted a variety of management measures to promote the sustainability of the groundfish fisheries and dependent fishing communities.

- Management measures to account for uncertainty ensure the sustainability of the managed species by maintaining a spawning stock biomass for the target species with the potential to produce sustained yields.
- The transition to privilege-based management in the short-term could disrupt stability, however in the long-term, the stability of fisheries would be increased in comparison to a derby-style fishery.
- Communities would also tend to experience an increase in stability as a result of built-in community protections to the privilege-based management programs.

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# Appendix H Research Needs

Although research needs are identified in this appendix to the Fishery Management Plan (FMP), ongoing research and research needs are constantly being updated. It may therefore be useful to the reader to access other sources in order to obtain the North Pacific Fishery Management Council (Council)'s most current description of research and research needs on the Bering Sea and Aleutian Islands (BSAI) groundfish fisheries. A complete discussion of up-to-date sources is included in Chapter 6 of the FMP. In particular, the Council's Science and Statistical Committee regularly updates the Council on its research needs, and these can be found on the Council's website. Additionally, ongoing research by National Marine Fisheries Service (NMFS)' Alaska Fisheries Science Center (AFSC) is also accessible through their website. Website addresses are in Chapter 6.

The FMP management policy identifies several research programs that the Council would like to encourage. These are listed in Section H.1. The Council relies on its Scientific and Statistical Committee (SSC) to assist the Council in interpreting biological, sociological, and economic information. The SSC also plays an important role in providing the Council with recommendations regarding research direction and priorities based on identified data gaps and research needs. The SSC and Council's research priorities are listed in Section H.2. Additionally, NMFS regularly develops a five-year strategy for fisheries research which is described in Section H.3. Research needs specific to essential fish habitat are described in Section H.4.

## H.1 Management Policy Research Programs

The management objectives of the FMP (see Section 2.2.1) include several objectives that provide overarching guidance as to research programs that the Council would like to encourage.

- Encourage research programs to evaluate current population estimates for non-target species with a view to setting appropriate bycatch limits as information becomes available.
- Encourage programs to review status of endangered or threatened marine mammal stocks and fishing interactions and develop fishery management measures as appropriate.
- Encourage development of a research program to identify regional baseline habitat information and mapping, subject to funding and staff availability.
- Encourage a coordinated, long-term ecosystem monitoring program to collect baseline information and compile existing information from a variety of ongoing research initiatives, subject to funding and staff availability.

Other objectives in the management policy also contain research elements without which they cannot be achieved. Research initiatives that would support other FMP management objectives are discussed in Section H.1.2 below.

## H.2 Council Research Priorities

At its March 2003 meeting, the SSC reviewed the list of research priorities as developed by the Council's BSAI and Gulf of Alaska (GOA) groundfish Plan Teams, and developed the following short list of research topics:

A. Critical Assessment Problems

For rockfish stocks there is a general need for better assessment data, particularly investigation of stock structure and biological variables.

- Supplement triennial trawl survey biomass estimates with estimates of biomass or indices of biomass obtained from alternative survey designs.
- Obtain age and length samples from the commercial fishery, especially for Pacific ocean perch, northern rockfish, and dusky rockfish.
- Increase capacity for production ageing of rockfish so that age information from surveys and the fishery can be included in stock assessments in a timely manner.
- Further research is needed on model performance in terms of bias and variability. In particular, computer simulations, sensitivity studies, and retrospective analyses are needed. As models become more complex in terms of parameters, error structure, and data sources, there is a greater need to understand how well they perform.

There is a need for life history information for groundfish stocks, e.g., growth and maturity data, especially for rockfish.

- There is a need for information about stock structure and movement of all FMP groundfish species, especially temporal and spatial distributions of spawning aggregations.

B. Stock Survey Concerns

- There is a need to explore ways for inaugurating or improving surveys to assess rockfish, including nearshore pelagics.
- There is a need to develop methods to measure fish density in habitats typically inaccessible to NMFS survey gear, i.e., untrawlable habitats.

C. Expanded Ecosystem Studies

- Research effort is required to develop methods for incorporating the influence of environmental and climate variability, and there influence on processes such as recruitment and growth into population models, especially for crab stocks.
- Forage fish are an important part of the ecosystem, yet little is known about these stocks. Effort is needed on stock status and distribution for forage fishes such as capelin, eulachon, and sand lance.
- Studies are needed to identify essential habitat for groundfish and forage fish. Mapping of nearshore and shelf habitat should be continued for FMP species.

D. Social and Economic Research

- Development of time series and cross-sectional databases on fixed and variable costs of fishing and fish processing.
- Pre- and post-implementation economic analyses of crab and GOA groundfish rationalization.
- Identification of data needed to support analyses of community level consequences of management actions.
- Development of integrated multispecies and multifishery models for use in analyses of large scale management actions, such as the Alaska Groundfish Fisheries Programmatic Supplemental Environmental Impact Statement and the Environmental Impact Statement for Essential Fish Habitat Identification and Conservation in Alaska.

E. Bycatch

- Identify sources of variability in actual and estimated bycatch rates.

F. Monitoring

- Promote advancement in video monitoring of otherwise unobserved catch for improved estimation of species composition of total catch and discrimination of retained and discarded catch

G. Research Priorities Identified by the National Research Council's Steller Sea Lion Committee

The SSC held a brief discussion on the research and monitoring recommendations of the NRC Steller sea lion Committee, as presented in the Executive Summary of their report. The SSC noted that their recommendations are consistent with recognized needs, but also that there is considerable ongoing Steller sea lion research. Among the National Research Council's recommendations, the SSC wishes to particularly identify their recommendation for a spatially-explicit, adaptive management experiment to definitively conclude whether fishing is playing a role in the current lack of Steller sea lion recovery. As noted in the SSC's February 2003 minutes, there are a number of scientific, economic, and Endangered Species Act regulatory considerations that must be addressed before such a plan can be seriously considered for implementation. However, the SSC supports further exploration of the merits of this adaptive management approach.

## H.3 National Marine Fisheries Service

NMFS is responsible for ensuring that management decisions are based on the best available scientific information relevant to the biological, social, and economic status of the fisheries. As required by the Magnuson-Stevens Fishery Management and Conservation Act, NMFS published the *NMFS Strategic Plan for Fisheries Research* in December 2001, outlining proposed research efforts for fiscal years 2001-2006. The Strategic Plan outlines the following broad goals and objectives for NMFS: 1) to improve scientific capability; 2) to increase science quality assurance; 3) to improve fishery research capability; 4) to improve data collection; 5) to increase outreach/information dissemination; and 6) to support international fishery science. The document also outlines the AFSC's research priorities for this time period. Summarized below are the AFSC's research priorities grouped into four major research areas: research to support fishery conservation and management; conservation engineering research; research on the fisheries themselves; and information management research.

