Fishery Management Plan for Groundfish of the Gulf of Alaska

APPENDICES

Appendix A History of the Fishery Management Plan

The Fishery Management Plan (FMP) for Groundfish of the Gulf of Alaska (GOA) was implemented on December 1, 1978. Since that time it has been amended over sixty 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 75. Outdated catch data or other scientific information, and obsolete references, were also removed or updated.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 1978. 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 D 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 December 1, 1978:

1. Extended optimum yields (OYs), domestic annual harvest (DAH), total allowable level of foreign fishing (TALFF) to October 31, 1979.
2. Changed fishing year to November 1 - October 31.

Amendment 2 implemented January 1, 1979:

Allowed directed foreign longline fishery for Pacific cod west of 157° W. longitude outside of 12 miles year-round.

Amendment 3 implemented December 1, 1978:

1. Established special joint venture reserve wherein TALFF = 0.8(OY)- DAH, - joint venture processing (JVP).
2. Specified that allocations will be reevaluated on January 1, 1979 and reapportioned if necessary.

Amendment 4 implemented August 16, 1979:

1. Allowed foreign fishing beyond 3 miles between 169° W. and 170° W. longitude.
2. Removed prohibition on taking more than 25 percent TALFF during December 1 to May 31.
3. Allowed foreign longlining for sablefish seaward of 400 m from May 1 to September 30 and seaward of 500 m from October 1 to April 30 between 140° W. and 170° W. longitude.
4. Allowed directed Pacific cod longline fishery between 140° W. and 157° W. longitude beyond 12 miles except as prohibited within 400 m isobath during halibut season.
5. Exempted foreign longliners from nationwide closures upon attaining OY if the OY is not for species targeted by longliners.

6. Increased squid OY to 5,000 mt from 2,000 mt.
7. Increased Atka mackerel OY to 26,800 mt from 24,800 mt.
8. Reduced number of management areas to three from five.
9. Removed domestic one-hour tow restriction on off-bottom trawls from December to May.
10. Provided for the annual review of domestic permits and the reporting of catch within 7 days of landing.

<u>Amendment 5</u> implemented June 1, 1979:

Established a separate OY for rattails (grenadiers) of 13,200 mt.

<u>Amendment 6</u> implemented September 22, 1979:

Released unused DAH to TALFF and reapportioned DAH by regulatory areas.

<u>Amendment 7</u> implemented November 1, 1979:

1. Extended plan year through October 31, 1980.
2. Implemented the processor preference amendment wherein

   DAH = domestic annual processed catch (DAP) + the portion of U.S. harvest discarded + JVP + the amount of non-processed fish harvested;

   Reserve = 20 percent of OY;

   TALFF = OY - DAH, - Reserve
3. Provided for review and reapportionment of Reserve to DAH or TALFF on January 2, March 2, May 2, and July 2.
4. Increased Pacific cod OY to 60,000 mt from 34,800 mt.
5. Increased Atka mackerel OY to 28,700 mt from 26,800 mt.
6. Created separate OY for Sebastolobus species, of 3,750 mt.
7. Provided for new domestic reporting requirements to increase accuracy of forecasting U.S. fishing activity.

<u>Amendment 8</u> implemented November 1, 1980:

1. Changed FMP year to calendar year and eliminated expiration date.
2. Distributed OYs for squid, ‘Other species’, Sebastolobus spp., and ‘Other rockfish’ Gulfwide.
3. Established four species categories: Unallocated, Target, Other, and Non-specified.
4. Divided Eastern regulatory area into Yakutat, Southeast Inside and Southeast Outside for sablefish only.
5. Set a reserve release schedule of 40 percent in April, 40 percent in June, and 20 percent in August.
6. Required biodegradable panels in sablefish pots.

<u>Amendment 9</u> implemented October 2, 1981:

Established Lechner Line around Kodiak which is closed from two days before king crab season to February 15.

<u>Amendment 10</u> implemented June 1, 1982:

1. Closed area east of 140° W. longitude to all foreign fishing.
2. Deleted U.S. sanctuaries east of 140° W. longitude as not necessary.
3. Permitted foreign mid_water trawling only, year_round between 140° W. and 147° W. longitude.
4. For Pacific Ocean perch (POP) in the Eastern regulatory area: reduced ABC to 875 mt from 29,000 mt, changed OY = ABC, DAH = 500 mt, TALFF = 200 mt, and Reserve = 175 mt.

<u>Amendment 11</u> implemented October 16, 1983:

1. Increased pollock OY in Central Gulf to 143,000 mt from 95,200 mt.
2. Established a new management objective for sablefish: sablefish in the Gulf of Alaska will be managed Gulfwide to benefit the domestic fishery.
3. Divided the Yakutat district into two sablefish management districts: Western Yakutat and Eastern Yakutat.
4. Set sablefish OY equal to ABC. ABC set at 75 percent of equilibrium yield to promote stock rebuilding. Gulfwide OY is 8,230_9,478 mt, of which 500 mt is in State internal waters of Southeast.
5. Specified that DAH will be determined annually based on previous year's domestic catch, plus amounts necessary to accommodate projected needs of the domestic fishery reserves and unneeded DAH can be reapportioned as needed.
6. Granted field order authority for Regional Director to adjust time and/or area restrictions on foreign fisheries for conservation reasons.
7. Placed radio or telephone catch reporting requirements on domestic vessels leaving State waters to land fish outside Alaska.

<u>Amendment 12</u> was not submitted.

<u>Amendment 13</u> implemented August 13, 1984:

Combined Western and Central regulatory areas for pollock management and set a combined OY of 400,000 mt (follow up to emergency regulations passed in December 1983 and May 1984).

<u>Amendment 14</u> implemented November 18, 1985:

1. Established gear and area restrictions and OY apportionments to specific gear types for sablefish.
2. Established a Central Southeast Outside District with a 600 mt OY for demersal shelf rockfish.

3. Reduced pollock OY in the combined Western/Central regulatory area from 400,000 mt to 305,000 mt.
4. Reduced Pacific Ocean perch OY in the Western and Central regulatory areas from 2,700 mt and 7,900 mt to 1,302 mt and 3,906 mt, respectively.
5. Reduced Gulfwide 'Other Rockfish' OY from 7,600 mt to 5,000 mt.
6. Reduced Atka mackerel OY in the Central and Eastern regulatory areas from 20,836 mt and 3,186 mt to bycatch levels only of 500 mt and 100 mt, respectively.
7. Reduced Gulfwide 'Other species' OY to the framework amount of 22,460 mt.
8. Established catcher/processor reporting requirements.
9. Implemented a framework procedure for setting and adjusting halibut prohibited species catch (PSC) limits.
10. Implemented NMFS Habitat Policy.
11. Set season for hook and longline and pot sablefish fishery.

<u>Amendment 15</u> implemented April 8, 1987:

1. Revised and expanded management goals and objectives.
2. Established a single OY range and an administrative framework procedure for setting annual harvest levels for each species category.
3. Established framework procedures for setting PSCs for fully utilized groundfish species applicable to joint ventures and foreign fisheries.
4. Revised reporting requirements for domestic at_sea processors.
5. Established time and area restrictions on non-pelagic trawling around Kodiak to protect king crab for three years, until December 31, 1989.
6. Established authority for the Regional Director to make inseason adjustments in the fisheries.

<u>Amendment 16</u> implemented April 7, 1988:

1. Revised definition of "prohibited species" (to include an identical definition as in the BSAI groundfish FMP).
2. Updated the FMP's descriptive sections, reorganized chapters, and incorporated current Council policy.
3. Revised reporting requirements to include maintenance of at_sea transfer logs by catcher/processer vessels.

<u>Amendment 17</u> implemented May 26, 1989:

Required all processing vessels receiving fish caught in the Exclusive Economic Zone (EEZ) to report to NMFS when fishing for or receiving groundfish will begin or cease, and to submit to NMFS weekly catch/receipt and product transfer reports.

Amendment 18 implemented November 1, 1989:

1. Established a procedure for annually setting fishing seasons using a regulatory amendment for implementation.
2. Established a Shelikof District in the Central regulatory area.
3. Continued the Type I and II trawl closure zones and added a Type III trawl closure zone around Kodiak Island to protect king and Tanner crab. This measure sunsets December 31, 1992.
4. Suspended the halibut PSC framework for 1990 only, substituting 2,000 mt trawl and 750 mt fixed gear halibut PSC caps; the halibut PSC framework, including halibut PSC apportionments by gear type, to be reinstituted January 1, 1991 by regulatory amendment.
5. Implemented an observer program.
6. Implemented a revised recordkeeping and data reporting system.
7. Clarified the Secretary's authority to split or combine species groups within the target species management category by a framework procedure.

Amendment 19 implemented November 15, 1990:

1. Prohibited the practice of pollock roe-stripping (defined as the taking of roe from female pollock and the subsequent discard of the female carcass and all male pollock).
2. Divided the pollock TAC into equal quarterly allowances in the Western and Central regulatory areas.

Amendment 20 approved by the Secretary on January 1, 1991:

Established an Individual Fishing Quota (IFQ) program for directed fixed gear sablefish fisheries in the GOA.

Amendment 21 implemented January 18, 1991:

1. Amended the definition of overfishing.
2. Established interim harvest levels until superseded by publication of final groundfish specifications in the Federal Register.
3. Provided limited authority to the State of Alaska to manage the demersal shelf rockfish fishery with Council oversight.
4. Provided for legal fishing gear to be defined by regulatory amendment.
5. Clarified and expanded the existing framework for managing halibut bycatch, including the adoption of an incentive program to impose sanctions on vessels with excessively high halibut bycatch rates. The vessel incentive program originally adopted by the Council was disapproved by the Secretary. The Council adopted a revised incentive program which was submitted on November 30, 1990 to the Secretary for review and approval.

Amendment 22 implemented April 24, 1992:

1. Authorized the NMFS Regional Director to approve experimental fishing permits after consultation with the Council.
2. Rescinded GOA reporting area 68 (East Yakutat Area) and combined it with Area 65 (Southeast Outside).
3. Required groundfish pots to be identified by some form of tag (regulatory amendment).

Amendment 23 implemented June 1, 1992:

Established allocations of pollock and Pacific cod for the inshore and offshore components of the GOA groundfish fishery. 90 percent of the Pacific cod TAC and 100 percent of the pollock TAC for each fishing year, is allocated to the inshore component of the groundfish fishery. Ten percent of the Pacific cod TAC, and an appropriate percentage of the pollock TAC for bycatch purposes, is allocated to the offshore component.

Amendment 24 implemented September 23, 1992:

1. Established hot spot authority in the GOA that parallels a revised hotspot in the BSAI management area.
2. Established time/area closures to reduce bycatch rates of prohibited species.
3. Expanded the Vessel Incentive Program to include all trawl fisheries in the GOA. The new incentive program includes chinook salmon as well as halibut (regulatory amendment).
4. Delayed opening of all trawl fisheries in the GOA until January 20. The opening date for non-trawl fisheries, including hook-and-line, pot and jigging, continues to be January 1. Delayed the GOA rockfish opening date by six months until the beginning of the third quarter (regulatory amendment).
5. Homogenized the fishery definitions for both the Vessel Incentive Program and the PSC allowance limits. The definitions of fisheries for these programs are: Mid-water pollock if pollock is greater than or equal to 95 percent of the total catch, and other target fisheries would be determined by the dominate species in terms of retained catch (regulatory amendment).

Amendment 25 implemented January 19, 1992:

1. Established three new districts in the combined Western and Central regulatory area for purposes of managing pollock, and rescinded the existing Shelikof Strait management district. The Western/Central regulatory area is divided into three districts by boundaries at 154° W. and 159° W longitudes.
2. Limit the maximum amount of any quarterly pollock TAC allowance that may be carried over to subsequent quarters to 150 percent of the initial quarterly allowance.
3. Prohibit trawling year round in the GOA within 10 nautical miles of 14 Steller sea lion rookeries.

Amendment 26 implemented December 17, 1992:

Reinstate King Crab Protective Zones around Kodiak Island on a permanent basis.

Amendment 27 implemented January 22, 1993:

Establish legal zones for trawl testing when fishing is otherwise prohibited.

Amendment 28 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 is to last until the Council replaces or rescinds the action, but is scheduled to sunset on December 31, 1998, unless the Council extends the moratorium.

Amendment 29 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 30 implemented October 6, 1994, superseded Amendment 18:

Implemented language changes to the FMP to indicate that observer requirements under the FMP are contained in the North Pacific Fisheries Research Plan.

Amendment 31 implemented October 18, 1993:

Created a separate target category for Atka mackerel in the FMP.

Amendment 32 implemented March 31, 1994:

Established a procedure for deriving the annual GOA TACs for Pacific Ocean perch. POP stocks are considered to be rebuilt when the total biomass of mature females is equal to, or greater than, BMSY.

Amendment 33 was not submitted.

Amendment 34 implemented September 23, 1994.

Corrected the inadvertent inclusion of the Community Development Quota (CDQ) program in the FMP by removing and reserving Section 4.4.1.1.8 on "Community Development Quotas".

Amendment 35 implemented November 7, 1994, revised Amendment 20:

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 36 implemented February 23, 1996, revised Amendment 20:

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

Amendment 37 implemented July 26, 1996, revised Amendment 20:

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

Amendment 38 implemented September 25, 1996, revised Amendment 32:

Revised the rebuilding plan formula for setting TAC for Pacific Ocean perch to allow the Council to recommend a POP TAC at or below the amount dictated by the formula.

Amendment 39 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 40 implemented January 1, 1996, superseded Amendment 23:

Extended provision of Amendment 23, inshore/offshore allocation.

Amendment 41, implemented January 1, 1999, except for some parts on January 1, 2000, replaces Amendment 28:

Created a license program for vessels targeting groundfish in the GOA, other than fixed gear sablefish that is pending regulatory implementation. The license program replaces the vessel moratorium and will last until the Council replaces or rescinds the action.

Amendment 42 implemented August 16, 1996, revised Amendment 20:

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 20:

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

Amendment 44 implemented January 9, 1997, revised Amendment 21:

Established a more conservative definition of overfishing.

Amendment 45 implemented May 30, 1996:

Authorized the combining of the third and fourth quarter seasonal allowances of pollock TAC for the combined Western/Central regulatory areas.

Amendment 46 implemented April 6, 1998:

Removed black and blue rockfishes from the FMP.

Amendment 47 was not submitted.

Amendment 48 was implemented December 8, 2004:

1. Revised the harvest specifications process.
2. Updated the FMP to reflect the 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 shallow water flatfish beginning January 1, 2003.

Amendment 50 implemented July 13, 1998, revised Amendment 29:

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 was partially implemented on January 20, 1999, superseded Amendment 40:

Extended the inshore/offshore allocation established with Amendment 23.

Amendment 52 was not submitted.

Amendment 53 was not submitted.

Amendment 54 implemented April 29, 2002, revised Amendment 20:

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 GOA groundfish and describes and identifies fishing and non-fishing threats to GOA 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 January 19, 1999, superseded Amendment 28:

Extended the vessel moratorium through December 31, 1999.

Amendment 58 implemented October 24, 2001 and January 1, 2002; superseded Amendment 57:

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 license limitation program (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 that 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 59 implemented December 11, 2000:

Prohibits vessels holding a Federal fisheries permit from fishing for groundfish or anchoring in the Sitka Pinnacles Marine Reserve.

Amendment 60 implemented December 27, 2002.

Prohibited bottom trawling in Cook Inlet.

Amendment 61 implemented January 21, 2000:

1. Conformed the FMP with the American Fisheries Act (AFA) of 1998 that established sideboard measures to protect non-AFA (non-pollock) fisheries from adverse impacts resulting from AFA.
2. Extended the inshore/offshore allocations for the GOA.

Amendment 62 was approved by the Council in October 2002, revised Amendment 61:

1. Changed single geographic location regulations for AFA stationary floating processors operating in the GOA.
2. Revised inshore/offshore language in light of the American Fisheries Act.
3. Removed the sunset date for inshore/offshore allocations for the GOA.

Amendment 63 implemented May 12, 2004:

Moved skates from the ‘other species’ category to the ‘target species’ category.

Amendment 64 implemented in August 28, 2003:

Changed recordkeeping and reporting requirements for the IFQ program.

Amendment 65 implemented July 28, 2006:

Identified specific sites as HAPCs for the GOA groundfish fisheries and established management measures to reduce potential adverse effects of fishing on HAPCs. Specifically, Amendment 65 establishes the following HAPCs: the Alaska Seamount Habitat Protection Areas (fourteen sites in the GOA management area listed in Appendix B) and three sites of GOA coral HAPCs (two on the Fairweather Grounds and one off Cape Ommaney) within which five smaller areas comprise the GOA Coral Habitat Protection Areas.

Amendment 66 implemented April 20, 2004:

Established a community quota share purchase program for the IFQ sablefish fishery.

Amendments 67-69 are not assigned.

Amendment 70 was not submitted.

Amendment 71 is unassigned.

Amendment 72 was approved by the Council in April 2003, revised Amendment 49:

1. Removed shallow water flatfish from the improved retention/improved utilization program.
2. Created an annual review for fisheries that exceed a discard rate of 5 percent of shallow water flatfish.

Amendment 73 implemented July 28, 2006, revised 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.

Amendment 74 implemented August 27, 2004, revised Amendment 15:

Revised the management policy and objectives.

Amendment 75 implemented June 13, 2005, revised Amendment 16:

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.

[this page intentionally left blank

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 two types: Gulf of Alaska (GOA) management area, regulatory areas, and districts (Section B.1), and closed areas (Section B.2).

B.1 Management Area, Regulatory Areas and Districts

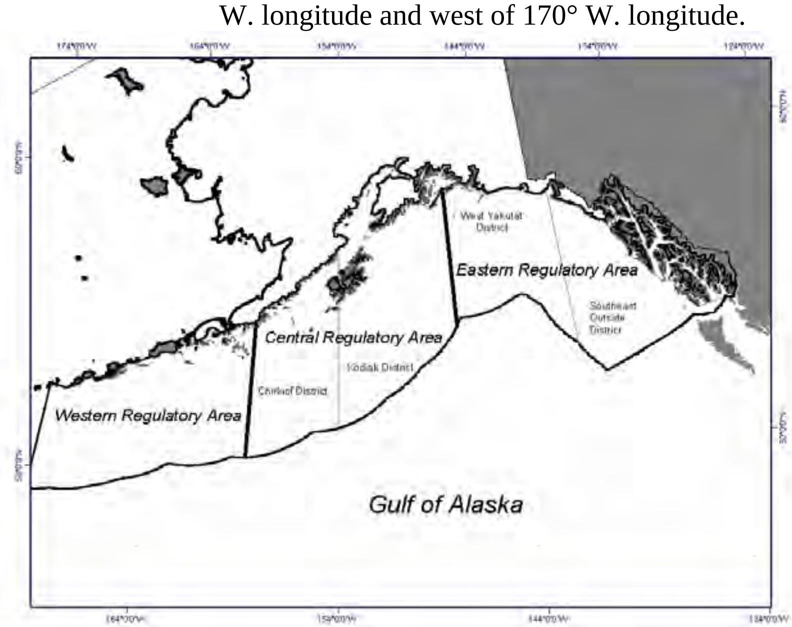
B.1.1 Management Area

The GOA management area encompasses the United States (U.S.) exclusive economic zone (EEZ) of the North Pacific Ocean, exclusive of the Bering Sea, between the eastern Aleutian Islands at 170° W. longitude and Dixon Entrance at 132°40' W. longitude.

B.1.2 Regulatory Areas

Three regulatory areas are described in Section 3.1 of the FMP and are defined as follows:

Eastern regulatory area:	that part of the GOA management area that is west of 147° W. longitude.
Central regulatory area:	that part of the GOA management area that is east of 147° W. longitude and west of 159° W. longitude.
Western regulatory area:	that part of the GOA management area that is east of 159° W. longitude and west of 170° W. longitude.



B.1.3 Districts

The Central regulatory area is divided into two districts, defined as follows:

Chirikof District:	that part of the Central regulatory area between 154° W. longitude and 159° W. longitude.
Kodiak District:	that part of the Central regulatory area between 147° W. longitude and 154° W. longitude.

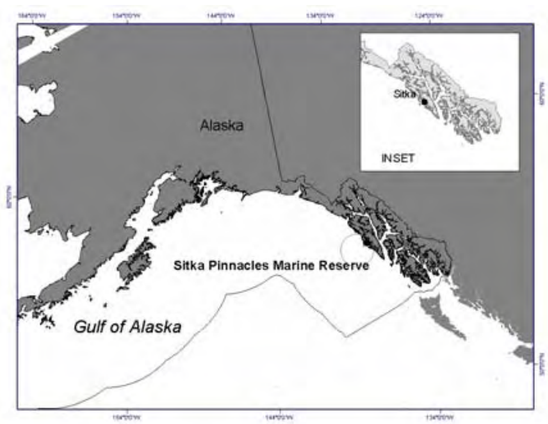
The Eastern regulatory area is divided into two districts, defined as follows:

West Yakutat District:	That part of the Eastern regulatory area between 140° W. longitude and 147° W. longitude.
Southeast Outside District:	That part of the Eastern regulatory area between 132°40' W. longitude and 140° W. longitude, and north of 54°30' N. latitude.

B.2 Closed Areas

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

B.2.1 Sitka Pinnacles Marine Reserve



The Sitka Pinnacles Marine Reserve encompasses an area totaling 2.5 square nautical miles off Cape Edgecumbe. Vessels holding a Federal fisheries permit are prohibited at all times from fishing for groundfish or anchoring in the Sitka Pinnacles Marine Reserve. The area is defined by straight lines connecting the following pairs of coordinates in a counter-clockwise manner:

(56°55.5' N., 135°54.0' W.)

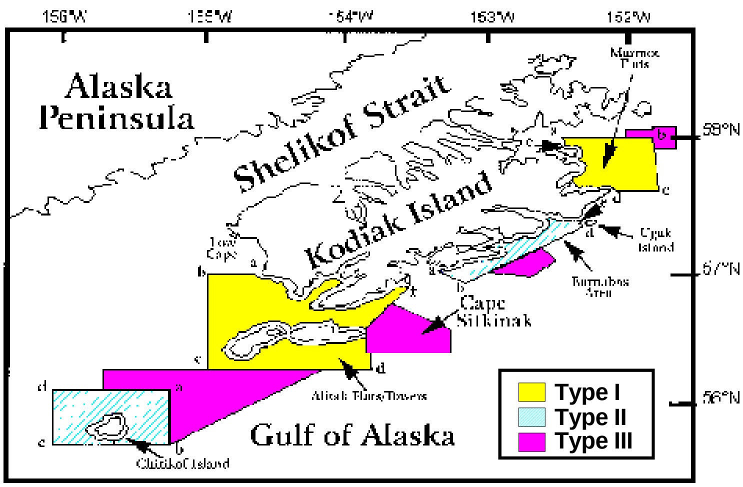
(56°57.0' N., 135°54.0' W.)

(56°57.0' N., 135°57.0' W.)

(56°55.5' N., 135°57.0' W.)

B.2.2 King Crab Closures around Kodiak Island

The reference points described in the Type I and II areas can be found on the Kodiak Island King Crab Closures figure below.



Type I Areas

Alitak Flats and Towers Areas: All waters of Alitak Flats and the Towers Areas enclosed by a line connecting the following 7 points in the order listed:

a	(56°59.4' N.,	154°31.1' W.)	Low Cape
b	(57°00.0' N.,	155°00.0' W.)	
c	(56°17.0' N.,	155°00.0' W.)	
d	(56°17.0' N.,	153°52.0' W.)	
e	(56°33.5' N.,	153°52.0' W.)	Cape Sitkinak
f	(56°54.5' N.,	153°32.5' W.)	East Point of Twoheaded Island
g	(56°56.0' N.,	153°35.5' W.)	Kodiak Island, then along coastline until
a	(56°59.4' N.,	154°31.1' W.)	Low Cape

Marmot Flats Area: All waters enclosed by a line connecting the following five points in the clockwise order listed:

a	(58°00.0' N.,	152°30.0' W.)	
b	(58°00.0' N.,	151°47.0' W.)	
c	(57°37.0' N.,	151°47.0' W.)	
d	(57°37.0' N.,	152°10.1' W.)	Cape Chiniak, then along the coastline of Kodiak Island
e	(57°54.5' N.,	152°30.0 W.)	North Cape
a	(58°00.0' N.,	152°30.0 W.)	

Type II Areas

Chirkof Island Area: All waters surrounding Chirkof Island enclosed by a line connecting the following four points in the counter-clock wise order listed:

a	(56°07' N.,	155°13' W.)
b	(56°07' N.,	156°00' W.)
c	(55°41' N.,	156°00' W.)
d	(55°41' N.,	155°13' W.)
a	(56°07' N.,	155°13' W.)

Barnabas Area: All waters enclosed by a line connecting the following six points in the counter clockwise order listed:

a	(57°00.0' N.	153°18.0' W.)	Black Point
b	(56°56.0' N.	153°09.0' W.)	
c	(57°22.0' N.	152°18.5' W.)	South Tip of Ugak Island
d	(57°23.5' N.	152°17.5' W.)	North Tip of Ugak Island
e	(57°25.3' N.	152°20.0' W.)	Narrow Cape, then along the coastline of Kodiak Island
f	(57°04.2' N.	153°30.0' W.)	Cape Kasick
a	(57°00.0' N.	153°18.0' W.)	Black Point, including inshore waters

Type III Areas

Outer Marmot Bay: All waters bounded by lines connecting the following coordinates in the order listed:

(58°00.0' N.,	151°55.4' W.)
(58°02.3' N.,	151°55.4' W.)
(58°02.3' N.,	151°47.0' W.)
(58°4.53' N.,	151°47.0' W.)
(58°4.53' N.,	151°35.25' W.)
(57°57.4' N.,	151°35.25' W.)
(57°57.4' N.,	151°47.0' W.)
(58°00.0' N.,	151°47.0' W.)
(58°00.0' N.,	151°55.4' W.)

Barnabas: All waters bounded by lines connecting the following coordinates in the order listed:

(57°14.3' N.,	152°37.5' W.)	
(57°10.0' N.,	152°25.3' W.)	
(57°02.32' N.,	152°35.02' W.),	then following the 3 mile limit to
(57°04.25' N.,	152°54.15' W.),	then following the 3 mile limit to
(57°14.3' N.,	152°37.5' W.)	

Horse's Head: All waters bounded by lines connecting the following coordinates in the order listed:

(56°49.55' N., 153°36.3' W.)

(56°34.35' N., 153°05.37' W.)

(56°28.35' N., 153°05.37' W.)

(56°28.35' N., 153°52.05' W.), then following the 3 mile limit to

(56°49.55' N., 153°36.3' W.)

Chirikof: All waters bounded by lines connecting the following coordinates in the order listed:

(56°16.45' N., 155°39.0' W.)

(56°16.45' N., 154°11.45' W.)

(55°41.0' N., 155°13.0' W.)

(56°07.1' N., 155°13.0' W.)

(56°07.1' N., 155°39.0' W.)

(56°16.45' N., 155°39.0' W.)

B.2.3 Cook Inlet non-Pelagic Trawl Closure Area

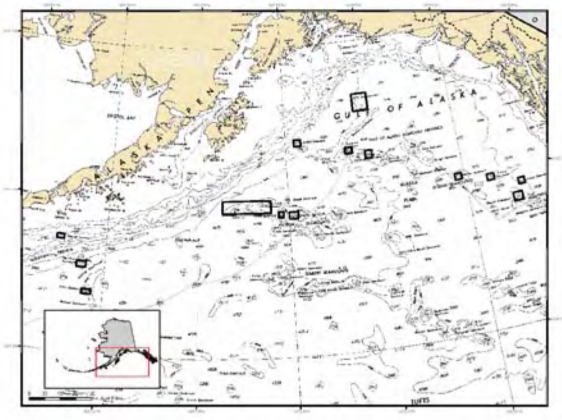
The use of non-pelagic trawl gear in Cook Inlet north of a line extending between Cape Douglas (58°51.10' N. latitude) and Point Adam (59°15.27' N. latitude) is prohibited.

B.2.4 Southeast Outside Trawl Closure

The use of trawl gear in Southeast Outside district (defined under Section B.1 above) is prohibited.

B.2.5 Alaska Seamount Habitat Protection Area (ASHPA)

Bottom contact gear fishing and anchoring is prohibited in the portion of the ASHPA located in the GOA. Coordinates for the ASHPA 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. Projected coordinate system is North American Datum 1983, Albers.

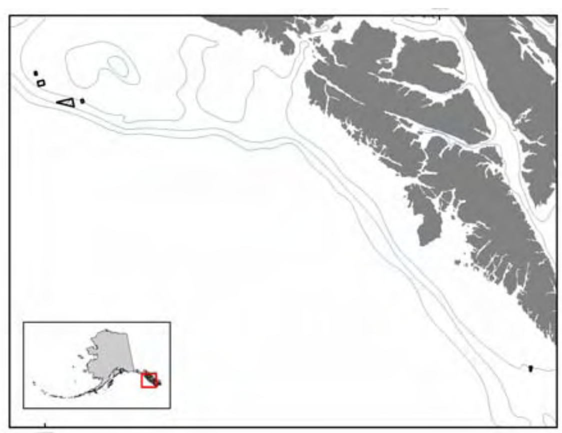


Area Number	Name	Latitude			Longitude		
1	Dickins Seamount	54	39.00	N	136	48.00	W
		54	39.00	N	137	9.00	W
		54	27.00	N	137	9.00	W
		54	27.00	N	136	48.00	W
2	Denson Seamount	54	13.20	N	137	6.00	W
		54	13.20	N	137	36.00	W
		53	57.00	N	137	36.00	W
		53	57.00	N	137	6.00	W
3	Brown Seamount	55	0.00	N	138	24.00	W
		55	0.00	N	138	48.00	W
		54	48.00	N	138	48.00	W
		54	48.00	N	138	24.00	W
4	Welker Seamount	55	13.80	N	140	9.60	W
		55	13.80	N	140	33.00	W
		55	1.80	N	140	33.00	W
		55	1.80	N	140	9.60	W
5	Dall Seamount	58	18.00	N	144	54.00	W
		58	18.00	N	145	48.00	W
		57	45.00	N	145	48.00	W
		57	45.00	N	144	54.00	W
6	Quinn Seamount	56	27.00	N	145	0.00	W
		56	27.00	N	145	24.00	W
		56	12.00	N	145	24.00	W
		56	12.00	N	145	0.00	W
7	Giacomini Seamount	56	37.20	N	146	7.20	W
		56	37.20	N	146	31.80	W
		56	25.20	N	146	31.80	W
		56	25.20	N	146	7.20	W

Area Number	Name	Latitude			Longitude		
8	Kodiak Seamount	57	0.00	N	149	6.00	W
		57	0.00	N	149	30.00	W
		56	48.00	N	149	30.00	W
		56	48.00	N	149	6.00	W
9	Odessey Seamount	54	42.00	N	149	30.00	W
		54	42.00	N	150	0.00	W
		54	30.00	N	150	0.00	W
		54	30.00	N	149	30.00	W
10	Patton Seamount	54	43.20	N	150	18.00	W
		54	43.20	N	150	36.00	W
		54	34.20	N	150	36.00	W
		54	34.20	N	150	18.00	W
11	Chirikof & Marchand Seamounts	55	6.00	N	151	0.00	W
		55	6.00	N	153	42.00	W
		54	42.00	N	153	42.00	W
		54	42.00	N	151	0.00	W
12	Sirius Seamount	52	6.00	N	160	36.00	W
		52	6.00	N	161	6.00	W
		51	57.00	N	161	6.00	W
		51	57.00	N	160	36.00	W
13	Derickson Seamount	53	0.00	N	161	0.00	W
		53	0.00	N	161	30.00	W
		52	48.00	N	161	30.00	W
		52	48.00	N	161	0.00	W
14	Unimak Seamount	53	48.00	N	162	18.00	W
		53	48.00	N	162	42.00	W
		53	39.00	N	162	42.00	W
		53	39.00	N	162	18.00	W

Gulf of Alaska Coral Habitat Protection Area

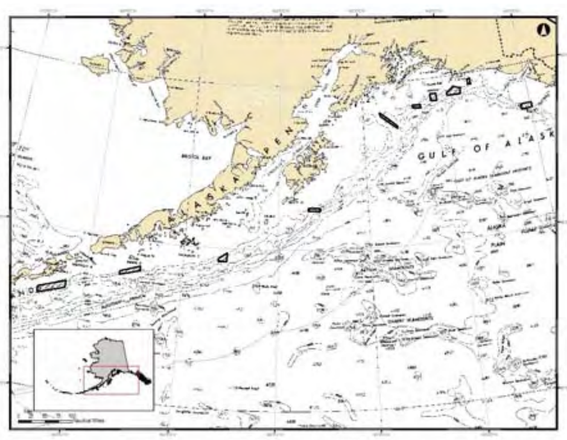
Bottom contact gear fishing and anchoring is prohibited in the Gulf of Alaska Coral Habitat Protection Area. Coordinates are listed in the table below. Note: Each area is delineated by connecting the coordinates in the order listed by straight lines. The last set of coordinates for each area is connected to the first set of coordinates for the area by a straight line. Projected coordinate system is North American Datum 1983, Albers.



Area number	Name		Latitude			Longitude	
1	Cape Ommaney 1	56	10.85	N	135	5.83	W
		56	11.18	N	135	7.17	W
		56	9.53	N	135	7.68	W
		56	9.52	N	135	7.20	W
2	Fairweather FS2	58	15.00	N	138	52.58	W
		58	15.00	N	138	54.08	W
		58	13.92	N	138	54.08	W
		58	13.92	N	138	52.58	W
3	Fairweather FS1	58	16.00	N	138	59.25	W
		58	16.00	N	139	9.75	W
		58	13.17	N	138	59.25	W
4	Fairweather FN2	58	24.10	N	139	14.58	W
		58	24.10	N	139	18.50	W
		58	22.55	N	139	18.50	W
		58	22.55	N	139	14.58	W
5	Fairweather FN1	58	27.42	N	139	17.75	W
		58	27.42	N	139	19.08	W
		58	26.32	N	139	19.08	W
		58	26.32	N	139	17.75	W

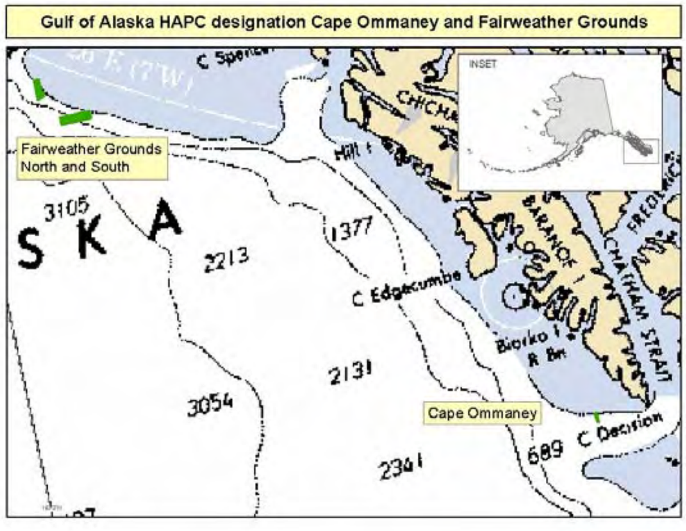
Gulf of Alaska Slope Habitat Conservation Area

Nonpelagic trawl gear fishing is prohibited in the Gulf of Alaska Slope Habitat Conservation Area. Coordinates 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. Projected coordinate system is North American Datum 1983, Albers.



Area Number	Name	Latitude			Longitude		
1	Yakutat	58	47.00	N	139	55.00	W
		58	47.00	N	140	32.00	W
		58	37.00	N	140	32.00	W
		58	36.97	N	139	54.99	W
2	Cape Suckling	59	50.00	N	143	20.00	W
		59	50.00	N	143	30.00	W
		59	40.00	N	143	30.00	W
		59	40.00	N	143	20.00	W
3	Kayak I.	59	35.00	N	144	0.00	W
		59	40.00	N	144	25.00	W
		59	30.00	N	144	50.00	W
		59	25.00	N	144	50.00	W
		59	25.00	N	144	2.00	W
4	Middleton I. east	59	32.31	N	145	29.09	W
		59	32.13	N	145	51.14	W
		59	20.00	N	145	51.00	W
		59	18.85	N	145	29.39	W
5	Middleton I. west	59	14.64	N	146	29.63	W
		59	15.00	N	147	0.00	W
		59	10.00	N	147	0.00	W
		59	8.74	N	146	30.16	W
6	Cable	58	40.00	N	148	0.00	W
		59	6.28	N	149	0.28	W
		59	0.00	N	149	0.00	W
		58	34.91	N	147	59.85	W
7	Albatross Bank	56	16.00	N	152	40.00	W
		56	16.00	N	153	20.00	W
		56	11.00	N	153	20.00	W
		56	10.00	N	152	40.00	W
8	Shumagin I.	54	51.49	N	157	42.52	W
		54	40.00	N	158	10.00	W
		54	35.00	N	158	10.00	W
		54	36.00	N	157	42.00	W
9	Sanak I.	54	12.86	N	162	13.54	W
		54	0.00	N	163	15.00	W
		53	53.00	N	163	15.00	W
		54	5.00	N	162	12.00	W
10	Unalaska I.	53	26.05	N	165	55.55	W
		53	6.92	N	167	19.40	W
		52	55.71	N	167	18.20	W
		53	13.05	N	165	55.55	W

Gulf of Alaska Coral Habitat Areas of Particular Concern



The coordinates for the Gulf of Alaska Coral Habitat Areas of Particular Concern are listed in the table below.

HAPC	Latitude	Longitude
Cape Ommaney	56° 12' 51" N	135° 07' 41" W
	56° 12' 51" N	135° 05' 30" W
	56° 09' 32" N	135° 05' 30" W
	56° 09' 32" N	135° 07' 41" W
Fairweather Ground	58° 28' 10" N	139° 19' 44" W
NW Area	58° 28' 10" N	139° 15' 42" W
	58° 22' 00" N	139° 15' 42" W
	58° 22' 00" N	139° 19' 44" W
Fairweather Ground	58° 16' 00" N	139° 09' 45" W
Southern Area	58° 16' 00" N	138° 51' 34" W
	58° 13' 10" N	138° 51' 34" W
	58° 13' 10" N	139° 09' 45" W

Appendix C Section 211 of the American Fisheries Act

C.1 American Fisheries Act, Section 211

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.*

Appendix D Life History Features and Habitat Requirements of Fishery Management Plan Species

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

GOA Groundfish – Nearshore, Shelf, Slope

Species	Life Stage	Nearshore: Freshwater	Nearshore: Estuarine	Nearshore: Intertidal	Nearshore: Subtidal	Shelf: Inner 1-50m	Shelf: Middle 51-100m	Shelf: Outer 101-200m	Slope: Upper 201-300m	Slope: Upper 301-500m	Slope: Intermediate 501-700m	Slope: Intermediate 701-1000m	Slope: Lower 1001-3000m	Slope: Basin >3000m
Walleye Pollock	M						x	x	x	x				x
	J					x	x	x						
	L						x	x						
	E						x	x	x	x	x	x	x	x
Pacific Cod	M					x	x	x	x	x				
	LJ					x	x							
	EJ				x	x								
	L					x	x	x						
	E					x	x	x						
Atka Mackerel	M					x	x	x						
	J													
	L													
	E					x								
Sablefish	M								x	x	x	x	x	
	LJ							x	x	x	x			
	EJ					x	x	x						
	L						x	x	x	x	x	x	x	x
	E								x	x	x	x	x	x
Pacific Ocean Perch	M							x	x	x				
	LJ					x	x	x	x					
	EJ					x	x	x					x	x
	L													
Flathead Sole	M					x	x	x	x					
	LJ					x	x	x						
	EJ					x	x							
	L					x	x	x						
	E					x	x	x						
Yellowfin Sole	M					x	x							
	LJ					x	x							
	EJ					x								
	L					x	x							
	E					x	x							
Arrowtooth Flounder	M					x	x	x	x	x	x			
	LJ					x	x	x						
	EJ					x	x							
	L					x	x	x	x	x				
	E					x	x	x	x	x				
Rock Sole	M					x	x	x						
	LJ					x	x							
	EJ					x								
	L					x	x	x						
	E					x	x	x						
Dover Sole	M					x	x	x	x	x	x	x		
	LJ					x	x	x	x	x				
	EJ					x	x							
	L					x	x	x	x	x				
	E					x	x	x	x	x				
Rex Sole	M					x	x	x	x	x				
	LJ					x	x	x	x					
	EJ					x	x							
	L					x	x	x	x					
	E					x	x	x	x					

Stratum Reference, Location, Physical Oceanography

Species	Life Stage	Shallows	Island Pass	Bay/Fjord	Bank	Flat	Edge	Gully	Surfcae	Near surface	Semi-demersal	Demersal	Pelagic: 1-200m (epi)	Pelagic: 201-1000m (meso)	Pelagic: >1000m (bathy)	Upwelling areas	Gyres	Thermo/pycnocline	Fronts	Edges (ice, bath)
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
	L		x	x	x	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	
Pacific Cod	M	x	x	x	x	x	x					x								
	LJ	x	x	x	x	x	x					x								
	EJ	x		x							x	x								
	L												x							
	E											x								
Atka Mackerel	M		x							x	x					x			x	x
	J																			
	L								x	x										
	E		x									x								
Sablefish	M			x				x				x				x				
	LJ			x				x				x				x				
	EJ			x								x	x	x		x				
	L								x	x						x				
	E												x	x		x				
Pacific Ocean Perch	M				x	x	x	x			x	x	x			x				
	LJ																			
	EJ										x	x	x	x	x	x				
	L									x	x		x	x		x				
Flathead Sole	M											x								x
	LJ											x								
	EJ											x								
	L												x					x		
	E												x							
Yellowfin Sole	M											x								
	LJ											x								
	EJ											x								
	L												x							
	E												x							
Arrowtooth Flounder	M											x								
	LJ											x								
	EJ											x								
	L												x					x		
	E											x								
Rock Sole	M											x								
	LJ											x								
	EJ											x								
	L												x					x		
	E											x								
Dover Sole	M											x								
	LJ											x								
	EJ											x								
	L												x					x		
	E												x							
Rex Sole	M											x								
	LJ											x								
	EJ											x								
	L												x							
	E												x							

Substrate

Species	Life Stage	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	
	J		x	x	x	x	x	x	x	x	x	x	x	
	L		x	x	x	x	x	x	x	x	x	x	x	
	E													
Pacific Cod	M		x	x	x	x	x	x	x	x	x	x	x	x
	LJ		x	x	x	x	x	x	x	x	x	x	x	x
	EJ		x	x	x	x	x	x	x	x	x	x		
	L													
	E		x	x	x	x	x	x	x	x	x	x	x	x
Atka Mackerel	M			x	x									x
	J													
	L													
	E				x									x
Sablefish	M		x	x	x								x	x
	LJ		x	x	x								x	x
	EJ													
	L													
	E													
Pacific Ocean Perch	M				x								x	x
	LJ													
	EJ				x								x	x
	L													
Flathead Sole	M		x	x	x			x		x				
	LJ		x	x	x			x		x				
	EJ			x	x									
	L							x						
	E													
Yellowfin Sole	M		x	x				x						
	LJ		x	x				x						
	EJ		x	x				x						
	L													
	E													
Arrowtooth Flounder	M		x	x	x			x						
	LJ		x	x	x			x						
	EJ		x	x	x			x						
	L													
	E													
Rock Sole	M		x	x				x						
	LJ		x	x				x						
	EJ		x	x				x						
	L													
	E													
Dover Sole	M		x	x			x							
	LJ		x	x			x							
	EJ		x	x			x							
	L													
	E													
Rex Sole	M		x	x				x						
	LJ		x	x				x						
	EJ		x	x				x						
	L		x	x										
	E													

Structure, Community Associations, Oceanographic Properties

Species	Life Stage	Bars	Sinks	Slumps\Rockfalls\Debris	Channels	Ledges	Pinnacles	Seamount	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				x	x			x				x	x	x	x	x					x	x				M
	LJ				x	x			x				x	x	x	x	x					x	x				LJ
	EJ											x	x	x			x		x								EJ
	L																										L
	E																							3-6	13-23	2-3	E
Atka Mackerel	M								x										x					3-5	>17		M
	J																							3-5			J
	L																							2-12			L
	E																		x					3-20			E
Sablefish	M							x																			M
	LJ																										LJ
	EJ																										EJ
	L																										L
	E																										E
Pacific Ocean Perch	M														x												M
	LJ																										LJ
	EJ																										EJ
	L																										L
Flathead Sole	M																										M
	LJ																										LJ
	EJ																										EJ
	L																										L
	E																										E
Yellowfin Sole	M																										M
	LJ																										LJ
	EJ																										EJ
	L																										L
	E																										E
Arrowtooth Flounder	M																										M
	LJ																										LJ
	EJ																										EJ
	L																										L
	E																										E
Rock Sole	M																										M
	LJ																										LJ
	EJ																										EJ
	L																										L
	E																										E
Dover Sole	M																										M
	LJ																										LJ
	EJ																										EJ
	L																										L
	E																										E
Rex Sole	M																										M
	LJ																										LJ
	EJ																										EJ
	L																										L
	E																										E

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

GOA Groundfish		Nearshore				Shelf			Slope						Stratum Reference							Location							Physical Oceanography					Substrate													Structure										Community Associations												Oceanographic Properties			
						Inner	Middle	Outer	Upper		Inter-mediate		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	Seamount	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
Greenland Turbot	M							x	x	x	x														x										x	x	x		x																																	M
	LJ					x	x																		x										x	x			x																																	LJ
	EJ																								x										x	x			x																																	EJ
	L					x	x	x	x	x																x					x																																									L
	E					x	x	x	x	x																x																																														E
Yelloweye Rockfish	M					x	x	x	x	x						x	x								x											x									x	x						x			x																		M
	LJ					x	x	x								x	x								x																					x																											LJ
	EJ					x	x	x								x	x								x																					x						x			x																		EJ
	L																																																																								L
	E																																																																									E
Shortraker/Rougheye Rockfish	M								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																																																	EJ
	L																										x																																														L
Northern Rockfish	M						x	x										x							x																				x	x																											M
	LJ						x	x										x	x						x																																																	LJ
	EJ																									x																																															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
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
Sculpins	M			x	x	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x			x	x																												x																					M
	LJ																																																																									LJ
	EJ																																																																									EJ
	L																																																																									L
	E																																																																									E
Skates	M			x	x	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x			x	x																																																	M
	LJ																																																																									LJ
	EJ																																																																										EJ
	L																																																																									L
	E																																																																									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																																															M
	LJ																																																																									LJ
	EJ																																																																									EJ
	L																																																																									L
	E																																																																									E
Squid	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																					M
	LJ																																																																									LJ
	EJ																																																																									EJ
	L																																																																									L
	E																																																																									E

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

GOA Groundfish		Nearshore				Shelf			Slope						Stratum Reference						
						Inner	Middle	Outer	Upper		Inter-mediate		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
Octopus	M			x	x	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x
	LJ																				
	EJ																				
	L																				
	E																				
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						
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				

GOA 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
Octopus	M				x	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																									

GOA Groundfish		Structure										Community Associations												Oceanographic Properties			
Species	Life Stage	Bars	Sinks	Slumps\Rockfalls\Debris	Channels	Ledges	Pinnacles	Seamount	Reefs	Vertical Walls	Man-made	Algal Cover	Anenomes	Enchinoderms	Soft Coral	Hard Coral	Mollusca	Drift Algae\Kelp	Kelp	Polychaetes	Sea Grasses	Sea Onions	Tunicates	Temperature (Celsius)	Salinity (ppt)	Oxygen Conc (ppm)	Life Stage
Octopus	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 GOA groundfish.

GOA Groundfish		Reproductive Traits																										
		Age at Maturity (unless otherwise noted)				Fertilization/Egg Development					Spawning Behavior						Spawning Season											
		Female		Male																								
Species	Life Stage	50%	100%	50%	100%	External	Internal	Oviparous	Ovoviviparous	Viviparous	Batch Spawner	Broadcast Spawner	Egg Case Deposition	Nest Builder	Egg/Young Guarder	Egg/Young Bearer	January	February	March	April	May	June	July	August	September	October	November	December
Walleye Pollock	M	4-5		4-5		x						x						x	x	x	x							
Pacific Cod	M	5		5		x						x					x	x	x	x	x							
Atka Mackerel	M	3.6		3.6		x								x	x						x	x	x	x	x	x		
Sablefish	M	65cm		67cm		x						x					x	x	x	x	x							
Pacific Ocean Perch	M	10.5					x			x	x														x	x	x	x
Flathead Sole	M	10				x											x	x	x	x								x
Yellowfin Sole	M	10.5				x					x										x	x	x					
Arrowtooth Flounder	M	5		4		x											x	x	x	x							x	x
Rock Sole	M	9				x					x						x	x	x									
Rex Sole	M	24cm		16cm		x												x	x	x	x	x	x					
Greenland Turbot	M	5-10				x											x	x	x							x	x	x
Dover Sole	M	33cm				x											x	x	x	x	x	x	x	x				
Yelloweye Rockfish	M	22							x											x	x	x	x					
Shortraker/Rougheye Rockfish	M	20+					x			x	x												x	x	x	x	x	x
Northern Rockfish	M	13					x			x	x																	
Thornyhead Rockfish	M	12									x							x				x						
Dusky Rockfish	M	11					x			x	x																	
Sculpins	M					x									x													
Skates	M						x	x					x															
Sharks	M						x	x	x	x			x			x												
Squid	M						x				x																	
Octopus	M						x				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 reproductive traits for GOA groundfish.

GOA Groundfish — Predator to

Species	Life Stage	Algae	Plants	Plankton	Zooplankton	Diatoms	Sponges	Eusphausiid	Hydroids	Amphipoda	Copepods	Starfish	Polychaetes	Squid	Philodae (gunnels)	Bi-valves	Mollusks	Crustaceans	Ophiuroids (brittle stars)	Shrimps, mysidacae	Sand lance	Osmerid (eulachon)	Herring	Myctophid (lantern fishes)	Cottidae (sculpins)	Arrowtooth	Rockfish	Salmon	Pacific cod	Pollock	Halibut
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	
	LJ							X		X			X							X										X	
	EJ							X		X			X							X											
	L			X	X						X																				
	E																														
Atka Mackerel	M							X			X													X							
	J							X			X																				
	L										X																				
	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																														
Pacifc Ocean Perch	M							X																							
	LJ							X			X																				
	EJ																														
	L			X	X																										
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																														
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																														
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																														
Rock Sole	M									X			X			X	X														
	LJ									X			X			X	X														
	EJ				X																										
	L	X		X																											
	E																														

GOA Groundfish — Prey of

Species	Life Stage	Jellyfish	Starfish	Chaetognaths (arrowworms)	Crab	Herring	Salmon	Pollock	Pacific cod	Ling cod	Rockfish	Rock Sole	Flathead Sole	Yellowfin sole	Arrowtooth flounder	Hailbut	Salmon Shark	Northern Fur Seal	Harbor Seal	Steller sea lion	Dalls Porpoise	Beluga whale	Killer Whale	Minke whale	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						
	EJ															X	X	X				X	X	X			X			
	L																													
	E																													
Atka Mackerel	M								X						X	X			X	X	X			X						
	J																			X						X	X			
	L																													
	E																													
Sablefish	M																													
	LJ						X									X														
	EJ																													
	L																													
	E																													
Pacifc Ocean Perch	M															X														
	LJ																													
	EJ						X																							
	L																													
Flathead Sole	M								X				X		X	X														
	LJ																													
	EJ																													
	L																													
	E																													
Yellowfin Sole	M																													
	LJ								X							X														
	EJ								X							X														
	L																													
	E																													
Arrowtooth Flounder	M																													
	LJ							X	X																					
	EJ																													
	L																													
	E																													
Rock Sole	M																													
	LJ							X	X					X		X														
	EJ																													
	L																													
	E																													

Table D.3 Summary of reproductive traits for GOA groundfish (continued).

Predator to

GOA 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
Dover Sole	M												X				X	X													
	LJ												X				X	X													
	EJ																														
	L	X		X																											
	E																														
Rex Sole	M							X		X			X					X													
	LJ							X		X			X					X													
	EJ																														
	L	X		X																											
	E																														
Greenland Turbot	M												X					X	X	X			X	X						X	
	LJ																														
	EJ				X																										
	L	X		X																											
	E																														
Yelloweye Rockfish	M																	X		X	X		X				X				
	LJ																														
	EJ										X																				
	L																														
	E																														
Shortraker/Rougheye Rockfish	M													X						X				X							
	LJ																														
	EJ																														
	L																														
Northern Rockfish	M							X			X																				
	LJ																														
	EJ																														
	L																														
Thornyhead Rockfish	M																			X					X						
	LJ																														
	EJ																														
	L																														
	E																														
Light Dusky Rockfish	M							X																							
	LJ																														
	EJ																														
	L																														
Sculpins	M				X			X	X	X	X	X	X		X	X	X	X	X	X	X	X	X		X	X			X	X	
	LJ																														
	EJ																														
	L																														
	E																														

Prey of

GOA 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	Eagles	Murres	Puffin	Kittiwake	Gull	Terrestrial Mammals
Dover Sole	M								X						X															
	LJ								X						X															
	EJ																													
	L																													
	E																													
Rex Sole	M								X						X															
	LJ								X						X															
	EJ																													
	L																													
	E																													
Greenland Turbot	M																													
	LJ																													
	EJ							X	X					X																
	L																													
	E																													
Yelloweye Rockfish	M						X			X	X					X														
	LJ																													
	EJ																													
	L																													
	E																													
Shortraker/Rougheye Rockfish	M																													
	LJ																													
	EJ																													
	L																													
Northern Rockfish	M																													
	LJ																													
	EJ																													
	L																													
Thornyhead Rockfish	M																													
	LJ																													
	EJ																													
	L																													
	E																													
Light Dusky Rockfish	M																													
	LJ																													
	EJ																													
	L																													
Sculpins	M							X	X		X	X	X		X	X	X	X	X	X	X									
	LJ																													
	EJ																													
	L																													
	E																													

Table D.3 Summary of reproductive traits for GOA groundfish (continued).

Predator to

GOA 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
Skates	M								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																														
Sharks	M						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																														
Squid	M							X			X										X	X	X	X							
	LJ																														
	EJ																														
	L																														
	E																														
Octopus	M															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

GOA 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	Eagles	Murres	Puffin	Kittiwake	Gull	Terrerstrial Mammals
Skates	M																		X											
	LJ																													
	EJ																													
	L																													
	E																													
Sharks	M															X														
	LJ																													
	EJ																													
	L																													
	E																													
Squid	M	X						X	X	X	X					X	X	X	X	X	X		X	X		X	X	X	X	
	LJ																													
	EJ																													
	L																													
	E																													
Octopus	M							X	X	X	X					X	X	X	X	X										
	LJ																													
	EJ																													
	L																													
	E																													
Eulachon	M						X	X	X							X		X	X	X	X					X	X			X
	LJ						X	X	X							X		X	X	X	X					X	X			
	EJ					X	X	X	X							X														
	L					X	X	X	X							X														
	E																													
Capelin	M						X	X	X						X	X		X	X	X	X					X	X			
	LJ						X	X	X						X	X		X	X	X	X					X	X			
	EJ					X	X	X	X						X	X														
	L					X	X	X	X						X	X														
	E																													
Sand Lance	M						X	X	X						X	X		X	X	X	X					X	X			
	LJ						X	X	X						X	X		X	X	X	X					X	X			
	EJ					X	X	X	X						X	X														
	L					X	X	X	X						X	X														
	E																													

D.1 Walleye pollock (Theragra calcogramma)

The Gulf of Alaska (GOA) pollock stocks are managed under the GOA Groundfish Fisheries Management Plan, and the eastern Bering Sea (EBS) and AI pollock stocks are managed under the EBS and AI Groundfish Fisheries Management Plan. Pollock occur throughout the area covered by the FMP and straddle into the Canadian and Russian U.S. Exclusive Economic Zone (EEZ), international waters of the central BS, and into the Chukchi Sea.

D.1.1 Life History and General Distribution

Pollock is the most abundant species within the EBS comprising 75 to 80 percent of the catch and 60 percent of the biomass. In the GOA, pollock is the second most abundant groundfish stock comprising 25 to 50 percent of the catch and 20 percent of the biomass.

Four stocks of pollock are recognized for management purposes: GOA, EBS, AI, and Aleutian Basin. There appears to be a high degree of interrelationship among the EBS, AI, and Aleutian Basin stocks with suggestions of movement from one area to the others. There appears to be stock separation between the GOA stocks and stocks to the north.

The most abundant stock of pollock is the EBS stock, which is primarily distributed over the EBS outer continental shelf between approximately 70 to 200 m. Information on pollock distribution in the EBS comes from commercial fishing locations, annual bottom trawl surveys, and triennial acoustic surveys.

The AI stock extends through the AI from 170 W to the end of the AI (Attu Island), with the greatest abundance in the eastern Aleutians (170 W to Seguam Pass). Most of the information on pollock distribution in the AI comes from triennial bottom trawl surveys. These surveys indicate that pollock are primarily located on the BS side of the AI, and have a spotty distribution throughout the AI chain. The bottom trawl data may not provide an accurate view of pollock distribution because a significant portion of the pollock biomass is likely to be unavailable to bottom trawls. Also, many areas of the AI shelf are untrawlable due to rough bottom.

The third stock, Aleutian Basin, appears to be distributed throughout the Aleutian Basin which encompasses the EEZ, Russian EEZ, and international waters in the central BS. This stock appears to move throughout the Basin for feeding, but concentrate in deepwater near the continental shelf for spawning. The principal spawning location is near Bogoslof Island in the eastern AI, but data from pollock fisheries in the first quarter of the year indicate that there are other concentrations of deepwater spawning concentrations in the western AI. The Aleutian Basin spawning stock appears to be derived from migrants from the EBS shelf stock, and possibly some western BS pollock. Recruitment to the stock occurs generally around age 5; very few pollock younger than age 5 have been found in the Aleutian Basin. Most of the pollock in the Aleutian Basin appear to originate from strong year classes.

The GOA stock extends from southeast Alaska to the AI (170 W), with the greatest abundance in the western and central regulatory areas (147 W to 170 W). Most of the information on pollock distribution in the GOA comes from triennial bottom trawl surveys. These surveys indicate that pollock are distributed throughout the shelf regions of the GOA at depths less than 300 m. The bottom trawl data may not provide an accurate view of pollock distribution because a significant portion of the pollock biomass may be pelagic and not available to bottom trawls. The principal spawning location is in Shelikof Strait, but data from pollock fisheries and exploratory surveys indicate that there are other concentrations of spawning in the Shumagin Islands, the east side of Kodiak Island and near Prince William Sound.

Peak pollock spawning occurs on the southeastern BS and eastern AI along the outer continental shelf around mid-March. North of the Pribilof Islands, spawning occurs later (April to May) in smaller spawning aggregations. The deep spawning pollock of the Aleutian Basin appear to spawn slightly earlier, late February to early March. In the GOA, peak spawning occurs in late March in Shelikof Strait. Peak spawning in the Shumagin area appears 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 BS shelf, 150 to 200 m in Shelikof Strait). Development is dependent on water temperature. In the BS, eggs take about 17 to 20 days to develop at 4 degrees (º) in the Bogoslof area and 25.5 days at 2º on the shelf. In the GOA, development takes approximately 2 weeks at ambient temperature (5ºC). Larvae are also distributed in the upper water column. In the BS, 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 (~25 millimeters [mm] standard length). In the GOA, larvae are distributed in the upper 40 m of the water column and the diet is similar to BS larvae. FOCI 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 EBS both in the water column and on bottom. 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 ages 2-3, pollock are primarily pelagic and then appear to be most abundant on the outer and mid-shelf northwest of the Pribilof Islands. As pollock reach maturity (age 4) in the BS, 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 centimeters (cm).

