GOA Groundfish FMP Amendment 90 - amendment text for updating EFH description and non-fishing impacts to EFH, changing HAPC timeline, and updating EFH research objectives (EFH Omnibus Amendment)

Make the following changes to Sections 3, 4, and 6, Appendix A, Appendix D, Appendix E, Appendix F, and Appendix H of the Fishery Management Plan for Groundfish of the Bering Sea / Aleutian Islands Management Area. When edits to existing sections are proposed, words indicated with strikeout (e.g., ~~strikeout~~) should be deleted from the FMP, and words that are underlined (e.g., underlined) should be inserted into the FMP. Instructions are italicized and highlighted. Note, instructions reference three supplemental files: Appendix D, Appendix E, and Appendix F.2.

1. ***In Section 3.10.2, Schedule for Review, revise the second paragraph under the subheading "Essential Fish Habitat Components" as follows:***

Additionally, the Council may ~~use the FMP amendment cycle every three years to~~ solicit proposals for habitat areas of particular concern (HAPC) and/or conservation and enhancement measures to minimize the potential adverse effects of fishing. Those proposals that the Council endorses would be implemented through FMP amendments. HAPC proposals may be solicited every 5-years, coinciding with the EFH 5-year review, or may be initiated at any time by the Council.

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

4.2.2 Essential Fish Habitat Definitions

EFH is defined in the Magnuson-Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act) as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity." EFH for groundfish species is determined to be the general distribution of a species described by life stage. General distribution is a subset of a species' total population distribution, and is identified as the distribution of 95 percent of the species population, for a particular life stage, if life history data are available for the species. Where information is insufficient and a suitable proxy cannot be inferred, EFH is not described. General distribution is used to describe EFH for all stock conditions whether or not higher levels of information exist, because the available higher level data are not sufficiently comprehensive to account for changes in stock distribution (and thus habitat use) over time.

EFH is described for FMP-managed species by life stage as general distribution using ~~new~~ guidance from the EFH Final Rule (50 CFR 600.815), ~~such as~~ including the ~~updated~~ EFH Level of Information definitions. New analytical tools are used and recent scientific information is incorporated for each life history stage from updated scientific habitat assessment reports (see Appendix F to ~~the~~ NMFS 2005, and NPFMC and NMFS 2010). EFH descriptions include both text (Section 4.2.2.2) and maps (Section 4.2.2.3 and Appendix E), if information is available for a species' particular life stage. These descriptions are risk averse, supported by scientific rationale, and account~~s~~ for changing oceanographic conditions, regime shifts, and the seasonality of migrating fish stocks.

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

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

Table 4-13 Levels of essential fish habitat information currently available for GOA groundfish, by life history stage.

Species	Eggs	Larvae	Early Juveniles	Late Juveniles	Adults
Walleye pollock	1	1	x	1	1
Pacific cod	1	1	x	1	1
Sablefish	1	1	x	1	1
Yellowfin sole	1	1	x	1	1
Northern rock sole	x	1	x	1	1
Southern rock sole	x	1	x	1	1
Alaska plaice	1	1	x	1	1
Dover sole	1	1	x	1	1
Rex sole	1	1	x	1	1
Arrowtooth flounder	x	1	x	1	1
Flathead sole	1	1	x	1	1
Pacific ocean perch	x	1	x	1	1
Northern rockfish	x	x	x	x	1
Shortraker rockfish	x	x	x	x	1
Blackspotted/rougheye rockfish	x	x	x	x	1
Dusky rockfish	x	1	x	x	1
Yelloweye rockfish	x	1	1	1	1
Thornyhead rockfish	x	1	1	1	1
Atka mackerel	1	1	x	x	1
Skates	X	x	x	x	1
Octopuses	x	x	x	x	x
Sharks	x	x	x	x	x
Sculpins	x	x	x	1	1
Squids	x	x	x	1	1
Forage fish complex	x	x	x	x	x

Juveniles were subdivided into early and late juvenile stages based on survey selectivity curves.

Note: "1" indicates general distribution data are available for some or all portions of the geographic range of the species; "x" indicates insufficient information is available to describe EFH.

4. In Section 4.2.2.2.1, make the following edits to the early juvenile, late juvenile, and adult descriptions for pollock:

Early Juveniles: No EFH d~~D~~escription d~~D~~etermined. ~~Limited information exists to describe walleye pollock early juvenile larval general distribution; however, the data cannot be analyzed in the same manner as directed by the approach for Alternative 3.~~ Information is insufficient due to these ages (primarily age 2) being unavailable to bottom-trawl survey gear and partially available to echo-integrated mid-water trawl surveys.

Late Juveniles: EFH for late juvenile walleye pollock is the general distribution area for this life stage, located in the lower and middle portion of the water column along the inner (0 to 50 m), middle (50 to 100 m), and outer (100 to 200 m) shelf throughout the GOA, as depicted in Figure E-3. ~~No known preference for~~ ~~s~~Substrate preferences, if they exist, are unknown.

Adults: EFH for adult walleye pollock is the general distribution area for this life stage, located in the lower and middle portion of the water column along the entire shelf (~10 to 200

m) and slope (200 to 1,000 m) throughout the GOA, as depicted in Figure E-3. ~~No known preference for substrates exist.~~ Substrate preferences, if they exist, are unknown.

5. In Section 4.2.2.2.3, replace references to "Figure E-26", "Figure E-27", and "Figure E-28" with "Figure E-7", "Figure E-8", and "Figure E-9", respectively. Make the following edits to the early juvenile description for sablefish:

Early Juveniles: No EFH d~~D~~escription d~~D~~etermined. ~~Insufficient information is available.~~ Generally, have been observed in inshore water, bays, and passes, and on shallow shelf pelagic and demersal habitat. Information is limited.

6. In Section 4.2.2.2.4, Yellowfin Sole, replace references to "Figure E-7", "Figure E-8", and "Figure E-9" with "Figure E-10", "Figure E-11", and "Figure E-12", respectively.

7. In Section 4.2.2.2.5, change the title from "Rock Sole" to "Northern Rock Sole". Make the following edits to the larvae, late juvenile, and adult descriptions for northern rock sole:

Larvae: EFH for larval northern rock sole is the general distribution area for this life stage, located in pelagic waters along the entire shelf (0 to 200 m) and upper slope (200 to 1,000 m) throughout the GOA, as depicted in Figure E-~~12~~13.

Late Juveniles: EFH for late juvenile northern rock sole is the general distribution area for this life stage, located in the lower portion of the water column along the inner (0 to 50 m), middle (50 to 100 m), and outer (100 to 200 m) shelf throughout the GOA~~BSAI~~ wherever there are softer substrates consisting of sand, gravel, and cobble, as depicted in Figure E-~~13~~14.

Adults: EFH for adult northern rock sole is the general distribution area for this life stage, located in the lower portion of the water column along the inner (0 to 50 m), middle (50 to 100 m), and outer (100 to 200 m) shelf throughout the GOA wherever there are softer substrates consisting of sand, gravel, and cobble, as depicted in Figure E-~~13~~14.

8. In Section 4.2.2.2.6, Alaska Plaice, replace references to "Figure E-14", "Figure E-15", and "Figure E-16" with "Figure E-16", "Figure E-17", and "Figure E-18", respectively.

9. In Section 4.2.2.2.7, Rex Sole, replace references to "Figure E-17", "Figure E-18", and "Figure E-19" with "Figure E-19", "Figure E-20", and "Figure E-21", respectively.

10. In Section 4.2.2.2.8, Dover Sole, replace references to "Figure E-20", "Figure E-21", and "Figure E-22" with "Figure E-22", "Figure E-23", and "Figure E-24", respectively.

11. In Section 4.2.2.2.9, Flathead Sole, replace references to "Figure E-23", "Figure E-24", and "Figure E-25" with "Figure E-25", "Figure E-26", and "Figure E-27", respectively.

12. In Section 4.2.2.2.10, Arrowtooth Flounder, replace references to "Figure E-10" and "Figure E-11" with "Figure E-28" and "Figure E-29", respectively.

13. In Section 4.2.2.2.11, Pacific Ocean perch and "Other Slope" Rockfish, replace references to "Figure E-29" and "Figure E-30" with "Figure E-30" and "Figure E-31", respectively.

14. In Section 4.2.2.2.12, Northern rockfish, make the following edits to the egg, larvae, and adult descriptions for northern rockfish:

Eggs: ~~No EFH Description Determined. Insufficient information is available.~~ Eggs develop internally, so EFH description is not applicable.

Larvae: No EFH description determined. Insufficient information is available. ~~EFH for larval northern rockfish is the general distribution area for this life stage, located in pelagic waters along the entire shelf (0 to 200 m) and slope (200 to 3,000 m) throughout the GOA, as depicted in Figure E-29, General Distribution of Rockfish Larvae.~~

Adults: EFH for adult northern rockfish is the general distribution area for this life stage, located in the ~~middle and~~ lower portions of the water column along the outer continental shelf~~slope~~ (75~~100~~ to 200 m) and upper slope (200 to 3~~5~~00 m) in the central and western ~~throughout the~~ GOA wherever there are substrates of cobble and rock, as depicted in Figure E-32.

15. In Section 4.2.2.2.13, retitle the section as "Shortraker Rockfish", make the following edits to the egg, larvae, and adult descriptions:

Eggs: ~~No EFH Description Determined. Insufficient information is available.~~ Eggs develop internally, so EFH description is not applicable.

Larvae: No EFH description determined. Insufficient information is available. ~~EFH for larval shortraker and rougheye rockfish is the general distribution area for this life stage, located in pelagic waters along the entire shelf (0 to 200 m) and slope (200 to 3,000 m) throughout the GOA, as depicted in Figure E-29, General Distribution of Rockfish Larvae.~~

Adults: EFH for adult shortraker ~~and rougheye~~ rockfish is the general distribution area for this life stage, located in the lower portion of the water column along the ~~outer shelf (100 to 200 m) and~~ upper slope (200 to 500 m) region~~s~~ throughout the GOA wherever there are substrates consisting of mud, sand, sandy mud, muddy sand, rock, cobble, and gravel, as depicted in Figure E-~~26~~33. Adults are especially found on steep slopes with frequent boulders.

16. In Section 4.2.2.2.14, Dusky Rockfish, replace references to "Figure E-29" with "Figure E-30".

17. In Section 4.2.2.2.15, Yelloweye Rockfish, replace references to "Figure E-29" and "Figure E-34" with "Figure E-30" and "Figure E-36", respectively. Replace the existing early juvenile description with the following:

Early Juveniles: EFH for early juvenile yelloweye rockfish is the general distribution area for this life stage, located in the lower portion of the water column within bays and island passages and along the inner (0to 50 m), middle (50 to 100 m), and outer shelf (100 to 200 m) throughout the GOA wherever there are substrates of rock and in areas of vertical relief, such as crevices, overhangs, vertical walls, coral, and larger sponges, as depicted in Figure E-36.

18. In Section 4.2.2.2.16, Thornyhead Rockfish, replace references to "Figure E-29" and "Figure E-33" with "Figure E-30" and "Figure E-37", respectively. Replace the existing early juvenile description with the following:

Early Juveniles: EFH for early juvenile thornyhead rockfish is the general distribution area for this life stage, located in pelagic waters along the entire shelf (0 to 200 m) and slope (200 to 3,000 m) throughout the GOA, as depicted in Figure E-30, General Distribution of Rockfish Larvae.

19. In Section 4.2.2.2.17, Atka Mackerel, replace reference to "Figure E-36" with "Figure E-39". Replace reference to "Figure E-37" with "Figure E-40". Replace the existing egg description for Atka mackerel with the following:

Eggs: Several nesting sites in the GOA have been identified. There are general distribution data available, but it is not complete for the entire GOA, as depicted in Figure E-38.

20. In Section 4.2.2.2.18, Skates, replace reference to "Figure E-39" with "Figure E-41".

21. In Section 4.2.2.2.19, Squid, replace references to "Figure E-40" with "Figure E-42".

22. In Section 4.2.2.2.20, Sculpins, replace references to "Figure E-38" with "Figure E-43".

23. Insert a new section after Section 4.2.2.2.5 "Northern Rock Sole", titled Section 4.2.2.2.6 "Southern Rock Sole", and renumber all subsequent subsections up to and including the subsection titled "Shortraker Rockfish". Insert the following text descriptions for the new Section 4.2.2.2.6:

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

Larvae: EFH for larval southern rock sole is the general distribution area for this life stage, located in pelagic waters along the entire shelf (0 to 200 m) and upper slope (200 to 1,000 m) throughout the GOA, as depicted in Figure E-13.

Early Juveniles: No EFH description determined. Insufficient information is available; settlement patterns are unknown.

Late Juveniles: EFH for late juvenile southern rock sole is the general distribution area for this life stage, located in the lower portion of the water column along the inner (0 to 50 m), middle (50 to 100 m), and outer (100 to 200 m) shelf throughout the GOA wherever there are softer substrates consisting of sand, gravel, and cobble, as depicted in Figure E-15.

Adults: EFH for adult southern rock sole is the general distribution area for this life stage, located in the lower portion of the water column along the inner (0 to 50 m), middle (50 to 100 m), and outer (100 to 200 m) shelf throughout the GOA wherever there are softer substrates consisting of sand, gravel, and cobble, as depicted in Figure E-15.

24. Insert a new subsection in Section 4.2.2.2, to follow the subsection titled "Shortraker Rockfish", titled "Rougheye and Blackspotted Rockfish", and number it and renumber all subsequent subsections in 4.2.2.2 accordingly. Insert the following text descriptions for the new subsection:

Eggs: Eggs develop internally, so this category is not applicable.

Larvae: No EFH description determined. Insufficient information is available. The larval stage is pelagic, but larval studies are hindered because the larvae at present can only be positively identified by genetic analysis, which is expensive and labor-intensive.

Early Juveniles: No EFH description determined. Insufficient information is available. The post-larvae and early young-of-the-year stages also appear to be pelagic. Genetic techniques have been used recently to identify a few post-larval rougheye rockfish from samples collected in epipelagic waters far offshore in the GOA. This is the only documentation of habitat preference for this life stage.

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

Adults: EFH for adult rougheye and blackspotted rockfish is the general distribution area for this life stage, located in the lower portion of the water column along the outer shelf (100 to 200 m) and upper slope (200 to 500 m) regions throughout the GOA wherever there are substrates consisting of mud, sand, sandy mud, muddy sand, rock, cobble, and gravel, as depicted in Figure E-34.

25. In Section 4.2.2.3, make the following edit to the existing text:

Figures E-1 through E-~~40~~43 in Appendix E show EFH distribution for the GOA groundfish species.

26. In Section 4.2.3, delete the second paragraph and associated bullets, as follows:

~~HAPCs are those areas of special importance that may require additional protection from adverse effects. Regulations at 50 CFR 600.815(a)(8) provide the following:~~

> ~~FMPs should identify specific types or areas of habitat within EFH as habitat areas of particular concern based on one or more of the following considerations:~~
>
> ~~(i) The importance of the ecological function provided by the habitat.~~
>
> ~~(ii) The extent to which the habitat is sensitive to human-induced environmental degradation.~~
>
> ~~(iii) Whether, and to what extent, development activities are, or will be, stressing the habitat type.~~
>
> ~~(iv) The rarity of the habitat type.~~

27. In Section 4.2.3.1, revise the existing final two paragraphs, as follows:

The Council will initiate the HAPC process by setting priorities and issuing a request for HAPC proposals. Any member of the public may submit a HAPC proposal. HAPC proposals may be solicited every ~~3 years or on a schedule established by the Council~~ 5 years, to coincide with the EFH 5-year review, or may be initiated at any time by the Council. The Council will establish a process to review the proposals. The Council may periodically review existing HAPCs for efficacy and considerations based on new scientific research.

~~Criteria to evaluate the HAPC proposals will be reviewed by the Council and the Scientific and Statistical Committee prior to the request for proposals. The Council will establish a process to review the proposals and may establish HAPCs and conservation measures (NPFMC 2005).~~

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

In 2009–2010, the Council undertook a 5-year review of EFH for the Council's managed species, which was documented in the Final EFH 5-year Review Summary Report published in April 2010 (NPFMC and NMFS 2010). The review evaluated new information on EFH, including EFH descriptions and identification, and fishing and non-fishing activities that may adversely affect EFH. The review also assessed information gaps and research needs, and identified whether any revisions to EFH are needed or suggested. The Council identified various elements of the EFH descriptions meriting revision, and approved omnibus amendments 98/90/40/15/11 to the BSAI Groundfish FMP, the GOA Groundfish FMP, the BSAI King and Tanner Crab FMP, the Scallop FMP, and the Salmon FMP, respectively, in 2011.

29. In Section 6.3, insert the following reference for NPFMC and NMFS 2010 alphabetically, and delete reference for NPFMC 2005 (in strikeout).

NPFMC and NMFS. 2010. Essential Fish Habitat (EFH) 5-year Review for 2010 Summary Report: Final. April 2010. http://www.alaskafisheries.noaa.gov/habitat/efh/review.htm

~~NPFMC. 2005. Environmental Assessment/Regulatory Impact Review/Regulatory Flexibility Analysis for Amendments 65/65/12/7/8 to the BSAI Groundfish FMP (#65), GOA Groundfish FMP (#65), BSAI Crab FMP (#12), Scallop FMP (#7) and the Salmon FMP (# 8) and regulatory amendments to provide Habitat Areas of Particular Concern. March 2005. NPFMC 605 West 4th St. Ste. 306, Anchorage, AK 99501-2252. 248pp.~~

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

Amendment 90, implemented on _____ *(insert effective date)*_____, revised Amendment 73:

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

Amendment 88 implemented on October 24, 2011, replaced Amendment 68:
Implemented the Central Gulf of Alaska Rockfish Program. This program allocates quota share to LLP licenses for rockfish primary and secondary species based on legal landings associated with that LLP during particular qualifying years. Primary rockfish species are northern rockfish, Pacific ocean perch, and pelagic shelf rockfish. Secondary rockfish species are Pacific cod, rougheye rockfish, shortraker rockfish, sablefish, and thornyhead rockfish.

31. In Appendix D, delete existing text and tables, and replace with revised life history text and tables in attached file. Update date in footer.

32. In Appendix E, delete existing text and figures, and replace with revised maps of essential fish habitat text and Figures E-1 to E-43 in attached file. Update date in footer.

33. In Appendix F, Section F.1.5.3, Sablefish, revise the final paragraph as follows :

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~~ 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.

34. In Appendix F, Section F.1.5.4, Atka Mackerel, replace "dependance" with "dependence" in the first full paragraph, and revise the final paragraph as follows :

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~~ relatively high level. The stock has produced several years of above average recruitment since 1977, and recent recruitment has been strong.

35. In Appendix F, Section F.1.5.7, Arrowtooth Flounder, revise the two existing paragraphs as follows :

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~~ and Wildebuer 2009). 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 et al. 2010b~~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.

36. In Appendix F, Section F.1.5.11, change the title from "Shortraker and Rougheye Rockfish (GOA)" to "Shortraker Rockfish (GOA)", and revise the existing paragraph as follows :

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~~ shortraker rockfish, 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 the long term effect index (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 adult shortraker ~~and rougheye~~ rockfish appears to be negligible, as their major food items ~~of these fish~~ are relatively small and ~~semi~~ some may be bathypelagic; therefore, these items are generally not retained in large amounts by demersal fishing gear.

37. In Appendix F, Section F.1.5.12, Northern Rockfish, revise the final paragraph as follows:

Summary of Effects—Although northern rockfish may eat a small amount of ~~some~~ epifaunal prey, such as polychaetes~~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.

38. In Appendix F, Section F.1.5.15.5, change the title from "GOA octopi (5 or more species)" to "GOA octopuses (7 or more species)", and revise the existing paragraph as follows:

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 octopus~~i~~. Octopuses~~i~~ 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 octopus~~i~~ distributions are insufficient to allow comparison with fishing effects.

39. Insert a new section after Section F.1.5.11 "Shortraker Rockfish", titled Section F.1.5.12 "Rougheye and Blackspotted Rockfish", and renumber all subsequent subsections in F.1.5 accordingly. Insert the following text descriptions for the new Section F.1.5.12:

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 rougheye and blackspotted rockfish in the GOA are unknown. 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 rougheye and blackspotted rockfish is very limited. However, adults inhabit areas subject to bottom trawling, as do juveniles of rougheye and blackspotted rockfish, so fishing may be affecting the habitat of these fish. Of particular concern is the observed association of adult rougheye and blackspotted rockfish with corals such as *Primnoa* spp. 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 rougheye and blackspotted rockfish, damage to corals by fishing gear may have a negative impact on these fish. The habitat requirements of juvenile rougheye and blackspotted 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 rougheye and blackspotted rockfish appears to be negligible, as their major food items are relatively small and some may be bathypelagic; therefore; these items are generally not retained in large amounts by fishing gear.

40. In Appendix F, Section F.1.6.1, add a new paragraph to the end of the section, as follows:

The evaluation of fishing effects on EFH for GOA groundfish species was reconsidered as part of the Council's EFH 5-year Review for 2010, and is documented in the Final Summary Report for that review (NPFMC and NMFS 2010). The review evaluated new information since the development of the EFH EIS, for individual species and their habitat needs, as well as the distribution of fishing intensity, spatial habitat classifications, classification of habitat features, habitat- and feature-specific recovery rates, and gear- and habitat-specific sensitivity of habitat features. Based on the review, the Council concluded that recent research results are consistent with the habitat sensitivity and recovery parameters and distributions of habitat types used in the analysis of fishing effects documented in the EFH EIS. The review noted that fishing intensity has decreased overall, gear regulations have been designated to reduce habitat damage, and area closures have limited the expansion of effort into areas of concern.

41. In Appendix F, Section F.1.6.2.1, References, add the following references in alphabetical order, and delete references that are marked below in strikeout:

NPFMC and NMFS. 2010. Essential Fish Habitat (EFH) 5-year Review for 2010 Summary Report: Final. April 2010. http://www.alaskafisheries.noaa.gov/habitat/efh/review.htm.

Turnock, B.J. and T.K. Wilderbuer. 2009. Arrowtooth flounder. *In* Appendix B Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Gulf of Alaska. North Pacific Fishery Management Council, 605 West 4th Ave., Suite 306, Anchorage, AK 99501. Pp. 627-680.

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

~~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.~~

~~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.~~

42. In Appendix F, delete existing text in Section F.2 Non-fishing Impacts, and replace with the revised Section F.2 in the attached file.

43. In Appendix H, Section H.4.1, delete existing text under the heading "Objectives" and replace with the following:

Establish a scientific research and monitoring program to understand the degree to which impacts have been reduced within habitat closure areas, and to understand how benthic habitat recovery of key species is occurring.

44. In Appendix H, Section H.4.3, delete existing text under the heading "Research Activities" and replace with the following:

- Fishing effort data from observers and remote sensing would be used to study changes in bottom trawl and other fishing gear activity in the closed (and open) areas. Effects of displaced fishing effort would have to be considered. The basis of comparison would be changes in the structure and function of benthic communities and populations, as well as important physical features of the seabed, after comparable harvests of target species are taken with each gear type.
- Monitor the structure and function of benthic communities and populations in the newly closed areas, as well as important physical features of the seabed, for changes that may indicate recovery of benthic habitat. Whether these changes constitute recovery from fishing or just natural variability/shifts requires comparison with an area that is undisturbed by fishing and otherwise comparable.
- Validate the LEI model and improve estimates of recovery rates, particularly for the more sensitive habitats, including coral and sponge habitats in the Aleutian Islands region, possibly addressed through comparisons of benthic communities in trawled and untrawled areas.
- Obtain high resolution mapping of benthic habitats, particularly in the on-shelf regions of the Aleutian Islands.
- Time series of maturity at age should be collected to facilitate the assessment of whether habitat conditions are suitable for growth to maturity.
- In the case of red king crab spawning habitat in southern Bristol Bay, research the current impacts of trawling on habitat in spawning areas and the relationship of female crab distribution with respect to bottom temperature.

45. Update the Table of Contents for the main document.

46. Update the Table of Contents for the appendices.

47. In alphabetical order, add "LEI" to the list of acronyms used in the FMP (page ix), with the definition "long-term effect index".

Life History Features and Habitat Requirements of Fishery Management Plan Species

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

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

Location

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

Water column

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

General

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

Bottom Type

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

Oceanographic Features

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

Table 0.1 Summary of habitat associations for groundfish of the GOA.

GOA Groundfish Species	LIFE STAGE	Nearshore				Shelf			Slope						Stratum Reference						
						Inner	Middle	Outer	Upper		Inter-mediate		Lower	Basin							
		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
Walleye Pollock	M						x	x	x	x				x		x	x	x	x	x	x
	J					x	x	x								x	x	x	x	x	x
	L						x	x								x	x	x	x	x	x
	E						x	x	x	x	x	x	x	x		x	x	x	x	x	x
Pacific Cod	M					x	x	x	x	x					x	x	x	x	x	x	
	LJ					x	x								x	x	x	x	x	x	
	EJ				x	x									x		x				
	L					x	x	x													
	E					x	x	x													
Sablefish	M								x	x	x	x	x				x				x
	LJ							x	x	x	x						x				x
	EJ					x	x	x							x		x				
	L						x	x	x	x	x	x	x	x							
	E								x	x	x	x	x	x							
Yellowfin Sole	M					x	x														
	LJ					x	x														
	EJ					x															
	L					x	x														
	E					x	x														
Northern Rock Sole	M					x	x	x													
	LJ					x	x														
	EJ					x															
	L					x	x	x													
	E					x	x	x													
Southern Rock Sole	M					x	x	x													
	LJ					x	x														
	EJ					x															
	L					x	x	x													
	E					x	x	x													
Alaska Plaice	M					x	x	x													
	LJ					x	x	x													
	EJ					x	x														
	L					x	x	x													
	E					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												

GOA Groundfish Species	LIFE STAGE	Location				Pelagic			Physical Oceanography					Substrate												
		Surafce	Near surface	Semi-demersal	Demersal	1-200m (epi)	201-1000m (meso)	>1000m (bathy)	Upwelling areas	Gyres	Thermo/pycnocline	Fronts	Edges (ice, bath)	Organic Debris	Mud	Sand	Gravel	Mud & sand	Mud & gravel	Sand & mud	Gravel & mud	Gravel & sand	Gravel & sand & mud	Gravel & mud & sand	Cobble	Rock
Walleye Pollock	M		x	x	x	x	x		x	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	
	J		x	x	x	x			x	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	
	L		x	x	x	x			x	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	
	E		x	x		x			x	x	x	x														
Pacific Cod	M				x										x	x	x	x	x	x	x	x	x	x	x	x
	LJ				x										x	x	x	x	x	x	x	x	x	x	x	x
	EJ			x	x										x	x	x	x	x	x	x	x	x	x		
	L					x																				
	E				x										x	x	x	x	x	x	x	x	x	x	x	x
Sablefish	M				x				x						x	x	x								x	x
	LJ				x				x						x	x	x								x	x
	EJ		x	x	x	x	x		x																	
	L	x	x						x																	
	E					x	x		x																	
Yellowfin Sole	M				x										x	x				x						
	LJ				x										x	x				x						
	EJ				x										x	x				x						
	L					x																				
	E					x																				
Northern Rock Sole	M				x										x	x				x						
	LJ				x										x	x				x						
	EJ				x										x	x				x						
	L					x					x															
	E				x																					
Southern Rock Sole	M				x										x	x				x						
	LJ				x										x	x				x						
	EJ				x										x	x				x						
	L					x					x															
	E				x																					
Alaska Plaice	M				x										x	x				x						
	LJ				x										x	x				x						
	EJ				x										x	x				x						
	L					x					x															
	E					x																				
Rex Sole	M				x										x	x				x						
	LJ				x										x	x				x						
	EJ				x										x	x				x						
	L					x									x	x										
	E					x																				

GOA Groundfish Species	LIFE STAGE	Structure										Community Associations												Oceanographic Properties			LIFE STAGE
		Bars	Sinks	Slumps\Rockfalls\Debris	Channels	Ledges	Pinnacles	Seamount	Reefs	Vertical Walls	Man-made	Algal Cover	Anenomes	Enchinoderms	Soft Coral	Hard Coral	Mollusca	Drift Algae\Kelp	Kelp	Polychaetes	Sea Grasses	Sea Onions	Tunicates	Temperature (Celsius)	Salinity (ppt)	Oxygen Conc (ppm)	
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
Sablefish	M							x																			M
	LJ																										LJ
	EJ																										EJ
	L																										L
	E																										E
Yellowfin Sole	M																										M
	LJ																										LJ
	EJ																										EJ
	L																										L
	E																										E
Northern Rock Sole	M																										M
	LJ																										LJ
	EJ																										EJ
	L																										L
	E																										E
Southern Rock Sole	M																										M
	LJ																										LJ
	EJ																										EJ
	L																										L
	E																										E
Alaska Plaice	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 (continued) Summary of habitat associations for groundfish of the GOA.