1. Research to Support Fishery Conservation and Management

   a. Biological research concerning the abundance and life history parameters of fish stocks

      - Conduct periodic (annual, biennial, triennial) bottom trawl, midwater trawl-acoustic, hydroacoustic bottom trawl, longline surveys on groundfish in the BSAI and GOA.
      - Conduct field operations to study marine mammal-fish interactions, with particular emphasis on sea lion and pollock, Pacific cod, and Atka mackerel interactions in the GOA and the BSAI management areas.
      - Observer programs for groundfish fisheries that occur off Alaska.
      - Assessments of the status of stocks, including their biological production potentials (maximum sustainable yield, acceptable biological catch, overfishing levels), bycatch requirements, and other parameters required for their management.
      - Assessments of the population dynamics, ecosystem interactions, and abundance of marine mammal stocks and their incidental take requirements.

   b. Social and economic factors affecting abundance levels

   c. Interdependence of fisheries or stocks of fish

   d. Identifying, restoring, and mapping of essential fish habitat

   e. Assessment of effects of fishing on essential fish habitat and development of ways to minimize adverse impacts.

2. Conservation Engineering Research

   - Continue to conduct research to measure direct effects of bottom trawling on seafloor habitat according to a five-year research plan.
   - Conduct fishing gear performance and fish behavioral studies to reduce bycatch and bycatch mortality of prohibited, undersized, or unmarketable species, and to understand performance of survey gear.
   - Work with industry and the Council to develop bycatch reduction techniques.

3. Research on the Fisheries

   a. Social and economic research

   b. Seafood safety research

   c. Marine

4. Information Management Research

   - Continue to build data infrastructure and resources for easy access and data processing. The AFSC's key data bases are its survey data bases from the 1950s (or earlier) and the scientific observer data base that extends back to the foreign fishing days of the 1960s.
   - Continue to provide information products based on experts and technical data that support NMFS, the Council, international scientific commissions, and the overall research and management community.

## H.4 Essential Fish Habitat Research and Information Needs

The EIS for Essential Fish Habitat Identification and Conservation (NMFS 2005) identified the following research approach for EFH regarding minimizing fishing impacts.

### Objectives

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

### Research Questions

*Reduce impacts.* Does the closure effectively restrict higher-impact trawl fisheries from a portion of the GOA slope? Is there increased use of alternative gears in the GOA closed areas? Does total bottom trawl effort in adjacent open areas increase as a result of effort displaced from closed areas? Do bottom trawls affect these benthic habitats more than the alternative gear types? What are the research priorities? Are fragile habitats in the AI affected by any fisheries that are not covered by the new EFH closures? Are sponge and coral essential components of the habitat supporting FMP species?

*Benthic habitat recovery*. Did the habitat within closed areas recover or remain unfished because of these closures? Do recovered habitats support more abundant and healthier FMP species? If FMP species are more abundant in the EFH protection areas, is there any benefit in yield for areas that are still fished without EFH protection?

### Research Activities

- Fishing effort data from observers and remote sensing would be used to study changes in bottom trawl and other fishing gear activity in the closed (and open) areas. Effects of displaced fishing effort would have to be considered. The basis of comparison would be changes in the structure and function of benthic communities and populations, as well as important physical features of the seabed, after comparable harvests of target species are taken with each gear type.
- Monitor the structure and function of benthic communities and populations in the newly closed areas, as well as important physical features of the seabed, for changes that may indicate recovery of benthic habitat. Whether these changes constitute recovery from fishing or just natural variability/shifts requires comparison with an area that is undisturbed by fishing and otherwise comparable.
- Validate the LEI model and improve estimates of recovery rates, particularly for the more sensitive habitats, including coral and sponge habitats in the Aleutian Islands region; possibly address through comparisons of benthic communities in trawled and untrawled areas.
- Obtain high resolution mapping of benthic habitats, particularly in the on-shelf regions of the Aleutian Islands.
- Time series of maturity at age should be collected to facilitate the assessment of whether habitat conditions are suitable for growth to maturity.
- In the case of red king crab spawning habitat in southern Bristol Bay, research the current impacts of trawling on habitat in spawning areas and the relationship of female crab distribution with respect to bottom temperature.

### Research Time Frame

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

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# Appendix I Information on Marine Mammal and Seabird Populations

This appendix contains information on the marine mammal and seabird populations in the Bering Sea and Aleutian Islands (BSAI) and Gulf of Alaska (GOA) management areas. Much of the information in this appendix is from the Programmatic Supplemental Environmental Impact Statement for Alaska Groundfish Fisheries, published by National Marine Fisheries Service (NMFS) in 2004.

## I.1 Marine Mammal Populations

Marine mammals occur in diverse habitats, including deep oceanic waters, the continental slope, and the continental shelf (Lowry et al. 1982). In the areas fished by the federally managed groundfish fleets, twenty-six species of marine mammals are present from the orders Pinnipedia (seals, sea lion, and walrus), Carnivora (sea otter and polar bear), and Cetacea (whales, dolphins, and porpoises) (Lowry and Frost 1985). Most species are resident throughout the year, while others seasonally migrate into and out of Alaskan waters.

### I.1.1 Potential impacts of fisheries on marine mammals

#### Direct Mortality from Intentional Take

Commercial harvests of marine mammals have occurred at various times and places, sometimes with devastating impacts on the populations of particular species. In some cases, such as the northern right whale, the species have not recovered to pre-exploitation population levels even though commercial whaling was halted decades ago.

#### Direct Mortality from Incidental Take in Fisheries

Some types of fisheries are much more likely to catch marine mammals incidentally than others. High seas driftnet fishing killed thousands of mammals before it was prohibited in 1991. Longline and pot fisheries very rarely catch marine mammals directly.

#### Indirect Effects through Entanglement

The following effects are classified as indirect because the impacts are removed in time and/or space from the initial action although in the analysis, these effects are considered together with the direct effect of incidental take. In some cases, individual marine mammals may be killed outright by the effect. In other cases, individuals are affected in ways that may decrease their chances of surviving natural phenomenon or reproducing successfully. These sub-lethal impacts may reduce their overall “fitness” as individuals and may have population-level implications if enough individuals are impacted.