The upper size limit for juvenile pollock in the EBS and GOA 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 Fishery

The EBS pollock fishery has, since 1990, been divided into two fishing periods; an "A season" occurring in January-March, and a "B season" occurring in August-October. The A season concentrates fishing effort on prespawning pollock in the southeastern BS. During the B season fishing is still primarily in the southeastern BS, but some fishing also occurs on the northwestern shelf. Also during the B season, catcher processor vessels are required to fish north of lat. 56 N because the area to the south is reserved for catcher vessels delivering to shoreside processing plants on Unalaska and Akutan.

Since 1992, the GOA pollock total allowable catch (TAC) has been apportioned spatially and temporally to reduce impacts on Steller sea lions. Although the details of the apportionment scheme have evolved over time, the general objective is to allocate the TAC to management areas based on the distribution of surveyed biomass and to establish three or four seasons between mid-January and autumn during which some fraction of the TAC can be taken. The Steller Sea Lion Protection Measures implemented in 2001 establish four seasons in the Central and Western GOA beginning January 20, March 10, August 25, and October 1, with 25 percent of the total TAC allocated to each season. Allocations to management areas 610, 620, and 630 are based on the seasonal biomass distribution as estimated by groundfish surveys. In addition, a new harvest control rule was implemented that requires a cessation of fishing when spawning biomass declines below 20 percent of unfished stock biomass.

In the GOA, approximately 90 percent of the pollock catch is taken using pelagic trawls. During winter, fishing effort usually targeted primarily on pre-spawning aggregations in Shelikof Strait and near the Shumagin Islands. The pollock fishery has a very low bycatch rate with discards averaging about 2 percent since 1998 (with the 1991-1997 average around 9 percent). Most of the discards in the pollock fishery are juvenile pollock, or pollock too large to fit filleting machines. In the pelagic trawl fishery, the catch is almost exclusively pollock.

The EBS pollock fishery primarily harvests mature pollock. The age where fish are selected by the fishery roughly corresponds to the age at maturity (management guidelines are oriented towards conserving spawning biomass). Fishery selectivity increases to a maximum around age 6-8 and declines slightly. The reduced selectivity for older ages is due to pollock becoming increasingly demersal with age. Younger pollock form large schools and are semi-demersal, thereby being easier to locate by fishing vessels. Immature fish (ages 2 and 3) are usually caught in low numbers. Generally the catch of immature pollock increases when strong year-classes occur and the abundance of juveniles increase sharply. This occurred with the 1989 year-class, the second largest year-class on record. Juvenile bycatch increased sharply in 1991 and 1992 when this year-class was age 2 and 3. A secondary problem is that strong to moderate year-classes may reside in the Russian EEZ adjacent to the EEZ as juveniles. Russian catch-age data and anecdotal information suggest that juveniles may comprise a major portion of the catch. There is a potential for the Russian fishery to reduce subsequent abundance in the U.S. fishery.

The GOA pollock fishery also targets mature pollock. Fishery selectivity increases to a maximum around age 5-7 and then declines. In both the EBS and GOA, the selectivity pattern varies between years due to shifts in fishing strategy and changes in the availability of different age groups over time.

In response to continuing concerns over the possible impacts groundfish fisheries may have on rebuilding populations of Steller sea lions, NMFS and the North Pacific Fishery Management Council (Council) have made changes to the Atka mackerel (mackerel) and pollock fisheries in the Bering Sea/Aleutian Islands (BSAI) and GOA. These have been designed to reduce the possibility of competitive interactions with Steller sea lions. For the pollock fisheries, comparisons of seasonal fishery catch and pollock biomass distributions (from surveys) by area in the EBS led to the conclusion that the pollock fishery had disproportionately high seasonal harvest rates within critical habitat which could lead to reduced sea lion prey densities. Consequently, the management measures were designed to redistribute the fishery both temporally and spatially according to pollock biomass distributions. The underlying assumption in this approach was that the independently derived area-wide and annual exploitation rate for pollock would not reduce local prey densities for sea lions. Here NMFS examines the temporal and spatial dispersion of the fishery to evaluate the potential effectiveness of the measures.

Three types of measures were implemented in the pollock fisheries:

- Additional pollock fishery exclusion zones around sea lion rookery or haulout sites
- Phased-in reductions in the seasonal proportions of TAC that can be taken from critical habitat
- Additional seasonal TAC releases to disperse the fishery in time

Prior to the management measures, the pollock fishery occurred in each of the three major fishery management regions of the North Pacific ocean managed by the Council: the AI (1,001,780 square kilometer [km2] inside the EEZ), the EBS (968,600 km2), and the GOA (1,156,100 km2). The marine portion of Steller sea lion critical habitat in Alaska west of 150ºW encompasses 386,770 km2 of ocean surface, or 12 percent of the fishery management regions.

Prior to 1999, a total of 84,100 km2, or 22 percent of critical habitat, was closed to the pollock fishery. Most of this closure consisted of the 10 and 20 nm radius all-trawl fishery exclusion zones around sea lion rookeries (48,920 km2 or 13 percent of critical habitat). The remainder was largely management area 518 (35,180 km2, or 9 percent of critical habitat) which was closed pursuant to an international agreement to protect spawning stocks of central BS pollock.

In 1999, an additional 83,080 km2 (21 percent) of critical habitat in the AI was closed to pollock fishing along with 43,170 km2 (11 percent) around sea lion haulouts in the GOA and EBS. Consequently, a total of 210,350 km2 (54 percent) of critical habitat was closed to the pollock fishery. The portion of critical habitat that remained open to the pollock fishery consisted primarily of the area between 10 and 20 nm from rookeries and haulouts in the GOA and parts of the EBS foraging area.

The BSAI pollock fishery was also subject to changes in total catch and catch distribution. Disentangling the specific changes in the temporal and spatial dispersion of the EBS pollock fishery resulting from the sea lion management measures from those resulting from implementation of the 1999 American Fisheries Act (AFA) is difficult. The AFA reduced the capacity of the catcher/processor fleet and permitted the formation of cooperatives in each industry sector by 2000. Both of these changes would be expected to reduce the rate at which the catcher/processor sector (allocated 36 percent of the EBS pollock TAC) caught pollock beginning in 1999, and the fleet as a whole in 2000. Because of some of its provisions, the AFA gave the industry the ability to respond efficiently to changes mandated for sea lion conservation that otherwise could have been more disruptive to the industry.

In 2000, further reductions in seasonal pollock catches from BSAI sea lion critical habitat were realized by closing the entire AI region to pollock fishing and by phased-in reductions in the proportions of seasonal TAC that could be caught from the Sea Lion Conservation Area, an area which overlaps considerably with sea lion critical habitat. In 1998, over 22,000 t of pollock were caught in the Aleutian Island regions, with over 17,000 t caught in AI critical habitat. Since 1998 directed fishery removals of pollock have been prohibited.

D.1.3 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 BS. 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 EBS 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.1.4 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 GOA.

Larvae: Pelagic outer to mid-shelf region in BS. Pelagic throughout the continental shelf within the top 40 m in the GOA.

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 GOA, EBS and AI. In the EBS few adult pollock occur in waters shallower than 70 m. Adult pollock also occur pelagically in the Aleutian Basin. Adult pollock range throughout the BS in both the U.S. and Russian waters, however, the maps provided for this document detail distributions for pollock in the EEZ and the 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 d. at 5 C	None	Feb-Apr	OCS, UCS	P	N/A	G?	
Larvae	60 days	copepod naupli and small euphausiids	Mar-Jul	MCS, OCS	P	N/A	G? F	pollock larvae with jellyfish
Juveniles	0.4 to 4.5 years	Pelagic crustaceans, copepods and euphausiids	Aug. +	OCS, MCS, ICS	P, SD	N/A	CL, F	
Adults	4.5 to 16 years	Pelagic crustaceans and fish	Spawning Feb-Apr	OCS, BSN	P, SD	UNK	F UP	Increasingly demersal with age

D.1.5 Additional Information Sources

Eggs and Larvae: Jeff Napp, Alaska Fisheries Science Center, 7600 Sand Point Way NE, Seattle, WA.

Shallow Water Concentrations: Bill Bechtol, Alaska Department of Fish and Game, 3298 Douglas Place, Homer, Alaska 99603-8027.

D.1.6 Literature

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 GOA, 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 EBS. Fish. Res.,5:199_215.

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

Brodeur, R.D., and M.T. Wilson. 1996. A review of the distribution, ecology and population dynamics of age-0 walleye pollock in the GOA. 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 GOA. Mar. Bio. 112:23-30.

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

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

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

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

Hollowed, A.B., J.N. Ianelli, and P. Livingston. 2000. Including predation mortality in stock assessments: a case study for GOA pollock. ICES J. Mar. Sci. 57:279-293.

Hughes, S.E., and G. Hirschhorn. 1979. Biology of walleye pollock, *Theragra chalcogramma*, in Western GOA. Fish. Bull., U.S. 77:263-274.

Ianelli, J.N. 2002. BS walleye pollock stock structure using morphometric methods. Tech. Report Hokkaido National Fisheries Research Inst. No. 5, 53_58.

Ianelli, J.N., S. Barbeaux, T. Honkalehto, G. Walters, and N. Williamson. 2002. BS-AI Walleye Pollock Assessment for 2003. In Stock assessment and fishery evaluation report for the groundfish resources of the EBS and Aleutian Island Region, 2002. Council, Box 103136, Anchorage, AK 99510. 88 p.

Kendall, A.W., Jr., and S.J. Picquelle. 1990. Egg and larval distributions of walleye pollock *Theragra chalcogramma* in Shelikof Strait, GOA. 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, GOA, in relation to water movement. Rapp. P.-v. Reun. Cons. int. Explor. Mer 191:127-136.

Livingston, P.A. 1991. Groundfish food habits and predation on commercially important prey species in the EBS 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 GOA. Fish. Bull. 100:559-581.

Mulligan, T.J., R.W. Chapman, and B.L. Brown. 1992. Mitochondrial DNA analysis of walleye pollock, *Theragra chalcogramma*, from the EBS and Shelikof Strait, GOA. 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 GOA, with emphasis on the period of peak abundance of walleye pollock (*Theragra chalcogramma*) larvae. NWAFC Proc. Rep. 90-01, 162 pp.

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

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

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

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

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 lat. 34° N, with a northern limit of about lat. 63° N. Adults are demersal and form aggregations during the peak spawning season, which extends approximately from January through May. Pacific cod eggs are demersal and adhesive. Eggs hatch in about 15 to 20 days. Little is known about the distribution of Pacific cod larvae, which undergo metamorphosis at about 25 to 35 mm. Juvenile Pacific cod start appearing in trawl surveys at a fairly small size, as small as 10 cm in the EBS. Pacific cod can grow to be more than 1 m in length, with weights in excess of 10 kilogram (kg). Natural mortality is believed to be somewhere between 0.3 and 0.4. Approximately 50 percent of Pacific cod are mature by ages 5 to 6. The maximum recorded age of a Pacific cod from the BSAI or GOA is 19 years.

The estimated size at 50 percent maturity is 67 cm.

D.2.2 Fishery

The fishery is conducted with bottom trawl, longline, pot, and jig gear. The age at 50 percent recruitment varies between gear types and regions. In the BSAI, the age at 50 percent recruitment is 6 years for trawl gear, 4 years for longline, and 5 years for pot gear. In the GOA, the age at 50 percent recruitment is 5 years for trawl gear and 6 years for longline and pot gear. More than 100 vessels participate in each of the three largest fisheries (trawl, longline, pot). The trawl fishery is typically concentrated during the first few months of the year, whereas fixed-gear fisheries may sometimes run, intermittently, at least, throughout the year. Bycatch of crab and halibut sometimes causes the Pacific cod fisheries to close prior to reaching the TAC. In the BSAI, trawl fishing is concentrated immediately north of Unimak Island, whereas the longline fishery is distributed along the shelf edge to the north and west of the Pribilof Islands. In the GOA, the trawl fishery has centers of activity around the Shumagin Islands and south of Kodiak Island, while the longline fishery is located primarily in the vicinity of the Shumagins.

D.2.3 Relevant Trophic Information

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

D.2.4 Habitat and Biological Associations

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

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

Juveniles: Juveniles occur mostly over the inner continental shelf at depths of 60 to 150 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 Age	Diet/Prey	Season/ Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs	15 to 20 days	NA	winter-spring	ICS, MCS, OCS	D	M, SM, MS, S	U	optimum 3-6°C optimum salinity 13-23 ppt
Larvae	U	copepods (?)	winter-spring	U	P (?), N (?)	U	U	
Early Juveniles	to 2 years	Small invertebrates (mysids, euphausiids, shrimp)	all year	ICS, MCS	D	M, SM, MS, S	U	
Late Juveniles	to 5 years	pollock, flatfish, fishery discards, crab	all year	ICS, MCS, OCS	D	M, SM, MS, S	U	
Adults	5+ yr	pollock, flatfish, fishery discards, crab	Spawning (Jan-May) Non-spawning (Jun-Dec)	ICS, MCS, OCS ICS, MCS, OCS	D	M, SM, MS, S,G	U	

D.2.5 Additional Information Sources

NMFS, Alaska Fisheries Science Center, FOCI Program, Ann Matarese.

D.2.6 Literature

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

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

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

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

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

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

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.

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

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

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

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

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

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

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

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

Thompson, G.G., and M.W. Dorn. 2002. Assessment of the Pacific cod stock in the EBS and AI area. *In* Stock assessment and fishery evaluation report for the groundfish resources of the BSAI Regions, Plan Team for the Groundfish Fisheries of the BS and AI (editor), p. 121-205. Available from Council, 605 West 4th Avenue, Suite 306, Anchorage, AK 99501.

Thompson, G.G., H.H. Zenger, and M.W. Dorn. 2002. Assessment of the Pacific cod stock in the GOA. *In* Stock assessment and fishery evaluation report for the groundfish resources of the GOA, Plan Team for the GOA (editor), p. 89-167. Available from Council, 605 West 4th Avenue, Suite 306, Anchorage, AK 99501.

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

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, BS, along the Asian coast from Sagami Bay, and along the Pacific sides of Honshu and Hokkaido Islands and the Kamchatkan 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. Spawning or very ripe sablefish are observed in late winter or early spring along the continental slope. Eggs are apparently released near the bottom where they incubate. After hatching and yolk adsorption, the larvae rise to the surface, where they have been collected with neuston nets. Larvae are oceanic through the spring and by late summer, small pelagic juveniles (10 to 15 cm) have been observed along the outer coasts of Southeast Alaska, where they apparently 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 highly inefficient and sparse. During the occasional times of large year-classes, the juveniles are easily found in many inshore areas during their second summer. They are typically 30 to 40 cm long during their second summer, after which they apparently leave the nearshore bays. One or two years later, they begin appearing on the continental shelf and move to their adult distribution as they mature.

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 southerly. Recruitment success also appeared related to water temperature. Recruitment was above average in 61 percent of the years when temperature was above average, but was above average in only 25 percent of the years when temperature was below average. Recruitment success did not appear to be directly related to the presence of El Ninos 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 gulleys. 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 demersal conditions that may have been brought about by bottom trawling (habitat, bycatch, and increased competitors) have limited the ability of the large year classes that, though abundant at the young-of-the-year stage, survive to adults.

Size at 50 percent maturity is as follows:

BS: males 65 cm, females 67 cm

AI: males 61 cm, females 65 cm

GOA: males 57 cm, females 65 cm

At the end of the second summer (~1.5 years old), they are 35 to 40 cm long.

D.3.2 Fishery

The major fishery for sablefish in Alaska uses longlines; however sablefish are valuable in the trawl fishery as well. Sablefish enter the longline fishery at 4 to 5 years of age, perhaps slightly younger in the trawl fishery. The longline fishery takes place between March 1 and November 15. The take of the trawl share of sablefish occurs primarily in association with openings for other species, such as the July rockfish openings, where they are taken as allowed bycatch. Deeper dwelling rockfish, such as shortraker, rougheye, and thornyhead rockfish are the primary bycatch in the longline sablefish fishery. Halibut and rattails (Albatrossia pectoralis and Corphaenoides acrolepis) also are taken. By regulation, there is no directed trawl fishery for sablefish; however, directed fishing standards have allowed some trawl hauls to target sablefish, where the bycatch is similar to the longline fishery, in addition perhaps to some deep dwelling flatfish.

In addition to the fishery for sablefish, there are significant fisheries for other species that may have an effect on the habitat of sablefish, primarily juveniles. As indicated above, before moving to adult habitat on the slope and deep gulleys, sablefish 2 to 4 years of age reside on the continental shelf, where significant trawl fisheries have taken place. It is difficult to evaluate the potential effect such fisheries could have had on sablefish survival, as a clear picture of the distribution and intensity of the groundfish fishery prior to 1997 has not been available. It is worth noting however, that the most intensely trawled area from 1998 to 2002 which is just north of the Alaska Peninsula, was closed to trawling by Japan in 1959 and apparently was untrawled until it was opened to U.S. trawling in 1983 (Witherell 1997, Fredin 1987). Juvenile sablefish of the 1977 year class were observed in the western portion of this area by the AFSC trawl survey in 1978 to 1980 at levels of abundance that far exceed levels that have been seen since (Umeda et al 1983). Observations of 1-year-old and young-of-the-year sablefish in inshore waters from 1980 to 1990 indicate that above-average egg to larval survival has occurred for a number of year classes since.

D.3.3 Relevant Trophic Information

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

In their demersal stage, juvenile sablefish less than 60 cm feed primarily on euphausiids, shrimp, and cephalopods (Yang and Nelson 2000) 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, euphasiids, and jellyfish were also found, squid being the most important of the invertebrates (Yang and Nelson 2000). Feeding studies conducted in Oregon and California found that fish made up 76 percent of the diet (Laidig et al. 1997). Off the southwest coast of Vancouver Island, euphausiids dominated sablefish diet (Tanasichuk 1997). Among other goundfish in the GOA, the diet of sablefish overlaps mostly with that of large flatfish, arrowtooth flounder and Pacific halibut (Yang and Nelson 2000).

Nearshore residence during their second year provides sablefish with the opportunity to feed on salmon fry and smolts during the summer months, while young-of-the-year sablefish are commonly found in the stomachs of salmon taken in the Southeast Alaska troll fishery during the late summer.

D.3.4 Stock Condition

The estimated productivity and sustainable yield of the combined GOA,BS, and AI 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. While years of strong young-of-the-year survival has occurred in the 1980s and the1990s, the failure of strong recruitment to the mature stage suggests a decreased survival of juveniles during their residence as 2 to 4 year olds on the continental shelf.

D.3.5 Habitat and Biological Associations

Egg/Spawning

Larvae

Juveniles

Adults - other than depth, none is noted

Habitat and Biological Associations: Sablefish

Stage - EFH Level	Duration or Age	Diet/Prey	Season/ Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs	14 to 20 days	NA	late winter-early spring: Dec-Apr	USP, LSP, BSN	P,200-3000 m	NA	U	
Larvae	up to 3 months	copepod nauplii, small copepodites, etc.	spring-summer: Apr-July	MCS, OCS, USP, LSP, BSN	N, neustonic near surface	NA	U	
Early Juveniles	up to 3 years	small prey fish, sandlance, salmon, herring, etc		OCS, MCS, ICS, during first summer, then obs in BAY, IP, till end of 2nd summer; not obs'd 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 obs. to assume typical.	U	
Late Juveniles	3 to 5 years	opportunistic: other fish,shellfish, worms, jellyfish, fishery discards	all year	continental slope, and deep shelf gullies and fjords.	Presumably D	varies	U	
Adults	5 to 35+ years	opportunistic: other fish, shellfish, worms, jellyfish, fishery discards	apparently year around, spawning movements (if any) are undescribed	continental slope, and deep shelf gullies and fjords.	Presumably D	varies	U	

D.3.6 Additional Sources of Information

Eggs and Larvae: NMFS, Alaska Fisheries Science Center, FOCI Program, Art Kendall, NMFS Auke Bay Lab, Bruce Wing.

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

Juveniles: ADFG groundfish surveys: Jim Blackburn, ADFG, Kodiak, AK, Paul Anderson, NMFS/RACE, Kodiak, AK.

Kendall, A.W. and A.C. Materese. 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.

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

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

Witherell, D 1997. A brief history of bycatch management measures for EBS groundfish fisheries. Marine Fisheries Review

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.

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

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.

D.3.7 Literature

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

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

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

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

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

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.

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.

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.

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.

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

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

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

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

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

Wolotera, R.J., Jr., T.M. Sample, S.F. Noel, and C.R. Iten. 1993. Geographic and bathymetric distributions for many commercially important fishes and shellfishes off the west coast of North America, based on research survey and commercial catch data, 1912-1984. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-6, 184 p.

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

D.4 Yellowfin Sole (Limanda aspera)

Yellowfin sole is part of the shallow water flatfish management complex in the GOA.

D.4.1 Life History and General Distribution

Yellowfin sole are distributed in North American waters from off British Columbia, Canada (approximately lat. 49° N) to the Chukchi Sea (about lat. 70° N) and south along the Asian coast to about lat. 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 EBS 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 - early September. The age or size at metamorphosis is unknown. 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. 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 Fishery

Yellowfin sole are caught in bottom trawls both as a directed fishery and in the pursuit of other bottom-dwelling species. Recruitment begins at about age 6 and they are fully selected at age 13. Historically, the fishery has occurred throughout the mid and inner BS shelf during ice-free conditions although much effort has been directed at the spawning concentrations in nearshore northern Bristol Bay. They are caught as bycatch in Pacific cod, bottom pollock and other flatfish fisheries and are caught with these species and Pacific halibut in yellowfin sole directed fisheries.

D.4.3 Relevant Trophic Information

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

D.4.4 Habitat and Biological Associations

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

Adults: Summertime spawning and feeding on sandy substrates of the EBS shelf. Widespread distribution mainly on the middle and inner portion of the shelf, feeding mainly on bivalves, polychaetes, 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 to 3 months?	U phyto/zoo plankton?	summer autumn?	BAY BCH ICS	P			
Early Juveniles	to 5.5 years	polychaetes bivalves amphipods echiurids	all year	BAY ICS OCS MCS	D	S[1]		
Late Juveniles	5.5 to 10 years	polychaetes bivalves amphipods echiurids	all year	BAY ICS, OCS, MCS IP	D	S[1]		
Adults	10+ years	polychaetes bivalves amphipods echiurids	spawning/ feeding May-August non-spawning Nov.-April	BAY BEACH ICS, MCS, OCS IP	D	S[1]	ice edge	

[1]Pers. Comm. Dr. Robert McConnaughey

D.4.5 Literature

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

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

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

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

Livingston, P.A. and Y. DeReynier. 1996. Groundfish food habits and predation on commercially important prey species in the EBS from 1990 to 1992. AFSC processed Rep. 96-04, 51 p.

Alaska Fish. Sci. Cent., Natl. Mar. Fish. Serv., NOAA, 7600 Sand Point Way NE., Seattle, WA 98115.

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

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

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

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

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

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

D.5 Rock sole (Lepidopsetta bilineatus)

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

D.5.1 Life History and General Distribution

Rock sole are distributed from California waters north into the GOA and BS to as far north as the Gulf of Anadyr. The distribution continues along the AI 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 GOA, and in the southeastern BS (Alton and Sample 1975). Adults exhibit a benthic lifestyle and, in the EBS, occupy separate winter (spawning) and summertime feeding distributions on the continental shelf. Rock sole spawn during the winter-early spring period of December-March. Soviet investigations in the early 1960s established two spawning concentrations: an eastern concentration north of Unimak Island at the mouth of Bristol Bay and a western concentration eastward of the Pribilof Islands between 55°30' and 55°0' N and approximately

165°2' W (Shubnikov and Lisovenko 1964). Rock sole spawning in the eastern and western BS was found to occur at depths of 125 to 250 m, close to the shelf/slope break. Spawning females deposit a mass of eggs that are demersal and adhesive (Alton and Sample 1975). Fertilization is believed to be external. Incubation time is temperature dependent and may range from 6.4 days at 11ºC to about 25 days at 2.9ºC (Forrester 1964). Newly hatched larvae are pelagic and have occurred sporadically in EBS 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 1975). Forrester and Thompson (1969) report that by age 1 they are found with adults on the continental shelf during summer.

In the springtime, after spawning, 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 1975) and western (Shvetsov 1978) areas of the BS. 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 EBS is rare (Musienko 1963). The age or size at metamorphosis is unknown. Juveniles are separate from the adult population, remaining in shallow areas until they reach age 1 (Forrester 1969). The estimated age of 50 percent maturity is 9 years for southern rock sole females (approximately 35 cm) and 7 years for northern rock sole females (Stark and Somerton 2002). The natural mortality rate is believed to range from 0.18 to 0.20 (Tournock et al. 2002).

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

D.5.2 Fishery

Rock sole are caught in bottom trawls both as a directed fishery and in the pursuit of other bottom-dwelling species. Recruitment begins at about age 4 and they are fully selected at age 11. Historically, the fishery has occurred throughout the mid and inner BS shelf during ice-free conditions and on spawning concentrations north of the Alaska Peninsula during winter for their high-value roe. They are caught as bycatch in Pacific cod, bottom pollock, and other flatfish fisheries and are caught with these species and Pacific halibut in rock sole directed fisheries.

D.5.3 Relevant Trophic Information

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

D.5.4 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 EBS shelf. Widespread distribution mainly on the middle and inner portion of the shelf, feeding on bivalves, polychaetes, 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 to 3 months?	U phyto/zoo plankton?	winter/spring	OCS MCS ICS	P			
Early Juveniles	to 3.5 years	polychaetes bivalves amphipods misc. crust.	all year	BAY ICS OCS MCS	D	S[1],G		
Late Juveniles	up to 9 years	polychaetes bivalves amphipods misc. crust.	all year	BAY ICS OCS MCS	D	S[1],G		
Adults	9+ years	polychaetes bivalves amphipods misc. crust.	Feeding May-September Spawning Dec.-April	MCS ICS MCS OCS	D	S[1], G	ice edge	

[1]Pers. Comm. Dr. Robert McConnaughey

D.5.5 Literature

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

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

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

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

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

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

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

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

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

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

Turnock, B.J., T.K. Wilderbuer, and E.S. Brown. 2002. Flatfish. In Appendix B Stock Assessment and Fishery Evaluation for Groundfish Resources of the GOA Region. Pages 169-197. Council, 605 West 4th Ave., Suite 306, Anchorage, AK 99501.

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

D.6 Rex sole (Glyptocephalus zachirus)

D.6.1 Life History and General Distribution

Rex sole are distributed from Baja California to the BS and western AI (Hart 1973, Miller and Lea 1972), and are widely distributed throughout the GOA. Adults exhibit a benthic lifestyle and are generally found in water deeper than 300 m. 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 GOA 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. Juveniles less than 15 cm are rarely found with the adult population. The natural mortality rate used in recent stock assessments is 0.2 (Turnock et al. 2002).

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

D.6.2 Fishery

Rex sole are caught in bottom trawls both as a directed fishery and in the pursuit of other bottom-dwelling species. Recruitment begins at about age 3 or 4. They are caught as bycatch in the Pacific ocean perch, Pacific cod, bottom pollock, and other flatfish fisheries and are caught with these species and Pacific halibut in rex sole directed fisheries.

D.6.3 Relevant Trophic Information

Groundfish predators include Pacific cod and most likely arrowtooth flounder.

D.6.4 Habitat and Biological Associations

Larvae/Juveniles: Planktonic larvae for an unknown time period 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 polychaetes, amphipods, euphausids and snow crabs.

Habitat and Biological Associations: Rex sole

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

D.6.5 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.

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.

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

D.7 Dover sole (Microstomus pacificus)

D.7.1 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 BS and the western AI (Hart 1973, Miller and Lea 1972). They exhibit a widespread distribution throughout the GOA. Adults are demersal and are mostly found in water deeper than 300 m in the winter but occur in highest biomass in the 100- to 200-m depth range during summer in the GOA (Turnock et al. 2004). The spawning period off Oregon is reported to range from January through May (Hunter et al. 1992). Off California, Dover sole spawn in deep water, and the larvae eventually settle in the shallower water of the continental shelf. They gradually move down the slope into deeper water as they grow and reach sexual maturity (Jacobson and Hunter 1993,Vetter et al. 1994, Hunter et al. 1990). For mature adults, most of the biomass may inhabit the oxygen minimum zone in deep waters Spawning in the GOA has been observed from January through August, with a peak period in May (Hirschberger and Smith 1983). Eggs have been collected in neuston and bongo nets in the summer, east of Kodiak Island (Kendall and Dunn 1985), but the duration of the incubation period is unknown. Larvae were captured in bongo nets only in summer over mid-shelf and slope areas (Kendall and Dunn 1985). The age or size at metamorphosis is unknown, but the pelagic larval period is known to be protracted and may last as long as 2 years (Markle et al. 1992). Pelagic postlarvae as large as 48 mm have been reported, and the young may still be pelagic at 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. 2002).

The approximate upper size limit of juvenile Dover sole is 32 cm.

D.7.2 Fishery

Dover sole are caught in bottom trawls, both as a directed fishery and in the pursuit of other bottom-dwelling species. Recruitment begins at about age 5. They are caught as bycatch in the rex sole, thornyhead, and sablefish fisheries, and they are caught with these species and Pacific halibut in Dover sole directed fisheries.

D.7.3 Relevant Trophic Information

Groundfish predators include Pacific cod and most likely arrowtooth flounder.

D.7.4 Habitat and Biological Associations

Larvae/Juveniles: Dover sole are planktonic larvae for up to 2 years until metamorphosis occurs; juvenile distribution is unknown.

Adults: Dover sole are winter and spring spawners, and summer feeding occurs on soft substrates (combination of sand and mud) of the continental shelf and upper slope. Shallower summer distribution occurs mainly on the middle to outer portion of the shelf and upper slope. They feed mainly on polychaetes, annelids, crustaceans, and mollusks (Livingston and Goiney 1983).

Habitat and Biological Associations: Dover sole

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

D.7.5 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., J.L. Butler, C.A. Kimbrell, and E.A. Lynn. 1990. Bathymetric patterns in size, age, sexual maturity, water content, caloric density of Dover sole, *Microstomus pacificus*. CALCOFI Rep., Vol. 31, 1990.

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

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

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

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

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

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

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

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

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

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

D.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 GOA and the BS, 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 EBS shelf and in the GOA. From over-winter grounds near the shelf margins, adults begin a migration onto the mid and outer continental shelf in April or May each year for feeding. The spawning period may range from 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 and have been found in ichthyoplankton sampling on the southern portion of the BS 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. Nearshore sampling indicates that newly settled larvae are in the 40 to 50 mm size range (Norcross et al. 1996). Flathead sole females in the GOA become 50 percent mature at 8 years or about 32 cm (Turnock et al. 2002). Juveniles less than age 2 have not been found with the adult population, remaining in shallow areas. The natural mortality rate used in recent stock assessments is 0.2.

The approximate upper size limit of juvenile fish is 31 cm.

D.8.2 Fishery

Flathead sole are caught in bottom trawls both as a directed fishery and in the pursuit of other bottom-dwelling species. Recruitment begins at about age 3. Historically, the fishery has occurred throughout the mid and outer BS shelf during ice-free conditions (mostly summer and fall). They are caught as bycatch in Pacific cod, bottom Pollock and other flatfish fisheries and are caught with these species and Pacific halibut in flathead sole directed fisheries.

D.8.3 Relevant Trophic Information

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

D.8.4 Habitat and Biological Associations

Larvae/Juveniles: Planktonic larvae for 3 to 5 months 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 polychaetes.

Habitat and Biological Associations: Flathead sole

Stage - EFH Level	Duration or Age	Diet/Prey	Season/ Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs		NA	winter	ICS MCS OCS	P			
Larvae	U	U phyto/zoo plankton?	spring summer	ICS MCS OCS	P			
Juveniles	U	polychaetes bivalves ophiuroids	all year	MCS ICS OCS	D	S+M[1]		
Adults	U	polychaetes bivalves ophiuroids pollock and Tanner crab	Spawning Jan-April non-spawning May-December	MCS OCS ICS	D	S+M[1]	ice edge	

[1]Pers. Comm. Dr. Robert McConnaughey (206) 526-4150

D.8.5 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 EBS from 1990 to 1992. AFSC processed Rep. 96-04, 51 p. Alaska Fish. Sci. Cent., Natl. Mar. Fish. Serv., NOAA, 7600 Sand Point Way NE., Seattle, WA 98115.

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

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

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

Turnock, B.J., T.K. Wilderbuer, and E. S. Brown. 2002. Flathead sole. *In* Stock assessment and fishery evaluation Report for the groundfish resources of the GOA. p 361-408. North Pac. Fish. Mgmt. Council, 605 West 4th Ave., Suite 306, Anchorage, AK 99501.

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

D.9 Greenland Turbot (Reinhardtius hoppglossoides)

D.9.1 Life History and General Distribution

Greenland turbot has an amphiboreal distribution, occurring in the North Atlantic and North Pacific, but not in the intervening Arctic Ocean. In the North Pacific, species abundance is centered in the EBS and, secondly, in the Aleutians. On the Asian side, they occur in the Gulf of Anadyr along the BS 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 (<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 EBS and may be protracted starting in September or October and continuing until March with an apparent peak period in November to February (Shuntov 1970, 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 BS (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; this is reported to occur at 15 to 18 mm with the onset of feeding (Pertseva-Ostroumova 1961 and Smidt 1969). 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 0ºC (Hognestad 1969) and have been found on the northern part of the BS 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 0.18 has been used in the most recent BS stock assessment (Ianelli et al. 2002).

The approximate upper size limit of juvenile fish is 59 cm.

D.9.2 Fishery

Greenland turbot are not a fishery target in the GOA. They are caught in bottom trawls and on longlines both as a directed fishery and in the pursuit of other bottom-dwelling species (primarily sablefish). These fisheries operate on the southern side of the AI. Bycatch primarily occurs in the sablefish directed fisheries and also to a smaller extent in the Pacific cod fishery. Recruitment begins at about 50 and 60 cm in the trawl and longline fisheries, respectively.

D.9.3 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.9.4 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 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. Diet consists of walleye pollock and other miscellaneous fish species.

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 to 9 months	U phyto/zoo plankton?	Spring summer	OCS ICS MCS	P			
Juveniles	1 to 5 years	euphausiids polychaets small pollock	all year	ICS MCS OCS USL	D, SD	M/S+M[1]		
Adults	5+ years	pollock small fish	Spawning Nov-February non-spawning March-October	OCS USP LSP OCS USP LSP	D, SD	M/S+M[1]		

[1]Pers. Comm. Dr. Robert McConnaughey

D.9.5 Literature

Alton, M.S., R.G. Bakkala, G.E. Walters, and P.T. Munro. 1988. Greenland turbot, *Reinhardtius hippoglossoides*, of the EBS and AI. 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.

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

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 BS. J. Ichthyol. [Engl. Trans. Vopr. Ikhtiol.] 22(5):59-64.

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.,C. Minte-Vera, T.K. Wilderbuer, and T.M. Sample. 2002. Greenland turbot. *In* Appendix A Stock Assessment and Fishery Evaluation Report for the groundfish resources of the BSAI Regions, Pages 255-282Council, 605 West 4th Avenue, Suite 306, Anchorage, AK 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 EBS from 1990 to 1992. AFSC processed Rep. 96-04, 51 p. Alaska Fish. Sci. Cent., Natl. Mar. Fish. Serv., NOAA, 7600 Sand Point Way, NE., Seattle, WA 98115.

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

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.]

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.10 Arrowtooth flounder (Atheresthes stomias)

D.10.1 Life History and General Distribution

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

Adults exhibit a benthic lifestyle and occupy separate winter and summer distributions on the EBS shelf. From over-winter grounds near the shelf margins and upper slope areas, adults begin a migration onto the middle and inner shelf in April or early May each year with the onset of warmer water temperatures. A protracted and variable spawning period may range from as early as September through March (Rickey 1994, Hosie 1976). Little is known of the fecundity of arrowtooth flounder. Larvae have been found from ichthyoplankton sampling over a widespread area of the EBS shelf in April and May and also on the continental shelf east of Kodiak Island during winter and spring (Waldron and Vinter 1978, Kendall and Dunn 1985). Nearshore sampling in the Kodiak Island area indicates that newly settled larvae are in the 40 to 60 mm size range (Norcross et al. 1996). Juveniles are separate from the adult population, remaining in shallow areas until they reach the 10 to 15 cm range (Martin and Clausen 1995). The estimated length at 50 percent maturity is 28 cm for males (4 years) and 37 cm for females (5 years) from samples collected off the Washington coast (Rickey 1994) and 47 cm for GOA females (Zimmerman 1997). The natural mortality rate used in stock assessments differs by sex with females estimated at 0.2 and male natural mortality ranging from 0.28 to 0.35 (Turnock et. al 2002, Wilderbuer and Sample 2002).

The approximate upper size limit of juvenile fish is 27cm in males and 46 cm in females.

D.10.2 Fishery

Arrowtooth flounder are caught in bottom trawls usually in pursuit of other higher value bottom-dwelling species. Historically, they have been undesirable to harvest due to a flesh softening condition caused by protease enzyme activity. Recruitment begins at about age 3 and females are fully selected at age 10. They are caught as bycatch in Pacific cod, bottom pollock, sablefish, and other flatfish fisheries.

D.10.3 Relevant Trophic Information

Arrowtooth flounder are very important as a large, aggressive and abundant predator of other groundfish species. Groundfish predators include Pacific cod and pollock, mostly on small fish.

D.10.4 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 OCS	P			
Larvae	2 to 3 months?	U phyto/zoo plankton?	spring summer?	BAY ICS OCS	P			
Juveniles	males - 4 years females - 5 years	euphausiids crustaceans amphipods pollock	all year	ICS OCS USP	D	GMS[1]		
Adults	males - 4+ years females- 5+ years	pollock misc. fish Gadidae sp. Euphausiids	spawning Nov-March non-spawning April-Oct.	ICS OCS USP BAY	D	GMS[1]	ice edge (EBS)	

[1]Pers. Comm., Dr. Robert McConnaughey

D.10.5 Literature

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

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

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

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

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

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

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

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

Turnock, B.J., T.K. Wilderbuer, and E.S. Brown. 2002. Arrowtooth flounder. *In* Appendix B Stock Assessment and Fishery Evaluation Report for the groundfish resources of the GOA, Pages 199-228. Council, 605 W. 4th Ave., Suite 306, Anchorage, AK 99501.

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

Wilderbuer, T.K., and T.M. Sample. 2002. Arrowtooth flounder. *In* Appendix A Stock Assessment and Fishery Evaluation Report for the groundfish resources of the BSAI, Pages 283-320. Council, 605 W. 4th Ave., Suite 306, Anchorage, AK 99501.

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

D.11 Pacific Ocean perch

D.11.1 Life History and General Distribution

Pacific ocean perch (Sebastes alutus, POP) has a wide distribution in the North Pacific from southern California around the Pacific rim to northern Honshu Island, Japan, including the BS. The species appears to be most abundant in northern British Columbia, the GOA, and the AI (Allen and Smith 1988). Adults are found primarily offshore on the outer continental shelf and the upper continental slope in depths from 150 to 420 m. Seasonal differences in depth distribution have been noted by many investigators. In the summer, adults inhabit shallower depths, especially those between 150 and 300 m. In the fall, the fish apparently migrate farther offshore to depths from approximately 300 to 420 m. They reside in these deeper depths until about May, when they return to their shallower summer distribution (Love et al. 2002). This seasonal pattern is probably related to summer feeding and winter spawning. Although small numbers of Pacific ocean perch are dispersed throughout their preferred depth range on the continental shelf and slope, most of the population occurs in patchy, localized aggregations (Hanselman et al. 2001). Pacific ocean perch are generally considered to be semi-demersal, but there can at times be a significant pelagic component to their distribution. Pacific ocean perch often move off-bottom at night to feed, apparently following diel euphausiid migrations. Commercial fishing data in the GOA since 1995 show that pelagic trawls fished off-bottom have accounted for as much as 20 percent of the annual harvest of this species.

There is much uncertainty about the life history of Pacific ocean perch, although generally more is known than for other rockfish species (Kendall and Lenarz 1986). The species appears to be viviparous (the eggs develop internally and receive at least some nourishment from the mother), with internal fertilization and the release of live young. Insemination occurs in the fall, and sperm are retained within the female until fertilization takes place approximately 2 months later. The eggs hatch internally, and parturition (release of larvae) occurs in April and May. Information on early life history is very sparse, especially for the first year of life. Pacific ocean perch larvae are thought to be pelagic and drift with the current. Oceanic conditions may sometimes cause advection to suboptimal areas (Ainley et al. 1993), resulting in high recruitment variability. However, larval studies of rockfish have been hindered by difficulties in species identification since many larval rockfish species share the same morphological characteristics (Kendall 2001). Genetic techniques using allozymes (Seeb and Kendall 1991) and mitochondrial DNA (Li 2004) are capable of identifying larvae and juveniles to species, but are expensive and time-consuming. Post-larval and early young-of-the-year Pacific ocean perch have been positively identified in offshore, surface waters of the GOA (Gharrett et al. 2002), which suggests this may be the preferred habitat of this life stage. Transformation to a demersal existence may take place within the first year (Carlson and Haight 1976). Small juveniles probably reside inshore in very rocky, high relief areas and begin to migrate to deeper offshore waters of the continental shelf by age 3 (Carlson and Straty 1981). As they grow, they continue to migrate deeper, eventually reaching the continental slope, where they attain adulthood.

Pacific ocean perch is a very slow growing species, with a low rate of natural mortality (estimated at 0.06), a relatively old age at 50 percent maturity (10.5 years for females in the GOA), and a very old maximum age of 98 years in Alaska (84 years maximum age in the GOA) (Hanselman et al. 2003). Age at 50 percent recruitment to the commercial fishery has been estimated to be between 7 and 8 years in the GOA. Despite their viviparous nature, the fish is relatively fecund with number of eggs/female in Alaska ranging from 10,000 to 300,000, depending upon size of the fish (Leaman 1991).

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

D.11.2 Fishery

The Pacific ocean perch is the most abundant GOA rockfish and the most important commercially. The species was fished intensely in the 1960s by foreign factory trawlers (350,000 mt at its peak in 1965), and the population declined drastically due to this pressure. The domestic fishery began developing in 1985. Quotas climbed rapidly, and the species was declared overfished in 1989. A rebuilding plan was put into place, and quotas were small in the early 1990s. After some good recruitments and high survey biomass estimates, the stock was declared to be recovered in 1995. Pacific ocean perch are caught almost exclusively with trawls. Before 1996, nearly all the catch was taken by factory trawlers using bottom trawls, but a sizeable portion (up to 20 percent some years) has also been taken by pelagic trawls since then. Also in 1996, a shore-based fishery developed that consisted of smaller vessels operating out of the port of Kodiak. These shore-based trawlers now take about 50 percent of the catch in the central GOA. The fishery in the Gulf in recent years has occurred in the summer months, especially July, due to management regulations. Reflecting the summer distribution of this species, the fishery is concentrated in a relatively narrow depth band at approximately180 to 250 m along the outer continental shelf and shelf break, inside major gullies and trenches running perpendicular to the shelf break, and along the upper continental slope. Major fishing grounds include Ommaney Trough (which is no longer fished because of an Council amendment that prohibits trawling in the eastern GOA), Yakutat Canyon, Amatuli Trough, off Portlock and Albatross Banks, Shelikof Trough, off Shumagin Bank, and south of Unimak and Unalaska Islands.

Major bycatch species in the GOA Pacific ocean perch trawl fishery from 1994 to 1996 (the most recent years for which an analysis was done) included (in descending order by percent bycatch rate) other species of rockfish, arrowtooth flounder, and sablefish. Among the other species of rockfish, northern rockfish and shortraker/rougheye were most common, followed by pelagic shelf rockfish (Ackley and Heifetz 2001).

Because collection of small juvenile Pacific ocean perch is virtually unknown in any existing type of commercial fishing gear, it is assumed that fishing does not occur in their habitat. Trawling on the offshore fishing grounds of adults may affect the composition of benthic organisms, but the impact of this on Pacific ocean perch or other fish is unknown.

D.11.3 Relevant Trophic Information

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

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

D.11.4 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 off-bottom at depths from 360 to 400 m.

Larvae: Little information is known. Earlier information suggested that after parturition, larvae rise quickly to near surface, where they become part of the plankton. More recent data from British Columbia indicates that larvae may remain at depths 175 m for some period of time (perhaps 2 months), after which they slowly migrate upward in the water column.

Post-larvae and early young-of-the year: A recent, preliminary study has identified Pacific ocean perch in these life stages from samples collected in epipelagic waters far offshore in the GOA (Gharrett et al. 2002). Some of the samples were as much as 100 nm from land, beyond the continental slope and over very deep water.

Juveniles: Again, information is very sparse, especially for younger juveniles. It is unknown how long young-of-the-year remain in a pelagic stage before eventually becoming demersal. At ages 1 to 3, the fish probably live in very rocky inshore areas. 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.

Adults: Commercial fishery and research data have consistently indicated that adult Pacific ocean perch are found in aggregations over reasonably smooth, trawlable bottom of the outer continental shelf and upper continental slope (Westrheim 1970; Matthews et al. 1989; Krieger 1993). Generally, they are found in shallower depths (150 to 300 m) in the summer, and deeper (300 to 420 m) in the fall, winter, and early spring. Observations from a manned submersible in Southeast Alaska found adult Pacific ocean perch associated with pebble substrate on flat or low-relief bottom (Krieger 1993). Pacific ocean perch have been observed in association with sea whips in both the GOA (Krieger 1993) and the BS (Brodeur 2001). The fish can at times also be found off-bottom in the pelagic environment, especially at night when they may move up in the water column to feed. There presently is no evidence to support previous conjectures that adult Pacific ocean perch might sometimes inhabit rough, untrawlable bottom.

Habitat and Biological Associations: Pacific ocean perch

Stage - EFH Level	Duration or Age	Diet/Prey	Season/ Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs	Internal incubation; ~90 d	NA	Winter-spring	NA	NA	NA	NA	NA
Larvae	U;2 months (?)	U; assumed to be micro-zooplankton	Spring-summer	ICS, MCS, OCS, USP, LSP, BSN	P	NA	U	U
Post-larvae/ early juvenile	U; 2 months to ?	U	Summer to ?	LSP, BSN	Epipelagic	NA	U	U
Juveniles	<1 year (?) to 10 years	Calanoid copepods (young juv.); Euphausiids (older juv.)	All year	ICS, MCS, OCS, USP	D	R (<age 3); CB,G,?M, ?SM,?MS (>age 3)	U	U
Adults	10 to 84 years of age (98 years in AI)	Euphausiids	Insemination (fall); Fertilization, incubation (winter); Larval release (spring); Feeding in shallower depths (summer)	OCS, USP	D, SD, P	CB, G,? M, ? SM,?MS	U	Eggs

D.11.5 Additional Source of Information

Larvae: NMFS, Alaska Fisheries Science Center, Auke Bay Laboratory, Bruce Wing; NMFS, Alaska Fisheries Science Center, FOCI program, Ann Matarese; Art Kendall, AJALA Enterprises, La Conner, WA.

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

Adults: Lunsford, C. R. 1999. Distribution patterns and reproductive aspects of Pacific ocean perch (Sebastes alutus) in the GOA. M.S. Thesis. Univ. of Alaska Fairbanks, Juneau AK. 154 p.

D.11.6 Literature

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

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

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

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

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

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

Chikuni, S. 1975. Biological study on the population of the Pacific ocean perch in the North Pacific. Bull. Far Seas Fish. Res. Lab 12: 1-119.

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.

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

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.

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

Gunderson, D.R. 1971. Reproductive patterns of Pacific ocean perch (*Sebastodes 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.

Hanselman, D.H., J. Heifetz., J. Fujioka., and J. Ianelli. 2003. GOA Pacific ocean perch. *In* Stock assessment and fishery evaluation report for the groundfish resources of the GOA. North Pacific Fisheries Management Council. p. 429-479.

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

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

Ito, D.H. 1982. A cohort analysis of Pacific ocean perch stocks from the GOA and BS 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 BSAI 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.

Krieger, K.J., and B.L. Wing. 2002. Megafauna associations with deepwater corals (Primnoa spp) in the GOA. Hydrobiologia 471: 8.

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

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

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

Lunsford, C.R. 1999. Distribution patterns and reproductive aspects of Pacific ocean perch (*Sebastes alutus*) in the GOA. M.S. Thesis. Univ. of Alaska Fairbanks, Juneau AK. 154 p.

Lunsford, C.R., L. Haldorson, J.T. Fujioka, and T.J. Quinn II. 2001. Distribution patterns and survey design considerations of Pacific ocean perch (*Sebastes alutus*) in the GOA. Spatial Processes and Management of Marine Populations, Alaska Sea Grant College Program. Lowell Wakefield Fisheries Symposium. Anchorage, AK., AK_SG_01_ 02.

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

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

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

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 southeast 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.

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.

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

Westrheim, S.J. 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 GOA, 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 GOA in 1990. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-22, 150 p.

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

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

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

D.12 Northern rockfish

D.12.1 Life History and General Distribution

Northern rockfish range from northern British Columbia through the GOA and AI to eastern Kamchatka, including the BS. The species is most abundant from about Portlock Bank in the central GOA to the western end of the AI. Within this range, adult fish appear to be concentrated at discrete, relatively shallow offshore banks of the outer continental shelf. Typically, these banks are separated from land by an intervening stretch of deeper water. The preferred depth range is ~75 to 150 m in the GOA. Information available at present suggests the fish are mostly demersal, as very few have been caught in pelagic trawls. In common with many other rockfish species, northern rockfish tend to have a localized, patchy distribution, even within their preferred habitat, and most of the population occurs in aggregations. Most of what is known about northern rockfish is based on data collected during the summer months from the commercial fishery or in research surveys. Consequently, there is little information on seasonal movements or changes in distribution for this species.

Life history information on northern rockfish is extremely sparse. The fish are assumed to be viviparous, as other Sebastes appear to be, with internal fertilization and incubation of eggs. Observations during research surveys in the GOA suggest that parturition (larval release) occurs in the spring, and is mostly completed by summer. Pre-extrusion larvae have been described, 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 is a slow growing species, with a low rate of natural mortality (estimated at 0.06), a relatively old age at 50 percent maturity (12.8 years for females in the GOA), and an old maximum age of 72 years in Alaska (maximum reported age in the GOA is 44 years). No information on fecundity is available.

The approximate upper size limit for juvenile fish is 38 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.12.2 Fishery

Northern rockfish are caught almost exclusively with bottom trawls. Age at 50 percent recruitment is unknown. The fishery in the GOA in recent years has mostly occurred in the summer months, especially July, due to management regulations. Catches are concentrated of live relatively shallow, offshore banks of the outer continental shelf: which include Portlock Bank, Albatross Bank, the “Snakehead” south of Kodiak Island, Shumagin Bank, and Davidson Bank. Of these, the Snakehead has been the most productive. Outside of these banks, catches are generally sparse. The majority of the catch in the GOA comes from depths of 75 to 125 m.

The major bycatch species in the GOA northern rockfish trawl fishery in 1994-96 included (in descending order by percent bycatch rate): light dusky rockfish, “other slope rockfish”, and Pacific ocean perch. Of these, light dusky rockfish was by far the most common bycatch, having a bycatch rate as high as 34 percent, depending on the year.

D.12.3 Relevant Trophic Information

Although no comprehensive food study of northern rockfish has been done, smaller studies have all shown euphausiids to be the predominant food item of adults in both the GOA and AI. 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.12.4 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 (<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. Substrate preference of these larger juveniles is unknown.

Adults: Commercial fishery and research survey data have consistently indicated that adult northern rockfish in the GOA are primarily found on offshore banks of the outer continental shelf at depths of 75 to 150 m. Preferred substrate in this habitat has not been documented, but observations from trawl surveys suggest that large catches of northern rockfish are often associated with hard or rough bottoms. For example, some of the largest catches in the trawl surveys have occurred in hauls in which the net hung-up on the bottom or was torn by a rough substrate. Generally, the fish appear to be demersal, and most of the population occurs in large aggregations. There is no information on seasonal migrations. Northern rockfish often co-occur with light 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	U	?P	U	U	U
Late Juveniles	to 13 years	U	All year	MCS, OCS	D	U	U	U
Adults	13 to 44 years of age (maximum of 72 years in AI)	Euphausiids	U, except that larval release is probably in the spring in the GOA	OCS,	D	CB, R	U	Often co-occur with light dusky rockfish

D.12.5 Additional Sources of Information

Eggs and Larvae: None at present.

Older juveniles and adults: NMFS, Alaska Fisheries Science Center, Auke Bay Laboratory, David Clausen.

D.12.6 Literature

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

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

Clausen, D.M., and J. Heifetz. 2003. The northern rockfish, Sebastes polyspinis, in Alaska: commercial fishery, distribution, and biology. Unpubl. manuscr. (submitted for publication to Mar. Fish. Rev. Avail. from NMFS Auke Bay Laboratory, 11305 Glacier Hwy., Juneau AK 99801).

Heifetz, J., D.L. Courtney, D.M. Clausen, D. Hanselman, J.T. Fujioka, and J.N. Ianelli. 2002. Slope rockfish. In Stock assessment and fishery evaluation report for the groundfish resources of the GOA, p. 295-382. Council, 605 W 4th Ave, Suite 306 Anchorage, AK 99501.

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

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

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

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

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

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

D.13 Shortraker Rockfish and Rougheye Rockfish

D.13.1 Life History and General Distribution

Shortraker and rougheye rockfish are found around the arc of the north Pacific from southern California to northern Japan, including the BS (Mecklenburg et al. 2002). Both species are demersal. Rougheye rockfish inhabit depths ranging from 82 to 2,953 feet (25 to 900 m), and shortraker rockfish range from 328 to 3,937 feet (100 to 1,200 m) (Mecklenburg et al. 2002). However, survey and commercial fishery data indicate that the fish are most abundant along a narrow band of the continental slope at depths of 984 to 1,640 feet (300 to 500 m) (Ito 1999), where both shortraker and rougheye rockfish often co-occur in the same haul. Within this habitat, shortraker and rougheye rockfish tend to have a relatively even distribution when compared with the highly aggregated and patchy distribution of many other rockfish such as Pacific ocean perch[1]. Similar to other Sebastes,

[1] Clausen, D. M., and J. T. Fujioka. Variability in trawl survey catches of shortraker rockfish, rougheye rockfish, and Pacific ocean perch, and possible implications for survey design. Presentation at 2002 Western Groundfish Conference, Ocean Shores, WA, February 12-14, 2002.

the fish appear to be viviparous (the eggs develop internally and receive at least some nourishment from the mother), with internal fertilization and the release of live young. Though relatively little is known about their biology and life history, both species appear to be K-selected with late maturation, slow growth, extreme longevity, and low natural mortality. Rougheye rockfish attain maturity relatively late in life, at about 20 years of age (McDermott 1994). Age of maturity for shortraker rockfish is unknown, but is presumably similar to that of rougheye rockfish. Both species are among the largest Sebastes species in the north Pacific, attaining sizes of up to 47 inches (120 cm) for shortraker and 38 inches (97 cm) for rougheye rockfish (Mecklenburg et al. 2002). Shortraker and rougheye rockfish are estimated to attain ages in excess of 100 years, and one ageing laboratory has reported ages up to 157 years for shortraker and 205 years for rougheye (Chilton and Beamish 1982, Munk 2001). Natural mortality for both species is low, estimated to be on the order of 0.01 to 0.04 (Archibald et al. 1981, McDermott 1994, Nelson and Quinn 1987, Clausen et al. 2003).

Length at 50 percent sexual maturity has been estimated to be about 45 cm fork length for female shortraker rockfish and about 44 cm fork length for female rougheye rockfish (McDermott 1994). For both species, the largest immature females were about 50 to 55 cm. For either species, there is no information on male size at maturity or on maximum size of juvenile males.

D.13.2 Fishery

Although shortraker and rougheye rockfish are found as far south as southern California, commercial quantities are primarily harvested from Washington north to Alaska waters. Shortraker and rougheye rockfish are presently managed as bycatch-only species in Alaska and are taken by both trawl and longline gear. In recent years, trawling has accounted for about 60 percent of the catch and longlining about 40 percent (Clausen et al. 2003). Commercial harvests usually occur on the slope from 984 to 1,640 feet (300 to 500 m) deep. Both species are associated with soft to rocky habitats along the continental slope, although boulders and steeply sloping terrain appear to be a desirable habitat feature for both species (Krieger 1992, Krieger and Ito 1999). Trawling in such habitats often requires specialized fishing skills to avoid gear damage and to keep the trawl in the proper fishing configuration. One study estimated age at recruitment for rougheye rockfish to be 30 years (Nelson and Quinn 1987), and it is probably on the order of 20+ years for shortraker rockfish. Shortraker and rougheye rockfish are often caught as bycatch in trawl fisheries for Pacific ocean perch and in longline fisheries for sablefish and halibut.

D.13.3 Relevant Trophic Information

Rougheye rockfish in Alaska feed primarily on shrimps (especially pandalids), and various fish species such as myctophids are also consumed (Yang and Nelson 2000; Yang 2003). However, smaller juvenile rougheye rockfish (less than 12 inches [30 cm] fork length) in the GOA also consume a substantial amount of smaller invertebrates such as amphipods, mysids, and isopods (Yang and Nelson 2000). The diet of shortraker rockfish in the GOA is not well known; however, based on a very small sample size in the Yang and Nelson (2000) study, the diet appears to be mostly squid, shrimp, and deepwater fish such as myctophids. A food study in the AI with a larger sample size of shortraker rockfish also found myctophids, squid, and shrimp to be major prey items (Yang 2003). In addition, gammarid amphipods, mysids, and miscellaneous fish were important food items in some years. It is uncertain what constitute the main predators on both species.

D.13.4 Habitat and Biological Associations

Egg/Spawning: The timing of reproductive events is apparently protracted. One study indicated that vitellogenesis was present for 4 to 5 months and lasted from about July until late October and November (McDermott 1994). This study also reported that parturition (i.e., larval release) occurred mainly in February through August for shortraker rockfish and December through April for rougheye rockfish. There is no information as to when males inseminate females or if migrations for spawning/breeding occur.

Larvae: Information on larval shortraker and rougheye rockfish is very limited. Larval shortraker rockfish have been identified in pelagic plankton tows in coastal Southeast Alaska (Gray et al. 2004), and it is likely that larval rougheye rockfish are also pelagic. Larval studies are hindered because the larvae at present can be positively identified only by genetic analysis, which is both expensive and labor-intensive.

Post-larvae and early young-of-the year: One study used genetics to identify two specimens of shortraker rockfish and one of rougheye rockfish in these life stages from samples collected in epipelagic waters far offshore in the GOA (Gharrett et al. 2002). This limited information is the only documentation of habitat preferences for these life stages.

Juveniles: Little information is available regarding the habitats and biological associations of juvenile shortraker and rougheye rockfish. This is especially true for small juvenile shortraker rockfish, as only a few specimens less than 14 inches (35 cm) fork length have been caught in the GOA. Juvenile shortraker rockfish are presumably demersal, as there have been no known catches in pelagic trawls or in off-bottom sampling gear. In contrast, juvenile rougheye rockfish 6 to 16 inches (15 to 40 cm) fork length are frequently caught in GOA bottom trawl surveys (Clausen et al. 2003). They are generally found at shallower, more inshore areas than adults. These areas range from inshore fiords to offshore waters of the continental shelf. Other than the fact that they have been taken on trawlable bottom, however, habitat preferences for juvenile rougheye rockfish are unknown.