GOA Groundfish Species	LIFE STAGE	Nearshore				Shelf			Slope						Stratum Reference						
						Inner	Middle	Outer	Upper		Inter-mediate		Lower	Basin							
		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
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											
Flathead Sole	M					x	x	x	x												
	LJ					x	x	x													
	EJ					x	x														
	L					x	x	x													
	E					x	x	x													
Arrowtooth Flounder	M					x	x	x	x	x	x										
	LJ					x	x	x													
	EJ					x	x														
	L					x	x	x	x	x											
	E					x	x	x	x	x											
Pacific Ocean Perch	M							x	x	x								x	x	x	x
	LJ					x	x	x	x												
	EJ					x	x	x													
	L																				
Northern Rockfish	M						x	x										x			
	LJ						x	x										x	x		
	EJ																				
	L																				
Shortraker Rockfish	M								x	x										x	
	LJ																				
	EJ												x	x							
	L																				
Rougheye/ Blackspotted Rockfish	M								x	x								x	x	x	x
	LJ							x	x								x		x		
	EJ												x	x							
	L																				
Dusky Rockfish	M							x	x									x		x	x
	LJ						x	x										x		x	
	EJ																				
	L																				
Yelloweye Rockfish	M					x	x	x	x	x						x	x				
	LJ					x	x	x								x	x				
	EJ					x	x	x								x	x				
	L					x	x														
	E																				
Thornyhead Rockfish	M								x	x	x	x	x								
	LJ						x	x	x												
	EJ																				
	L																				
	E																				

GOA Groundfish Species	LIFE STAGE	Location				Pelagic			Physical Oceanography					Substrate												
		Surafce	Near surface	Semi-demersal	Demersal	1-200m (epi)	201-1000m (meso)	>1000m (bathy)	Upwelling areas	Gyres	Thermo/pycnocline	Fronts	Edges (ice, bath)	Organic Debris	Mud	Sand	Gravel	Mud & sand	Mud & gravel	Sand & mud	Gravel & mud	Gravel & sand	Gravel & sand & mud	Gravel & mud & sand	Cobble	Rock
Dover Sole	M				x										x	x			x							
	LJ				x										x	x			x							
	EJ				x										x	x			x							
	L					x					x															
	E					x																				
Flathead Sole	M				x										x	x	x			x		x				
	LJ				x										x	x	x			x		x				
	EJ				x										x	x										
	L					x					x									x						
	E					x																				
Arrowtooth Flounder	M				x										x	x	x			x						
	LJ				x										x	x	x			x						
	EJ				x										x	x	x			x						
	L					x					x															
	E				x																					
Pacific Ocean Perch	M			x	x	x			x					x	x	x	x	x	x	x	x	x	x	x	x	x
	LJ								x																x	x
	EJ			x	x	x	x	x	x								x								x	x
	L		x	x		x	x		x																	
Northern Rockfish	M				x																				x	x
	LJ				x																					
	EJ					x																				
	L																									
Shortraker Rockfish	M				x								x		x	x	x	x	x	x	x	x	x	x	x	x
	LJ				x																					
	EJ		x																							
	L					x																				
Rougheye/ Blackspotted Rockfish	M				x										x	x	x	x	x	x	x	x	x	x	x	x
	LJ																								x	x
	EJ		x	x		x																				
	L		x			x																				
Dusky Rockfish	M				x												x								x	x
	LJ				x																					
	EJ																									
	L																									
Yelloweye Rockfish	M				x				x							x									x	x
	LJ				x				x																	x
	EJ				x				x																	x
	L			x	x	x			x																	x
	E																									
Thornyhead Rockfish	M				x										x		x								x	x
	LJ				x										x		x									x
	EJ					x																				
	L					x																				
	E					x																				

GOA Groundfish Species	LIFE STAGE	Structure										Community Associations												Oceanographic Properties			LIFE STAGE
		Bars	Sinks	Slumps\Rockfalls\Debris	Channels	Ledges	Pinnacles	Seamount	Reefs	Vertical Walls	Man-made	Algal Cover	Anenomes	Enchinoderms	Soft Coral	Hard Coral	Mollusca	Drift Algae\Kelp	Kelp	Polychaetes	Sea Grasses	Sea Onions	Tunicates	Temperature (Celsius)	Salinity (ppt)	Oxygen Conc (ppm)	
Dover Sole	M																										M
	LJ																										LJ
	EJ																										EJ
	L																										L
	E																										E
Flathead Sole	M																										M
	LJ																										LJ
	EJ																										EJ
	L																										L
	E																										E
Arrowtooth Flounder	M																										M
	LJ																										LJ
	EJ																										EJ
	L																										L
	E																										E
Pacific Ocean Perch	M														x												M
	LJ																										LJ
	EJ																										EJ
	L																										L
Northern Rockfish	M																										M
	LJ																										LJ
	EJ																										EJ
	L																										L
Shortraker Rockfish	M							x								x											M
	LJ																										LJ
	EJ																										EJ
	L																										L
Rougheye/ Blackspotted Rockfish	M							x								x											M
	LJ																										LJ
	EJ																										EJ
	L																										L
Dusky Rockfish	M																										M
	LJ															x											LJ
	EJ																										EJ
	L																										L
Yelloweye Rockfish	M					x	x			x			x		x												M
	LJ					x	x			x			x		x												LJ
	EJ					x	x			x			x		x												EJ
	L					x	x			x																	L
	E																										E
Thornyhead Rockfish	M							x																			M
	LJ																										LJ
	EJ																										EJ
	L																										L
	E																										E

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

GOA Groundfish Species	LIFE STAGE	Nearshore: Freshwater	Nearshore: Estuarine	Nearshore: Intertidal	Nearshore: Subtidal	Shelf Inner: 1-50m	Shelf Middle: 51-100m	Shelf Outer: 101-200m	Slope Upper: 201-300m	Slope Inter-mediate: 301-500m	Slope Inter-mediate: 501-700m	Slope Inter-mediate: 701-1000m	Slope Lower: 1001-3000m	Slope Basin: >3000m	Stratum Reference: Shallows	Island Pass	Bay/Fjord	Bank	Flat	Edge	Gully
Atka Mackerel	M					x	x	x	x							x					
	J																				
	L																				
	E					x	x	x								x					
Skates	M			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	x	x	x	x	x	x	x	x	x	x	x
	LJ																				
	EJ																				
	L																				
	E																				
Sculpins	M			x	x	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x
	LJ																				
	EJ																				
	L																				
	E																				
Octopus	M			x	x	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x
	LJ																				
	EJ																				
	L																				
	E																				
Sharks	M			x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
	LJ																				
	EJ																				
	L																				
	E																				
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 Species	LIFE STAGE	Location: Surfce	Near surface	Semi-demersal	Demersal	Pelagic: 1-200m (epi)	Pelagic: 201-1000m (meso)	Pelagic: >1000m (bathy)	Physical Oceano-graphy: Upwelling areas	Gyres	Thermo/pycnocline	Fronts	Edges (ice, bath)	Substrate: Organic Debris	Mud	Sand	Gravel	Mud & sand	Mud & gravel	Sand & mud	Gravel & mud	Gravel & sand	Gravel & sand & mud	Gravel & mud & sand	Cobble	Rock
Atka Mackerel	M		x	x	x				x			x	x			x	x								x	x
	J	x	x																							
	L	x	x																							
	E				x												x								x	x
Skates	M			x	x																					
	LJ																									
	EJ																									
	L																									
	E																									
Squid	M	x	x	x	x	x	x	x																		
	LJ																									
	EJ																									
	L																									
	E																									
Sculpins	M			x	x																					
	LJ																									
	EJ																									
	L																									
	E																									
Octopus	M				x	x	x																			
	LJ																									
	EJ																									
	L																									
	E																									
Sharks	M	x	x	x	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 Species	LIFE STAGE	Structure: Bars	Sinks	Slumps\Rockfalls\Debris	Channels	Ledges	Pinnacles	Seamount	Reefs	Vertical Walls	Man-made	Community Associations: Algal Cover	Anenomes	Enchinoderms	Soft Coral	Hard Coral	Mollusca	Drift Algae\Kelp	Kelp	Polychaetes	Sea Grasses	Sea Onions	Tunicates	Oceano-graphic Properties: Temperature (Celsius)	Salinity (ppt)	Oxygen Conc (ppm)	LIFE STAGE
Atka Mackerel	M								x							x			x					3-5	>17		M
	J																							3-12			J
	L																							2-12			L
	E																		x					3-10			E
Skates	M																										M
	LJ																										LJ
	EJ																										EJ
	L																										L
	E																										E
Squid	M							x																			M
	LJ																										LJ
	EJ																										EJ
	L																										L
	E																										E
Sculpins	M							x																			M
	LJ																										LJ
	EJ																										EJ
	L																										L
	E																										E
Octopus	M																										M
	LJ																										LJ
	EJ																										EJ
	L																										L
	E																										E
Sharks	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 0.2 Summary of biological associations for GOA groundfish.

GOA Groundfish Species	Life Stage	Reproductive Traits: Age at Maturity (unless otherwise noted)				Fertilization/ Egg Development						Spawning Behavior						Spawning Season											
		Female		Male																									
		50%	100%	50%	100%	External	Internal	Oviparous	Ovoviviparous	Aplacental viviparous	Viviparous	Batch Spawner	Broadcast Spawner	Egg Case Deposition	Nest Builder	Egg/Young Guarder	Egg/Young Bearer	January	February	March	April	May	June	July	August	September	October	November	December
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							
Sablefish	M	65cm		67c		x							x					x	x	x									
Yellowfin Sole	M	10.5				x						x										x	x	x					
Northern Rock Sole	M	9				x						x						x	x	x									
Southern Rock Sole	M	9				x						x						x	x	x									
Alaska Plaice	M	6-7				x														x	x	x							x
Rex Sole	M	24cm		16cm		x													x	x	x	x	x	x					
Dover Sole	M	6.7	11			x						x							x	x	x	x							
Flathead Sole	M	8.7				x						x								x	x	x	x						
Arrowtooth Flounder	M	5		4		x												x	x	x	x							x	x
Pacific Ocean Perch	M	10.5	20.0				x				x	x							x	x	x	x	x	x	x				
Northern Rockfish	M	13					x				x	x																	
Shortraker Rockfish	M	20+					x				x	x												x	x	x	x	x	x
Rougheye/Blackspotted Rock	M	19+					x				x	x						x	x	x	x								
Dusky Rockfish	M	11					x				x	x																	
Yelloweye Rockfish	M	22		18			x		x												x	x	x	x					
Thornyhead Rockfish	M	21.5 cm							x			x									x	x	x	x					
Atka Mackerel	M	3.6		3.6		x						x			x	x							x	x	x	x	x		
Skates	M						x	x						x															
Squid	M						x					x																	
Sculpins	M					x										x													
Octopus	M						x					x			x	x													
Sharks	M	35		21			x	x	x	x	x			x			x	x	x	x						x	x	x	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 0.3 Summary of reproductive traits for GOA groundfish.

Predator to

GOA Groundfish Species	Life Stage	Algae	Plants	Plankton	Zooplankton	Diatoms	Sponges	Eusphausiid	Hydroids	Amphipoda	Copepods	Starfish	Polychaetes	Squid	Philodae (gunnels)	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																														
Sablefish	M							x	x	x	x		x	x				x		x		x	x		x	x		x	x	x	
	LJ							x	x	x	x		x	x				x		x		x	x		x	x		x	x	x	
	EJ							x		x	x		x	x	x			x		x			x					x			
	L				x						x																				
	E																														
Yellowfin Sole	M							x		x			x			x		x		x					x					x	
	LJ							x		x			x			x		x		x					x						
	EJ				x																										
	L	x		x																											
	E																														
Northern Rock Sole	M									x			x			x	x														
	LJ									x			x			x	x														
	EJ				x																										
	L	x		x																											
	E																														
Southern Rock Sole	M									x			x			x	x														
	LJ									x			x			x	x														
	EJ				x																										
	L	x		x																											
	E																														
Alaska Plaice	M									x			x																		
	LJ																														
	EJ																														
	L																														
	E																														
Rex Sole	M							x		x			x					x													
	LJ							x		x			x					x													
	EJ																														
	L	x		x																											
	E																														
Dover Sole	M												x						x												
	LJ												x						x												
	EJ																														
	L	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	Sperm whale	Eagles	Murres	Puffin	Kittiwake	Gull	Tererstrial 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																														
Sablefish	M																														
	LJ						x									x									x						
	EJ																														
	L																														
	E																														
Yellowfin Sole	M																														
	LJ								x							x															
	EJ								x							x															
	L																														
	E																														
Northern Rock Sole	M																														
	LJ							x	x					x		x															
	EJ																														
	L																														
	E																														
Southern Rock Sole	M																														
	LJ							x	x					x		x															
	EJ																														
	L																														
	E																														
Alaska Plaice	M																														
	LJ																														
	EJ																														
	L																														
	E																														
Rex Sole	M														x																
	LJ														x																
	EJ																														
	L																														
	E																														
Dover Sole	M							x								x															
	LJ							x								x															
	EJ																														
	L																														
	E																														

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

Predator to

GOA Groundfish Species	Life Stage	Algae	Plants	Plankton	Zooplankton	Diatoms	Sponges	Eusphausiid	Hydroids	Amphipoda	Copepods	Starfish	Polychaetes	Squid	Philodae (gunnels)	Bi-valves	Mollusks	Crustaceans	Ophiuroids (brittle stars)	Shrimps, mysidacae	Sand lance	Osmerid (eulachon)	Herring	Myctophid (lantern fishes	Cottidae (sculpins)	Arrowtooth	Rockfish	Salmon	Pacific cod	Pollock	Halibut
Flathead Sole	M							x		x	x		x			x	x	x	x		x	x								x	
	LJ							x		x	x		x			x	x	x	x											x	
	EJ				x								x			x			x											x	
	L	x		x																											
	E																														
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																														
Pacifc Ocean Perch	M							x		x	x									x											
	LJ							x		x	x									x											
	EJ																														
	L			x	x																										
Northern Rockfish	M				x			x			x																				
	LJ																														
	EJ																														
	L																														
Shortraker Rockfish	M													x						x				x							
	LJ																														
	EJ																														
	L																														
Rougheye/ Blackspotted Rockfish	M							x			x			x				x		x				x							
	LJ									x										x											
	EJ																														
	L																														
Dusky Rockfish	M							x																							
	LJ																														
	EJ																														
	L																														
Yelloweye Rockfish	M																	x		x	x		x				x				
	LJ																														
	EJ										x																				
	L																														
	E																														
Thornyhead Rockfish	M				x					x								x		x											
	LJ				x					x								x		x											
	EJ																														
	L																														
	E																														
Atka Mackerel	M							x			x													x							
	J							x			x																				
	L										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	Halibut	Salmon Shark	Northern Fur Seal	Harbor Seal	Steller sea lion	Dalls Porpoise	Beluga whale	Killer Whale	Minke whale	Sperm whale	Eagles	Murres	Puffin	Kittiwake	Gull	Terrerstrial Mammals
Flathead Sole	M								x				x		x	x															
	LJ																														
	EJ																														
	L																														
	E																														
Arrowtooth Flounder	M																														
	LJ							x	x																						
	EJ																														
	L																														
	E																														
Pacifc Ocean Perch	M									x						x															
	LJ									x						x															
	EJ						x			x	x					x															
	L																														
Northern Rockfish	M																														
	LJ																														
	EJ																														
	L																														
Shortraker Rockfish	M																														
	LJ																														
	EJ																														
	L																														
Rougheye/ Blackspotted Rockfish	M								x							x															
	LJ																														
	EJ																														
	L																														
Dusky Rockfish	M																														
	LJ																														
	EJ																														
	L																														
Yelloweye Rockfish	M						x			x	x					x															
	LJ						x			x	x					x															
	EJ																														
	L																														
	E																														
Thornyhead Rockfish	M														x																
	LJ														x																
	EJ																														
	L																														
	E																														
Atka Mackerel	M								x						x	x		x	x	x	x			x							
	J																	x		x							x	x			
	L																														
	E																														

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

Predator to

GOA Groundfish Species	Life Stage	Algae	Plants	Plankton	Zooplankton	Diatoms	Sponges	Eusphausiid	Hydroids	Amphipoda	Copepods	Starfish	Polychaetes	Squid	Philodae (gunnels)	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																														
Squid	M							x			x										x	x	x	x							
	LJ																														
	EJ																														
	L																														
	E																														
Sculpins	M				x			x	x	x	x	x	x		x	x	x	x	x	x	x	x	x		x	x			x	x	
	LJ																														
	EJ																														
	L																														
	E																														
Octopus	M															x	x	x	x	x	x				x		x		x		x
	LJ																														
	EJ																														
	L																														
	E																														
Sharks	M						x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	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	Halibut	Salmon Shark	Northern Fur Seal	Harbor Seal	Steller sea lion	Dalls Porpoise	Beluga whale	Killer Whale	Minke whale	Sperm whale	Eagles	Murres	Puffin	Kittiwake	Gull	Terrestrial Mammals
Skates	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																														
Sculpins	M							x	x		x	x	x		x	x	x	x	x	x	x										
	LJ																														
	EJ																														
	L																														
	E																														
Octopus	M							x	x	x	x					x	x	x	x	x		x									
	LJ																														
	EJ																														
	L																														
	E																														
Sharks	M									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 Fishery Management Plan for Groundfish of the Gulf of Alaska (FMP), and the eastern Bering Sea and Aleutian Islands pollock stocks are managed under the Fishery Management Plan for Groundfish of the Bering Sea and Aleutian Islands Management Area. Pollock occur throughout the area covered by the FMP and straddle into the Canadian and Russian Exclusive Economic Zone (EEZ), the U.S. EEZ, international waters of the central Bering Sea, and into the Chukchi Sea.

D.1.1 Life History and General Distribution

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

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

The most abundant stock of pollock is the eastern Bering Sea stock which is primarily distributed over the eastern Bering Sea outer continental shelf between approximately 70 m and 200 m. Information on pollock distribution in the eastern Bering Sea comes from commercial fishing locations, annual bottom trawl surveys, and regular (every two or three years) echo-integration mid-water trawl surveys.

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

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

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

Peak pollock spawning occurs on the southeastern Bering Sea and eastern Aleutian Islands along the outer continental shelf around mid-March. North of the Pribilof Islands spawning occurs later (April and May) in smaller spawning aggregations. The deep spawning pollock of the Aleutian Basin appear to spawn slightly earlier, late February and early March. In the GOA, peak spawning occurs in late March in Shelikof Strait. Peak spawning in the Shumagin area appears to be 2 to 3 weeks earlier than in Shelikof Strait.

Spawning occurs in the pelagic zone and eggs develop throughout the water column (70 to 80 m in the Bering Sea shelf, 150 to 200 m in Shelikof Strait). Development is dependent on water temperature. In the Bering Sea, eggs take about 17 to 20 days to develop at 4 °C in the Bogoslof area and 25.5 days at 2 °C on the shelf. In the GOA, development takes approximately 2 weeks at ambient temperature (5 °C). Larvae are also distributed in the upper water column. In the Bering Sea the larval period lasts approximately 60 days. The larvae eat progressively larger naupliar stages of copepods as they grow and then small euphausiids as they approach transformation to juveniles (approximately 25 mm standard length). In the GOA, larvae are distributed in the upper 40 m of the water column, and their diet is similar to Bering Sea larvae. Fisheries-Oceanography Coordinated Investigations survey data indicate larval pollock may utilize the stratified warmer upper waters of the mid-shelf to avoid predation by adult pollock, which reside in the colder bottom water.

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

Growth varies by area with the largest pollock occurring on the southeastern shelf. On the northwest shelf the growth rate is slower. A newly maturing pollock is around 40 centimeters (cm).

The upper size limit for juvenile pollock in the eastern Bering Sea 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 eastern Bering Sea pollock fishery has since 1990 been divided into two fishing periods: an “A season” occurring from January through March, and a “B season” occurring from June through October. The A season concentrates fishing effort on prespawning pollock in the southeastern Bering Sea. During the B season fishing is more dispersed with concentrations in the southeastern Bering Sea and extending north generally along the 200 m isobaths. During the B season the offshore fleet (catcher/processors and motherships) are required to fish north of 56° N. latitude while the area to the south is reserved for catcher vessels delivering to shoreside processing plants on Unalaska and Akutan Islands.

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 the unfished stock biomass estimate.

In the GOA approximately 90 percent of the pollock catch is taken using pelagic trawls. During winter, fishing effort usually is 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 to 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 eastern Bering Sea 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 to 8 and then 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. Under the 1999 American Fisheries Act (AFA), the pollock fishery became rationalized and effectively ended the “race for fish.” This generally slowed the pace of the fishery and also reduced the tendency to catch smaller pollock. A secondary problem is that strong to moderate year-classes may reside in the Russian EEZ adjacent to the U.S. 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 to 7 and then declines. In both the eastern Bering Sea 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 and pollock fisheries in the Bering Sea and 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 eastern Bering Sea 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; and
- Additional seasonal TAC releases to disperse the fishery over the year.

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 Aleutian Islands (1,001,780 square kilometer [km^2] inside the U.S. EEZ), the eastern Bering Sea (968,600 km^2), and the GOA (1,156,100 km^2). The marine portion of Steller sea lion critical habitat in Alaska west of 150º W. encompasses 386,770 km^2 of ocean surface, or 12 percent of the fishery management regions.

Prior to 1999, a total of 84,100 km^2, 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 km^2 or 13 percent of critical habitat). The remainder was largely management area 518 (35,180 km^2, or 9 percent of critical habitat), which was closed pursuant to an international agreement to protect spawning stocks of central Bering Sea pollock.

In 1999, an additional 83,080 km^2 (21 percent) of critical habitat in the Aleutian Islands was closed to pollock fishing along with 43,170 km^2 (11 percent) around sea lion haulouts in the GOA and eastern Bering Sea. Consequently, a total of 210,350 km^2 (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 eastern Bering Sea 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 eastern Bering Sea pollock fishery resulting from the Steller sea lion management measures from those resulting from implementation of the 1999 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 were expected to reduce the rate at which the catcher/processor sector (allocated 36 percent of the eastern Bering Sea 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 Steller sea lion critical habitat were realized by closing the entire Aleutian Islands 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 Steller sea lion critical habitat. In 1998, over 22,000 mt of pollock were caught in the Aleutian Island regions, with over 17,000 mt caught in Aleutian Islands 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 Bering Sea. Most of the pollock consumed by pollock are age 0 and 1 pollock, and recent research suggests that cannibalism can regulate year-class size. Weak year-classes appear to be those located within the range of adults, while strong year-classes are those that are transported to areas outside the range of adult abundance.

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

D.1.4 Habitat and Biological Associations

<u>Egg-Spawning:</u> 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.

<u>Larvae:</u> Pelagic outer to mid-shelf region in the Bering Sea. Pelagic throughout the continental shelf within the top 40 m in the GOA.

<u>Juveniles:</u> 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.

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

Habitat and Biological Associations: Walleye Pollock

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

D.1.5 Literature

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D.2 Pacific cod (*Gadus macrocephalus*)

D.2.1 Life History and General Distribution

Pacific cod is a transoceanic species, occurring at depths from shoreline to 500 m. The southern limit of the species’ distribution is about latitude 34° N. with a northern limit of about latitude 63° N. Adults are largely demersal and form aggregations during the peak spawning season, which extends approximately from January through May. Pacific cod eggs are demersal and adhesive. Eggs hatch in about 15 to 20 days. Little is known about the distribution of Pacific cod larvae, which undergo metamorphosis at about 25 to 35 mm. Juvenile Pacific cod start appearing in trawl surveys at a fairly small size, as small as 10 cm in the eastern Bering Sea. Pacific cod can grow to be more than 1 m in length, with weights in excess of 10 kilogram (kg). Natural mortality is currently estimated to be 0.34 in the BSAI and 0.38 in the GOA. Approximately 50 percent of Pacific cod are mature by age 5 in the BSAI and age 4 in the GOA . The maximum recorded age of a Pacific cod is 17 years in the BSAI and 14 years in the GOA.

The estimated size at 50 percent maturity is 58 cm in the BSAI and 50 cm in the GOA.

D.2.2 Fishery

The fishery is conducted with bottom trawl, longline, pot, and jig 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. Historically, bycatch of crab and halibut has sometimes caused 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 Shumagin Islands.

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 the bottom. Eggs sink to the bottom after fertilization and are somewhat adhesive. Optimal temperature for incubation is 3 to 6 °C, optimal salinity is 13 to 23 parts per thousand (ppt), and optimal oxygen concentration is from 2 to 3 ppm to saturation. Little is known about the optimal substrate type for egg incubation.

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

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 (euphausiids, mysids, 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	

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D.3 Sablefish (*Anoplopoma fimbria*)

D.3.1 Life History and General Distribution

Sablefish are distributed from Mexico through the GOA to the Aleutian Chain, Bering Sea, along the Asian coast from Sagami Bay, and along the Pacific sides of Honshu and Hokkaido Islands and the Kamchatka Peninsula. Adult sablefish occur along the continental slope, shelf gullies, and in deep fjords such as Prince William Sound and southeast Alaska, at depths generally greater than 200 m. Adults are assumed to be demersal. 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 Niño or eddies, but these phenomena could potentially influence recruitment indirectly in years following their occurrence (Sigler et al. 2001).

While pelagic oceanic conditions determine the egg, larval, and juvenile survival through their first summer, juvenile sablefish spend 3 to 4 years in demersal habitat along the shorelines and continental shelf before they recruit to their adult habitat, primarily along the upper continental slope, outer continental shelf, and deep gullies. As juveniles in the inshore waters and on the continental shelf, they are subject to a myriad of 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:

Bering Sea:	males 65 cm, females 67 cm
Aleutian Islands:	males 61 cm, females 65 cm
GOA:	males 57 cm, females 65 cm

At the end of the second summer (approximately 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 fisheries for other species, such as rockfish, where they are taken as allowed bycatch. Grenadier (*Albatrossia pectoralis* and *Coryphaenoides acrolepis*), and deeper dwelling rockfish, such as shortraker, rougheye, and thornyhead rockfish, are the primary bycatch in the longline sablefish fishery. Halibut 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. Pot fishing for sablefish has increased in the BSAI in recent years as a response to depredation of longline catches by killer whales.

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 continental slope and deep gullies, 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 Alaska Fisheries Science Center 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 nauplii to small amphipods. The epipelagic juveniles feed primarily on macrozooplankton and micronekton (i.e., euphausiids).

In their demersal stage, juvenile sablefish less than 60 cm feed primarily on euphausiids, shrimp, and cephalopods (Yang and Nelson 2000, Yang et al. 2006) while sablefish greater than 60 cm feed more on fish. Both juvenile and adult sablefish are considered opportunistic feeders. Fish most important to the sablefish diet include pollock, eulachon, capelin, Pacific herring, Pacific cod, Pacific sand lance, and some flatfish, with pollock being the most predominant (10 to 26 percent of prey weight, depending on year). Squid, euphausiids, pandalid shrimp, Tanner crabs, and jellyfish were also found, squid being the most important of the invertebrates (Yang and Nelson 2000, Yang et al. 2006). Feeding studies conducted in Oregon and California found that fish made up 76 percent of the diet (Laidig et al. 1997). Off the southwest coast of Vancouver Island, euphausiids dominated sablefish diet (Tanasichuk 1997). Among other groundfish in the GOA, the diet of sablefish overlaps mostly with that of large flatfish, arrowtooth flounder and Pacific halibut (Yang and Nelson 2000).

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

D.3.4 Habitat and Biological Associations

The estimated productivity and sustainable yield of the combined GOA, Bering Sea, and Aleutian Islands sablefish stock have declined steadily since the late 1970s. This is demonstrated by a decreasing trend in recruitment and subsequent estimates of biomass reference points and the inability of the stock to rebuild to the target biomass levels despite the decreasing level of the targets and fishing rates below the target fishing rate. While years of strong young-of-the-year survival has occurred in the 1980s and the 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.

Habitat and Biological Associations: Sablefish

Stage - EFH Level	Duration or Age	Diet/Prey	Season/ Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs	14 to 20 days	NA	late winter–early spring: Dec–Apr	USP, LSP, BSN	P, 200–3,000 m	NA	U	
Larvae	up to 3 months	copepod nauplii, small copepodites	spring–summer: Apr–July	MCS, OCS, USP, LSP, BSN	N, neustonic near surface	NA	U	
Early Juveniles	up to 3 years	small prey fish, sandlance, salmon, herring		OCS, MCS, ICS, during first summer, then observed in BAY and IP, until end of 2nd summer; not observed until found on shelf	P when offshore during first summer, then D, SD/SP when inshore	NA when pelagic. The bays where observed were soft bottomed, but not enough observed to assume typical.	U	
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	

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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 latitude 49° N.) to the Chukchi Sea (about latitude 70° N.) and south along the Asian coast to about latitude 35° N. off the South Korean coast in the Sea of Japan. Adults exhibit a benthic lifestyle and are consistently caught in shallow areas along the Alaska Peninsula and around Kodiak Island during resource assessment surveys in the GOA. From over-winter grounds near the shelf margins, adults begin a migration onto the inner shelf in April or early May each year for spawning and feeding. A protracted and variable spawning period may range from as early as late May through August occurring primarily in shallow water. Fecundity varies with size and was reported to range from 1.3 to 3.3 million eggs for fish 25 to 45 cm long. Larvae have primarily been captured in shallow shelf areas in the Kodiak Island area and have been measured at 2.2 to 5.5 mm in July and 2.5 to 12.3 mm in late August and early September in the Bering Sea. The age or size at metamorphosis is unknown. Juveniles are separate from the 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 classified as part of the shallow water flatfish management complex and are caught in bottom trawls directed at northern and southern rock sole and in pursuit of other bottom-dwelling species. Recruitment begins at about age 6 and they are fully selected at age 13.

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 typically nearshore in shallow shelf areas 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/zooplankton?	summer, autumn?	BAY, BCH,ICS	P			
Early Juveniles	to 5.5 years	polychaetes, bivalves, amphipods, echiurids	all year	BAY, ICS, OCS, MCS	D	S		
Late Juveniles	5.5 to 10 years	polychaetes, bivalves, amphipods, echiurids	all year	BAY, ICS, OCS, MCS, IP	D	S		
Adults	10+ years	polychaetes, bivalves, amphipods, echiurids	spawning/ feeding May–August non-spawning Nov–April	BAY, BCH, ICS, MCS, OCS, IP	D	S	ice edge	

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D.5 Northern rock sole (*Lepidopsetta polyxystra*)

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

D.5.1 Life History and General Distribution

Northern rock sole are distributed from Puget Sound through the BSAI to the Kuril Islands, overlapping with southern rock sole in the GOA (Orr and Matarese 2000). Centers of abundance occur off the Kamchatka Peninsula (Shubnikov and Lisovenko 1964), British Columbia (Forrester and Thompson 1969), the central GOA, and in the southeastern Bering Sea (Alton and Sample 1976). Adults exhibit a benthic lifestyle and, in the eastern Bering Sea, occupy separate winter (spawning) and summertime feeding distributions on the continental shelf. Northern rock sole spawn during the winter through early spring period of December through March. Soviet investigations in the early 1960s established two spawning concentrations: an eastern concentration north of Unimak Island at the mouth of Bristol Bay and a western concentration eastward of the Pribilof Islands between 55°30' and 55°0' N. and approximately 165°2' W. (Shubnikov and Lisovenko 1964). Northern rock sole spawning in the GOA has been found to occur at depths of 43 to 61 m (Stark and Somerton 2002). Spawning females deposit a mass of eggs that are demersal and adhesive (Alton and Sample 1976). Fertilization is believed to be external. Incubation time is temperature dependent and may range from 6.4 days at 11 ºC to about 25 days at 2.9 ºC (Forrester 1964). Newly hatched larvae are pelagic and have occurred sporadically in eastern Bering Sea plankton surveys (Waldron and Vinter 1978). Kamchatka larvae are reportedly 20 mm in length when they assume their side-swimming, bottom-dwelling form (Alton and Sample 1976, Orr and Matarese 2000). Forrester and Thompson (1969) report that by age 1, they are found with adults on the continental shelf during summer.

In the springtime, after spawning, northern rock sole begin actively feeding and exhibit a widespread distribution throughout the shallow waters of the continental shelf. This migration has been observed on both the eastern (Alton and Sample 1976) and western (Shvetsov 1978) areas of the Bering Sea and in the GOA. Summertime trawl surveys indicate most of the population can be found at depths from 50 to 100 m (Armistead and Nichol 1993). The movement from winter/spring to summer grounds is in response to warmer temperatures in the shallow waters and the distribution of prey on the shelf seafloor (Shvetsov 1978). In September, with the onset of cooling in the northern latitudes, northern rock sole begin the return migration to the deeper wintering grounds. Fecundity varies with size and was reported to be 450,000 eggs for fish 42 cm long. Larvae are pelagic, but their occurrence in plankton surveys in the eastern Bering Sea is rare (Musienko 1963). Juveniles are separate from the adult population, remaining in shallow areas until they reach age 1 (Forrester 1964). The estimated age of 50 percent maturity is 7 years for northern rock sole females (approximately 33 cm). The natural mortality rate is believed to range from 0.18 to 0.20 (Turnock et al. 2002).

D.5.2 Fishery

Northern 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 nearshore to the Kodiak Island area and along the Alaska peninsula. 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 eastern Bering Sea 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: Northern rock sole

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

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D.6 Southern rock sole (*Lepidopsetta bilineata*)

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

D.6.1 Life History and General Distribution

Southern rock sole are distributed from Baja California waters north into the GOA and the eastern Aleutian Islands. Centers of abundance occur off the Kamchatka Peninsula (Shubnikov and Lisovenko 1964), British Columbia (Forrester and Thompson 1969), the central GOA, and to a lesser extent in the extreme southeastern Bering Sea (Alton and Sample 1976, Orr and Matarese 2000). Adults exhibit a benthic lifestyle and occupy separate winter (spawning) and summertime feeding distributions on the continental shelf. Southern rock sole spawn during the summer in the GOA (Stark and Somerton 2002). Before they were identified as two separate species, Russian investigations in the early 1960s established two spawning concentrations: an eastern concentration north of Unimak Island at the mouth of Bristol Bay and a western concentration eastward of the Pribilof Islands between 55°30' and 55°0' N. and approximately 165°2' W. (Shubnikov and Lisovenko 1964). Southern rock sole spawning in the GOA was found to occur at depths of 35 and 120 m. Spawning females deposit a mass of eggs that are demersal and adhesive (Alton and Sample 1976). Fertilization is believed to be external. Incubation time is temperature dependent and may range from 6.4 days at 11 ºC to about 25 days at 2.9 ºC (Forrester 1964). Newly hatched larvae are pelagic (Waldron and Vinter 1978) and have been captured on all sides of Kodiak Island and along the Alaska Peninsula (Orr and Matarese 2000). Kamchatka larvae are reportedly 20 mm in length when they assume their side-swimming, bottom-dwelling form (Alton and Sample 1976) and have been present in nearshore juvenile sampling catches around Kodiak Island in September and October (Abookire et al. 2007). Forrester and Thompson (1969) report that age 1 fish are found with adults on the continental shelf during summer.

In the springtime southern rock sole begin actively feeding and commence a migration to the shallow waters of the continental shelf to spawn in summer. Summertime trawl surveys indicate most of the population can be found at depths from 50 to 100 m (Armistead and Nichol 1993). The movement from winter/spring to summer grounds may be a response to warmer temperatures in the shallow waters and the distribution of prey on the shelf seafloor (Shvetsov 1978). In September, with the onset of cooling in the northern latitudes, southern rock sole begin the return migration to the deeper wintering grounds. Fecundity varies with size and was reported to be 450,000 eggs for fish 42 cm long. Larvae are pelagic and settlement occurs in September and October. The age or size at metamorphosis is unknown. Juveniles are separate from the adult population, remaining in shallow areas until they reach age 1 (Forrester 1964). The estimated age of 50 percent maturity is 9 years for southern rock sole females at approximately 35 cm length (Stark and Somerton 2002). The natural mortality rate is believed to range from 0.18 to 0.20 (Turnock et al. 2002).