Although some fisheries have no recorded incidental take of marine mammals, all of them probably contribute to the effects of entanglement in lost fishing gear. Evidence of entanglement comes from observations of animals trailing ropes, buoys, or nets or bearing scars from such gear. Sometimes stranded marine mammals also have evidence of entanglement but it may not be possible to ascertain whether the entanglement caused the injury or whether the corpse picked up gear as it floated around after death. Sometimes an animal is observed to become entangled in specific fishing gear, in which case an incidental take or minor injury may be recorded for that particular fishery, but many times the contributions of individual fisheries to the overall effects of entanglement are difficult to document and quantify.

The Marine Plastic Pollution Research and Control Act of 1987 (33 USC §§ 1901 et seq.), implements the provisions relating to garbage and plastics of the Act to Prevent Pollution from Ships (MARPOL Annex V). These regulations apply to all vessels, regardless of flag, on the navigable waters of the U.S. and in the exclusive economic zone of the U.S. It applies to U.S. flag vessels wherever they are located. The discharge of plastics into the water is prohibited, including synthetic ropes, fishing nets, plastic bags, and biodegradable plastics.

### Indirect Effects through Changes in Prey Availability

The availability of prey to marine mammals depends on a large number of factors and differs among species and seasons. Among these factors are oceanographic processes such as upwellings, thermal stratification, ice edges, fronts, gyres, and tidal currents that concentrate prey at particular times and places. Prey availability also depends on the abundance of competing predators and the ecology of prey species, including their natural rates of reproduction, seasonal migration, and movements within the water column. The relative contributions of factors that influence prey availability for particular species and areas are rarely known. Most critical is the lack of information on how events outside an animal's foraging range or in a different season may influence the availability of prey to animals in a particular place and time.

Marine mammal species differ greatly from one another in their prey requirements and feeding behaviors, leading to substantial differences in their responses to changes in the environment. For some species, such as the baleen whales, diets consist largely of planktonic crustaceans or small squid and have no overlap of prey with species that are targeted or taken as bycatch in the groundfish fisheries. For other species, notably Steller sea lions, there is a high degree of overlap between their preferred size and species of prey and the groundfish catch. Many other species are in between, perhaps feeding on the same species but smaller sizes of fish than what is typically taken in the fisheries. Although they may take a wide variety of prey species during the year, many species may depend on only one or a few prey species in a given area and season. In addition, the prey requirements and foraging capabilities of nursing females and subadult animals may be much more restricted than for non-breeding adults, with implications for reproductive success and survival.

The question of whether different types of commercial fisheries have had an effect on the availability of prey to marine mammals has been addressed by examining the degree of direct competition (harvest) of prey and by looking for potential indirect or cascading effects of the fisheries on the food web of the mammals. For marine mammals whose diets overlap to some extent with the target or bycatch species of the fisheries, fishery removals could potentially decrease the density of prey fields or cause changes in the distribution of prey such that the foraging success of the marine mammals is affected. If alternate prey is not available or is of poorer nutritional quality than the preferred species, or if the animal must spend more time and energy searching for prey, reproductive success and/or survival can be compromised. In the case of marine mammals that do not feed on fish or feed on different species than are taken in the fisheries, the removal of a large number of target fish from the ecosystem may alter the predator and prey dynamics and thus the abundance of another species that is eaten by marine mammals. The mechanisms and causal pathways for many potential food web effects are poorly documented because they are very difficult to study scientifically at sea.

Although reductions in the availability of forage fish to marine mammals have been attributed to both climatic cycles and commercial fisheries, a National Research Council study on the Bering Sea ecosystem (NRC 1996) concluded that both factors probably are significant. Regime shifts are major changes in atmospheric conditions and ocean climate that take place on multi-decade time scales and trigger community-level reorganizations of the marine biota (Anderson and Piatt 1999). Two cycles of warm and cold regimes have been documented in the GOA in the past 100 years, with the latest shift being from a cold regime to a warm regime in 1977. The consequences of this shift on fish and crustacean populations have been documented, including major improvements in groundfish recruitment and the collapse of some high-value forage species such as shrimp, capelin, and Pacific sand lance (Anderson and Piatt 1999). Directed fisheries on forage fish can deepen and prolong their natural low population cycles (Duffy 1983, Steele 1991), with potential effects on marine mammal foraging success. There is some evidence that another regime shift may have begun in

1998 with colder water temperatures and increases in certain forage populations (NPFMC 2002), but the implications for marine mammals are still unclear. Climate change may also affect the dynamics of the ice pack, with serious consequences for the marine mammals associated with the ice pack, such as bowhead whales, the ice seals, and walrus.

#### Direct Effects through Disturbance by Fishing Vessels

The effects of disturbance caused by vessel traffic, fishing operations, engine noise, and sonar pulses on marine mammals are largely unknown. With regard to vessel traffic, many baleen and toothed whales appear tolerant, at least as suggested by their reactions at the surface. Observed behavior ranges from attraction to the vessel to course modification or maintenance of distance from the vessel. Dall's porpoise, Pacific white-sided dolphins, and even beaked whales have been observed adjacent to vessels for extended periods of time. Conversely, harbor porpoise tend to avoid vessels. However, a small number of fatal collisions with various vessels have been recorded in California and Alaska in the past decade and others likely go unreported or undetected (Angliss et al. 2001).

Reactions to some fishing gear, such as pelagic trawls, are poorly documented, although the rarity of incidental takes suggests either partitioning of foraging and fishing areas or avoidance. Given their distribution throughout the fishing grounds, at least some individuals may be expected to occasionally avoid contact with vessels or fishing gear, which would constitute a reaction to a disturbance. Assuming these instances occur, the effects are likely temporary. Sonar devices are used routinely during fishing activity as well as during vessel transit. The sounds produced by these devices may be audible to marine mammals and may thus constitute disturbance sources. Wintering humpback whales have been observed reacting to sonar pulses by moving away (Maybaum 1990, 1993), although few other cases of reaction have been documented.

#### Indirect Effects through Contamination by Oil Spills

For species such as the pinnipeds and sea otters that spend a substantial amount of time on the surface of the water or hauled out on shore, oil spills pose a significant environmental hazard, even in small amounts. The toxicological effects of ingested oil, ranging from potential organ damage to weakening of the immune system, are poorly known for most species, especially in regard to chronic low doses. Sea otters are particularly susceptible to oil spills because they depend on their thick fur to protect them from cold water, rather than layers of fat, and oil destroys the insulative properties of their fur. Thousands of sea otters died over a large expanse of the GOA as a result of the Exxon Valdez oil spill in 1989 (Garshelis 1997, Garrot et al. 1993, DeGange et al. 1994). There is very little data on the mortality of marine mammals from the much smaller volumes of oil that are more typical of marine vessel spills, resulting from fuel transfer accidents and bilge operations.