Adults: Adult shortraker and rougheye rockfish are demersal and are concentrated at depths of 984 to 1,640 feet (300 to 500 m) along the continental slope. Observations from a manned submersible indicate that these fish occur over a wide range of habitats (Krieger 1992, Krieger and Ito 1999, Krieger and Wing 2002). Soft substrates of sand or mud usually had the highest densities, whereas hard substrates of bedrock, cobble, or pebble usually had the lowest adult densities (Krieger and Ito 1999). Habitats with steep slopes and frequent boulders were used at a higher rate than habitats with gradual slopes and few boulders (Krieger 1992, Krieger and Ito 1999). One of the submersible studies found shortraker and rougheye rockfish had a strong association with Primnoa spp. coral growing on boulders: less than 1 percent of the observed boulders had coral, but 85 percent of the "large" rockfish (which included redbanded rockfish along with shortraker and rougheye) were next to boulders with coral (Krieger and Wing 2002).

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	U	N/A	N/A	N/A	N/A	N/A	N/A	
Larvae	U	U	Parturition: SR: Feb-Aug RE: Dec-Apr	U	Pelagic	N/A	U	
Post-larvae/ early juvenile	< 6 months	U	Summer	LSP, BSN	Epipelagic	N/A	U	
Juveniles	Up to 20 years of age	Shrimp Mysids Amphipods Isopods	U	SR: U RE: ICS, MCS, OCS	SR: U, probably D RE: D	SR: U RE: U, but trawlable	U	
Adults	20 to >100 years of age	Shrimp Squid Myctophids	Year-round?	USP	D	M, S, R, SM, CB, MS, G, C steep slopes and boulders	U	Observed associated with *Primnoa* coral

D.13.5 Additional Sources of Information

Larvae: Art Kendall, AJALA Enterprises, La Conner, WA.

D.13.6 Literature

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

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

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

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

Gray, A.K., A.W. Kendall, B.L. Wing, M.G. Carls, J. Heifetz, Z. Li, and A.J. Gharrett. 2004. Identification of larval rockfish (Sebastes spp.) collected in Southeast Alaska coastal waters (1997-2000) using restriction site analysis of the mitochondrial ND3/ND4 region. Unpubl. manuscr. 22 p. (Available from NMFS Auke Bay Laboratory, 11305 Glacier Hwy., Juneau AK 99801).

Krieger, K. 1992. Shortraker rockfish, Sebastes borealis, observed from a manned submersible. Mar. Fish. Rev., 54(4): 34-37.

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

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

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

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

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

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

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

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

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

D.14 Light Dusky rockfish *(Sebastes ciliatus)*

Previously, the taxonomy of dusky rockfish was unclear. Two varieties occur which are now believed to be distinct species: an inshore, shallow water, dark-colored variety; and a lighter-colored variety found in deeper water offshore. A taxonomic study is soon to be completed that will describe the light variety as a new species. To avoid confusion, and because the light variety appears to be more abundant and is the object of a directed trawl fishery, this discussion of essential habitat will deal only with “light” dusky rockfish.

D.14.1 Life History and General Distribution

Light dusky rockfish range from Dixon Entrance at the US/Canada boundary, around the arc of the GOA, and westward throughout the AI. They are also found in the EBS north to about Zhemchug Canyon west of the Pribilof Islands. In the northwest Pacific, dusky rockfish are reported to range southwestward to Japan, but it is unknown which variety this refers to. Their distribution south of Dixon Entrance in Canadian waters is likewise uncertain; dusky rockfish have been reported as far south as Johnstone Strait, Vancouver Island, but it is likely these were of the dark variety. The center of abundance for light dusky rockfish appears to be the GOA. Adult light dusky rockfish have a very patchy distribution, and are usually found in large aggregations at specific localities of the outer continental shelf. These localities are often relatively shallow offshore banks. Because the fish are taken with bottom trawls, they are presumed to be mostly demersal. Whether they also have a pelagic distribution is unknown, but there is no particular evidence of a pelagic tendency based on the information available at present. Most of what is known about light 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 light dusky rockfish is extremely sparse. The fish are assumed to be viviparous, as are other Sebastes, with internal fertilization and incubation of eggs. Observations during research surveys in the GOA suggest that parturition (larval release) occurs in the spring, and is probably completed by summer. Another, older source, however, lists parturition as occurring "after May." Pre-extrusion larvae have been described, but field-collected larvae cannot be identified to species at present. Length of the larval stage, and whether a pelagic juvenile stage occurs, are unknown. There is no information on habitat and abundance of young juveniles (<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.

Light dusky rockfish is a slow growing species, with a low rate of natural mortality estimated at 0.09. However, it appears to be faster growing than many other rockfish species. Maximum age is 51 to 59 years. Estimated age at 50 percent maturity for females is 11.3 years. No information on fecundity is available.

The approximate upper size limit of juvenile fish is 47 cm for females (size at 50 percent maturity is 43 cm); 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.14.2 Fishery

Light dusky rockfish are caught almost exclusively with bottom trawls. A precise estimate of age at 50 percent recruitment is not available, but has been roughly estimated to be about 10 years based on length frequency information from the fishery. The fishery in the GOA in recent years has mostly occurred in the summer months, especially July, due to management regulations. Catches are concentrated at a number of relatively shallow, offshore banks of the outer continental shelf, especially the "W" grounds west of Yakutat, and Portlock Bank. Other fishing grounds include Albatross Bank, the "Snakehead" south of Kodiak Island, and Shumagin Bank. Outside of these banks, catches are generally sparse. Most of the catch appears to be taken at depths of 100 to 200 m.

The major bycatch species in the GOA light dusky rockfish trawl fishery in 1994-96 included (in descending order by percent bycatch rate) northern rockfish and Pacific ocean perch.

D.14.3 Relevant Trophic Information

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

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

D.14.4 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 <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. A manned submersible study in the eastern Gulf observed juvenile (<40 cm) light dusky rockfish associated with Primnoa spp. coral.

Adults: Commercial fishery and research survey data indicate that adult light dusky rockfish are primarily found on offshore banks of the outer continental shelf at depths of 100 to 200 m. Type of substrate in this habitat has not been documented, but it may be rocky. During submersible dives on the outer shelf (40 to 50 m) in the eastern Gulf, adult light dusky rockfish were observed in association with rocky habitats and in areas with extensive sponge beds where the fish were observed resting in large vase sponges (pers. Comm. V. O'Connell). Light dusky rockfish are the most highly aggregated of the rockfish species caught in GOA trawl surveys. Outside of these aggregations, the fish are sparsely distributed. Because the fish are generally taken only with bottom trawls, they are presumed to be mostly demersal. Whether they also have a pelagic distribution is unknown, but there is no evidence of a pelagic tendency based on the information available at present. There is no information on seasonal migrations. Light dusky rockfish often co-occur with northern rockfish.

Habitat and Biological Associations: Light Dusky Rockfish

Stage - EFH Level	Duration or Age	Diet/Prey	Season/ Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs	U	NA	U	NA	NA	NA	NA	NA
Larvae	U	U	Spring-summer	U	P (assumed)	NA	U	U
Early Juveniles	U	U	All year	U	U	U	U	U
Late Juveniles	Up to 11 years	U	U	ICS, MCS, OCS	D	CB, R, G	U	Observed associated with *Primnoa* coral
Adults	11 up to 51-59 years.	Euphausiids	U, except that larval release may be in the spring in the GOA	OCS, USP	D,	CB, R, G	U	Observed associated with large vase-type sponges

D.14.5 Additional Sources of Information

Eggs, Larvae, and Juveniles: None at present.

Adults: Rebecca Reuter, c/o NMFS, Alaska Fisheries Science Center, REFM Division.

D.14.6 Literature

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

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

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

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

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

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

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

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

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

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

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

D.15 Yelloweye rockfish *(Sebastes ruberrimus)* and other demersal rockfishes

Yelloweye rockfish (primary, described below), *Sebastes ruberrimus*

Quillback rockfish, *Sebastes maliger*

Rosethorn rockfish, *Sebastes helvomaculatus*

Tiger rockfish, *Sebastes nigrocinctus*

Canary rockfish, *Sebastes pinniger*

China rockfish, *Sebastes nebulosus*

Copper rockfish, *Sebastes caurinus*

D.15.1 Life History and General Distribution

These species are distributed from Ensendada, northern Baja California to Umnak Island and Unalaska Island, Aleutians in depths from 60 to 1,800 feet but commonly in 300 to 600 feet in rocky, rugged habitat (Allen and Smith 1988, Eschmeyer et al. 1983). Little is known about the young of the year and settlement. Young juveniles between 2.5 and 10 cm have been observed in areas of high and steep relief, in depths deeper than 15 m. Subadult and adult fish are generally solitary, occurring in rocky areas and high relief with refuge space, particularly overhangs, caves and crevices (O'Connell and Carlile 1993). Yelloweye are ovoviviparous. Parturition occurs in southeast Alaska between April and July with a peak in May (O'Connell 1987). Fecundity ranges from 1,200,000 to 2,700,000 eggs per season (Hart 1942, O'Connell unpublished data). Yelloweye feed on a variety of prey, primarily fishes (including other rockfishes, herring, and sandlance) as well as caridean shrimp and small crabs. Yelloweye are a K-selected species with late maturation, slow growth, extreme longevity, and low natural mortality. They reach a maximum length of about 91 cm and growth slows considerably after age 30. Approximately 50 percent are mature at 45 cm and 22 years, natural mortality (M) is estimated to be 0.02, and maximum age reported is 118 years (O'Connell and Fujioka 1991, O'Connell and Funk 1987).

Length at 50 percent sexual maturity is 45 cm for females and 50 cm for males.

D.15.2 Fishery

Demersal shelf rockfish are the target of a directed longline fishery and are the primary bycatch species in the longline fishery for Pacific halibut. They recruit into the fishery at about age 18 to 20 at a length between 45 and 50 cm. The commercial fishery grounds are usually areas of rocky bottom between 20 and 100 fm. The directed fishery now occurs between November and March both because of higher winter prices and limitations imposed due to the halibut IFQ regulations.

D.15.3 Relevant Trophic Information

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

D.15.4 Habitat and Biological Associations

Young juveniles between 2.5 (1 inch) and 10 cm (4 inches) have been observed in areas of high relief (vertical walls, cloud sponges, fjord-like areas) in depths deeper than 15 m (Christiansen, Jeff, The Seattle Aquarium, personal communication). Subadult (late juveniles) and adult fish are generally solitary, occurring in rocky areas and high relief with refuge spaces particularly overhangs, caves and crevices (O'Connell and Carlile 1993). Not infrequently an adult yelloweye rockfish will cohabitate a cave or refuge space with a tiger rockfish. Habitat specific density data shows an increasing density with increasing habitat complexity: deep water boulder fields consisting of very large boulders have significantly higher densities than other rock habitats (O'Connell and Carlile 1993). Although yelloweye do occur over cobble and sand bottoms, generally this is when foraging and often these areas directly interface with a rock wall or outcrop.

Habitat and Biological Associations: Yelloweye Rockfish

Stage - EFH Level	Duration or Age	Diet/Prey	Season/ Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs	na							
Larvae	<6 mo	Copepod	Spring/ Summer	U	N?	U	U	
Early Juveniles	to 10 years	U		ICS, MCS, OCS, BAY, IP	D	R, C	U	
Late Juveniles	10 to 18 years	U		ICS, MCS, OCS, BAY, IP	D	R, C	U	
Adults	At least 118 years	Fish, shrimp, crab	Parturition: Apr-Jul	ICS, MCS, OCS, USP, BAY, IP	D	R, C, CB	U	

Habitat and Biological Associations: Other Rockfishes.

Species	Range/Depth	Maximum Age	Trophic	Parurition	Known Habitat
Quillback	Kodiak Island to San Miguel Island, CA To 274 m (commonly 12-76 m)	At least 32 50 percent SM=30 cm	Main prey = crustaceans, herring, Sandlance	Spring (Mar-Jun)	Juveniles have been observed at the margins of kelp beds, adults occur over rock bottom, or over cobble/sand next to reefs
Copper	Shelikof St to central Baja, CA Shallow to 183 m (commonly to 122 m)	At least 31 years 50 percent SM=5 yr	Crustaceans Octopi Small fishes	Mar-Jul	Juveniles have been observed near eelgrass beds and in kelp, in areas of mixed sand and rock. Adults are in rocky bays and shallow coastal areas, generally less exposed than the other DSR
Tiger	Kodiak Is and Prince William Sound to Tanner-Cortes Banks, CA From 33 to 183 m	To 116 years	Invertebrates, primarily crustaceans	Early spring	Juveniles and adults in rocky areas: most frequently observed in boulder areas, generally under overhangs.
China	Kachemak Bay to San Miguel Island, CA To 128 m	To 72 years	Invertebrates, Brittle stars are significant component of diet	Apr-Jun	Juveniles have been observed in shallow kelp beds, adults in rocky reefs and boulder fields. Some indications that adults have a homesite.
Rosethorn	Kodiak Is to Guadalupe Is, Baja, CA To 25 m to 549 m	To 87 years Mature 7-10 years		Feb-Sept (May)	Observed over rocky habitats and in rock pavement areas with large sponge cover
Canary	Shelikof St to Cape Colnett, Baja, CA To 424 m (commonly to 137 m)	To 75 years 50 percent sm = 9	Macroplankton and small fishes		Occur over rocky and sand/cobble bottoms, often hovering in loose schools over soft bottom near rock outcrops. Schools often associate with schools of yellowtail and silvergrey.

D.15.5 Additional Sources of Information

NMFS, Alaska Fisheries Science Center.

D.15.6 Literature

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

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

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

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

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

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

D.16 Thornyhead Rockfish *(Sebastolobus spp.)*

D.16.1 Life History and General Distribution

Thornyheads of the northeastern Pacific Ocean comprise two species, the shortspine thornyhead (Sebastolobus alascanus) and the longspine thornyhead (S. altivelis). The longspine thornyhead is not common in the GOA. The shortspine thornyhead is a demersal species which inhabits deep waters from 93 to 1,460 m from the BS to Baja California. This species is common throughout the GOA, EBS and AI. The population structure of shortspine thornyheads, however, is not well defined. Thornyheads 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. Juvenile shortspine thornyheads have a pelagic period of about 14 to 15 months and settle out at about 22 to 27 mm. Fifty percent of female shortspine thornyheads are sexually mature at about 21 cm and 12 to 13 years of age.

Female shortspine thornyheads appear to be mature at about 21 to 22 cm.

D.16.2 Fishery

Trawl and longline gear are the primary methods of harvest. The bulk of the fishery occurs in late winter or early spring through the summer. In the past, this species was seldom the target of a directed fishery. Today thornyheads are one of the most valuable of the rockfish species, with most of the domestic harvest exported to Japan. Thornyheads are taken with some frequency in the longline fishery for sablefish and cod and is often part of the bycatch of trawlers concentrating on pollock and Pacific ocean perch.

D.16.3 Relevant Trophic Information

Shortspine thornyheads prey mainly on epibenthic shrimp and fish. Yang (1993, 1996) showed that shrimp were the top prey item for shortspine thornyheads in the GOA; whereas, cottids were the most important prey item in the AI 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 AI area was larger than that in the GOA (33.4 cm vs 29.7 cm).

D.16.4 Habitat and Biological Associations

Egg/Spawning: Eggs float in masses of various sizes and shapes. Frequently the masses are bilobed with the lobes 15 cm 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, S. Macrochir, are infrequently encountered in the GOA.

Habitat and Biological Associations: Thornyhead Rockfish

Stage - EFH Level	Duration or Age	Diet/Prey	Season/ Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs	U	U	Spawning: Late winter and early spring	U	P	U	U	
Larvae	<15 Months	U	Early spring through summer	U	P	U	U	
Juveniles	> 15 months when settling to bottom occurs (?)	U Shrimp, Amphipods, Mysids, Euphausiids?	U	MCS, OCS, USP	D	M, S, R, SM, CB, MS, G	U	
Adults	U	Shrimp Fish (cottids), Small crabs	MCS, OCS, USP, LSP	D	M, S, R, SM, CB, MS, GU		Year-round?	

D.16.5 Additional Sources of Information

NMFS, Alaska Fisheries Science Center.

D.16.6 Literature

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

Aton, M. 1981. GOA bottomfish and shellfish resources. U.S. Dep. Commer. Tech. Memo. NMFS F/NWC-10, 51 p.

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 GOA, p. 230-270. Council, 605 West 4th Avenue, Suite 306, Anchorage, AK 99501.

Ianelli, J.N., D.H. Ito, and M. Martin. 1996. Thornyheads (Sebastolobus sp.). In Stock Assessment and fishery evaluation report for the groundfish resources of the GOA, p. 303-330. Council, 605 West 4th Avenue, Suite 306, Anchorage, AK 99501.

Jacobson, L.D. 1993. Thornyheads. In Status of living marine resources off the Pacific coast of the United States for 1993. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-26, 35-37 p.

Kramer, D.E., and V.M. O’Connell. 1986. Guide to northeast Pacific rockfishes, Genera Sebastes and Sebastolobus. Marine Advisory Bulletin No. 25: 1-78. Alaska Sea Grant College Program, University of Alaska.

Low, L.L. 1994. Thornyheads. In Status of living marine resources off Alaska, 1993. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-27, 56-57 p.

Sigler, M.F., and H.H. Zenger, Jr. 1994. Relative abundance of GOA sablefish and other groundfish based on the domestic longline survey, 1989. NOAA Tech. Memo. NMFS-AFSC-40.

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

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

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

D.17 Atka mackerel

D.17.1 Life History and General Distribution

Atka mackerel are distributed from the GOA to the Kamchatka Peninsula, and they are most abundant along the Aleutians. 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 AI Atka mackerel. Adults are semi-demersal, displaying strong diel behavior with vertical movements away from the bottom occurring almost exclusively during the daylight hours, presumably for feeding, and little to no movement at night. Spawning is demersal in moderately shallow waters and peaks in June through September, but may occur intermittently throughout the year. Female Atka mackerel deposit eggs in nests built and guarded by males on rocky substrates or on kelp in shallow water. Eggs develop and hatch at depth in 40 to 45 days, releasing planktonic larvae that have been found up to 800 km from shore. Little is known of the distribution of young Atka mackerel before their appearance in trawl surveys and the fishery at about age 2 to 3 years. R-traits are as follows: young age at maturity (approximately 50 percent are mature at age 3), fast growth rates, high natural mortality (M=0.3), and young average and maximum ages (about 5 and 14 years, respectively). K-selected traits indicate low fecundity (only about 30,000 eggs/female/year, large egg diameters (1 to 2 mm) and male nest-guarding behavior).

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

D.17.2 Fishery

The fishery consists of bottom trawls, which recruit at about age 3, and it is conducted in the AI and western GOA at depths between from 70 to 225 m, in trawlable areas on rocky, uneven bottom, along edges, and in the lee of submerged hills during periods of high current. Currently, the fishery occurs on reefs west of Kiska Island, south and west of Amchitka Island, in Tanaga Pass and near the Delarof Islands, and south of Seguam and Umnak Islands. Historically the fishery occurred east into the GOA as far as Kodiak Island (through the mid-1980s), but is no longer conducted there.

D.17.3 Relevant Trophic Information

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

D.17.4 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 moderately shallow water.

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

<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 AI Atka mackerel. Adults are semi-demersal/pelagic during

much of the year, but they migrate annually to moderately shallow waters where 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 to 45 days	NA	summer	IP,ICS	D	GR,R,K	U	develop 3-20°C optimum 9-13°C
Larvae	up to 6 mos	U copepods?	fall-winter	U	U N?	U	U	2-12°C optimum 5-7°C
Juveniles	½ to 2 years of age	U copepods & euphausiids?	all year	U	U	U	U	3-5°C
Adults	3+ years of age	copepods euphausiids meso-pelagic fish (myctophids)	Spawning (May-Oct) non-spawning (Nov-Apr) tidal/diurnal, year-round?	ICS and MCS, IP MCS and OCS, IP ICS,MCS, OCS,I	PD (males) SD females SD/D all sexes D when currents high/day SD slack tides/night	GR,R,K	F,E	3-5°C all stages >17 ppt only

D.17.5 Additional Sources of Information

NMFS, Alaska Fishery Science Center, FOCI program, Sandra Lowe.

D.17.6 Literature

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

Byrd, G.V., J.C. Williams, and R. Walder. 1992. Status and biology of the tufted puffin in the AI, Alaska, after a ban on salmon driftnets. U.S. Fish and Wildlife Service, Alaska Maritime National Wildlife Refuge, AI Unit, PSC 486, Box 5251, FPO AP 96506_5251, Adak, Alaska.

Doyle, M.J., W.C. Rugen, and R.D. Brodeur. 1995. Neustonic ichthyoplankton in the western GOA during spring. Fishery Bulletin 93: 231-253.

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

Gorbunova, N.N. 1962. Razmnozhenie I razvite ryb semeistva terpugovykh (Hexagrammidae) (Spawning and development of greenlings (family Hexagrammidae). Tr. Inst. Okeanol., Akad. Nauk SSSR 59:118_182. In Russian. (Trans. by Isr. Program Sci. Trans., 1970, p. 121_185 in T.S. Rass (editor), Greenlings: taxonomy, biology, interoceanic transplantation; available from the U.S. Dep. Commer., Natl. Tech. Inf. Serv., Springfield, VA., as TT 69_55097).

Kajimura, H. 1984. Opportunistic feeding of the northern fur seal Callorhinus ursinus, in the eastern north Pacific Ocean and EBS. 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. 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.

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.

Levada, T.P. 1979. Some data on biology and catch of Atka mackerel. Pac. Sci. Res. Inst. Fish. Oceanogr. (TINRO), Vladivostok, U.S.S.R., Unpublished manuscript.

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

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

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

Morris, B.F. 1981. An assessment of the living marine resources of the central BS 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 BS 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., and D.A. Somerton. 2002. Diurnal vertical migration of the Atka mackerel *Pleurogrammus monopterygius* as shown by archival tags. Mar Ecol Prog Ser 239: 193-207.

National Marine Fisheries Service (NMFS). 2004. Website: Resources Assessment and Conservation Engineering Field Videos—Underwater Habitat Footage, Alaska Fisheries Science Center. http://www.afsc.noaa.gob/race/media/videos/vids_habitat.htm.

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

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.

Rugen, W.C. 1990. Spatial and temporal distribution of larval fish in the western GOA, 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.

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).

Stone, R. 2004. Depth distribution, fisheries interactions, and habitat of deep-sea corals in the AI off of Alaska-Preliminary research data presented at American Association for the Advancement of Science. Seattle, Washington. NOAA Fisheries. Alaska Fisheries Science Center. Auke Bay Laboratory.

Waldron, K.D. 1978. Ichthyoplankton of the EBS, 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 EBS. Final Report (RU 380), Environmental Assessment of the Alaskan continental shelf, REFM, AFSC, NMFS, 7600 Sand Point Way, NE, Seattle, WA 98115. 88 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. Commer., NOAA Tech. Memo. NMFS-AFSC-6, 184 p.

Yang, M-S. 1996. Trophic role of Atka mackerel in the AI. Publ. Abstract in Role of forage fishes in marine ecosystems. Symposium held Nov 1996, AK Sea Grant, U. Alaska, Fairbanks.

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

D.18 Skates (Rajidae)

The species representatives for skates are:

Alaska skate (*Bathyraja parmifera)*

Aleutian skate (*Bathyraja aleutica)*

Bering skate (*Bathyraja interrupta)*

D.18.1 Life History and General Distribution:

Skates (Rajidae) that occur in the BSAI and GOA are grouped into two genera: Bathyraja sp., or soft-nosed species (rostral cartilage slender and snout soft and flexible), and Raja sp., or hard-nosed species (rostral cartilage is thick making the snout rigid). Skates are oviparous; fertilization is internal, and eggs (one to five or more in each case) are deposited in horny cases for incubation. Adults and juveniles are demersal and feed on bottom invertebrates and fish. Adult distributions from survey are Alaska skate: mostly 50 to 200 m on shelf in EBS and AI (AI), less common in the GOA (GOA); Aleutian skate: throughout EBS and AI, but less common in GOA, mostly 100 to 350 m; Bering Skate: throughout EBS and GOA, less common in AI, mostly 100 to 350 m. Little is known of their habitat requirements for growth or reproduction, nor of any seasonal movements. BSAI skate biomass estimate more than doubled between 1982 to 1996 from bottom trawl survey; it may have decreased in the GOA and remained stable in the AI in the 1980s.

Approximate upper size limit of juvenile fish is unknown.

D.18.2 Fishery

Until 2003, skates were not a target of groundfish fisheries of BSAI or GOA, but were caught as bycatch (13,000 to 17,000 mt per year in the BSAI from 1992 to 1995; 1,000 to 2,000 mt per year in the GOA) principally by the longline Pacific cod and bottom trawl pollock and flatfish fisheries; almost all were discarded. Skate bycatches in the EBS groundfisheries ranged between 1 and 4 percent of the annual EBS trawl survey biomass estimates from 1992 to 1995.

Starting in 2003, a directed fishery for skates developed in the GOA centered around Kodiak Island. It is prosecuted primarily on longline vessels less than 60 feet long, with some additional targeting by trawlers using large mesh nets. The primary target species appears to be Raja binoculata, followed by Raja rhina, but this is difficult to determine given that there is almost no observer coverage of the fishery. As of late July 2003, over 2,000 tons of skates had been landed. The market price per pound of skates is comparable to that of cod so the fishery is expected to continue and perhaps expand.

D.18.3 Relevant Trophic Information

Skates feed on bottom invertebrates (crustaceans, molluscs, and polychaetes) and fish.

D.18.4 Habitat and Biological Associations

<u>*Egg/Spawning*</u>: Skates deposit eggs in horny cases on shelf and 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; surveys found most skates at depths <500 m in the GOA and EBS, but >500 m in the AI. In the GOA, most skates found between 4-7°C, but data are limited.

Habitat and Biological Associations: Skates

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

D.18.5 Additional sources of information

NMFS, Alaska Fisheries Science Center, Sarah Gaichas

D.18.6 Literature

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

Eschmyer, W.N., and E.S. Herald. 1983. A field guide to Pacific coast fishes, North America. Houghton Mifflin Co., Boston. 336 p.

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

Hart, J.L. 1973. Pacific fishes of Canada. Fisheries Res. Bd. Canada Bull. 180. Ottawa. 740 p.

Teshima, K., and T.K. Wilderbuer. 1990. Distribution and abundance of skates in the EBS, AI region, and the GOA. Pp. 257-267 *in* H.L. Pratt, Jr., S.H. Gruber, and T. Taniuchi (eds.)., Elasmobranchs as living resources: advances in the biology, ecology, systematics and the status of the fisheries. U.S. Dep. Commerce., NOAA Technical Report 90.

D.19 Squid

The species representatives for squid are:

Gonaditae:	Red or magistrate armhook squid (Berryteuthis magister)
Onychoteuthidae:	Boreal clubhook squid (Onychoteuthis banksii borealjaponicus)
	Giant or robust clubhook squid (Moroteuthis robusta)
Sepiolidae:	eastern Pacific bobtail squid (Rossia pacifica)

D.19.1 Life History and General Distribution:

Squid are members of the molluscan class *Cephalopoda*, along with octopus, cuttlefish, and nautiloids. In the BSAI and GOA, gonatid and onychoteuthid squids are generally the most common, along with chiroteuthids. All cephalopods are stenohaline, occurring only at salinities >30 ppt. Fertilization is internal, and 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-early summer, with eggs hatching during the summer. Most small squid are generally thought to live only 2 to 3 years, but the giant *Moroteuthis robusta* clearly lives longer.

B magister is widely distributed in the boreal north Pacific from California, throughout the BS, to Japan in waters 30 to 1,500 m deep; adults are most often found at mesopelagic depths or near bottom on shelf, rising to the surface at night; juveniles are widely distributed across shelf, slope, and abyssal waters in meso- and epipelagic zones, and they rise to the surface at night. They migrate seasonally, moving northward and inshore in summer, and southward and offshore in winter, particularly in the western north Pacific. Maximum size for females is 50 cm mantle length (ML); for males, maximum size is 40 cm ML. Spermatophores are transferred into the mantle cavity of the 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 of eggs occurs from February to March in Japan, but apparently year-round in the BS.

Eggs hatch after 1 to 2 months of incubation; development is direct. Adults are gregarious prior to and most die after mating.

O. banksii borealjaponicus, an active, epipelagic species, is distributed in the north Pacific from the Sea of Japan, throughout the AI and south to California, but is absent from the Sea of Okhotsk and is not common in the BS. Juveniles can be found over shelf waters at all depths and near shore. Adults apparently prefer the upper layers over slope and abyssal waters; they 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 BS, AI, and GOA. Mantle length can be up to 2.5 m long, with tentacles, at least 7 m, 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 BS in waters of about 20 to 300 m depth. Other *Rossia* spp. deposit demersal egg masses.

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

D.19.2 Fishery

Squid are not currently a target of groundfish fisheries of BSAI or GOA. A Japanese fishery catching up to 9,000 mt of squid annually existed until the early 1980s for B. magister in the BS and O. banksii borealjaponicus in the AI. Since 1990, annual squid bycatch has been about 1,000 mt or less in the BSAI and between 30 to 150 mt in the GOA; in the BSAI, almost all squid bycatch is in the midwater pollock fishery near the continental shelf break and slope, while in the GOA, trawl fisheries for rockfish and pollock (again mostly near the edge of the shelf and on the upper slope) catch most of the squid bycatch.

D.19.3 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, small planktonic zooplankton (copepods) are eaten. Squid are preyed upon by marine mammals, seabirds, and, to a lesser extent by fish, and they occupy an important role in marine food webs worldwide. Perez (1990) estimated that squids comprise over 80 percent of the diets of sperm whales, bottlenose whales, and beaked whales and about half of the diet of Dall's porpoise in the EBS and AI. 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 (Hatch et al. 1990, Byrd et al. 1992, Springer 1993). In the GOA, only about 5 percent or less of the diets of most groundfish consisted of squid (Yang 1993). However, squid play a larger role in the diet of salmon (Livingston and Goiney 1983).

D.19.4 Habitat and Biological Associations for B. 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) on the shelf (summer only?), but mostly in outer shelf/slope waters (to lesser extent over the open ocean). They migrate to slope waters to mate and spawn demersally.

Habitat and Biological Associations: Berryteuthis magister (red squid)

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

D.19.5 Additional sources of information

NMFS, Alaska Fisheries Science Center, Sarah Gaichas

NMFS, Alaska Fisheries Science Center, Beth Sinclair

D.19.6 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 BS. 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 AI, Alaska, after a ban on salmon driftnets. U. S. Fish and Wildlife Service, Alaska Maritime National Wildlife Refuge, AI 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 BSAI Regions as Projected for 1997. 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.

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.

Perez, M. 1990. Review of marine mammal population and prey information for BS 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 BS. Pp. 135-141 *In* O.A. Mathisen and K.O. Coyle (eds.), Ecology of the BS: 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 GOA in 1990. U.S. Dep. Commerce., NOAA Tech. Memo. NMFS-AFSC-22, 150 p.

D.20 Sculpins

The species representatives for sculpins are:

Yellow Irish lord (*Hemilepidotus jordani)*

Red Irish lord (*Hemilepidotus hemilepidotus*)

Butterfly sculpin (*Hemilepidotus papilio*)

Bigmouth sculpin (*Hemitripterus bolini*)

Great sculpin (*Myoxocephalus polyacanthocephalus*)

Plain sculpin (*Myoxocephalus jaok*)

D.20.1 Life History and General Distribution

Cottidae (sculpins) is a large circumboreal family of demersal fishes inhabiting a wide range of habitats in the north Pacific Ocean and BS. 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 all year-round in ichthyoplankton collections from the southeast BS and 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: They are distributed from subtidal areas near shore to the edge of the continental shelf (down to 200 m) throughout the BS, AI, and eastward into the GOA as far as Sitka, AK; up to 40 cm in length. 12 to 26 mm larvae collected in spring on the western GOA shelf.

Red Irish lords: They are 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 BS 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.

Butterfly sculpins: They are distributed primarily in the western north Pacific and northern BS, from Hokkaido, Japan, Sea of Okhotsk, Chukchi Sea, to southeast BS and in AI; depths of 20 to 250 m, most frequent 50 to 100 m.

Bigmouth sculpin: They are distributed in deeper waters offshore, between about 100 to 300 m in the BS, AI, and throughout the GOA; up to 70 cm in length.

Great sculpin: They are 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. They are found throughout the BS, AI, 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: They are distributed throughout the BS and GOA (not common in the AI) from intertidal areas to depths of about 100 m, but most common in shallow waters (<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.20.2 Fishery

Sculpins are not a target of groundfish fisheries of BSAI or GOA, but sculpin bycatch (second to skates in weight amongst the other species) has ranged from 6,000 to 11,000 metric tons (mt) per year in the BSAI from 1992 to 1995, and 500 to 1,400 mt per year in the GOA. Bycatch occurs principally in bottom trawl fisheries for flatfish, Pacific cod, and pollock, but also while longlining for Pacific cod; almost all is discarded. Annual sculpin bycatch in the BSAI ranges between 1 and 4 percent of annual survey biomass estimates; however, little is known of the species distribution of the bycatch.

D.20.3 Relevant Trophic Information

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

D.20.4 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 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 in 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 (MSC-OSC?)	D	R (others?)	U	
Larvae	U	copepods	all year?	ICS-MSC,OCS,US	N,P	na?	U	
Juveniles and Adults	U	bottom invertebrates (crabs, molluscs, barnacles) and small fish	all year	BCH,ICS, MSC, OSC, USP	D	R, S, M, SM	U	

D.20.5 Additional sources of information

NMFS, Alaska Fisheries Science Center, Sarah Gaichas.

D.20.6 Literature

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

Doyle, M.J., W.C. Rugen, and R.D. Brodeur. 1995. Neustonic ichthyoplankton in the western GOA 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 BSAI Regions as Projected for 1997. Council, 605 West 4th Avenue, Suite 306, Anchorage, AK 99501.

Hart, J.L. 1973. Pacific fishes of Canada. Fisheries Res. Bd. Canada Bull. 180. Ottawa. 740 p.

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.

Rugen, W.C. 1990. Spatial and temporal distribution of larval fish in the western GOA, 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 EBS, 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 EBS. 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.21 Sharks

The species representatives for sharks are:

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

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. The Lamnidae are large, ovoviviparous (with small litters, 1 to 4; embryos nourished by intrauterine cannibalism), widely migrating sharks which are highly aggressive predators (salmon and white sharks). The Lamnidae are partly warm-blooded; the heavy trunk muscles are warmer than water for greater power and efficiency. Salmon sharks are distributed epipelagically along the shelf (can be found in shallow waters) from California through the GOA (where they occur all year and are probably most abundant in Alaska waters), the BS, and off Japan. In groundfish fishery and survey data, they occur chiefly on outer shelf/upper slope areas in the BS, but near the coast to the outer shelf in the GOA, particularly near Kodiak Island. They are not commonly seen in AI. They are believed to eat primarily fish, including salmon, sculpins, and gadids and can be up to 3 m in length.

The Pacific sleeper shark is distributed from California around the Pacific rim to Japan and in the BS principally on the outer shelf and upper slope (but has been observed nearshore), generally demersal (but also seen near surface). Other members of the Squalidae are ovoviviparous, but fertilization and development of sleeper sharks are not known; adults are up to 8 m in length. They are voracious, omnivorous predators of flatfish, cephalopods, rockfish, crabs, seals, and salmon; they may also prey on pinnipeds. In groundfish fishery and survey data, they occur chiefly on outer shelf/upper slope areas in the BS, but near coast to the outer shelf in the GOA, particularly near Kodiak Island.

Spiny dogfish (or closely related species?) are widely distributed through the Atlantic, Pacific, and Indian Oceans. In the north Pacific, they may be most abundant in the GOA, but are also common in the BS. They are pelagic species and are found at surface and to depths of 700 m; they are mostly found at 200 m or less on shelf and neritic; they are often found in aggregations. They are ovoviviparous, with litter size proportional to the size of the female, from 2 to 9; gestation may be 22 to 24 months. Young are 24 to 30 cm at birth, with growth initially rapid, then it slows dramatically. Maximum adult size is about 1.6 m and 10 kg; maximum age is about 40 years. Fifty percent of females are mature at 94 cm and 29 years old; males are mature at 72 cm and 19 years old. Females give birth in shallow coastal waters, usually from September to January. Dogfish eat a wide variety of foods, including fish (smelts, herring, sand lance, and other small schooling fish), crustaceans (crabs, euphausiids, shrimp), and cephalopods (octopus). 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.

The approximate upper size limit of juvenile fish is unknown for salmon sharks and sleeper sharks; for spiny dogfish, it is 94 cm for females, and 72cm for males.

D.21.2 Fishery

Sharks are not a target of groundfish fisheries of BSAI or GOA, but shark bycatch has ranged from 300 to 700 mt per year in the BSAI from 1992 to 1995; 500 to 1,400 mt per year in the GOA principally by pelagic trawl fishery for pollock, longline fisheries for Pacific cod and sablefish, and bottom trawl fisheries for pollock, flatfish, and cod; almost all are discarded. Little is known of shark biomass in BSAI or GOA.

D.21.3 Habitat and Biological Associations

Egg/Spawning: Salmon sharks and spiny dogfish are ovoviviparous; reproductive strategy of sleeper sharks is not known. Spiny dogfish give birth in shallow coastal waters, while salmon sharks probably give birth offshore and pelagic.

Juveniles and Adults: Spiny dogfish are widely dispersed throughout the water column on shelf in the GOA, and along outer shelf in the EBS; apparently they are not as commonly found in the AI and are not commonly found at depths >200 m.

Salmon sharks are found throughout the GOA, but are less common in the EBS and AI; they are epipelagic and are found primarily over shelf/slope waters in the GOA and on the outer shelf in the EBS.

Sleeper sharks are widely dispersed on shelf/upper slope in the GOA and along the outer shelf/upper slope only in the EBS; they are generally demersal and may be less commonly found in the AI.

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 and Larvae								
Juveniles and Adults								
Salmon shark	U	fish (salmon, sculpins and gadids)	all year	ICS, MSC. OCS, US in GOA; OCS, US in BSAI	P	NA	U	
Sleeper shark	U	omnivorous; flatfish, cephalopods, rockfish, crabs, seals, salmon, pinnipeds	all year	ICS, MSC, OCS, US in GOA; OCS, US in BSAI	D	U	U	
Spiny dogfish	40 years	fish (smelts, herring, sand lance, and other small schooling fish), crustaceans (crabs, euphausiids, shrimp), and cephalopods (octopus)	all year	ICS, MSC, OCS in GOA; OCS in BSAI give birth ICS in fall/winter?	P	U	U	Euhaline 4-16°C

D.21.4 Additional sources of information

NMFS, Alaska Fisheries Science Center, Sarah Gaichas.

D.21.5 Literature

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

Eschmyer, W.N., and E.S. Herald. 1983. A field guide to Pacific coast fishes, North America. Houghton Mifflin Co., Boston. 336 p.

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

Hart, J.L. 1973. Pacific fishes of Canada. Fisheries Res. Bd. Canada Bull. 180. Ottawa. 740 p.

D.22 Octopus

The species representatives for octopus are:

Octopoda: Octopus *(Octopus gilbertianus; O. dofleini*)

Vampyromorpha: Pelagic octopus (*Vampyroteuthis infernalis*)

D.22.1 Life History and General Distribution

Octopus are members of the molluscan class Cephalopoda, along with squid, cuttlefish, and nautiloids. In the BSAI and GOA, the most commonly encountered octopods are the shelf demersal species *O. gilbertianus* and *O. dofleini*, and the bathypelagic finned species, *V. infernalis*. Octopods, like other cephalopods are dioecious, with fertilization of eggs (usually within the mantle cavity of the female) requiring transfer of spermatophores during copulation. Octopods probably do not live longer than about 2 to 4 years, and females of some species (e.g., *O. vulgaris*) die after brooding their eggs on the bottom.

O. gilbertianus is a medium-size octopus (up to 2 m in total length) distributed across the shelf (to 500 m depth) in the eastern and western BS (where it is the most common octopus), AI, and GOA (endemic to the North Pacific). Little is known of its reproductive or trophic ecology, but eggs are laid on the bottom and tended by females. It lives mainly among rocks and stones.

O. dofleini is a giant octopus (up to 10 m in total length, though mostly about 3 to 5 m) distributed in the southern boreal region from Japan and Korea, through the AI, GOA, and south along the Pacific coast of North America to California. Inhabits the sublittoral to upper slope. Egg length is 6 to 8 mm, and they are laid on the bottom. Copulation may occur in late fall and winter, but oviposition is the following spring; each female lays several hundred eggs.

V. infernalis is a relatively small (up to about 40 cm total length) bathypelagic species, living at depths well below the thermocline; they may be most commonly found at 700 to 1,500 m. They are found throughout the world's oceans. Eggs are large (3 to 4 mm in diameter) and are shed singly into the water. Hatched juveniles resemble adults, but with different fin arrangements, which change to the adult form with development. Little is known of their food habits, longevity, or abundance.

The approximate upper size limit of juvenile fish is unknown.

D.22.2 Fishery

Octopus are not currently a target of groundfish fisheries of BSAI or GOA. Bycatch has ranged between 200 to 1,000 mt in the BSAI and 40 to 100 mt in the GOA, chiefly in the pot fishery for Pacific cod and bottom trawl fisheries for cod and flatfish, but sometimes in the pelagic trawl pollock fishery. Directed octopus landings have been less than 8 mt/year from 1988 to 1995. Age/size at 50 percent recruitment is unknown. Most of the bycatch occurs on the outer continental shelf (100 to 200 m depth), chiefly north of the Alaska Peninsula from Unimak Island to Port Moller and northwest to the Pribilof Islands; also around Kodiak Island and many of the AI.

D.22.3 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).

D.22.4 Habitat and Biological Associations

Egg/Spawning: Occurs on shelf; eggs are laid on bottom, maybe preferentially among rocks and cobble.

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

Old Juveniles and Adults: Are demersal; are 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 Features	Other
Eggs	U (1 to 2 months?)	NA	spring-summer?	U (IS, MS?)	D	R, G?	U	Euhaline waters
Young juveniles	U	zooplankton	summer-fall	U (IS, MS, OS, USL?)	D,SD	U	U	Euhaline waters
Older Juveniles and Adults	U (2 to 3 years? for *O. gilbertianus*; older for *O.dofleini*)	crustaceans, molluscs	all year	IS, MS, OS, USL	D?	R, G, S, MS	U	Euhaline waters

D.22.5 Additional sources of information

NMFS, Alaska Fisheries Science Center, Sarah Gaichas.

D.22.6 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.

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

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

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

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

D.23 Capelin (*osmeridae*)

The species representative for capelin is *Mallotus villosus*.

D.23.1 Life History and General Distribution

Capelin is a short-lived marine (neritic), pelagic, filter-feeding schooling fish distributed along the entire coastline of Alaska and the BS, and south along British Columbia to the Strait of Juan de Fuca; circumpolar. In the North Pacific, capelin grow to a maximum of 25 cm and 5 years of age. Spawn at ages 2 to 4 in spring and summer (May to 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, along the Alaska Peninsula and near Kodiak. Age at 50 percent maturity is 2 years. Fecundity is 10,000 to 15,000 eggs per female. Eggs hatch in 2 to 3 weeks. Most capelin die after spawning. Larvae and juveniles are distributed on 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. They are distributed along outer shelf and under ice edge in winter. Larvae, juveniles, and adults have diurnal vertical migrations following scattering layers – night near surface, at depth during the day. Smelts are captured during trawl surveys, but their patchy distribution both in space and time reduces the validity of biomass estimates.

The approximate upper size limit of juvenile fish is 13cm.

D.23.2 Fishery

Capelin are not a target species in groundfish fisheries of BSAI or GOA, but are caught as bycatch (up to several hundred tons per year in the 1990s) principally during the yellowfin sole trawl fishery in Kuskokwim and Togiak Bays in spring in the BSAI; almost all are discarded. Small local coastal fisheries occur in spring and summer.

D.23.3 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 (Hunt et al. 1981a, Sanger 1983). 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 (Frost and Lowry 1987, Wespestad 1987). 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 BS (Allen 1987, Yang 1993, Livingston, in prep.).

D.23.4 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-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 9ºC.

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 GOA, and around Kodiak Island.

Juveniles: In fall, juveniles are distributed pelagically in mid-shelf waters (50 to 100 m depth; -2 to 3ºC), 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 (~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 to 3 weeks to hatch	na	May-August	BCH (to 10 m)	D	S,CB		5-9°C peak spawning
Larvae	4 to 8 months?	Copepods phytoplankton	summer/fall/ winter	ICS-MCS	N,P	U NA?	U	
Juveniles	1.5+ years up to age 2	Copepods Euphausiids	all year	ICS-MCS	P	U NA?	U F? Ice edge in winter	
Adults	2 years ages 2-4+	Copepods Euphausiids polychaetes small fish	Spawning (May-August) non-spawning (Sep-Apr)	BCH (to 10 m) ICS-MCS-OCS	D,SD P	S,CB NA?	 F Ice edge in winter	 -2 - 3°C Peak distributions in EBS?

D.23.5 Additional Sources of Information

Paul Anderson, NMFS/RACE, Kodiak, AK.

Jim Blackburn, ADFG, Kodiak, AK.

Mark W. Nelson, NMFS/REFM, Seattle, WA.

D.23.6 Literature

Allen, M.J. 1987. Demersal fish predators of pelagic forage fishes in the southeastern BS. Pp. 29-32 In Forage fishes of the southeastern BS. 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 BS 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 GOA 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 BSAI Regions as Projected for 1997. 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 BS and GOA. Pp. 30-44 <u>In</u> 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 BS. Pp. 11-18 <u>In</u> Forage fishes of the southeastern BS. 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 EBS. Pp 629-647 <u>In</u> D.W. Hood and J.A. Calder (eds.), The EBS 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.

Livingston, P.A. In prep. Groundfish utilization of walleye pollock (*Theragra chalcogramma*), Pacific herring (*Clupea pallasi*) and capelin (*Mallotus villosus*) resources in the GOA. In preparation.

Morris, B.F., M.S. Alton, and H.W. Braham. 1983. Living marine resources of the GOA: a resource assessment for the GOA/Cook Inlet Proposed Oil and Gas Lease Sale 88. U.S. Dept. Commerce., NOAA, NMFS.

Murphy, E.C., R.H. Day, K.L. Oakley, and 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 BS. Pp. 237-256 *In* O.A. Mathisen and K.O. Coyle (eds.), Ecology of the BS: 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.

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 GOA. Fish. Bull., U.S. 78: 544-549.

Rugen, W.C. 1990. Spatial and temporal distribution of larval fish in the western GOA, 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 EBS, 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 EBS. 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 EBS. Pp. 55-60 In Forage fishes of the southeastern BS. 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 GOA in 1990. U.S. Dept. Commerce., NOAA Tech. Memo. NMFS-AFSC-22. 150 pp.

D.24 Eulachon *(osmeridae)*

The species representative for eulachon is the candlefish *(Thaleichthys pacificus*).

D.24.1 Life History and General Distribution

Eulachon is a short-lived anadromous, pelagic schooling fish distributed from the Pribilof Islands in the EBS, throughout the GOA, and south to California. Consistently found pelagically in Shelikof Strait (hydroacoustic surveys in late winter-spring) and between Unimak Island and the Pribilof Islands (bycatch in groundfish trawl fisheries) from the middle shelf to over the slope. In the North Pacific, eulachon grow to a maximum of 23 cm and 5 years of age. They spawn at ages 3 to 5 in spring and early summer (April to June) when they are about 14 to 20 cm in rivers on coarse sandy bottom. Their age at 50 percent maturity is 3 years. Fecundity equals ~25,000 eggs per female. Eggs adhere to sand grains and other substrates on river bottom. Eggs hatch in 30 to 40 days in BC at 4 to 7ºC. Most eulachon die after first spawning. Larvae drift out of rivers and develop at sea. Smelts are captured during trawl surveys, but their patchy distribution both in space and time reduces the validity of biomass estimates.

The approximate upper size limit of juvenile fish is 14cm.

D.24.2 Fishery

Eulachon and candlefish are not target species in groundfish fisheries of BSAI or GOA, but are caught as bycatch (up to several hundred tons per year in the 1990s) principally by midwater pollock fisheries in Shelikof Strait (GOA), on the east side of Kodiak (GOA), and between the Pribilof Islands and Unimak Island on the outer continental shelf and slope (EBS); almost all are discarded. Small local coastal fisheries occur in spring and summer.

D.24.3 Relevant Trophic Information

Eulachon may be 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 (Hunt et al. 1981a, Sanger 1983). 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 (Frost and Lowry 1987, Wespestad 1987). 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 BS (Allen 1987; Yang 1993; Livingston, in prep.).

D.24.4 Habitat and Biological Associations

Egg/Spawning: Anadromous; return to spawn in spring (May to June) in rivers; demersal eggs adhere to bottom substrate (sand, cobble, etc.). 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 1,000 m water depth), and have been found in highest concentrations between the Pribilof Islands and Unimak Island on the outer shelf, and in Shelikofeast of the Pribilof Islands, west of St. Matthew and St. Lawrence Islands and north into the Gulf of Anadyr.

Habitat and Biological Associations: Eulachon (Candlefish)

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

D.24.5 Additional Sources of Information

Paul Anderson, NMFS/RACE, Kodiak, AK.

Jim Blackburn, ADFG, Kodiak, AK.

Mark W. Nelson, NMFS/REFM, Seattle, WA.

D.24.6 Literature

Allen, M.J. 1987. Demersal fish predators of pelagic forage fishes in the southeastern BS. Pp. 29-32 In Forage fishes of the southeastern BS. 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 high 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 BS and GOA. 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 BS. Pp. 11-18 In Forage fishes of the southeastern BS. 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 EBS. Pp 629-647 In D.W. Hood and J.A. Calder (eds.), The EBS 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.

Livingston, P.A. In prep. Groundfish utilization of walleye pollock (*Theragra chalcogramma*), Pacific herring (*Clupea pallasi*) and capelin (*Mallotus villosus*) resources in the GOA. In preparation.

Morris, B.F., M.S. Alton, and H.W. Braham. 1983. Living marine resources of the GOA: a resource assessment for the GOA/Cook Inlet Proposed Oil and Gas Lease Sale 88. U.S. Dept. Commerce., NOAA, NMFS.

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 GOA. Fish. Bull., U.S. 78: 544-549.

Sanger, G.A. 1983. Diets and food web relationships of seabirds in the GOA 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 EBS. Pp. 55-60 In Forage fishes of the southeastern BS. 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 GOA in 1990. U.S. Dept. Commerce., NOAA Tech. Memo. NMFS-AFSC-22. 150 pp.