D.6.2 Fishery

Southern 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 on continental shelf areas proximate to Kodiak Island. They are caught as bycatch in Pacific cod, bottom pollock, and other shallow water flatfish species and are caught with these species and Pacific halibut in rock sole directed fisheries.

D.6.3 Relevant Trophic Information

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

D.6.4 Habitat and Biological Associations

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

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

Habitat and Biological Associations: Southern rock sole

Stage - EFH Level	Duration or Age	Diet/Prey	Season/ Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs		NA	summer	OCS	D			
Larvae	2 to 3 months?	U phyto/zooplankton?	summer	OCS, MCS, ICS	P			
Early Juveniles	to 3.5 years	polychaetes, bivalves, amphipods, misc. crustaceans	all year	BAY, ICS, OCS, MCS	D	S, G		
Late Juveniles	up to 9 years	polychaetes, bivalves, amphipods, misc. crustaceans	all year	BAY, ICS, OCS, MCS	D	S, G		
Adults	9+ years	polychaetes, bivalves, amphipods, misc. crustaceans	feeding May–September spawning June–August	MCS, ICS MCS, OCS	D	S, G	ice edge	

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D.7 Alaska plaice (*Pleuronectes quadrituberculatus*)

Alaska plaice are managed as part of the shallow water flatfish assemblage in the GOA.

D.7.1 Life History and General Distribution

Alaska plaice inhabit continental shelf waters of the North Pacific ranging from the GOA to the Bering and Chukchi Seas and in Asian waters as far south as Peter the Great Bay (Pertseva-Ostroumova 1961; Quast and Hall 1972). Adults exhibit a benthic lifestyle and live year round on the shelf and move seasonally within its limits (Fadeev 1965). Alaska plaice are caught in near shore areas along the Alaska Peninsula and Kodiak Island in summer resource assessment surveys. From over-winter grounds near the shelf margins, adults begin a migration onto the central and northern shelf of the eastern Bering Sea, primarily at depths of less than 100 m, although it is unknown if this behavior is also consistent with the GOA. Spawning usually occurs in March and April on hard sandy ground (Zhang 1987). The eggs and larvae are pelagic and transparent and have been found in ichthyoplankton sampling in late spring and early summer over a widespread area of the continental shelf, particularly in the Shelikof Strait area (Waldron and Favorite 1977).

Fecundity estimates (Fadeev 1965) indicate female fish produce an average of 56,000 eggs at lengths of 28 to 30 cm and 313,000 eggs at lengths of 48 to 50 cm. The age or size at metamorphosis is unknown. The estimated length of 50 percent maturity is 32 cm from collections made in March and 28 cm from April, which corresponds to an age of 6 to 7 years. Natural mortality rate estimates range from 0.19 to 0.22 (Wilderbuer and Zhang 1999).

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

D.7.2 Fishery

Alaska plaice are caught in bottom trawls, primarily in pursuit of other bottom-dwelling species such as flatfish of the shallow water group. Recruitment begins at about age 6, and they are fully selected at age 12.

D.7.3 Relevant Trophic Information

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

D.7.4 Habitat and Biological Associations

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

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

Habitat and Biological Associations: Alaska plaice

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

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D.8 Rex sole (*Glyptocephalus zachirus*)

D.8.1 Life History and General Distribution

Rex sole are distributed from Baja California to the Bering Sea and western Aleutian Islands (Hart 1973, Miller and Lea 1972). They are most abundant at depths between 100 and 200 m and are found fairly uniformly throughout the GOA outside the spawning season. The spawning period off Oregon is reported to range from January through June with a peak in March and April (Hosie and Horton 1977). Using data from research surveys, Hirschberger and Smith (1983) found that spawning in the GOA occurred from February through July, with a peak period in April and May, although they had few, if any, observations from October to February. More recently, Abookire (2006) found evidence for spawning starting in October and ending in June, based on one year's worth of monthly histological sampling (October through July) that included both research survey and fishery samples. It seems reasonable, then, that the actual spawning season extends from October to July. Fecundity estimates from samples collected off the Oregon coast ranged from 3,900 to 238,100 ova for fish 24 to 59 cm (Hosie and Horton 1977). During the spawning season, adult rex sole concentrate along the continental slope, but also appear on the outer shelf (Abookire and Bailey 2007). Eggs are fertilized near the sea bed, become pelagic, and probably require a few weeks to hatch (Hosie and Horton 1977). Abookire and Bailey (2007) concluded that larval duration is about 9 months in the GOA (rather than 12 months off the coast of Oregon) and that size-at-transformation for rex sole is 49 to 72 mm. Although maturity studies from Oregon indicate that females are 50 percent mature at 24 cm, females in the GOA achieve 50 percent maturity at larger size (35.2 cm) and grow faster such that they achieve 50 percent maturity at about the same age (5.1 years) as off Oregon (Abookire 2006). Juveniles less than 15 cm are rarely found with the adult population. The natural mortality rate used in recent stock assessments is 0.17 (Stockhausen et al. 2007).

D.8.2 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.8.3 Relevant Trophic Information

Based on results from an ecosystem model for the GOA (Aydin et al. 2007), rex sole in the GOA occupy an intermediate trophic level. Polychaetes, euphausiids, and miscellaneous worms were the most important prey for rex sole. Other major prey items included benthic amphipods, polychaetes, and shrimp

(Livingston and Goiney, 1983; Yang, 1993; Yang and Nelson, 2000). Important predators on rex sole include longnose skate and arrowtooth flounder.

D.8.4 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, euphausiids, and miscellaneous worms.

Habitat and Biological Associations: Rex sole

Stage - EFH Level	Duration or Age	Diet/Prey	Season/ Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs	several weeks	NA	Oct –July	ICS?, MCS, OCS	P			
Larvae	9 months	U phyto/zooplankton?	spring summer	ICS?, MCS, OCS	P			
Juveniles	ages 1–5 years	polychaetes, euphausiids, misc. worms	all year	MCS, ICS, OCS	D	G, S, M		
Adults	ages 5–33 years	polychaetes, amphipods, euphausiids, misc. worms	spawning Oct–July non-spawning July–Sep	MCS, OCS, USP	D	G, S, M		

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D.9 Dover sole (*Microstomus pacificus*)

D.9.1 Life History and General Distribution

Dover sole are distributed in deep waters of the continental shelf and upper slope from northern Baja California to the Bering Sea and the western Aleutian Islands (Hart 1973, Miller and Lea 1972). They exhibit a widespread distribution throughout the GOA. Adults are demersal and are mostly found in water deeper than 300 m in the winter but occur in highest biomass in the 100- to 200-m depth range during summer in the GOA (Turnock et al. 2002). The spawning period off Oregon is reported to range from January through May (Hunter et al. 1992). Off California, Dover sole spawn in deep water, and the larvae eventually settle in the shallower water of the continental shelf. They gradually move down the slope into deeper water as they grow and reach sexual maturity (Jacobson and Hunter 1993,Vetter et al. 1994, Hunter et al. 1990). For mature adults, most of the biomass may inhabit the oxygen minimum zone in deep waters. Spawning in the GOA has been observed from January through August, with a peak period in May (Hirschberger and Smith 1983), although a more recent study found spawning limited to February through May (Abookire and Macewicz 2003). Eggs have been collected in neuston and bongo nets in the summer, east of Kodiak Island (Kendall and Dunn 1985), but the duration of the incubation period is unknown. Larvae were captured in bongo nets only in summer over mid-shelf and slope areas (Kendall and Dunn 1985). The age or size at metamorphosis is unknown, but the pelagic larval period is known to be protracted and may last as long as 2 years (Markle et al. 1992). Pelagic postlarvae as large as 48 mm have been reported, and the young may still be pelagic at 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. A comparison of maturity studies from Oregon and the GOA indicates that females mature at similar age in both areas (6 to 7 years), but GOA females are much larger (44 cm) than their southern counterparts (33 cm) at 50 percent maturity (Abookire and Macewicz 2003). 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 0.085 yr^{-1} based on a maximum observed age in the GOA of 54 years (Stockhausen et al. 2007).

D.9.2 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 rockfish, and sablefish fisheries, and they are caught with these species and Pacific halibut in Dover sole directed fisheries.

D.9.3 Relevant Trophic Information

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

D.9.4 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. Dover sole commonly feed on brittle stars, polychaetes, and other miscellaneous worms (Aydin et al. 2007; Buckley et al. 1999).

Habitat and Biological Associations: Dover sole

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

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D.10 Flathead sole (*Hippoglossoides elassodon*)

D.10.1 Life History and General Distribution

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

Adults exhibit a benthic lifestyle and occupy separate winter spawning and summertime feeding distributions in the GOA. From over-winter grounds near the shelf margins, adults begin a migration onto the mid- and outer continental shelf in April or May each year for feeding. In the GOA, the spawning period may start as early as March but is known to occur in April through June, primarily in deeper waters near the margins of the continental shelf. Eggs are large (2.75 to 3.75 mm), and females have egg counts ranging from about 72,000 (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 western portion of the GOA shelf in April through June (Porter 2004). Porter (2004) found that egg density increased late in development such that mid-stage eggs were found near the surface but eggs about to hatch were found at depth (125 to 200 m). Larvae absorb the yolk sac in 6 to 17 days, but the extent of their distribution is unknown. Nearshore sampling indicates that newly settled larvae are in the 30 to 50 mm size range (Norcross et al. 1996, Abookire et al. 2001). Flathead sole females in the GOA become 50 percent mature at 8.7 years or about 33 cm (Stark 2004). Juveniles less than age 2 have not been found with the adult population and remain in shallow areas. The natural mortality rate used in recent stock assessments is 0.2 (Stockhausen et al. 2007).

D.10.2 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. 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.10.3 Relevant Trophic Information

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

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

D.10.4 Habitat and Biological Associations

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

Juveniles: Usually inhabit shallow areas (less than100 m), preferring muddy habitats.

Adults: Spring spawning and summer feeding on sand and mud substrates of the continental shelf. Widespread distribution mainly on the middle and outer portion of the shelf, feeding mainly on pandalid shrimp and brittle stars.

Habitat and Biological Associations: Flathead sole

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

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D.11 Arrowtooth flounder (*Atheresthes stomias*)

D.11.1 Life History and General Distribution

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

Adults exhibit a benthic lifestyle and occupy separate winter and summer distributions on the eastern Bering Sea shelf. From over-winter grounds near the shelf margins and upper slope areas, adults begin a migration onto the middle and inner shelf in April or early May each year with the onset of warmer water temperatures. A protracted and variable spawning period may range from as early as September through March (Rickey 1994, Hosie 1976). Little is known of the fecundity of arrowtooth flounder. Larvae have been found from ichthyoplankton sampling over a widespread area of the eastern Bering Sea shelf in April and May and also on the continental shelf east of Kodiak Island during winter and spring (Waldron and Vinter 1978, Kendall and Dunn 1985). Nearshore sampling in the Kodiak Island area indicates that newly settled larvae are in the 40 to 60 mm size range (Norcross et al. 1996). Juveniles are separate from the adult population, remaining in shallow areas until they reach the 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 estimated at 0.35 (Turnock et al. 2009, Wilderbuer et al. 2009).

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

D.11.2 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.11.3 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.11.4 Habitat and Biological Associations

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

<u>*Adults*</u>: 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/ zooplankton?	spring, summer?	BAY, ICS, OCS	P			
Juveniles	males - up to 4 years females - up to 5 years	euphausiids, crustaceans, amphipods, pollock	all year	ICS, OCS, USP	D	G,M,S		
Adults	males 4+ years females 5+ years	pollock, Gadidae sp., misc. fish, euphausiids	spawning Nov–March non-spawning April–Oct	ICS, OCS, USP, BAY	D	G,M,S	ice edge (EBS)	

D.11.5 Literature

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

D.12.1 Life History and General Distribution

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

There is much uncertainty about the life history of Pacific ocean perch, although generally more is known than for other rockfish species (Kendall and Lenarz 1986). The species appears to be viviparous (the eggs develop internally and receive at least some nourishment from the mother), with internal fertilization and the release of live young. Insemination occurs in the fall, and sperm are retained within the female until fertilization takes place approximately 2 months later. The eggs hatch internally, and parturition (release of larvae) occurs in April and May. Information on early life history is very sparse, especially for the first year of life. Pacific ocean perch larvae are thought to be pelagic and drift with the current. Oceanic conditions may sometimes cause advection to suboptimal areas (Ainley et al. 1993), resulting in high recruitment variability. However, larval studies of rockfish have been hindered by difficulties in species identification since many larval rockfish species share the same morphological characteristics (Kendall 2000). Genetic techniques using allozymes (Seeb and Kendall 1991) and mitochondrial DNA (Li 2004) are capable of identifying larvae and juveniles to species, but are expensive and time-consuming. Post-larval and early young-of-the-year Pacific ocean perch have been positively identified in offshore, surface waters of the GOA (Gharrett et al. 2002), which suggests this may be the preferred habitat of this life stage. Transformation to a demersal existence may take place within the first year (Carlson and Haight 1976). Small juveniles probably reside inshore in very rocky, high relief areas and begin to migrate to deeper offshore waters of the continental shelf by age 3 (Carlson and Straty 1981). As they grow, they continue to migrate deeper, eventually reaching the continental slope, where they attain adulthood.

Pacific ocean perch is a slow growing species, with a low rate of natural mortality (estimated at 0.06), a relatively old age at 50 percent maturity (10.5 years for females in the GOA), and a very old maximum age of 98 years in Alaska (84 years maximum age in the GOA) (Hanselman et al. 2007a). Age at 50 percent recruitment to the commercial fishery has been estimated to be between 7 and 8 years in the GOA. Despite their viviparous nature, the fish is relatively fecund with number of eggs per female in Alaska ranging from 10,000 to 300,000, depending upon size of the fish (Leaman 1991).

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.12.2 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 account for more than 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 a North Pacific Fishery Management 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. A localized depletion analysis has shown that after fairly intense fishing, localized areas recovered to their former levels in the following year (Hanselman et al. 2007b).

In 2007, the Central Gulf of Alaska Rockfish Pilot Program was implemented to enhance resource conservation and improve economic efficiency for harvesters and processors who participate in the Central Gulf of Alaska rockfish fishery. This 5-year rationalization program established cooperatives among trawl vessels and processors, which receive exclusive harvest privileges for rockfish management groups. The program was revised and reimplemented in 2012. The primary rockfish management groups are northern rockfish, Pacific ocean perch, and pelagic shelf rockfish. Effects of this program on Pacific ocean perch include (1) extended fishing season lasting from May 1 through November 15, (2) changes in spatial distribution of fishing effort within the Central GOA, (3) improved at-sea and plant observer coverage for vessels participating in the rockfish fishery, and (4) a higher potential to harvest 100 percent of the TAC in the Central GOA region.

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.12.3 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 Aleutian Islands, myctophids have increasingly comprised a substantial portion of the

Pacific ocean perch diet, which also compete for euphausiid prey (Yang 2003). It has been suggested that Pacific ocean perch and walleye pollock compete for the same euphausiid prey. Consequently, the large removals of Pacific ocean perch by foreign fishermen in the GOA in the 1960s may have allowed walleye pollock stocks to greatly expand in abundance.

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

D.12.4 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 m off the bottom at depths from 360 to 400 m.

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

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 180 km 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 Bering Sea (Brodeur 2001). The fish can at times also be found off-bottom in the pelagic environment, especially at night when they may move up in the water column to feed. There presently is little evidence to support previous conjectures that adult Pacific ocean perch populations might be denser in rough, untrawlable bottom.

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 Aleutian Islands)	euphausiids	insemination (fall); fertilization, incubation (winter); larval release (spring); feeding in shallower depths (summer)	OCS, USP	D, SD, P	CB, G, M?, SM?, MS?	U	U

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D.13 Northern rockfish (*Sebastes polyspinis*)

D.13.1 Life History and General Distribution

Northern rockfish range from northern British Columbia through the GOA and Aleutian Islands to eastern Kamchatka and the Kuril Islands, including the Bering Sea (Mecklenburg et al. 2002). The species is most abundant from about Portlock Bank in the central GOA to the western end of the Aleutian Islands; it is rarely found in the eastern GOA. In the GOA, adult fish appear to be concentrated at discrete, relatively shallow offshore banks of the outer continental shelf (Clausen and Heifetz 2002). Typically, these banks are separated from land by an intervening stretch of deeper water. The preferred depth range is approximately 75 to 150 m in the GOA. Information available at present suggests the fish are mostly demersal, as very few have been caught off-bottom or in pelagic trawls (Clausen and Heifetz 2002). In common with many other rockfish species, northern rockfish tend to have a localized, patchy distribution, even within their preferred habitat, and most of the population occurs in aggregations. Most of what is known about northern rockfish is based on data collected during the summer months from the commercial fishery or in research surveys. Consequently, there is little information on seasonal movements or changes in distribution for this species.

Life history information on northern rockfish is extremely sparse. The fish are assumed to be viviparous, as other *Sebastes* appear to be, with internal fertilization and incubation of eggs. Observations during research surveys in the GOA suggest that parturition (larval release) occurs in the spring, and is mostly completed by summer. Pre-extrusion larvae have been described (Kendall 1989), but field-collected larvae cannot be unequivocally identified to species at present, even using genetic techniques (Li et al. 2006). Length of the larval stage is unknown, but the fish apparently metamorphose to a pelagic juvenile stage, which also has been described (Matarese et al. 1989). However, similar to the larvae, smaller-sized post-larval northern rockfish cannot be positively identified at present, even with genetic methods (Kondzela et al. 2007). There is no information on when the juveniles become benthic or what habitat they occupy. Older juveniles are found on the continental shelf, generally at locations inshore of the adult habitat (Clausen and Heifetz 2002).

Northern rockfish is a slow growing species, with a low rate of natural mortality (estimated at 0.06), a relatively old age at 50 percent maturity (12.8 years for females in the GOA), and an old maximum age of 67 years in the GOA (Heifetz et al. 2007). Size at 50 percent maturity for females has been estimated to be 36 cm; it is unknown for males, but presumed to be slightly smaller than for females based on what is commonly the case in other species of *Sebastes*. No information on fecundity is available.

D.13.2 Fishery

Northern rockfish are caught almost exclusively with bottom trawls. The majority of the catch in the GOA comes from depths of 75 to 125 m (Clausen and Heifetz 2002). Age at 50 percent recruitment is unknown. Before 2007, the fishery in the GOA occurred in the summer months, especially July, due to management regulations. With the implementation of the Central Gulf Rockfish Pilot Program in 2007, catches have been spread out more throughout the year (Heifetz et al. 2007). From 1990 to 1998, catches were concentrated at five 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 (Clausen and Heifetz 2002). Of these, the Snakehead was especially productive. Outside of these banks, catches were generally sparse. Since 1998, Portlock, Albatross, and Shumagin Banks have generally continued to be important, but the amount taken from the Snakehead has diminished greatly (Heifetz et al. 2008). An analysis of catch data indicated that significant depletion of northern rockfish likely occurred in the Snakehead in the 1990s (Hanselman et al. 2007); subsequently, it appears that catch rates in this area have not recovered.

The major bycatch species in the GOA northern rockfish trawl fishery in 1994–96 included (in descending order by percent bycatch rate): dusky rockfish, “other slope rockfish,” and Pacific ocean perch (Ackley and Heifetz 2001). Of these, dusky rockfish was by far the most common bycatch, having a bycatch rate as high as 34 percent, depending on the year.

D.13.3 Relevant Trophic Information

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

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

D.13.4 Habitat and Biological Associations

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

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

Juveniles: No information known for small juveniles (less than 20 cm), except that post-larval fish apparently undergo a pelagic phase immediately after metamorphosis from the larval stage. How long the pelagic stage lasts, and when juveniles assume a demersal existence, is unknown. Observations from manned submersibles in offshore waters of the GOA (e.g., Krieger 1993; Freese and Wing 2003) have consistently indicated that small juvenile rockfish are associated with benthic living and non-living structure and appear to use this structure as refuge. The living structure includes corals and sponges. Although the juvenile rockfish could not be identified to species in the submersible studies, the studies suggest that small juvenile northern rockfish possibly utilize these habitats. Large juvenile northern rockfish have been taken in bottom trawls at various localities of the continental shelf, usually inshore of the adult fishing grounds (Clausen and Heifetz 2002). Substrate preference of these larger juveniles is unknown.

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

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

Habitat and Biological Associations: Northern Rockfish

Stage - EFH Level	Duration or Age	Diet/ Prey	Season/ Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs	U	NA	NA	NA	NA	NA	NA	NA
Larvae	U	U	spring–summer	U	P (assumed)	NA	U	U
Early Juveniles	From end of larval stage to ?	U	summer to ?	U	P?	U	U	U
Late Juveniles	to 13 years	U	all year	MCS, OCS	D	U	U	U
Adults	13 to 67 years of age	Euphausiids	U, except that larval release is probably in the spring in the GOA	OCS	D	CB, R	U	often co-occur with dusky rockfish

D.13.5 Literature

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D.14 Shortraker Rockfish (*Sebastes borealis*)

D.14.1 Life History and General Distribution

Shortraker rockfish are found around the arc of the north Pacific from southern California to northern Japan, including the Bering Sea and the Sea of Okhotsk (Mecklenburg et al. 2002). They also occur on seamounts in the GOA (Maloney 2004). Except for the adult stage, information on the life history of shortraker rockfish is extremely limited. Similar to other *Sebastes*, the fish appear to be viviparous; fertilization is internal and the developing eggs receive at least some nourishment from the mother. Parturition (release of larvae) may occur from February through August (McDermott 1994). Larvae can be positively identified only by using genetic techniques (Gray et al. 2006), which greatly hinders study of this life stage. Based on genetic identification, a few larval shortraker rockfish have been found in coastal waters of Southeast Alaska (Gray et al. 2006). Post-larvae are also difficult to identify, but genetic identification confirmed the presence of two specimens in epipelagic offshore waters of the GOA over depths greater than 1,000 m (Kondzela et al. 2007). It is unknown whether this very limited sampling of larval and post-larval fish is a good indication of the habitat preference of these life stages; clearly, additional sampling is needed. Similarly, almost nothing is known about juvenile shortraker rockfish in the GOA; only a few specimens less than 35-cm fork length have ever been caught by fishing gear in this region. Juveniles have been caught in somewhat larger numbers in bottom trawl surveys of the Aleutian Islands (e.g., Harrison 1993), but these data have not been analyzed to determine patterns of distribution or habitat preference. As adults, shortraker rockfish are demersal and inhabit depths from 328 to 3,937 feet (100 to 1,200 m) (Mecklenburg et al. 2002). However, survey and commercial fishery data indicate that the fish are most abundant along a narrow band of the continental slope at depths of 984 to 1,640 feet (300 to 500 m) (Ito 1999), where they often co-occur with rougheye and blackspotted rockfish. Within this habitat, shortraker rockfish tend to have a relatively even distribution when compared with the highly aggregated and patchy distribution of many other rockfish such as Pacific ocean perch (Clausen and Fujioka 2007).

Though relatively little is known about its biology and life history, shortraker rockfish appears to be a K-selected species with late maturation, slow growth, extreme longevity, and low natural mortality. Age of 50 percent maturity for female shortraker rockfish has been estimated to be 21.4 years for the GOA, with a maximum age of 116 years (Hutchinson 2004). Both these values are very old relative to other fish species. Another study reported an even older maximum age of 157 years (Munk 2001). Female length of 50 percent maturity has been estimated to be 44.9 cm (McDermott 1994). There is no information on age or length of maturity for males. Shortraker rockfish attains the largest size of any species in the genus *Sebastes*, with a maximum length of up to 47 inches (120 cm; Mecklenburg et al. 2002). Estimates of natural mortality for shortraker rockfish range between 0.027 and 0.042 (McDermott 1994), and a mortality of 0.03 has been used in recent stock assessments to determine values of acceptable biological catch and overfishing for the GOA (Clausen 2007).

D.14.2 Fishery

Shortraker rockfish since 2005 have been assigned their own values of acceptable biological catch and TAC in the GOA, although technically there is no directed fishery. Instead, all the catch is taken as bycatch in other fisheries. Before 2005, shortraker rockfish were combined with rougheye rockfish for management purposes in the GOA. Shortraker rockfish can be caught with either bottom trawls or longlines. In recent years, each gear type has taken about one half the total catch (Clausen 2007). Most of the trawl catch comes as bycatch in the Pacific ocean perch fishery, whereas the longline catch is taken in the sablefish or Pacific halibut fishery. Although shortraker rockfish are supposedly a "bycatch only" species, present management regulations indirectly allow a limited amount of *de facto* targeted fishing on these fish by rockfish trawlers in some situations (Clausen 2007). In contrast, virtually all the longline catch of shortraker rockfish appears to come as "true" incidental catch. Shortraker rockfish is one of the most valuable rockfish species in Alaska in terms of landed price; consequently, the discard rate for this species is generally quite low.

D.14.3 Relevant Trophic Information

The diet of adult shortraker rockfish in the GOA is not well known, but shrimp, deepwater fish such as myctophids, and squid appear to be the major prey items (Yang and Nelson 2000; Yang et al. 2006), A food study in the Aleutian Islands with a larger sample size of shortraker rockfish also found the diet to be mostly myctophids, squid, and shrimp (Yang 2003). In addition, gammarid amphipods, mysids, and miscellaneous fish were important food items in some years. There is no information on predators of shortraker rockfish. Due to their large size, older shortraker rockfish likely have few potential predators other than very large animals such as sleeper sharks or sperm whales.

D.14.4 Habitat and Biological Associations

Egg/Spawning: The timing of reproductive events is apparently protracted. Similar to all *Sebastes*, egg development for shortraker rockfish is completely internal. One study suggested parturition (i.e., larval release) may occur from February to August (McDermott 1994). Another study indicated the peak month of parturition in Southeast Alaska was April (Westrheim 1975). There is no information as to when males inseminate females or if migrations occur for spawning/breeding.

Larvae: Information on larval shortraker rockfish is very limited. Larval shortraker rockfish have been identified in pelagic plankton tows in coastal Southeast Alaska (Gray et al. 2006). Larval studies are hindered because the larvae at present can be positively identified only by genetic analysis, which is both expensive and labor-intensive.

Post-larvae and early young-of-the year: One study used genetics to identify two specimens of post-larval shortraker rockfish from samples collected in epipelagic waters far offshore in the GOA beyond the continental slope (Kondzela et al. 2007). This limited information is the only documentation of habitat preference for this life stage.

Juveniles: Information is negligible regarding the habitat and biological associations of juvenile shortraker rockfish. Only a few specimens less than 14 inches (35 cm) fork length have ever been caught in the GOA. The habitat is presumably demersal, as all specimens caught in the GOA as well others caught in the Aleutian Islands (Harrison 1993) and off Russia (Orlov 2001) have been taken by bottom trawls.

Adults: Adult shortraker rockfish are demersal and in the GOA are concentrated at depths of 984 to 1,640 feet (300 to 500 m) along the continental slope. Much is this area is generally considered by fishermen to be steep and difficult to trawl. Observations from a manned submersible indicated that shortraker rockfish occurred over a wide range of habitats, but soft substrates of sand or mud usually had the highest densities of fish (Krieger 1992). However, this study also showed that habitats with steep slopes and frequent boulders were used at a higher rate than habitats with gradual slopes and few boulders. Another submersible study also found that shortraker and rougheye rockfish occur more frequently on steep slopes with numerous boulders (Krieger and Ito 1999). Although the study could not distinguish between the two species, it is highly probable that many of the fish were shortraker rockfish. Finally, a third submersible study found that "large" rockfish had a strong association with *Primnoa* spp. coral growing on boulders: less than 1 percent of the observed boulders had coral, but 85 percent of the "large" rockfish, which included redbanded rockfish along with shortraker and rougheye, were next to boulders with coral (Krieger and Wing 2002). Again, in this latter study, "large" rockfish were not positively identified, but it is likely based on location and depth that many were shortraker rockfish.

Habitat and Biological Associations: Shortraker Rockfish

Stage - EFH Level	Duration or Age	Diet/Prey	Season/ Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs	U	NA	NA	NA	NA	NA	NA	
Larvae	U	U	parturition: Feb–Aug	U; BAY	probably P	NA	U	
Post-larvae/ early juvenile	U	U	summer to ?	LSP, BSN	probably D	NA	U	
Juveniles	Up to 21 years of age	U	U	OCS?, USP?	probably D	U	U	
Adults	21 to >100 years of age	shrimp, squid, myctophids	year-round?	USP	D	M, S, R, SM, CB, MS, G, C; steep slopes and boulders	U	observed associated with *Primnoa* coral

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D.15 Rougheye rockfish (*Sebastes aleutianus*) and blackspotted rockfish (*Sebastes melanostictus*)

D.15.1 Life History and General Distribution

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

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

Though relatively little is known about their biology and life history, rougheye and blackspotted rockfish appear to be K-selected with late maturation, slow growth, extreme longevity, and low natural mortality. Age and size at 50 percent maturity for female rougheye rockfish is estimated at 19 years and 44 cm, respectively (McDermott 1994). There is no information on male size at maturity or on maximum size of juvenile males. Rougheye is considered the oldest of the *Sebastes* spp. with a maximum age of 205 years (Chilton and Beamish 1982, Munk 2001). It is also considered one of the larger rockfish attaining sizes of up to 38 inches (98 cm) (Mecklenburg et al. 2002). Natural mortality is low, estimated to be on the order of 0.004 to 0.07 (Archibald et al. 1981, McDermott 1994, Nelson and Quinn 1987, Clausen et al. 2003, Shotwell et al. 2007).

D.15.2 Fishery

Although rougheye and blackspotted rockfish are found as far south as southern California, commercial quantities are primarily harvested from Washington north to Alaska waters. Commercial harvests usually occur on the continental slope from 984 to 1,640 feet (300 to 500 m) deep. Rougheye and blackspotted rockfish have been managed as "bycatch" only species since the creation of the shortraker/rougheye rockfish management subgroup in the GOA in 1991. Historically, Gulf-wide catches of the shortraker/rougheye subgroup have been consistently around 1,500 to 2,000 mt in the years since 1992. Annual TACs have been the major determining factor of these catch amounts, as TACs have also ranged between approximately 1,500 and 2,000 mt over these years. Rougheye are caught in either bottom trawls or with longline gear, and about half came from each gear type in recent years (Shotwell et al. 2007). Nearly all the longline catch of rougheye appears to come as "true" bycatch in the sablefish or halibut longline fisheries. Rougheye and blackspotted rockfish are associated with soft to rocky habitats along the continental slope, although boulders and steeply sloping terrain also appear to be a desirable habitat feature (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).

Since 2005, rougheye and blackspotted rockfish were assessed separately from shortraker rockfish and assigned their own values of acceptable biological catch and TAC in the GOA. Gulf-wide discard rates (percent of the total catch discarded within management categories) of fish in the shortraker/rougheye subgroup were available for the years 1991 through 2004, and range from approximately 10 percent to 42 percent. Beginning in 2005, discards for the rougheye rockfish complex are reported separately and range from 20 percent to 38 percent, which are relatively high when compared to other *Sebastes* species in the GOA (Shotwell et al. 2007).

In 2007, the Central Gulf of Alaska Rockfish Pilot Program was implemented to enhance resource conservation and improve economic efficiency for harvesters and processors who participate in the Central Gulf of Alaska rockfish fishery. This is a 5-year rationalization program that establishes cooperatives among trawl vessels and processors which receive exclusive harvest privileges for rockfish management groups. The program was revised and reimplemented in 2012. The primary rockfish management groups are northern, Pacific ocean perch, and pelagic shelf rockfish, while the secondary species include rougheye and shortraker rockfish. This implementation impacts primary management groups but will also effect secondary groups with a maximum retained allowance. Potential effects of this program to rougheye rockfish include (1) changes in spatial distribution of fishing effort within the Central GOA, (2) improved at-sea and plant observer coverage for vessels participating in the rockfish fishery, (3) a higher potential to harvest 100 percent of the TAC in the Central GOA region, and (4) an extended fishing season lasting from May 1 through November 15. This should spread out the fishery in time and space, allowing for better prices for product and reducing the pressure of what was an approximately 2-week fishery in July.

D.15.3 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). Recent food studies show the most common prey of rougheye as pandalid shrimp, euphausiids, and tanner crab (*Chionoecetes bairdi*). Other prey include octopuses and copepods (Yang et al. 2006). Predators of rougheye rockfish likely include halibut (*Hippoglossus stenolepis*), Pacific cod (*Gadus macrocephalus*), and sablefish (*Anoplopoma fimbria*).