### I.1.2 Statutory protection for marine mammals

There are two major laws that protect marine mammals and require the North Pacific Fishery Management Council (Council) to address their conservation in the FMPs. The first is the Marine Mammal Protection Act (MMPA) of 1972 (amended 1994). Management responsibility for cetaceans and pinnipeds other than walrus is vested with National Marine Fisheries Service (NMFS) Protected Resources Division (PRD). The United States Fish and Wildlife Service (USFWS) is responsible for management of walrus and sea otters. The goal of the MMPA is to provide protection for marine mammals so that their populations are maintained as a significant, functioning element of the ecosystem. The MMPA established a moratorium on the taking of all marine mammals in the United States with the exception of subsistence use by Alaska Natives. Under the authority of this Act, NMFS PRD monitors populations of marine mammals to determine if a species or population stock is below its optimum sustainable population. Species that fall below this level are designated as "depleted." Populations or stocks (e.g., the western stock of Steller sea lions) listed as threatened or endangered under the Endangered Species Act (ESA), are automatically designated as depleted under the MMPA.

The ESA was enacted in 1973 and reauthorized in 1988. This law provides broad protection for species that are listed as threatened or endangered under the Act. The species listed under the ESA that spend all or part of their time in the BSAI and GOA and that may be affected by the groundfish fisheries are included in the table below. There are eight whale species, and two distinct population segments of Steller sea lions.

| **Listed Species** | **Population or Distinct Population Segment (DPS)** | **Latin Name** | **Status** |
|---|---|---|---|
| Blue whale | North Pacific | *Balaenoptera musculus* | Endangered |
| Bowhead whale | Western Arctic | *Balaena mysticetus* | Endangered |
| Fin whale | Northeast Pacific | *Balaenoptera physalus* | Endangered |
| Humpback whale | Western and Central North Pacific | *Megaptera novaeangliae* | Endangered |
| Right whale | North Pacific | *Eubalaena japonica* | Endangered |
| Sei whale | North Pacific | *Balaenoptera borealis* | Endangered |
| Sperm whale | North Pacific | *Physeter macrocephalus* | Endangered |
| Gray whale | Eastern Pacific | *Eschrichtius robustus* | Delisted |
| Steller sea lion | Western Alaska DPS | *Eumetopias jubatus* | Endangered |
| Steller sea lion | Eastern Alaska DPS | *Eumetopias jubatus* | Threatened |

The mandatory protection provisions of the ESA have led to numerous administrative and judicial actions and have brought the issue of fisheries/sea lion interactions under intense scrutiny. Section 7(a)(2) of the ESA requires federal agencies to ensure that any action authorized, funded, or carried out by such agencies is not likely to jeopardize the continued existence of any endangered or threatened species or result in the destruction or adverse modification of its designated critical habitat. For federal fishery management actions, the action agency, NMFS Sustainable Fisheries Division, is required under Section7(a)(2) to consult with the Steller sea lion expert agency, NMFS PRD, to determine if the proposed action may adversely affect Steller sea lions or their critical habitat. If the proposed action may adversely affect Steller sea lions or its designated critical habitat, formal consultation is required. Formal consultation is a process between the action and expert agency that determines whether a proposed action is likely to jeopardize the continued existence of listed species or destroy or adversely modify designated critical habitat. The process begins with the action agency's assessment of the effects of their proposed action on listed species and concludes with the issuance of a "Biological Opinion" by the expert agency. A biological opinion is a document which includes: a) the opinion of NMFS PRD as to whether or not a federal action (such as federally authorized fisheries) is likely to jeopardize the continued existence of listed species or adversely modify designated critical habitat; b) a summary of the information on which the opinion is based; and c) a detailed discussion of the effects of the action on listed species or designated critical habitat. If the Biological Opinion concludes that the proposed action is likely to jeopardize the continued existence of threatened or endangered species or adversely modify critical habitat, then the expert agency recommends Reasonable and Prudent Alternatives to avoid the likelihood of "jeopardy" or "adverse modification" of critical habitat. The resulting legal requirements limit the Council from adopting FMP policies that result in a jeopardy finding for the Steller sea lions.

### I.1.3 Consideration of marine mammals in groundfish fishery management

In order to fulfill their oversight responsibilities under the MMPA, NMFS PRD and the U.S. Fish and Wildlife Service (USFWS) have developed appropriate survey methodologies to census the various species of marine mammals. The results of these surveys, and other factors that affect the status of each species, are published in an annual "Marine Mammal Stock Assessment" report that is available on the NMFS national website (www.nmfs.noaa.gov).

Some species are much more difficult to census accurately than others, so there is a great deal of variation in the uncertainty of various population estimates. In addition, the huge expanses over which many species traverse and the remoteness of their habitats make surveys logistically difficult and expensive. For budgetary and logistical reasons, surveys of most species are not carried out every year and survey effort is prioritized for species of management concern. As a result, population estimates for some species may be outdated and trend information may not exist.

NMFS PRD requires all commercial fisheries in the U.S. Exclusive Economic Zone to report the incidental take and injury of marine mammals that occur during their operations (50 CFR 229.6). In addition to self-reported records, which NMFS PRD considers to be negatively biased and under representing actual take levels, certified observers are required in some fisheries to provide independent monitoring of incidental take as well as other fishery data.

Management measures are in place in the BSAI and GOA groundfish fisheries to protect Steller sea lions. These protection measures were deemed necessary based on the hypothesis that the continued decline of the western stock of the Steller sea lion is due to nutritional stress and that groundfish fisheries contribute to this stress by competing with sea lions for their key prey species. Management measures were specifically developed to reduce competitive interaction between Steller sea lions and the groundfish fisheries (NMFS 2001a). Mitigation efforts have focused on protecting the integrity of food supplies near rookeries and haulouts. Competitive interactions with the fishery may have the greatest effect on juvenile Steller sea lions between the time they are weaned and the time they reach adult size and foraging capability as the diving capacity of juveniles (and thus available foraging space) is less than that of adults. Adult females may also be susceptible to nutritional stress due to reduced prey availability in the vicinity of rookeries because of the limited foraging distribution and increased energetic demands when caring for pups. Specifically, the intent of the protection measures was to avoid competition around rookeries and important haulouts with extra precaution in the winter, and to disperse the fisheries outside of those time periods and areas.