[this page intentionally left blank

Appendix E Maps of Essential Fish Habitat

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

Figures E-1 to E-3	Walleye pollock (eggs, larvae, late juveniles/adults)
Figures E-4 to E-6	Pacific cod (eggs, larvae, late juveniles/adults)
Figures E-7 to E-9	Yellowfin sole (eggs, larvae, late juveniles/adults)
Figures E-10 to E-11	Arrowtooth flounder (larvae, late juveniles/adults)
Figures E-12 to E-13	Rock sole (larvae, late juveniles/adults)
Figures E-14 to E-16	Alaska Plaice (eggs, larvae, late juveniles/adults)
Figures E-17 to E-19	Rex sole (eggs, larvae, late juveniles/adults)
Figures E-20 to E-22	Dover sole (eggs, larvae, late juveniles/adults)
Figures E-23 to E-25	Flathead sole (eggs, larvae, late juveniles/adults)
Figures E-26 to E-28	Sablefish (eggs, larvae, late juveniles/adults)
Figure E-30	Pacific ocean perch (late juveniles/adults)
Figures E-29 and E-31	Shortraker and rougheye rockfish (larvae, adults)
Figures E-29 and E-32	Northern rockfish (larvae, adults)
Figures E-29 and E-33	Thornyhead rockfish (larvae, late juveniles/adults)
Figures E-29 and E-34	Yelloweye rockfish (larvae, late juveniles/adults)
Figures E-29 and E-35	Dusky rockfish (larvae, adults)
Figures E-36 to E-37	Atka mackerel (larvae, adults)
Figure E-38	Sculpin species (juveniles/adults)
Figure E-39	Skates species (adults)
Figure E-40	Squid (late juveniles/adults)