D.15.4 Habitat and Biological Associations

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

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

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

Juveniles: There is no information on when juvenile fish become demersal. Juvenile rougheye rockfish 6 to 16 inches (15 to 40 cm) fork length have been frequently taken in GOA bottom trawl surveys, implying the use of low relief, trawlable bottom substrates (Clausen et al. 2003). They are generally found at shallower, more inshore areas than adults and have been taken in a variety of locations, ranging from inshore fiords to offshore waters of the continental shelf. Studies using manned submersibles have found that large numbers of small, juvenile rockfish are frequently associated with rocky habitat on both the shallow and deep shelf of the GOA (Carlson and Straty 1981). Another submersible study on the GOA shelf observed juvenile red rockfish closely associated with sponges that were growing on boulders (Freese and Wing 2004). Although these studies did not specifically identify rougheye rockfish, it is reasonable to suspect that juvenile rougheye rockfish may be among the species that utilize this habitat as refuge during their juvenile stage.

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

Habitat and Biological Associations: Rougheye and Blackspotted Rockfish

Stage - EFH Level	Duration or Age	Diet/Prey	Season/ Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs	U	NA	NA	NA	NA	NA	NA	
Larvae	U	U	parturition: Dec–Apr	U	Pelagic	NA	U	
Post-larvae/ early juvenile	U	U	summer to ?	LSP, BSN	Epipelagic	NA	U	
Juveniles	up to 20 years of age	shrimp, mysids, amphipods, isopods	U	OCS, USP	D	U	U	
Adults	20 to >100 years of age	shrimp, euphausiids, myctophids, tanner crab	year-round?	USP	D	M, S, R, SM, CB, MS, G, C steep slopes and boulders	U	observed associated with *Primnoa* coral

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D.16 Dusky rockfish *(Sebastes variabilis)*

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

D.16.1 Life History and General Distribution

Dusky rockfish range from central Oregon through the North Pacific Ocean and Bering Sea in Alaska and Russia to Japan. The center of abundance for dusky rockfish appears to be the GOA (Reuter 1999). The species is much less abundant in the Aleutian Islands and Bering Sea (Reuter and Spencer 2006). Adult dusky rockfish have a very patchy distribution and are usually found in large aggregations at specific localities of the outer continental shelf. These localities are often relatively shallow offshore banks. Because the fish are taken with bottom trawls, they are presumed to be mostly demersal. Whether they also have a pelagic distribution is unknown, but there is no particular evidence of a pelagic tendency based on the information available at present. Most of what is known about dusky rockfish is based on data collected during the summer months from the commercial fishery or in research surveys. Consequently, there is little information on seasonal movements or changes in distribution for this species.

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

Dusky rockfish is a slow growing species, with a low rate of natural mortality estimated at 0.09. However, it appears to be faster growing than many other rockfish species. Maximum age is 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.16.2 Fishery

Dusky rockfish are mostly caught with bottom trawl gear and to a much lesser extent by jig gear. In 2007, the Central Gulf of Alaska Rockfish Pilot Program was implemented to enhance resource conservation and improve economic efficiency for harvesters and processors who participate in the Central Gulf of Alaska rockfish fishery. This is a 5-year rationalization program that establishes cooperatives among trawl vessels and processors which receive exclusive harvest privileges for rockfish management groups. The program was revised and reimplemented in 2012. The primary rockfish management groups are northern rockfish, Pacific ocean perch, and pelagic shelf rockfish. Potential effects of this program on Pacific ocean perch include (1) extended fishing season lasting from May 1 through November 15, (2) changes in spatial distribution of fishing effort within the Central GOA, (3) Improved at-sea and plant observer coverage for vessels participating in the rockfish fishery, and (4) a higher potential to harvest 100 percent of the TAC in the Central GOA region. This program also makes dusky rockfish increasing available to jig and hook-and-line gear through a specific allocation of TAC.

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 trawl catch of dusky rockfish is taken at depths of 100 to 200 m offshore, while most of the catch by jig gear occurs in shallow, inshore waters.

D.16.3 Relevant Trophic Information

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

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

D.16.4 Habitat and Biological Associations

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

Larvae: No information is known.

Juveniles: No information is known for small juveniles less than 25 cm fork length. Larger juveniles have been taken infrequently in bottom trawls at various localities of the continental shelf, usually inshore of the adult fishing grounds. A manned submersible study in the eastern Gulf observed juvenile (less than 40 cm) dusky rockfish associated with *Primnoa* spp. coral.

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

Habitat and Biological Associations: Dusky Rockfish

Stage - EFH Level	Duration or Age	Diet/Prey	Season/ Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs	U	NA	U	NA	NA	NA	NA	NA
Larvae	U	U	spring–summer	U	P (assumed)	NA	U	U
Early Juveniles	U	U	all year	U	U	U	U	U
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.16.5 Literature

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D.17 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.17.1 Life History and General Distribution

These species are distributed from Ensenada, in northern Baja California, to Umnak Island and Unalaska Island, of the Aleutian Islands, in depths from 60 to 1,800 feet but commonly in 300 to 600 feet in rocky, rugged habitat (Allen and Smith 1988, Eschmeyer et al. 1983). Little is known about the young of the year and settlement. Young juveniles between 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, ADFG, personal communication). Yelloweye feed on a variety of prey, primarily fishes (including other rockfishes, herring, and sandlance) as well as caridean shrimp and small crabs. Yelloweye are a K-selected species with late maturation, slow growth, extreme longevity, and low natural mortality. They reach a maximum length of about 91 cm and growth slows considerably after age 30 years. Approximately 50 percent of females are mature at 45 cm and 22 years. Age of 50 percent maturity for males is 18 years and length is 43 cm . Natural mortality is estimated to be 0.02, and maximum age published is 118 years (O’Connell and Fujioka 1991, O’Connell and Funk 1987). However a 121-year-old specimen was harvested in the commercial fishery off Southeast Alaska in 2000.

D.17.2 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 years at a length between 45 and 50 cm. The commercial fishery grounds are usually areas of rocky bottom with varying degrees of vertical relief in water depths between 20 and 100 fathoms. The directed fishery now occurs between November and March both because of higher winter prices and limitations imposed due to the halibut individual fishing quota regulations.

D.17.3 Relevant Trophic Information

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

D.17.4 Habitat and Biological Associations

Early juveniles: Young juveniles between 2.5 (1 inch) and 10 cm (4 inches) have been observed in areas of high relief. This relief can be provided by the geology of an area such as vertical walls, fjord-like areas, and pinnacles, or by large invertebrates such as cloud sponges, *Farrea occa*, *Metridium farcimen*, and *Primnoa* coral. These observations were made in depths deeper than 13 m during the course of submersible research in the Eastern GOA (Southeast Alaska Groundfish Project, Alaska Department of Fish and Game, unpublished data).

Late juveniles/adults: 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), and can co-occur with gorgonian corals (Krieger and Wing 2002). 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, O'Connell et al. 2007). Although yelloweye do occur over cobble and sand bottoms, generally this is when foraging and often these areas directly interface with a rock wall or outcrop.

Habitat and Biological Associations: Yelloweye Rockfish

Stage - EFH Level	Duration or Age	Diet/Prey	Season/ Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs	NA	NA	NA	NA	NA	NA	NA	NA
Larvae	<6 mo	copepod	spring/ summer	U	N?	U	U	
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	Parturition	Known Habitat
Quillback	Kodiak Island to San Miguel Island, CA to 274 m (commonly 12–76 m)	At least 32 size at 50 percent maturity=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 size at 50 percent maturity =5 yr	crustaceans octopuses small fishes	Mar–Jul	Juveniles have been observed near eelgrass beds and in kelp, in areas of mixed sand and rock. Adults are in rocky bays and shallow coastal areas, generally less exposed than the other demersal shelf rockfish.
Tiger	Kodiak Is and Prince William Sound to Tanner-Cortes Banks, CA from 33 to 183 m	to 116 years	invertebrates, primarily crustaceans	early spring	Juveniles and adults in rocky areas: most frequently observed in boulder areas, generally under overhangs.
China	Kachemak Bay to San Miguel Island, CA to 128 m	to 72 years	invertebrates, brittle stars are significant component of diet	Apr–Jun	Juveniles have been observed in shallow kelp beds, adults in rocky reefs and boulder fields. Some indications that adults have a homesite.
Rosethorn	Kodiak Is to Guadalupe Is, Baja, CA to 25 m to 549 m	to 87 years mature 7–10 years		Feb–Sept (May)	observed over rocky habitats and in rock pavement areas with large sponge cover
Canary	Shelikof St to Cape Colnett, Baja, CA To 424 m (commonly to 137 m)	To 75 years size at 50 percent maturity = 9	macroplankton and small fishes		Occur over rocky and sand/cobble bottoms, often hovering in loose schools over soft bottom near rock outcrops. Schools often associate with schools of yellowtail and silvergrey.

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D.18 Thornyhead rockfish *(Sebastolobus* spp.*)*

D.18.1 Life History and General Distribution

Thornyhead rockfish of the northeastern Pacific Ocean comprise two species, the shortspine thornyhead (*Sebastolobus alascanus*) and the longspine thornyhead (*S. altivelis*). The longspine thornyhead is not common in the GOA. The shortspine thornyhead is a demersal species which inhabits deep waters from 17 to 1,524 m along the Pacific rim from the Seas of Okhotsk and Japan in the western north Pacific, throughout the Aleutian Islands, Bering Sea slope, and GOA, and south to Baja California. This species is common throughout the GOA, eastern Bering Sea, and Aleutian Islands. The population structure of shortspine thornyheads, however, is not well defined. Thornyhead rockfish are slow-growing and long-lived with maximum age in excess of 50 years and maximum size greater than 75 cm and 2 kg. Shortspine thornyhead spawning takes place in the late spring and early summer, between April and July in the GOA Thornyhead rockfish spawn a bi-lobed mass of fertilized eggs which floats in the water column. Juvenile shortspine thornyhead rockfish have an extended pelagic period of about 14 to 15 months and settle out at about 22 to 27 mm into relatively shallow benthic habitats between 100 and 600 m and then migrate deeper as they grow. Fifty percent of female shortspine thornyhead rockfish are sexually mature at about 21.5 cm.

D.18.2 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 thornyhead rockfish are one of the most valuable of the rockfish species, with most of the domestic harvest exported to Japan. Despite their high value, they are still managed using a "bycatch only" fishery status in the GOA because they are nearly always taken in fisheries directed at sablefish (*Anoplopoma fimbria*) and other rockfish (*Sebastes* spp.). The incidental catch of shortspine thornyhead rockfish in these fisheries has been sufficient to capture a substantial portion of the thornyhead quota established in recent years, so directed fishing on shortspine thornyhead rockfish exclusively is not permitted. Although the thornyhead fishery is conducted operationally as a "bycatch" fishery, the high value and desirability of shortspine thornyhead rockfish means they are still considered a "target" species for the purposes of management.

D.18.3 Relevant Trophic Information

Shortspine thornyhead rockfish prey mainly on epibenthic shrimp and fish. Yang (1993, 1996) showed that shrimp were the top prey item for shortspine thornyhead rockfish in the GOA, whereas, cottids were the most important prey item in the Aleutian Islands region. Differences in abundance of the main prey between the two areas might be the main reason for the observed diet differences. Shortspine thornyhead rockfish are consumed by a variety of piscivores, including arrowtooth flounder, sablefish, "toothed whales" (sperm whales), and sharks. Juvenile shortspine thornyhead rockfish are thought to be consumed almost exclusively by adult thornyhead rockfish.

D.18.4 Habitat and Biological Associations

<u>Egg/Spawning</u>: 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.

<u>Larvae</u>: Three-day-old larvae are about 3 mm long and apparently float to the surface.

<u>Juveniles</u>: Juvenile shortspine thornyhead rockfish have an extended pelagic period of about 14 to 15 months and settle out at about 22 to 27 mm into relatively shallow benthic habitats between 100 and 600 m and then migrate deeper as they grow

<u>Adults</u>: Adults are demersal and can be found at depths ranging from about 90 to 1,500 m. Once in benthic habitats thornyhead rockfish associate with muddy substrates, sometimes near rocks or gravel, and distribute themselves evenly across this habitat, appearing to prefer minimal interactions with individuals of the same species. They have very sedentary habits and are most often observed resting on the bottom in small depressions. Groundfish species commonly associated with thornyhead rockfish include: arrowtooth flounder (*Atheresthes stomias*), Pacific ocean perch (*Sebastes alutus*), sablefish (*Anoplopoma fimbria*), rex sole (*Glyptocephalus zachirus*), Dover sole (*Microstomus pacificus*), shortraker rockfish (*Sebastes borealis*), rougheye rockfish (*Sebastes aleutianus*), and grenadiers (family *Macrouridae*).

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, G	year-round?	

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D.19 Atka mackerel (*Pleurogrammus monopterygius*)

D.19.1 Life History and General Distribution

Atka mackerel are distributed from the GOA to the Kamchatka Peninsula, and they are most abundant along the Aleutian Islands. Adult Atka mackerel occur in large localized aggregations usually at depths less than 200 m and generally over rough, rocky, and uneven bottom near areas where tidal currents are swift. Associations with corals and sponges have been observed for Aleutian Islands Atka mackerel. Adults are semi-demersal, displaying strong diel behavior with vertical movements away from the bottom occurring almost exclusively during the daylight hours, presumably for feeding, and little to no movement at night. Spawning is demersal in moderately shallow waters (down to bottom depths of 144 m) and peaks in June through September, but may occur intermittently throughout the year. Female Atka mackerel deposit eggs in nests built and guarded by males on rocky substrates or on kelp in shallow water. Eggs develop and hatch at depth in 40 to 45 days, releasing planktonic larvae that have been found up to 800 km from shore. Little is known of the distribution of young Atka mackerel before their appearance in trawl surveys and the fishery at about age 2 to 3 years. R-traits are as follows: young age at maturity (approximately 50 percent are mature at age 3.6), fast growth rates, high natural mortality (mortality equals 0.3), and young average and maximum ages (about 5 and 14 years, respectively). K-selected traits indicate low fecundity (only about 30,000 eggs/female/year, large egg diameters [1 to 2 mm] and male nest-guarding behavior).

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

D.19.2 Fishery

The directed fishery is conducted with bottom trawls in the Aleutian Islands, at depths between about 70 and 300 m, in trawlable areas on rocky, uneven bottom, along edges, and in the lee of submerged hills during periods of high current. The fishery generally catches fish ages 3 to 11 years old. 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. Directed fishing for Atka mackerel in the GOA is prohibited by Steller sea lion protection measures. Atka mackerel are taken as bycatch in the Shumagin (610) and Kodiak (620) areas in the rockfish fisheries

D.19.3 Relevant Trophic Information

Atka mackerel are important food for Steller sea lions in the Aleutian Islands, particularly during summer, and for other marine mammals (minke whales, Dall's porpoise, and northern fur seals). Juveniles are eaten by thick billed murres, tufted puffins, and short-tailed shearwaters. The main groundfish predators are Pacific halibut, arrowtooth flounder, and Pacific cod. Adult Atka mackerel consume a variety of prey, but principally calanoid copepods and euphausiids. Predation on Atka mackerel eggs by cottids and other hexagrammids is prevalent during the spawning season as is cannibalism by other Atka mackerel.

D.19.4 Habitat and Biological Associations

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

Larvae/Juveniles: 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.

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

Habitat and Biological Associations: Atka mackerel

Stage - EFH Level	Duration or Age	Diet/Prey	Season/ Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs	40 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	P, D (males) semidemersal (females) semidemersal / D (all sexes): D when currents high/day, semidemersal slack tides/night	GR, R, K	F,E	3–5 °C all stages >17 ppt only

D.19.5 Literature

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D.20 Skates (*Rajidae*)

The species representatives for skates are:

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

D.20.1 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. Big skates (*Raja binoculata*) and longnose skates (*Raja rhina*) are the most abundant skates in the GOA. Most of the biomass for these two species is located in the Central GOA (NMFS statistical areas 620 and 630). Depth distributions from surveys show that big skates are found primarily from 0 to 100 m; longnose skates are found primarily from 100 to 200 m, although they are found at all depths shallower than 300 m. Below 200 m depth, *Bathyraja* sp. skates are dominant. Little is known of their habitat requirements for growth or reproduction, nor of any seasonal movements. BSAI skate biomass estimate more than doubled between 1982 and 1996 from bottom trawl surveys; it may have decreased in the GOA and remained stable in the Aleutian Islands in the 1980s.

Approximate upper size limit of juvenile fish is unknown.

D.20.2 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 eastern Bering Sea groundfisheries ranged between 1 and 4 percent of the annual eastern Bering Sea 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 appeared to be *R. binoculata*, followed by *R. rhina*, but this is difficult to determine given that there is almost no observer coverage of the fishery. Directed fishing for skates has been prohibited in the GOA since 2005. There continues to be substantial incidental catch; the official 2008 estimate for all skates gulfwide was 2,351 mt. There is also undocumented catch in the individual fishing quota halibut fisheries.

D.20.3 Relevant Trophic Information

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

D.20.4 Habitat and Biological Associations

Egg/Spawning: Skates deposit eggs in horny cases on shelf and slope.

Juveniles and Adults: After hatching, juveniles probably remain in shelf and slope waters, but distribution is unknown. Adults found across wide areas of shelf and slope; surveys found most skates at depths less than 500 m in the GOA and eastern Bering Sea, but greater than 500 m in the Aleutian Islands. In the GOA, most skates found between 4 and 7 °C, but data are limited.

Habitat and Biological Associations: Skates

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

D.20.5 Literature

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D.21 Squids (*Cephalopoda*, *Teuthida*)

The species representatives for squids 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.21.1 Life History and General Distribution:

Squids 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 less than 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 through 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 Bering Sea, to Japan in waters 30 to 1,500 m deep; adults are most often found at mesopelagic depths or near the bottom on the shelf, rising to the surface at night; juveniles are widely distributed across shelf, slope, and abyssal waters in mesopelagic and epipelagic zones, and they rise to the surface at night. Juveniles and adults migrate seasonally, moving northward and inshore in summer, and southward and offshore in winter, particularly in the western north Pacific. The approximate upper size limit of juvenile fish is 20 cm mantle length (ML) for males and 25 cm ML for females; both are at approximately 1 year of age. Maximum size for females is 50 cm 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 per female. Spawning of eggs occurs from February to March in Japan, but apparently year-round in the Bering Sea. 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 Aleutian Islands and south to California, but is absent from the Sea of Okhotsk and is not common in the Bering Sea. Juveniles can be found over shelf waters at all depths and near shore. Adults apparently prefer the upper layers over slope and abyssal waters; 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 continental slope and mesopelagically over abyssal waters; it is rare on the shelf. It is distributed in all oceans and is found in the Bering Sea, Aleutian Islands, and GOA. Mantle length can be up to 2.5 m long (at least 7 m with tentacles), but most are about 2 m long.

R. pacifica is a small (maximum length with tentacles of less than 20 cm) demersal, neritic and shelf, boreal species, distributed from Japan to California in the North Pacific and in the Bering Sea in waters of about 20 to 300 m depth. Less is known about *R. pacifica*, but other *Rossia* spp. deposit demersal egg masses.

D.21.2 Fishery

Squids are not currently a target of groundfish fisheries of the 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 Bering Sea and *O. banksii borealjaponicus* in the Aleutian Islands. 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.21.3 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 eastern Bering Sea and Aleutian Islands. Seabirds (e.g., kittiwakes, puffins, murres) on island rookeries close to the shelf break (e.g., Buldir Island, Pribilof Islands) are also known to feed heavily on squid (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.21.4 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 (possibly only in the summer), 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	varies	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	semipelagic, P	UP, F?	U	euhaline waters, 2–4 °C

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D.22 Sculpins (Cottidae)

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.22.1 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 Bering Sea. Most species live in shallow water or in tidepools, but some inhabit the deeper waters (to 1,000 m) of the continental shelf and slope. Most species do not attain a large size (generally 10 to 15 cm), but those that live on the continental shelf and are caught by fisheries can be 30 to 50 cm; the cabezon is the largest sculpin and can be as long as 100 cm. Most sculpins spawn in the winter. All species lay eggs, but in some genera, fertilization is internal. The female commonly lays demersal eggs amongst rocks where they are guarded by males. Egg incubation duration is unknown; larvae were found across broad areas of the shelf and slope all year-round in ichthyoplankton collections from the southeast Bering Sea 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. The approximate upper size limit of juvenile fish is unknown.

Yellow Irish lords: They are distributed from subtidal areas near shore to the edge of the continental shelf (down to 200 m) throughout the Bering Sea, Aleutian Islands, and eastward into the GOA as far as Sitka, Alaska. They grow up to 40 cm in length. Twelve to 26 mm larvae have been 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 and throughout the Bering Sea and GOA. They are rarely over 30 cm in length and spawn 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 Bering Sea, from Hokkaido, Japan, Sea of Okhotsk, and Chukchi Sea, to the southeast Bering Sea and in the Aleutian Islands. They are found at 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 Bering Sea and Aleutian Islands, and throughout the GOA. They are up to 70 cm in length.

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

Plain sculpin: They are distributed throughout the Bering Sea and GOA (not common in the Aleutian Islands) from intertidal areas to depths of about 100 m, but most common in shallow waters (less than 50 m). They are 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.

D.22.2 Fishery

Sculpins are not a target of groundfish fisheries of the GOA, but sculpin bycatch (which comprises 75 percent of the other species complex biomass) has ranged from 500 to 1,600 mt per year in the GOA. Bycatch occurs principally in bottom trawl fisheries for flatfish, Pacific cod, and rockfish, and in the Pacific cod pot fishery; in 2007 about 20 percent of sculpins were retained. Since 2006 sculpin bycatch has increased due to the capture of large sculpins in the shallow water flatfish fishery (Reuter and TenBrink 2008). Bycatch of sculpin species is about 5 percent of total sculpin biomass in the GOA.

D.22.3 Relevant Trophic Information

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

D.22.4 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 (MCS-OCS?)	D	R (others?)	U	
Larvae	U	copepods	all year?	ICS-MCS, OCS, US	N,P	NA?	U	
Juveniles and Adults	U	bottom invertebrates (crabs, molluscs, barnacles) and small fish	all year	BCH, ICS, MCS, OCS, USP	D	R, S, M, SM	U	

D.22.5 Literature

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D.23 Sharks

The species representatives for sharks are:

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

D.23.1 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, aplacental, viviparous (with small litters, one to four pups, and embryos nourished by yolk sac, oophagy, and/or 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 Bering Sea, and off Japan. In groundfish fishery and survey data, they occur chiefly on outer shelf/upper slope areas in the Bering Sea, but near the coast to the outer shelf in the GOA, particularly near Kodiak Island. They are not commonly seen in the Aleutian Islands. 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 Bering Sea principally on the outer shelf and upper slope (but has been observed nearshore). It is generally demersal (but also seen near surface). Other members of the Squalidae are aplacental viviparous, but fertilization and development of sleeper sharks are not known. Adults are up to 8 m in length. They are 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 Bering Sea, but near coast to the outer shelf in the GOA, particularly near Kodiak Island.

Spiny dogfish are widely distributed through the Atlantic, Pacific, and Indian Oceans. In the north Pacific, they may be most abundant in the GOA, but also occur in the Bering Sea. 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 aplacental viviparous, with litter size proportional to the size of the female. Litter size ranges from 2 to 23 and averages 10. 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 80+ years. Fifty percent of females are mature at 97 cm and 35 years old; males are mature at 74 cm and 21 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.23.2 Fishery

Sharks are not a target of groundfish fisheries of BSAI or GOA, but shark bycatch has ranged from 187 to 1,603 mt per year in the BSAI from 1997 to 2008; 409 to 1,603 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.23.3 Relevant Trophic Information

Sharks are top level predators in the GOA; the only likely predator would be larger fish preying on young/small sharks. Spiny dogfish tend be opportunistic and generalist feeders (Tribuzio et al. 2008), feeding more on invertebrates (such as shrimp and hermit crabs) when young and having a more varied diet when older, including fish species (forage fish, rockfish, and some salmon). Salmon shark feed primarily on squid and larger fish species (e.g., pollock and salmon). Pacific sleeper shark diet is less well known; a study by Sigler et al. (2006) found squid to be a major component, but also found flesh from grey whale and harbor seal in the stomachs. However, results were inconclusive as to whether the prey was scavenged or hunted.

D.23.4 Habitat and Biological Associations

Egg/Spawning: Salmon sharks and spiny dogfish are aplacental viviparous; 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 eastern Bering Sea; apparently they are not as commonly found in the Aleutian Islands and are not commonly found at depths greater than 200 m.

Salmon sharks are found throughout the GOA, but are less common in the eastern Bering Sea and Aleutian Islands; they are epipelagic and are found primarily over shelf/slope waters in the GOA and on the outer shelf in the eastern Bering Sea.

Sleeper sharks are widely dispersed on shelf/upper slope in the GOA and along the outer shelf/upper slope only in the eastern Bering Sea; they are generally demersal and may be less commonly found in the Aleutian Islands.

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, MCS. OCS, US in GOA	P	NA	U	
Sleeper shark	U	omnivorous; flatfish, cephalopods, rockfish, crabs, seals, salmon, pinnipeds	all year	ICS, MCS, OCS, US in GOA	D	U	U	
Spiny dogfish	80+ years	fish (smelts, herring, sand lance, and other small schooling fish), crustaceans (crabs, euphausiids, shrimp), and cephalopods (octopus)	all year	ICS, MCS, OCS in GOA give birth ICS in fall/winter?	P	U	U	euhaline 4–16 °C

D.23.5 Literature

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D.24 Octopuses

There are at least seven species of octopuses currently identified from the GOA, including one species of genus *Octopus* that has not been fully described (*Octopus sp. A*, Conners and Jorgensen 2008). The species most abundant at depths less than 200 m is the giant Pacific octopus *Enteroctopus dofleini* (formerly *Octopus dofleini*). Several species are found primarily in deeper waters along the shelf break and slope, including, *Benthoctopus leioderma* and the cirrate octopus *Opisthoteuthis* cf *californiana. Octopus californicus* is reported from the eastern GOA at depths ranging from 100 to 1,000 m. *Japetella diaphana* and bathypelagic finned species *Vampyroteuthis infernalis* are found in pelagic waters of the GOA. Preliminary evidence (Conners and Jorgensen 2008, Conners et al. 2004) indicates that octopus taken as incidental catch in groundfish fisheries are primarily *Enteroctopus dofleini*. This species has been extensively studied in British Columbia and Japan, and is used as the primary indicator for the assemblage. Species identification of octopuses in the Bering Sea and GOA has changed since the previous essential fish habitat review and is still developing. The state of knowledge of octopuses in the GOA, including the true species composition, is very limited.

D.24.1 Life History and General Distribution

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

In the GOA, octopuses are found from subtidal waters to deep areas near the outer slope. The highest diversity is along the shelf break region of the GOA, although, unlike the Bering Sea, there is a high abundance of octopuses on the shelf. While octopuses were observed throughout the GOA, they are more commonly observed in the Central and Western GOA (statistical areas 610, 620, and 630) than in the Eastern GOA. The greatest number of observations is clustered around the Shumagin Islands and Kodiak Island. These spatial patterns are influenced by the distribution of fishing effort. Alaska Fisheries Science Center survey data also show the presence of octopus throughout the GOA but also indicate highest biomass in areas 610 and 630. Octopuses were caught at all depths ranging from shallow inshore areas (mostly pot catches) to trawl and longline catches on the continental slope at depths to nearly 1,000 m. The majority of octopus caught with pots in the GOA came from 40 to 60 fathoms (70 to 110 m); catches from longline vessels tended to be in deeper waters of 200 to 400 fathoms (360 to 730 m). The distribution of octopuses between state waters (within three miles of shore) and federal waters remains unknown. *Enteroctopus dofleini* in Japan undergo seasonal depth migrations associated with spawning; it is unknown whether similar migrations occur in Alaskan waters.

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

E. dofleini is sexually mature after approximately three years. In Japan, females weigh between 10 to 15 kg at maturity while males are 7 to 17 kg (Kanamaru and Yamashita 1967). *E. dofleini* in the Bering Sea may mature at larger sizes given the more productive waters in the Bering Sea. *E. dofleini* in Japan move to deeper waters to mate during July through October and move to shallower waters to spawn during October through January. There is a 2-month lag time between mating and spawning. This time may be necessary for the females to consume extra food to last the seven months required for hatching of the eggs, during which time the female guards and cleans the eggs but does not feed. *E. dofleini* is a terminal spawner, females die after the eggs hatch while males die shortly after mating. While females may have 60,000 to 100,000 eggs in their ovaries, only an average of 50,000 eggs are laid (Kanamaru 1964). Hatchlings are approximately 3.5 mm. Mottet (1975) estimated survival to 6 mm at 4 percent, while survival to 10 mm was estimated to be 1 percent; mortality at the 1 to 2 year stage was also estimated to be high (Hartwick 1983). Since the highest mortality occurs during the larval stage it is likely that ocean conditions have the largest effect on the number of *E. dofleini* in the Bering Sea and large fluctuations in numbers of *E. dofleini* should be expected.

Octopus californicus is a medium-sized octopus, maximum total length of approximately 40 cm. Very little is known about this species of octopus. It is collected between 100 and 1,000 m. It is believed to spawn 100 to 500 eggs. Hatchlings are likely benthic; hatchling size is unknown. The female likely broods the eggs and dies after hatching.

Octopus sp. A is a small-sized species, maximum total length less than 10 cm. This species has only recently been identified in the GOA and its full taxonomy has not been determined. *Octopus sp. A* is likely a terminal spawner with a life-span of 12 to 18 months. The eggs of *Octopus sp. A* are likely much larger than those of *O. rubescens*, as benthic larvae are often bigger; they could take up to six months or more to hatch. Females have 80 to 90 eggs.

Benthoctopus leioderma is a medium-sized species, maximum total length approximately 60 cm. Its life span is unknown. It occurs from 250 to 1,400 m and is found throughout the shelf break region. It is a common octopus and often occurs in the same areas where *E. dofleini* are found. The eggs are brooded by the female but mating and spawning times are unknown. They are thought to spawn under rock ledges and crevices. The hatchlings are benthic.

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

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

V. infernalis is a relatively small (up to about 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.

D.24.2 Fishery

There is no federally managed directed fishery for octopus in the GOA. The State of Alaska allows directed fishing for octopus in state waters under a commissioner's permit. One processor in Kodiak purchases incidentally-caught octopus, primarily for halibut bait. Recent increases in market value have increased retention of incidentally-caught octopus in the GOA). Catches in federal waters are incidental, chiefly in the pot fishery for Pacific cod and bottom trawl fisheries for cod and flatfish, but sometimes in the pelagic trawl pollock fishery. Total incidental catch has ranged between an estimated 200 and 400 mt in the BSAI and 80 and 300 mt in the GOA. Most of the bycatch occurs on the outer continental shelf (100 to 200 m depth), chiefly in the western GOA around Kodiak Island and south of the Alaska peninsula in the Sanak-Shumagin region. The North Pacific Fishery Management Council is currently considering dividing the GOA "other species" category into several subgroups for separate management; one of these subgroups would be octopus (all species).

D.24.3 Relevant Trophic Information

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

D.24.4 Habitat and Biological Associations

<u>Egg/Spawning</u>: Occurs on shelf; *E. dofleini* lays strings of eggs in cave or den in boulders or rubble, which are guarded by the female until hatching. The exact habitat needs and preferences for denning are unknown.

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

Young Juveniles: 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: *Enteroctopus dofleini*, *Octopus gilbertianus*

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

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

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D.25 Capelin (*osmeridae*)

The species representative for capelin is *Mallotus villosus*.

D.25.1 Life History and General Distribution

Capelin are a short-lived marine (neritic), pelagic, filter-feeding schooling fish with a circumpolar distribution that includes the entire coastline of Alaska and the Bering Sea, and south along British Columbia to the Strait of Juan de Fuca. In the North Pacific, capelin grow to a maximum of 25 cm and 5 years of age. Capelin, which are a type of smelt, 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 and 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 the inner-mid shelf in summer (rarely found in waters deeper than about 200 m), and juveniles and adults congregate in fall in mid-shelf waters east of the Pribilof Islands, west of St. Matthew and St. Lawrence Islands, and north into the Gulf of Anadyr. They are distributed along the outer shelf and under the ice edge in winter. Larvae, juveniles, and adults have diurnal vertical migrations following scattering layers; at night they are near the surface and 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 13 cm.

D.25.2 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.25.3 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). 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 Bering Sea (Allen 1987, Yang 1993, Livingston, in prep.).