Section 118 of the MMPA (50 CFR 229.2) requires all commercial fisheries to be placed into one of three categories, based on the frequency of incidental take (serious injuries and mortalities) relative to the value of potential biological removal (PBR) for each stock of marine mammal. PBR is defined as the maximum number of animals, not including natural mortalities, that may be removed from a stock while allowing that stock to reach or maintain its optimum sustainable population. In order to categorize each fishery, NMFS PRD first looks at the level of incidental take from all fisheries that interact with a given marine mammal stock. If the combined take of all fisheries is less than or equal to 10 percent of PBR, each fishery in that combined total is assigned to Category III, the minimal impact category. If the combined take is greater than 10 percent of PBR, NMFS PRD then looks at the individual fisheries to assign them to a category. Category I designates fisheries with frequent incidental take, defined as those with takes greater than or equal to 50 percent of PBR for a particular stock; Category II designates fisheries with occasional serious injuries and mortalities, defined as those with takes between one percent and 50 percent of PBR; Category III designates fisheries with a remote likelihood or no known serious injuries or mortalities, defined as those with take less than or equal to one percent of PBR. Owners of vessels or gear engaging in Category I or II fisheries are required to register with NMFS PRD to obtain a marine mammal authorization in order to lawfully take a marine mammal incidentally in their fishing operation (50 CFR 229.4). In Alaska, this registration process has been integrated into other state and federal permitting programs to reduce fees and paperwork. Owners of vessels or gear engaging in Category III fisheries are not required to register with NMFS PRD for this purpose. Every year, NMFS PRD reviews and revises its list of Category I, II, and III fisheries based on new information and publishes the list in the Federal Register.

Under provisions of the MMPA, NMFS PRD is required to establish take reduction teams with the purpose of developing take reduction plans to assist in the recovery or to prevent the depletion of strategic stocks that interact with Category I and II fisheries. A “strategic” stock is one which: 1) is listed as endangered or threatened under the ESA, 2) is declining and likely to be listed as threatened under the ESA, 3) is listed as depleted under the MMPA, or 4) has direct human-caused mortality which exceeds the stock’s PBR.

The immediate goal of a take reduction plan is to reduce, within six months of its implementation, the incidental serious injury or mortality of marine mammals from commercial fishing to levels less than PBR. The long-term goal is to reduce, within five years of its implementation, the incidental serious injury and mortality of marine mammals from commercial fishing operations to insignificant levels approaching a zero serious injury and mortality rate, taking into account the economics of the fishery, the availability of existing technology, and existing state or regional Fishery Management Plans. Take reduction teams are to consist of a balance of representatives from the fishing industry, fishery management councils, state and federal resource management agencies, the scientific community, and conservation organizations. Fishers participating in Category I or II fisheries must comply with any applicable take reduction plan and may be required to carry an observer onboard during fishing operations.

In 2002, all of the Alaska groundfish fisheries (trawl, longline, and pot gear in the BSAI and GOA) were listed as Category III fisheries (67 FR 2410). However, NMFS PRD has recently proposed that the BSAI groundfish trawl fishery be elevated to Category II status based on a review of Observer Program records of marine mammal incidental take from 1990-2000 (68 FR 1414). According to the records, total incidental take of all fisheries is greater than 10 percent of PBR for the Alaska stocks of western and central North Pacific humpback whales, resident killer whales, transient killer whales, and the western stock of Steller sea lions. Based on the incidental take of these species relative to their respective PBRs, and some other considerations in the case of humpback whales, NMFS PRD determined in their "Tier 2" analysis that the BSAI groundfish trawl fishery posed a modest risk to these species. In addition, a number of state-managed salmon drift and set gillnet fisheries are listed in Category II, including those in Bristol Bay, Aleutian Islands, Alaska Peninsula, Kodiak, Cook Inlet, Prince William Sound, and Southeast Alaska. NMFS PRD has recently proposed reclassifying the Cook Inlet drift and set gillnet fisheries from Category II to Category III (68 FR 1414).

### I.1.4 Bibliography


Anderson, P.J., and Piatt, J.F.(1999). "Community reorganization in the Gulf of Alaska following ocean climate regime shift." Marine Ecology Progress Series, 189, pp.117-123.

Angliss, R.P., Lopez, A., and DeMaster, D.P.(2001)."Draft Alaska Marine Mammal Stock Assessments, 2001." National Marine Mammal Laboratory, 7600 Sand Point Way NE, Seattle, WA 98115.pp.181.

Duffy, D.C.(1983). "Environmental uncertainty and commercial fishing: Effects on Peruvian guano birds." Biological Conservation, 26, pp.227-238.

Lowry, L.F., and Frost, K.J.(1985). "Biological interactions between marine mammals and commercial fisheries in the Bering Sea." Marine mammals and fisheries, J.R.Beddington, R.J.H.Beverton, and D.M.Lavigne, eds., George Allen & Unwin, London, pp.42-61.

Lowry, L.F., Frost, K.J., Calkins, D.G., Swartzman, G.L., and Hills, S.(1982)."Feeding habits, food requirements, and status of Bering Sea marine mammals." Document Nos.19 and 19A, NPFMC, 605 W. 4th Avenue, Suite 306, Anchorage, AK 99501-2252.pp.574.

Maybaum, H.(1990). "Effects of a 3.3 kHz sonar system on humpback whales (Megaptera novengliae) in Hawaiian waters." EOS, Transactions, American Geophysical Union, 71(2), pp.92.

Maybaum, H.(1993). "Response of humpback whales to sonar sounds." Journal of Acoustic Soc.Am., 94(3), pp.1848-1849.

NMFS.(2001a). Alaska Groundfish Fisheries: Draft Programmatic Supplemental Environmental Impact Statement. NMFS, Alaska Region, NOAA, U.S.DOC.

NPFMC.(2002). Ecosystem Considerations. Appendix C of the Stock Assessment and Fishery Evaluation Reports for the Groundfish Resources of the Bering Sea/Aleutian Islands and Gulf of Alaska Regions. NPFMC, 605 W. 4th Ave., Suite 306, Anchorage, AK 99501. 229 pp.

Steele, J.H.(1991). "Marine Functional diversity." BioScience, 41, pp.4.

## I.2 Seabird Populations

Over 70 species of seabirds occur over waters off Alaska and could potentially be affected by direct and indirect interactions with the Bering Sea Aleutian Islands and Gulf of Alaska groundfish fisheries. Thirty-eight of these species regularly breed in Alaska and waters of the EEZ. More than 1,600 seabird colonies have been documented, ranging in size from a few pairs to 3.5 million birds (USFWS 2000). Breeding populations of seabirds are estimated at approximately 48 million birds and non-breeding migrant birds probably account for an additional 30 million birds (USFWS 1998). Most of the migrant birds are present only during the summer months (May through September) although some non-breeding albatross have been sighted at all months of the year (USFWS 1999). The distributions of species that breed in Alaska are well known in summer but for some species winter distributions are poorly documented or completely unknown.