Figure E-1
GOA Walleye Pollock Egg Presence

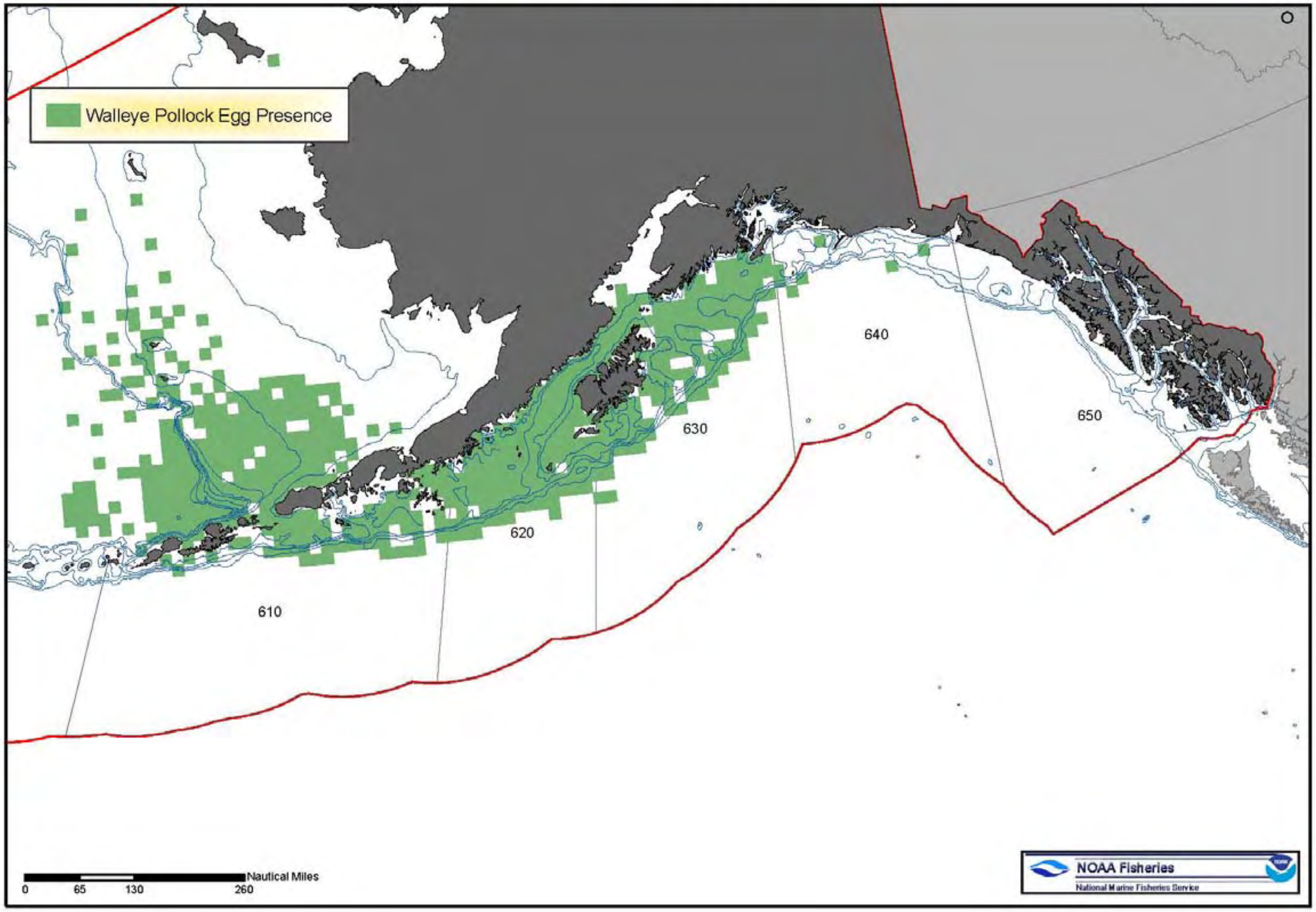


Figure E-2
GOA Walleye Pollock Larval Presence

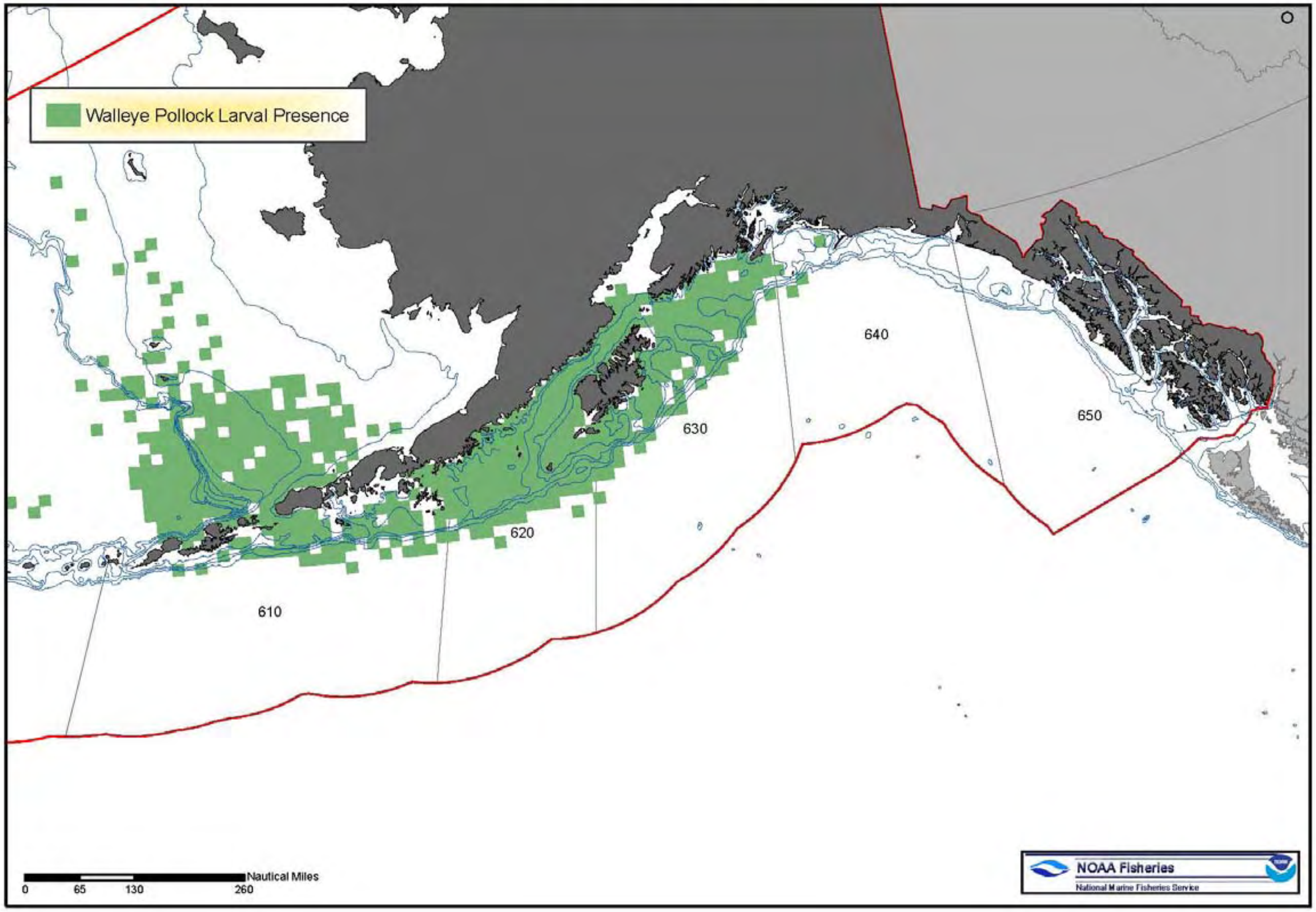


Figure E-3
GOA Walleye Pollock Late Juveniles/Adults

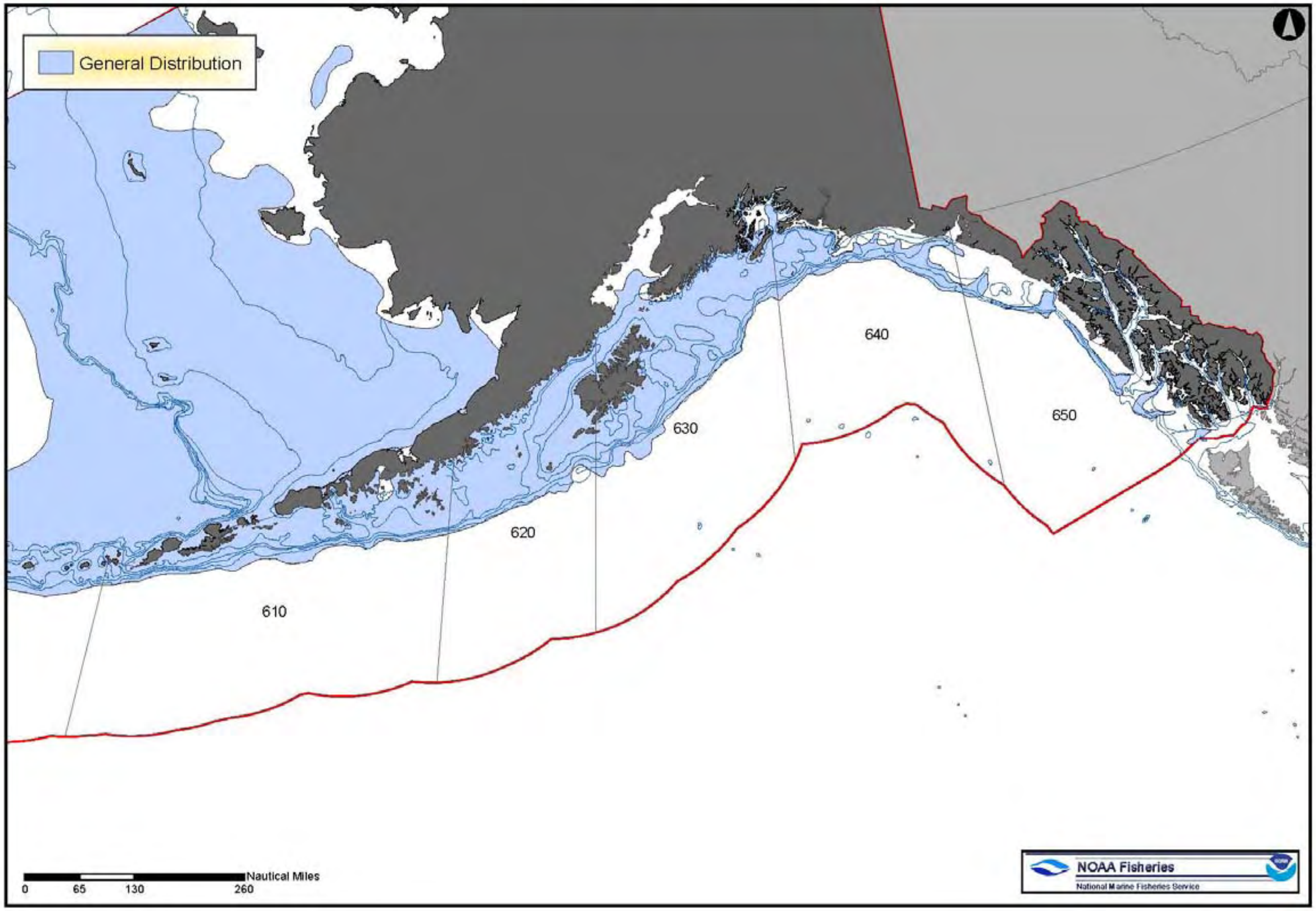


Figure E-4
GOA Pacific Cod Egg Presence

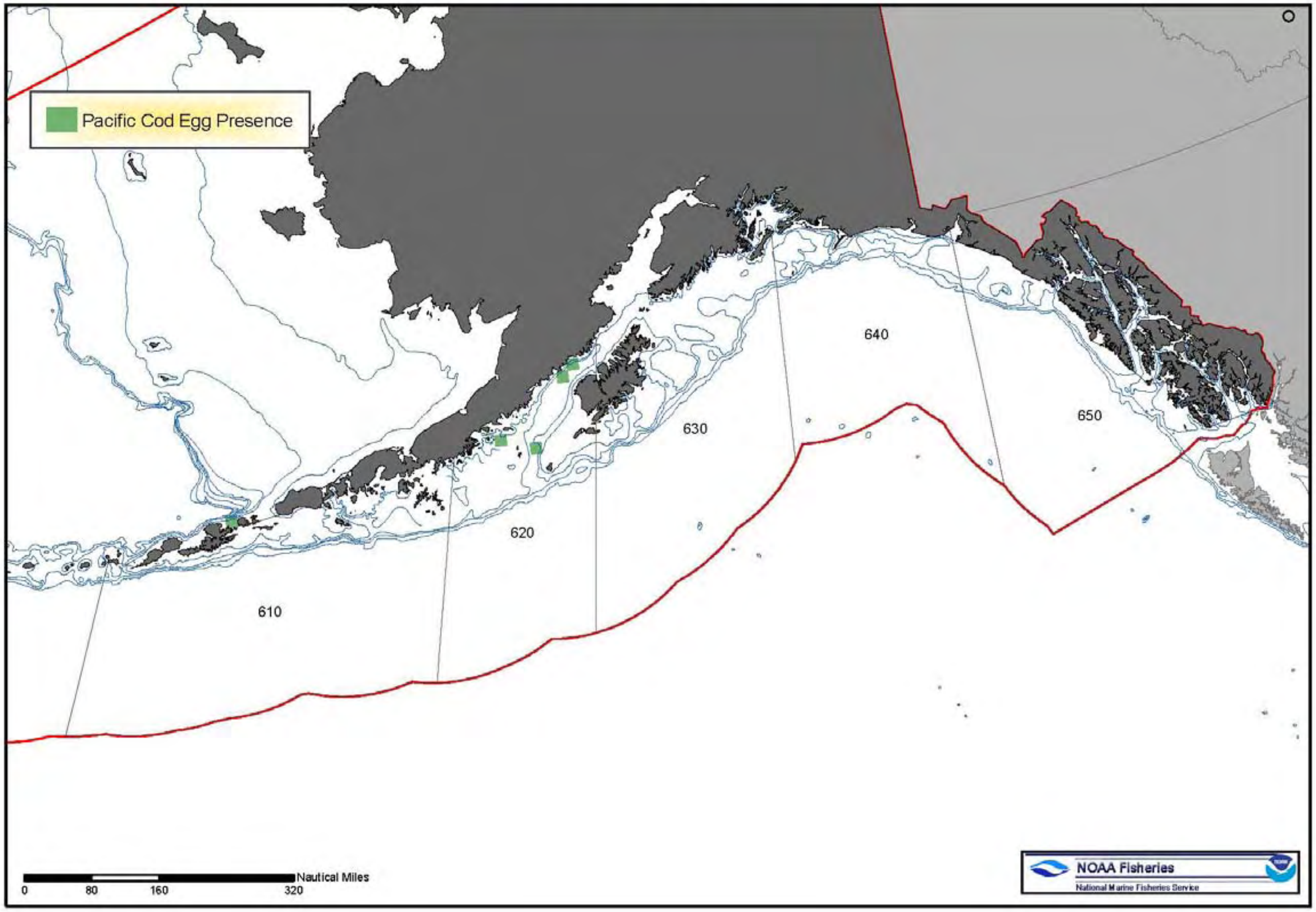


Figure E-5
GOA Pacific Cod Larval Presence

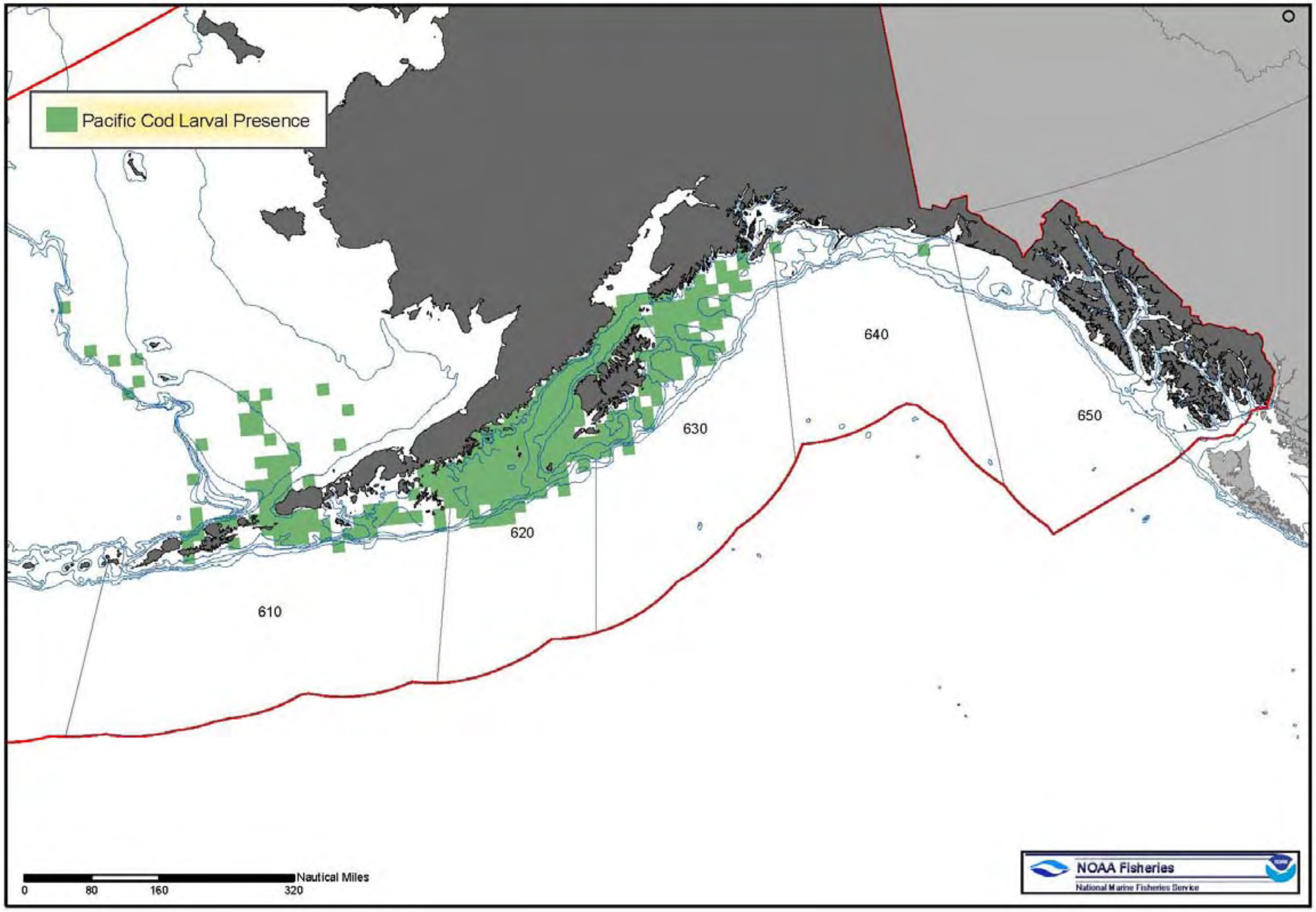


Figure E-6
GOA Pacific Cod Late Juveniles/Adults

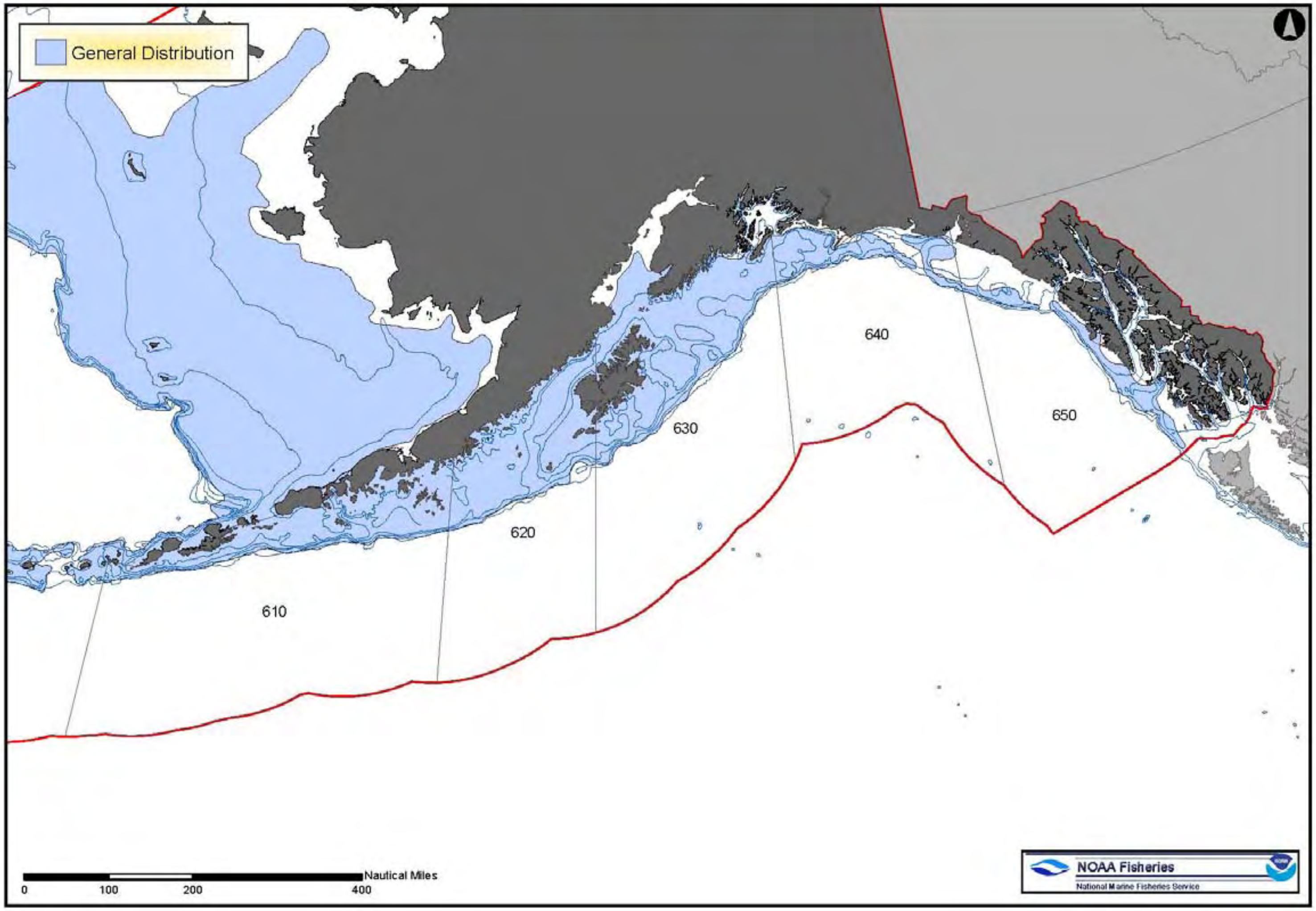


Figure E-7
GOA Yellowfin Sole Egg Presence

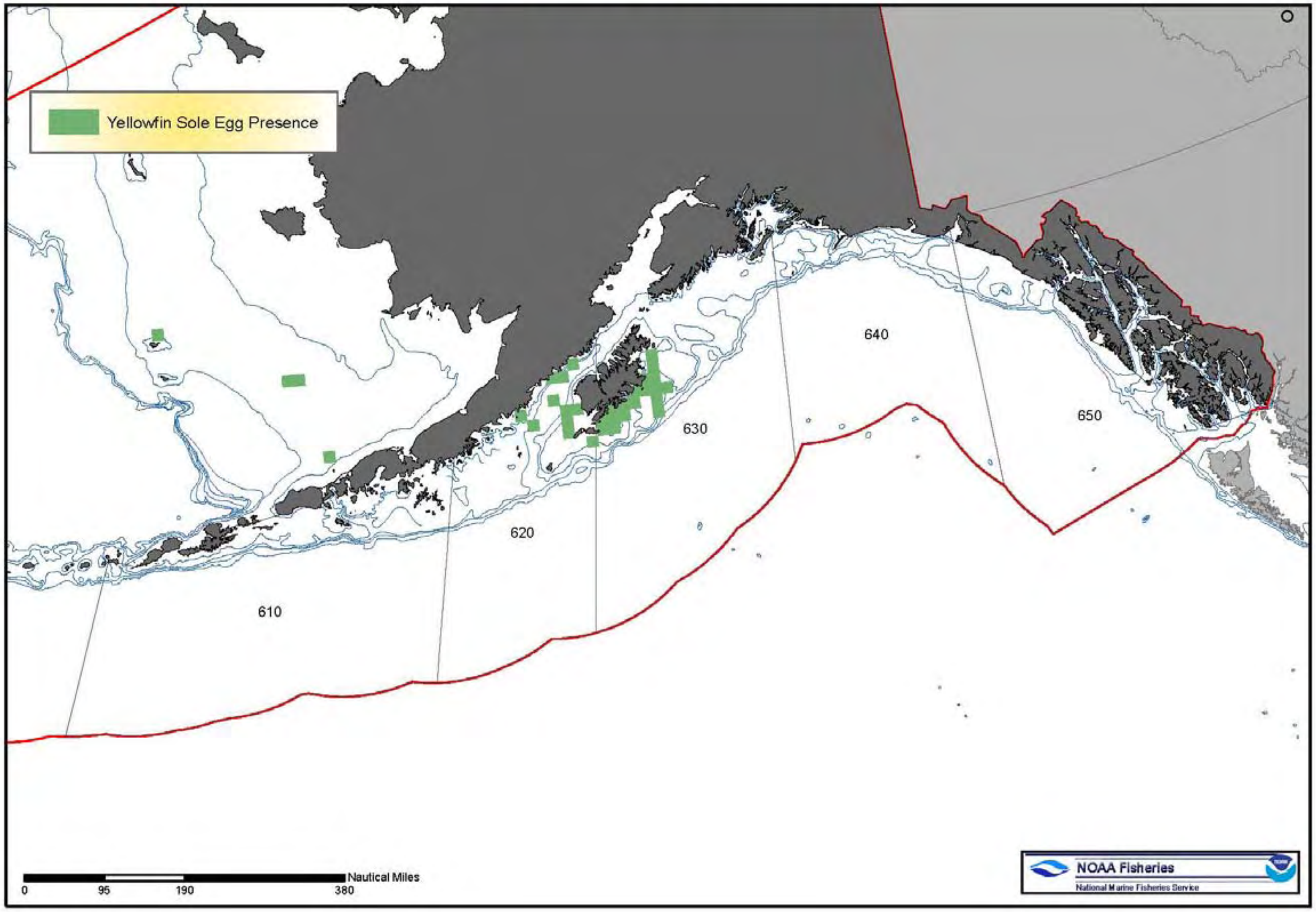


Figure E-8
GOA Yellowfin Sole Larval Presence

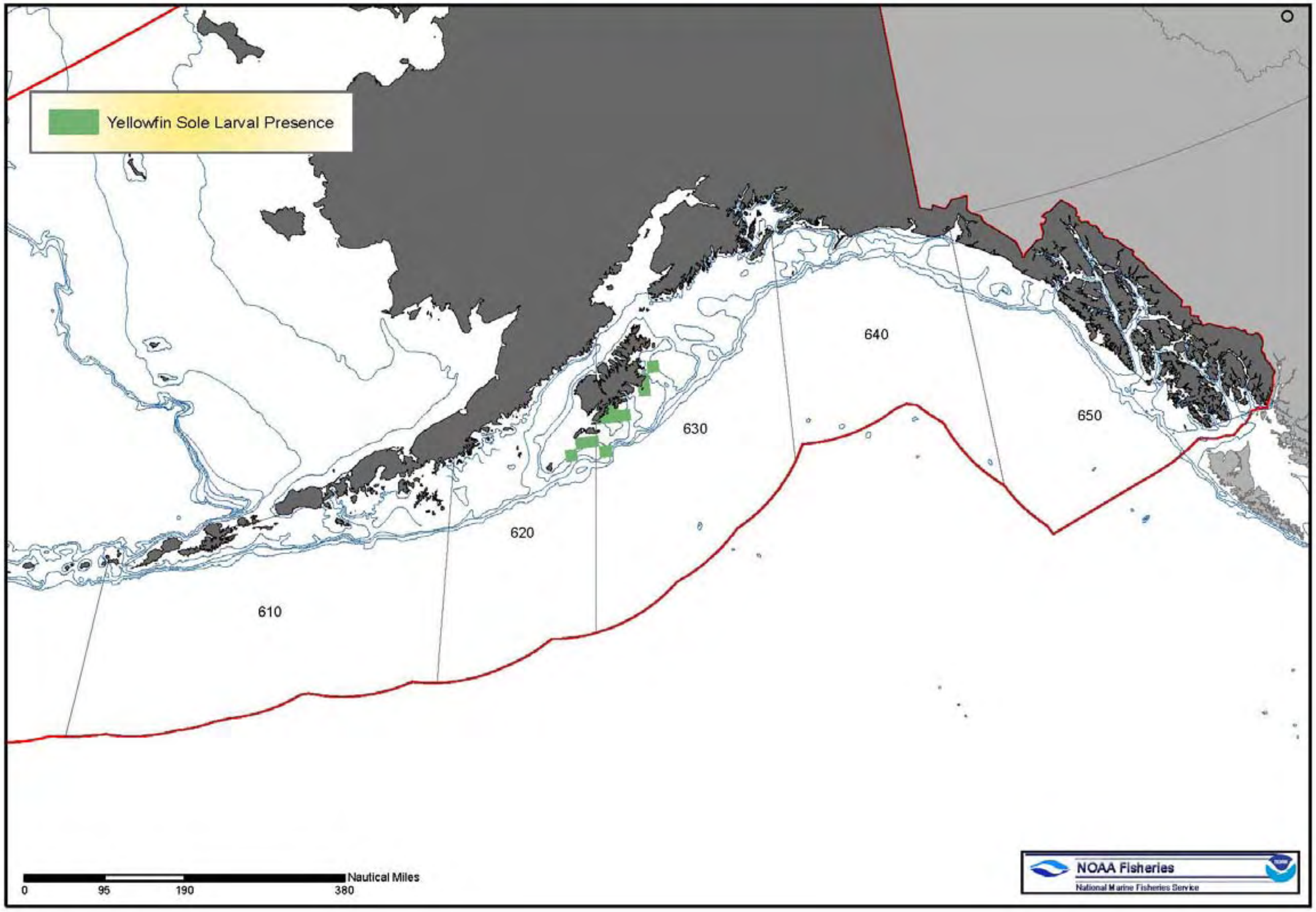


Figure E-9
GOA Yellowfin Sole Late Juveniles/Adults

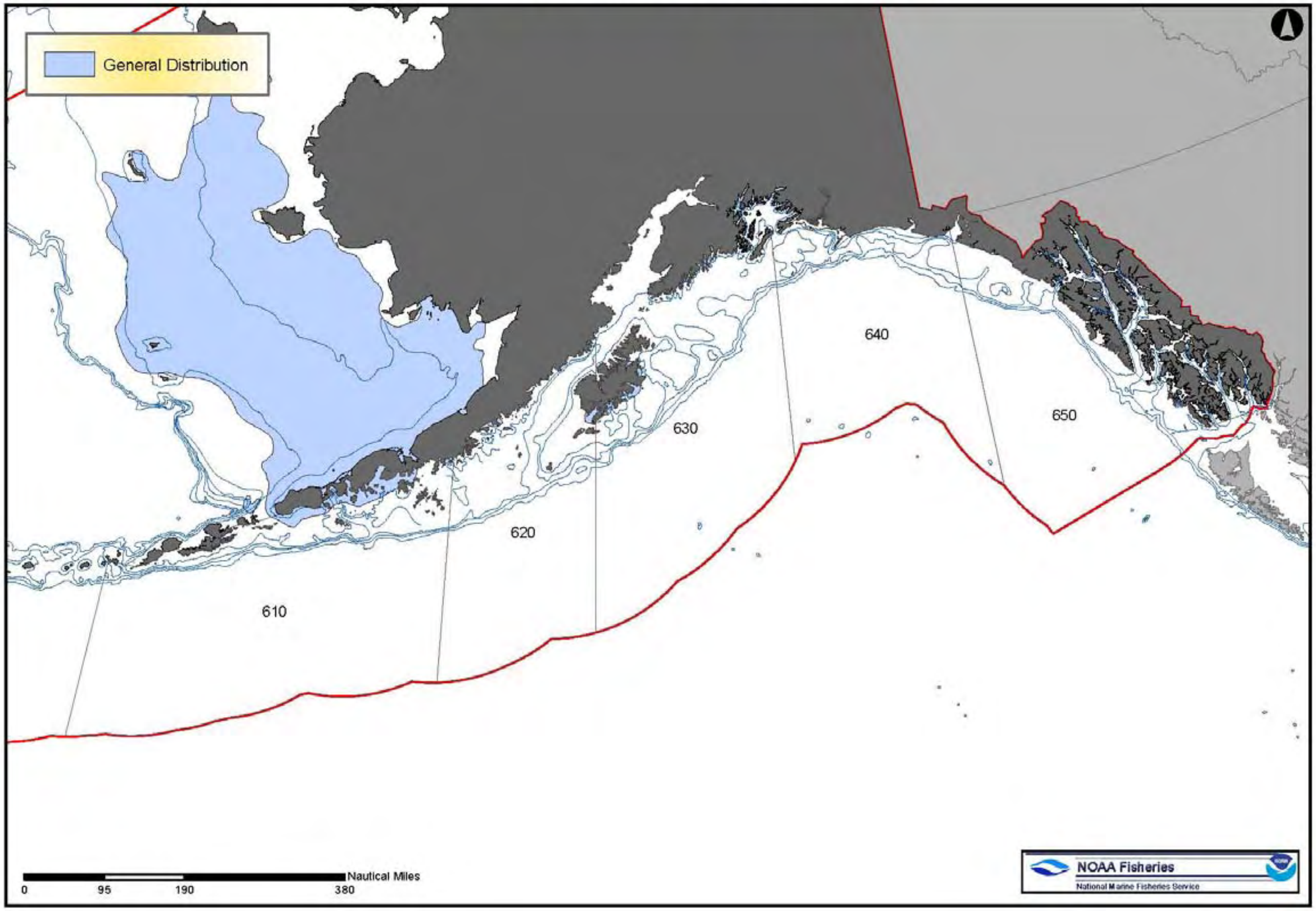


Figure E-10
GOA Arrowtooth Flounder Larval Presence

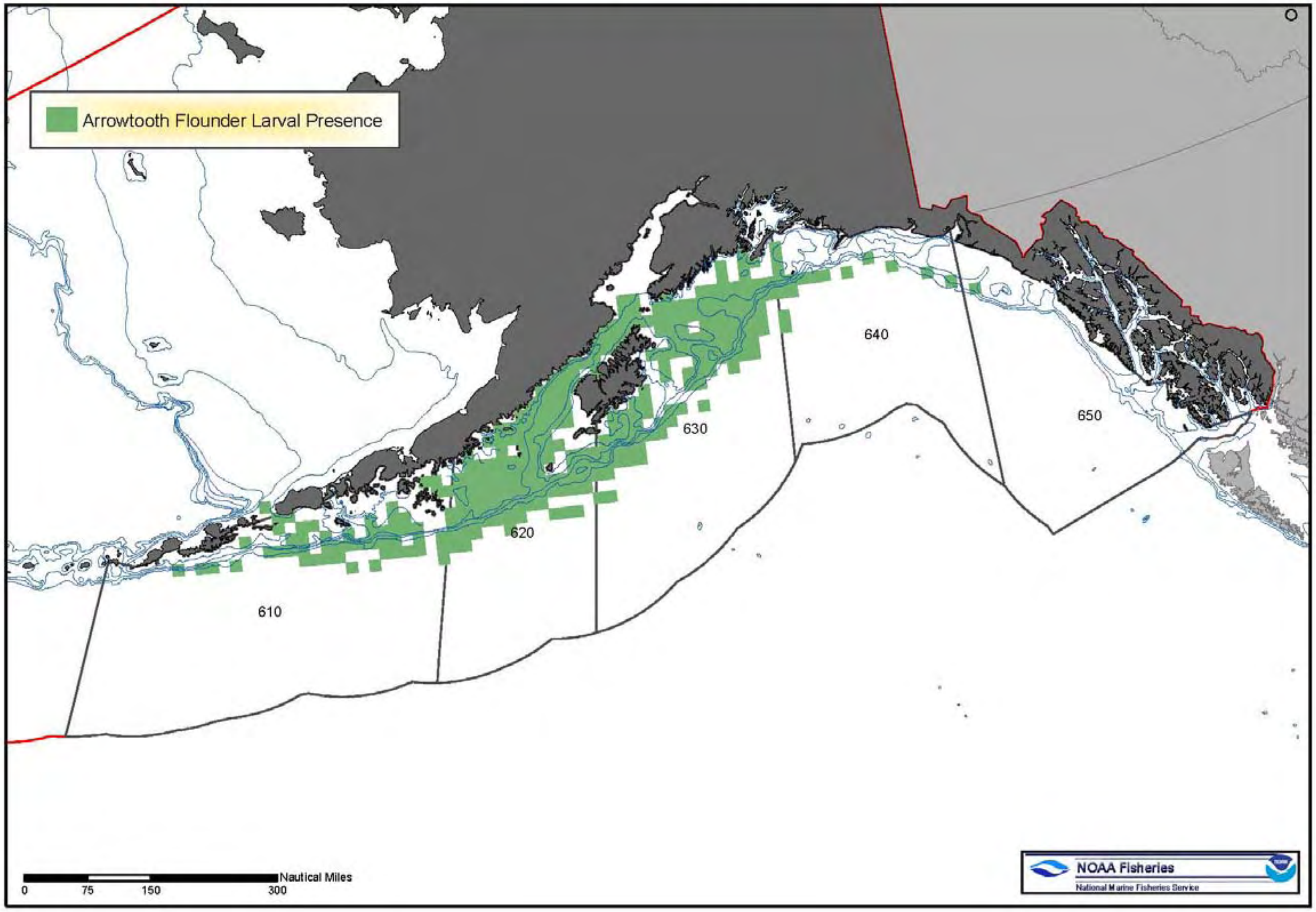


Figure E-11
GOA Arrowtooth Flounder Late Juveniles/Adults

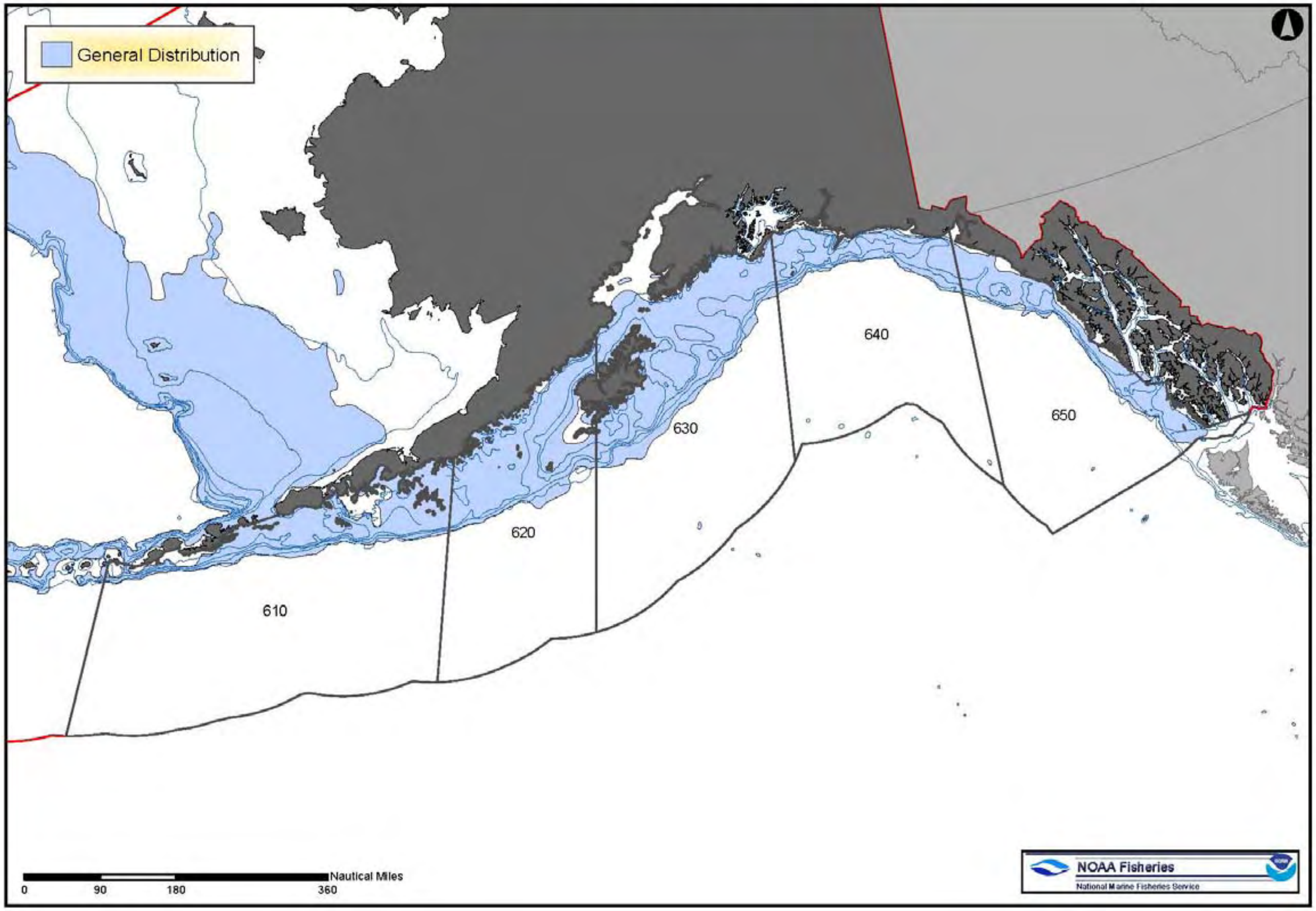


Figure E-12
GOA Rock Sole Larval Presence

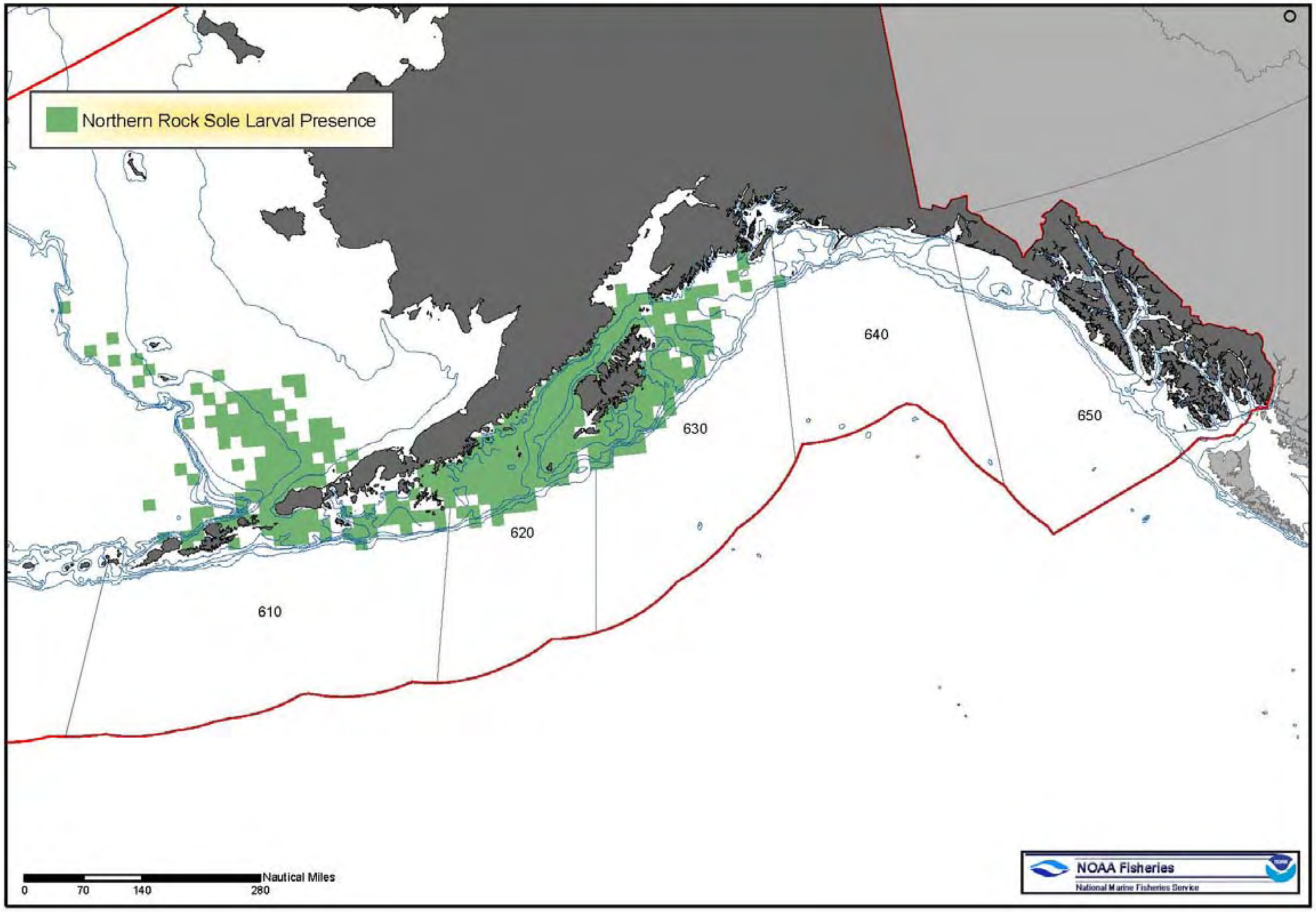


Figure E-13
GOA Rock Sole Late Juveniles/Adults

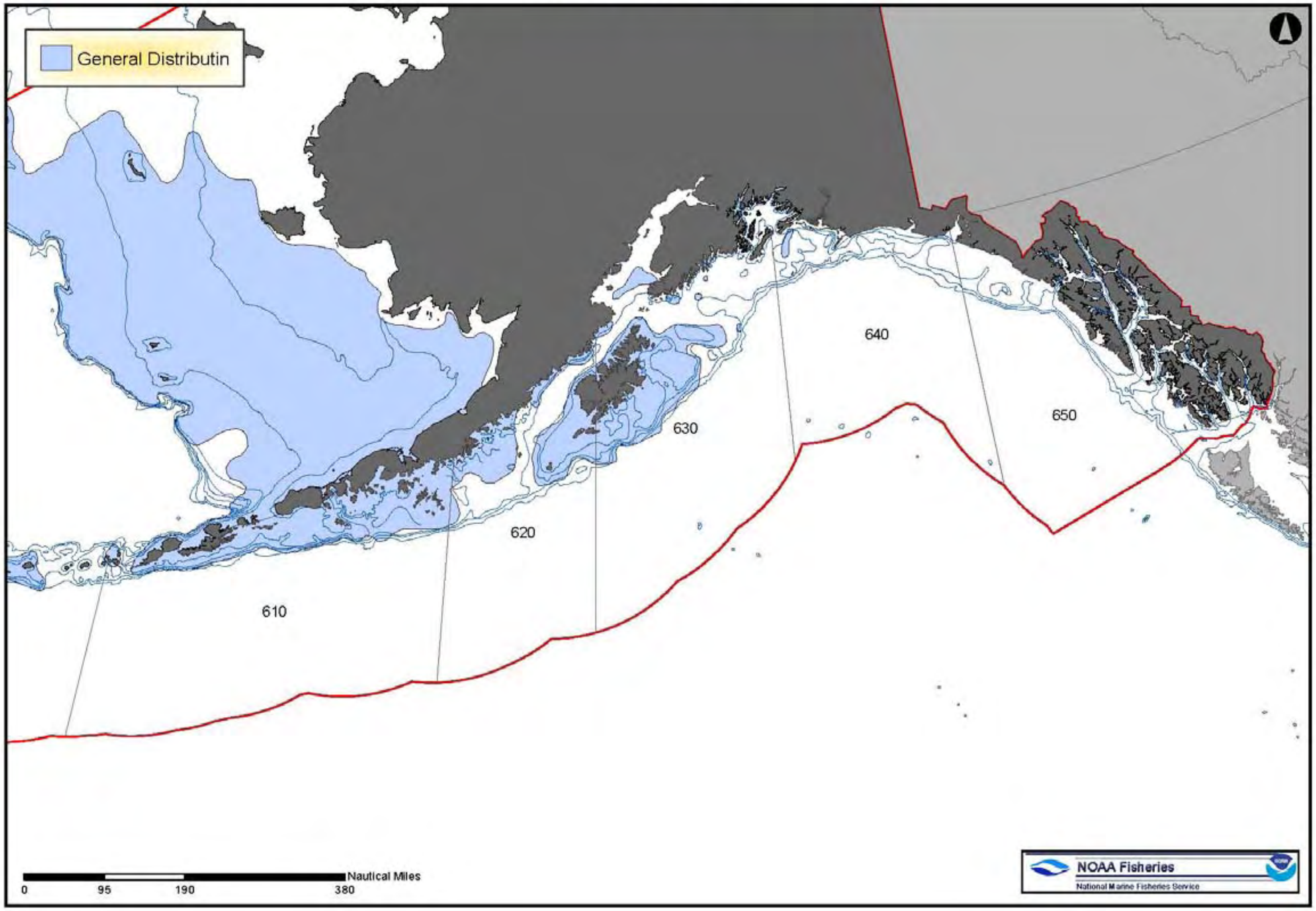


Figure E-14
GOA Alaska Plaice Egg Presence

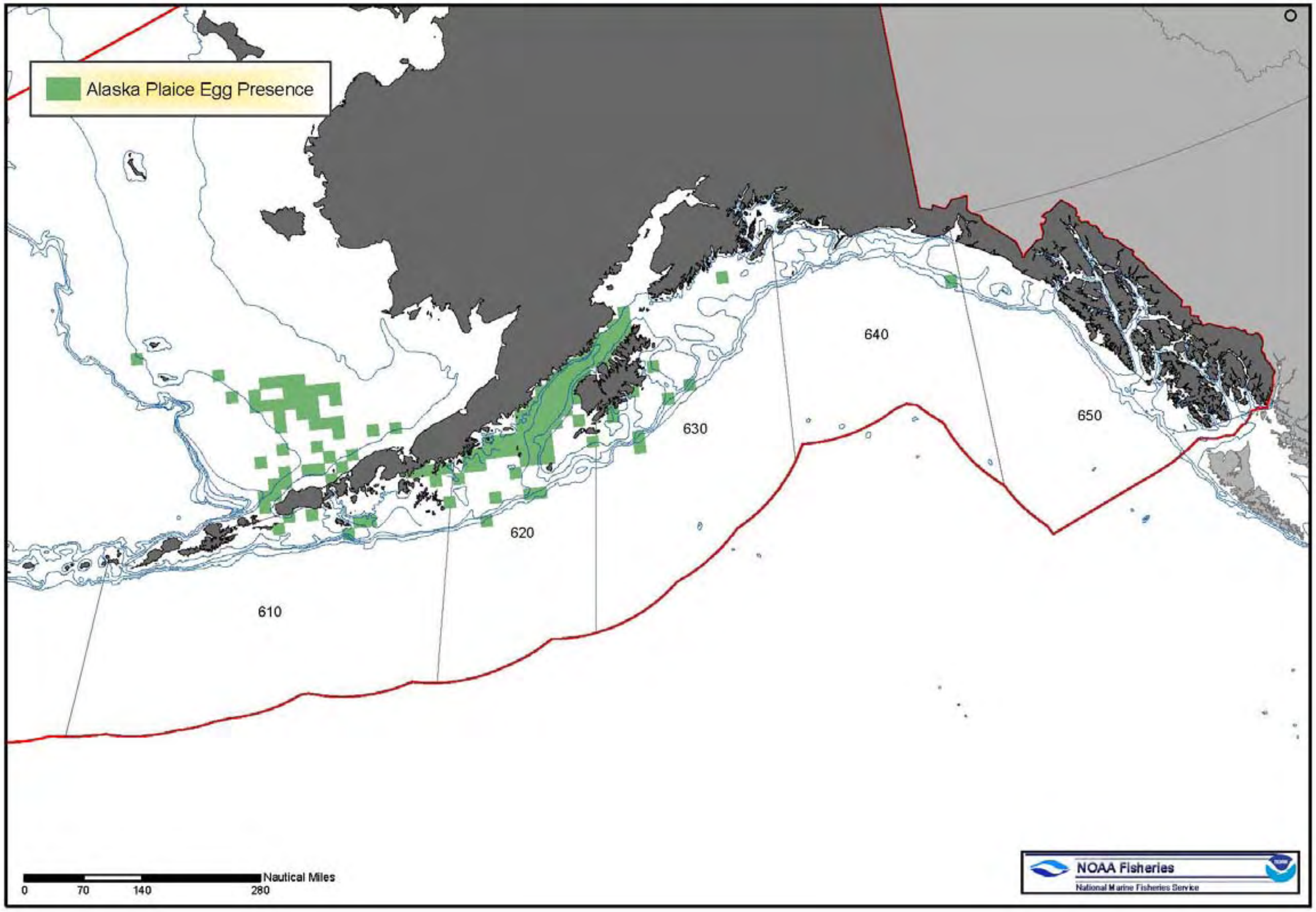


Figure E-15
GOA Alaska Plaice Larval Presence

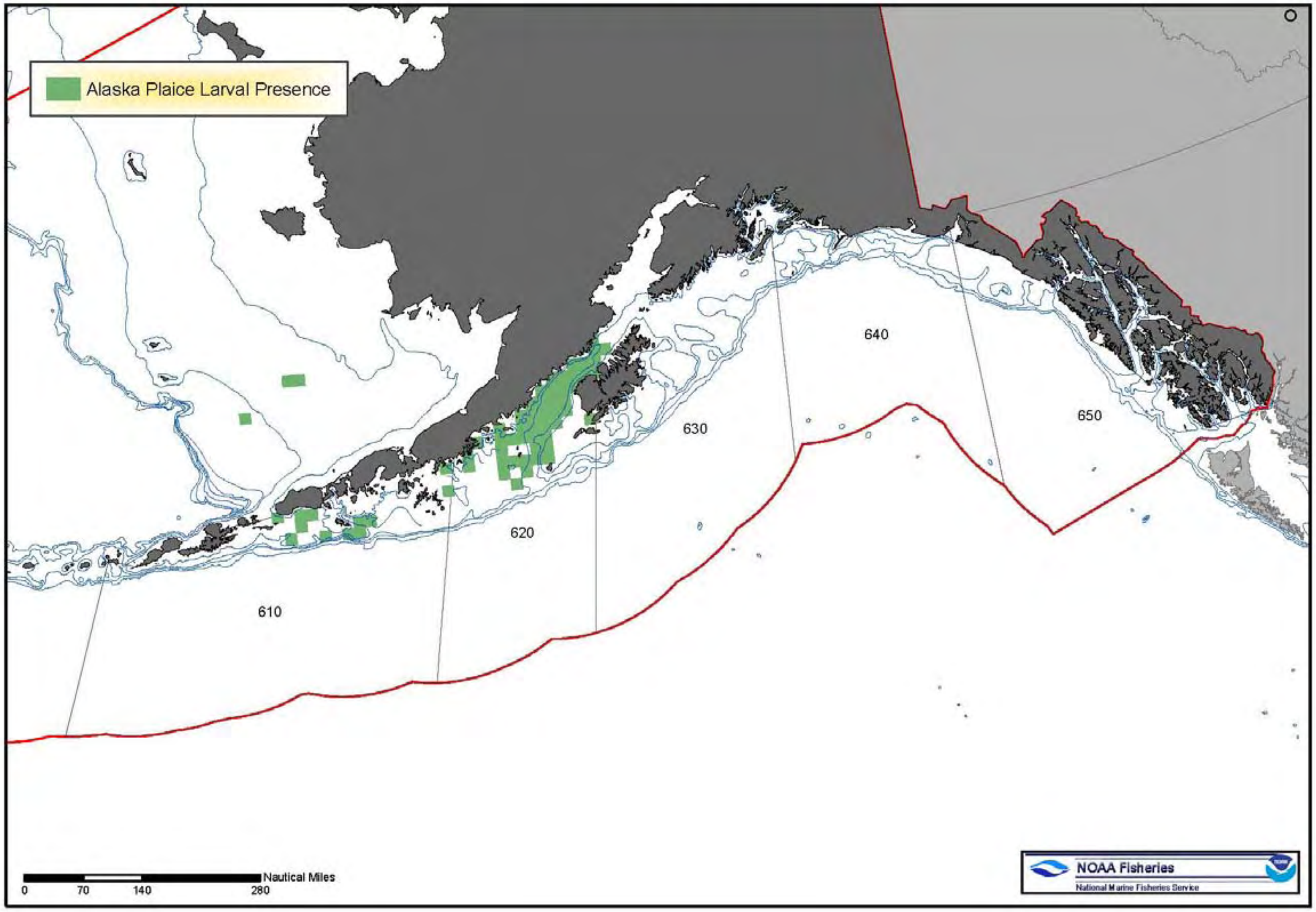


Figure E-16
GOA Alaska Plaice Late Juveniles/Adults

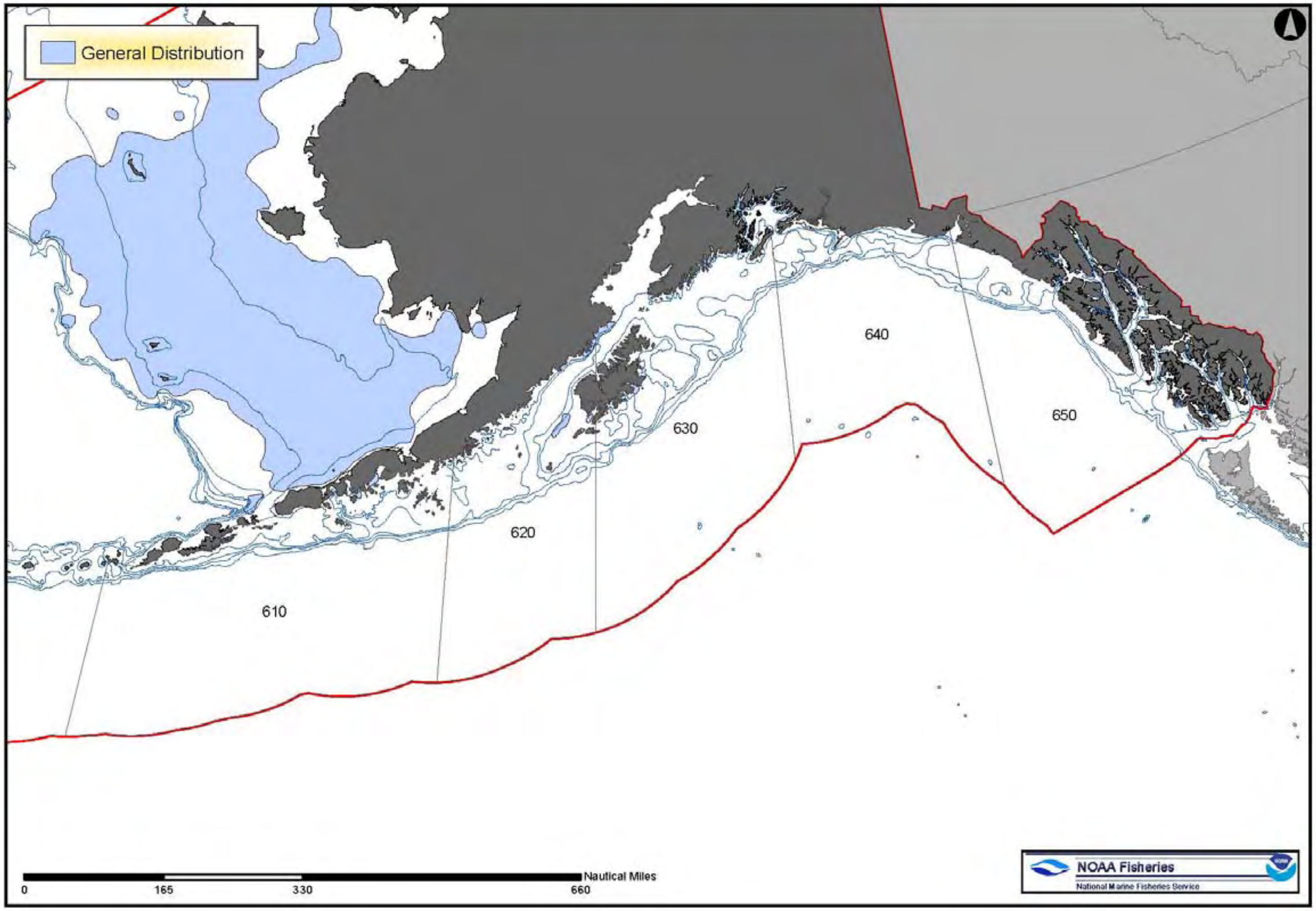


Figure E-17
GOA Rex Sole Egg Presence

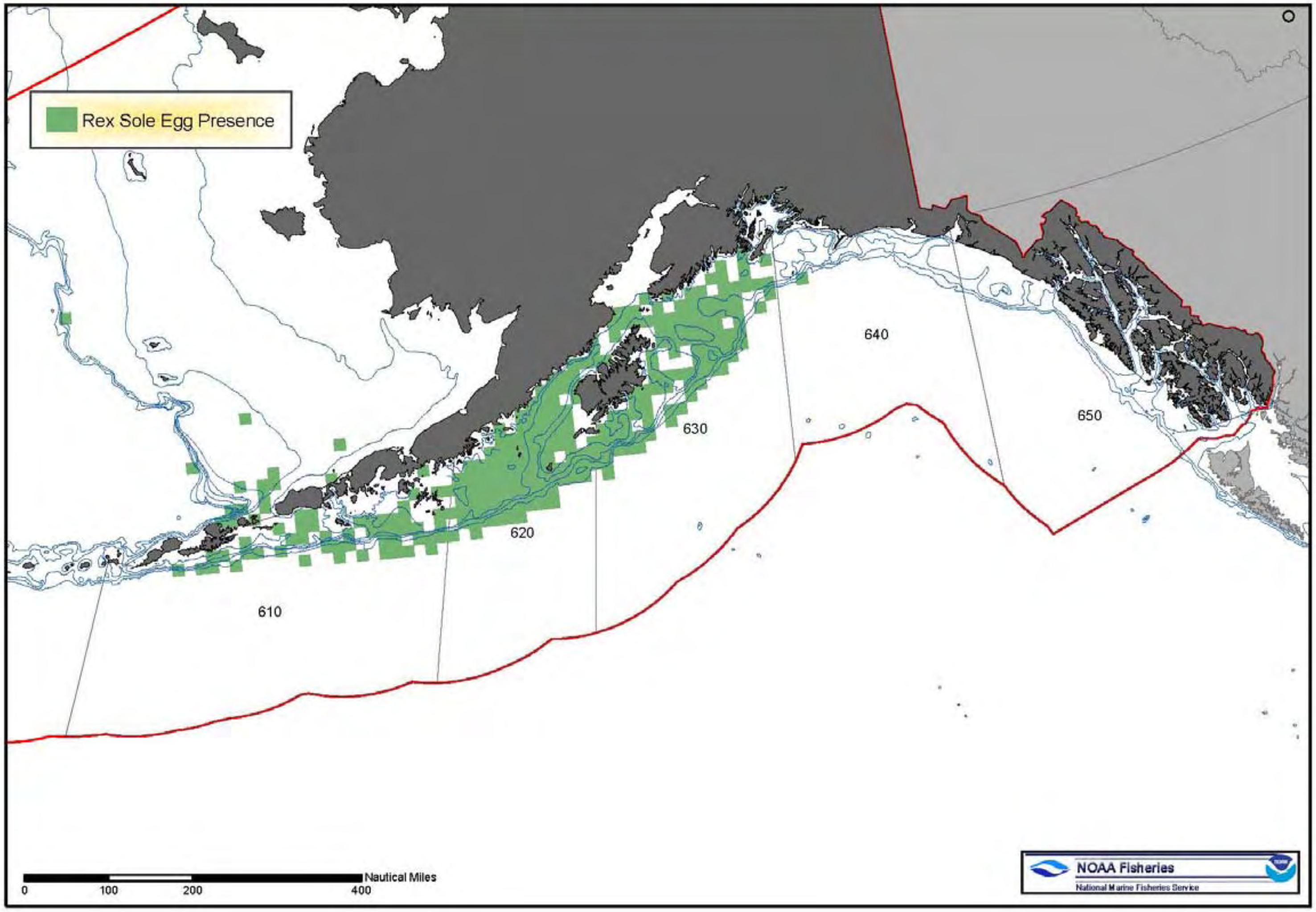


Figure E-18
GOA Rex Sole Larval Presence

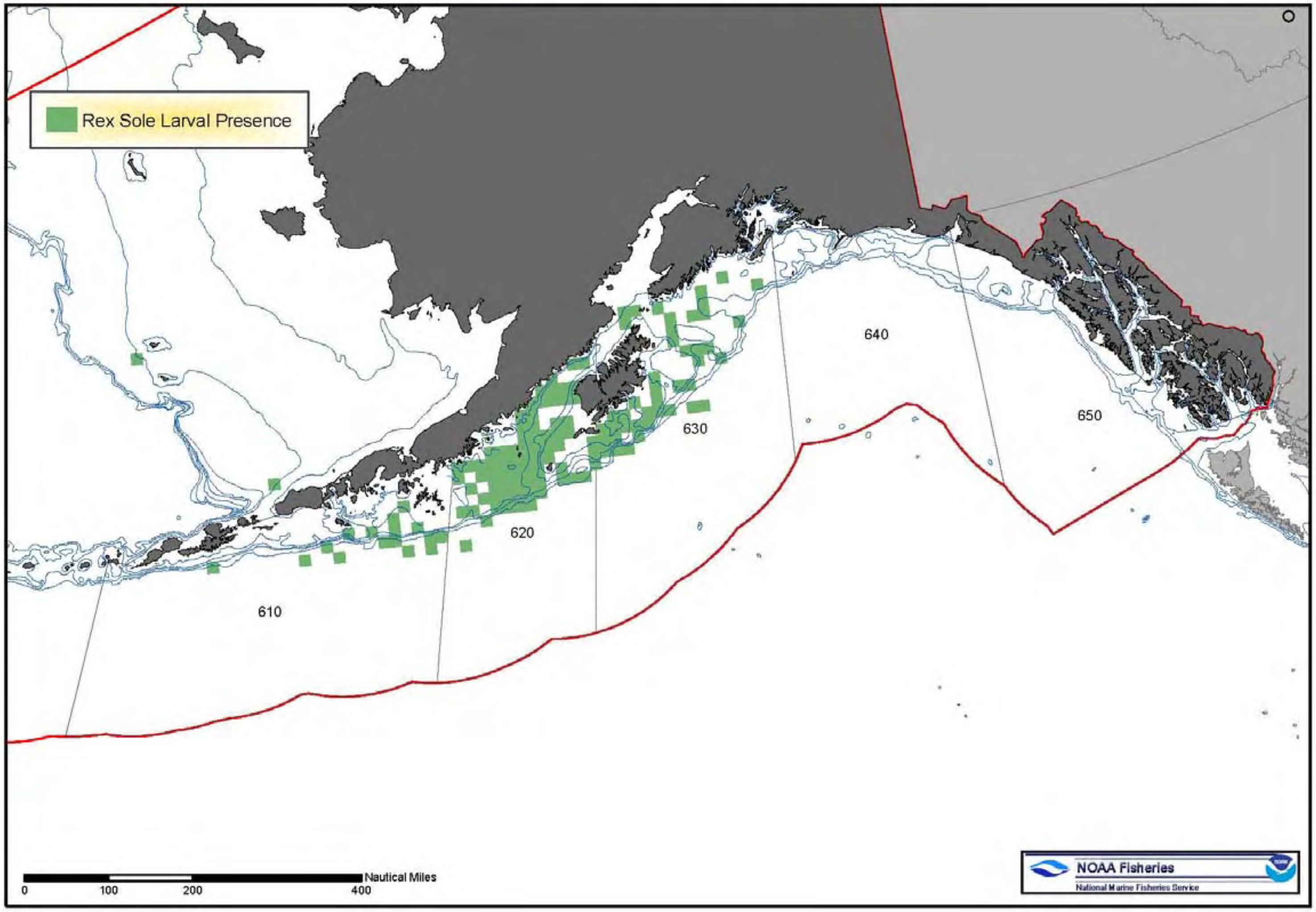


Figure E-19
GOA Rex Sole Late Juveniles/Adults

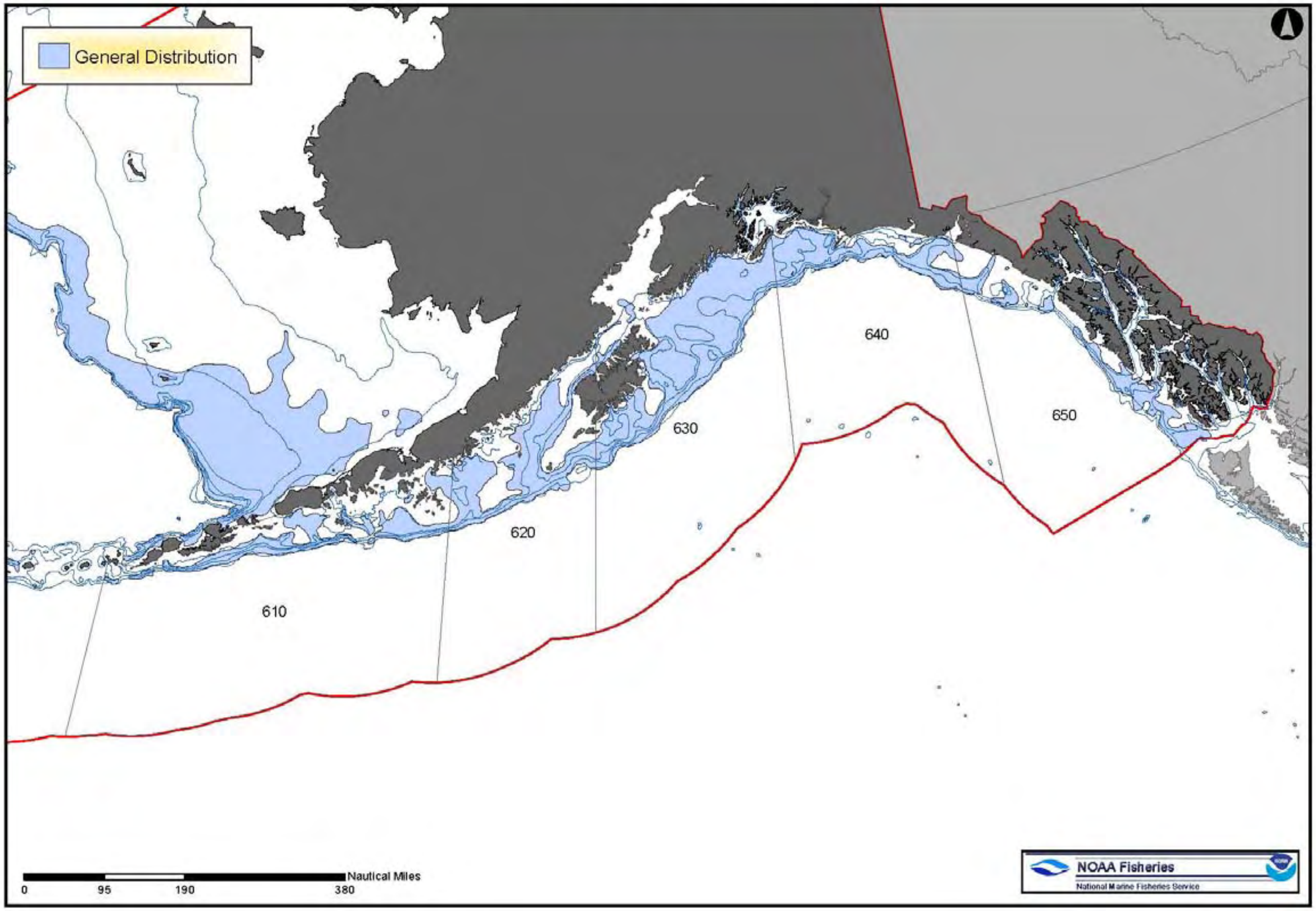


Figure E-20
GOA Dover Sole Egg Presence

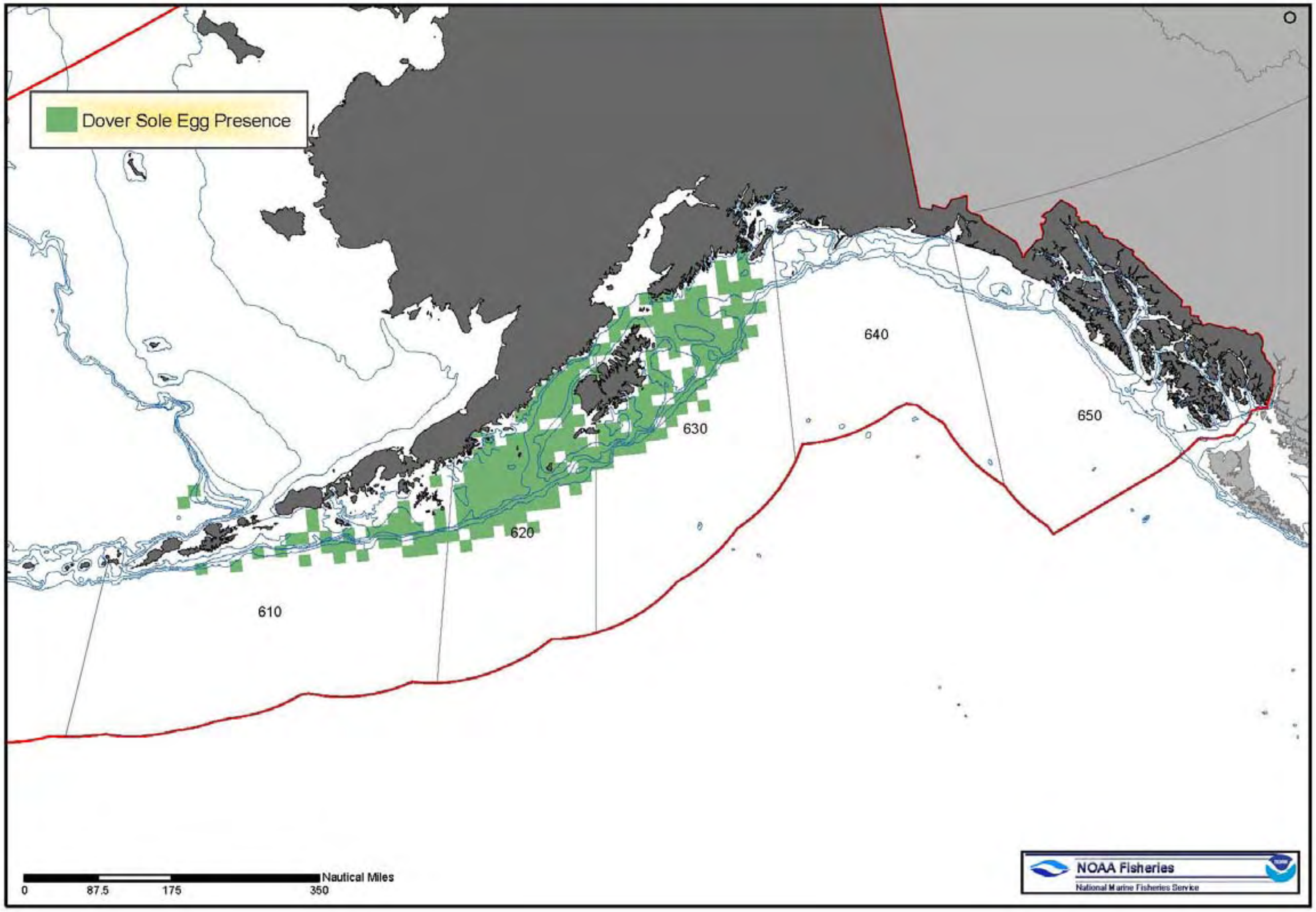


Figure E-21
GOA Dover Sole Larval Presence

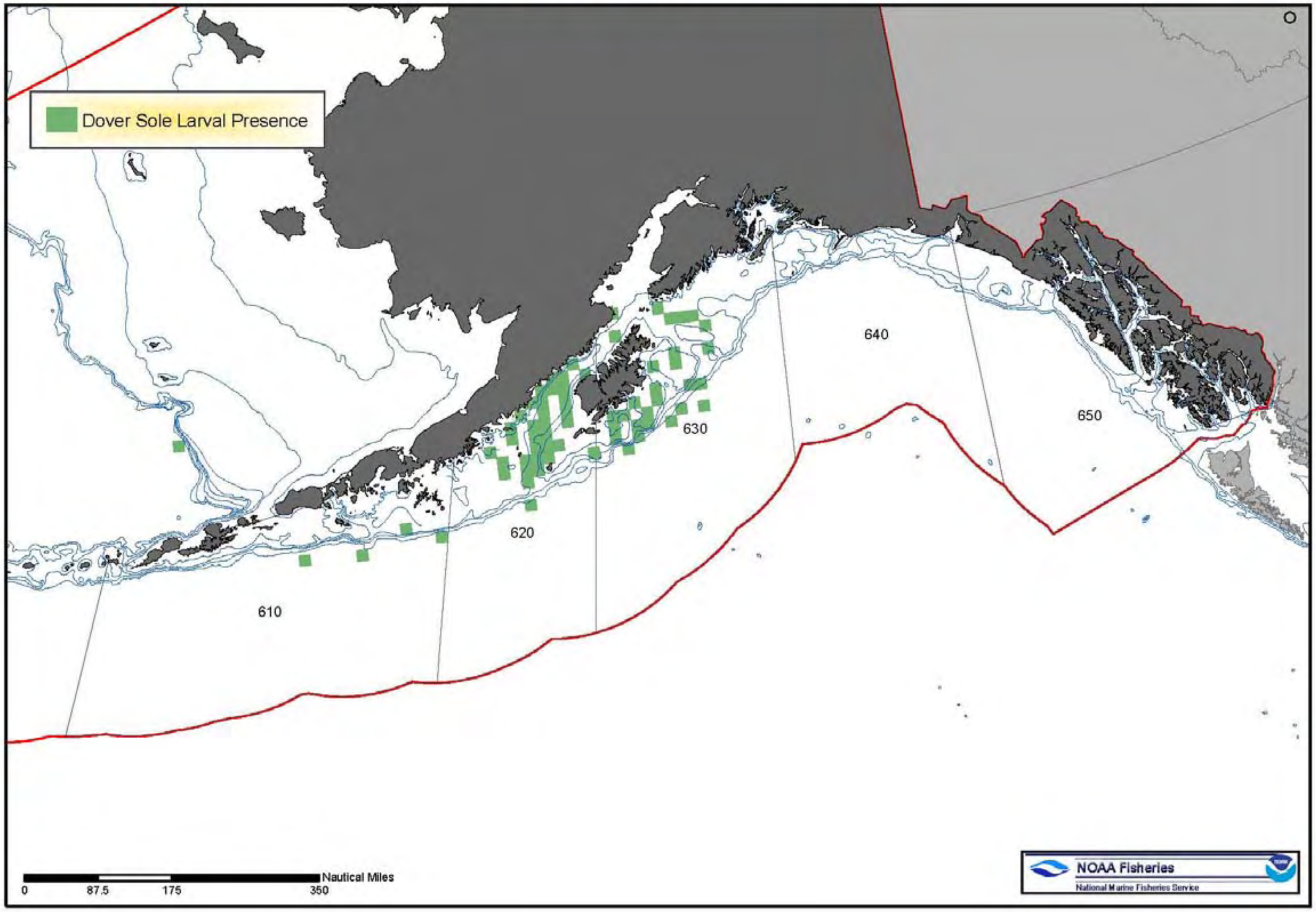


Figure E-22
GOA Dover Sole Late Juveniles/Adults

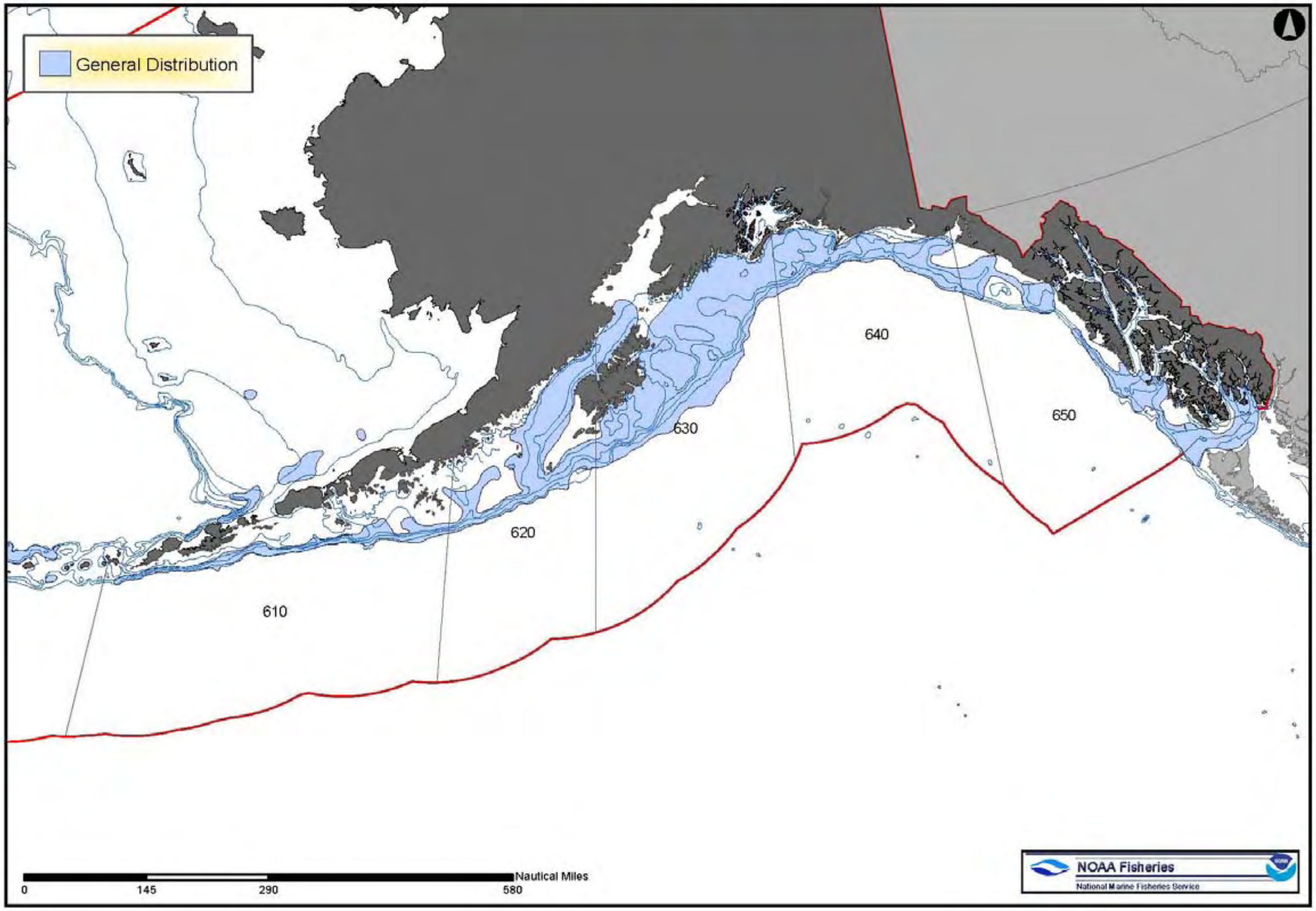


Figure E-23
GOA Flathead Sole Egg Presence

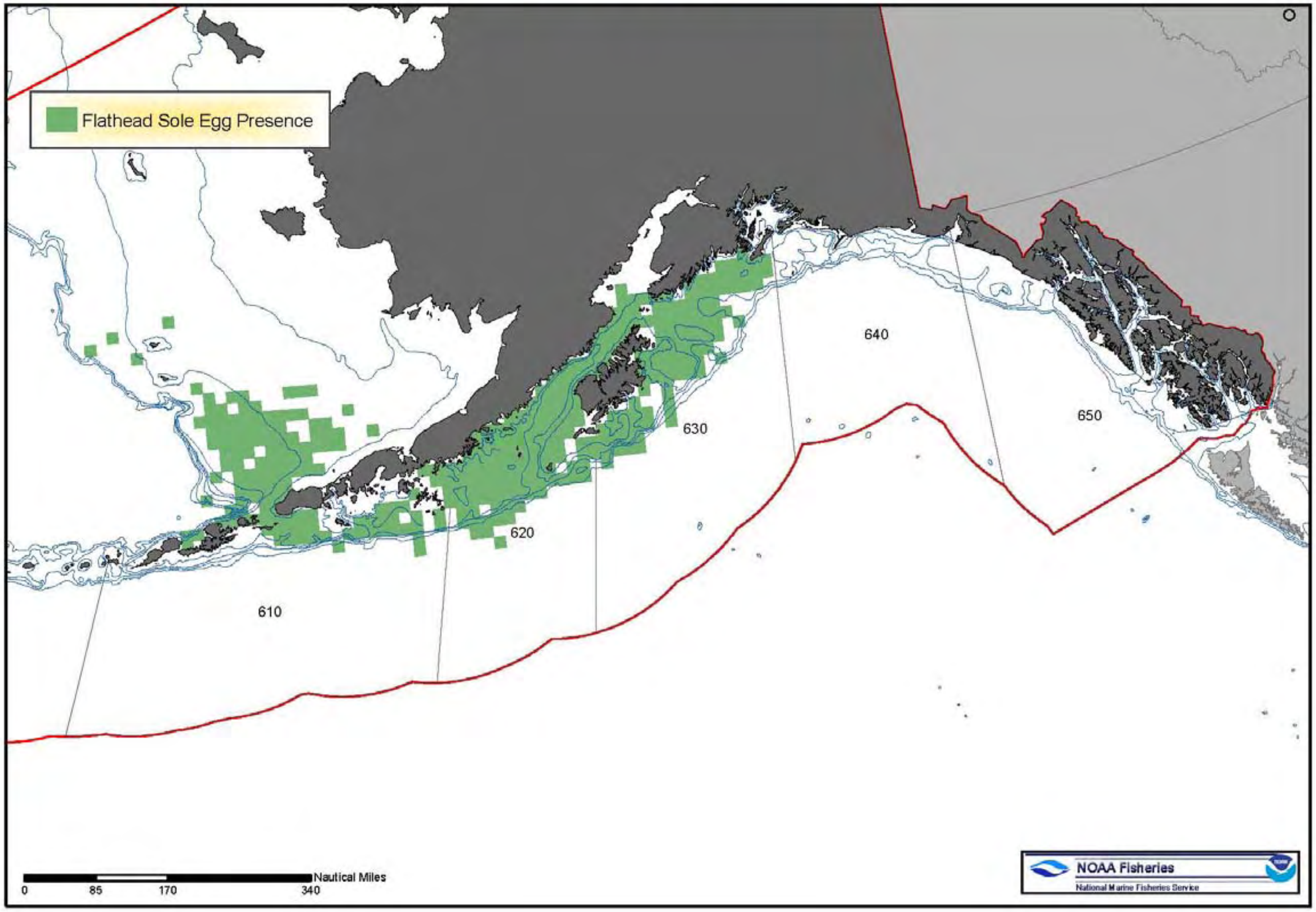


Figure E-24
GOA Flathead Sole Larval Presence

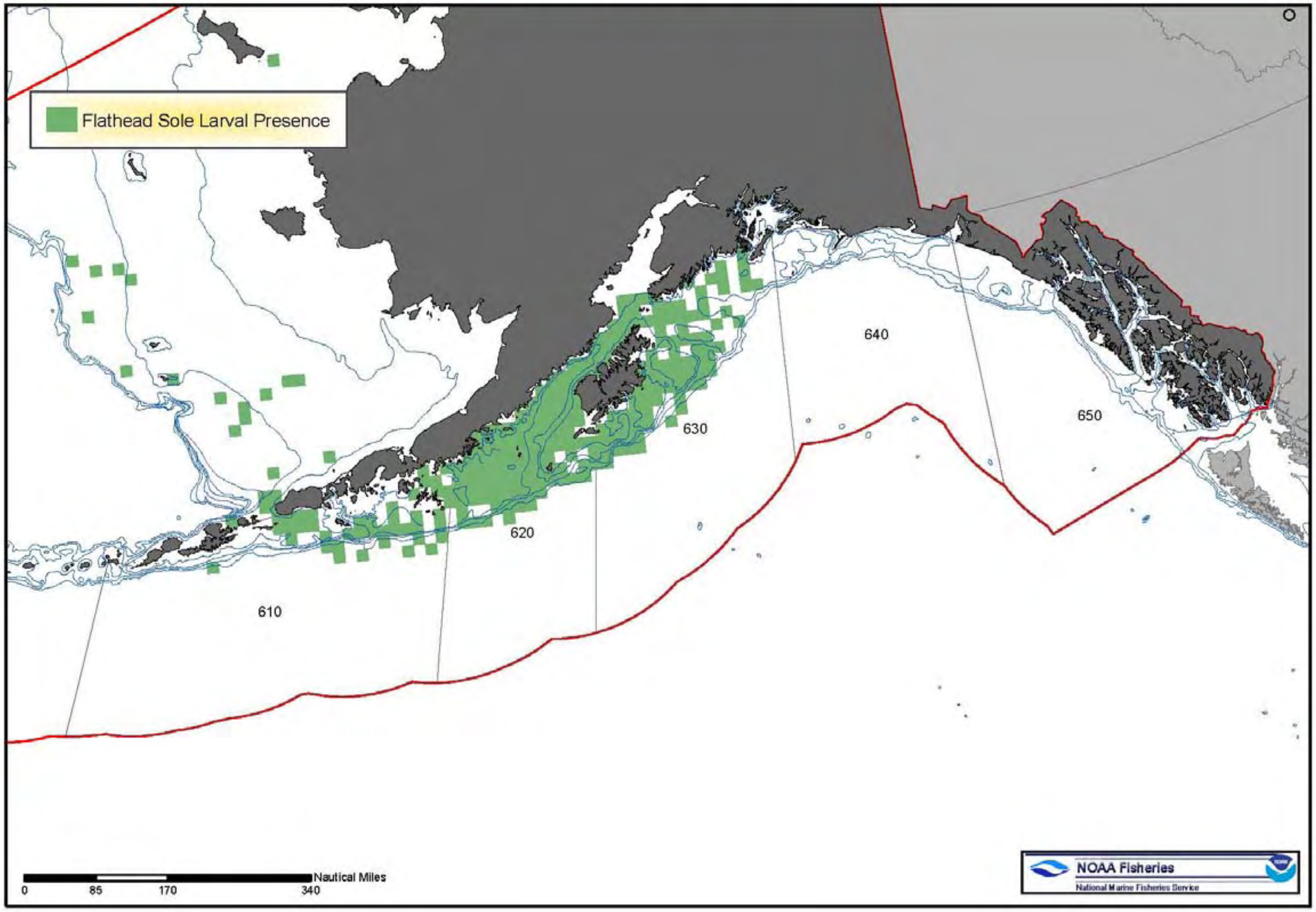


Figure E-25
GOA Flathead Sole Late Juveniles/Adults

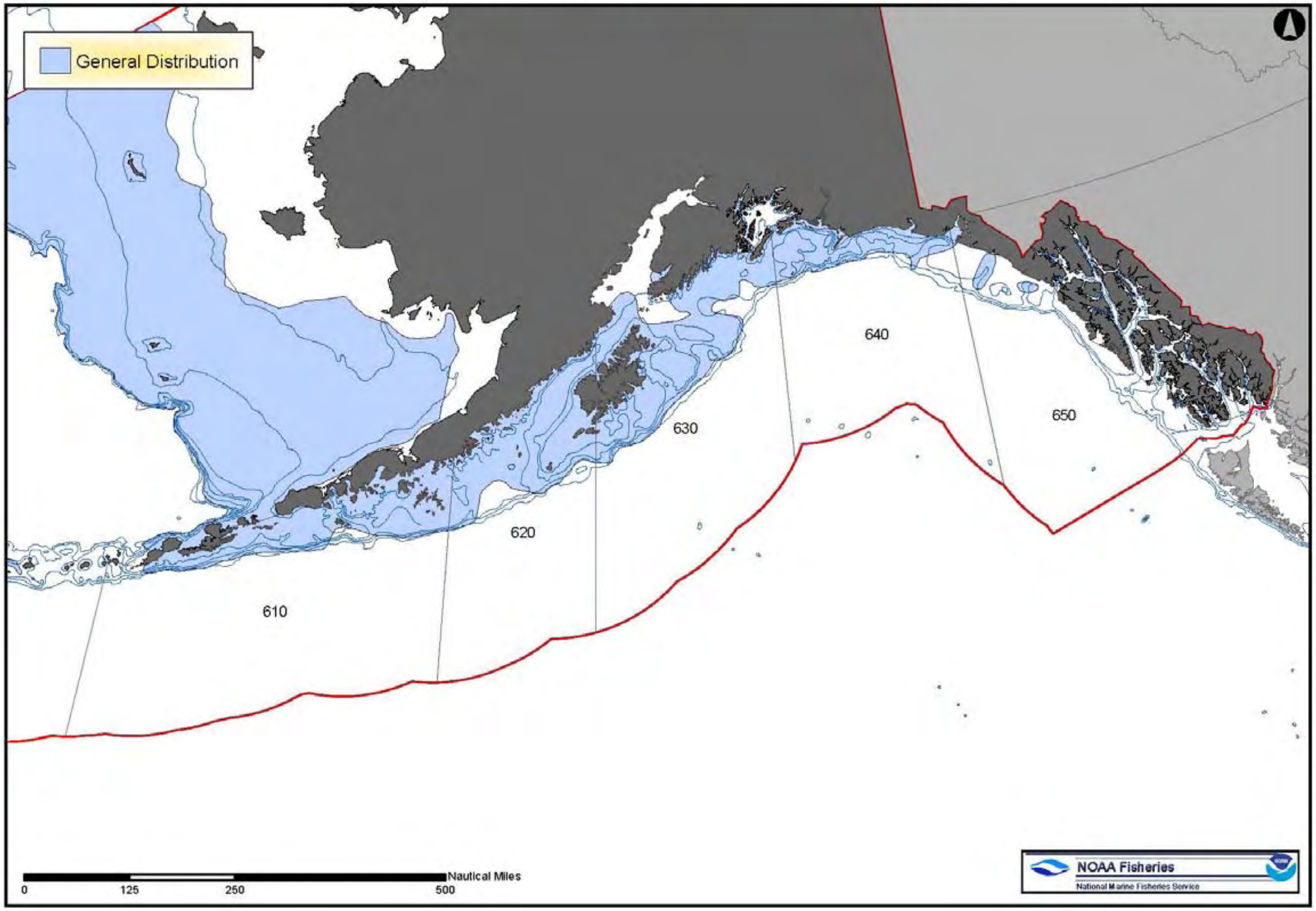


Figure E-26
GOA Sablefish Egg Presence

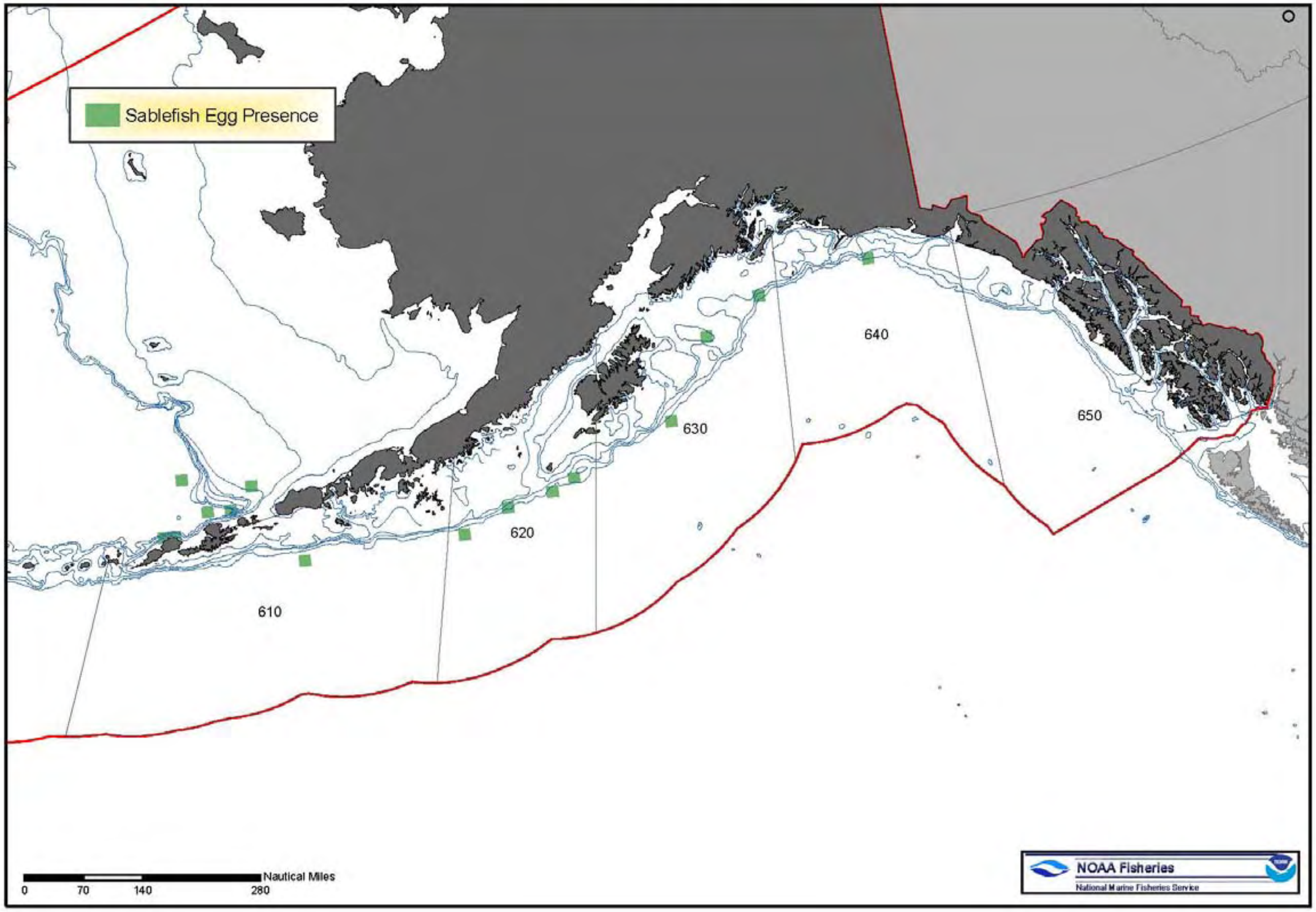


Figure E-27
GOA Sablefish Larval Presence

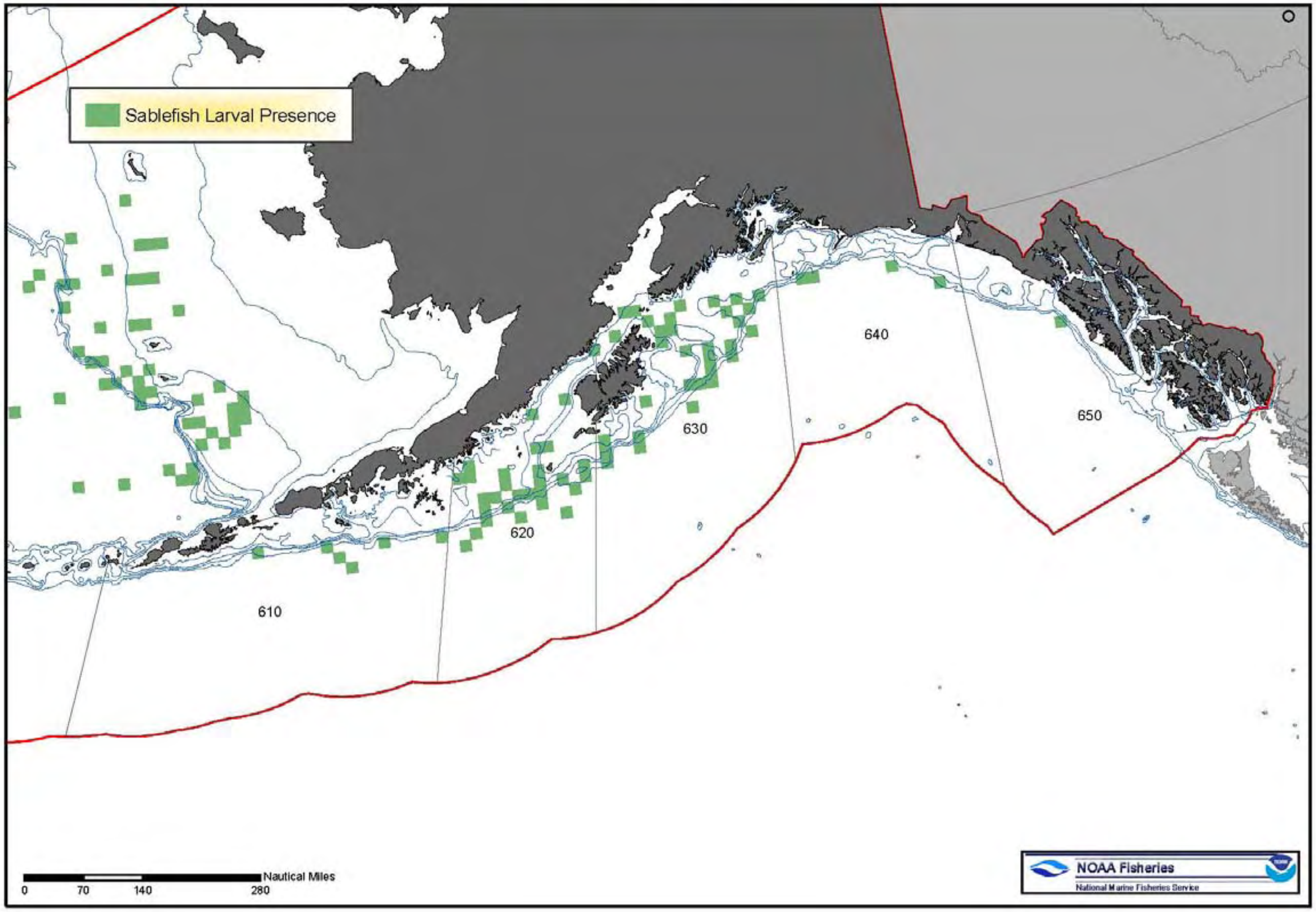


Figure E-28
GOA Sablefish Late Juveniles/Adults

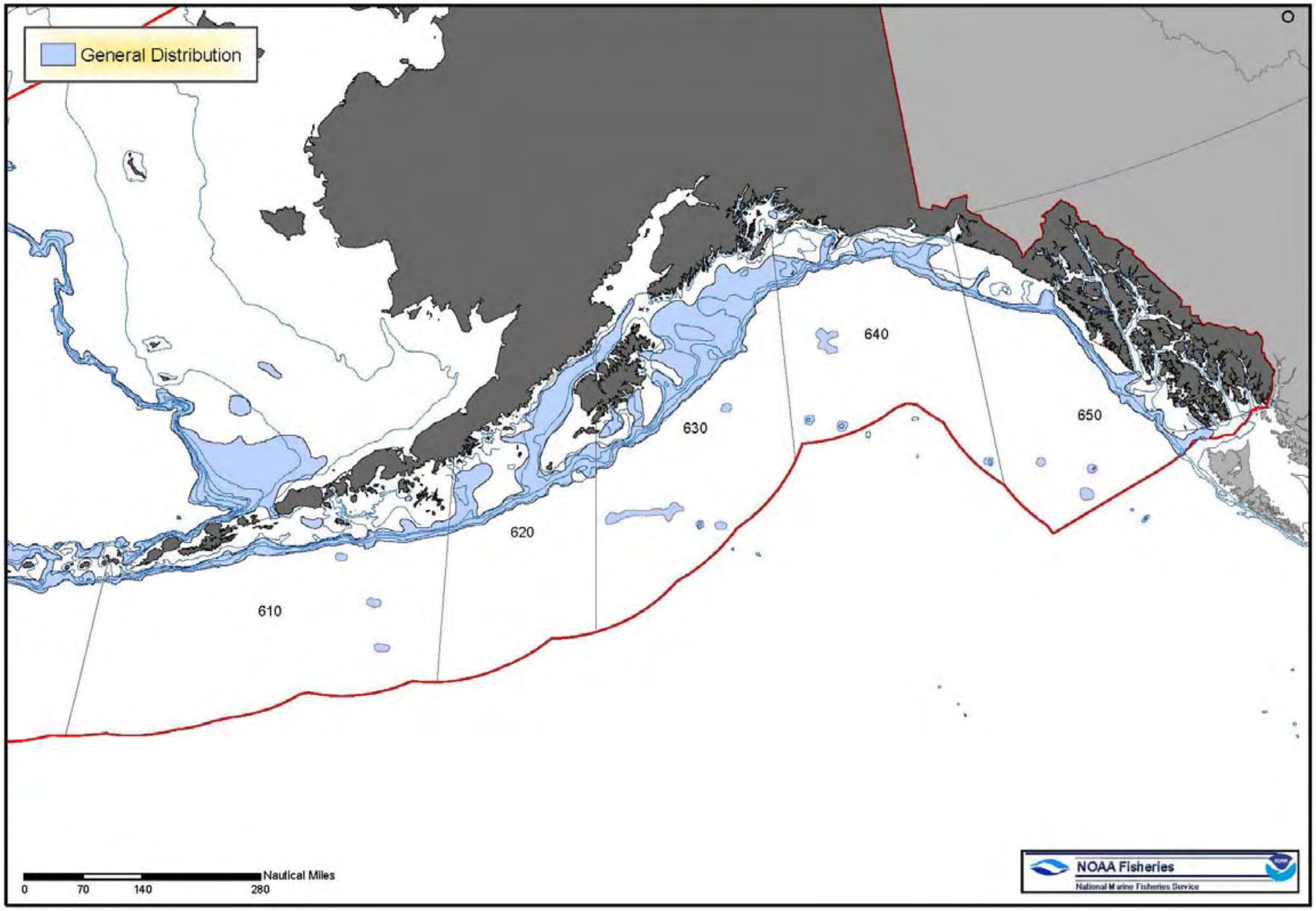


Figure E-29
GOA Rockfish Larval Presence

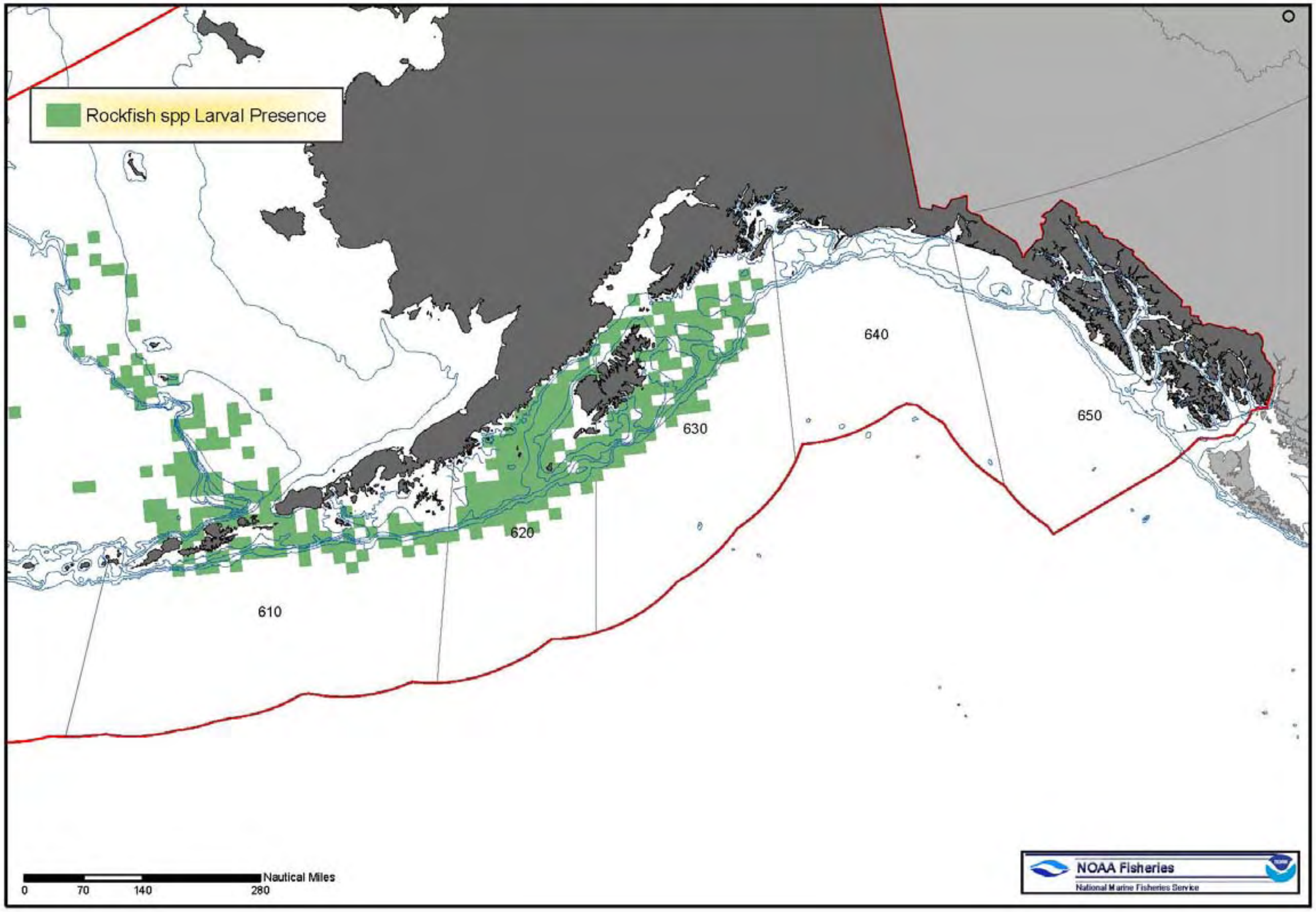


Figure E-30
GOA Pacific Ocean Perch Late Juveniles/Adults

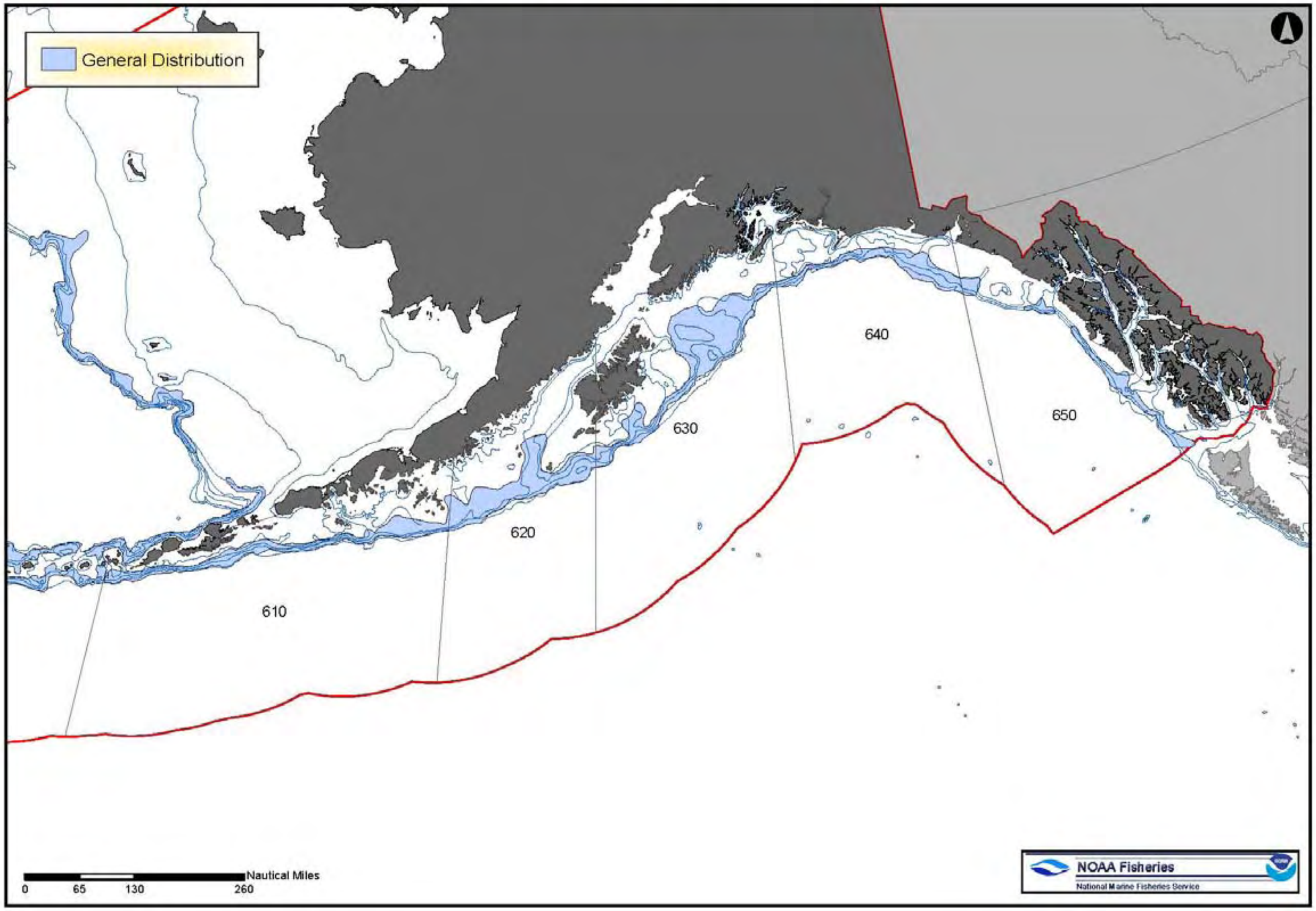


Figure E-31
GOA Shortraker/Rougheye Rockfish Adults

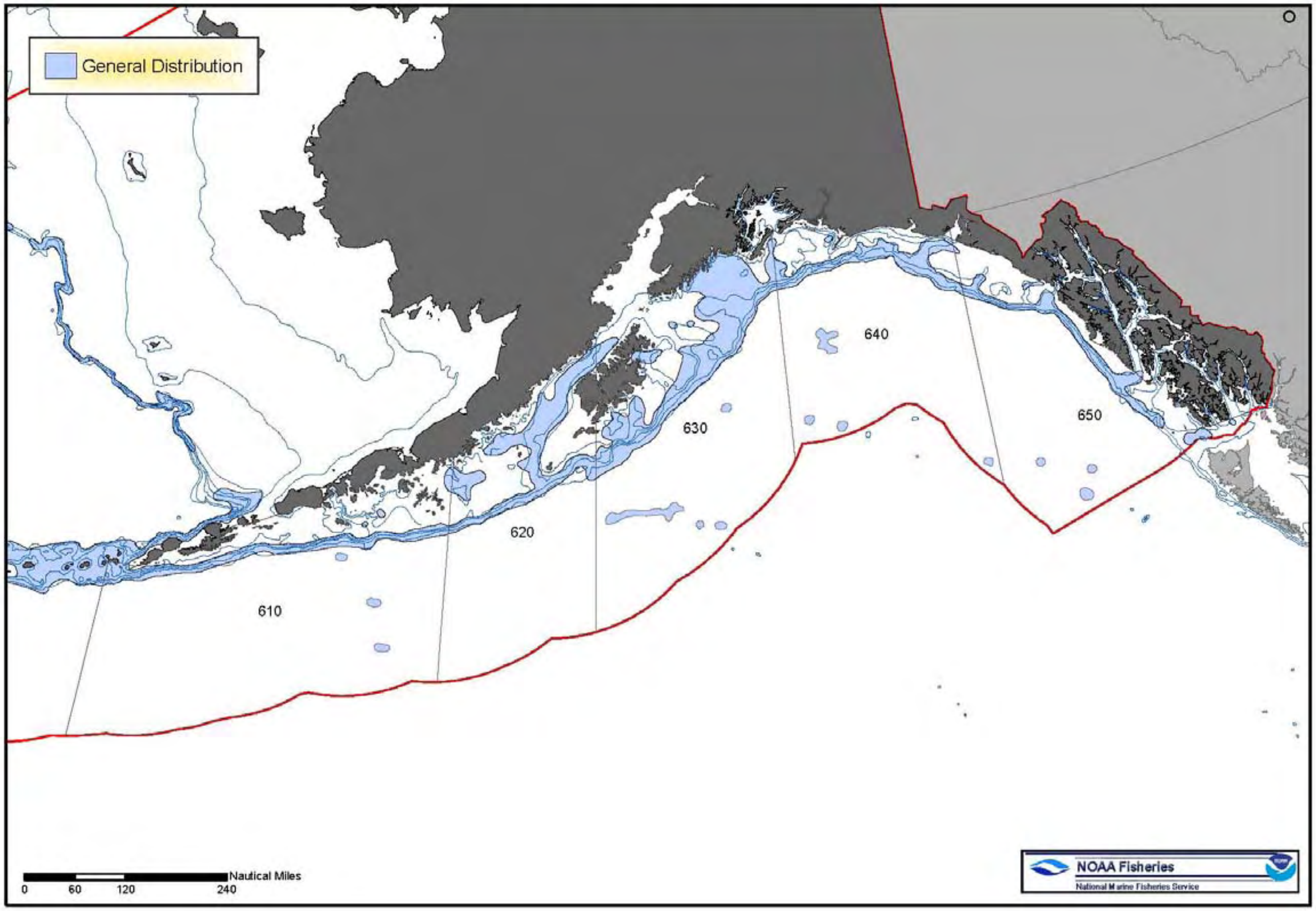


Figure E-32
GOA Northern Rockfish Adults

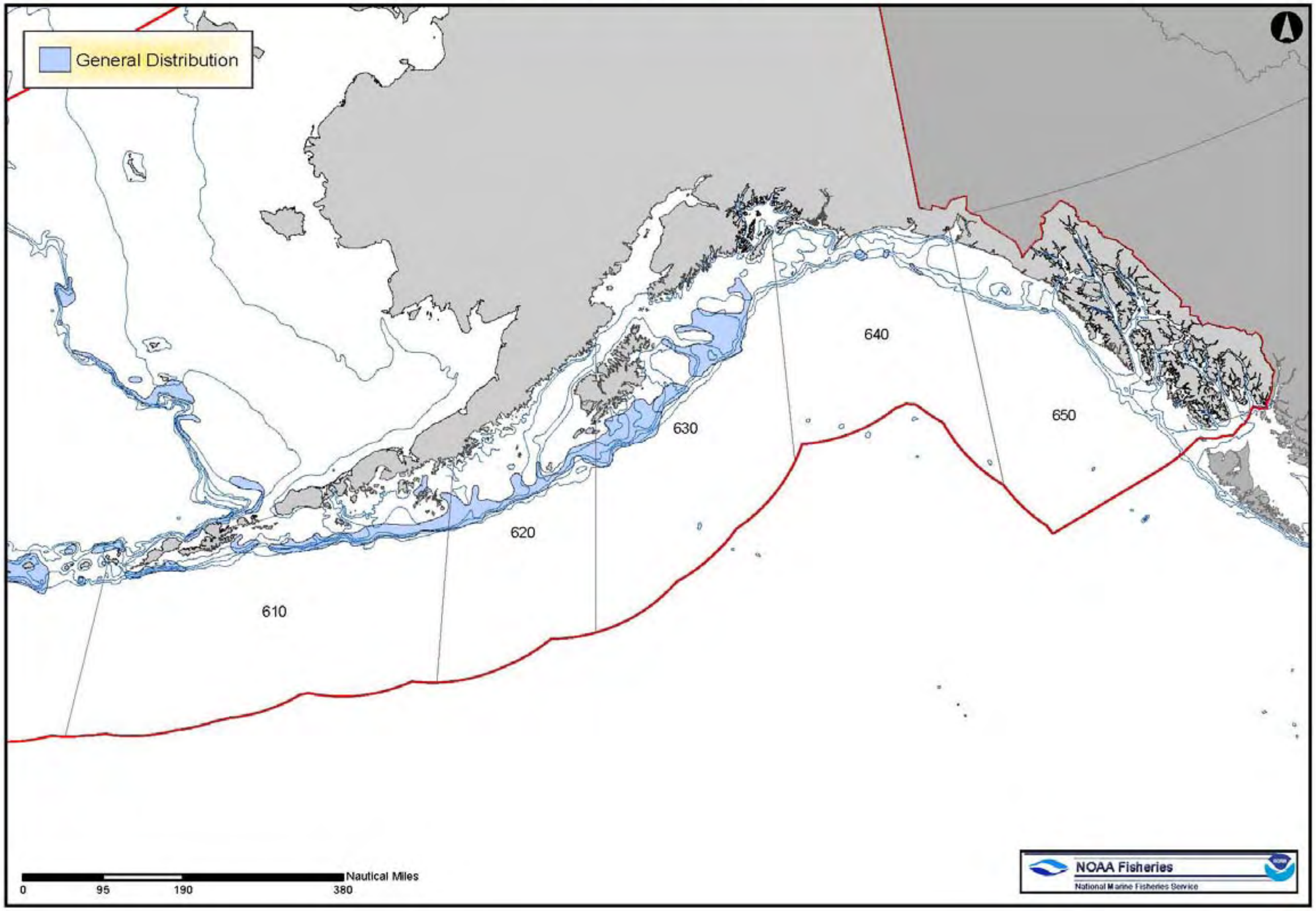


Figure E-33
GOA Thornyhead Rockfish Late Juveniles/Adults

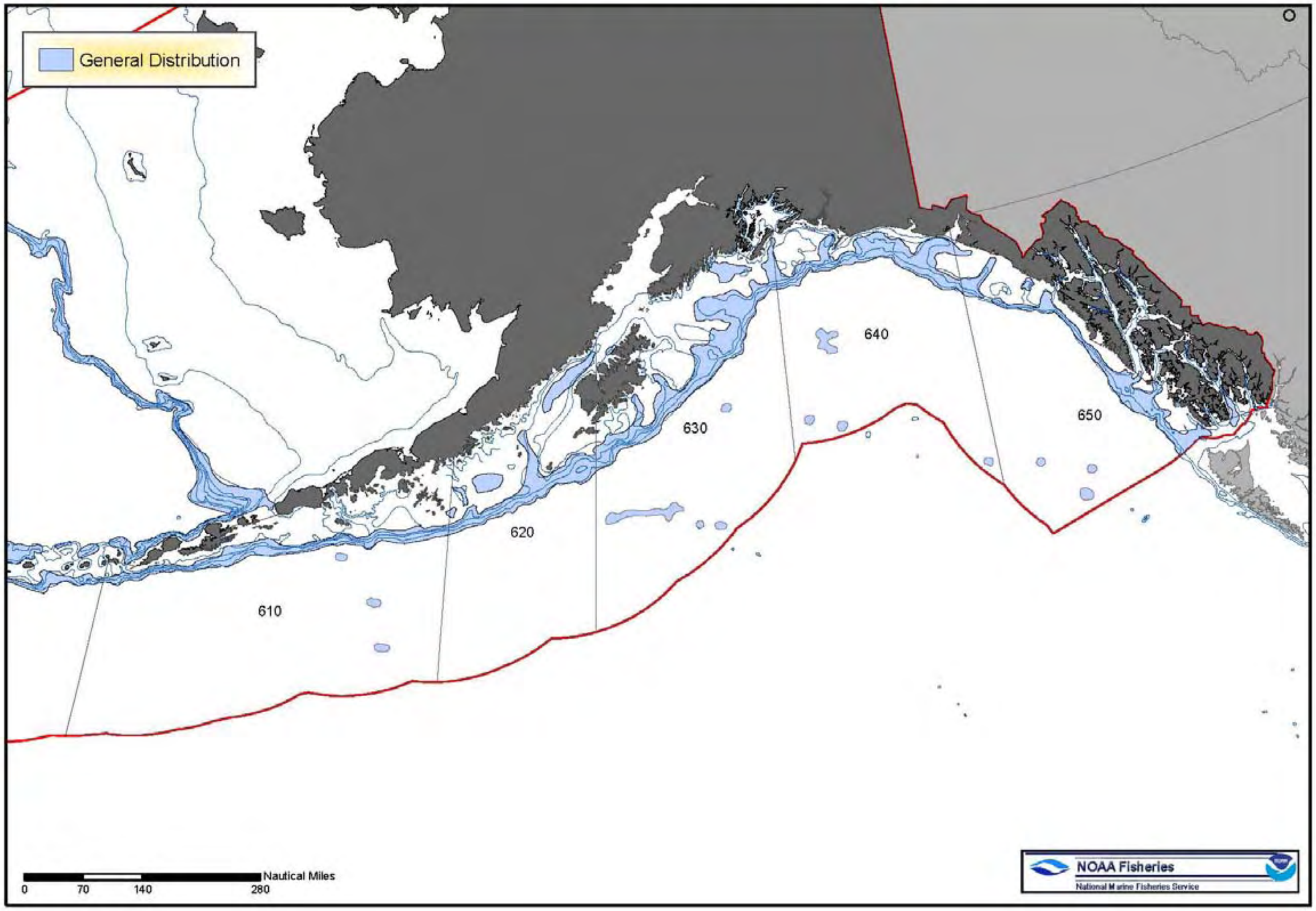


Figure E-34
GOA Yelloweye Rockfish Late Juveniles/Adults

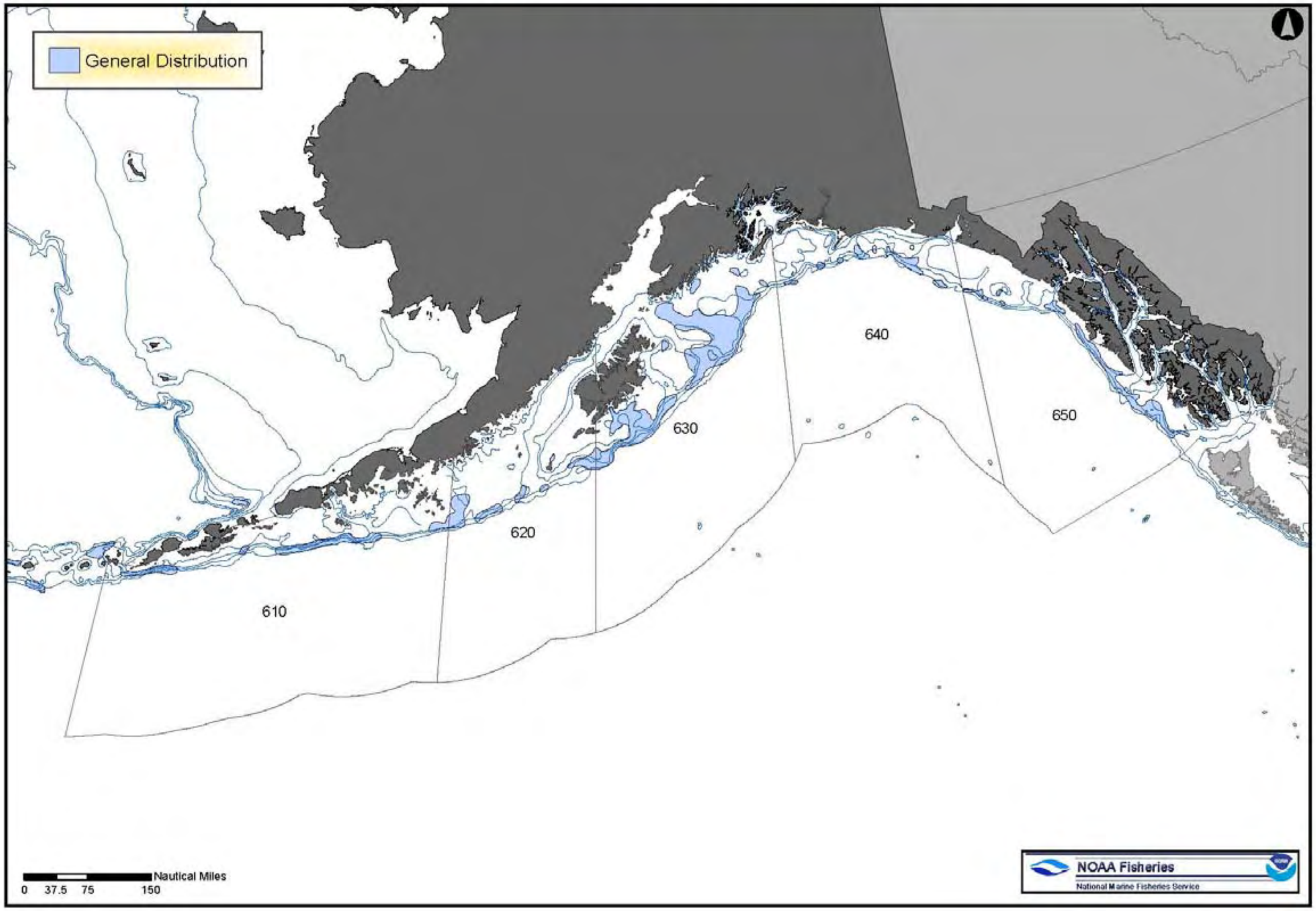


Figure E-35
GOA Dusky Rockfish Adults

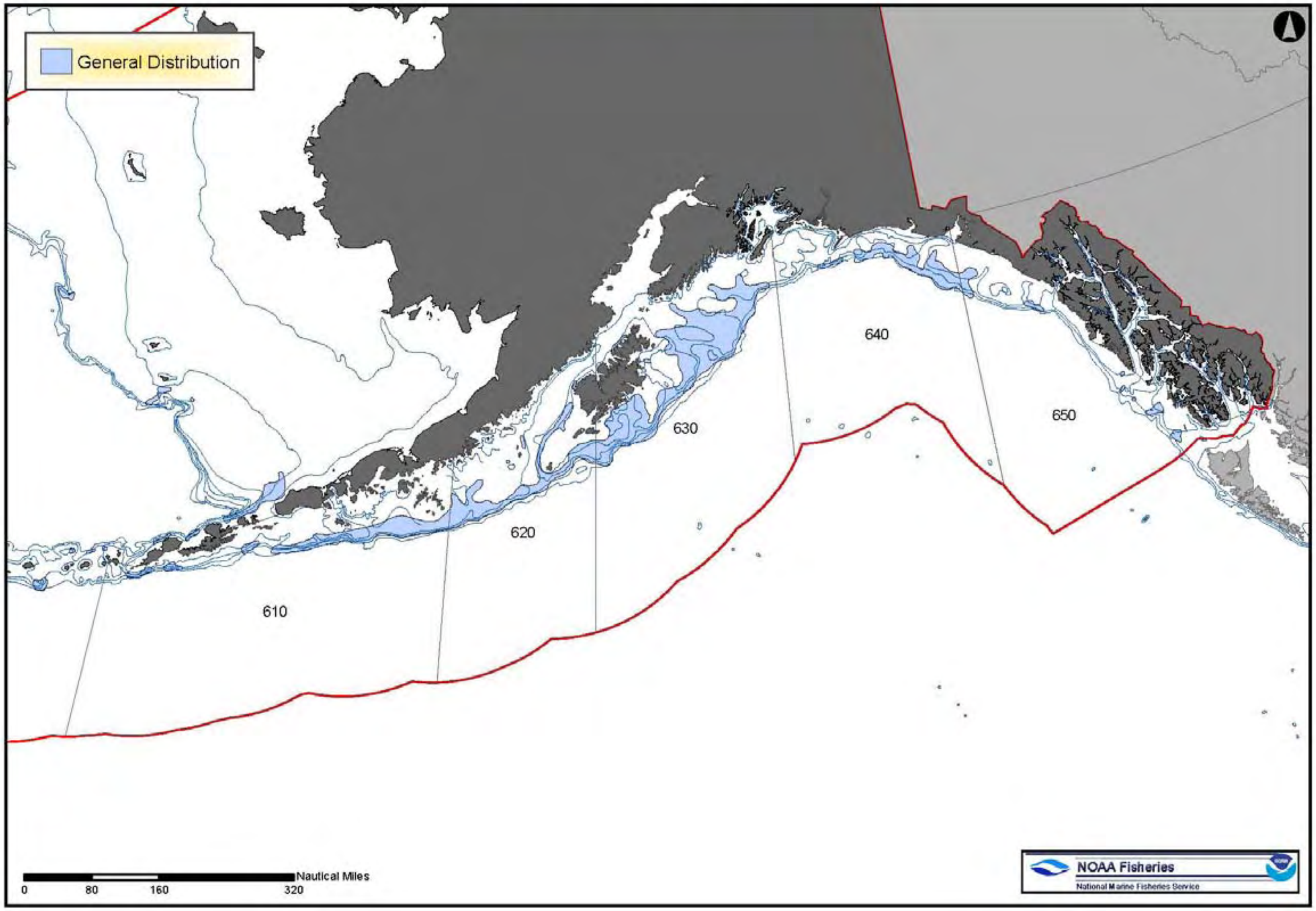


Figure E-36
GOA Atka Mackerel Larval Presence

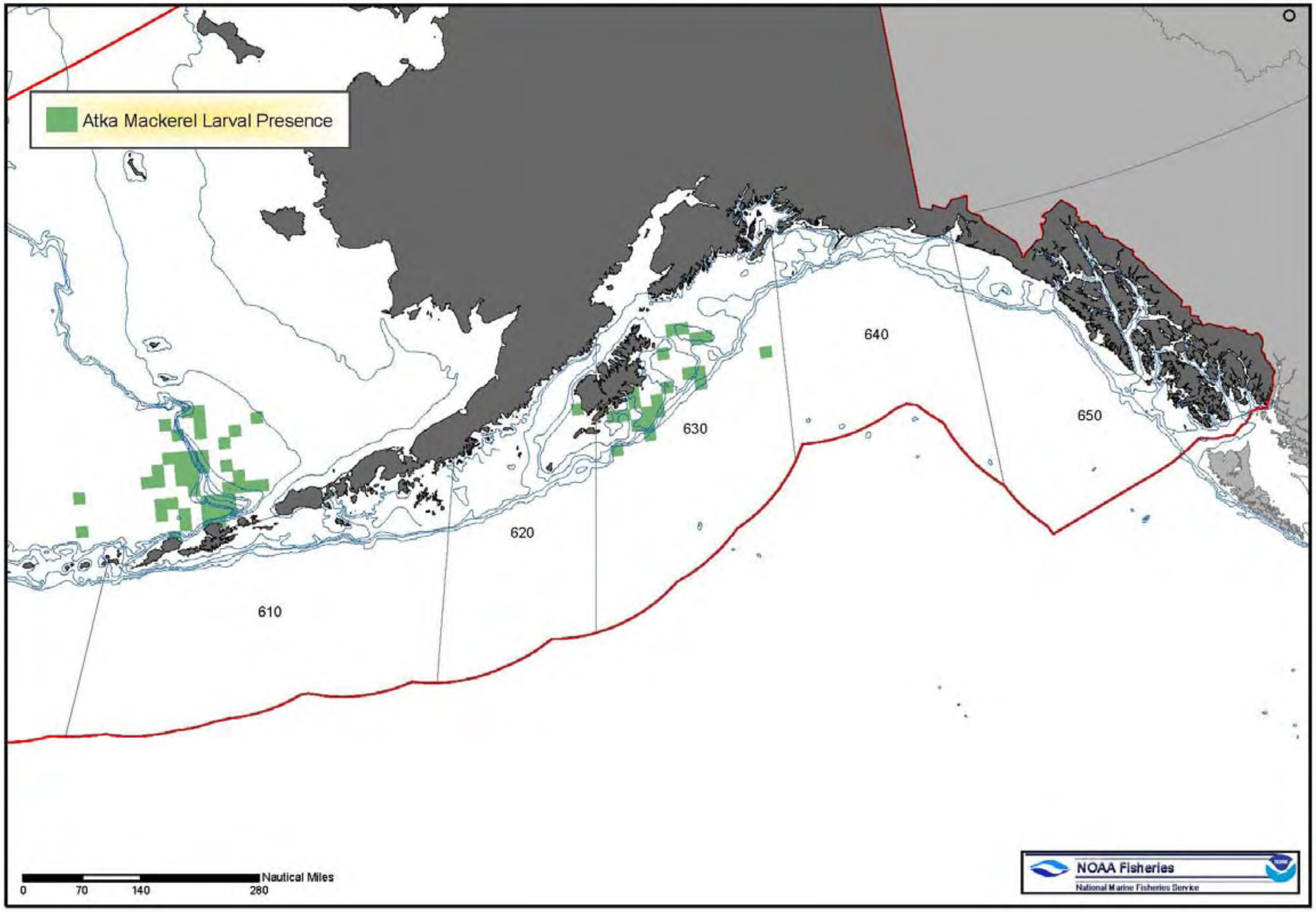


Figure E-37
GOA Atka Mackerel Adults

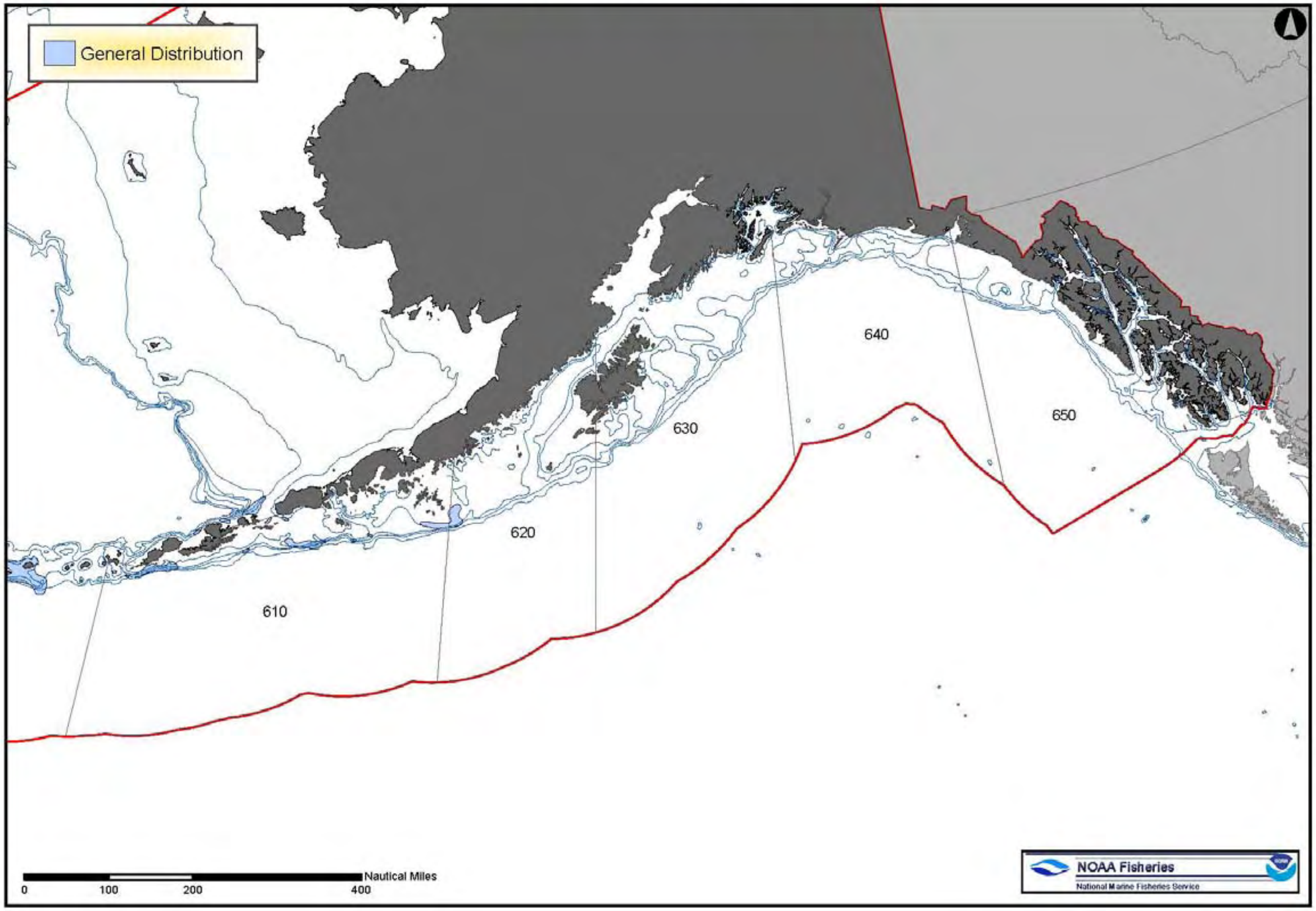


Figure E-38
GOA Sculpin Juveniles/Adults

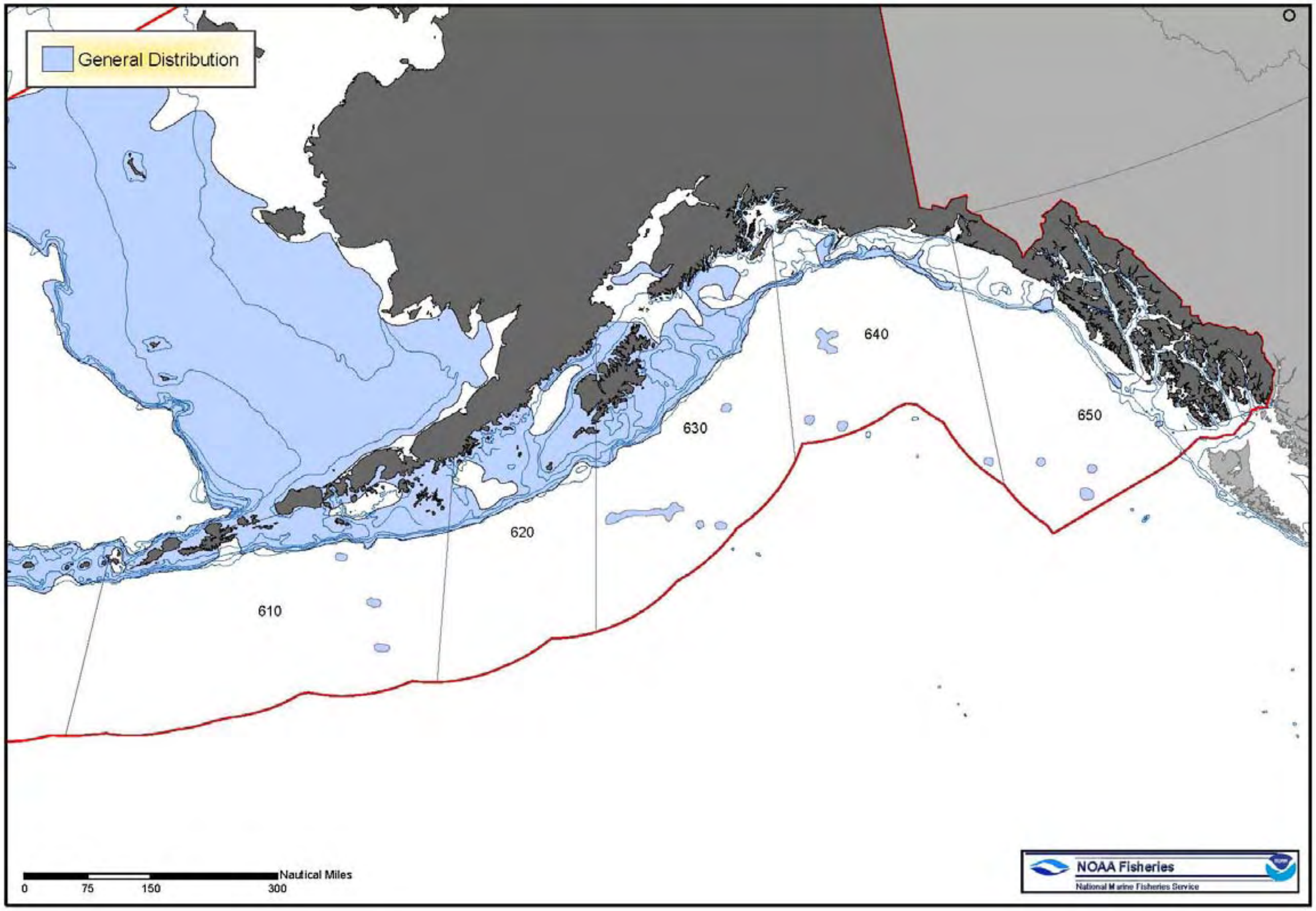


Figure E-39
GOA Skate Adults

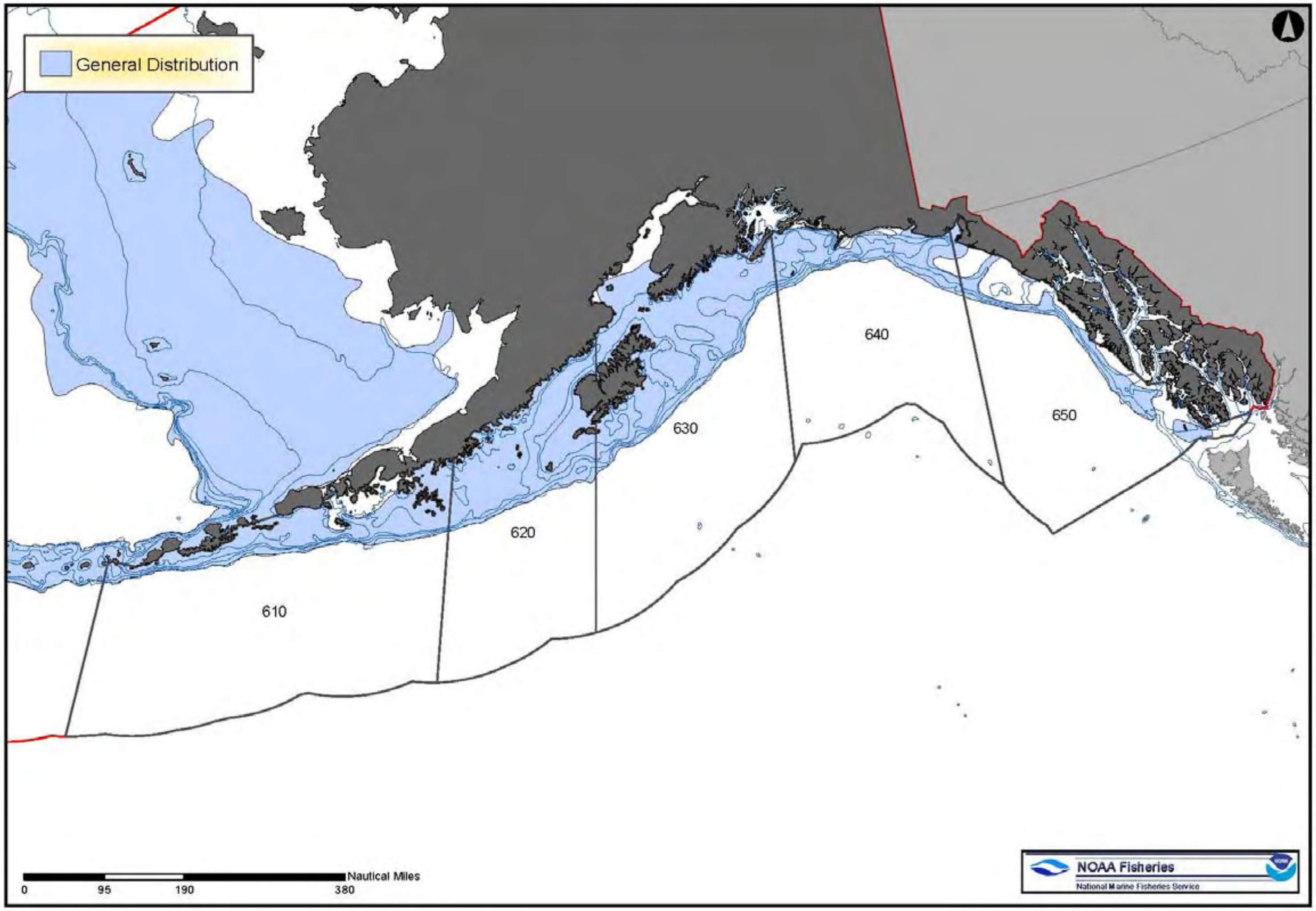
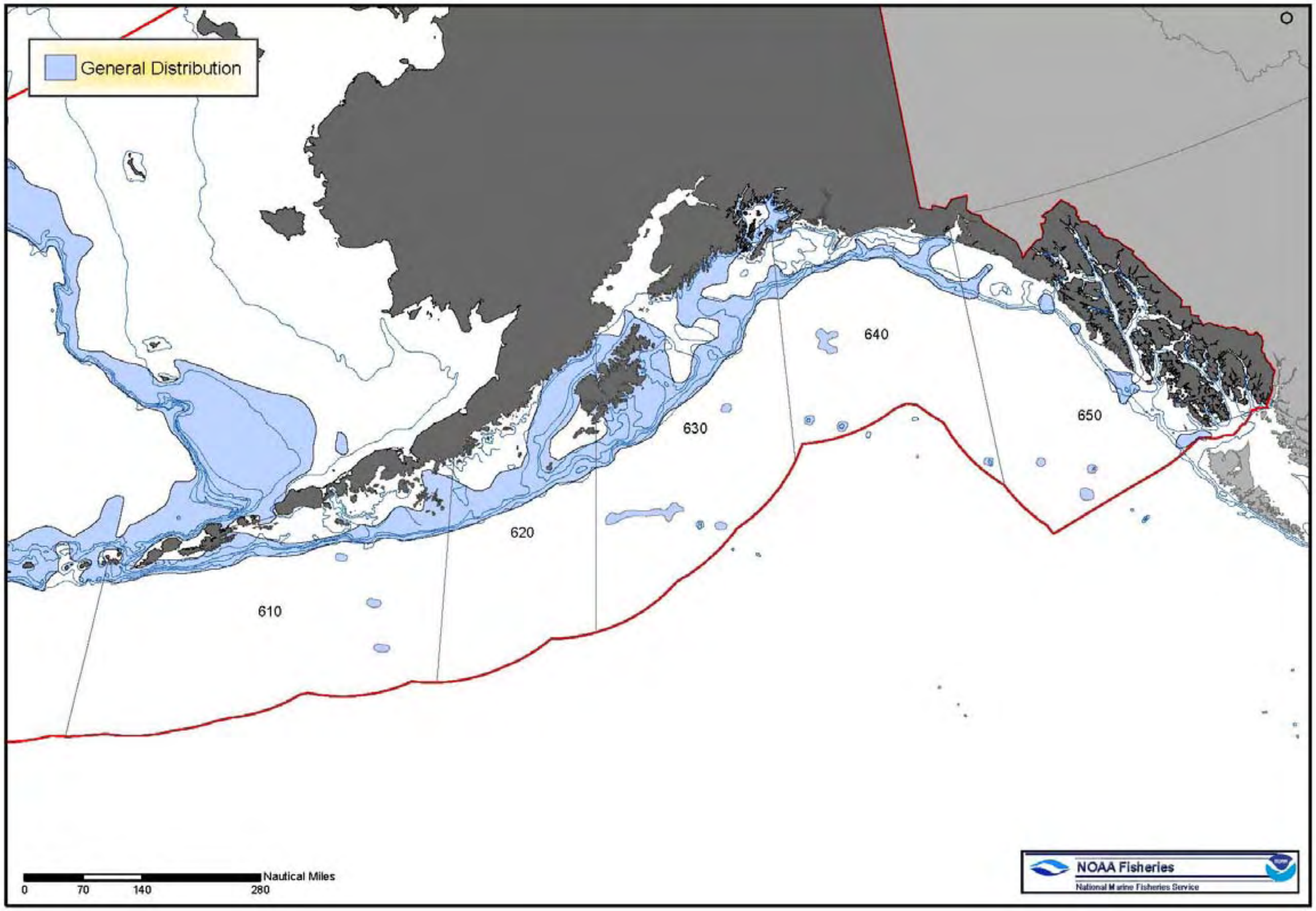


Figure E-40
GOA Squid Late Juveniles/Adults



[this page intentionally left blank

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 Gulf of Alaska (GOA) 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 and Conservation Measures

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, 5) 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.

Much of the material responsive to this evaluation is located in the following sections of the environmental impact statement (EIS) for EFH (NMFS 2005). These areas include:

- Descriptions of fishing activities (including gear, intensity, extent and frequency of effort) - Sections 3.4.1 and 3.4.2.
- Effects of fishing activities on fish habitat - Section 3.4.3.
- Past management actions that minimize potential adverse effects on EFH - Sections 2.2 and 4.3.
- Habitat requirements of managed species - Sections 3.2.1, 3.2.2, and Appendices D and F.
- Features of the habitat - Sections 3.1, 3.2.4 and 3.3.
- HAPCs - 2.2.2.7, 2.2.2.8, 2.3.2, and 4.2

Appendix B of the EFH EIS also contains a comprehensive, peer-reviewed analysis of fishing effects on EFH and detailed results for each managed species. This FMP incorporates by reference the complete analysis in Appendix B of the EFH EIS and summarizes the results for each managed species.

Section B.1 of Appendix B of the EFH EIS has a detailed discussion regarding the relevant rules and definitions that must be considered in developing the fishing effects on EFH analysis. The analysis is based on determining whether an effect on EFH is more than minimal and not temporary (50 CFR 600.815(a)(2)(ii)).

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.

A mathematical model was developed as a tool to structure the relationships among available sources of information that may influence the effects of fishing on habitat. This model was designed to estimate proportional effects on habitat features that would persist if current fishing levels were continued until affected habitat features reached an equilibrium with the fishing effects. Details on the limitations and uncertainties of the model and the process used by the analyst are in Section B.1 of Appendix B of the EFH EIS (NMFS 2005).

F.1.2 Effects of Fishing Analysis

Section B.2 of Appendix B of the EFH EIS (NMFS 2005) contains details on the fishing effects on EFH analysis. Fishing operations can adversely affect the availability of various habitat features for use by fish species. Habitat features are those parts of the habitat used by a fish species for the processes of spawning, breeding, feeding, or growth to maturity. A complex combination of factors influences the effects of fishing on habitat features, including the following:

1. Intensity of fishing effort
2. Sensitivity of habitat features to contact with fishing gear
3. Recovery rates of habitat features
4. Distribution of fishing effort relative to different types of habitat

The goal of this analysis was to combine available information on each of these factors into an index of the effects of fishing on features of fish habitat that is applicable to issues raised in the EFH regulations.

The effects of fishing on recovery for EFH is described by the long term effect index (LEI). Features that recover very quickly could achieve a small LEI under any fishing intensity. Features that recover very slowly may have a high LEI even with small rates of fishing effects. The LEI is used in the summaries to describe the fishing effects on EFH for managed species. The LEI scores represent the ability of fishing to reduce however much of each feature was present in an area as a proportional reduction. LEIs were calculated for all areas where fishing occurred, including some areas where the subject feature may never have existed.

Section B.2.4.3 of Appendix B of the EFH EIS contains information regarding recovery rates for various habitat types. Long and short recovery times were 3 to 4 months for sand, 6 to 12 months for sand/mud, and 6 to 18 months for mud habitats. In general, very little data are available on the recovery periods for living structure. Recovery rates of structure-forming invertebrates associated with the soft bottom, based on their life history characteristics, is estimated at 10 to 30 percent per year with a mean of 20 percent per year. Hard-bottom recovery rates are estimated to be slower, 1 to 9 percent per year, with a mean of 5 percent per year based on hard-bottom invertebrate life history characteristics. Recovery rates of gorgonian corals are potentially much longer, with rates of 50, 100, and 200 years estimated.

The habitat and regional boundaries were overlaid using geographic information systems (GIS) (ArcMap), resulting in the classification of each of the 5-by-5-km blocks by habitat type. Where a boundary passed through a block, the area within each habitat was calculated, and those areas were analyzed separately. For the GOA and AI habitats, the estimates of proportions of hard and soft substrate habitat types were entered into the classification matrix for each block. The total area of each benthic habitat was calculated through GIS based on coastlines, regional boundaries, habitat boundaries, and depth contours (Table B.2-7 of the EFH EIS).

Additional details on the quantity and quality of data and studies used to develop the analysis, how the analysis model was derived and applied, and considerations for the LEIs are contained in Section B.2 of Appendix B of the EFH EIS.

F.1.3 Fishing Gear Impacts

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

F.1.3.1 Bottom Trawls

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

F.1.3.1.1 Infaunal Prey

Infaunal organisms, such as polychaetes, other worms, and bivalves, are significant sources of prey for Alaska groundfish species. Because researchers were not able to determine which crustaceans cited in trawl effects studies were actually infauna, all crustaceans were categorized as epifaunal prey. 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. The resulting median effect was 14 percent reduction in biomass.

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.

In a recent master's thesis, 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. Only three results were provided for infauna in roller gear tracks, but the results were so variable (-50 percent, +12 percent, +57 percent) that they were useless for the purpose of this analysis. 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. Doors make up less than 4 percent of the area of the seafloor contacted by Alaska trawls.

The results of Kenchington et al. (2001), Bergman and Santbrink (2000), and Brown (2003) were combined for inclusion in the model, resulting in a median of 10 percent reduction in biomass per gear contact for infaunal species due to trawling, and 25th and 75th percentiles of 5 and 21 percent, respectively (Table B.2-5 of the EFH EIS).

F.1.3.1.2 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. These are the q values used for the analysis of the effects of full trawls on epifaunal prey, except for those fisheries using tire gear (see below).

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. However, for comparison with previously discussed studies, the resulting median and 75th percentile reductions in biomass for six species of epifauna (excluding snails and crabs) were 12 and 28 percent, respectively. The median result was within the same range as those from the more direct studies, and the 75th percentile result was not sufficiently higher as to indicate substantial error in the direct estimates.

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. Before snails were removed, the 25th percentile indicated an increase in biomass of 82 percent due to colonization by snails. The resulting values when two snail taxa were removed were 38 and 43 percent medians and a 5 percent reduction in epifaunal biomass for the 75th and 25th percentiles. The authors noted a strong transition to apparently smaller effects outside of the direct path of the tire gear. For fisheries in hard-bottom areas, where tire gear is most common, epifaunal effects were adjusted for this increased effect within the path of the tire gear. Typical tire gear covers about 25 percent of the full trawl path (i.e., 14 m out of 55 m total), so the resulting q values are 17 percent reduction in epifaunal biomass for the median (0.25 times 38 plus 0.75 times 10), 23 percent reduction for epifaunal biomass for the 75th percentile (0.25 times 43 plus 0.75 times17), and 5 percent reduction for the 25th percentile.

F.1.3.1.3 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). After adjustment for multiple contacts, *Gersemia* had a q of 10 percent reduction in biomass per gear contact.

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). Lacking better information, the damaged organisms from Freese et al. (1999) were assigned a 50 percent loss of structural function, and the heavily and lightly damaged organisms from VanDolah et al. (1987) were assigned 75 and 25 percent losses of their function respectively.

Adjustments to the Freese et al.(1999) results were based on observations of a further decrease in vase sponge densities 1 year post-study. Freese (2001) indicates that some of the damaged sponges had suffered necrotization (decay of dead tissues) to the extent that they were no longer identifiable. This percentage was added to the category of removed organisms, resulting in q estimates for epifauna structures in the path of tire gear of a 35 percent median reduction in biomass per contact and a 75th percentile of 55 percent reduction in biomass per contact. Summary results of the VanDolah data show a median of 17 percent reduction in biomass per gear contact and a 75th percentile of 22 percent reduction in biomass per gear contact. Moran and Stephenson (2000) combined all erect epifauna taller than 20 cm and studied their reductions subsequent to each of a series of trawl contacts. They estimated a per contact reduction in biomass (q) of 15 percent. Combining the non-tire gear studies gives a full gear q median per contact reduction estimate of 15 percent and a 75th percentile per contact reduction estimate of 21 percent. Using the same methods as applied to epifauna for combining non-tire gear data with the tire gear data produced effect estimates for trawls employing tire gear of a median per contact reduction of 20 percent and a 75th percentile per contact reduction of 30 percent.

Data from McConnaughey et al. (2000) combining initial effects of high-intensity trawling and recovery had a median value for structure-forming epifauna per contact reduction of 23 percent and a 75th percentile reduction of 44 percent. While these results show greater reductions than the single pass estimates from the other studies, the effects of multiple years of high-intensity trawling can reasonably account for such a difference; thus, the above values for q were not altered.

F.1.3.1.4 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. This value was used for coral sensitivity in the analysis bracketed by low and high values of 22 and 35 percent.

F.1.3.1.5 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 and proposes preliminary values of q for the analysis.

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. This consideration was done by studies cited in the prey sections above. Since the observed effects of a single gear contact are relatively subtle, with ambiguous effects on function, the parameter selected for this analysis represents a small negative effect (-2 percent). This provides some effect size that can be scaled up or down if greater or lesser effects are hypothesized or measured.

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), the effect would only increase to 2 percent. Lacking better information, this speculative value was applied in the analysis.

F.1.3.2 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.

Two studies of small footrope trawls were used to represent the effects of pelagic trawl footropes on infaunal prey. Since most infaunal prey are too small to be effectively retained by bottom trawls, the large mesh size of pelagic trawls was not considered a relevant difference for the feature. Ball et al. (2000) investigated the effects of two tows of a Nephrops trawl in the Irish Sea on a muddy sand bottom in two different years. Eighteen taxonomic groups were measured in each year, including bivalves, gastropods, crustaceans, and annelids. For the 27 abundance reductions cited, the median effect was a 19 percent reduction abundance per gear contact, and the 75th percentile was a 40 percent reduction in abundance per gear contact, with the adjustment for multiple tows. Sparks-McConkey and Wating (2001) used four passes of a whiting trawl on a clay-silt bottom in the Bay of Maine. The infauna responses measured included three bivalves and seven polychaetes and nemerteans. The median response was a 24 percent reduction in abundance per gear contact, and the 75th percentile was a 31 percent reduction in abundance per gear contact, with the adjustment for multiple tows. Combining the two studies gave a median per contract reduction of 21 percent and a 75th percentile per contact reduction of 36 percent. These values were higher than those for roller gear trawls since there is continuous contact across the footrope and a greater ability of smaller footropes to penetrate the substrate.

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. Based on these considerations, values of 20 percent reduction per gear contact and 30 percent reduction per gear contact were selected for both living and non_living structure.

F.1.3.3 Longlines

Studies that quantitatively assess the effects of longlines on seafloor habitat features were not found. Due to 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. Values for reduction of living structure equal to one-half of those for bottom trawls were used for the area contacted by longlines.

F.1.3.4 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. Therefore, structure reduction values 5 percent greater than those determined for pelagic trawls were used.

F.1.3.5 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.1.3.6 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 (mollusks) 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 effect the benthic community and physical environment relative to the intensity of the fishery.

Adverse effects of scallop dredges on benthic communities in Alaska may be lower in intensity than trawl gear. Studies on effects of trawl and dredge gear have revealed that, in general, the heavier the gear in contact with the seabed, the greater the damage (Jones 1992). Scallop dredges generally weigh less than most trawl doors, and the relative width they occupy is significantly smaller. A 15 ft wide New Bedford style scallop dredge weighs about 1,900 lbs (Kodiak Fish Co. data). Because scallop vessels generally fish two dredges, the total weight of the gear is 3,800 lbs. Trawl gear can be significantly heavier. An 850 horsepower vessel pulling a trawl with a 150 ft sweep may require a pair of doors that weigh about 4,500 pounds. Total weight of all trawl gear, including net, footrope, and mud gear would weigh even more (T. Kandianis, personal communication). Hence, based on weight of gear alone, scallop fishing may have less effect than bottom trawling, however its effects may be more concentrated.

F.1.4 Results of the Analysis of Effects of Fishing on Habitat Features

No fishing occurred in blocks covering a large proportion of the seafloor area shallower than 1,000 m from 1998 to 2002 (Table B.2-8 of the EFH EIS), and even more blocks were unaffected by trawling. Most of the fished blocks experienced intensities less than 0.1, and only a small proportion of the area (2.5 percent BS, 0.8 percent AI, and 0.9 percent GOA) was in blocks with intensities above 1.0. These fishing intensities determined the spatial distribution of the indices of fishing effects estimated by the model.

The analysis estimated an LEI of the effects of fishing on infaunal prey, epifaunal prey, living structure (coral treated separately), and non-living structure across different habitats and between fisheries. The LEI estimated the percentage by which these habitat features would be reduced from a hypothetical unfished abundance if recent intensity and distribution of fishing effort were continued over a long enough term to achieve equilibrium. Equilibrium is defined as a point where the rate of loss of habitat features from fishing effects equal the gain from feature recovery. The spatial pattern of long-term effect indices largely reflects the distribution of fishing effort scaled by the sensitivity and recovery rates assigned to different features in different habitat types. Thus, patterns on the charts of LEI for each feature class were very similar, with higher overall LEIs for more sensitive or slower recovering features (Figures B.2-2 to B.2-5 of the EFH EIS). Prey LEIs were substantially lower than structure LEIs, reflecting their lower sensitivity and faster recovery rates.

All habitats included substantially unfished and lightly fished areas that have low LEIs (less than 1 percent) as well as some areas of high fishing that resulted in high LEIs (more than 50 percent or even more than 75 percent). In the AI, GOA, and EBS slope, substantial LEIs were primarily concentrated into many small, discrete pockets. On the EBS shelf, there were two larger areas where high LEIs were concentrated: (1) an area of sand/mud habitat between Bristol Bay and the Pribilof Islands and (2) an area of sand habitat north of Unimak Island and Unimak Pass, mostly inside of the 100-m contour.

Some of the patterns in fishing effects can be related to areas closed to bottom trawl fishing. In the GOA, no bottom trawling is allowed east of 140ºE longitude, and fishing effects are light there. Bottom trawling has been substantially restricted within specified radii (10 and 20 nm) of Steller sea lion rookeries and haulouts. The effects of these actions on LEI values are most clearly seen in the AI, where high LEI values are concentrated in small patches where the narrow shelf does not intersect these closures. Two large EBS areas around the Pribilof Islands and in and adjacent to Bristol Bay both mostly in sand substrates, are closed to bottom trawling to protect red king crab habitat. These closures concentrate fishing in the southern part of the EBS into the remaining sand, sand/mud, and slope habitats, which likely increases the predicted LEI in those areas.

Aggregate LEIs for each of the habitats are shown in Table B.2-9 of the EFH EIS. As discussed above, prey declined less than biostructure due to lower sensitivity and faster recovery rates. No prey feature was reduced by more than 3.5 percent (BS slope habitat). Biological structure features had LEIs between 7 and 9 percent in the hard substrate habitats where recovery rates were slow. LEIs above 10 percent were indicated for the biological structure of the sand/mud and slope habitats of the EBS where fishing effort is concentrated, and recovery rates are moderately slow.