D.25.4 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 through July in Alaska (later to the north in Norton Sound). Hatching occurs in 2 to 3 weeks. Most intense spawning when coastal water temperatures are 5 to 9 ºC.

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 3 ºC), 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 and fall, feed along semi-permanent fronts separating inner, mid, and outer shelf regions (approximately 50 and 100 m). In winter, found in concentrations under ice-edge and along mid-outer shelf.

Habitat and Biological Associations: Capelin

Stage - EFH Level	Duration or Age	Diet/Prey	Season/ Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs	2 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?

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D.26 Eulachon *(osmeridae)*

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

D.26.1 Life History and General Distribution

Eulachon are a short-lived anadromous, pelagic schooling fish distributed from the Pribilof Islands in the eastern Bering Sea, throughout the GOA, and south to California. Eulachon are 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 continental shelf to over the slope. In the North Pacific, eulachon, which are a type of smelt, grow to a maximum of 23 cm and 5 years of age. They spawn at ages 3 to 5 years 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 approximately 25,000 eggs per female. Eggs adhere to sand grains and other substrates on river bottom. Eggs hatch in 30 to 40 days at 4 to 7 ºC. 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 14 cm.

D.26.2 Fishery

Eulachon and candlefish are not target species in groundfish fisheries of the BSAI or GOA, but are caught as bycatch (ranging from at least 18 to 850 mt from 2003 to 2009; observers have only consistently identified smelts to species since 2005) 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 (eastern Bering Sea); almost all are discarded. Small local coastal fisheries occur in spring and summer and eulachon are a very important subsistence resource for coastal Alaska residents.

D.26.3 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 Bering Sea (Allen 1987; Yang 1993; Livingston, in prep.).

D.26.4 Habitat and Biological Associations

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

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

Juveniles and Adults: Distributed pelagically in mid-shelf to upper slope waters (50 to 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 Shelikof Strait east 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		spawning May–June	Rivers, FW	D	S (CB?)		
	ages 3 to 5+	copepods, euphausiids	non-spawning (July–Apr)	MCS, OCS, USP	P	NA?	F?	

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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	Sablefish (eggs, larvae, late juveniles/adults)
Figures E-10 to E-12	Yellowfin sole (eggs, larvae, late juveniles/adults)
Figures E-13 and E-14	Northern rock sole (larvae, late juveniles/adults)
Figures E-13 and E-15	Southern rock sole (larvae, late juveniles/adults)
Figures E-16 to E-18	Alaska plaice (eggs, larvae, late juveniles/adults)
Figures E-19 to E-21	Rex sole (eggs, larvae, late juveniles/adults)
Figures E-22 to E-24	Dover sole (eggs, larvae, late juveniles/adults)
Figures E-25 to E-27	Flathead sole (eggs, larvae, late juveniles/adults)
Figures E-28 and E-29	Arrowtooth flounder (larvae, late juveniles/adults)
Figure E-30 and E-31	Pacific ocean perch (larvae, late juveniles/adults)
Figures E-30 and E-32	Northern rockfish (larvae, late juveniles/adults)
Figures E-30 and E-33	Shortraker rockfish (larvae, late juveniles/adults)
Figures E-30 and E-34	Blackspotted and rougheye rockfish (larvae, late juveniles/adults)
Figures E-30 and E-35	Dusky rockfish (larvae, adults)
Figures E-30 and E-36	Yelloweye rockfish (larvae, juveniles/adults)
Figures E-30 and E-37	Thornyhead rockfish (larvae, late juveniles/adults)
Figures E-38 to E-40	Atka mackerel (eggs, larvae, late juveniles/adults)
Figure E-41	Skates (adults)
Figure E-42	Squid species (late juveniles/adults)
Figure E-43	Sculpin species (juveniles/adults)

Figure E- 1 EFH Distribution – GOA Walleye Pollock (Eggs)

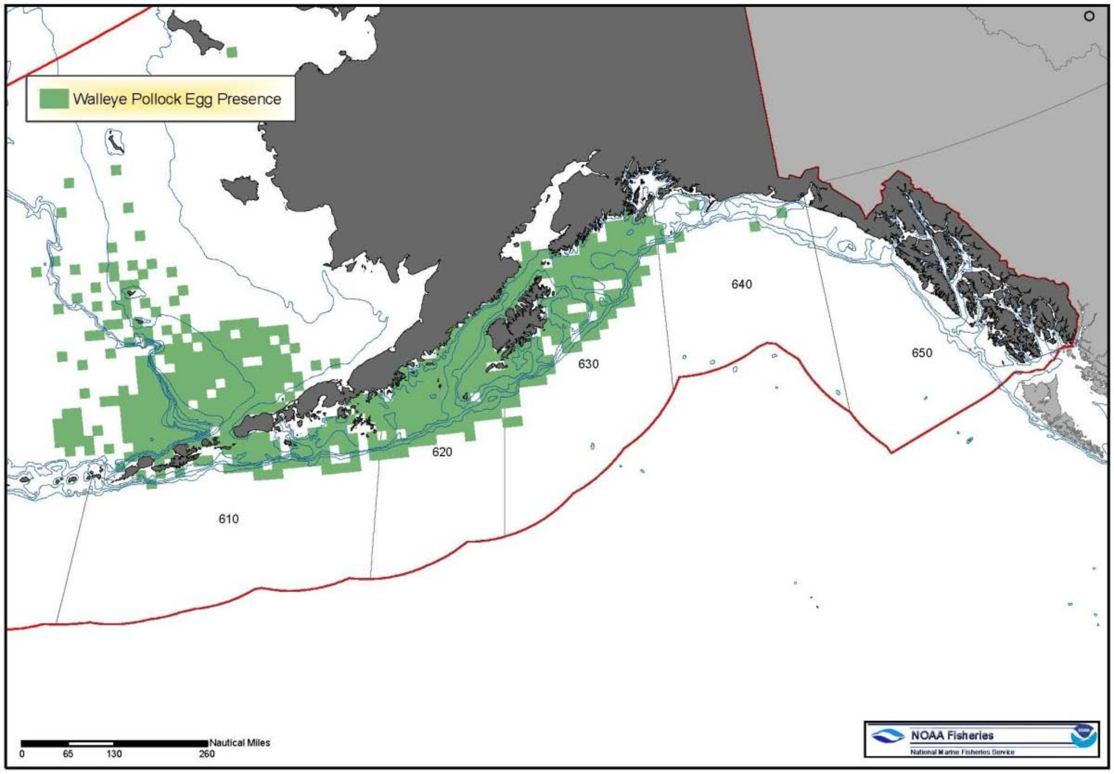


Figure E- 2 EFH Distribution – GOA Walleye Pollock (Larvae)

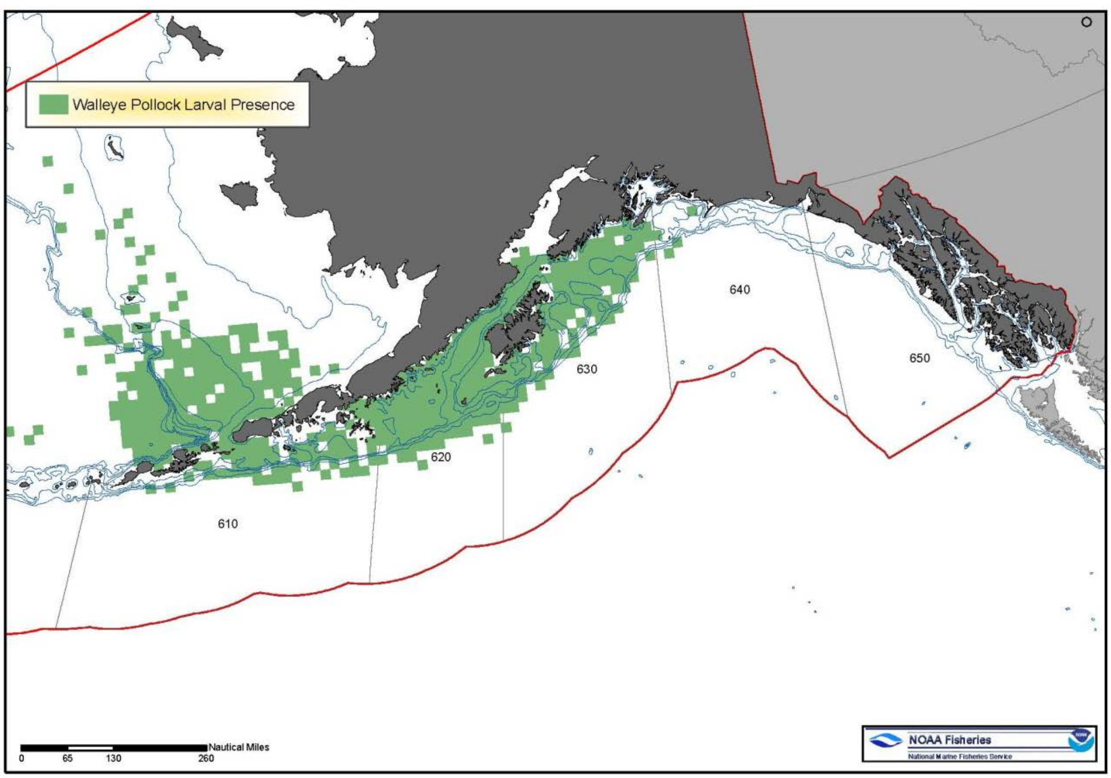


Figure E- 3 EFH Distribution – GOA Walleye Pollock (Late Juveniles/Adults)

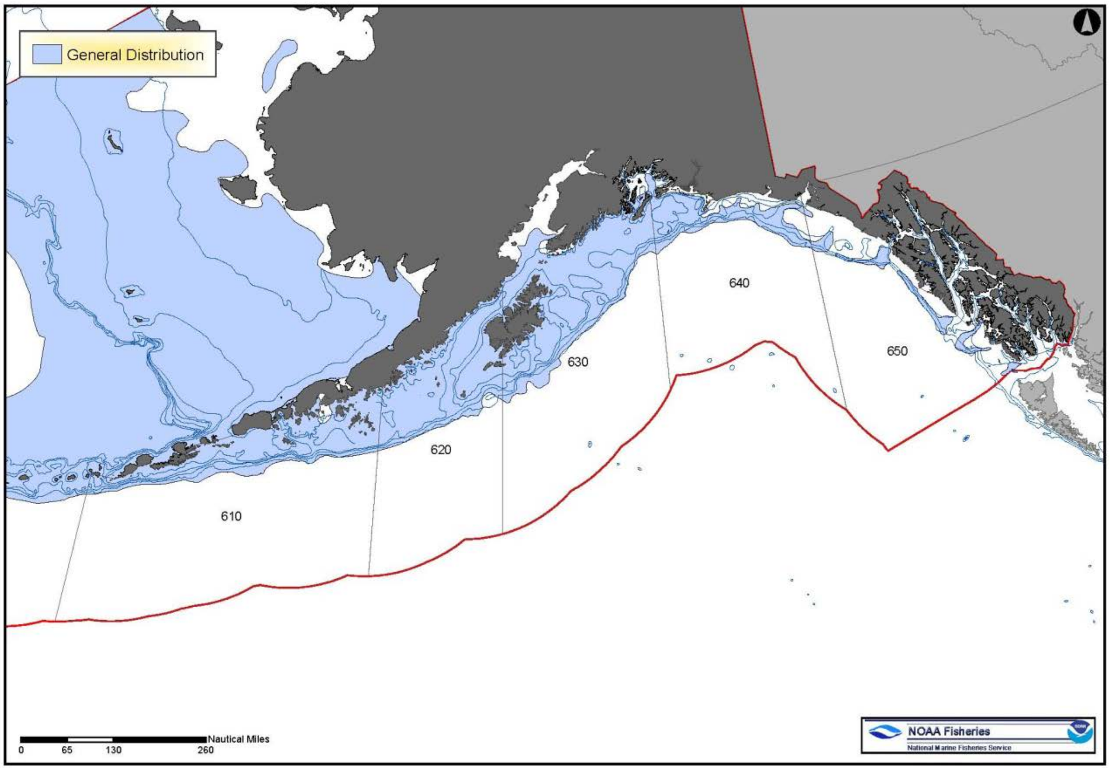


Figure E- 4 EFH Distribution – GOA Pacific Cod (Eggs)

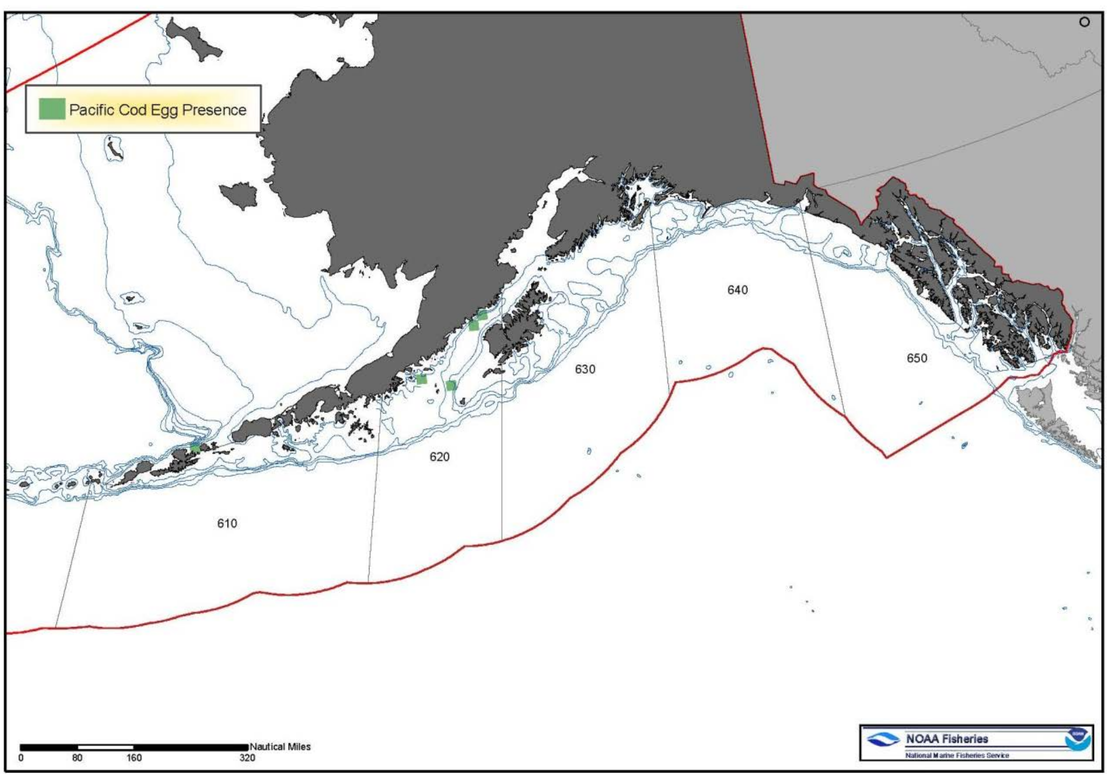


Figure E- 5 EFH Distribution – GOA Pacific Cod (Larvae)

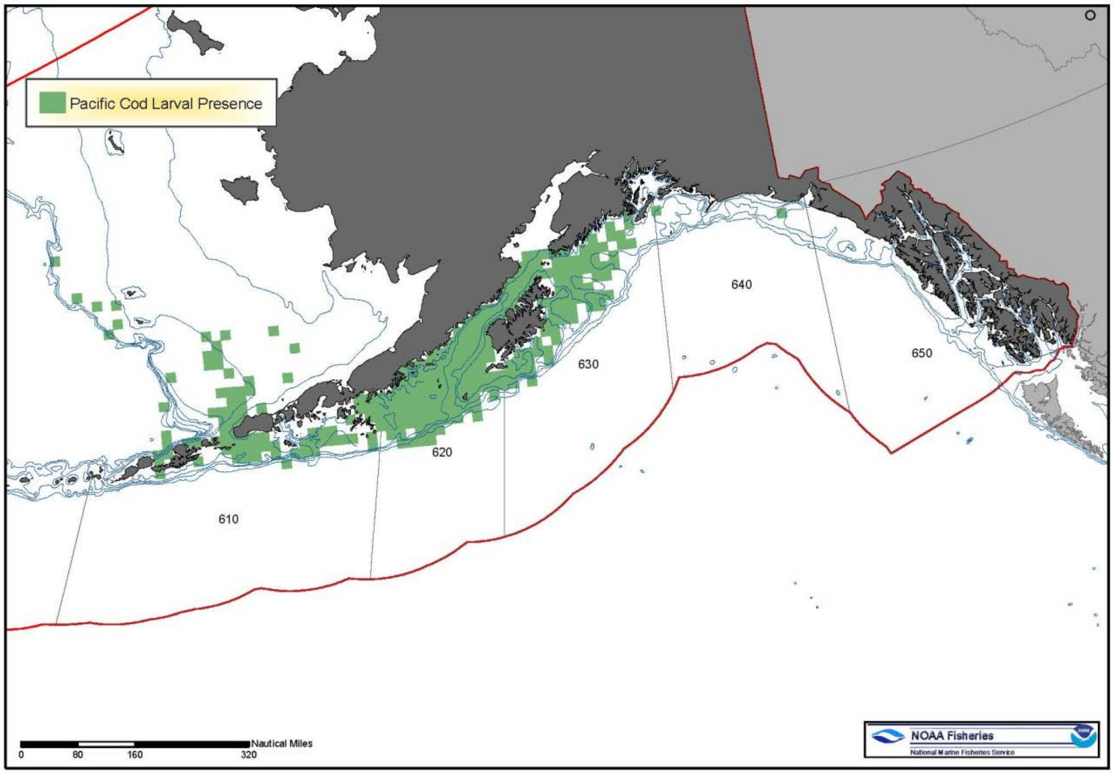


Figure E- 6 EFH Distribution – GOA Pacific Cod (Late Juveniles/Adults)

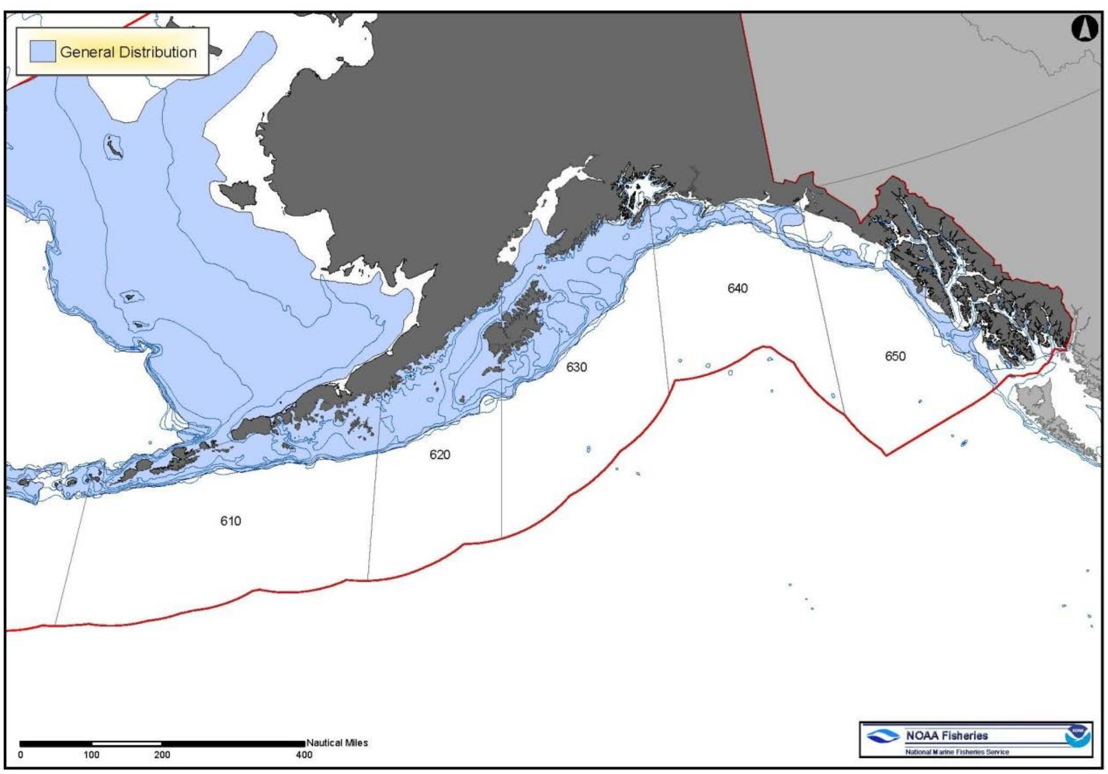


Figure E- 7 EFH Distribution – GOA Sablefish (Eggs)

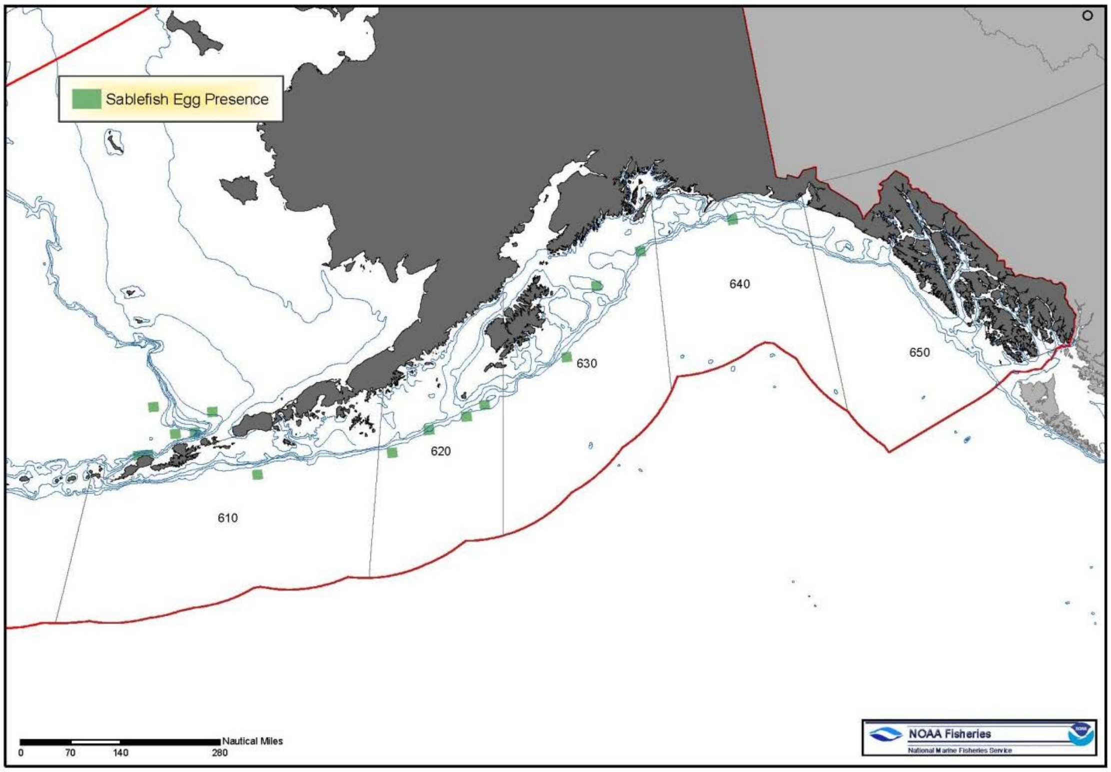


Figure E- 8 EFH Distribution – GOA Sablefish (Larvae)

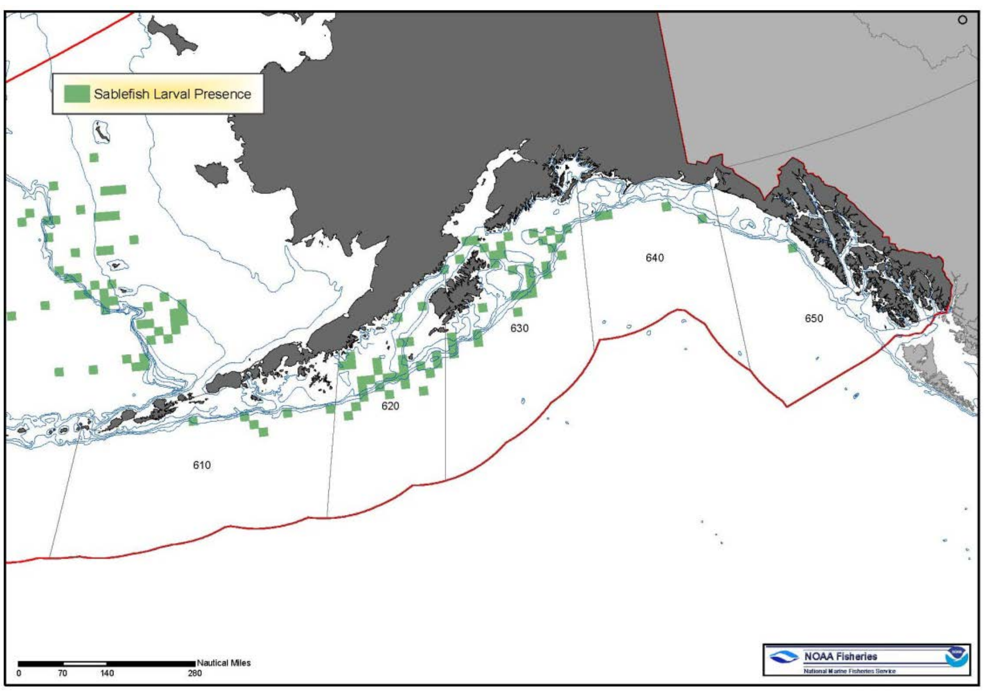


Figure E- 9 EFH Distribution – GOA Sablefish (Late Juveniles/Adults)

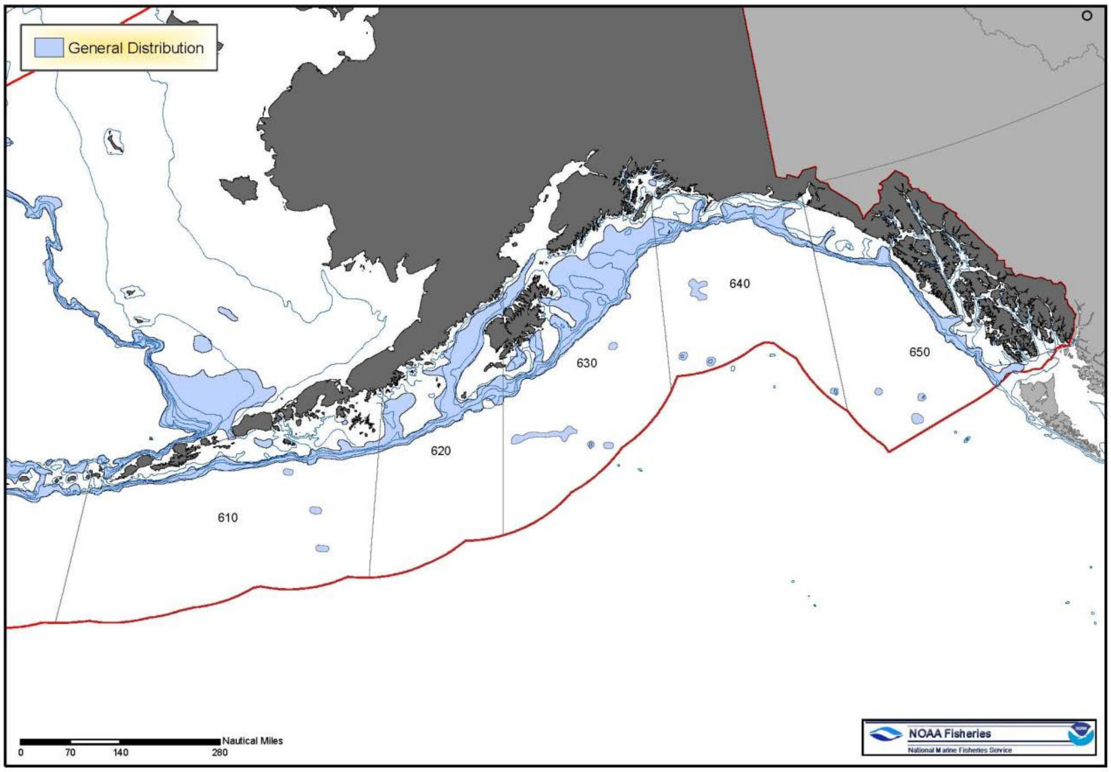


Figure E- 10 EFH Distribution – GOA Yellowfin Sole (Eggs)

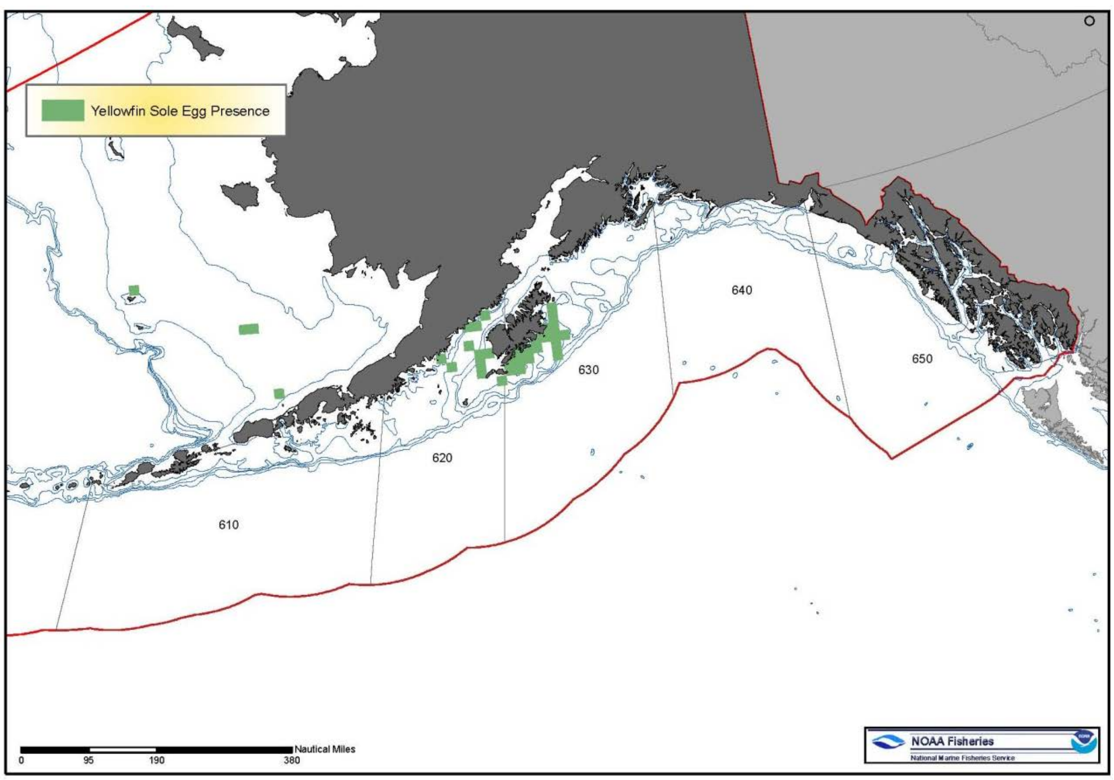


Figure E- 11 EFH Distribution – GOA Yellowfin Sole (Larvae)