### I.2.1 Potential impacts of fisheries on seabird species

Potential fisheries impacts on a given seabird species could theoretically be measured by changes in survival or reproductive rates and ultimately by changes in the population. For all of these biological parameters, one would expect fluctuations in time and space as part of "normal" or natural conditions. The ability to distinguish these natural fluctuations from potential human-caused fluctuations requires reasonably accurate measurements of several parameters over a long time period and in many different areas. The USFWS surveys a number of large seabird colonies every year. Data is collected for selected species at geographically dispersed breeding sites along the entire coastline of Alaska. Some sites are scheduled for annual monitoring while others are monitored every three years. Although trends in sampling plots are reasonably well known at particular colonies, overall population estimates for most species are not precise enough to detect anything but the largest fluctuations in numbers. This is especially true for species that do not nest in dense concentrations. For some species, like the burrow and crevice-nesting alcids and storm-petrels, field methods for censusing populations are not available and require additional budgetary support for development. Population trends for those species that are regularly monitored are presented in an annual report entitled, "Breeding status, population trends, and diets of seabirds in Alaska", published by the USFWS (Dragoo et al. 2001).

Seabirds can interact with fisheries in a number of direct and indirect ways. Direct effects occur at the same time and place as the fishery action. Seabirds are attracted to fishing vessels to feed on prey churned up in the boat's wake, escaping fish from trawl nets, baited hooks of longline vessels, and offal discharged from trawl, pot, and longline vessels. In the process of feeding, seabirds sometimes come into contact with fishing gear and are caught incidentally. A direct interaction is usually recorded as the injury or killing of a seabird and is referred to as an "incidental take". Information on the numbers of birds caught incidentally in the various gear types comes from the North Pacific Groundfish Observer Program (Observer Program) and is reported in the annual *Stock Assessment and Fishery Evaluation* reports in the seabird section of "Ecosystem Considerations" appendix (NPFMC 2002, Tables 8, 9, 11, and 12).

Another direct fishery effect is the striking of vessels and fishing gear by birds in flight. Some birds fly away without injury but others are injured or killed and are thus considered incidental take. The Observer Program does not collect data on vessel strikes in a systematic way but there are some records of bird-strikes that have been collected on an opportunistic basis. These sporadic observations of vessel strikes from 1993-2000 have been entered into the Observer Notes Database, which is maintained by the USFWS, but have only received preliminary statistical analysis (seabird section of "Ecosystem Considerations for 2003", NPFMC 2002). Indirect effects refer to either positive or negative impacts on the reproductive success or survival of seabirds that may be caused by the fishery action but are separated in time or geographic location. The indirect effect which has received the most attention is the potential impact of fisheries competition or disturbance on the abundance and distribution of prey species that seabirds depend on, thus affecting seabird foraging success. Of particular note would be those effects on breeding piscivorous (fish-eating) seabirds that must meet the food demands of growing chicks at the nest colony. Reproductive success in Alaskan seabirds is strongly linked to the availability of appropriate fish (Piatt and Roseneau 1998, Suryan et al. 1998a, Suryan et al. 2000, Golet et al. 2000). Although seabird populations remain relatively stable during occasional years of poor food and reproduction, a long-term scarcity of forage fish leads to population declines. Other potential indirect effects on seabirds include physical disruption of benthic foraging habitat by bottom trawls, consumption of processing wastes and discarded offal, contamination by oil spills, introductions of nest predators (i.e., rats) to nesting islands, and ingestion of plastics released intentionally or accidentally from fishing vessels. Some of these potential impacts are related more to the presence of fishing vessels rather than the process of catching fish.

### I.2.2 Statutory protection for seabirds

There are two major laws that protect seabirds and require the Council to address seabird conservation in their Fishery Management Plans. The first is the Migratory Bird Treaty Act of 1918 (16 U.S.C. 703-712), as amended over the years. This law pertains to all of the seabird species found in the BSAI and GOA area (66 FR 52282) and governs the taking, killing, possession, transportation, and importation of migratory birds, their eggs, parts and nests. The definition of "take" in the Migratory Bird Treaty Act is "to pursue, hunt, shoot, wound, kill, trap, capture, or collect, or attempt to pursue, hunt, shoot, wound, kill, trap, capture, or collect" (50 CFR 10.12). In a fishery context, "take" refers to birds killed or injured during commercial fishing operations, whether in fishing gear or by striking some part of a vessel. Under the Migratory Bird Treaty Act, take of migratory birds is illegal, even if it is accidental or inadvertent, unless permitted through regulations (such as hunting regulations or permit exemptions). Thus far, only certain forms of intentional take have been legalized in these ways. There are currently no regulations to allow unintentional take. The USFWS and Department of Justice are vested with enforcement discretion, which has been used in lieu of a permitting program. Enforcement has focused on those who take birds with disregard for the law and the impact of their actions on the resource, particularly where effective conservation measures are available but have not been applied ("Fact sheet" on the Migratory Bird Treaty Act, K. Laing, USFWS). Executive Order 13186 (66 FR 3853-3856), "Responsibilities of Federal Agencies to Protect Migratory Birds," which was signed by the President on January 10, 2001, directs federal agencies to develop and implement a "Memorandum of Understanding" with the USFWS to promote the conservation of migratory birds affected by their actions, including mitigation of activities that cause unintentional take. NMFS and USFWS are currently developing this framework document which will incorporate seabird protection measures designed for specific fisheries (K. Rivera, NMFS National Seabird Coordinator, personal communication).

The second law is the ESA which provides broad protection for species that are listed as threatened or endangered. Presently there are three species listed under the ESA that spend all or part of their time in the BSAI and GOA and that may be affected by the groundfish fisheries: short-tailed albatross (endangered), Steller's eider (threatened), and spectacled eider (threatened). Section 7(a)(2) of the ESA requires federal agencies to ensure that any action authorized, funded, or carried out by such agencies is not likely to jeopardize the continued existence of the species or result in the destruction or adverse modification of habitat important to the continued existence of the species (Critical Habitat). For ESA listed seabirds, the USFWS is the agency responsible for conducting an assessment of the proposed action and preparing the appropriate Section 7 document, a "Biological Opinion". If the Biological Opinion concludes that the proposed action is likely to jeopardize the continued existence of threatened or endangered species or adversely modify its Critical Habitat, then the agency must develop Reasonable and Prudent Alternatives to minimize or mitigate the effect of the action. Even if a "no jeopardy" determination is made, as has been done for all three listed species in the BSAI and GOA, the agency may require and/or recommend that certain mitigation measures be adopted. In addition, the agency may establish a threshold number of incidental takes that would trigger a new Section 7 consultation to reexamine the required mitigation measures. In the case of the short-tailed albatross, the number of incidental takes that could be reasonably expected, given the designated mitigation measures, has been adopted as a threshold value and is described in the Incidental Take Statement attached to the Biological Opinion (USFWS 1999). These provisions of the ESA, as applied to the short-tailed albatross, have played a major role in the development of seabird protection measures for the longline sector of the BSAI and GOA groundfish fisheries.