Because of uncertainties in key input parameters, some evaluation was needed to determine how widely the resulting estimates might vary. In addition to the LEIs cited above, which were generated with median or central estimates for each input parameter (referred to below as central LEIs), LEI was estimated for both large and small values of sensitivity and recovery. High estimates of sensitivity were combined with low recovery rates to provide an upper LEI, and low estimates of sensitivity were combined with high recovery rates to produce a lower LEI. Lower LEIs for the habitat features (except for coral, which is discussed below) ranged from 8 to 50 percent of the original median estimates. Infaunal and epifaunal prey lower LEIs were all at or below 0.5 percent proportional reduction habitat, those for non-living structure were below 2 percent, and those for living structure were below 4 percent. The corresponding upper LEIs ranged from 1.5 to 3 times the original median estimate. The largest upper LEI values for infauna and epifauna prey were for the EBS sand/mud and slope habitats and ranged from 3.5 to 7 percent, with all other upper LEIs below 2 percent. Non-living structure upper LEIs were greatest on the GOA hard substrates, the AI shallow water habitat, and the EBS slope, ranging from 7 to 14 percent, with all other upper LEIs below 4 percent. In six habitats (the three GOA hard substrates, the AI shallow water habitats, and the EBS sand/mud and slope habitats), the upper LEI exceeded 10 percent, with the highest value (21 percent) on the GOA slope.

The analysis also calculated the proportion of each LEI attributable to each fishery. Fishery-specific LEI values for the habitat/feature combinations with the highest overall LEIs (all involving living structure) in each region are presented in Table B.2-10 of the EFH EIS. While the pollock pelagic trawl fishery was the largest single component (4.6 percent) of the total effects on living structure in the EBS sand/mud habitat, the combined effects of the bottom trawl fisheries made up all of the remaining 6.3 percent (total LEI of 10.9 percent). This was not true for living structure on the EBS slope, where nearly all (7.2 percent out of 10.9 percent) of the LEI was due to the pollock pelagic trawl fishery. Living structure on hard bottom substrates of the GOA slope was affected by bottom trawling for both deepwater flatfish and rockfish. While the LEIs of these two fisheries were nearly equal, it is likely that much more of the rockfish effort occurred on hard substrates as compared with trawling for deepwater flatfish. [Because the spatial distribution of hard and soft substrate was unknown, such differences are not explicitly accounted for in the fishing effects analysis.] Therefore, most of the effects on this feature were attributed to the rockfish trawl fishery. In the shallow, hard substrate habitat of the AI, most of the effects (4.2 out of 7.3 percent) on living structure were attributable to the trawl fishery for Pacific cod. The remainder was attributed to Atka mackerel trawling at 2.5 percent. Living structure was the only habitat feature in which the effect of a passive gear fishery, longlining for Pacific cod, had an LEI above 0.1 percent. This fishery accounts for the consistent light blue (less than 1 percent LEI) coverage in Figure B.2-3 (a, b, and c) of the EFH EIS of many shallow areas of the AI not open to trawling.

Results for ultra-slow recovering structures, represented by hard corals, were different from those of other living structure in several ways. Corals had the highest LEI values of the fishing effects analyses. Because the very slow recovery rate of these organisms results in very high (more than 75 percent LEI) eventual effects with more than the most minimal amount of trawl fishing (annual trawl effort less than one tenth the area of the block), the distribution of high LEI values directly reflects the distribution of blocks subject to more than minimal trawl effort (Figure B.2-6 [a, b, and c] of the EFH EIS). The LEI values by habitat range from 6 to 20 percent with the highest values in the shallow AI and GOA slopes. These results mostly reflect the proportion of blocks in each habitat type subject to more than minimal trawl effort. Even though fairly wide ranges of both sensitivity and recovery rates were used for the upper and lower LEI estimates for coral, the range between upper and lower LEI was not as wide as for the other living structure organisms, ranging from plus 40 to -33 percent of the central value.

This analysis combined available information to assess the effects of Alaska fisheries on marine fish habitat. It estimated the effects (as measured by LEIs) of fisheries on habitat features that may be used by fish for spawning, breeding, feeding, or growth to maturity. These LEIs represent the proportion of feature abundances (relative to an unfished state) that would be lost if recent fishing patterns were continued indefinitely (to equilibrium). Therefore, all LEIs represent effects that are not limited in duration and satisfy the EFH regulation's definition of "not temporary." The magnitude and distribution of feature LEIs can, thus, be compared with the distribution of the use of that feature by fish species to assess whether the effects are "more than minimal" relative to that species' EFH (Section B.3 of the EFH EIS). Effects meeting this second element would necessarily meet both elements (more than minimal and not temporary) due to the nature of the LEI estimates.

Additional information regarding the LEI analysis, including the comparison of results to groundfish surveys and literature, the quality of information used, and the limitations of the results are in Section B.2.6 of Appendix B of the EFH EIS.

F.1.5 Evaluation of Effects on EFH of Groundfish Species

The fishing effects analysis is performed to evaluate whether the fisheries, as they are currently conducted off Alaska, will affect habitat that is essential to the welfare of the managed fish populations in a way that is more than minimal and not temporary. The previous statement describes the standard set in the EFH regulations which, if met, requires Councils to act to minimize such effects. The above analysis has identified changes to habitat features that are not expected to be temporary. The habitat features were selected as those which a) can be affected by fishing and b) may be important to fish in spawning, breeding, feeding, and growth to maturity. This section evaluates the extent that these changes relate to the EFH of each managed species and whether they constitute an effect to EFH that is more than minimal.

Two conclusions are necessary for this evaluation: (1) the definition of EFH draws a distinction between the amount of habitat necessary for a species to "support a sustainable fishery and the managed species' contribution to a healthy ecosystem" (50 CFR 600.10) and all habitat features used by any individuals of a species; (2) this distinction applies to both the designation of EFH and the evaluation of fishing effects on EFH. If these conclusions are valid, the "more than minimal" standard relates to impacts that potentially affect the ability of the species to fulfill its fishery and ecosystem roles, not just impacts on a local scale. The forgoing analysis has indicated substantial effects to some habitat features in some locations, many of which are within the spatial boundaries of the EFH of a species that may use them in a life-history function. These habitat changes may or may not affect the welfare of that species (a term used to represent "the ability of a species to support a sustainable fishery and its role in a healthy ecosystem").

The evaluation method is detailed in Section B.3.1 of Appendix B of the EFH EIS.

The Effects of Fishing on EFH analysis in the EFH EIS was designed to answer the question: "Is there evidence that fishing adversely affects EFH in a manner that is more than minimal and not temporary in nature?" The following text summarizes the results of the analysis for each managed species. The details of the analysis for each species, including the habitat connections and the evaluation of effects, are contained in Section B.3.3 of Appendix B of the EFH EIS (NMFS 2005) and are incorporated by reference.

F.1.5.1 Walleye Pollock (BSAI and GOA)

Issue	**Evaluation**
Spawning/breeding	MT (Minimal or temporary effect)
Feeding	MT (Minimal or temporary effect)
Growth to maturity	MT (Minimal or temporary effect)

Summary of Effects—Pollock is a generalist species that occupies a broad geographic niche and can use a wide variety of different habitats (Bailey et al. 1999). The ability of pollock to invade and adapt to marginal habitats has been suggested as a possible reason for the rapid increases in abundance during the environmental changes that occurred in the North Pacific in the 1970s (Bailey 2000). Pollock's ecological plasticity may allow adaption to habitats that have been modified by fishing impacts. Fishing impacts might even be beneficial, particularly if there are significant adverse impacts on predators or competitors more dependent on seafloor habitat features.

The overall evaluation of fishing impacts on pollock EFH is based primarily on extensive life history information that shows that pollock eggs, larvae, juveniles, and adults are not associated with seafloor habitat features affected by fishing. Some pollock life history stages are more demersal (i.e., age-1 juveniles), but even here the association is more likely related to temperature tolerances and avoidance of predators higher up in the water column than any characteristic of the bottom that can be impacted by trawling. The rating for fishing impacts on spawning/breeding for BSAI/GOA pollock is MT because pollock are pelagic spawners, as are their eggs and larvae. The rating for fishing impacts on feeding for BSAI/GOA pollock is MT because adults feed mainly on pelagic euphausiids followed by calanoid copepods.

The primary concern for pollock is the reduction in living structure in areas that support high pollock densities and its potential importance to juvenile pollock in providing refuge from predation. Changes in predation (or cannibalism) on juveniles have been proposed as a mechanism for population control in both the BSAI (Hunt et al. 2002) and the GOA (Bailey 2000). An increase in juvenile mortality will reduce spawning output per individual and, if large enough, could impair the ability of the stock to produce MSY over the long term (Dorn 2004). In the GOA, there is evidence of an increase in pollock mortality due to increases in the abundance of the dominant piscivores (Bailey 2000, Hollowed et al. 2000). However, evidence is weak that living structure plays a significant role in mediating mortality risk for juvenile pollock in the BSAI and the GOA, and it appears more likely that juveniles avoid predation risk through behavioral mechanisms such as shoaling and position in the water column. In addition, the overall reduction in living substrate for pollock EFH is relatively small (7 percent). Therefore, the rating for fishing impacts on growth to maturity for BSAI/GOA pollock is MT.

F.1.5.2 Pacific Cod (BSAI and GOA)

Issue	**Evaluation**
Spawning/Breeding	MT (Minimal or temporary effect)
Growth to Maturity	MT (Minimal or temporary effect)
Feeding	MT (Minimal or temporary effect)

Summary of Effects—Fishing's effects on the habitat of Pacific cod in the BSAI and GOA do not appear to have impaired either stocks' ability to sustain itself at or near the MSY level. When weighted by the proportions of habitat types used by Pacific cod, the long-term effect indices are low, particularly those of the habitat features most likely to be important to Pacific cod (infaunal and epifaunal prey). The fishery appears to have had minimal effects on the distribution of adult Pacific cod. Effects of fishing on weight at length, while statistically significant in some cases, are uniformly small and sometimes positive. While the fishery may impose some habitat-mediated effects on recruitment, these fall below the standard necessary to justify a rating of anything other than minimal or temporary.

F.1.5.3 Sablefish (GOA and BSAI)

Issue	Evaluation
Spawning/Breeding	MT
Growth to Maturity	U (Unknown)
Feeding	U (Unknown)

Summary of Effects—The estimated productivity and sustainable yield of sablefish 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 target biomass levels despite of the decreasing level of the targets and fishing rates below the target fishing rate. While years of strong young-of-the-year survival have occurred in the 1980s and 1990s, the failure of strong recruitment to the mature stage suggests a decreased survival of juveniles during their residence as 2_ to 4-year-olds on the continental shelf. While climate-related changes are a possible cause for reduced productivity, the observations noted above are consistent with possible effects of fishing on habitat and resulting changes in the juvenile ecology of sablefish, possibly through increased competition for food and space. Given the concern for the decline in the sustainable yield of sablefish, the possibility of the role of fishing effects on juvenile sablefish habitat, and the need for a better understanding of the possible causes, an MT rating is not merited, and sablefish growth to maturity and feeding is rated unknown.

F.1.5.4 Atka Mackerel (BSAI and GOA)

Issue	Evaluation
Spawning/Breeding	MT (Minimal, temporary, or no effect)
Growth to Maturity	MT (Minimal, temporary, or no effect)
Feeding	MT (Minimal, temporary, or no effect)

Summary of Effects—The effects of fishing on the habitat of Atka mackerel are considered to be minimal and temporary or negligible. Affected habitat areas may impact Atka mackerel, but environmental conditions may be the dominant factor affecting the Atka mackerel population, given the moderate exploitation levels since 1977. Environmental conditions since 1977 may favor Atka mackerel and override impacts of fishing on habitat features important to the species. Some information, however, suggests that bottom trawling may have a negative effect on the benthic habitat, especially corals and sponges. The LEI analysis indicates that there is a potential for large reductions in hard coral habitats, which intersect with Atka mackerel habitat, and Atka mackerel have been observed in association with sponges and corals. The extent and nature of the associations between AI Atka mackerel and living and non-living substrate and hard corals are largely unknown. If these are desirable habitat features for Atka mackerel, however, and there is a significant dependance on these features, the potential large reduction (more than 50 percent) in hard corals in many areas of the AI could be of concern. Overall the Atka mackerel stock is in relatively good condition and is currently at a high abundance level. There are no indications that the affected habitat areas that overlap with the distribution of Atka mackerel would impair the ability of the stock to produce MSY over the long term.

There is some presumed overlap of the fishery with the distribution of Atka mackerel nesting sites, but the extent of the overlap with the spatial distribution of fishing impacted areas is likely to be low due a variety of factors. These factors include Steller Sea Lion protection measures, which likely afford protection to several Atka mackerel spawning grounds. Other spawning grounds that are not in closed areas, but that occur in untrawlable habitat, are also afforded protection. Summer resource assessment trawl surveys conducted biennially in the AI at the time of spawning provide a relative measure of abundance of the spawning biomass and have not detected a shift in the spatial distribution of biomass. To date, there is no evidence to suggest a link between habitat disturbance and the spawning/breeding success of AI Atka mackerel. There is also no evidence to suggest that habitat disturbance impairs the stock's ability to produce MSY over the long term through impacts on spawning/breeding success. Therefore, the impact of habitat disturbance on the spawning/breeding success of Atka mackerel is minimal and temporary.

There is no evidence to suggest a link between habitat disturbance and growth to maturity of AI Atka mackerel. There is also no evidence to suggest that habitat disturbance impairs the stock's ability to produce MSY over the long term through impacts on growth to maturity. Analyses of growth data do not indicate any detectable adverse impacts on the growth to maturity for Atka mackerel due to habitat disturbance. Therefore, the impact of habitat disturbance on the growth to maturity of Atka mackerel is minimal and temporary.

The adults feed mainly on pelagic euphausiids followed by calanoid copepods, which are not one of the affected habitat features. As euphausiids and copepods are pelagic rather than benthic in their distribution and are too small to be retained by any fishing gear, fishing probably has a minimal and/or temporary effect on the availability of prey to Atka mackerel. There is no evidence to suggest that the diet or feeding distributions of Atka mackerel have changed. Overall, there is no evidence that habitat disturbance has affected feeding success of Atka mackerel. Therefore, the impact of habitat disturbance on the feeding success of Atka mackerel is minimal and temporary.

Stock assessment data do not show a negative trend in spawning biomass and recruitment or evidence of chronic low abundance and recruitment. There is no evidence that the cumulative effects of fishing activities on habitat have impaired the stock's ability to produce MSY since 1977. Spawning biomass is at a peak level. The stock has produced several years of above average recruitment since 1977, and recent recruitment has been strong.

F.1.5.5 Flathead Sole (GOA)

Issue	**Evaluation**
Spawning/breeding	MT (Minimal or temporary effect)
Feeding	MT (Minimal or temporary effect)
Growth to maturity	MT (Minimal or temporary effect)

Summary of Effects—The nearshore areas inhabited by flathead sole early juveniles are mostly unaffected by current fishery activities. Adult and late juvenile flathead sole concentrations in the GOA primarily overlap with the deepwater shelf during winter (15 percent) and shallow water habitats during summer (14 percent, Table B.3-3 of the EFH EIS). This species would be affected by reductions in the availability of infaunal and epifaunal prey. Both infaunal and epifaunal prey are predicted to be reduced 1 percent in concentration overlaps with deepwater shelf areas and less than 1 percent in shallow water habitat. Given this level of disturbance, it is unlikely that the adult feeding would be negatively impacted.

Additionally, stock assessment modeling indicates that flathead sole have been at a stable level above B_{MSY} for the past 20 years.

The combined evidence from individual fish length-weight analysis, examination of recruitment, stock biomass, adult and juvenile distribution, and CPUE trends indicate that the effects of the reductions in habitat features from fishing are minimal or temporary for GOA flathead sole.

F.1.5.6 Rex Sole (GOA)

Issue	**Evaluation**
Spawning/breeding	MT (Minimal or temporary effect)
Feeding	MT (Minimal or temporary effect)
Growth to maturity	MT (Minimal or temporary effect)

Summary of Effects—The nearshore areas inhabited by rex sole early juveniles are mostly unaffected by current fishery activities. Adult and late juvenile rex sole concentrations in the GOA primarily overlap with deepwater shelf habitat (51 percent) and slope habitat (14 percent) (Table B.3-3 of the EFH EIS). These fish would be affected by reductions in infaunal prey. However, the predicted reductions in these concentration overlaps are 1 percent for deepwater shelf habitat and 1 percent for slope habitat. Given this level of disturbance, it is unlikely that the adult feeding would be negatively impacted. Additionally, stock assessment modeling indicates that rex sole have been at a stable level above B_{MSY} for the past 20 years. The combined evidence from individual fish length-weight analysis, examination of recruitment, stock biomass, adult and juvenile distribution, and CPUE trends indicate that the effects of the reductions in habitat features from fishing are minimal or temporary for GOA rex sole.

F.1.5.7 Arrowtooth Flounder (BSAI and GOA)

Issue	**Evaluation**
Spawning/breeding	MT (Minimal or temporary effect)
Feeding	MT (Minimal or temporary effect)
Growth to maturity	MT (Minimal or temporary effect)

Summary of Effects—The nearshore areas inhabited by arrowtooth flounder early juveniles are mostly unaffected by current fishery activities. Adult and late juvenile concentrations primarily overlap the EBS sand/mud habitat (34 percent) and the GOA deep shelf habitat (35 percent) (Table B.3-3 of the EFH EIS). Overall, epifaunal prey reduction in those overlaps is predicted to be 3 percent for EBS sand/mud and 1 percent for GOA deep shelf habitats. Given this level of disturbance, and the large percentage of the diet of arrowtooth flounder not including epifauna prey, it is unlikely that the adult feeding would be negatively impacted. The arrowtooth flounder stock is currently at a high level of abundance due to sustained above-average recruitment in the 1980s and 1990s (Turnock et al. 2002). No change in weight and length at age has been observed in this stock from bottom trawl surveys conducted from 1984 through 2003.

The BS arrowtooth flounder stock is currently at a high level of abundance due to sustained above-average recruitment in the 1980s (Wilderbuer and Sample 2004). The productivity of the stock is currently believed to correspond to favorable atmospheric forces in which larvae are advected to nearshore nursery areas (Wilderbuer et al. 2002). The GOA stock has increased steadily since the 1970s and is at a very high level. Therefore, the combined evidence from individual fish length-weight analysis, length at age analysis, examination of recruitment, stock biomass, and CPUE trends indicate that the effects of the reductions in habitat features from fishing are minimal or temporary for BSAI and GOA arrowtooth flounder.