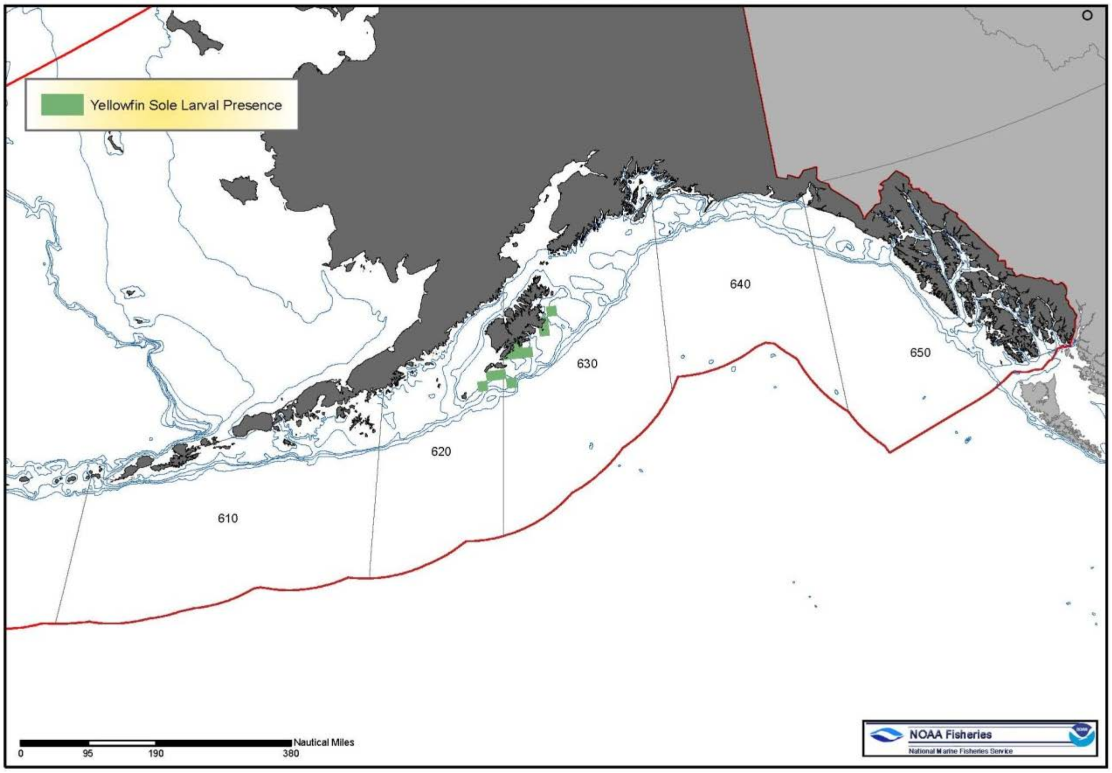


Figure E- 12 EFH Distribution – GOA Yellowfin Sole (Late Juveniles/Adults)

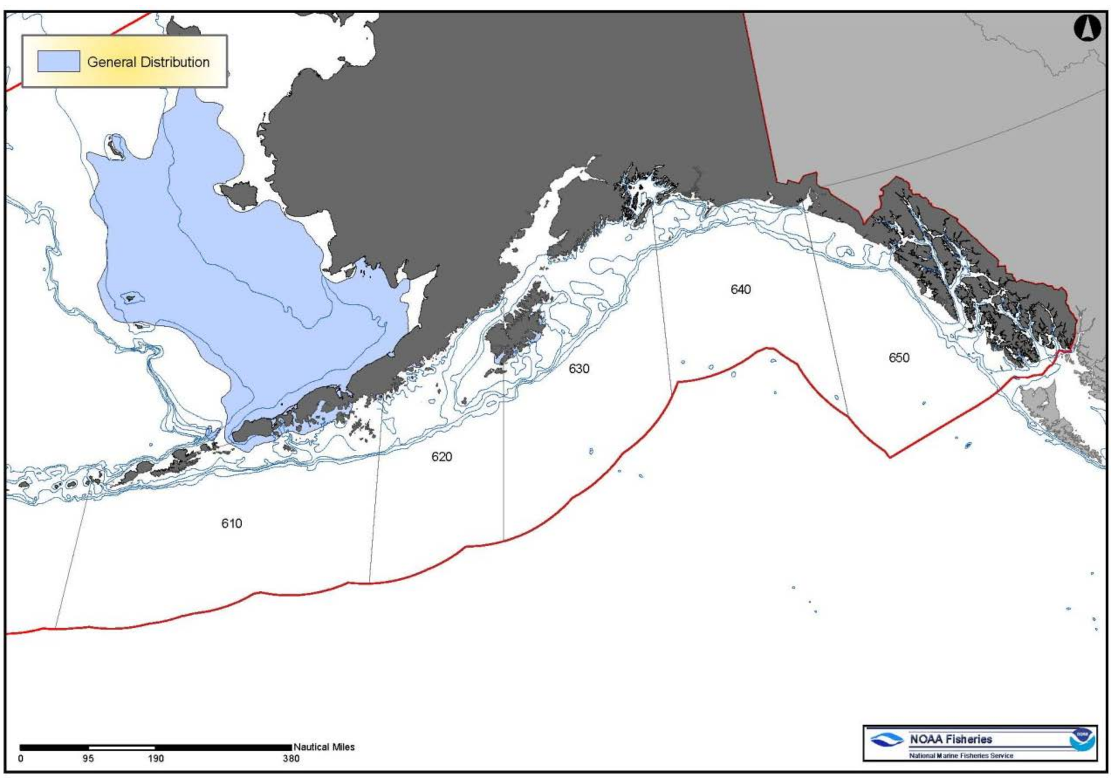


Figure E- 13 EFH Distribution – GOA Rock Sole (Larvae)

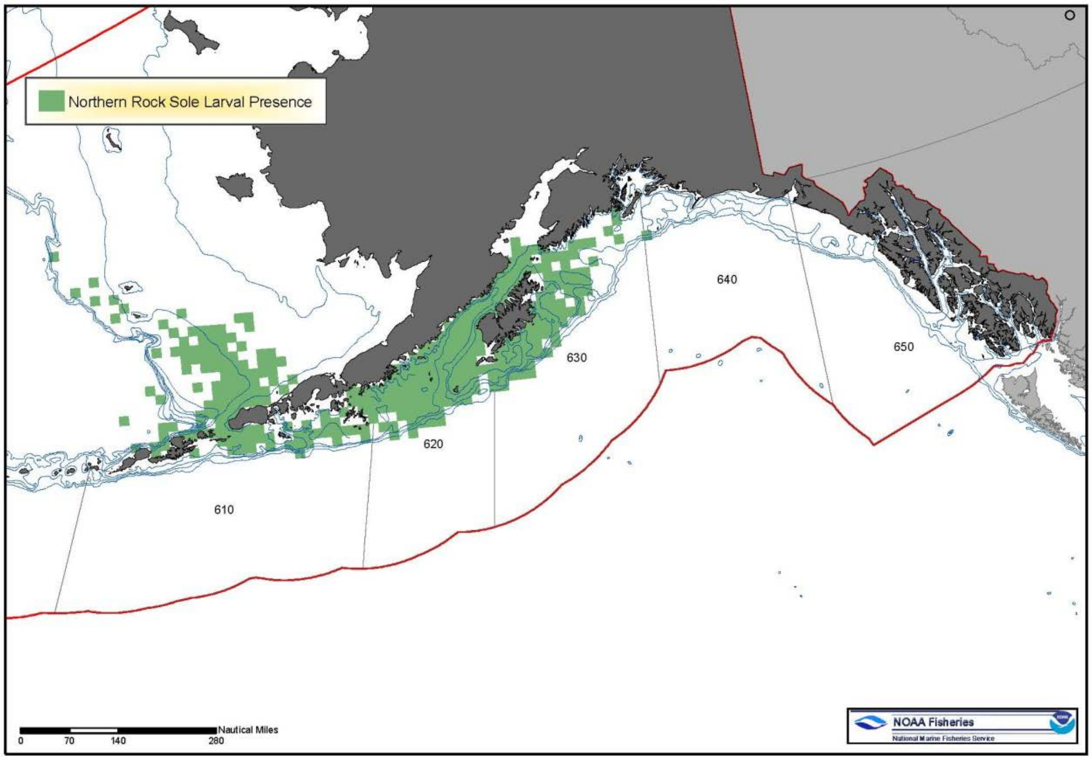


Figure E- 14 EFH Distribution – GOA Northern Rock Sole (Late Juveniles/Adults)

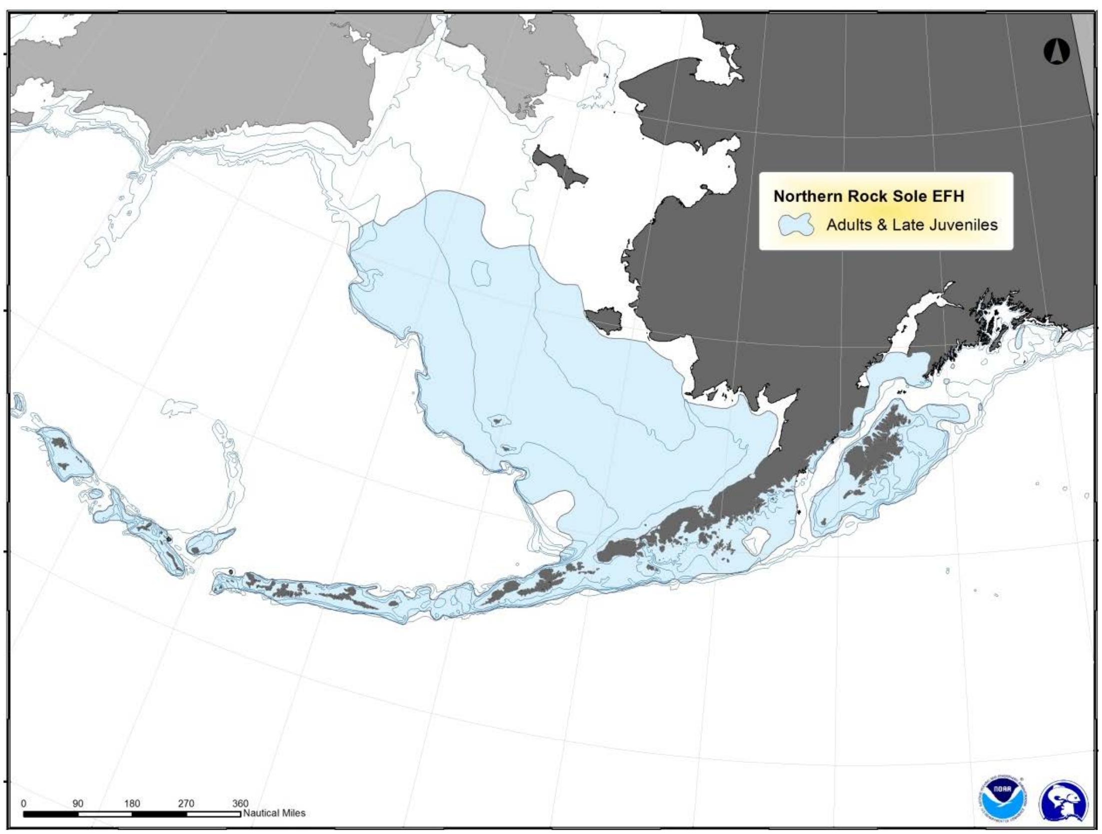


Figure E- 15 EFH Distribution – GOA Southern Rock Sole (Late Juveniles/Adults)

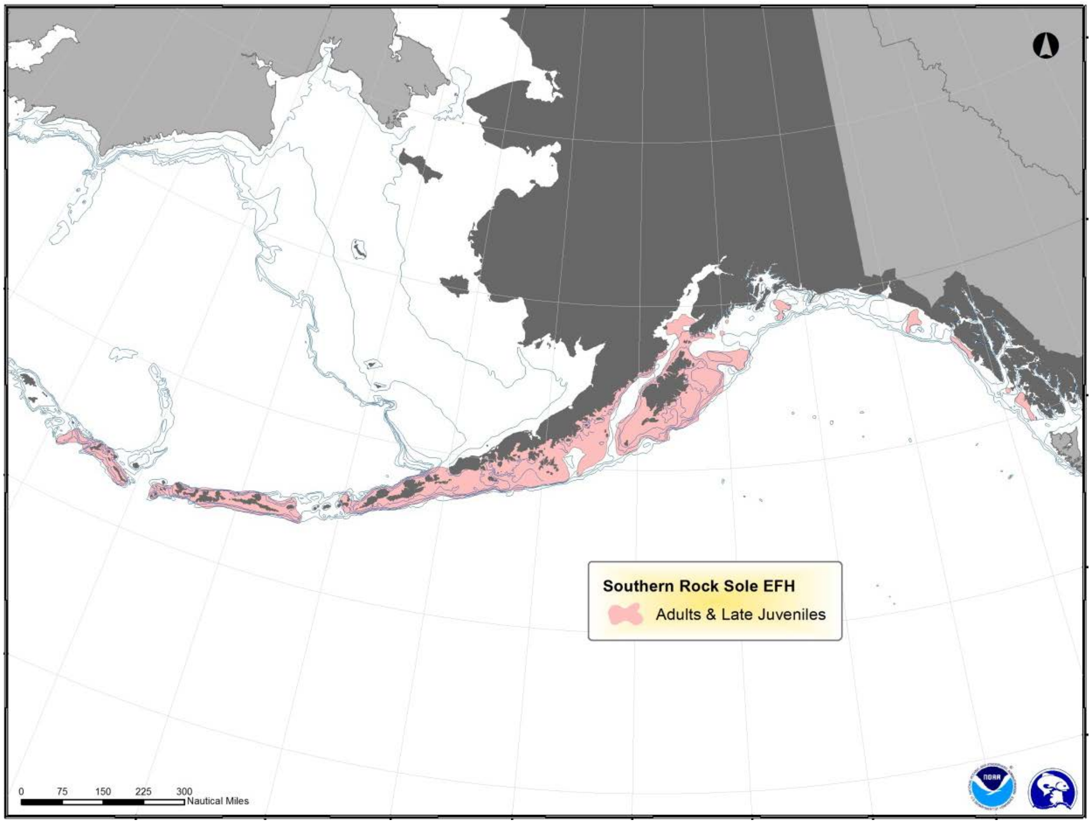


Figure E- 16 EFH Distribution – GOA Alaska Plaice (Eggs)

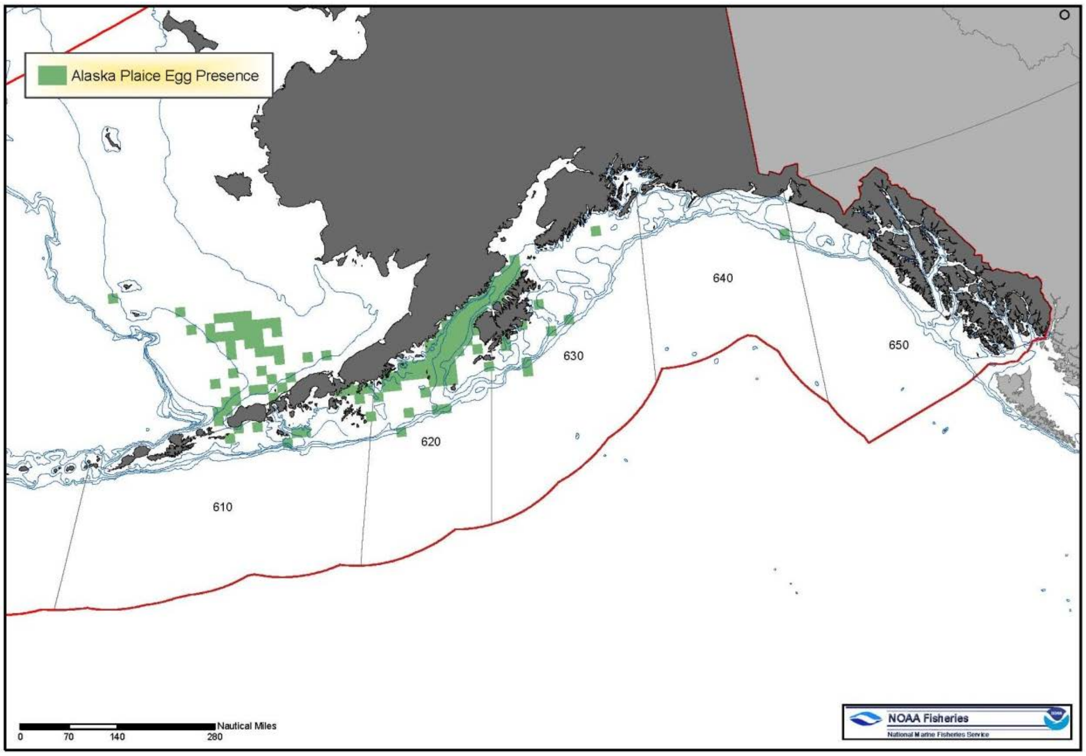


Figure E- 17 EFH Distribution – GOA Alaska Plaice (Larvae)

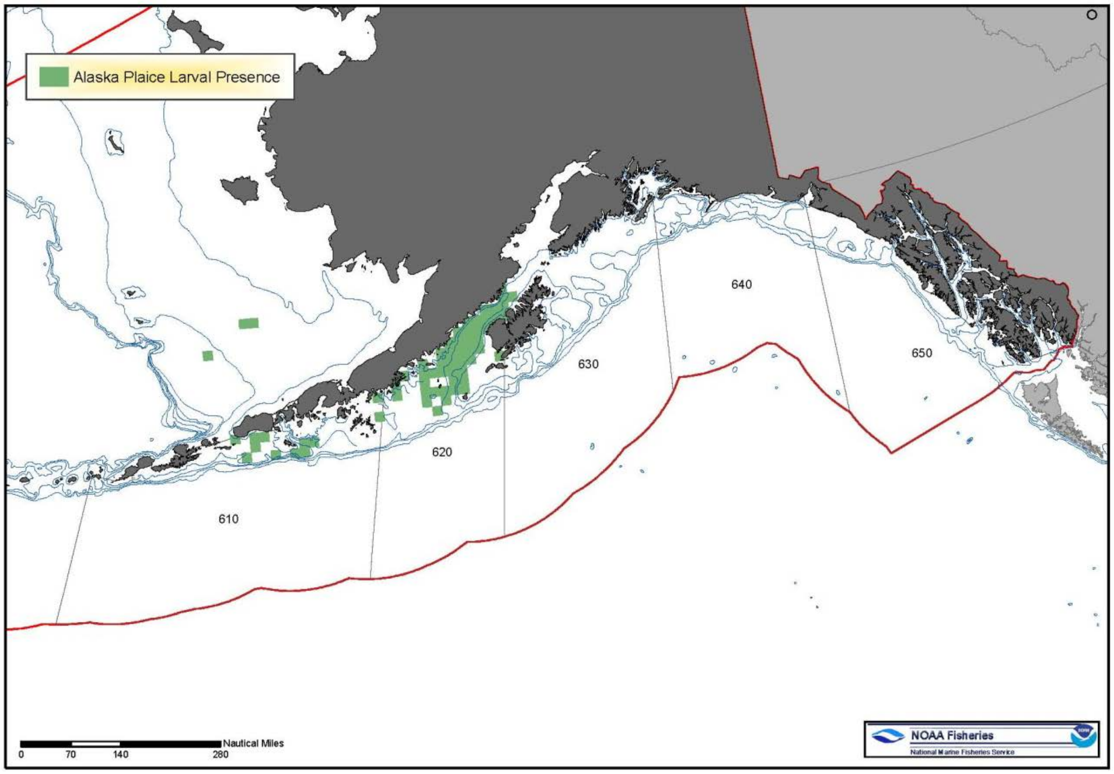


Figure E- 18 EFH Distribution – GOA Alaska Plaice (Late Juveniles/Adults)

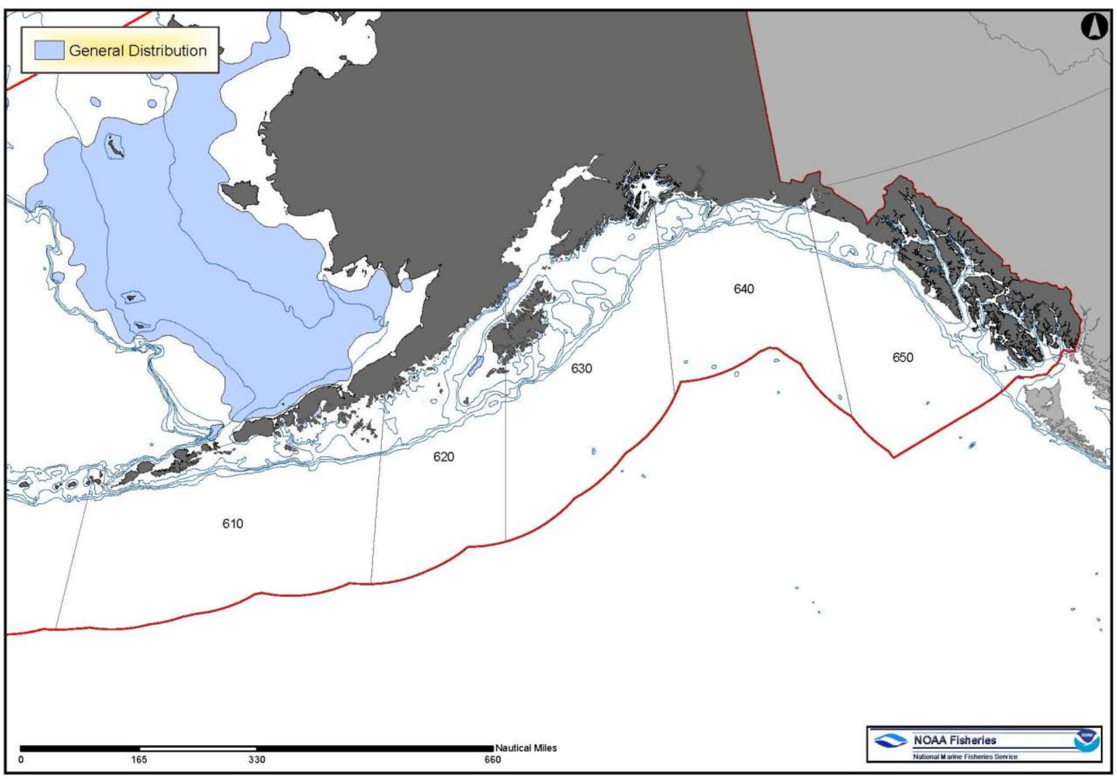


Figure E- 19 EFH Distribution – GOA Rex Sole (Eggs)

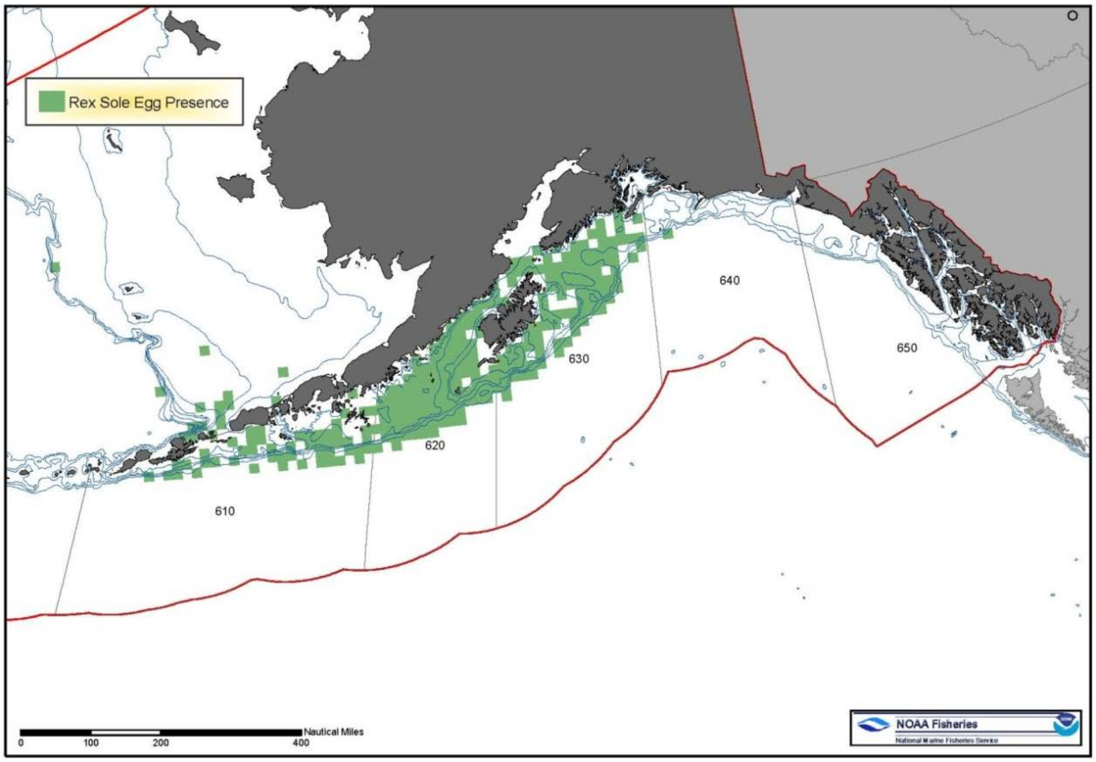


Figure E- 20 EFH Distribution – GOA Rex Sole (Larvae)

Note, EFH distribution includes both green boxes and black crosses.

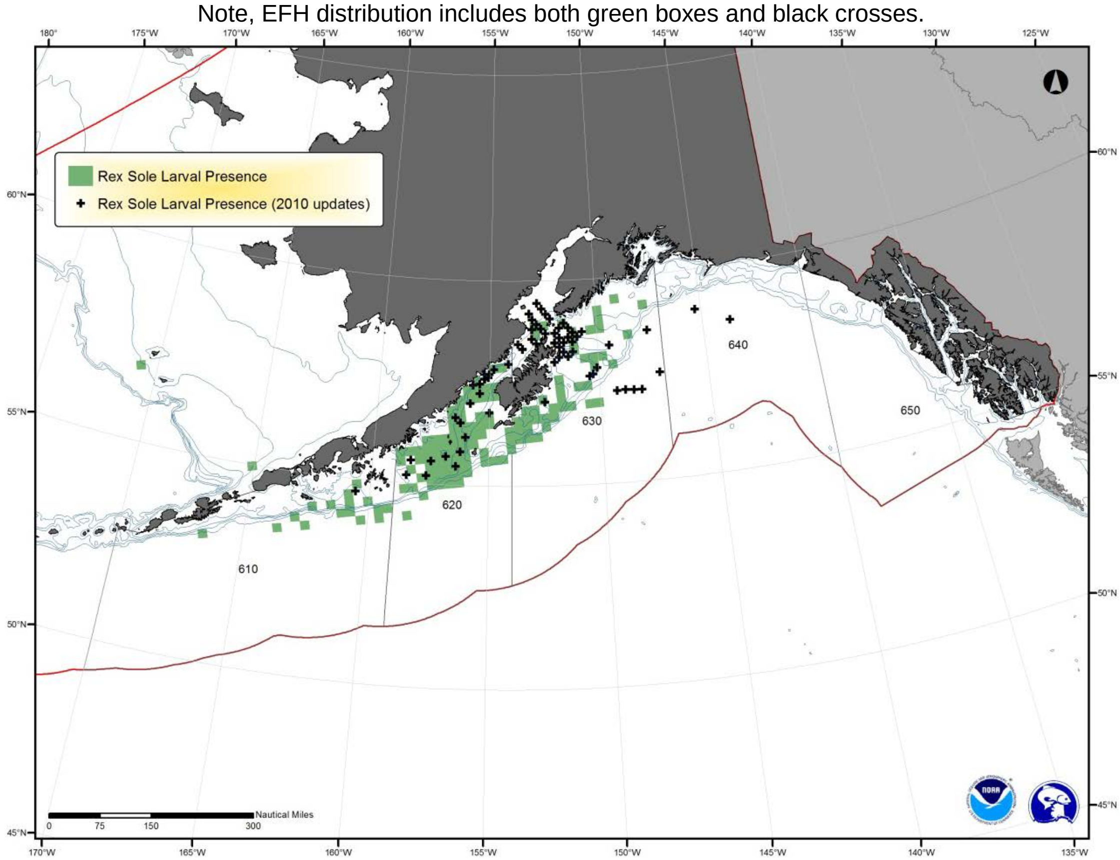


Figure E- 21 EFH Distribution – GOA Rex Sole (Late Juveniles/Adults)

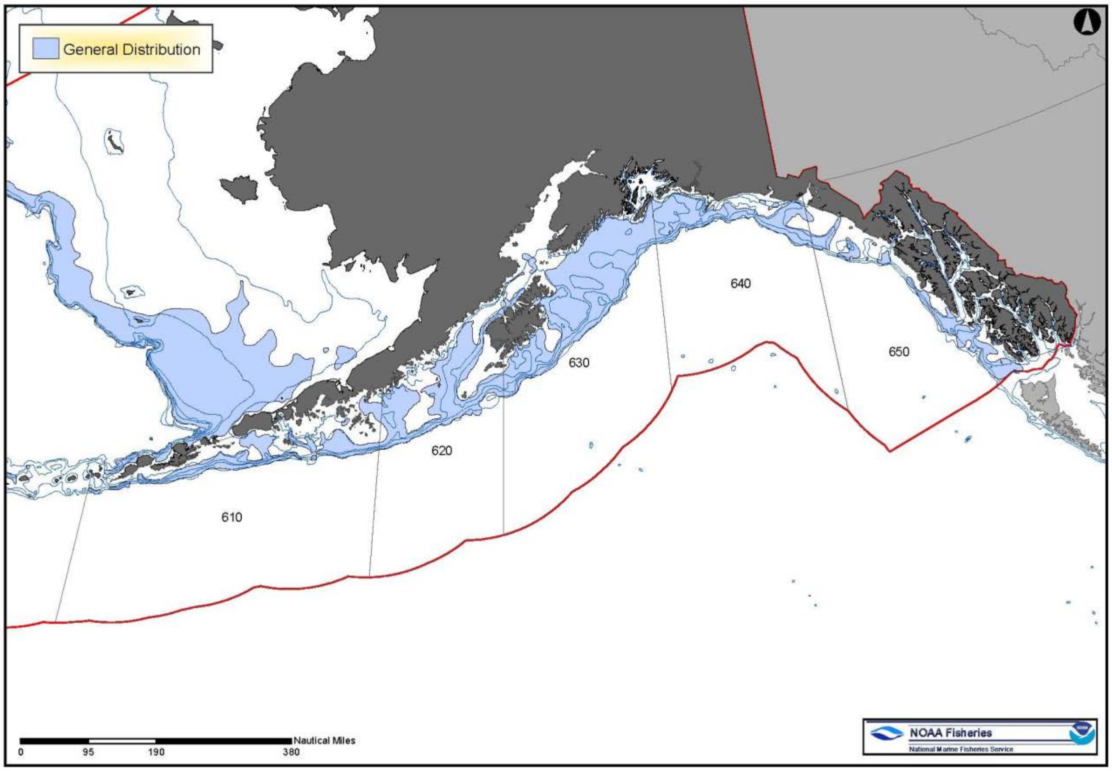


Figure E- 22 EFH Distribution – GOA Dover Sole (Eggs)

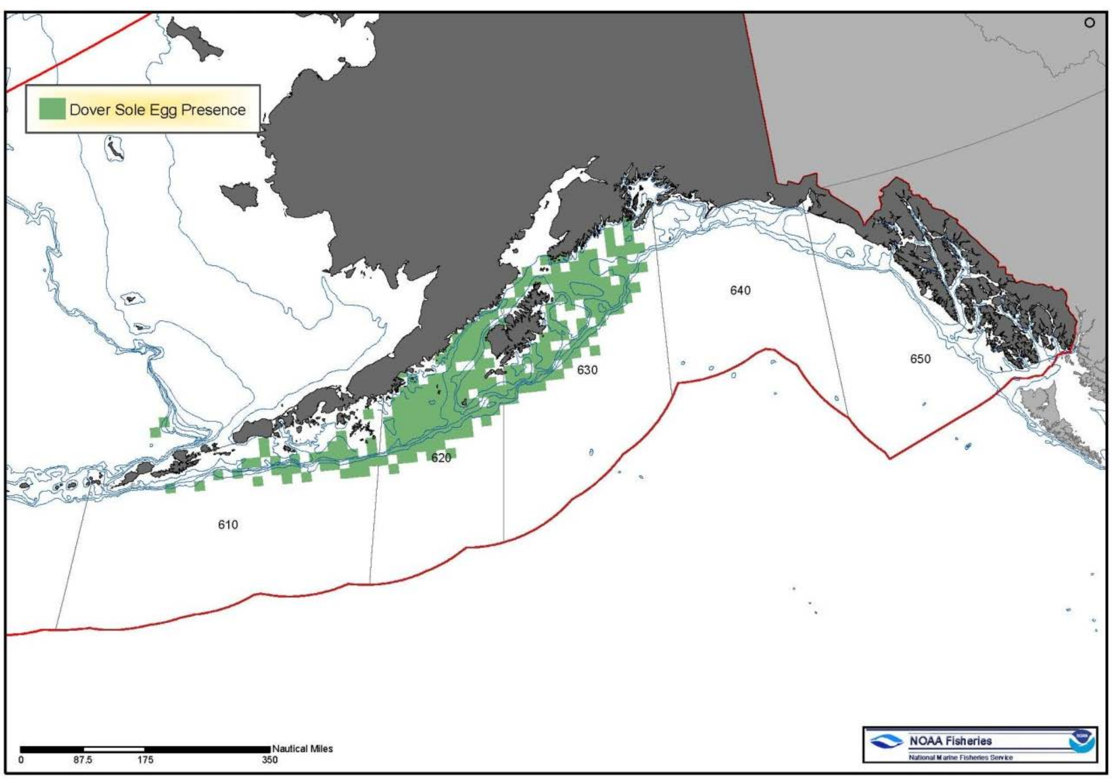


Figure E- 23 EFH Distribution – GOA Dover Sole (Larvae)

Note, EFH distribution includes both green boxes and black crosses.