USFWS may designate Critical Habitat areas for each species under the ESA if it can determine that those areas are important to the continued existence of the species. Critical Habitat may only be designated in U.S. territory, including waters of the Exclusive Economic Zone. Short-tailed albatross do not nest in U.S. waters but have been sighted throughout the BSAI and GOA area. No Critical Habitat has been designated for this species. Spectacled and Steller's eiders each have designated Critical Habitats in the BSAI where they concentrate in winter and during flightless molting periods (66 FR 9146 and 66 FR 8850 respectively; February 2001). Critical Habitat designations do not automatically restrict human activities like fishing. They do require the lead agency, in this case the USFWS, to monitor activities that may degrade the value of the habitat for the listed species.

### I.2.3 Consideration of seabirds in groundfish fishery management

Seabird protection measures in the BSAI and GOA groundfish fisheries were initiated in the 1990s and have focused primarily on collecting seabird and fishery interaction data and on requiring longliners to use specific types of gear and fishing techniques to avoid seabird incidental take. This emphasis on longline gear restrictions has been driven by conservation concerns for the endangered short-tailed albatross as well as other species. As of 2004, longline vessels over 26 ft LOA are required to use either single or paired streamer lines (or in some cases for smaller vessels, a buoy bag line) to reduce incidental take of seabirds (see www.fakr.noaa.gov/protectedresources.seabirds.html for further information).

Observers collect incidental take data in the trawl and pot sectors of the fishery. USFWS and the trawl sector of the fishing industry are collaborating on research into minimizing the effects of the trawl "third wire" (a cable from the vessel to the trawl net monitoring device) on incidental take of seabirds. However, there have been no regulatory or Fishery Management Plan-level efforts to mitigate seabird incidental take in the trawl and pot sectors.

For species listed as threatened or endangered under the ESA, the USFWS may establish a threshold number of incidental takes that are allowed before mitigation measures are reviewed and perhaps changed. Although this is sometimes viewed as a "limit" on the number of birds (e.g., short-tailed albatross) that can be taken, the result of exceeding this threshold number is a formal consultation process between NMFS and USFWS, not an immediate shutdown of the fishery.

Another management tool that may affect incidental take of seabirds is the regulation of who is allowed to fish. Limited entry and rationalization programs such as Individual Fishing Quota and Community Development Quota programs may impact seabird incidental take if the number or size of fishing vessels changes because regulations on protective measures are based on the size of the vessel. Since different types of fishing gear are more prone to take different kinds and numbers of seabirds, allocation of total allowable catch among the different gear sectors can also have a substantial impact on incidental take.

Food web impacts can be addressed with several management tools. The Council has designated particular species and size classes of fish as being important prey for seabirds and marine mammals and has prohibited directed fisheries on these forage fish (BSAI Amendment 36 and GOA Amendment 39). The Council may also manage the allocation, biomass, and species of fish targeted by the industry through the total allowable catch-setting process. These factors impact the food web and could thus alter the availability of food to seabirds. While more information is available for the dynamics of fish populations than of invertebrate prey, food web interactions are very complicated and there is a great deal of scientific uncertainty regarding the specific effects of different management options.

Each of the management tools listed above requires reliable data to monitor the extent of fishery interactions and the effectiveness of mitigation efforts in accordance with management policy objectives. The Council established the Observer Program in order to collect fishery information. Beginning in 1993, the Observer

Program was modified to provide information on seabird/fishery interactions. Observers are presently required on vessels 125 ft LOA or more for 100 percent of their fishing days and aboard vessels 60-124 ft LOA for 30 percent of their fishing days. Vessels less than 60 ft LOA do not have to carry observers.

Observers receive training in seabird identification, at least to the level of being able to place birds into the categories requested by the USFWS. Some of these categories identify individual species and others lump species under generalized groups, e.g., "unidentified alcids." In many cases, birds that were caught as the gear was being deployed have soaked at depth for hours and have been eaten by invertebrates. By the time they are retrieved on board they may be identifiable only to a generalized group level. NMFS is currently working to improve the training of its observers in identifying birds from their feet and bills, which are often the only parts of the bird that are recognizable (S. Fitzgerald, Observer Program, personal communication). When the Observer Program data is analyzed and reported (as in the Ecosystem Considerations appendix in *Stock Assessment and Fishery Evaluation* reports), individual species with relatively few records are often lumped into larger categories. For example, the "gull" category contains many "unidentified gulls" but also various numbers of five different gull species that observers have identified to species. Similarly, the "alcid" group contains separate records of seven different alcid species.

For those vessels operating without observers, regulations require captains to report the taking of any ESA-listed species and to retain and deliver the body to USFWS for positive identification. Unfortunately, such self-reporting is unreliable due to the inability or unwillingness of some crews to identify and retain species of concern. Other existing fishery record-keeping and reporting requirements provide data on the distribution of fishing effort which could potentially be used in conjunction with directed research to analyze potential food web and seabird population impacts.

### I.2.4 Bibliography

Dragoo, D.E., Byrd Jr., G.V., and Irons, D.B. (2001).Breeding status and population trends of seabirds in Alaska, 2000.U.S.Fish and Wildlife Service Report AMNWR 01/07.

Golet, G.H., Kuletz, K.J., Roby, D.D., and Irons, D.B. (2000). "Adult prey choice affects chick growth and reproductive success in pigeon guillemots." Auk, 117(1), pp. 82-91.

NPFMC. (2002). Ecosystem Considerations. Appendix C of the Stock Assessment and Fishery Evaluation Reports for the Groundfish Resources of the Bering Sea/Aleutian Islands and Gulf of Alaska Regions. NPFMC, 605 W. 4th Ave., Suite 306, Anchorage, AK 99501. 229 pp.

Piatt, J.F., and Roseneau, D.G. (1998). "Cook Inlet seabird and forage fish studies (CISEAFFS)." Pacific Seabirds, 25, pp. 39.