F.1.5.8 Shallow Water Flatfish (GOA)

Issue	Evaluation
Spawning/breeding	U (Unknown effect)
Feeding	U (Unknown effect)
Growth to maturity	U (Unknown effect)

Summary of Effects—The nearshore areas inhabited by early juveniles of GOA shallow water flatfish are mostly unaffected by current fishery activities. Adult and late juvenile rock sole concentrations, as a proxy for GOA shallow water flatfish, primarily overlap with shallow water habitats (13 percent) (Table B.3-3 of the EFH EIS). The predicted reduction of infaunal prey in this overlap is 1 percent. Given this level of disturbance, it is unlikely that adult feeding would be negatively impacted, and effects are believed to be minimal or temporary for rock sole. It is unknown, however, for the other seven species of the shallow water flatfish complex.

The level of information available for rock sole and the other species of the shallow water complex are insufficient to estimate the stock size relative to B_{MSY}, although trawl survey abundance estimates indicate a stable to increasing level of biomass since 1984. Because the population biomass level required to produce long-term sustainability is unknown, the impacts of the effects of fishing on the habitat required for spawning, adult feeding, or juvenile survival and growth to maturity are unknown.

F.1.5.9 Deep Water Flatfish (GOA)

Issue	Evaluation
Spawning/breeding	U (Unknown effect)
Feeding	U (Unknown effect)
Growth to maturity	U (Unknown effect)

Summary of Effects—The nearshore areas inhabited by early juveniles of GOA deepwater flatfish are mostly unaffected by current fishery activities. Adult and late juvenile Dover sole concentrations in the GOA, as a proxy for GOA deepwater flatfish, primarily overlap with deepwater shelf habitat (58 percent), slope habitat (19 percent), and shallow water habitat (21 percent) (Table B.3-3 of the EFH EIS). This species is dependent on infaunal prey. However, reductions of infaunal prey in those concentration overlaps are predicted to be 1 percent for each of those habitats. Given this level of disturbance, it is unlikely that the adult feeding would be negatively impacted.

The level of information available for the species other than Dover sole is insufficient to estimate the stock size relative to B_{MSY}. Because these levels are unknown for most of the species in this complex, the impacts of the effects of fishing on the habitat required for spawning, adult feeding, or juvenile survival and growth to maturity for the deep water complex are unknown.

F.1.5.10 Pacific Ocean Perch (GOA)

Issue	**Evaluation**
Spawning/Breeding	U (Unknown effect)
Growth to Maturity	U (Unknown effect)
Feeding	MT (Minimal, temporary, or no effect)

Summary of Effects—The effects of fishing on the habitat of Pacific ocean perch are either unknown or negligible; however, caution is warranted. There is some information to suggest that bottom trawling has a negative impact on benthic habitat, especially sponges. The LEI analysis indicates that there is a potential for minor reductions in living substrates inhabited by Pacific ocean perch. Whether the potential loss of these substrates would have an effect on spawning/breeding of Pacific ocean perch is unknown. Any effect on their ability to feed would likely be negligible. Very little information is available on these aspects of their life history, however, and further investigation may prove otherwise. A reduction in living structure may jeopardize these fishes' ability to grow to maturity. Several observations have shown juvenile red rockfish to be associated with sponges. The extent of this association is largely unknown, but it may be important if these substrates increase survival rates by acting as refugia to juveniles or adults. Significant differences in growth were found between heavily trawled and lightly trawled areas, but the cause is unknown. Current stock status trends show no indications of fishing impacting the ability of the stock to maintain MSY.

F.1.5.11 Shortraker and Rougheye Rockfish (GOA)

Issue	**Evaluation**
Spawning/Breeding	U (unknown effect)
Growth to Maturity	U (unknown effect)
Feeding	MT (minimal, temporary, or no effect)

Summary of Effects—The effects of fishing on the habitat of shortraker and rougheye rockfish in the GOA are either unknown or minimal. There is not enough information available to determine whether the habitat impacts of fishing affect spawning or growth to maturity of these fish. Virtually nothing is known about the spawning behavior of these fish, and information on the juvenile life history of shortraker rockfish is nil. However, adults of both species inhabit areas subject to bottom trawling, as do juveniles of rougheye rockfish, so fishing may be affecting the habitat of these fish. Of particular concern is the observed association of adult shortraker and rougheye rockfish with corals such as *Primnoa* spp. on rocky substrate of the slope. This coral is known to be easily damaged by bottom trawls, and it also may take years to recover from such damage. The fragile nature of corals and their long recovery time are reflected in the high values of LEI estimated for corals in this document. If corals are important to the long-term survival of adult shortraker and rougheye rockfish, damage to corals by fishing gear may have a negative impact on these fish. The habitat requirements of juvenile rougheye rockfish on the shelf are unknown. However, several studies have observed unidentified small juvenile rockfish on the shelf associated with rocks or sponges. If juvenile rougheye rockfish utilize this habitat, they could be adversely affected by trawling. Effects of fishing on the feeding of shortraker and rougheye rockfish appears to be negligible, as the major food items of these fish are relatively small and semipelagic; therefore, these items are generally not retained in large amounts by fishing gear.

F.1.5.12 Northern Rockfish (GOA)

Issue	Evaluation
Spawning/breeding	MT (Minimal, temporary, or no effect)
Feeding	MT (Minimal, temporary, or no effect)
Growth to maturity	U (Unknown effect)

Summary of Effects—Although northern rockfish may eat some epifaunal prey, such as crabs and shrimp, the largest component of their diet is euphausiids; thus, the percent reductions in epifaunal prey would not be expected to have a significant impact on their feeding. There is no evidence that links habitat features with northern rockfish accomplishing the spawning/breeding process. Consequently, a reduction in living and non-living structure would not be expected to have an effect on spawning/ breeding of GOA northern rockfish. A reduction in living and non-living structure may reasonably jeopardize growth to maturity due to a reduction of refuge habitat for juvenile GOA northern rockfish. However, no scientific studies have been conducted that specifically identify northern rockfish associations with living or non-living structures or the nature of those associations if they exist. Consequently, the effect of a reduction in living or non-living structures on northern rockfish accomplishing the growth to maturity process is unknown. Current stock status trends show no indications of fishing impacting the ability of the stock to maintain MSY, and there is no evidence to suggest that the potential reductions in living and non-living structure on growth and survival to maturity affects the ability of GOA northern rockfish to fulfill its role in a healthy ecosystem.

F.1.5.13 Pelagic Shelf Rockfish (GOA)

Issue	Evaluation
Spawning/Breeding	MT (Minimal, temporary, or no effect)
Growth to Maturity	U (Unknown effect)
Feeding	MT (Minimal, temporary, or no effect)

Summary of Effects—The effects of fishing on the habitat of dusky rockfish are either unknown or negligible; however, caution is warranted. There is some information to suggest that bottom trawling may have a negative impact on the benthic habitat, especially corals and sponges. The LEI analysis indicates that there is a potential for large reductions in living substrates and hard coral habitats that dusky rockfish inhabit. The potential loss of these habitats would likely not have an effect on spawning/breeding of dusky rockfish or their feeding behavior. Very little information is available on these aspects of their life history, however, and further investigation may prove otherwise. A reduction in living structure and hard corals may impede these fishes' ability to reach growth to maturity. Several observations have shown rockfish to be associated with sponges and coral. The extent of this association is largely unknown, though, but may be of significance if these substrates increase survival rates by acting as refugia to juveniles or adults. An age-structured model has recently been developed for dusky rockfish and indicates no obvious trends in recruitment or spawning biomass. Data for this model are limited, however, and recruitment in the years prior to 1977 is not known, making long-term effects difficult to detect.

F.1.5.14 Thornyhead Rockfish (GOA)

Issue	Evaluation
Spawning/breeding	MT (Minimal, temporary, or no effect)
Feeding	MT (Minimal, temporary, or no effect)
Growth to maturity	MT (Minimal, temporary, or no effect)

GOA thornyhead eggs are presumed to be associated with pelagic habitats based on observations off the West Coast. GOA juveniles and adults are also associated with benthic habitats; specifically, on the deep shelf and slope in any type of non-living substrate, but they may prefer hard, non-living substrate according to limited studies in the eastern GOA. Overall, the GOA deep shelf and slope habitats comprise 33 and 22 percent, respectively, of the area designated as the thornyhead concentration distribution within the GOA (Table B.3-3 of the EFH EIS). Of this 33 and 22 percent, 1 percent of the non-living substrate within the deep shelf and slope GOA habitat is projected to be reduced under status quo (Table B.3-3 of the EFH EIS). It is assumed that this would have a negligible impact. Therefore, the ratings for the effects of spawning/breeding and growth to maturity for GOA thornyheads are no effect. The adults feed mainly on epibenthic shrimp and other benthic organisms which are included in epifaunal and infaunal features and are projected to be reduced by 1 percent in each habitat. It is assumed that the 1 percent reduction of epifauna and infauna within the GOA shallow and deep shelf habitats occupied by thornyheads would not have an impact and the rating for feeding is also no effect.

F.1.5.15 Squid and Other Species

While there was considerable new information to evaluate habitat effects for the major target groundfish species in Alaska, there were some species where information was either too sparse to evaluate, or simply did not exist. For other species, especially nontarget species such as skates, sculpins, sharks, squids, and octopi, growth information has not been collected historically, and species-specific catch per unit effort information may be unreliable. Information on nontarget species is improving, but it is currently insufficient to evaluate habitat specific impacts. For these reasons, the original evaluations for the following species groups presented in the DEIS still represent the best available information, despite extensive inquiry to improve upon it.

F.1.5.15.1 GOA Sharks (dogfish, sleeper sharks, and salmon sharks)

Issue	Evaluation
Spawning/breeding	U (Unknown effect)
Feeding	U (Unknown effect)
Growth to maturity	U (Unknown effect)

Summary of Effects—Essential habitat requirements for species in this category are unknown. No studies have been conducted in the GOA to determine whether fishing activities have an effect on the habitat of dogfish, sleeper sharks, or salmon sharks. Dogfish are thought to occur in the middle and lower portions of the water column and appear to concentrate in gullies along the continental shelf in the GOA. Sleeper sharks are thought to occur mainly in the middle and lower portions of the water column along the outer continental shelf and upper slope region, as well as in similar depths in Shelikof Strait and other gully habitats. Salmon sharks are pelagic throughout the GOA and appear to concentrate in Prince William

Sound as well as in Shelikof Strait. Thus, any adverse affects to these habitat types may influence the health of GOA shark populations.

F.1.5.15.2 GOA Skates (two Raja species, Big and longnose skate, and 8-15 Bathyraja species)

Issue	**Evaluation**
Spawning/breeding	U (Unknown effect)
Feeding	U (Unknown effect)
Growth to maturity	U (Unknown effect)

Summary of Effects—Essential habitat requirements for species in this category are unknown. No studies have been conducted in the GOA to determine whether fishing activities have an effect on the habitat of skates. Skates are benthic dwellers. The big skate, a new commercial species in the GOA, comprises just under half of the skate complex biomass in the GOA and is distributed mainly on the upper continental shelf. However, other skate species are found throughout that habitat as well. The diversity of the group increases with depth in the gullies within the continental shelf and along the outer continental shelf and slope. Therefore, any adverse affects to the shallow shelf habitat may influence the health of the big skate populations as well as other skate species, while any adverse affects to outer continental shelf and slope habitats may influence the health of multiple species of skates.

F.1.5.15.3 GOA Sculpins (48 species identified in GOA trawl surveys)

Issue	**Evaluation**
Spawning/breeding	U (Unknown effect)
Feeding	U (Unknown effect)
Growth to maturity	U (Unknown effect)

Summary of Effects—Essential habitat requirements for species in this category are unknown. No studies have been conducted in the GOA to determine whether fishing activities have an effect on the habitat of sculpins. Sculpins are benthic dwellers. Some sculpin species guard their eggs, and at least one species, the bigmouth sculpin, lays its eggs in vase sponges, although it is not known whether a particular type of sponge, or sponges in general, are essential to reproductive success. There are so many diverse species in this category that almost all benthic areas in the GOA are likely to be inhabited by at least one sculpin species. Therefore, any adverse affects to habitat may influence the health of species in the sculpin complex.

F.1.5.15.4 GOA Squid (10 or more species)

Issue	**Evaluation**
Spawning/breeding	U (Unknown effect)
Feeding	U (Unknown effect)
Growth to maturity	U (Unknown effect)

Summary of Effects—Essential habitat requirements for species in this category are unknown. No studies have been conducted in the GOA to determine whether fishing activities have an effect on the habitat of squid. Squid are thought to occur in pelagic waters along the gullies within the continental shelf and the outer continental shelf, in the upper slope region of the GOA, and to concentrate over submarine canyons; thus, any adverse effects to this habitat may influence the health of the squid populations.

F.1.5.15.5 GOA Octopi (5 or more species)

Issue	Evaluation
Spawning/breeding	U (Unknown effect)
Feeding	U (Unknown effect)
Growth to maturity	U (Unknown effect)

Summary of Effects—Essential habitat requirements for species in this category are unknown. No studies have been conducted in the GOA to determine whether fishing activities have an effect on the habitat of octopi. Octopi occupy all types of benthic habitats, extending from very shallow subtidal areas to deep slope habitats; thus, any adverse effects to this habitat may influence the health of octopus populations. Knowledge of octopi distributions are insufficient to allow comparison with fishing effects.

F.1.5.16 Effects of Fishing on Essential Fish Habitat of Forage Species

The forage species category was created by Amendments 36 and 39 to the BSAI and GOA FMP. This category includes eight families of fish (Osmeridae, Myctophidae, Bathylagidae, Ammodytidae, Trichodontidae, Pholidae, Stichaeidae, and Gonostomatidae) and one order of crustaceans (Euphausiacea). The aforementioned amendments prohibit the directed fishery of any forage species. The species included in this category have diverse life histories and it is impractical to analyze the group as a whole. Therefore, for the purpose of this document, each family and order will be analyzed separately.

F.1.5.16.1 Family Osmeridae

Issue	Evaluation
Spawning/Breeding	MT (Minimal, temporary, or no effect)
Feeding	MT (Minimal, temporary, or no effect)
Growth to maturity	MT (Minimal, temporary, or no effect)

Summary of Effects—Most of the Alaska species of smelt spawn on beaches, rivers, or in estuaries. Certain species of smelt, such as capelin, have been shown to have an affinity towards spawning grounds with specific substrate grain size (coarse sand or fine gravel). Therefore, non-living substrate is assumed to be very important for spawning/breeding. However, smelt spawning areas do not overlap with areas of intensive fishing. There is little to no fishing pressure in the nearshore environment needed by these species. Hence, the effects of fishing are anticipated to have little impact on the stock. The rating for the effects of fishing on spawning and breeding of smelt is MT.

Juvenile and adult smelt feed primarily on neritic plankton. There is little evidence that survival or prey availability of smelt is dependent on habitat that is disturbed by fishing. Therefore, the effects of fishing on the feeding and growth to maturity of smelt are rated MT.

F.1.5.16.2 Family Myctophidae

Issue	Evaluation
Spawning/Breeding	MT (Minimal, temporary, or no effect)
Feeding	MT (Minimal, temporary, or no effect)
Growth to maturity	MT (Minimal, temporary, or no effect)

Summary of Effects—Myctophids are pelagic throughout all life history stages. There is little evidence that Myctophid survival is dependent on habitat affected by fishing. Myctophids are broadcast spawners with pelagic eggs. Juvenile and adult Myctophids prey on neritic zooplankton and do not require physical structure for protection. Therefore, the effects of fishing on the spawning and breeding, feeding, and growth to maturity of Myctophids is rated MT.

F.1.5.16.3 Family Ammodytidae

Issue	Evaluation
Spawning/Breeding	MT (Minimal, temporary, or no effect)
Feeding	MT (Minimal, temporary, or no effect)
Growth to maturity	MT (Minimal, temporary, or no effect)

Summary of Effects—The sole member of family Ammodytidae found in Alaska is the Pacific sand lance (*Ammodytes hexapterus*). Sand lance have been shown to have an affinity towards spawning grounds with specific substrate grain size (coarse sand). Therefore, non-living substrate is assumed to be very important for spawning/breeding. However, smelt spawning areas do not overlap with known areas of intensive fishing. There is little to no fishing pressure in the nearshore habitat needed by these species. Hence, the effects of fishing on the EFH of sand lance is rated MT.

Juvenile and adult sand lance feed primarily on copepods. There is little evidence that survival or prey availability of sand lance is dependent on habitat disturbed by fishing. Therefore, the effects of fishing on the feeding and growth to maturity of smelt are rated MT.

F.1.5.16.4 Family Trichodontidae

Issue	Evaluation
Spawning/Breeding	MT (Minimal, temporary, or no effect)
Feeding	U (Unknown)
Growth to maturity	U (Unknown)

Summary of Effects—Two members of the family Trichodontidae are found in the BSAI and GOA: the sailfin sandfish (*Arctoscopus japonicus*) and the Pacific sandfish (*Trichodon trichodon*). However, the sailfin sandfish is rarely encountered in Alaska waters. For the purposes of this document, attention will be focused on the Pacific sandfish.

Pacific sandfish lay demersal adhesive egg masses in rocky intertidal areas. The presence of the proper non-living substrate is important for the spawning/breeding of sandfish. However, there is little overlap of the spawning areas with known areas of intensive fishing. Hence, the effects of fishing on spawning/breeding of sandfish are rated MT.

Pacific sandfish are ambush predators that lay in wait for prey buried under the sand. They have been shown to consume some epifauna prey, but more than 95 percent of their diet consisted of small fish. It is unknown how the habitat for these prey species is affected by fishing.

Pacific sandfish larvae are pelagic, but juveniles and adults are demersal. Little is known about sandfish distribution in the BSAI and GOA. The effect of fishing on the survival of Pacific sandfish is unknown due to lack of data.

F.1.5.16.5 Family Pholidae

Issue	**Evaluation**
Spawning/Breeding	MT (Minimal, temporary, or no effect)
Feeding	MT (Minimal, temporary, or no effect)
Growth to maturity	MT (Minimal, temporary, or no effect)

Summary of Effects—There are several species of Pholids (or gunnels) found in Alaska waters. Most species of gunnels reside, feed, and breed in the shallow, nearshore habitat, where there is little to no fishing effort. Due to the lack of fishing pressure in the environs used by Pholids, the effects of fishing on the habitat necessary for spawning/breeding, feeding, and growth to maturity are all rated MT.

F.1.5.16.6 Family Stichaeidae

Issue	**Evaluation**
Spawning/Breeding	MT (Minimal, temporary, or no effect)
Feeding	MT (Minimal, temporary, or no effect)
Growth to maturity	MT (Minimal, temporary, or no effect)

Summary of Effects—Due to the lack of fishing pressure in the environs used by pricklebacks, the effects of fishing on the spawning/breeding, feeding, and growth to maturity are all rated MT.

F.1.5.16.7 Family Gonostomatidae

Issue	**Evaluation**
Spawning/Breeding	MT (Minimal, temporary, or no effect)
Feeding	MT (Minimal, temporary, or no effect)
Growth to maturity	MT (Minimal, temporary, or no effect)

Summary of Effects—Bristlemouths are pelagic throughout all life history stages. There is little evidence that bristlemouths survival is dependent on habitat that is affected by fishing. Bristlemouths are broadcast spawners with pelagic eggs. Juvenile and adult bristlemouths prey on neritic zooplankton and do not require physical structure for protection. Therefore, the effects of fishing on the habtitat necessary for spawning/breeding, feeding, and growth to maturity of bristlemouths are rated MT.

F.1.5.16.8 Order Euphausiacea

Issue	**Evaluation**
Spawning/Breeding	MT (Minimal, temporary, or no effect)
Feeding	MT (Minimal, temporary, or no effect)
Growth to maturity	MT (Minimal, temporary, or no effect)

Summary of Effects—Euphausiids (or krill) are small, shrimp-like crustaceans which, along with copepods, make up the base of the food web in the BSAI and GOA. Euphausiids are pelagic throughout their entire life cycle and do not have a strong link to habitat that is affected by fishing. Euphausiids do not require habitat that is disrupted by fishing for spawning/breeding, feeding, or growth to maturity. Therefore, the effects of fishing on habitat for euphausiids is MT.

F.1.6 Conclusions

F.1.6.1 Species Evaluations

Evaluations were completed for 26 managed species (or species groups) and 8 forage species (Table B.4_1 of the EFH EIS). See Sections B.3.2 to B.3.4 of the EFH EIS for more detailed information. Based on the available information, the analysis found no indication that continued fishing at the current rate and intensity would affect the capacity of EFH to support the life history processes of any species. In other words, the effects of fishing on EFH would not be more than minimal. Reasons for minimal ratings were predominantly either lack of a connection to affected habitat features, or findings from stock analyses that current fishing practices (including effects on habitat) do not jeopardize the ability of the stock to produce MSY over the long term. Other evaluations indicated that, even though a connection may exist between a habitat feature and a life-history process, the expected feature reductions were considered too small to make effects at the population level likely. There were also cases where the effects did not overlap significantly with the distribution of the species.

About one-third of the ratings were U (unknown effect). Most of unknown ratings were for species that have received relatively little study; hence, their life history needs and population status are poorly known. Most species with unknown ratings support small or no fisheries. Conversely, species that support significant fisheries have been studied more. In some cases, associations between the habitat features and life history processes were indicated, but the evaluator did not have enough information to assess whether the linkage and the amount of feature reduction would affect species welfare.

Even for well studied species, the knowledge to trace use of habitat features confidently for spawning, breeding, feeding, and growth to maturity to population level effects is not yet available. Several evaluators specifically cited uncertainty regarding the effect of particular noted linkages, and some urged caution. Most of these situations involved potential linkages between the growth-to-maturity of rockfish and Atka mackerel and habitat structure.

F.1.6.2 General Effects on Fish Habitat

While this evaluation identified no specific instances of adverse effects on EFH that were more than minimal and not temporary, the large number of unknown ratings and expressions of concern make it prudent to look for more general patterns across all of the species and habitat features (Table B.4-2 of the EFH EIS).

Specific areas with high fishing effort, and hence high LEIs, were identified in the effects-of-fishing analysis. These included two large areas of the EBS, one north of Unimak Island and Unimak Pass and the other between the Pribilof Islands and Bristol Bay. Both of these areas have continued to be highly productive fishing grounds through decades of intensive fishing. While that may initially seem at odds with the LEI results, it is consistent with the evaluation that the habitat features affected by fishing either are not those important to the species fished in those areas, or are not being affected in a way that limits species welfare.

Fishing concentrations in other areas were smaller, but made up higher proportions of the GOA and EBS slopes. The largest effect rates were on living structure, including coral. The high reliance on limited areas for fishing production and their high estimated LEIs make it prudent to obtain better knowledge of what processes occur in those locations.

Table B.3-1 of the EFH EIS shows the habitat connections identified for each life stage of managed species and species groups. Each row represents a species life stage and each column one of the habitat types from the fishing-effects analysis. At their intersections, evaluators entered letters representing each of the habitat features (prey or structure classes) used by that life stage in that habitat. Most species of groundfish have pelagic larval and egg stages. Only one species, Atka mackerel, had a connection with a benthic habitat feature for its egg or larval stages. A combined tally at the bottom of the table notes how many species/life-stages were identified for each habitat feature in each habitat. Prey features represented about twice as many connections as structure features. The habitat feature/type combinations that had LEIs above 5 percent, outlined in the table, tended to have few connections. The highest number of connections (six) were for living structures on the GOA deep shelf, which had the lowest LEI of the outlined habitat feature/type combinations (6.2 percent). Connections with the highlighted blocks mostly involved rockfish species, with a few connections from Atka mackerel and blue king crab.

Cropping and summing effects on habitat features by distributions of the adults of each species (Table B.3-3 of the EFH EIS) depicted how the fishing effects overlapped in the locations where each species is present. The general distribution values related to the broader areas occupied, while the concentration values related to areas of higher abundance. Concentration LEIs were generally higher than the estimates based on general distribution because adult species concentrations determine where fisheries operate. It is unfortunate that distributions were not available for juveniles because connections to the habitat feature with the highest LEIs (living structure) mostly involved the growth to maturity process. Characterizing juvenile distributions should be a high priority for future research.

Reductions across adult species distributions for the living structure were mostly between 10 and 17 percent. Higher values occurred for red king crab (29 percent for both coverages) and Atka mackerel (18 and 26 percent). The king crab evaluator noted that the distribution of juveniles was mostly outside of the affected areas. The evaluator for Atka mackerel emphasized use of non-living substrates by that species. Prey class effects by species distributions were all at or below 5 percent. In combination with negligible effects on habitat of forage species (Section B.3.5 of the EFH EIS), this indicates that effects on availability of prey were minimal.

While LEIs for hard corals are subject to the limitations mentioned in Section B.2.6 of the EFH EIS, they had the highest LEIs when considered by species distributions. Intersections where meaningful effects are most likely to occur are those between areas where hard corals are prevalent and species for which a significant portion of their distribution occurs in the same areas, including populations of golden king crab, Atka mackerel, sablefish, and the rockfish species. Coral LEIs at these points ranged from 23 to 59 percent. While few evaluators cited coral as specifically linked to life history functions, in some areas it may be an important component of the living structure that is potentially linked to growth to maturity for some of these species. Because of their very slow recovery, corals warrant particular consideration for protection and for the development of improved knowledge of their habitat functions and distribution.

F.1.6.2.1 References

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., 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.

Ball, B.J., G. Fox, and B.W. Munday. 2000. Long- and short-term consequences of a Nephrops trawl fishery on the benthos and environment of the Irish Sea. ICES Journal of Marine Science. 57(5):1,315-1,320.

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.

Blood, D.M., A.C. Matarese, and M.S. Busby. In prep. Spawning, egg development, and early life history dynamics of arrowtooth flounder (*Atheresthes stomias*) in the GOA (based on research conducted 2001_2003).

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.

Dorn, M.W. 2004. Extending separable age_structured assessment models to evaluate trends in juvenile mortality of walleye pollock in the GOA. ICES CM 2004/FF:31.

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.

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.

Freese, L., P.J.Auster, J. Heifetz, and B.L. Wing. 1999. Effects of trawling on seafloor habitat and associated invertebrate taxa in the GOA. Marine Ecology Progress Series 182:119-126.

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.

Hollowed, A., J. N. Ianelli, and P. Livingston. 2000. Including predation mortality in stock assessments: A case study for GOA pollock. ICES J. Mar. Sci 57(2):279_293.

Hunt, Jr., G.L., P. Stabeno, G. Walters, E. Sinclair, R.D. Brodeur, J.M. Napp, and N.A. Bond. 2002. Climate change and control of the southeastern BS pelagic ecosystem. Deep_Sea Res. Pt. II, 49(26), 5821–5853.

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. 2001. Coral impacted by fishing gear in the GOA. Proceedings of the First International Symposium on Deepwater Corals. (Ecology Action Centre and Nova Scotia Museum, Halifax, Nova Scotia 106-117).

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.

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.

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.

NMFS. 2004. Final Alaska Groundfish Fisheries Programmatic Supplemental Environmental Impact Statement. DOC, NOAA, National Marine Fisheries Service, Alaska Region, P. O. Box 21668, Juneau, Alaska 99802-1668. Volumes I-VII.

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.

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.

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).

Sparks-McConkey, P.J. and L. Watling. 2001. Effects on the ecological integrity of a soft-bottom habitat from a trawling disturbance. Hydrobiologia. 456(1-3):73-85.

Turnock, B.J., T.K. Wilderbuer, and E.S. Brown. 2002. Arrowtooth flounder. *In* Appendix B Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the GOA Region. P 199-228. North Pacific Fishery Management Council, 605 West 4th Ave., Suite 306, Anchorage, AK 99501.

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.

Wilderbuer, T.K, A.B. Hollowed, W.J. Ingraham Jr., P.D. Spencer, M.E. Conners, N.A. Bond, and G.E. Walters. 2002. Flatfish recruitment response to decadal climatic variability and ocean conditions in the EBS. Prog. Oceanog. 55 (2002) 235-247.

Wilderbuer, T.K. and T.M. Sample. 2004. Arrowtooth flounder. *In* Stock Assessment and Fishery Evaluation Document for Groundfish Resources in the BSAI Region as Projected for 2005. North Pacific Fishery Management Council, P.O. Box 103136, Anchorage Alaska 99510.

F.2 Non-fishing impacts overview

The diversity, widespread distribution, and ecological linkages with other aquatic and terrestrial environments make the waters and substrates that comprise EFH susceptible to a wide array of human activities unrelated to fishing.

Non-fishing activities have the potential to adversely affect the quantity or quality of EFH in riverine, estuarine, and marine systems. 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 each activity, known and potential adverse impacts to EFH are described in the EFH EIS, Appendix G (NMFS 2005). The descriptions explain the mechanisms or processes that may cause the adverse effects and how these may affect habitat function. This FMP incorporates by reference the complete analysis of non-fishing impacts in Appendix G of the EFH EIS and summarizes the results for each type of non-fishing activity (NMFS 2005).

Non-fishing activities discussed in this document are subject to a variety of regulations and restrictions designed to limit environmental impacts under federal, state, and local laws. Many current requirements help to avoid or minimize adverse effects to aquatic habitats, including EFH. The conservation recommendations contained in this document are rather general and may overlap with certain existing standards for specific development activities. Nevertheless, the recommendations highlight practices that can help to avoid and minimize adverse effects to EFH. During EFH consultations between NMFS and other agencies, NMFS strives to provide reasonable and scientifically based recommendations that account for restrictions imposed under various state and federal laws by agencies with appropriate regulatory jurisdiction. Moreover, the coordination and consultation required by Section 305(b) of the Magnuson-Stevens Act do not supersede the regulations, rights, interests, or jurisdictions of other federal or state agencies. NMFS will not recommend that state or federal agencies take actions beyond their statutory authority, and NMFS' EFH conservation recommendations are not binding.

The conservation measures discussed in this document should be viewed as options to avoid, minimize, or compensate for adverse impacts and promote the conservation and enhancement of EFH. Ideally, non-water-dependent actions should not be located in EFH if such actions may have adverse impacts on EFH. Activities that may result in significant adverse effects on EFH should be avoided where less environmentally harmful alternatives are available. If there are no alternatives, the impacts of these actions should be minimized. Environmentally sound engineering and management practices should be employed for all actions that may adversely affect EFH. 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 – the restoration, creation, enhancement, or in exceptional circumstances, preservation of wetlands and/or other aquatic resources for the purpose of compensating for unavoidable adverse impacts which remain after all appropriate and practicable avoidance and minimization has been achieved) should be considered to conserve and enhance EFH.

Section 303(a)(7) of the Magnuson-Stevens Act requires FMPs to identify activities other than fishing that may adversely affect EFH and define actions to encourage the conservation and enhancement of EFH, including recommended options to avoid, minimize, or compensate for the adverse effects identified. During consultation, agencies strive to consider all potential non-fishing impacts to EFH so that the appropriate recommendations can be made. Because impacts that may adversely affect EFH can be direct, indirect, and cumulative, the biologist must consider and analyze these interrelated impacts.

The conservation recommendations included with each activity present a series of site-specific measures the action agency can undertake to avoid, offset, or mitigate impacts to EFH. Not all of these suggested measures are necessarily applicable to any one project or activity that may adversely affect EFH. More specific or different measures based on the best and most current scientific information may be developed before or during EFH consultations and communicated to the appropriate agency. The conservation recommendations provided herein represent a short menu of actions that can contribute to the conservation, enhancement, and proper functioning of EFH.

While it is necessary to distinguish between activities to identify possible adverse impacts, it is equally important to consider and analyze these activities as they interrelate within habitats. This document is organized by activities that may potentially impact EFH occurring in four discrete ecosystems. The separation of these ecosystems is artificial, and many of the impacts and their related activities are not exclusive to one system.

The format for presenting the information in this document provides an introductory description of each activity, identification of potential adverse impacts, and suggested general conservation measures that would help minimize and avoid adverse effects of non-fishing activities on EFH. Table 3.4-36 in the EFH EIS identifies the categories from Appendix G and correlates them with possible changes in physical, chemical, and biological parameters, and Table 3.4-37 in the EFH EIS takes the same categories from Appendix G and broadly interprets whether the effects from the activities in Alaska have been positive, insignificant, negative, or unknown.

F.2.1 Upland Activities

F.2.1.1 Nonpoint Source Pollution

Nonpoint source pollution generally results from land runoff, precipitation, atmospheric deposition, seepage, or hydrologic modification. Technically, the term nonpoint source means anything that does not meet the legal definition of point source in Section 502(14) of the Clean Water Act (CWA), which refers to discernable, confined, and discrete conveyance from which pollutants are or may be discharged. The major categories of nonpoint pollution are as follows:

- Agricultural runoff
- Urban runoff, including developed and developing areas (Section G.2.2 of the EFH EIS)
- Silvicultural (forestry) runoff (Section G.2.1.1 of the EFH EIS)
- Marinas and recreational boating
- Road construction
- Channel and streambank modifications, including channelization (Section G.4.7 of the EFH EIS)
- Streambank and shoreline erosion

Nonpoint source pollution is usually lower in intensity than an acute point source event, but it may be more damaging to fish habitat in the long term. Nonpoint source pollution is often difficult to detect. It may affect sensitive life stages and processes, and the impacts may go unnoticed for a long time. When severe pollution impacts are finally noticed, they may not be tied to any one event; hence, it may be difficult to correct, clean up, or mediate.

F.2.1.2 Silviculture/Timber Harvest

Recent revisions of Alaska’s federal and state timber harvest regulations and best management practices (BMPs) have resulted in increased protection of EFH on federal, state, and private timber lands. Current forest management practices, when fully implemented and effective, avoid or minimize adverse effects to EFH that can result from the harvest and cultivation of timber and other forestry products. However, timber harvest can have both short- and long-term impacts throughout many coastal watersheds and estuaries if management practices are not fully implemented or effective. Past timber harvest in Alaska was not conducted under the current protective standards, and some effects from past harvesting continue to affect EFH.

If appropriate environmental standards are not followed, forest conditions after harvest may result in altered or impaired instream habitat structure and watershed function. In general, timber harvest can have a variety of effects such as removing the dominant vegetation; converting mature and old_growth upland and riparian forests to tree stands or forests of early seral stage; reducing permeability of soils and increasing the area of impervious surfaces; increasing sedimentation from surface runoff and mass wasting processes; altering hydrologic regimes; and impairing fish passage through inadequate design, construction, and/or maintenance of stream crossings (Northcote and Hartman 2004). Timber harvest may result in inadequate or excessive surface and stream flows, increased streambank and streambed erosion, loss of complex instream habitats, sedimentation of riparian habitat, and increased surface runoff with associated contaminants (e.g., herbicides, fertilizers, and fine sediments). Hydrologic characteristics (e.g., water temperature), annual hydrograph change, and greater variation in stream discharge can be associated with timber harvest. Alterations in the supply of large woody debris (LWD) and sediment can have negative effects on the formation and persistence of instream habitat features. Excess debris in the form of small pieces of wood and silt can cover benthic habitat and reduce dissolved oxygen levels.

Potential Adverse Impacts

There are many complex and important interactions, in both small and large watersheds, between fish and forests (Northcote and Hartman, 2004). Five major categories of activities can adversely affect EFH: 1) construction of logging roads, 2) creation of fish migration barriers, 3) removal of streamside vegetation, 4) hydrologic changes and sedimentation and 5) disturbance associated with log transfer facilities (LTFs) (Section G.4.9 of the EFH EIS). Potential impacts to EFH have been greatly reduced by the adoption of best management practices (BMPs) designed to protect fish habitat.

Recommended Conservation Measures

The following recommended conservation measures should be viewed as options to avoid and minimize adverse impacts and promote the conservation, enhancement, and proper functioning of EFH.

1. For timber operations near streams with EFH, adhere to modern forest management practices and BMPs, including the maintenance of vegetated buffers to reduce sedimentation and supply LWD.
2. Avoid timber operations to the extent practicable in wetlands contiguous with anadromous fish streams.
3. For timber operations near estuaries or beaches, maintain vegetated buffers as needed to protect EFH.
4. Maintain riparian buffers along all streams to the extent practicable. In Alaska, buffer width is site-specific and dependent on use by anadromous and resident fish and stream process type.
5. Incorporate watershed analysis into timber and silviculture projects whenever possible or practicable. Particular attention should be given to the cumulative effects of past, present, and future timber sales within the watershed.
6. For forest roads, see Section G.2.3 in the EFH EIS, Road Building and Maintenance.

F.2.1.3 Pesticide Application (includes insecticides, herbicides, fungicides)

Pesticides are frequently detected in freshwater and estuarine systems that provide EFH. Pesticides are substances intended to prevent, destroy, control, repel, or mitigate any pest. They include the following: insecticides, herbicides, fungicides, rodenticides, repellents, bactericides, sanitizers, disinfectants, and growth regulators. More than 800 different pesticides are currently registered for use in the U.S. Legal mandates covering pesticides are the CWA and the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA). Water quality criteria for the protection of aquatic life have only been developed for a few of the currently used chemicals (EPA, Office of Pesticide Programs). The most common pesticides are insecticides, herbicides, and fungicides. These are used for pest control on forested lands, agricultural crops, tree farms and nurseries, highways and utility rights of way, parks and golf courses, and residences. Pesticides can enter the aquatic environment as single chemicals or as complex mixtures. Direct applications, surface runoff, spray drift, agricultural return flows, and groundwater intrusions are all examples of transport processes that deliver pesticides to aquatic ecosystems.

Habitat alteration from pesticides is different from more conventional water quality parameters, such as temperature, suspended solids, or dissolved oxygen, because, unlike temperature or dissolved oxygen, the presence of pesticides can be difficult to detect due to limitations in proven methodologies. This monitoring may also be expensive. As analytical methodologies have improved in recent years, however, the number of pesticides documented in fish and their habitats has increased.

Potential Adverse Impacts

There are three basic ways that pesticides can adversely affect EFH. These are (1) a direct toxicological impact on the health or performance of exposed fish, (2) an indirect impairment of the productivity of aquatic ecosystems, and (3) a loss of aquatic vegetation that provides physical shelter for fish.

Recommended Conservation Measures

The following recommended conservation measures should be viewed as options to avoid and minimize adverse impacts and promote the conservation, enhancement, and proper functioning of EFH.

1. Incorporate integrated pest management and BMPs as part of the authorization or permitting process to ensure the reduction of pesticide contamination in EFH (Scott et al. 1999).
2. Carefully review labels and ensure that application is consistent. Follow local, supplemental instructions such as state-use bulletins where they are available.
3. Avoid the use of pesticides in and near EFH.
4. Refrain from aerial spraying of pesticides on windy days.

F.2.1.4 Urban/Suburban Development

Urban development is most likely the greatest non-fishing threat to EFH. Urban growth and development in the U.S. continue to expand in coastal areas at a rate approximately four times greater than in other areas. Urban and suburban development and the corresponding infrastructure result in four broad categories of impacts to aquatic ecosystems: hydrological, physical, water quality, and biological indicators (Center for Watershed Protection [CWP] 2003). Runoff from impervious surfaces is the most widespread source of pollution into the nation's waterways (EPA 1995). When a watershed's impervious cover exceeds 10 percent, impacts to stream quality can be expected (CWP 2003).

Potential Adverse Impacts

Development activities within watersheds and in coastal marine areas often impact the EFH of managed species on both long- and short-term scales. The CWP made a comprehensive review of the impacts associated with impervious cover and urban development and found a negative relationship between watershed development and about 26 stream quality indicators (CWP 2003). Many of the impacts listed here are discussed in greater detail in other sections of this document. The primary impacts include (1) the loss of riparian and shoreline habitat and vegetation and (2) runoff. Upland and shoreline vegetation removal can increase stream water temperatures, reduce supplies of LWD, and reduce sources of prey and nutrients to the water system. An increase in impervious surfaces, such as the addition of new roads (see Section G.2.3 of the EFH EIS), roofs, bridges, and parking facilities, results in a decreased infiltration to groundwater and increased runoff volumes. This also has the potential to adversely affect water quality and water quantity/timing in downstream water bodies (i.e., estuaries and coastal waters).

Recommended Conservation Measures

The following recommended conservation measures should be viewed as options to avoid and minimize adverse impacts and promote the conservation, enhancement, and proper functioning of EFH.

1. Implement BMPs (EPA 1993) for sediment control during construction and maintenance operations.
2. Avoid using hard engineering structures for shoreline stabilization and channelization when possible.
3. Encourage comprehensive planning for watershed protection to avoid filling and building in floodplain areas affecting EFH.
4. Where feasible, remove impervious surfaces such as abandoned parking lots and buildings from riparian and shoreline areas, and reestablish wetlands and native vegetation.
5. Protect and restore vegetated buffer zones of appropriate width along all streams, lakes, and wetlands that include or influence EFH.
6. Manage stormwater to duplicate the natural hydrologic cycle, maintaining natural infiltration and runoff rates to the maximum extent practicable.
7. Where in-stream flows are insufficient to maintain water quality and quantity needed for EFH, establish conservation guidelines for water use permits and encourage the purchase or lease of water rights and the use of water to conserve or augment instream flows in accordance with state and federal water laws.
8. Encourage municipalities to use the best available technologies in upgrading their wastewater systems to avoid combined sewer overflow problems and chlorinated sewage discharges into rivers, estuaries, and the ocean.
9. Design and install proper on-site disposal systems.

F.2.1.5 Road Building and Maintenance

The building and maintenance of roads can affect aquatic habitats by increasing rates of natural processes such as debris slides or landslides and sedimentation, introducing exotic species, degrading water quality, and introducing chemical contamination (e.g., petroleum-based contaminants; Section G.2.2 of the EFH EIS). Paved and dirt roads introduce an impervious or semipervious surface into the landscape. This surface intercepts rain and creates runoff, carrying soil, sand and other sediments, and oil-based materials quickly downslope. If roads are built near streams, wetlands, or other sensitive areas, they may experience increased sedimentation that occurs from maintenance and use, as well as during storm and snowmelt events. Even carefully designed and constructed roads can become sources of sediment and pollutants if they are not properly maintained.

Potential Adverse Impacts

The effects of roads on aquatic habitat can be profound. They include (1) increased deposition of fine sediments, (2) changes in water temperature, (3) elimination or introduction of migration barriers such as culverts, (4) changes in streamflow, (5) introduction of non-native plant species, and (6) changes in channel configuration (see Section G.2.1.1 and the standards referenced in the EFH EIS).

Recommended Conservation Measures

The following conservation measures for road building and maintenance should be viewed as options to avoid and minimize adverse impacts and promote the conservation, enhancement, and proper functioning of EFH.

1. To the extent practicable, avoid locating roads near fish-bearing streams.
2. Incorporate appropriate erosion control and stabilization measures into road construction plans to reduce erosion potential.
3. Build bridges when possible.
4. Locate stream crossings in stable stream reaches.
5. Design bridge abutments to minimize disturbances to streambanks and place abutments outside of the floodplain whenever possible.
6. To the extent practicable, avoid road construction across alluvial floodplains, mass wastage areas, or braided stream bottom lands unless site-specific protection can be implemented to ensure protection of soils, water, and associated resources.
7. Avoid side-casting of road construction and maintenance materials on native surfaces and into streams.
8. To the extent practicable, use native vegetation in stabilization plantings.
9. Ensure that maintenance operations avoid adverse affects to EFH.

F.2.2 Riverine Activities

F.2.2.1 Mining

Mining and mineral extraction activities take many forms, such as commercial dredging and recreational suction dredging, placer, area surface removal, and contour operations (Section G.5.6 of EIS EFH). Activities include gravel mining (NMFS 2004), exploration, site preparation, mining, milling, waste management, decommissioning or reclamation, and mine abandonment (American Fisheries Society [AFS] 2000). Mining and its associated activities have the potential to cause environmental impacts from exploration through post_closure. These impacts may include adverse effects to EFH. The operation of metal, coal, rock quarries, and gravel pit mining has caused varying degrees of environmental damage in urban, suburban, and rural areas. Some of the most severe damage, however, occurs in remote areas, where some of the most productive fish habitat is often located (Sengupta 1993). In Alaska, existing regulations, promulgated and enforced by other federal and state agencies, have been designed to control and manage these changes to the landscape to avoid and minimize impacts. These regulations are regularly updated as new technologies are developed to improve mineral extraction, reclaim mined lands, and limit environmental impacts. However, while environmental regulations may avoid, limit, control, or offset many of these potential impacts, mining will, to some degree, always alter landscapes and environmental resources (National Research Council [NRC] 1999).

F.2.2.1.1 Mineral Mining

Potential Adverse Impacts

The effects of mineral mining on EFH depend on the type, extent, and location of the activities. Potential impacts from mining include (1) adverse modification of hydrologic conditions so as to cause erosion of desirable habitats, (2) removal of substrates that serve as habitat for fish and invertebrates, (3) conversion of habitats,(4) release of harmful or toxic materials, and (5) creation of harmful turbidity levels.

Recommended Conservation Measures

The following conservation measures should be viewed as options to avoid and minimize adverse impacts and promote the conservation, enhancement, and proper functioning of EFH.

1. To the extent practicable, avoid mineral mining in waters, riparian areas, and floodplains containing EFH.
2. Schedule necessary in-water activities when the fewest species/least vulnerable life stages of federally managed species will be present.
3. Use an integrated environmental assessment, management, and monitoring package in accordance with state and federal law and regulations.
4. Minimize spillage of dirt, fuel, oil, toxic materials, and other contaminants into EFH.
5. Treat and test wastewater (acid neutralization, sulfide precipitation, reverse osmosis, electrochemical, or biological treatments) and recycle on site to minimize discharge to streams.
6. Minimize opportunities for sediments to enter or affect EFH.
7. If possible, reclaim, rather than bury, mine waste that contains heavy metals, acid materials, or other toxic compounds if leachate can enter EFH through groundwater.
8. Restore natural contours and plant native vegetation on site after use to restore habitat function to the extent practicable.
9. Minimize the aerial extent of ground disturbance (e.g., through phasing of operations), and stabilize disturbed lands to reduce erosion.

F.2.2.1.2 Sand and Gravel Mining

Potential Adverse Impacts

Sand and gravel mining is extensive and occurs by several methods. These include wet-pit mining (i.e., removal of material from below the water table), dry-pit mining on beaches, exposed bars, and ephemeral streambeds, and subtidal mining. Sand and gravel mining in riverine, estuarine, and coastal environments can create EFH impacts, including (1) turbidity plumes and resuspension effects, (2) removal of spawning habitat, and (3) alteration of channel morphology.

Recommended Conservation Measures

The following recommended conservation measures should be viewed as options to avoid and minimize adverse impacts and promote the conservation, enhancement, and proper functioning of EFH.

1. To the extent practicable, avoid sand/gravel mining in waters containing EFH.
2. Identify upland or off-channel (where the channel will not be captured) gravel extraction sites as alternatives to gravel mining in or adjacent to EFH, if possible.
3. Design, manage, and monitor sand and gravel mining operations to minimize potential direct and indirect impacts to EFH, if operations in EFH cannot be avoided.
4. Minimize the areal extent and depth of extraction.
5. Include restoration, mitigation, and monitoring plans, as appropriate in sand/gravel extraction plans.

F.2.2.2 Organic and Inorganic Debris

Natural occurring flotsam, such as LWD and macrophyte wrack (i.e., kelp), plays an important role in aquatic ecosystems, including EFH. LWD and wrack promote habitat complexity and provide structure to various aquatic and shoreline habitats. The natural deposition of LWD creates habitat complexity by altering local hydrologic conditions, nutrient availability, sediment deposition, turbidity, and other structural habitat conditions. Conversely, inorganic flotsam and jetsam debris can negatively impact EFH. Inorganic marine debris is a problem along much of the coastal U.S., where it litters shorelines, fouls estuaries, entangles fish and wildlife, and creates hazards in the open ocean. Marine debris consists of a wide variety of man_made materials, including general litter, plastics, hazardous wastes, and discarded or lost fishing gear. The debris enters waterbodies indirectly through rivers and storm drains, as well as directly via ocean dumping and accidental release. Although laws and regulatory programs exist to prevent or control the problem, marine debris continues to affect aquatic resources.

F.2.2.2.1 Organic Debris Removal

Natural occurring flotsam, such as LWD and macrophyte wrack (i.e., kelp), is sometimes intentionally removed from streams, estuaries, and coastal shores. This debris is removed for a variety of reasons, including dam operations, aesthetic concerns, and commercial and recreational uses. However, the presence of organic debris is important for maintaining aquatic habitat structure and function. Removal can alter the ecological conditions of riverine, estuarine, and coastal ecosystems and habitats.

Potential Adverse Impacts

The removal of organic debris from natural systems can reduce habitat function, adversely impacting habitat quality. Reductions in woody debris inputs to estuaries may also affect the ecological balance of estuarine systems by altering rates and patterns of nutrient transport, sediment deposition, and availability of in_water cover for larval and juvenile fish. Beach grooming and wrack removal can substantially alter the macrofaunal community structure of exposed sand beaches by reducing species richness, abundance, and biomass of macrofauna associated with beach wrack (e.g., sand crabs, isopods, amphipods, and polychaetes).

Recommended Conservation Measures

The following recommended conservation measures should be viewed as options to avoid and minimize adverse impacts and promote the conservation, enhancement, and proper functioning of EFH.

1. Leave LWD whenever possible, removing it only when it presents a threat to life or property.
2. Encourage appropriate federal, state, and local agencies to prohibit or minimize commercial removal of LWD from rivers, estuaries, and beaches.
3. Encourage appropriate federal, state, and local agencies to aid in the downstream movement of LWD around dams, culverts, and bridges wherever possible, rather than removing it from the system.
4. Educate landowners and recreationalists about the benefits of maintaining LWD.
5. Localize beach grooming practices, and minimize them whenever possible.

F.2.2.2.2 Inorganic Debris

Numerous national and international laws are intended to prevent the disposal of marine debris in ocean waters, including ocean dumping and land-based sources. Nationally, land_based sources of marine debris account for about 80 percent of the marine debris on beaches and in U.S. waters. Debris can originate from combined sewer overflows and storm drains, stormwater runoff, landfills, solid waste disposal, poorly maintained garbage bins, floating structures, and general littering of beaches, rivers, and open waters. Typical debris from these land_based sources includes raw or partially treated sewage, litter, hazardous materials, and discarded trash.

Potential Adverse Impacts

Land and ocean based marine debris is a very diverse problem, and adverse effects to EFH are likewise varied. Floating or suspended trash can directly affect fish that consume or are entangled in it. Toxic substances in plastics can kill or impair fish and invertebrates that use habitat polluted by these materials. The chemicals leach from plastics, persist in the environment, and can bioaccumulate through the food web.

Once floatable debris settles to the bottom of estuaries, coastal, and open ocean areas it may cover and suffocate immobile animals and plants, creating large spaces devoid of life. Currents can carry suspended debris to underwater reef habitats where the debris can become snagged, damaging these sensitive habitats. The typical floatable debris from combined sewer overflows includes street litter, sewage containing viral and bacterial pathogens, pharmaceutical by-products from human excretion, and pet wastes. Pathogens can also contaminate shellfish beds and reefs.

Recommended Conservation Measures

The following recommended conservation measures should be viewed as options to avoid and minimize adverse impacts and promote the conservation, enhancement, and proper functioning of EFH.

1. Encourage proper trash disposal in coastal and ocean settings.
2. Advocate and participate in coastal cleanup activities.
3. Encourage enforcement of regulations addressing marine debris pollution and proper disposal.
4. Provide resources and technical guidance for development of studies and solutions addressing the problem of marine debris.
5. Provide resources to the public explaining the impact of marine debris and giving guidance on how to reduce or eliminate the problem.

F.2.2.3 Dam Operation

Dams are constructed and operated to provide sources for hydropower, water storage, and flood control. Their operation, however, can affect water quality and quantity in riverine systems.

Potential Adverse Impacts

The effects of dam construction and operation on EFH can include (1) migratory impediments, (2) water flow and current pattern shifts, (3) thermal impacts, and (4) limits on sediment and woody debris transport.

Recommended Conservation Measures

The following recommended conservation measures should be viewed as options to avoid and minimize adverse impacts and promote the conservation, enhancement, and proper functioning of EFH.

1. Operate facilities to create flow conditions that provide for passage, water quality, proper timing of life history stages, and properly functioning channel conditions to avoid strandings and redd dewatering.

2. Develop water and energy conservation guidelines for integration into dam operation plans and into regional and watershed-based water resource plans.
3. Provide mitigation (including monitoring and evaluation) for nonavoidable adverse effects on EFH.

F.2.2.4 Commercial and Domestic Water Use

Commercial and domestic water use demands to support the needs of homes, farms, and industries require a constant supply of water. Freshwater is diverted directly from lakes, streams, and rivers by means of pumping facilities, or is stored in impoundments. Because human populations are expected to continue increasing in Alaska, it is reasonable to assume that water uses, including water impoundments and diversion, will similarly increase (Gregory and Bisson 1997).

Potential Adverse Impacts

Water diversions can involve either withdrawals (reducing flow) or discharges (increasing flow). The withdrawal of water can affect EFH by (1) altering natural flows and the process associated with flow rates, (2) affecting shoreline riparian habitats, (3) affecting prey bases, (4) affecting water quality, and (5) entrapping fishes. Problems associated with return flows include increased water temperature, increased salinity, introduction of pathogens, decreased dissolved oxygen, increased toxic contaminants from pesticides and fertilizers, and increased sedimentation (Northwest Power Planning Council [NPPC] 1986). Diversions can also physically divert or entrap EFH-managed species (Section G.5.3 of the EFH EIS).

Recommended Conservation Measures

The recommended conservation measures should be viewed as options to avoid and minimize adverse impacts and promote the conservation, enhancement, and proper functioning of EFH.

1. Design projects to create flow conditions that provide for adequate passage, water quality, proper timing of life history stages, and properly functioning channels to avoid juvenile stranding and redd dewatering, as well as to maintain and restore proper channel, floodplain, riparian, and estuarine conditions.
2. Establish adequate instream flow conditions for anadromous fish.
3. Screen water diversions on fish-bearing streams, as needed.
4. Incorporate juvenile and adult fish passage facilities on all water diversion projects (e.g., fish bypass systems).
5. Where practicable, ensure that mitigation is provided for nonavoidable impacts.

F.2.3 Estuarine Activities

F.2.3.1 Dredging

Dredging navigable waters creates a continuous impact primarily affecting benthic and water-column habitats in the course of constructing and operating marinas, harbors, and ports. Routine dredging (i.e., the excavation of soft-bottom substrates) is used to create deepwater navigable channels or to maintain existing channels that periodically fill with sediments. In addition, port expansion has become an almost continuous process due to economic growth, competition between ports, and significant increases in vessel size (Section G.4.3 of the EFH EIS). Elimination or degradation of aquatic and upland habitats is commonplace because port expansion almost always affects open water, submerged bottoms, and, possibly, riparian zones.

Potential Adverse Impacts

The environmental effects of dredging on EFH can include (1) direct removal/burial of organisms; (2) turbidity/siltation effects, including light attenuation from turbidity; (3) contaminant release and uptake, including nutrients, metals, and organics; (4) release of oxygen consuming substances; (5) entrainment; (6) noise disturbances; and (6) alteration to hydrodynamic regimes and physical habitat.

Recommended Conservation Measures

The following recommended conservation measures should be viewed as options to avoid and minimize adverse impacts and promote the conservation, enhancement, and proper functioning of EFH.

1. Avoid new dredging to the maximum extent practicable.
2. Where possible, minimize dredging by using natural and existing channels.
3. Site activities that would likely require dredging (such as placement of piers, docks, marinas, etc.) in deep-water areas or design such structures to alleviate the need for maintenance dredging.
4. Incorporate adequate control measures by using BMPs to minimize turbidity and dispersal of dredged material in areas where the dredging equipment would cause such effects.
5. For new dredging projects, undertake multi-season, pre-, and post-dredging biological surveys to assess the cumulative impacts to EFH and allow for implementation of adaptive management techniques.
6. Provide appropriate compensation for significant impacts (short-term, long-term, and cumulative) to benthic environments resulting from dredging.
7. Perform dredging at times when impacts to federally managed species or their prey are least likely. Avoid dredging in areas with submerged aquatic vegetation.
8. Reference all dredging latitude-longitude coordinates at the site so that information can be incorporated into a geographical information system format.
9. Test sediments for contaminants as per EPA and USACE requirements.
10. Identify excess sedimentation in the watershed that prompts excessive maintenance dredging activities, and implement appropriate management actions, if possible, to ensure that actions are taken to curtail those causes.
11. Ensure that bankward slopes of the dredged area are slanted to acceptable side slopes (e.g., 3:1) to prevent sloughing.
12. Avoid placing pipelines and accessory equipment used in conjunction with dredging operations to the maximum extent possible close to kelp beds, eelgrass beds, estuarine/salt marshes, and other high value habitat areas.

F.2.3.2 Material Disposal/Fill Material

The discharge of dredged materials subsequent to dredging operations or the use of fill material in aquatic habitats can result in sediments (e.g., dirt, sand, mud) covering or smothering existing submerged substrates, loss of habitat function, and adverse effects on benthic communities.

F.2.3.2.1 Disposal of Dredged Material

Potential Adverse Impacts

The disposal of dredged material can adversely affect EFH by (1) altering or destroying benthic communities, (2) altering adjacent habitats, and (3) creating turbidity plumes and introducing contaminants and/or nutrients.

Recommended Conservation Measures

The following recommended conservation measures should be viewed as options to avoid and minimize adverse impacts and promote the conservation, enhancement, and proper functioning of EFH.

1. Study all options for disposal of dredged materials, including upland disposal sites, and select disposal sites that minimize adverse effects to EFH.
2. Where long-term maintenance dredging is anticipated, acquire and maintain disposal sites for the entire project life.
3. Encourage beneficial uses of dredged materials.
4. State and federal agencies should identify the direct and indirect impacts open-water disposal permits for dredged material may have on EFH during proposed project reviews.
5. Minimize the areal extent of any disposal site in EFH, or avoid the site entirely. Mitigate all non-avoidable adverse impacts as appropriate.

F.2.3.2.2 Fill Material

Potential Adverse Impacts

Adverse impacts to EFH from the introduction of fill material include (1) loss of habitat function and (2) changes in hydrologic patterns.

Recommended Conservation Measures

The following recommended conservation measures should be viewed as options to avoid and minimize adverse impacts and promote the conservation, enhancement, and proper functioning of EFH:

1. Federal, state, and local resource management and permitting agencies should address the cumulative impacts of past and current fill operations on EFH and consider them in the permitting process for individual projects.
2. Minimize the areal extent of any fill in EFH, or avoid it entirely. Mitigate all non-avoidable adverse impacts as appropriate.
3. Consider alternatives to the placement of fill into areas that support EFH.

F.2.3.3 Vessel Operations/Transportation/Navigation

The growth in Alaska coastal communities is putting demands on port districts to increase infrastructure capacity to accommodate additional vessel operations for cargo handling activities and marine transportation. Port expansion has become an almost continuous process due to economic growth, competition between ports, and significant increases in vessel size (Council 1999). In addition, increasing boat sales have put more pressure on improving and building new commercial fishing and small boat harbors.

Potential Adverse Impacts

Port facilities, vessel/ferry operations, and recreational marinas can impact to EFH, especially by filling productive shallow water habitats. Potential adverse impacts to EFH can occur during both the construction and operation phases. These include direct, indirect, and cumulative impacts on shallow subtidal, deep subtidal, eelgrass beds, mudflats, sand shoals, rock reefs, and salt marsh habitats. There is considerable evidence that docks and piers block sunlight penetration, alter water flow, introduce chemicals, and restrict access and navigation (Section G.4.6 of the EFH EIS). The increase in hard surfaces close to the marine environment increases nonpoint surface discharges (Section G.2.2 of the EFH EIS), adds debris sources, and reduces buffers between land use and the aquatic ecosystem. Additional impacts include vessel groundings, modification of water circulation (breakwaters, channels, and fill), vessel wake generation, pier lighting, anchor and prop scour, discharge of contaminants and debris, and changing natural patterns of fish movement.