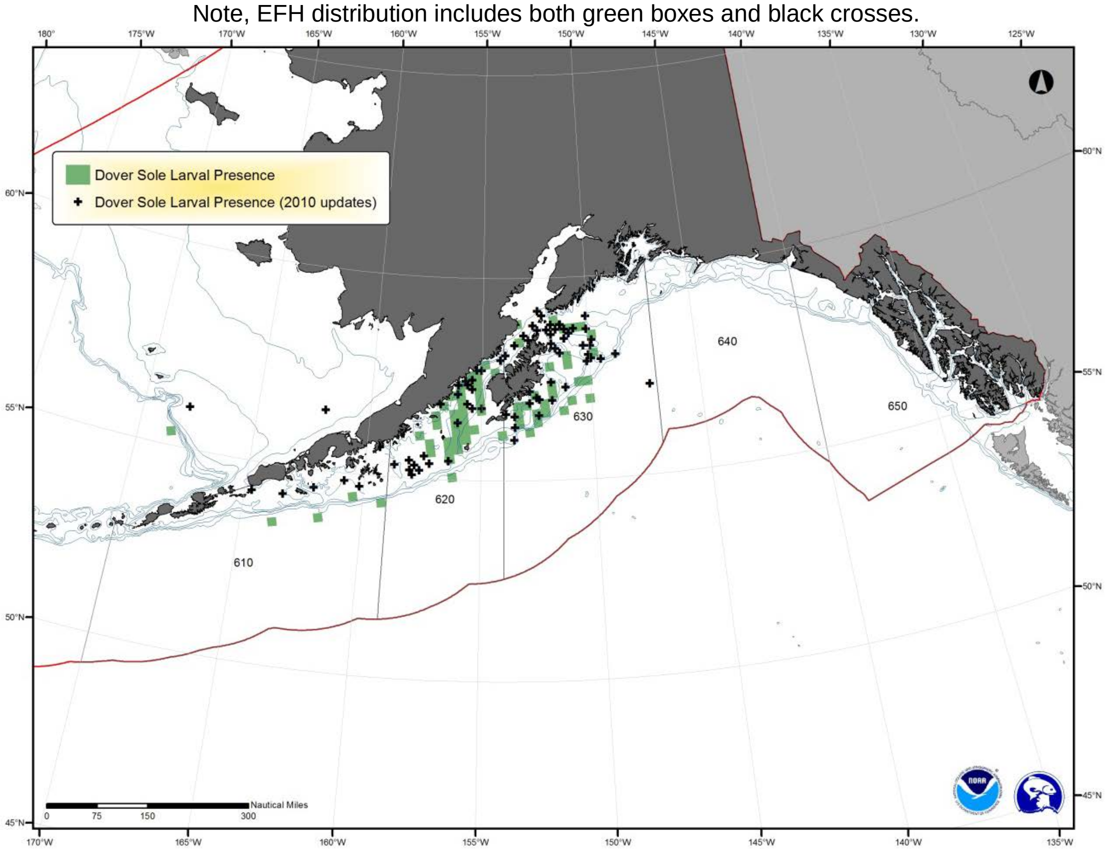


Figure E- 24 EFH Distribution – GOA Dover Sole (Late Juveniles/Adults)

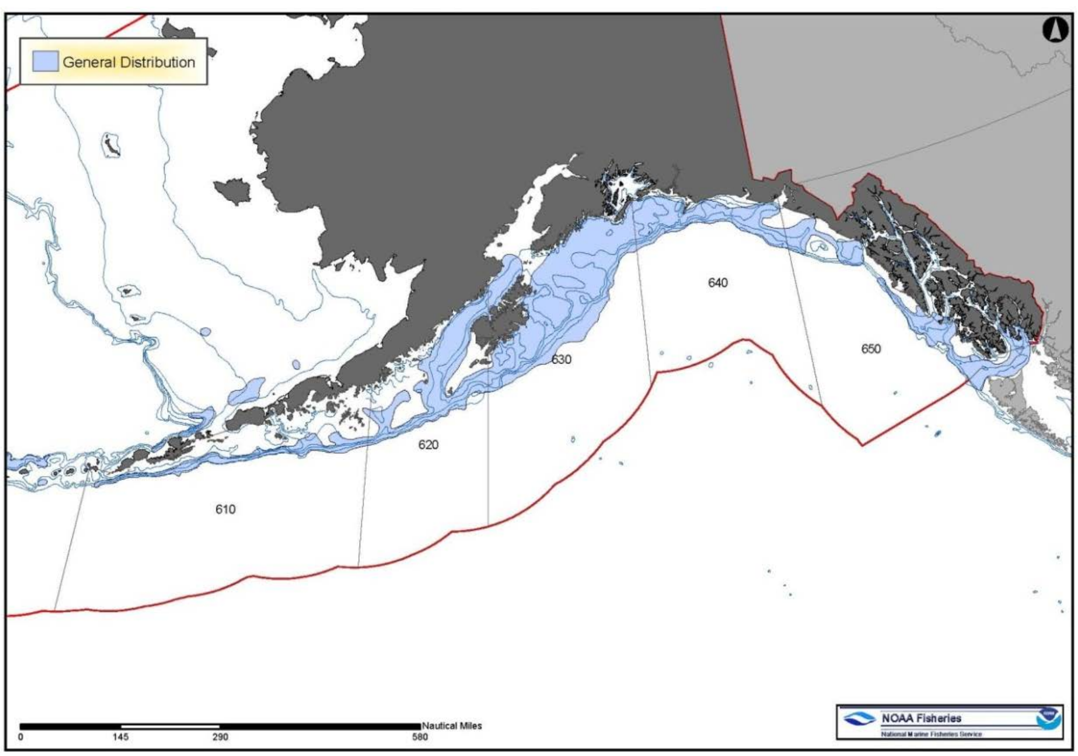


Figure E- 25 EFH Distribution – GOA Flathead Sole (Eggs)

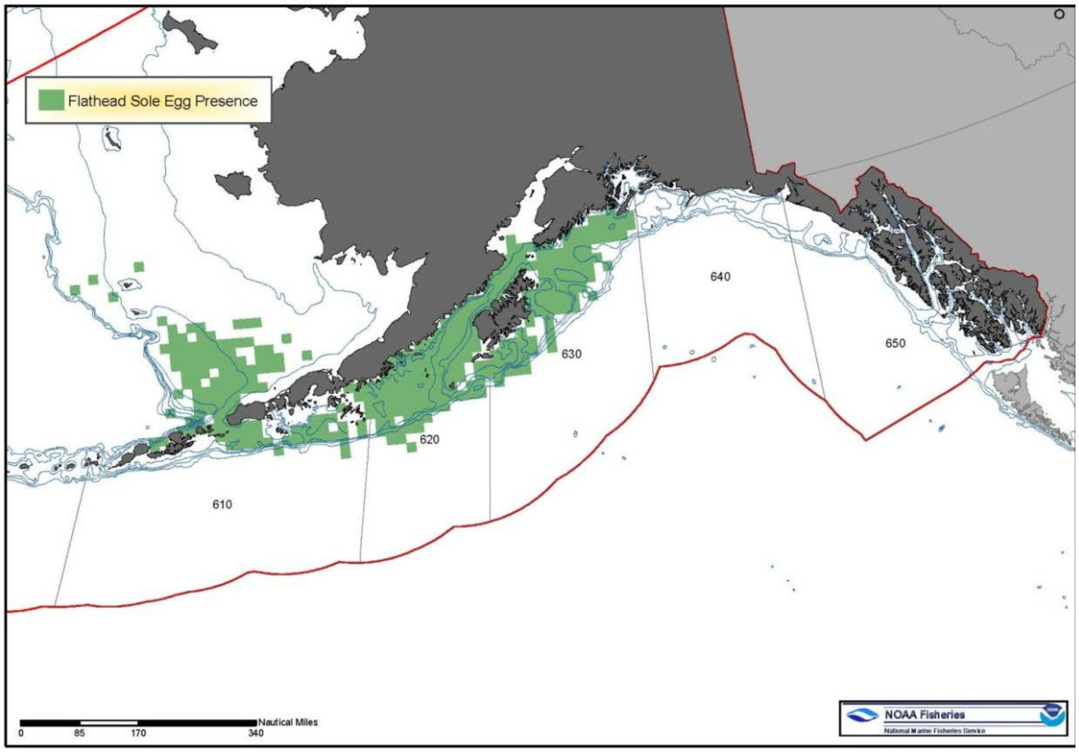


Figure E- 26 EFH Distribution – GOA Flathead Sole (Larvae)

Note, EFH distribution includes both green boxes and black crosses.

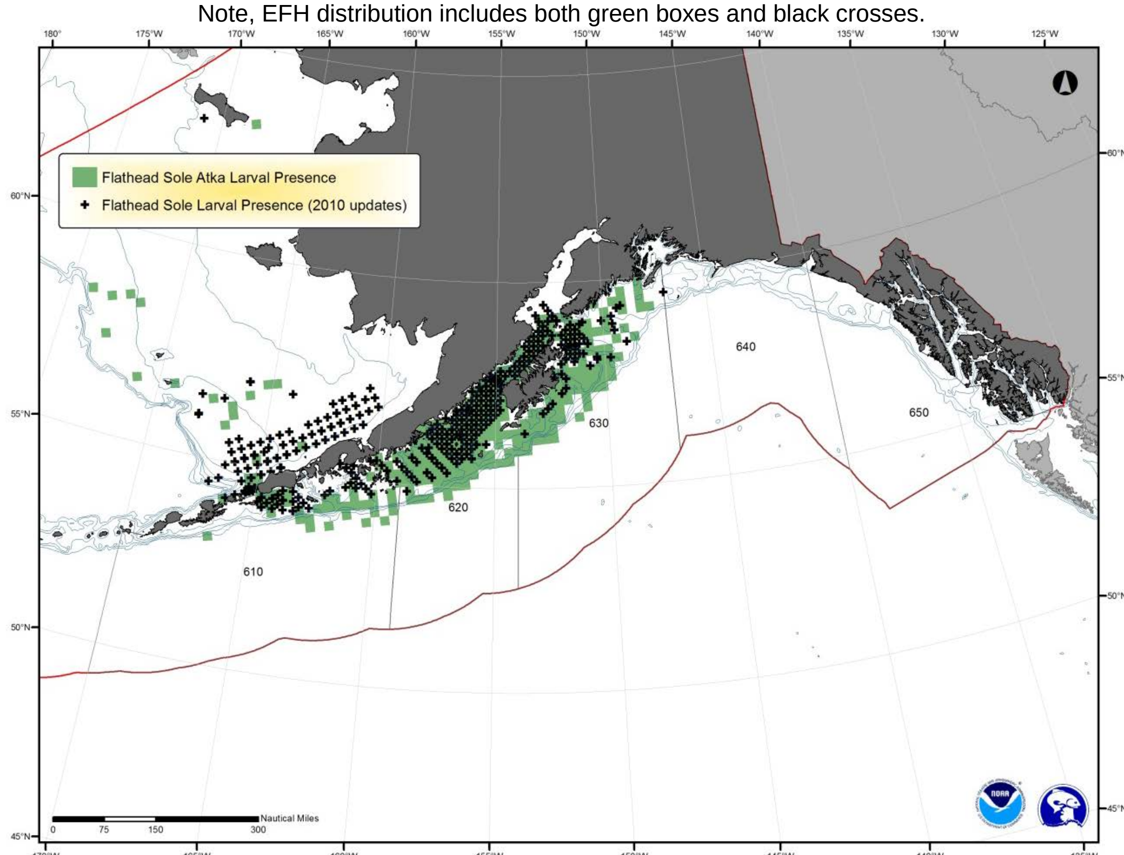


Figure E- 27 EFH Distribution – GOA Flathead Sole (Late Juveniles/Adults)

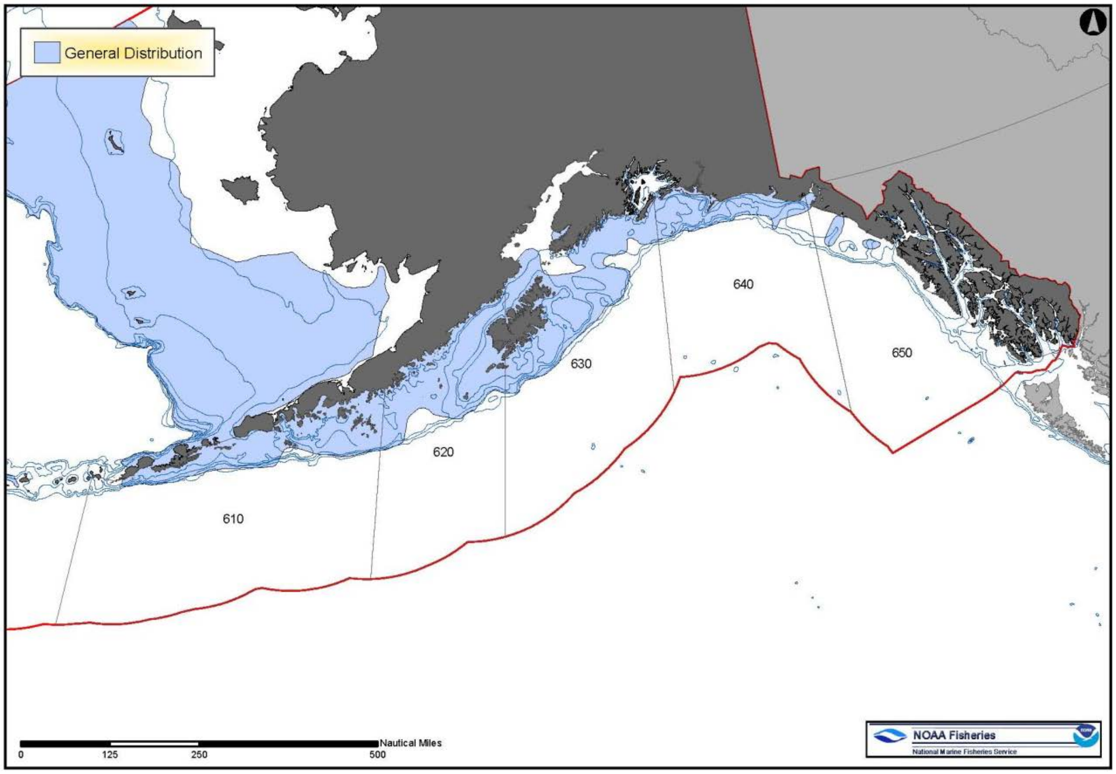


Figure E- 28 EFH Distribution – GOA Arrowtooth Flounder (Larvae)

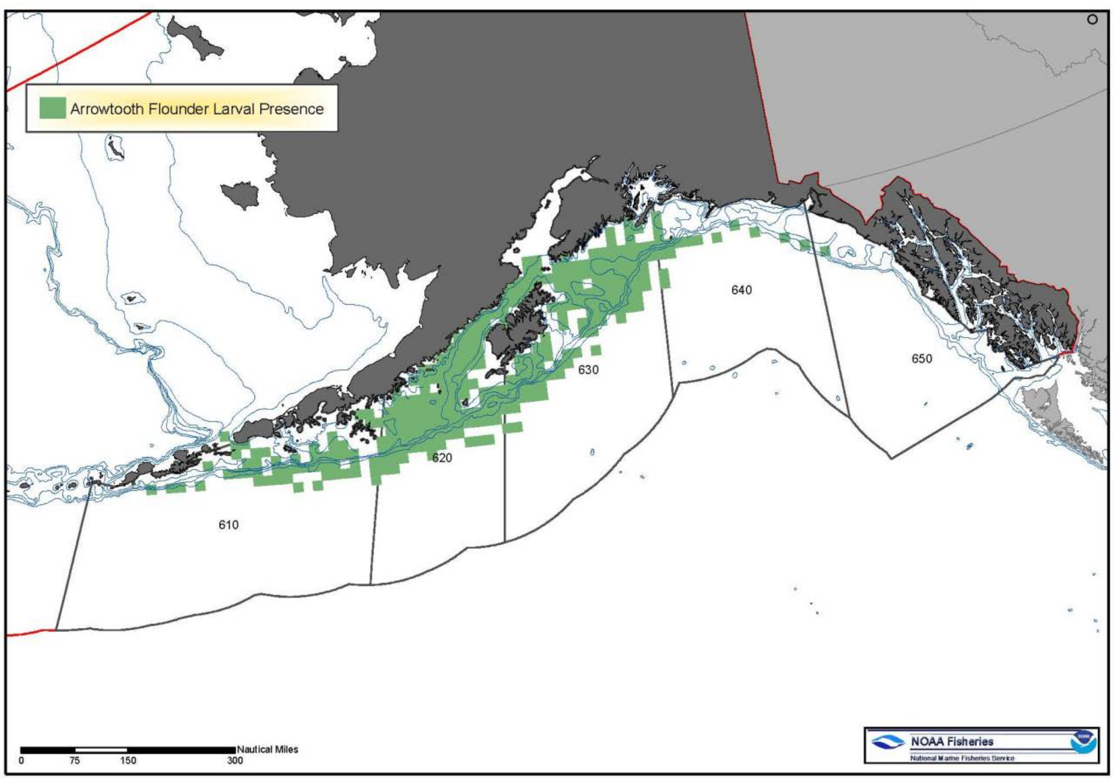


Figure E- 29 EFH Distribution – GOA Arrowtooth Flounder (Late Juveniles/Adults)

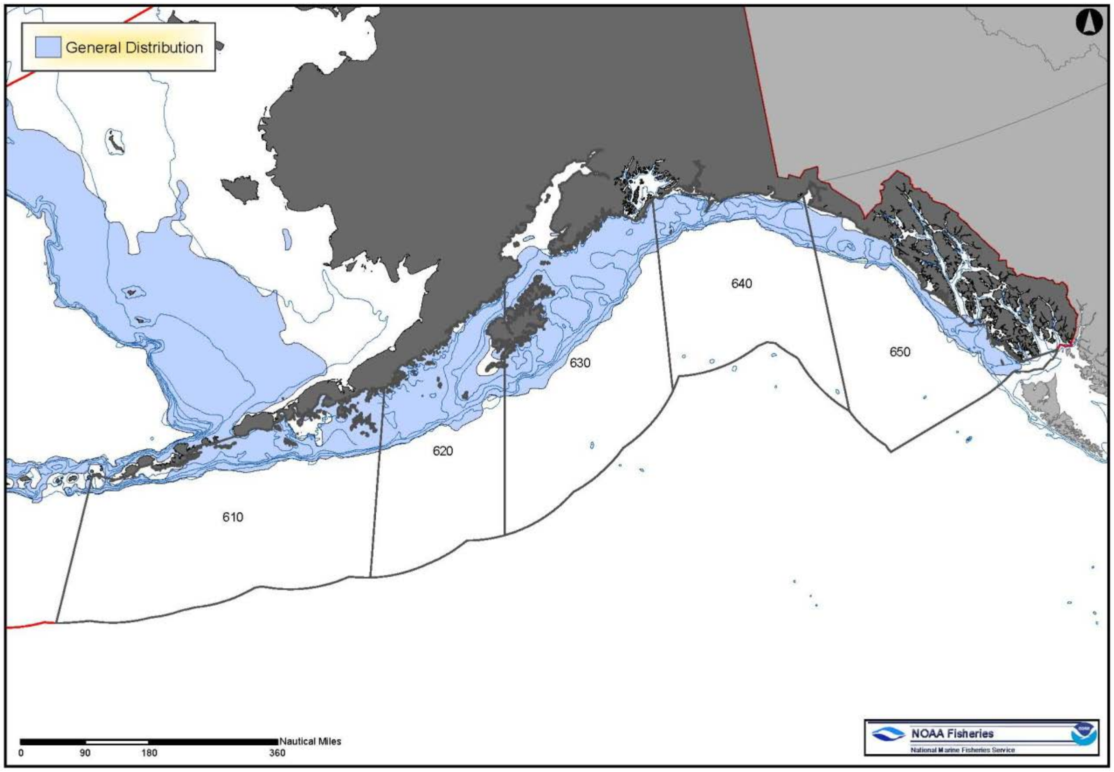


Figure E- 30 EFH Distribution – GOA Rockfish (Larvae)

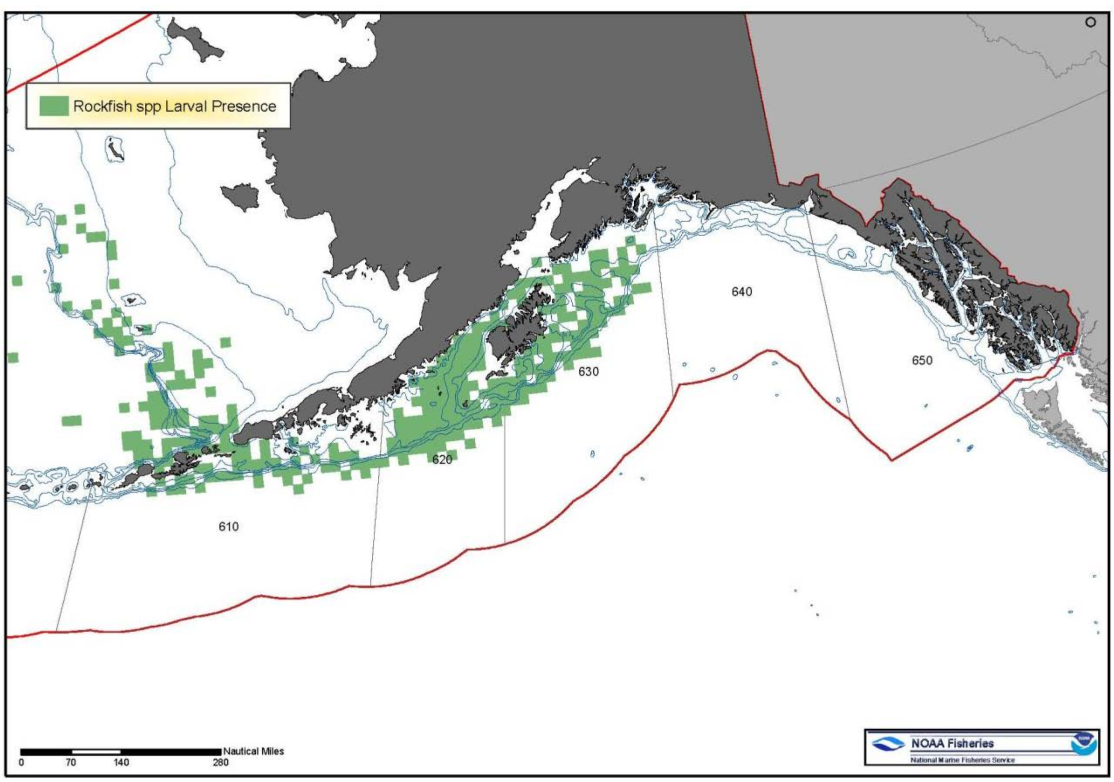


Figure E- 31 EFH Distribution – GOA Pacific Ocean Perch (Late Juveniles/Adults)

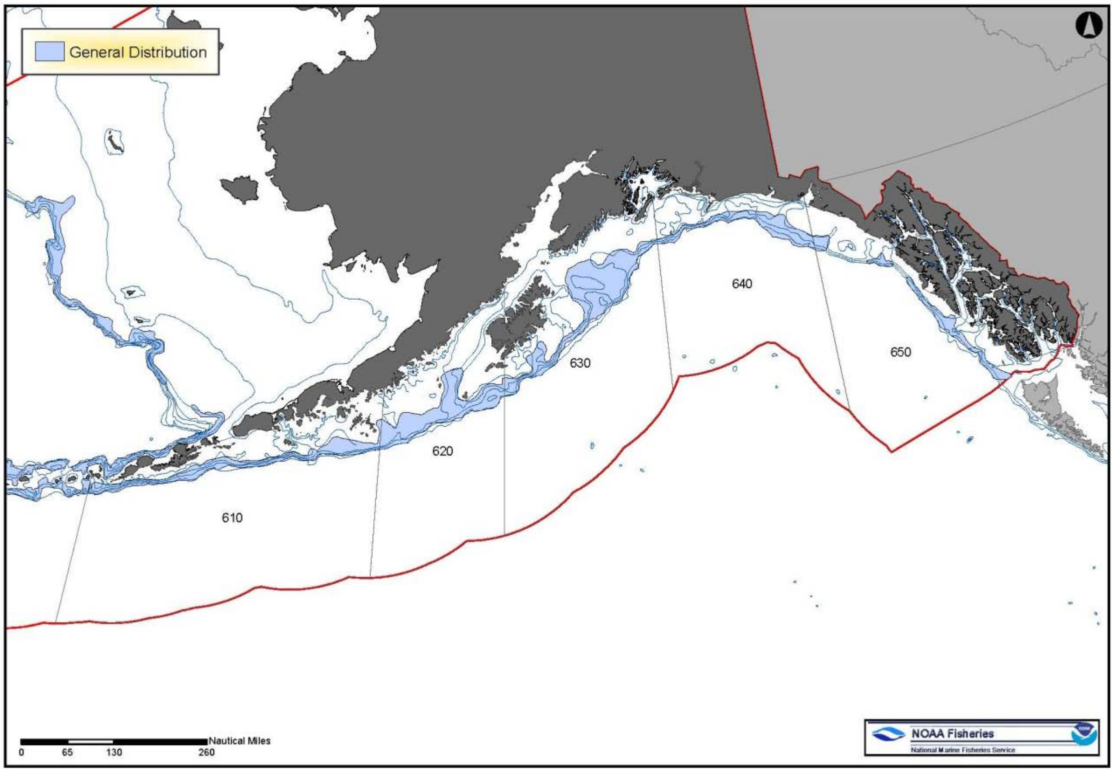


Figure E- 32 EFH Distribution – GOA Northern Rockfish (Late Juveniles/Adults)

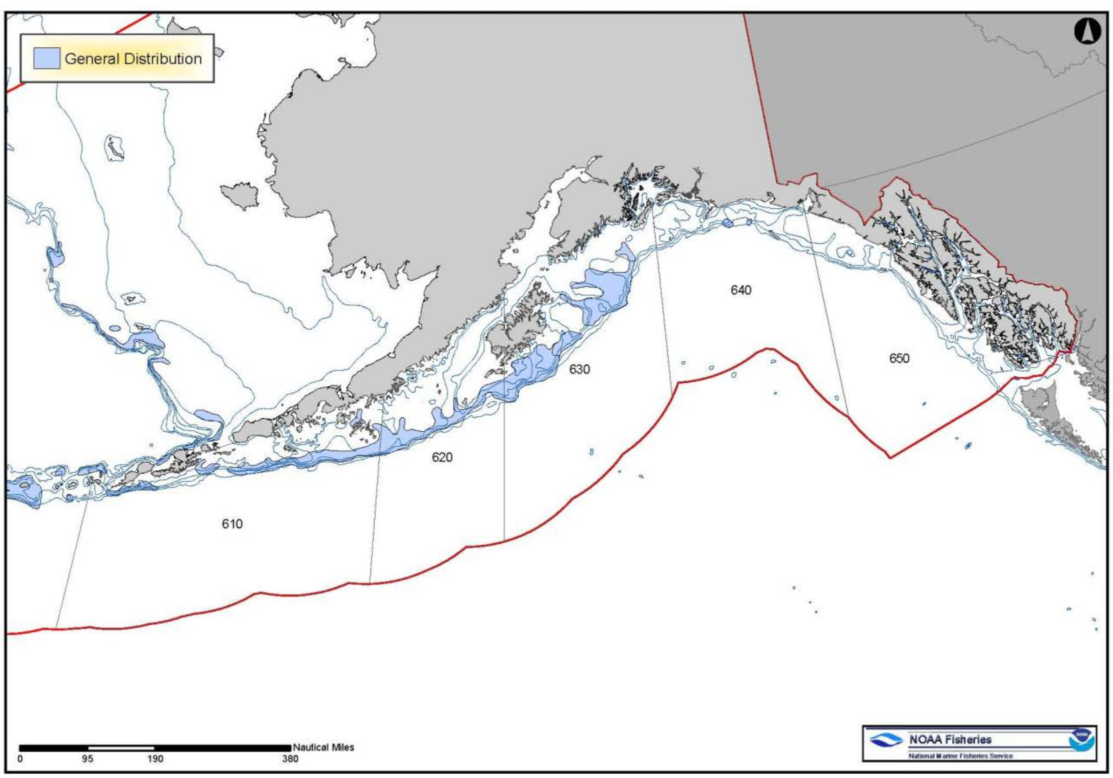


Figure E- 33 EFH Distribution – GOA Shortraker Rockfish (Late Juveniles/Adults)

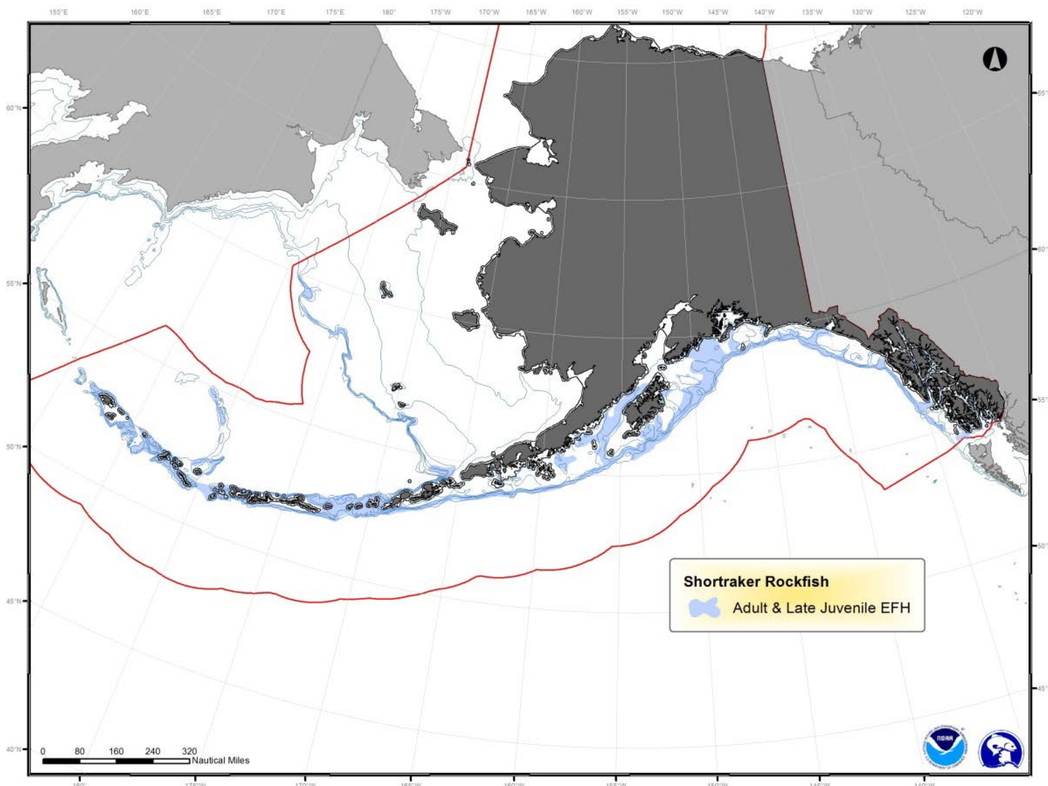


Figure E- 34 EFH Distribution – GOA Blackspotted/Rougheye Rockfish (Late Juveniles/Adults)