Suryan, R.M., Irons, D.B., and Benson, J.E. (1998a). "Foraging ecology of black-legged kittiwakes in Prince William Sound, Alaska, from radio tracking studies." Pacific Seabirds, 25, pp. 45.

Suryan, R.M., Irons, D.B., and Benson, J.E. (2000). "Prey switching and variable foraging strategies of black-legged kittiwakes and the effect on reproductive success." Condor, 102, pp. 373-384.

USFWS. (1998). Beringian Seabird Colony Catalog - computer database and colony status record archives. http://fw7raptor.r7.fws.gov/seabird/index.html. US Department of the Interior, US Fish and Wildlife Service, Migratory Bird Management, Anchorage, AK.

USFWS. (1999). "Endangered Species Act Formal Section 7 Consultation for 1999-2000 Hook-and-Line Groundfish Fisheries of the Gulf of Alaska and Bering Sea and Aleutian Islands Area (Short-tailed Albatross)."U.S. Department of the Interior, Fish and Wildlife Service, 1011 E. Tudor Road, Anchorage, AK 99503.pp. 36 + Tables and Figures.

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# Appendix J Consolidated Appropriations Act, 2005 (Public Law 108-447): Provisions related to catcher processor participation in the BSAI non-pollock groundfish fisheries

## J.1 Summary of the Consolidated Appropriations Act, 2005

On December 8, 2004, the President signed into law the Consolidated Appropriations Act, 2005 (Public Law 108-447). With respect to fisheries off Alaska, the Consolidated Appropriations Act, 2005, establishes catcher processor sector definitions for participation in: 1) the catcher processor subsectors of the BSAI non-pollock groundfish fisheries, and 2) the BSAI Catcher Processor Capacity Reduction Program. The following subsectors are defined in Section 219(a) of the Act: AFA trawl catcher processor; non-AFA trawl catcher processor; longline catcher processor; and pot catcher processor. Section 219(a) also states that 'non-pollock groundfish fishery' means target species of Atka mackerel, flathead sole, Pacific cod, Pacific Ocean perch, rock sole, turbot, or yellowfin sole harvested in the BSAI. Thus, this legislation provides the qualification criteria that each participant in the catcher processor subsectors must meet in order to operate as a catcher processor in the BSAI non-pollock groundfish fisheries and/or participate in the BSAI Catcher Processor Capacity Reduction Program.

The Consolidated Appropriations Act, 2005, includes numerous provisions that are not related to the management of groundfish and crab fisheries off Alaska. Only the portions of the legislation related to eligibility of the catcher processor subsectors are provided for reference. The portions of the legislation authorizing and governing the development of the BSAI Catcher Processor Capacity Reduction Program are not provided here.

## J.2 Consolidated Appropriations Act, 2005: Section 219(a) and (g)

***SEC. 219. (a) DEFINITIONS.—In this section:***

***(1) AFA TRAWL CATCHER PROCESSOR SUBSECTOR.—The term ''AFA trawl catcher processor subsector'' means the owners of each catcher/processor listed in paragraphs (1) through (20) of section 208(e) of the American Fisheries Act (16 U.S.C. 1851 note).***

***(2) BSAI.—The term ''BSAI'' has the meaning given the term ''Bering Sea and Aleutian Islands Management Area'' in section 679.2 of title 50, Code of Federal Regulations (or successor regulation).***

***(3) CATCHER PROCESSOR SUBSECTOR.—The term ''catcher processor subsector'' means, as appropriate, one of the following:***

***(A) The longline catcher processor subsector.***

***(B) The AFA trawl catcher processor subsector.***

***(C) The non-AFA trawl catcher processor subsector.***

***(D) The pot catcher processor subsector.***

***(4) COUNCIL.—The term ''Council'' means the North Pacific Fishery Management Council established in section 302(a)(1)(G) of the Magnuson-Stevens Fishery Conservation and Management Act (16 U.S.C. 1852(a)(1)(G)).***

***(5) LLP LICENSE.—The term ''LLP license'' means a Federal License Limitation program groundfish license issued pursuant to section 679.4(k) of title 50, Code of Federal Regulations (or successor regulation).***

***(6) LONGLINE CATCHER PROCESSOR SUBSECTOR.—The term ''longline catcher processor subsector'' means the holders of an LLP license that is noninterim and transferable, or that is interim and subsequently becomes noninterim and transferable, and that is endorsed for Bering Sea or Aleutian Islands catcher processor fishing activity, C/P, Pcod, and hook and line gear.***

***(7) NON-AFA TRAWL CATCHER PROCESSOR SUBSECTOR.—The term ''non-AFA trawl catcher processor subsector'' means the owner of each trawl catcher processor—***

***(A) that is not an AFA trawl catcher processor;***

***(B) to whom a valid LLP license that is endorsed for Bering Sea or Aleutian Islands trawl catcher processor fishing activity has been issued; and***

***(C) that the Secretary determines has harvested with trawl gear and processed not less than a total of 150 metric tons of non-pollock groundfish during the period January 1, 1997 through December 31, 2002.***

***(8) NON-POLLOCK GROUNDFISH FISHERY.—The term ''nonpollock groundfish fishery'' means target species of Atka mackerel, flathead sole, Pacific cod, Pacific Ocean perch, rock sole, turbot, or yellowfin sole harvested in the BSAI.***

***(9) POT CATCHER PROCESSOR SUBSECTOR.—The term ''pot catcher processor subsector'' means the holders of an LLP license that is noninterim and transferable, or that is interim and subsequently becomes noninterim and transferable, and that is endorsed for Bering Sea or Aleutian Islands catcher processor fishing activity, C/P, Pcod, and pot gear.***

***(10) SECRETARY.—Except as otherwise provided in this Act, the term ''Secretary'' means the Secretary of Commerce.***

***(g) NON-POLLOCK GROUNDFISH FISHERY.—***

***(1) PARTICIPATION IN THE FISHERY.—Only a member of a catcher processor subsector may participate in—***

***(A) the catcher processor sector of the BSAI non-pollock groundfish fishery; or***

***(B) the fishing capacity reduction program authorized by subsection (b).***

***(2) PLANS FOR THE FISHERY.—It is the sense of Congress that—***

***(A) the Council should continue on its path toward rationalization of the BSAI non-pollock groundfish fisheries, complete its ongoing work with respect to developing management plans for the BSAI non-pollock groundfish fisheries in a timely manner, and take actions that promote stability of these fisheries consistent with the goals of this section and the purposes and policies of the Magnuson-Stevens Fishery Conservation and Management Act; and***

***(B) such plans should not penalize members of any catcher processor subsector for achieving capacity reduction under this Act or any other provision of law.***