Recommended Conservation Measures

The following recommended conservation measures should be viewed as options to avoid and minimize adverse impacts and promote the conservation, enhancement, and proper functioning of EFH.

1. Locate marinas in areas of low biological abundance and diversity; if possible, for example, avoid the disturbance of eelgrass or other submerged aquatic vegetation including macroalgae, mudflats, and wetlands as part of the project design.
2. If practicable, excavate uplands to create marina basins rather than converting intertidal or shallow subtidal areas to deeper subtidal areas for basin creation.
3. Leave riparian buffers in place to help maintain water quality and nutrient input.
4. Should mitigation be required, include a monitoring plan to gauge the success of mitigation efforts.
5. Include low-wake vessel technology, appropriate routes, and BMPs for wave attenuation structures as part of the design and permit process.
6. Incorporate BMPs to prevent or minimize contamination from ship bilge waters, antifouling paints, shipboard accidents, shipyard work, maintenance dredging and disposal, and nonpoint source contaminants from upland facilities related to vessel operations and navigation.
7. Locate mooring buoys in water deep enough to avoid grounding and to minimize the effects of prop wash.
8. Use catchment basins for collecting and storing surface runoff from upland repair facilities.
9. Locate facilities in areas with enough water velocity to maintain water quality levels within acceptable ranges.
10. Locate marinas where they do not interfere with drift sectors determining the structure and function of adjacent habitats.
11. To facilitate the movement of fish around breakwaters, provide a shallow shelf or “fish bench” on the outside of the breakwater.
12. Harbor facilities should be designed to include practical measures for reducing, containing, and cleaning up petroleum spills.
13. Use appropriate timing windows for construction and dredging activities to avoid potential impacts on EFH.

F.2.3.4 Introduction of Exotic Species

Introductions of exotic species into estuarine, riverine, and marine habitats have been well documented and can be intentional (e.g., for the purpose of stock or pest control) or unintentional (e.g., fouling organisms). Exotic fish, shellfish, pathogens, and plants can enter the environment from industrial shipping (e.g., as ballast), recreational boating, aquaculture (Section G.4.10 of the EFH EIS), biotechnology, and aquariums. The transportation of nonindigenous organisms to new environments can have many severe impacts on habitat (Omori et al. 1994).

Potential Adverse Impacts

Long-term impacts from the introduction of nonindigenous and reared species can change the natural community structure and dynamics, lower the overall fitness and genetic diversity of natural stocks, and pass and/or introduce exotic lethal disease. Overall, exotic species introductions create five types of negative effects: (1) habitat alteration, (2) trophic alteration, (3) gene pool alteration, (4) spatial alteration, and (5) introduction of diseases.

Recommended Conservation Measures

The following recommended conservation measures should be viewed as options to avoid and minimize adverse impacts and promote the conservation, enhancement, and proper functioning of EFH.

1. Uphold fish and game regulations of the Alaska Board of Fisheries (AS 16.05.251) and Board of Game (AS 16.05.255), which prohibit and regulate the live capture, possession, transport, or release of native or exotic fish or their eggs.
2. Adhere to regulations and use best management practices outlined in the State of Alaska Aquatic Nuisance Species Management Plan (Fay 2002).
3. Encourage vessels to perform a ballast water exchange in marine waters (in accordance with the U.S. Coast Guard’s voluntary regulations) to minimize the possibility of introducing exotic estuarine species into similar habitats.
4. Discourage vessels that have not performed a ballast water exchange from discharging their ballast water into estuarine receiving waters.
5. Require vessels brought from other areas over land via trailer to clean any surfaces that may harbor non-native plant or animal species (propellers, hulls, anchors, fenders, etc.).
6. Treat effluent from public aquaria displays and laboratories and educational institutes using exotic species before discharge to prevent the introduction of viable animals, plants, reproductive material, pathogens, or parasites into the environment.
7. Prevent introduction of non_native plant species into aquatic and riparian ecosystems by avoiding use of non_native seed mixes or invasive, non_native landscaping materials near waterways and shorelines.
8. Encourage proper disposal of seaweeds and other plant materials used for packing purposes when shipping fish or other animals.

F.2.3.5 Pile Installation and Removal

Pilings are an integral component of many overwater and in-water structures. They provide support for the decking of piers and docks, function as fenders and dolphins to protect structures, support navigation markers, and help in the construction of breakwaters and bulkheads. Materials used in pilings include steel, concrete, wood (both treated and untreated), plastic, or a combination thereof. Piles are usually driven into the substrate by using either impact hammers or vibratory hammers. Impact hammers consist of a heavy weight that is repeatedly dropped onto the top of the pile, driving it into the substrate. Vibratory hammers use a combination of a stationary, heavy weight and vibration, in the plane perpendicular to the long axis of the pile, to force the pile into the substrate. Impact hammers are able to drive piles into most substrates (including hardpan, glacial till, etc.), vibratory hammers are limited to softer, unconsolidated substrates (e.g., sand, mud, and gravel).

Piles can be removed using a variety of methods, including vibratory hammer, direct pull, clam shell grab, or cutting/breaking the pile below the mudline, leaving the buried section in place.

F.2.3.5.1 Pile Driving

Potential Adverse Impacts

Pile driving can generate intense underwater sound pressure waves that may adversely affect EFH. These pressure waves have been shown to injure and kill fish (CalTrans 2001, Longmuir and Lively 2001, Stotz and Colby 2001, Stadler, pers. obs. 2002). Injuries associated directly with pile driving are poorly studied, but include rupture of the swimbladder and internal hemorrhaging (CalTrans 2001; Abbott and Bing-Sawyer 2002; Stadler, pers. obs. 2002). The type and intensity of the sounds produced during pile driving depend on a variety of factors, including, but not limited to, the type and size of the pile, the firmness of the substrate into which the pile is being driven, the depth of water, and the type and size of the pile-driving hammer. Driving large hollow-steel piles with impact hammers produces intense, sharp spikes of sound that can easily reach levels injurious to fish. Vibratory hammers, on the other hand, produce sounds of lower intensity, with a rapid repetition rate.

Systems successfully designed to reduce the adverse effects of underwater sounds on fish have included the use of air bubbles. Both confined (i.e., metal or fabric sleeve) and unconfined air bubble systems have been shown to attenuate underwater sound pressures (Longmuir and Lively 2001, Christopherson and Wilson 2002, Reyff and Donovan 2003).

Recommended Conservation Measures

The following recommended conservation measures should be viewed as options to avoid and minimize adverse impacts and promote the conservation, enhancement, and proper functioning of EFH.

1. Install hollow-steel piles with an impact hammer at a time of year when larval and juvenile stages of fish species with designated EFH are not present.
2. Drive piles during low tide when they are located in intertidal and shallow subtidal areas.
3. Use a vibratory hammer when driving hollow-steel piles.
4. Implement measures to attenuate the sound should it exceed threshold levels. If sound pressure levels are anticipated to exceed acceptable limits, implement appropriate mitigation measures when practicable. Methods to reduce the sound pressure levels include, but are not limited to, the following:
    a) Surround the pile with an air bubble curtain system or air-filled coffer dam.
    b) Because the sound produced has a direct relationship to the force used to drive the pile, use a smaller hammer to reduce the sound pressures.
    c) Use a hydraulic hammer if impact driving cannot be avoided. The force of the hammer blow can be controlled with hydraulic hammers; reducing the impact force will reduce the intensity of the resulting sound.
5. Drive piles when the current is reduced (i.e., centered around slack current) in areas of strong current to minimize the number of fish exposed to adverse levels of underwater sound.

F.2.3.5.2 Pile Removal

Potential Adverse Impacts

The primary adverse effect of removing piles is the suspension of sediments, which may result in harmful levels of turbidity and release of contaminants contained in those sediments. Vibratory pile removal tends to cause the sediments to slough off at the mudline, resulting in relatively low levels of suspended sediments and contaminants. Breaking or cutting the pile below the mudline may suspend only small amounts of sediment, providing that the stub is left in place, and little digging is required to access the pile. Direct pull or use of a clamshell to remove broken piles may, however, suspend large amounts of sediment and contaminants. When the piling is pulled from the substrate using these two methods, sediments clinging to the piling will slough off as it is raised through the water column, producing a potentially harmful plume of turbidity and/or contaminants. The use of a clamshell may suspend additional sediment if it penetrates the substrate while grabbing the piling.

While there is a potential to adversely affect EFH during the removal of piles, many of the piles removed are old creosote-treated timber piles. In some cases, the long-term benefits to EFH obtained by removing a chronic source of contamination may outweigh the temporary adverse effects of turbidity.

Recommended Conservation Measures

The following recommended conservation measures should be viewed as options to avoid and minimize adverse impacts and promote the conservation, enhancement, and proper functioning of EFH.

1. Remove piles completely rather than cutting or breaking them off, if they are structurally sound.
2. Minimize the suspension of sediments and disturbance of the substrate when removing piles. Measures to help accomplish this include, but are not limited to, the following:
    a) When practicable, remove piles with a vibratory hammer, rather than using the direct pull or clamshell method.
    b) Remove the pile slowly to allow sediment to slough off at, or near, the mudline.
    c) The operator should first hit or vibrate the pile to break the bond between the sediment and the pile to minimize the potential for the pile to break, as well as to reduce the amount of sediment sloughing off the pile during removal.
    d) Encircle the pile, or piles, with a silt curtain that extends from the surface of the water to the substrate.
3. Complete each pass of the clamshell to minimize suspension of sediment if pile stubs are removed with a clamshell.
4. Place piles on a barge equipped with a basin to contain all attached sediment and runoff water after removal.
5. Using a pile driver, drive broken/cut stubs far enough below the mudline to prevent release of contaminants into the water column as an alternative to their removal.

F.2.3.6 Overwater Structures

Overwater structures include commercial and residential piers and docks, floating breakwaters, barges, rafts, booms, and mooring buoys. These structures typically are located in intertidal areas out to about 49 feet (15 meters) below the area exposed by the mean lower low tide (i.e., the shallow subtidal zone). Light, wave energy, substrate type, depth, and water quality are the primary factors controlling the plant and animal assemblages found at a particular site. Overwater structures and associated activities can alter these factors and interfere with key ecological functions such as spawning, rearing, and refugia. Site-specific factors (e.g., water clarity, current, depth, etc.) and the type and use of a given overwater structure determine the occurrence and magnitude of these impacts.

Potential Adverse Impacts

Overwater structures and associated developments may adversely affect EFH in a variety of ways, primarily by (1) changes in ambient light conditions, (2) alteration of the wave and current energy regime, and (3) activities associated with the use and operation of the facilities (Nightingale and Simenstad 2001).

Recommended Conservation Measures

The following recommended conservation measures should be viewed as options to avoid and minimize adverse impacts and promote the conservation, enhancement, and proper functioning of EFH.

1. Use upland boat storage whenever possible to minimize need for overwater structures.
2. Locate overwater structures in deep enough waters to avoid intertidal and shade impacts, minimize or preclude dredging, minimize groundings, and avoid displacement of submerged aquatic vegetation, as determined by a preconstruction survey.
3. Design piers, docks, and floats to be multiuse facilities to reduce the overall number of such structures and to limit impacted nearshore habitat.
4. Incorporate measures that increase the ambient light transmission under piers and docks. These measures include, but are not limited to, the following:
    a) Maximize the height of the structure, and minimize the width of the structure to decrease the shade footprint and using grated decking material.
    b) Use reflective materials (e.g., concrete or steel instead of materials that absorb light such as wood) on the underside of the dock to reflect ambient light.
    c) Use the fewest number of pilings necessary to support the structures to allow light into under-pier areas and minimize impacts to the substrate.
    d) Align piers, docks, and floats in a north-south orientation to allow the arc of the sun to cross perpendicular to the structure and to reduce the duration of light limitation.
5. Use floating rather than fixed breakwaters whenever possible, and remove them during periods of low dock use. Encourage seasonal use of docks and off-season haul-out.
6. Locate floats in deep water to avoid light limitation and grounding impacts to the intertidal or shallow subtidal zone.
7. Maintain at least 1 foot (0.30 meter) of water between the substrate and the bottom of the float at extreme low tide.
8. Conduct in-water work when managed species and prey species are least likely to be impacted.
9. To the extent practicable, avoid the use of treated wood timbers or pilings and use alternative materials such as untreated wood, concrete, or steel.
10. Mitigate for unavoidable impacts to benthic habitats. Mitigation should be adequate, monitored, and adaptively managed.

F.2.3.7 Flood Control/Shoreline Protection

Protecting riverine and estuarine communities from flooding events can result in varying degrees of change in the physical, chemical, and biological characteristics of existing shoreline and riparian habitat. The use of dikes and berms can also have long-term adverse effects on tidal marsh and estuarine habitats. Tidal marshes are highly variable, but typically have freshwater vegetation at the landward side, saltwater vegetation at the seaward side, and gradients of species inbetween that are in equilibrium with the prevailing climatic, hydrographic, geological, and biological features of the coast. These systems normally drain through highly dendritic tidal creeks that empty into the bay or estuary. Freshwater entering along the upper edges of the marsh drains across the surface and enters the tidal creeks. Structures placed for coastal shoreline protection include, but are not limited to, concrete or wood seawalls, rip-rap revetments (sloping piles of rock placed against the toe of the dune or bluff in danger of erosion from wave action), dynamic cobble revetments (natural cobble placed on an eroding beach to dissipate wave energy and prevent sand loss), vegetative plantings, and sandbags.

Potential Adverse Impacts

Dikes, levees, ditches, or other water controls at the upper end of a tidal marsh can cut off all tributaries feeding the marsh, preventing freshwater flushing and annual flushing, annual renewal of sediments and nutrients, and the formation of new marshes. Water controls within the marsh proper intercept and carry away freshwater drainage, block freshwater from flowing across seaward portions of the marsh, increase the speed of runoff of freshwater to the bay or estuary, lower the water table, permit saltwater intrusion into the marsh proper, and create migration barriers for aquatic species. In deeper channels where reducing conditions prevail, large quantities of hydrogen sulfide are produced. These quantities are toxic to marsh grasses and other aquatic life. Acid conditions of these channels can also result in release of heavy metals from the sediments.

Long-term effects on the tidal marsh include land subsidence (sometimes even submergence), soil compaction, conversion to terrestrial vegetation, greatly reduced invertebrate populations, and general loss of productive wetland characteristics. Loss of these low-salinity environments reduces estuarine fertility, restricts suitable habitat for aquatic species, and creates abnormally high salinity during drought years. Low-salinity environments form a barrier that prevents the entrance of many marine species, including competitors, predators, parasites, and pathogens.

Armoring of shorelines to prevent erosion and to maintain or create shoreline real estate simplifies habitats, reduces the amount of intertidal habitat, and affects nearshore processes and the ecology of numerous species (Williams and Thom 2001). Hydraulic effects on the shoreline include increased energy seaward of the armoring, reflected wave energy, dry beach narrowing, substrate coarsening, beach steepening, changes in sediment storage capacity, loss of organic debris, and downdrift sediment starvation (Williams and Thom 2001). Installation of breakwaters and jetties can result in community changes from burial or removal of resident biota, changes in cover and preferred prey species, and predator attraction (Williams and Thom 2001). As with armoring, breakwaters and jetties modify hydrology and nearshore sediment transport, as well as movement of larval forms of many species (Williams and Thom 2001).

Recommended Conservation Measures

The following recommended conservation measures should be viewed as options to avoid and minimize adverse impacts and promote the conservation, enhancement, and proper functioning of EFH.

1. Minimize the loss of riparian habitats as much as possible.
2. Do not undertake diking and draining of tidal marshlands and estuaries.

3. Wherever possible, use soft approaches (such as beach nourishment, vegetative plantings, and placement of LWD) to shoreline modifications.
4. Include efforts to preserve and enhance EFH by providing new gravel for spawning areas, removing barriers to natural fish passage, and using weirs, grade control structures, and low-flow channels to provide the proper depth and velocity for fish.
5. Construct a low-flow channel to facilitate fish passage and help maintain water temperature in reaches where water velocities require armoring of the riverbed.
6. Offset unavoidable impacts to in-stream fish habitat by providing rootwads, deflector logs, boulders, and rock weirs and by planting shaded riverine aquatic cover vegetation.
7. Use an adaptive management plan with ecological indicators to oversee monitoring and to ensure that mitigation objectives are met. Take corrective action as needed.

F.2.3.8 Log Transfer Facilities/In-water Log Storage

Rivers, estuaries, and bays were historically the primary ways to transport and store logs in the Pacific Northwest. Log storage within the bays and estuaries remains an issue in several Pacific Northwest bays. Using estuaries and bays and nearby uplands for storage of logs is common in Alaska, with most LTFs found in Southeast Alaska and a few located in Prince William Sound.

Potential Adverse Impacts

Log handling and storage in the estuary and intertidal zones of rivers can result in modification of benthic habitat and water quality degradation within the area of bark deposition (Levings and Northcote 2004). EFH may also be physically impacted by activities associated with facilities, constructed in the water, that are used to transfer commercially harvested logs to or from a vessel or log raft, including log rafts. Bark and wood debris may accumulate as a result of the abrasion of log surfaces from transfer equipment and impact EFH. After the logs have entered the water, they usually are bundled into rafts and hooked to a tug for shipment. In the process, bark and other wood debris can pile up on the ocean floor. The piles can smother clams, mussels, some seaweed, kelp, and grasses, with the bark sometimes remaining for decades. Accumulation of bark debris in shallow and deep-water environments has resulted in locally decreased epifaunal macrobenthos richness and abundance (Kirkpatrick et al. 1998, Jackson 1986). Log storage may also result in a release of soluble organic compounds within the bark pile. The physical, chemical, and biological impacts of log operations can be substantially reduced by adherence to appropriate siting and operational constraints. Adherence operational and siting guidelines will reduce (1) the amount of bark and wood debris that enters the marine and coastal environment, (2) the potential for displacement or harm to aquatic species, and (3) the accumulation of bark and wood debris on the ocean floor.

Recommended Conservation Measures

The following recommended conservation measures should be viewed as options to avoid and minimize adverse impacts and promote the conservation, enhancement, and proper functioning of EFH.

1. Restrict or eliminate storage and handling of logs from waters where state and federal water quality standards cannot be met at all times outside of the authorized zone of deposition.
2. Minimize potential impacts of log storage by employing effective bark and wood debris control, collection, and disposal methods at log dumps, raft building areas, and mill-side handling zones; avoiding free-fall dumping of logs; using easy let-down devices for placing logs in the water; and bundling logs before water storage (bundles should not be broken except on land and at millside).

3. Do not store logs in the water if they will ground at any time or shade sensitive aquatic vegetation such as eelgrass.
4. Avoid siting log-storage areas and LTFs in sensitive habitat and areas important for specified species, as required by the ATTF guidelines.
5. Site log storage areas and LTFs in areas with good currents and tidal exchanges.
6. Use land-based storage sites where possible, with the goal of eliminating in-water storage of logs.

F.2.3.9 Utility Line/Cables/Pipeline Installation

With the continued development of coastal regions comes greater demand for the installation of cables, utility lines for power and other services, and pipelines for water, sewage, etc. The installation of pipelines, utility lines, and cables can have direct and indirect impacts on the offshore, nearshore, estuarine, wetland, beach, and rocky shore coastal zone habitats. Many of the primary and direct impacts occur during the construction phase of installation, such as ground disturbance in the clearing of the right-of-way, access roads, and equipment staging areas. Indirect impacts can include increased turbidity, saltwater intrusion, accelerated erosion, and introduction of urban and industrial pollutants.

Potential Adverse Impacts

Adverse effects on EFH from the installation of pipelines, utility lines, and cables can occur through (1) destruction of organisms and habitat, (2) turbidity impacts, (3) resuspension of contaminants, and (4) changes in hydrology.

Recommended Conservation Measures

The following recommended conservation measures should be viewed as options to avoid and minimize adverse impacts and promote the conservation, enhancement, and proper functioning of EFH.

1. Align crossings along the least environmentally damaging route. Avoid sensitive habitats such as hard-bottom (e.g., rocky reefs), cold-water corals, submerged aquatic vegetation, oyster reefs, emergent marsh, and mud flats.
2. Use horizontal directional drilling where cables or pipelines would cross anadromous fish streams, salt marsh, vegetated inter-tidal zones, or steep erodible bluff areas adjacent to the inter-tidal zone to avoid surface disturbances.
3. Avoid construction of permanent access channels since they disrupt natural drainage patterns and destroy wetlands through excavation, filling, and bank erosion.
4. Store and contain excavated material on uplands.
5. Backfill excavated wetlands with either the same or comparable material capable of supporting similar wetland vegetation and at original marsh elevations.
6. Use existing rights-of-way whenever possible to lessen overall encroachment and disturbance of wetlands.
7. Bury pipelines and submerged cables where possible.
8. Remove inactive pipelines and submerged cables unless they are located in sensitive areas (e.g., marsh, reefs, sea grass, etc.) or in areas that present no safety hazard.
9. Use silt curtains or other type barriers to reduce turbidity and sedimentation whenever possible near the project site.
10. Limit access for equipment to the immediate project area.

11. Limit construction equipment to the minimum size necessary to complete the work.
12. Conduct construction during the time of year when it will have the least impact on sensitive habitats and species.
13. Suspend transmission lines beneath existing bridges or conduct directional boring under streams to reduce the environmental impact.
14. For activities on the Continental Shelf, shunt drill cuttings through a conduit and either discharge the cuttings near the sea floor, or transport them ashore.
15. For activities on the Continental Shelf, and to the extent practicable, locate drilling and production structures, including pipelines, at least 1 mile (1.6 kilometers) from the base of a hard-bottom habitat.
16. For activities on the Continental Shelf, and to avoid and minimize adverse impacts to managed species, implement the following to the extent practicable:
    a) Bury pipelines at least 3 feet (0.9 meter) beneath the sea floor, whenever possible. Particular considerations (i.e., currents, ice scour) may require deeper burial or weighting to maintain adequate cover. Buried pipeline and cables should be examined periodically for maintenance of adequate earthen cover.
    b) Where burial is not possible, such as in hard-bottomed areas, attach pipelines and cables to substrate to minimize conflicts with fishing gear.
    c) Locate alignments along routes that will minimize damage to marine and estuarine habitat.
    d) Where user conflicts are likely, consult and coordinate with fishing stakeholder groups during the route_planning process to minimize conflict.

F.2.3.10 Commercial Utilization of Habitat

Productive embayments are often used for commercial culturing and harvesting operations. These locations provide protected waters which serve as sites for oyster and mussel culturing. These operations may occur in areas of productive eelgrass beds. In 1988, Alaska passed the Alaska Aquatic Farming Act which is designed to encourage establishment and growth of an aquatic farming industry in the state. The Act establishes four criteria for issuance of an aquatic farm permit, including the requirement that the farm may not significantly affect fisheries, wildlife, or other habitats in an adverse manner.

Potential Adverse Impacts

Adverse impacts to EFH by operations that directly or indirectly use habitat include (1) discharge of organic waste, (2) shading and direct impacts to the seafloor, (3) risk of introducing undesirable species, and (4) impacts on estuarine food webs.

Recommended Conservation Measures

The following recommended conservation measures should be viewed as options to avoid and minimize adverse impacts and promote the conservation, enhancement, and proper functioning of EFH.

1. Site mariculture operations away from exisiting kelp or eelgrass beds. If mariculture operations are to be located adjacent to existing kelp or eelgrass beds, monitor these beds on an annual basis and resite the mariculture facility if monitoring reveals adverse effects.
2. Do not enclose or impound tidally influenced wetlands for mariculture. Take into account the size of the facility, migratory patterns, competing uses, hydrographic conditions, and upstream uses when siting facilities.

3. Undertake a thorough scientific review and risk assessment before any non-native species are introduced.
4. Encourage development of harvesting methods to minimize impacts on plant communities and the loss of food and/or habitat to fish populations during harvesting operations.
5. Provide appropriate mitigation for the unavoidable, extensive, or permanent loss of plant communities.

F.2.4 Coastal/Marine Activities

F.2.4.1 Point-source Discharges

Point-source discharges from municipal sewage treatment facilities or storm water discharges are controlled through EPA's regulations under the CWA and by state water regulations. The primary concerns associated with municipal point-source discharges involve treatment levels needed to attain acceptable nutrient inputs and overloading of treatment systems due to rapid development of the coastal zone. Storm drains are contaminated from communities using settling and storage ponds, street runoff, harbor activities, and honey buckets. Annually, wastewater facilities introduce large volumes of untreated excrement and chlorine through sewage outfall lines, as well as releasing treated freshwater into the nation's waters. This can significantly alter pH levels of marine waters (Council 1999).

Potential Adverse Impacts

There are many potential impacts from point-source discharge, but point-source discharges and resulting altered water quality in aquatic environments do not necessarily result in adverse impacts, either to marine resources or EFH. Because most point-source discharges are regulated by the state or EPA, effects to receiving waters are generally considered on a case-by-case basis. Point-source discharges can adversely affect EFH by (1) reducing habitat functions necessary for growth to maturity, (2) modifying community structure, (3) bioaccumulation, and (4) modifying habitat.

Recommended Conservation Measures

The following recommended conservation measures should be viewed as options to avoid and minimize adverse impacts and promote the conservation, enhancement, and proper functioning of EFH.

1. Locate discharge points in coastal waters well away from shellfish beds, sea grass beds, coral reefs, and other similar fragile and productive habitats.
2. Reduce potentially high velocities by diffusing effluent to acceptable velocities.
3. Determine benthic productivity by sampling before any construction activity related to installation of new or modified facilities. Develop outfall design (e.g., modeling concentrations within the predicted plume or likely extent of deposition along a productive nearshore) with input from appropriate resource and Tribal agencies.
4. Provide for mitigation when degradation or loss of habitat occurs from placement and operation of the outfall structure and pipeline.
5. Institute source-control programs that effectively reduce noxious materials to avoid introducing these materials into the waste stream.
6. Ensure compliance with pollutant discharges regulated through discharge permits which set effluent discharge limitations and/or specify operation procedures, performance standards, or BMPs. These efforts rely on the implementation of BMPs to control polluted runoff (EPA 1993).

7. Treat discharges to the maximum extent practicable, including implementation of up-to-date methodologies for reducing discharges of biocides (e.g., chlorine) and other toxic substances.
8. Use land-treatment and upland disposal/storage techniques where possible. Limit the use of vegetated wetlands as natural filters and pollutant assimilators for large-scale discharges to those instances where other less damaging alternatives are not available, and the overall environmental and ecological suitability of such actions has been demonstrated.
9. Avoid siting pipelines and treatment facilities in wetlands and streams. Since pipelines and treatment facilities are not water-dependent with regard to positioning, it is not essential that they be placed in wetlands or other fragile coastal habitats. Avoiding placement of pipelines within streambeds and wetlands will also reduce inadvertent infiltration into conveyance systems and retain natural hydrology of local streams and wetlands.

F.2.4.2 Fish Processing Waste—Shoreside and Vessel Operation

Seafood processing facilities are either shore-based facilities discharging through stationary outfalls or mobile vessels engaged in the processing of fresh or frozen seafood (Science Applications International Corporation 2001). Discharge of fish waste from shoreside and vessel processing has occurred in marine waters since the 1800s (Council 1999). With the exception of fresh market fish, some form of processing involving butchering, evisceration, precooking, or cooking is necessary to bring the catch to market. Precooking or blanching facilitates the removal of skin, bone, shell, gills, and other materials. Depending on the species, the cleaning operation may be manual, mechanical, or a combination of both (EPA 1974). Seafood processing facilities generally consist of mechanisms to offload the harvest from fishing boats; tanks to hold the seafood until the processing lines are ready to accept them; processing lines, process water, and waste collection systems; treatment and discharge facilities; processed seafood storage areas; and necessary support facilities such as electrical generators, boilers, retorts, water desalinators, offices, and living quarters. In addition, marinas that cater to patrons who fish a large amount can produce an equally large quantity of fish waste at the marina from fish cleaning.

Potential Adverse Impacts

Generally, seafood processing wastes consist of biodegradable materials that contain high concentrations of soluble organic material. Seafood processing operations have the potential to adversely affect EFH through (1) direct and/or nonpoint source discharge, (2) particle suspension, and (3) increased turbidity and surface plumes.

Recommended Conservation Measures

The following recommended conservation measures should be viewed as options to avoid and minimize adverse impacts and promote the conservation, enhancement, and proper functioning of EFH.

1. To the maximum extent practicable, base effluent limitations on site-specific water quality concerns.
2. To the maximum extent practicable, avoid the practice of discharging untreated solid and liquid waste directly into the environment.
3. Do not allow designation of new ZODs. Explore options to eliminate or reduce ZODs at existing facilities.
4. Control stickwater by physical or chemical methods.
5. Promote sound fish waste management through a combination of fish_cleaning restrictions, public education, and proper disposal of fish waste.

6. Encourage the alternative use of fish processing wastes (e.g., fertilizer for agriculture and animal feed).
7. Explore options for additional research.
8. Locate new plants outside rearing and nursery habitat. Monitor both biological and chemical changes to the site.

F.2.4.3 Water Intake Structures/Discharge Plumes

The withdrawal of riverine, estuarine, and marine waters by water intake structures is a common aquatic activity. Water may be withdrawn and used, for example, to cool power-generating stations and create temporary ice roads and ice ponds. In the case of power plants, the subsequent discharge of heated and/or chemically treated discharge water can also occur.

Potential Adverse Impacts

Water intake structures and effluent discharges can interfere with or disrupt EFH functions in the source or receiving waters by (1) entrainment, (2) impingement, (3) discharge, (4) operation and maintenance, and (5) construction-related impacts.

Recommended Conservation Measures

The following recommended conservation measures should be viewed as options to avoid and minimize adverse impacts and promote the conservation, enhancement, and proper functioning of EFH.

1. Locate facilities that rely on surface waters for cooling in areas other than estuaries, inlets, heads of submarine canyons, rock reefs, or small coastal embayments where managed species or their prey concentrate.
2. Design intake structures to minimize entrainment or impingement.
3. Design power plant cooling structures to meet the best technology available requirements as developed pursuant to Section 316(b) of the CWA.
4. Regulate discharge temperatures (both heated and cooled effluent) so they do not appreciably alter the temperature to an extent that could cause a change in species assemblages and ecosystem function in the receiving waters.
5. Avoid the use of biocides (e.g., chlorine) to prevent fouling where possible. Implement the least damaging antifouling alternatives.
6. Mitigate for impacts related to power plants and other industries requiring cooling water.
7. Treat all discharge water from outfall structures to meet state water quality standards at the terminus of the pipe.

F.2.4.4 Oil/Gas Exploration/Development/Production

Offshore exploration, development, and production of natural gas and oil reserves have been, and continue to be, an important aspect of the U.S. economy. As demand for energy resources grows, the debate over trying to balance the development of oil and gas resources and the protection of the environment will also continue. Projections indicate that U.S. demand for oil will increase by 1.3 percent per year between 1995 and 2020. Gas consumption is projected to increase by an average of 1.6 percent during the same time frame (Waisley 1998). Much of the 1.9 billion acres within the offshore jurisdiction of the U.S. remains unexplored (Oil and Gas Technologies for the Arctic and Deepwater 1985). Some of the older oil and gas platforms in operation will probably reach the end of their productive life in the near future, and decommissioning them is also an issue.

Potential Adverse Impacts

Offshore oil and gas operations can be classified into exploration, development, and production activities (which includes transportation). These activities occur at different depths in a variety of habitats. Not all of the potential disturbances in this list apply to every type of activity. These areas are subject to an assortment of physical, chemical, and biological disturbances, including the following (Council 1999, Helvey 2002):

- Noise from seismic surveys, vessel traffic, and construction of drilling platforms or islands
- Physical alterations to habitat from the construction, presence, and eventual decommissioning and removal of facilities such as islands or platforms, storage and production facilities, and pipelines to onshore common carrier pipelines, storage facilities, or refineries
- Waste discharges, including well drilling fluids, produced waters, surface runoff and deck drainage, domestic waste waters generated from the offshore facility, solid waste from wells (drilling muds and cuttings), and other trash and debris from human activities associated with the facility
- Oil spills
- Platform storage and pipeline decommissioning

The potential disturbances and associated adverse impacts on the marine environment have been reduced through operating procedures required by regulatory agencies and, in many cases, self-imposed by facilities operators. Most of the activities associated with oil and gas operations are conducted under permits and regulations that require companies to minimize impacts or avoid construction in sensitive marine habitats. New technological advances in operating procedures also reduce the potential for impacts.

Recommended Conservation Measures

The following recommended conservation measures should be viewed as options to avoid and minimize adverse impacts and promote the conservation, enhancement, and proper functioning of EFH:

1. As part of pre-project planning, identify all species of concern regulated under federal or state fishery management plans that inhabit, spawn, or migrate through areas slated for exploration, development, or production.
2. Avoid the discharge of produced waters into marine waters and estuaries. Reinject produced waters into the oil formation whenever possible.
3. Avoid discharge of muds and cuttings into the marine and estuarine environment.
4. To the extent practicable, avoid the placement of fill to support construction of causeways or structures in the nearshore marine environment.
5. As required by federal and state regulatory agencies, encourage the use of geographic response strategies that identify EFH and environmentally sensitive areas.
6. To the extent practicable, use methods to transport oil and gas that limit the need for handling in environmentally sensitive areas, including EFH.

7. Ensure that appropriate safeguards have been considered before drilling the first development well into the targeted hydrocarbon formations whenever critical life history stages of federally managed species are present.
8. Ensure that appropriate safeguards have been considered before drilling exploration wells into untested formations whenever critical life stages of federally managed species are present.
9. Oil and gas transportation and production facilities should be designed, constructed, and operated in accordance with applicable regulatory and engineering standards.
10. Evaluate and minimize impacts to EFH during the decommissioning phase of oil and gas facilities, including possible impacts during the demolition phase.

F.2.4.5 Habitat Restoration/Enhancement

Habitat loss and degradation are major, long_term threats to the sustainability of fishery resources (NMFS 2002). Viable coastal and estuarine habitats are important to maintaining healthy fish stocks. Good water quality and quantity, appropriate substrate, ample food sources, and substantial hiding places are needed to sustain fisheries. Restoration and/or enhancement of coastal and riverine habitat that supports managed fisheries and their prey will assist in sustaining and rebuilding fisheries stocks and recovering certain threatened or endangered species by increasing or improving ecological structure and functions. Habitat restoration/enhancement may include, but is not limited to, improvement of coastal wetland tidal exchange or reestablishment of historic hydrology, dam or berm removal, fish passage barrier removal/ modification, road-related sediment source reduction, natural or artificial reef/substrate/habitat creation, establishment or repair of riparian buffer zones, improvement of freshwater habitats that support anadromous fishes, planting of native coastal wetland and submerged aquatic vegetation, creation of oyster reefs, and improvements to feeding, shade or refuge, spawning, and rearing areas that are essential to fisheries.

Potential Adverse Impacts

The implementation of restoration/enhancement activities may have localized and temporary adverse impacts on EFH. Possible impacts can include (1) localized nonpoint source pollution such as influx of sediment or nutrients, (2) interference with spawning and migration periods, (3) temporary or permanent removal feeding opportunities, and (4) indirect effects from actual construction portions of the activity.

Recommended Conservation Measures

The following recommended conservation measures should be viewed as options to avoid and minimize adverse impacts and promote the conservation, enhancement, and proper functioning of EFH.

1. Use BMPs to minimize and avoid potential impacts to EFH during restoration activities. BMPs should include, but are not limited to, the following:
    a) Use turbidity curtains, haybales, and erosion mats to protect the water column.
    b) Plan staging areas in advance, and keep them to a minimum size.
    c) Establish buffer areas around sensitive resources; flag and avoid rare plants, archeological sites, etc.
    d) Remove invasive plant and animal species from the proposed action area before starting work. Plant only native plant species. Identify and implement measures to ensure native vegetation or revegetation success (Section G.4.4 of the EFH EIS).
    e) Establish temporary access pathways before restoration activities to minimize adverse impacts from project implementation.

2. Avoid restoration work during critical life stages for fish such as spawning, nursery, and migration. Determine these periods before project implementation to reduce or avoid any potential impacts.
3. Provide adequate training and education for volunteers and project contractors to ensure minimal impact to the restoration site. Train volunteers in the use of low-impact techniques for planting, equipment handling, and any other activities associated with the restoration.
4. Conduct monitoring before, during, and after project implementation to ensure compliance with project design and restoration criteria. If immediate post-construction monitoring reveals that unavoidable impacts to EFH have occurred, ensure that appropriate coordination with NMFS occurs to determine appropriate response measures, possibly including mitigation.
5. To the extent practicable, mitigate any unavoidable damage to EFH within a reasonable time after the impacts occur.
6. Remove and, if necessary, restore any temporary access pathways and staging areas used in the restoration effort.
7. Determine benthic productivity by sampling before any construction activity in the case of subtidal enhancement (e.g., artificial reefs). Avoid areas of high productivity to the maximum extent possible. Develop a sampling design with input from state and federal resource agencies. Before construction, evaluate of the impact resulting from the change in habitat (sand bottom to rocky reef, etc.). During post-construction monitoring, examine the effectiveness of the structures for increasing habitat productivity.

F.2.4.6 Marine Mining

Mining activity, which is also described in Sections G.3.1.1 and G.3.1.2 of the EFH EIS, can lead to the direct loss of EFH for certain species. Offshore mining, such as the extraction of gravel and gold in the Bering Sea and the mining of gravel from beaches, can increase turbidity of water. Thus, the resuspension of organic materials could affect less motile organisms (i.e., eggs and recently hatched larvae) in the area. Benthic habitats could be damaged or destroyed by these actions. Mining large quantities of beach gravel may significantly affect the removal, transport, and deposition of sand and gravel along the shore, both at the mining site and down-current (Council 1999). Neither the future extent of this activity nor the effects of such mortality on the abundance of marine species is known.

Potential Adverse Impacts

Mining practices that can affect EFH include physical impacts from intertidal dredging and chemical impacts from the use of additives such as flocculates (Council 1999). Impacts may include the removal of substrates that serve as habitat for fish and invertebrates; habitat creation or conversion in less productive or uninhabitable sites, such as anoxic holes or silt bottom; burial of productive habitats, such as in near-shore disposal sites (as in beach nourishment); release of harmful or toxic materials either in association with actual mining, or in connection with machinery and materials used for mining; creation of harmful turbidity levels; and adverse modification of hydrologic conditions so as to cause erosion of desirable habitats. Submarine disposal of mine tailings can also alter the behavior of marine organisms. Submarine mine tailings may not provide suitable habitat for some benthic organisms. In laboratory experiments, benthic dwelling flatfishes (Johnson et al. 1998a) and crabs (Johnson et al. 1998b) strongly avoided mine tailings.

During beach gravel mining, water turbidity increases and the resuspension of organic materials can affect less motile organisms (i.e., eggs and recently hatched larvae) in the area. Benthic habitats can be damaged or destroyed by these actions. Changes in bathymetry and bottom type may also alter population and migrations patterns (Hurme and Pullen 1988).

Recommended Conservation Measures

The following recommended conservation measures for marine mining should be viewed as options to avoid and minimize adverse impacts and promote the conservation, enhancement, and proper functioning of EFH.

1. To the extent practicable, avoid mining in waters containing sensitive marine benthic habitat including EFH (e.g., spawning, migrating, and feeding sites).
2. Minimize the areal extent and depth of extraction to reduce recolonization times.
3. Monitor turbidity during operations, and cease operations if turbidity exceeds predetermined threshold levels. Use sediment or turbidity curtains to limit the spread of suspended sediments and minimize the area affected.
4. Monitor individual mining operations to avoid and minimize cumulative impacts. For instance, three mining operations in an intertidal area could impact EFH, whereas one may not. Disturbance of previously contaminated mining areas may cause additional loss of EFH.
5. Use seasonal restrictions, as appropriate, to avoid and minimize impacts to EFH during critical life history stages of managed species (e.g., migration and spawning).

F.2.4.7 Persistent Organic Pollutants

The single biggest pollution threat to marine waters in Alaska is the deposition of persistent pollutants from remote sources. A large variety of contaminants can be found in Alaska's marine environment, including persistent organic pollutants (POPs) and heavy metals. North Pacific and Alaska marine waters are perceived as pristine because most of Alaska's 6,640 miles (10,686 kilometers) of coastline are devoid of point-source pollution, unlike much of North America. Effluents from pulp mills, marinas and boat harbors, municipal outfalls, and other industrial activities are generally considered to be the primary sources of contamination in Alaska waters, so most efforts at monitoring and mitigation have been focused on the local level. However, there is an increasing body of evidence suggesting that the greatest contaminant threat in Alaska comes from atmospheric and marine transport of contaminants from areas quite distant from Alaska.

The geography of Alaska makes it particularly vulnerable to contaminants volatilized from Asia. Pesticides applied to crops in Southeast Asia can be volatilized into the air, bound to suspended particulates, transported in the atmosphere to Alaska, and deposited in snow or rain directly into marine ecosystems or indirectly from freshwater flow to nearshore waters. Revolatilization of these compounds is inhibited by the cold temperatures associated with Alaska latitudes, resulting in a net accumulation of these compounds in northern habitats. This same distillation process also transfers volatilized contaminants from the atmosphere to the Pacific at lower latitudes, and ocean currents also deliver the contaminants to Alaska. Concentrations will be very low, but there will extensive geographical marine or land areas to act as cold deposit zones. The effect of these transport mechanisms has been the appearance of persistent organic contaminants in northern latitudes, despite the absence of local sources.

With over 100,000 chemicals on the market and an additional 1,000 to 2,000 new ones introduced annually, there are likely other toxic compounds in the environment whose concentrations are increasing. In addition, combustion and industrial processes result in the inadvertent production of unregulated chemicals (Arctic Monitoring and Assessment Programme [AMAP] 2002).

Potential Adverse Impacts

It is not clear if the levels of contaminants in Alaska waters are causing deleterious effects to populations, because research in this area is still in its infancy. Relatively small and spotty contaminant surveys have established that POPs are present in Alaska waters, forage, and predators. No comprehensive geographical and temporal studies have been done to date to examine trends or sources of variation. The potential for the problem has been exposed; the extent and significance remain to be determined.

The existence of organic contaminants in biological tissues means these contaminants are being transported within the food webs in Alaska fish habitats. The trophic structure of Alaska marine food webs, coupled with the tendency of contaminants to accumulate in Alaska habitats, causes apex predators to concentrate significant amounts of POPs in their tissues. Contamination is probably widespread among forage species at low levels, but apex predators are likely be the most affected as a result of their longevity, lipid storage, and the relatively high concentrations they bear. Contamination can cause immunological and reproductive impairment, acute toxic effects, and population declines. This issue is particularly relevant when the contaminant loads experienced by Alaska natives subsisting on foods derived from marine habitats are considered. Impacts may also occur at lower trophic levels, but there has been even less research in this area.

The impacts of persistent contaminants on populations in Alaska waters are not likely to be acute. The impacts are more likely be expressed as sublethal impacts in apparently healthy animals. These sublethal impacts ultimately lead to reduced reproductive fitness or decreased survival to maturity; therefore, they manifest themselves indirectly. Science is certain that the physical properties of these compounds couple with global climate patterns to ensure that they will be deposited in Alaska habitats, while maintaining their toxicity and perfusing through Alaska food webs, which include some of the most valuable fisheries on the planet. What is uncertain is how these compounds impact the health of organisms deriving sustenance from those food webs and how those impacts might feed back into the food web.

Recommended Conservation Measures

No mitigation strategies are proposed at this time relative to contaminants. There are too many unknowns. POP contaminants are present in Alaska waters and forage species and in predators up through apex predators, but the significance of the present loads is not known. Also, the relative concentrations in forage species (pollock for example) from the EBS, near Russia, or the northern GOA are not known. Comprehensive studies on a geographical, temporal, or widespread species scale to determine any relationship between contaminant loads and population changes have not been conducted. POP contaminants may contribute to poor recovery in some species, but mitigation strategies, whether they would be changes in fishing regulations or international regulation to curb contaminant releases, will likely need a better research foundation to support changes.

F.2.5 References

Abbott, R. and E. Bing-Sawyer. 2002. Assessment of pile driving impacts on the Sacramento blackfish (*Othodon microlepidotus*). Draft report prepared for Caltrans District 4. October 10, 2002.

Arctic Monitoring and Assessment Programme (AMAP). 2002. Arctic pollution 2002: Persistent organic pollutants, heavy metals, radioactivity, human health, changing pathways. Arctic Monitoring and Assessment Programme. Oslo Norway. pp. iii - 111.

Ball, B.J., G. Fox, and B.W. Munday. 2000. Long- and short-term consequences of a Nephrops trawl fishery on the benthos and environment of the Irish Sea. ICES Journal of Marine Science. 57(5):1,315-1,320.

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.

Caltrans. 2001. Fisheries Impact Assessment, Pile Installation Demonstration Project for the San Francisco - Oakland Bay Bridge, East Span Seismic Safety Project, August 2001. 59 pp.

Center for Watershed Protection (CWP). 2003. Impacts of Impervious Cover on Aquatic Systems. Elliott City, MD, www.cwp.org, 141 pp.

Christopherson, A. and J. Wilson. 2002. Technical Letter Report Regarding the San Francisco-Oakland Bay Bridge East Span Project Noise Energy Attenuation Mitigation. Peratrovich, Nottingham & Drage, Inc. Anchorage, Alaska. 27 pp.

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.

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.

Environmental Protection Agency (EPA). 1995. National Water Quality Inventory: 1994 Report to Congress. EPA-841-R-95-005. EPA Office of Water, Washington, D.C.

EPA. 1993. Guidance for specifying management measures for sources of nonpoint pollution in coastal waters. EPA Office of Water. 840-B-92-002. 500+ pp.

EPA. 1993. Guidance for specifying management measures for sources of nonpoint pollution in coastal waters. EPA Office of Water. 840-B-92-002. 500+ pp.

EPA. 1974. Development Document for Effluent Limitations Guidelines and Standards of Performance for the Catfish, Crab, Shrimp, and Tuna segments of the Canned and Preserved Seafood Processing Industry Point Source Category. Effluent Guidelines Division, Office of Water and Hazardous Material, Washington, D.C. EPA-44011-74-020-a. 389 pp.

Favorite, F., A.J. Dodimead, and K. Nasu. 1976. "Oceanography of the Subarctic Pacific region, 1960-71." *International North Pacific Fisheries Commission Bulletin*, *33.* International North Pacific Fisheries Commission, 6640 Northwest Marine Drive, Vancouver, BC, Canada V6T 1X2. p. 187.

Fay, V. 2002. Alaska Aquatic Nuisance Species Management Plan. Alaska Department of Fish and Game Publication. Juneau, AK. http://www.adfg.state.ak.us/special/invasive/ak_ansmp.pdf.

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, L., P.J.Auster, J. Heifetz, and B.L. Wing. 1999. Effects of trawling on seafloor habitat and associated invertebrate taxa in the GOA. Marine Ecology Progress Series 182:119-126.

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.

Gregory, S.V. and P.A. Bisson. 1997. Degradation and loss of anadromous salmonid habitat in the Pacific Northwest. *In* Stouder, J.D., P.A. Bisson, and R.J. Naiman, eds. Pacific Salmon and Their Ecosystems: Status and Future Options, pp. 277-314. Chapman and Hall, New York.

Hattori, A., and J.J. Goering. 1986. "Nutrient distributions and dynamics in the eastern Bering Sea." The Eastern Bering Sea Shelf: Oceanography and Resources, D. W. Hood and J. A. Calder, eds., University of Washington Press, Seattle, Washington. pp. 975-992.

Helvey, M. 2002. "Are southern California oil and gas platforms essential fish habitat?" *ICES Journal of Marine Science*. 59:S266-S271.

Hurme, A.K. and E.J. Pullen. 1988. Biological effects of marine sand mining and fill placement for beach replenishment: Lesson for other use. *Marine Mining*. Vol. 7.

Johnson, S.W., S.D. Rice, and D.A. Moles. 1998a. Effects of submarine mine tailings disposal on juvenile yellowfin sole (*Pleuronectes asper*): a laboratory study. Marine Pollution Bulletin. *36:278-287.*

Johnson, S.W., R.P. Stone, and D.C. Love. 1998b. Avoidance behavior of ovigerous Tanner crabs *(Chionoecetes bairdi*) exposed to mine tailings: a laboratory study. Alaska Fish. Res. Bull. 5:39-45.

Johnson, E.A. 1983. "Textural and compositional sedimentary characteristics of the Southeastern Bristol Bay continental shelf, Alaska," M.S., California State University, Northridge, California.

Kinder, T.H., and J.D. Schumacher. 1981. "Hydrographic Structure Over the Continental Shelf of the Southeastern Bering Sea." The Eastern Bering Sea Shelf: Oceanography and Resources, D. W. Hood and J. A. Calder, eds., University of Washington Press, Seattle, Washington. pp. 31-52.

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. 2001. Coral impacted by fishing gear in the GOA. Proceedings of the First International Symposium on Deepwater Corals. (Ecology Action Centre and Nova Scotia Museum, Halifax, Nova Scotia 106-117).

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.

Livingston, P.A., and S. Tjelmeland. 2000. "Fisheries in boreal ecosystems." *ICES Journal of Marine Science*. p. 57.

Longmuir, C. and T. Lively. 2001. Bubble curtain systems for use during marine pile driving. Report by Fraser River Pile & Dredge Ltd., New Westminster, British Columbia. 9 pp.

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., and K.R. Smith. 2000. Associations between flatfish abundance and surficial sediments in the eastern Bering Sea. *Can. J. Fisher. Aquat. Sci.* 57(12):2,410-2,419.

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. Final Environmental Impact Statement for Essential Fish Habitat Identification and Conservation in Alaska. DOC, NOAA, National Marine Fisheries Service, Alaska Region, P. O. Box 21668, Juneau, Alaska 99802-1668. Volumes I-VII.

NMFS. 2004. Final Alaska Groundfish Fisheries Programmatic Supplemental Environmental Impact Statement. DOC, NOAA, National Marine Fisheries Service, Alaska Region, P. O. Box 21668, Juneau, Alaska 99802-1668. Volumes I-VII.

NMFS. 2002. Environmental Assessment, NMFS' Restoration Plan for the Community-Based Restoration Program. Prepared by the NOAA Restoration Center, Office of Habitat Conservation. Silver Spring, MD.

North Pacific Fishery Management Council (Council). 1999. Environmental Assessment for Amendment 55 to the Fishery Management Plan for the Groundfish Fishery of the Bering Sea and Aleutian Islands Area; Amendment 55 to the Fishery Management Plan for Groundfish of the Gulf of Alaska; Amendment 8 to the Fishery Management Plan for the King and Tanner Crab Fisheries in the Bering Sea/Aleutian Islands; Amendment 5 to the Fishery Management Plan for Scallop Fisheries off Alaska; Amendment 5 to the Fishery Management Plan for the Salmon Fisheries in the EEZ off the Coast of Alaska, Essential Fish Habitat. 605 West 4th Ave, Suite 306, Anchorage, AK 99501_2252. 20 January.

Nightingale, B. and C.A. Simenstad. 2001. Overwater Structures: Marine Issues. White paper submitted to Washington Department of Fish and Wildlife, Washington Department of Ecology and Washington Department of Transportation. www.wa.gov/wdfw/hab. 133 pp.

Northcote, T.G. and G.F. Hartman. 2004. Fishes and Forestry - Worldwide Watershed Interactions and Management, Blackwell Publishing, Oxford, UK, 789 pp.

Northwest Power Planning Council. 1986. Compilation of information on salmon and steelhead losses in the Columbia River Basin. Columbia River Basin and Wildlife Program. Portland, OR.

National Research Council (NRC), Committee on Hardrock Mining. 1999. Hardrock Mining on Federal Lands. Appendix B. Potential Environmental Impacts of Hardrock Mining. (http://www.nap.edu/html/hardrock_fed_lands/appB.html).

Oil and Gas Technologies for the Arctic and Deepwater. 1985. U.S. Congress, Office of Technology Assessment, OTA-O-270, May 1985. Library of Congress Catalog Card Number 85-600528. U.S. Government Printing Office, Washington, DC 20402.

Omori, M., S. Van der Spoel, C.P. Norman. 1994. Impact of human activities on pelagic biogeography. Progress in Oceanography 34 (2-3):211-219.

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.

Reed, R.K. 1984. "Flow of the Alaskan Stream and its variations." *Deep-Sea Research*, 31:369-386.

Reyff, J.A and P. Donovan. 2003. Benicia-Martinez Bridge Bubble Curtain Test - Underwater Sound Measurement Data. Memo to Caltrans dated January 31, 2003. 3 pp.

Reyff, J.A. 2003. Underwater sound levels associated with seismic retrofit construction of the Richmond-San Rafael Bridge. Document in support of Biological Assessment for the Richmond-San Rafael Bridge Seismic Safety Project. January 31, 2003. 18 pp.

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.

Science Applications International Corporation. 2001. Information Collection Request for National Pollutant Discharge Elimination System (NPDES) and Sewage Sludge Monitoring Reports. Prepared by Science Applications International Corporation, 11251 Roger Bacon Drive, Reston, VA 20190, for Tetra Tech, Inc., Fairfax, VA, for the U.S. Environmental Protection Agency, Office of Wastewater Management, Washington, D.C. EPA ICR# 0229.15. p. 11.

Scott G.I., M.H. Fulton, D.W. Moore, E.F. Wirth, G.T. Chandler, P.B. Key, J.W. Daugomah, E.D. Strozier, J. Devane, J.R. Clark, M.A. Lewis, D.B. Finley, W. Ellenberg, and K.J. Karnaky. 1999. "Assessment of risk reduction strategies for the management of agricultural nonpoint source pesticide runoff in estuarine ecosystems." *Toxicology and Industrial Health*. 15:200-213.

Sengupta, M. 1993. Environmental Impacts of Mining: Monitoring, Restoration, and Control. CRC Press, Inc. 2000 Corporate Blvd., N.W. Boca Raton, FL. 33431. p.1.

Sharma, G.D. 1979. The Alaskan shelf: hydrographic, sedimentary, and geochemical environment, Springer_Verlag, New York. 498 pp.

Smith, K.R., and R.A. McConnaughey. 1999. "Surficial sediments of the eastern Bering Sea continental shelf: EBSSED database documentation." NOAA Technical Memorandum, *NMFS-AFSC-104*, U.S. Department of Commerce, NMFS Alaska Fisheries Science Center, 7600 Sand Point Way NE, Seattle, Washington 98115-0070. 41 pp.

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).

Stotz, T. and J. Colby. 2001. January 2001 dive report for Mukilteo wingwall replacement project. Washington State Ferries Memorandum. 5 pp. + appendices.

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.

Waisley, S.L. 1998. Projections for U.S. and Global Supply and Demand for 2010 and 2020. presented at U.S. and China Oil and Gas Industrial Forum, Beijing, People's Republic of China, November 2-4, 1998. Office of Natural Gas and Petroleum Technology, U.S. DOE, Washington, D.C. (http://www.fe.doe.gov/oil_gas/china_forum/cl04000.html).

Williams, G.D. and R.M. Thom. 2001. Marine and estuarine shoreline modification issues. White paper submitted to Washington Department of Fish and Wildlife, Washington Department of Ecology and Washington Department of Transportation. www.wa.gov/wdfw/hab/ahg. 99 pp.

Würsig, B., C.R. Greene, Jr., and T.A. Jefferson. 2000. "Development of an air bubble curtain to reduce underwater noise of percussive pile driving." *Marine Environmental Research*. 49:79-93.

F.3 Cumulative Effects of Fishing and Non-Fishing Activities on EFH

This section discusses the cumulative effects of fishing and non-fishing activities on EFH. As identified in Section 4.4 of the 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 of the EFH EIS). The effects of current fishing activities on EFH are classified as minimal and temporary or unknown.

A review of the effects of non-fishing activities on EFH is found in section F.2 above. There are 29 non-fishing activities for which potential effects are described above. However, the magnitude of these effects cannot currently be quantified with available information. Of the 29 activities, most are described as likely having less than substantial potential effects on EFH. Some of these activities such as urban/suburban development, road building and maintenance (including the placement of fill material), vessel operations/transportation/navigation, silviculture (including LTFs), and point source discharge may have potential cumulative impacts due to the additive and chronic nature of these activities. 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 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 Enivonmental Impact Statement* (NMFS 2004). The following is a brief summary from this analysis.

The FMP has instituted privilege-based management programs in the sablefish fishery, and fishery managers, under the guidance of the FMP management policy, are moving towards extending privilege-based allocations to other groundfish fisheries.

- 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.
- 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.
- 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.
- 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.

[this page intentionally left blank

Appendix H Research Needs

Although research needs are expressed 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 Gulf of Alaska (GOA) 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 research needs, and these can be found on the Council's website. Additionally, ongoing research by National Marine Fisheries Service (NMFS)'s 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 GOA and Bering Sea and Aleutian Islands (BSAI) 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 National Research Council's 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 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 NMFS 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.

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.

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.

Research on the Fisheries

a. Social and economic research

b. Seafood safety research

c. Marine aquaculture

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.

H.4.1 Objectives

Reduce impacts. (1) Limit bottom trawling in the AI to areas historically fished and prevent expansion into new areas. (2) Limit bottom contact gear in specified coral garden habitat areas. (3) Restrict higher impact trawl fisheries from a portion of the GOA slope. (4) Increase monitoring for enforcement. (5) Establish a scientific research program.

Benthic habitat recovery. Allow recovery of habitat in a large area with relatively low historic effort.

H.4.2 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?

H.4.3 Research Activities

Reduce impacts. 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. First, the recent gear-specific fishing pattern must be characterized to establish a baseline for comparison with observed changes in effort after closures occur. An effective analysis of change requires comprehensive effort data with high spatial resolution, including accurate information about the tow path or setting location, as well as complete gear specifications. Effects of displaced fishing effort would have to be considered. The relative effects of bottom trawl and alternative gear/footrope designs and, thus, the efficacy of the measure should be investigated experimentally in a relatively undisturbed area that is representative of the closed areas. 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. Ultimately, there should be detectable increases in FMP species that are directly attributable to the reduced impacts on sponge and coral habitat.

Benthic habitat recovery. 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. A reference site would have to remain undisturbed by fishing during the entire course of the recovery experiment. Such a reference site may or may not exist, and the essential elements of comparability for identifying this area are presently unknown. Without proper reference sites, it may still be possible to deduce recovery dynamics based on changes observed in comparable newly closed areas with different histories of fishing disturbance.

H.4.4 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.

Appendix I Information on Marine Mammal and Seabird Populations

This appendix contains information on the marine mammal and seabird populations in the Gulf of Alaska (GOA) and Bering Sea and Aleutian Islands (BSAI) 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

I.1.1.1 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.

I.1.1.2 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.

I.1.1.3 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 my 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.

I.1.1.4 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.

I.1.1.5 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.

I.1.1.6 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 hazzard, 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 of 1972 (amended 1994) (MMPA). Management responsibility for cetaceans and pinnipeds other than walrus is vested with NMFS Protected Resources Division (PRD). The 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 GOA or BSAI 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 has 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 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 FMPs. 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 BSA 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 References

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 BSAI and GOA 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 other sites are monitored every three years. Although trends at 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 censussing 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.

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 (FMPs). 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/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 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 GOA or BSAI 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 GOA or BSAI, 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 GOA or BSAI 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 EEZ. Short-tailed albatross do not nest in U.S. waters but have been sighted throughout the GOA or BSAI areas. 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 GOA and BSAI groundfish fisheries were initiated in the 1990s and have focused primarily on collecting seabird/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 FMP-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 (GOA Amendment 39 and BSAI Amendment 36). 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 Reference

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 Wildl.Serv.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 succes 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-leffed 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.