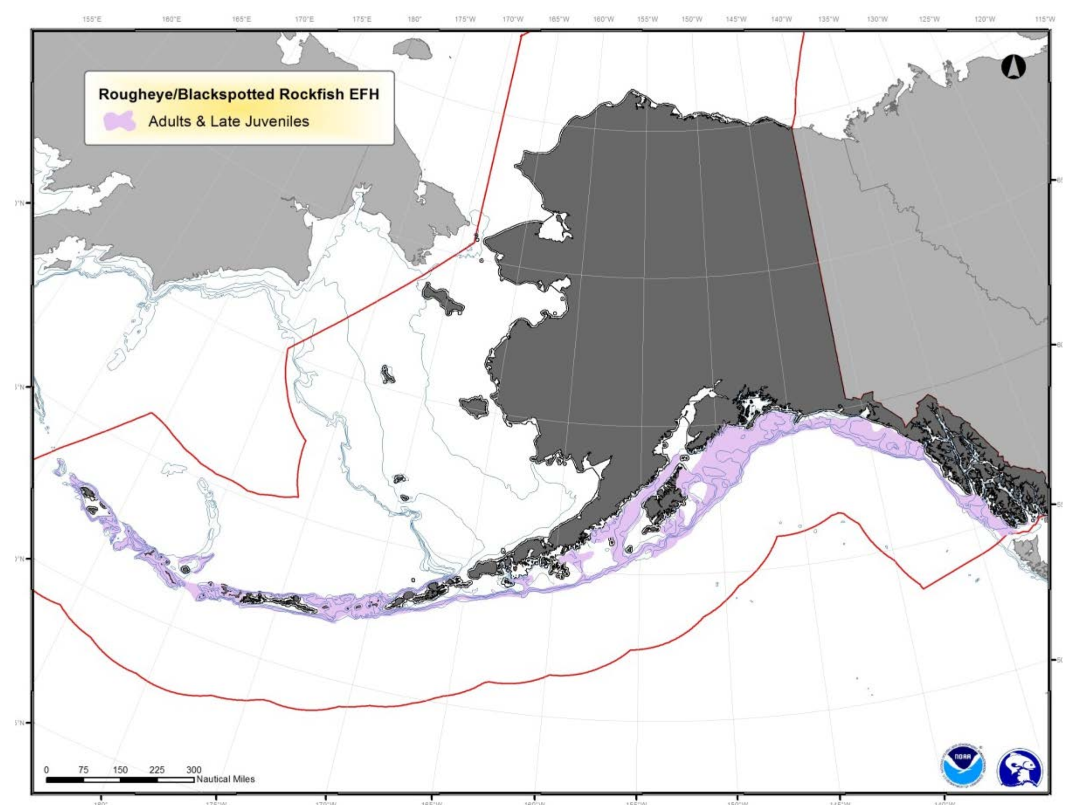


Figure E- 35 EFH Distribution – GOA Dusky Rockfish (Adults)

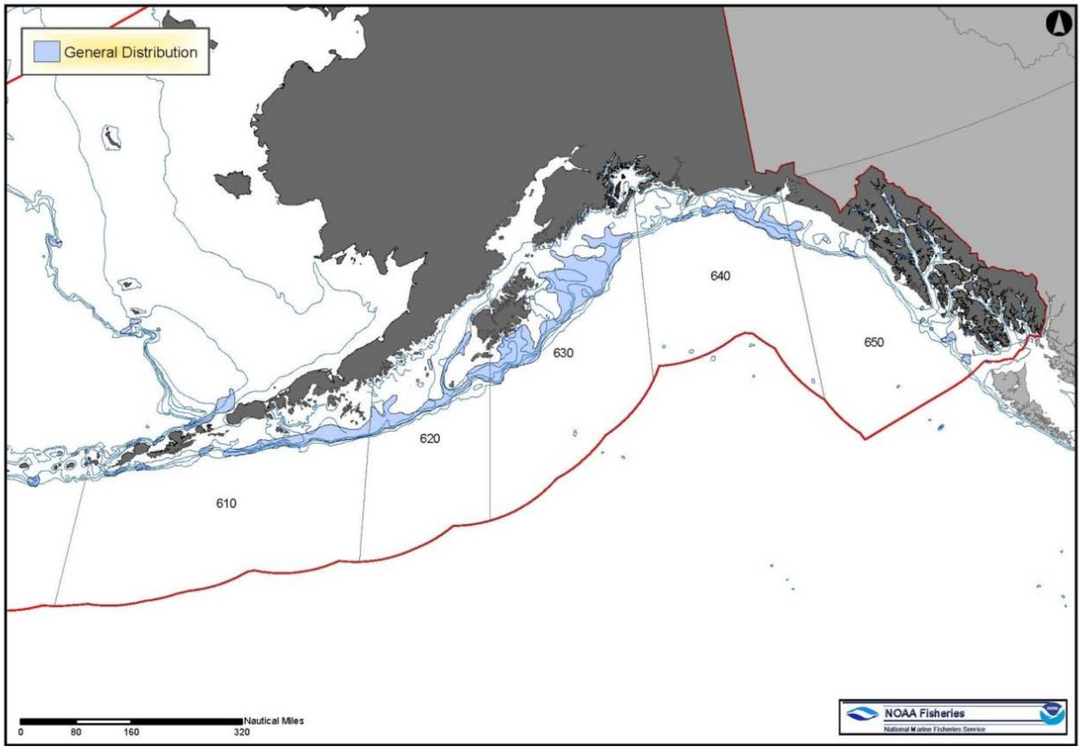


Figure E- 36 EFH Distribution – GOA Yelloweye Rockfish (Juveniles/Adults)

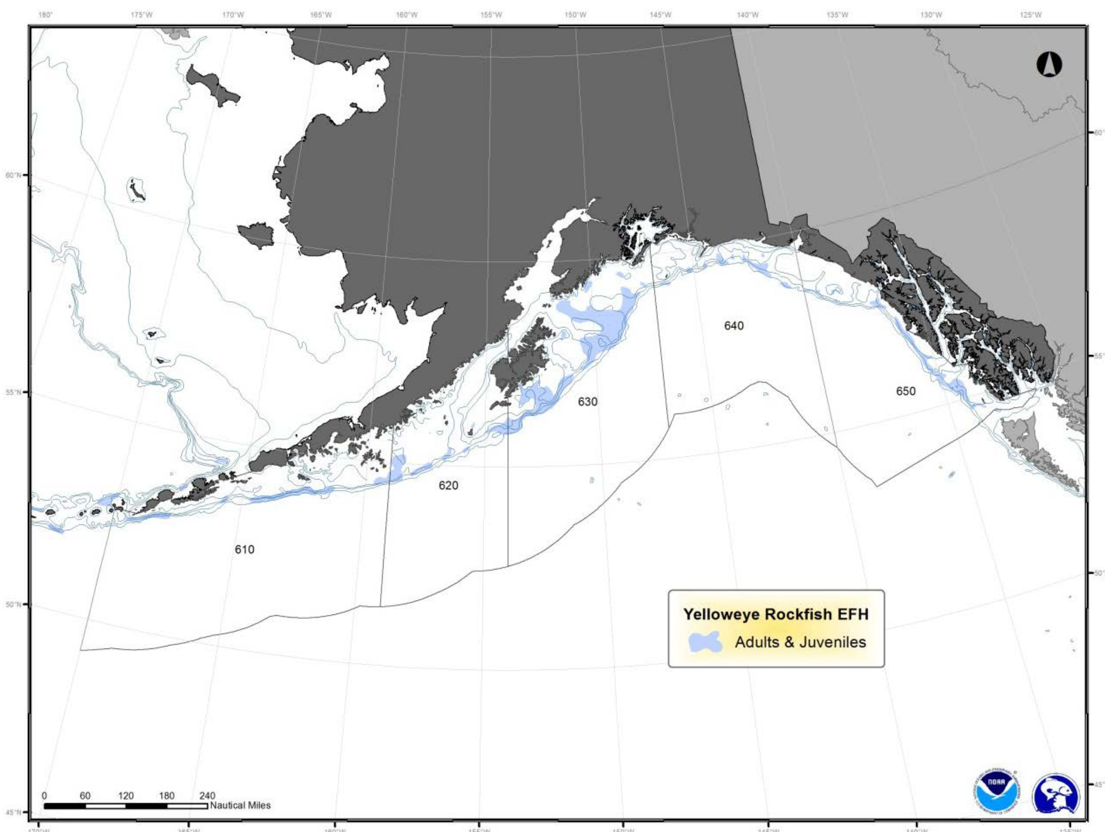


Figure E- 37 EFH Distribution – GOA Thornyhead Rockfish (Late Juveniles/Adults)

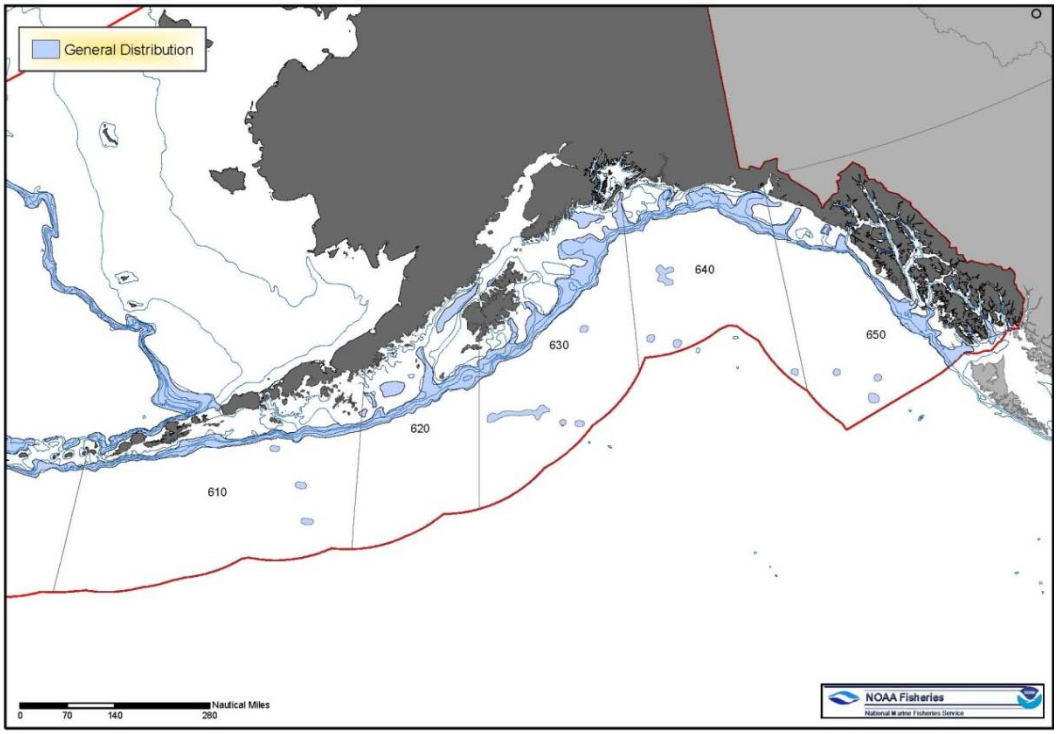


Figure E- 38 EFH Distribution – GOA Atka Mackerel (Eggs)

Note, map indicates known locations of Atka mackerel eggs, but is likely not all-inclusive.

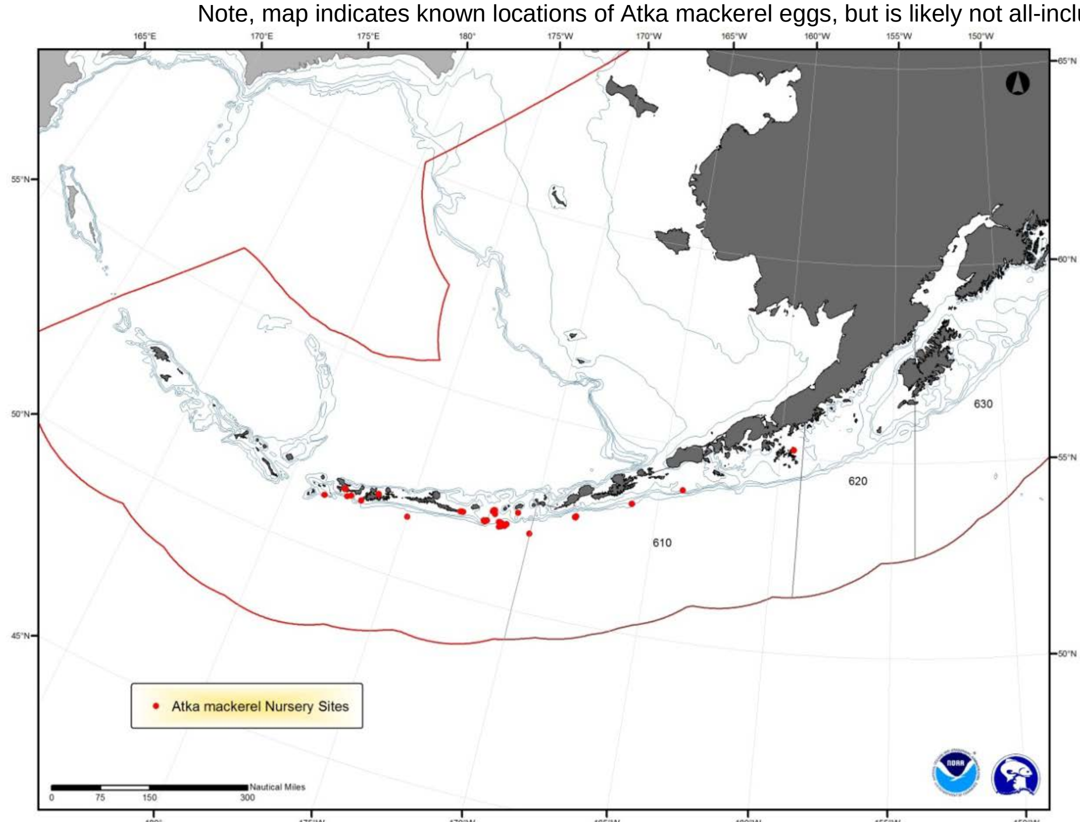


Figure E- 39 EFH Distribution – GOA Atka Mackerel (Larvae)

Note, EFH distribution includes both green boxes and black crosses.

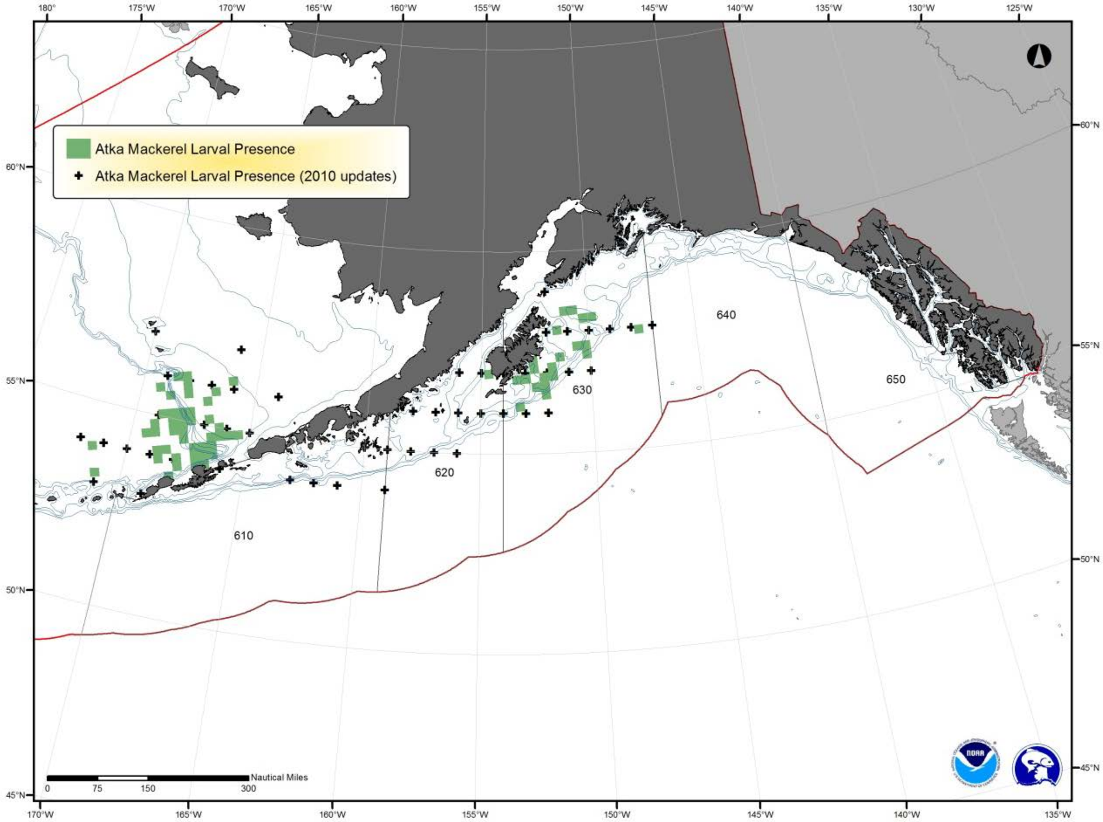


Figure E- 40 EFH Distribution – GOA Atka Mackerel (Late Juveniles/Adults)

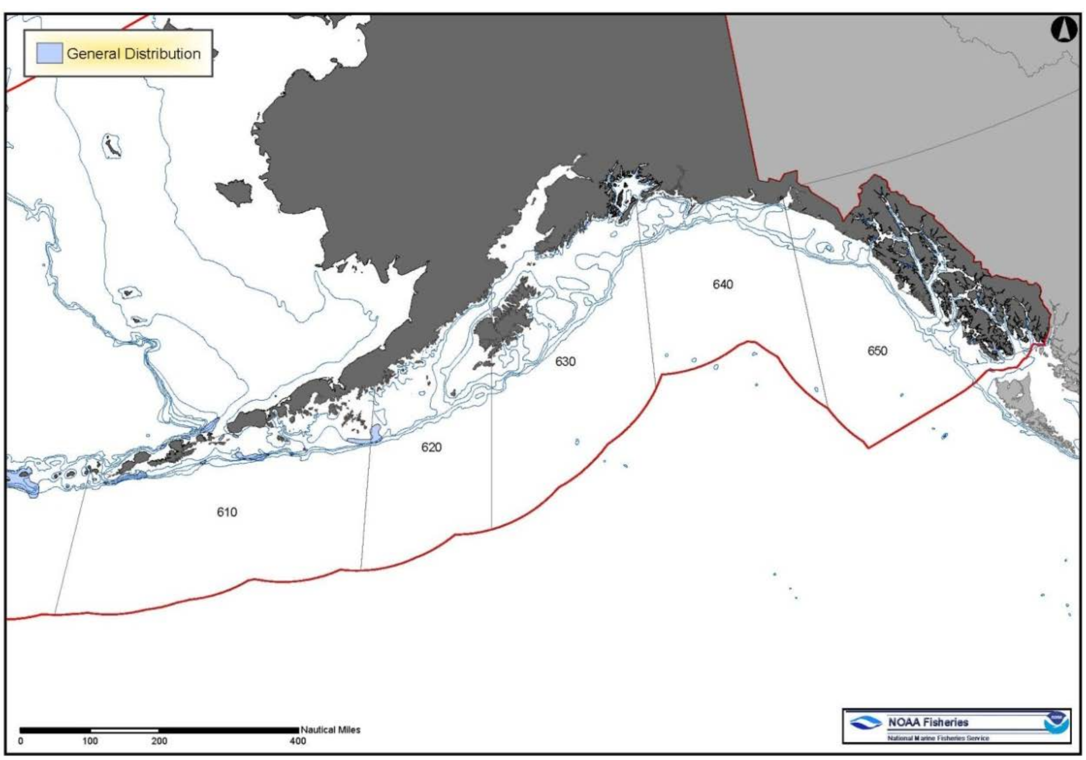


Figure E- 41 EFH Distribution – GOA Skate (Adults)

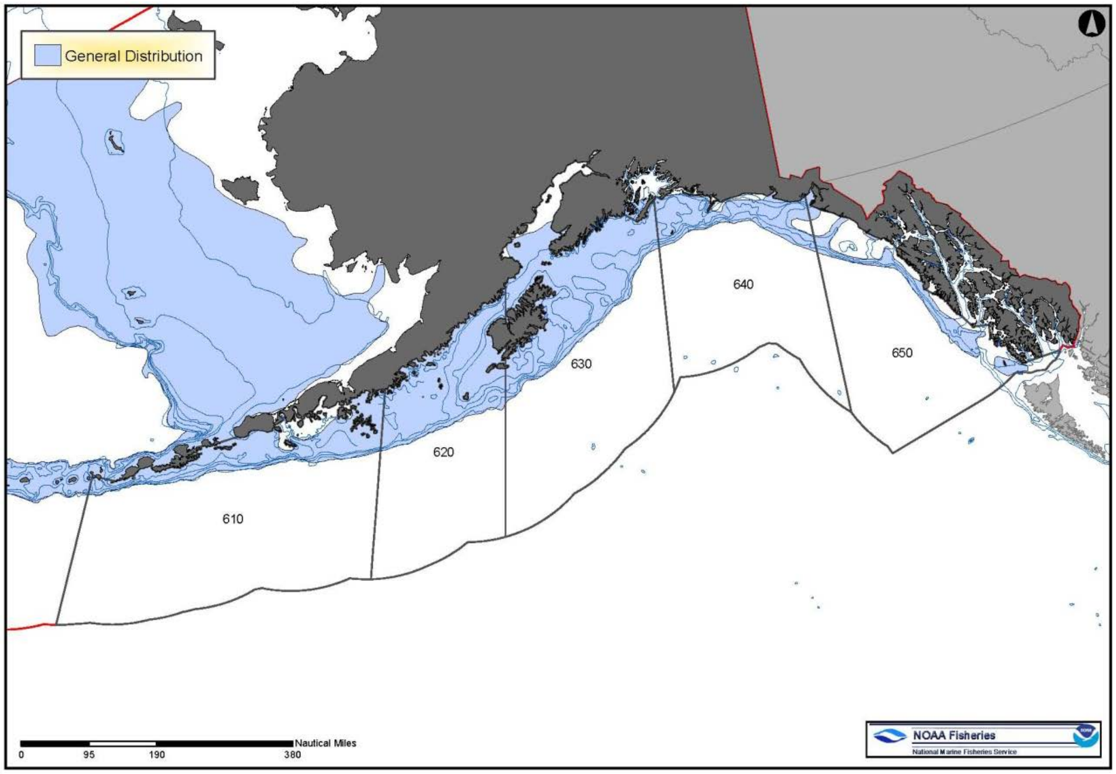


Figure E- 42 EFH Distribution – GOA Squid (Late Juveniles/Adults)

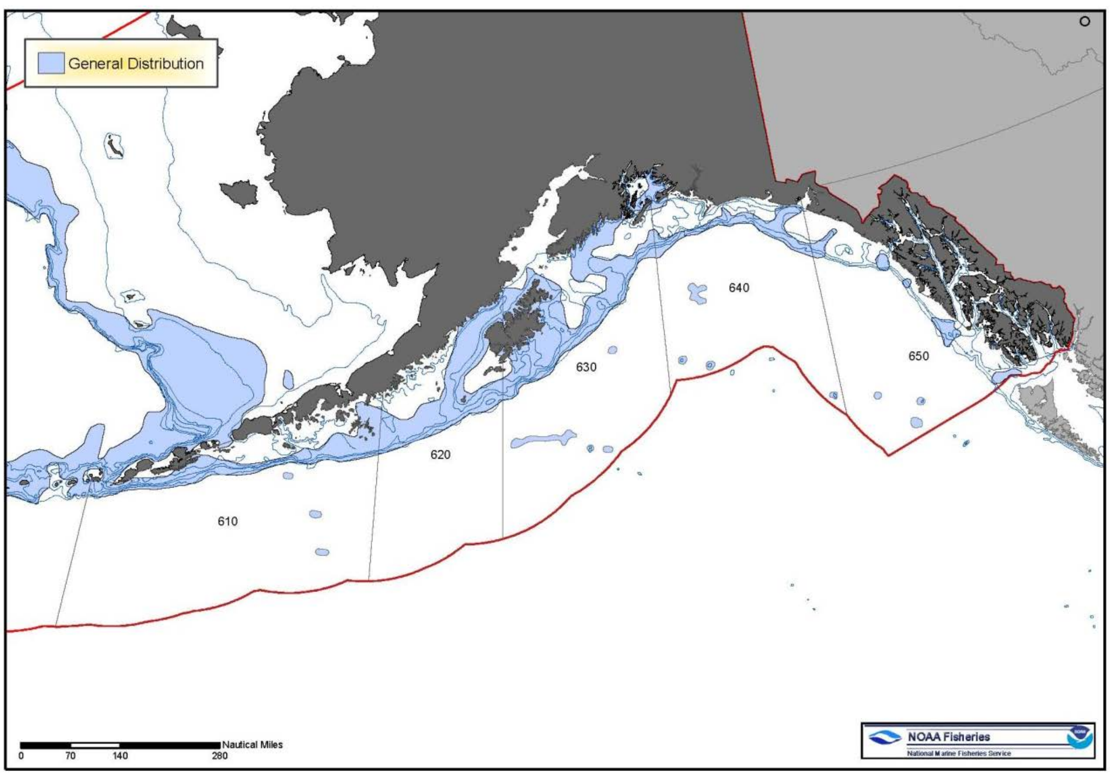
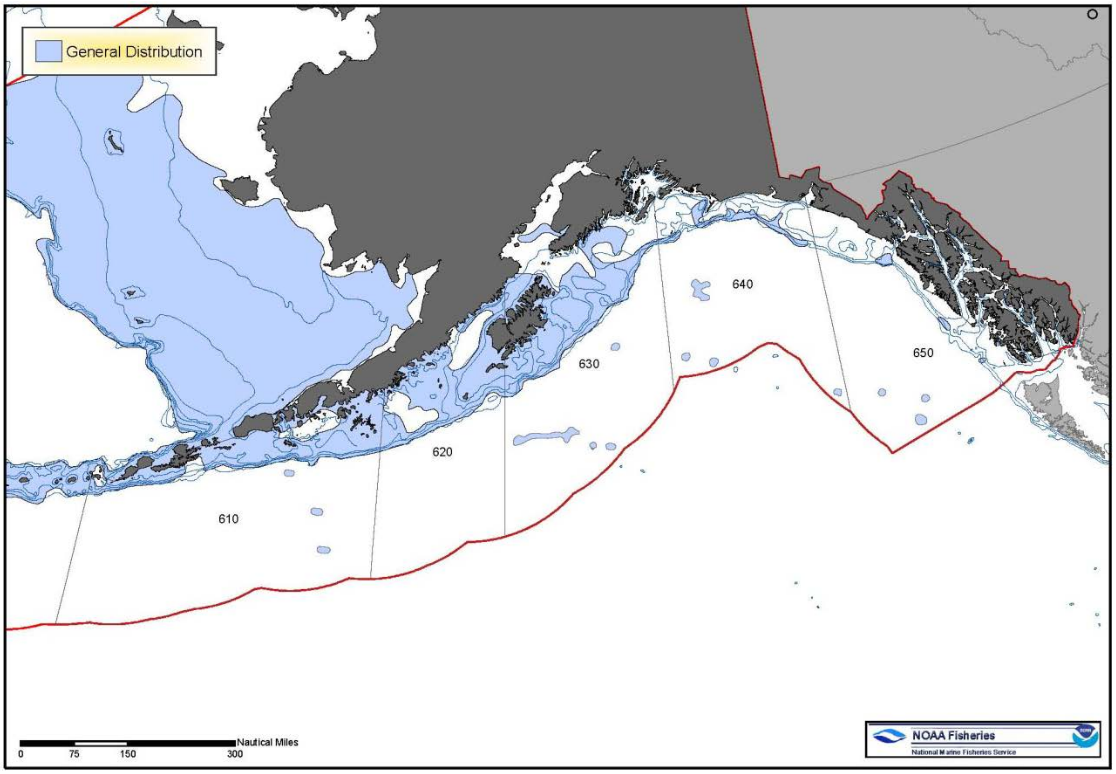


Figure E- 43 EFH Distribution – GOA Sculpin (Juveniles/Adults)



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Adverse Effects on Essential Fish Habitat

F.2 Non-fishing Activities that may Adversely Affect Essential Fish Habitat

The waters and substrates that comprise EFH are susceptible to a wide array of human activities unrelated to fishing. Broad categories of such activities include, but are not limited to, mining, dredging, fill, impoundment, discharges, 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. 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. Listing all applicable environmental laws and management practices is beyond the scope of the document. Moreover, the coordination and consultation required by section 305(b) of the Magnuson-Stevens Fishery Conservation and Management Act (MSA) does not supersede the regulations, rights, interests, or jurisdictions of other federal or state agencies. NMFS may use the information in this document as a source when developing conservation recommendations for specific actions under section 305(b)(4)(A) of the MSA. NMFS will not recommend that state or federal agencies take actions beyond their statutory authority, and NMFS' EFH conservation recommendations are not binding.

Ideally, actions that are not water-dependent 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 (CWA) should be considered to conserve and enhance EFH.

The potential for effects from larger, less readily managed processes associated with human activity also exists, such as climate change and ocean acidification. Climate change may lead to habitat changes that prompt shifts in the distribution of managed species. Likewise, should ocean conditions warm to allow for new shipping routes, new vectors may emerge for introducing invasive species in cargo and ballast waters. Ocean acidification could also alter species distributions and complicated food web dynamics. These larger ecosystem-level effects are discussed in this document where applicable, within each activity type.

This section of the fishery management plan (FMP) synthesizes a comprehensive review of the "Impacts to Essential Fish Habitat from Non-fishing Activities in Alaska" (NMFS 2011), which is incorporated in the FMP by reference. The general purpose of that document is to identify non-fishing activities that may adversely impact EFH and provide conservation recommendations that can be implemented for specific types of activities to avoid or minimize adverse impacts to EFH. This information must be included in FMPs under section 303(a)(7) of the MSA. It is also useful to NMFS biologists reviewing proposed actions that may adversely affect EFH, and the comprehensive document (NMFS 2011) will be utilized by federal action agencies undertaking EFH consultations with NMFS, especially in preparing EFH assessments.

The conservation recommendations for each activity category are suggestions the action agency or others can undertake to avoid, offset, or mitigate impacts to EFH. NMFS develops EFH conservation recommendations for specific activities case-by-case based on the circumstances; therefore, the recommendations in this document may or may not apply to any particular project. Because many non-fishing activities have similar adverse effects on living marine resources, some redundancy in the descriptions of impacts and the accompanying conservation recommendations between sections in this report is unavoidable.

The comprehensive non-fishing activities document (NMFS 2011) updates and builds upon a collaborative evaluation of non-fishing effects to EFH completed in 2004 by the NMFS Alaska Region, Northwest Region, and Southwest Region and the respective Fisheries Science Centers. In April 2005, NMFS completed the Final Environmental Impact Statement for Essential Fish Habitat Identification and Conservation in Alaska (EFH EIS; NMFS 2005), and the North Pacific Fishery Management Council (Council) amended its FMPs to address the EFH requirements of the MSA. The EFH EIS contained an Appendix (Appendix G) that addressed non-fishing impacts to EFH. A 5-year review of the Council's EFH provisions, including those addressing non-fishing impacts to EFH, was completed by the Council in April 2010 (NPFMC and NMFS 2010), on the basis of which this section has been updated.

The remainder of this section addresses non-fishing activities that may adversely affect EFH. These activities are grouped into the four different systems in which they usually occur: upland, river or riverine, estuary or estuarine, and coastal or marine.

F.2.1 Upland Activities

Upland activities can impact EFH through both point source and nonpoint source pollution. Nonpoint source impacts are discussed here. Technically, the term "nonpoint source" means anything that does not meet the legal definition of point source in section 502(14) of the CWA, which refers to discernible, confined, and discrete conveyance from which pollutants are or may be discharged. Land runoff, precipitation, atmospheric deposition, seepage, and hydrologic modification, generally driven by anthropogenic development, are the major contributors to nonpoint source pollution.

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

The impacts of nonpoint source pollution on EFH may not necessarily represent a serious, widespread threat to all species and life history stages. The severity of the threat of any specific pollutant to aquatic organisms depends upon the type and concentration of the pollutant and the length of exposure for a particular species and its life history stage. For example, species that spawn in areas that are relatively deep with strong currents and well-mixed water may not be as susceptible to pollution as species that inhabit shallow, inshore areas near or within enclosed bays and estuaries. Similarly, species whose egg, larval, and juvenile life history stages utilize shallow, inshore waters and rivers may be more prone to coastal pollution than are species whose early life history stages develop in offshore, pelagic waters.

F.2.1.1 Silviculture/Timber Harvest

Recent revisions to federal and state timber harvest regulations in Alaska and best management practices (BMPs) have resulted in increased protection of EFH on federal, state, and private timber lands (United States Department of Agriculture 2008; http://www.fs.fed.us/r10/tongass/projects/tlmp/).

These revised regulations include forest management practices, which when fully implemented and effective, could avoid or minimize adverse effects to EFH. However, if these management practices are ineffective or not fully implemented, timber harvest could have both short and long term impacts on EFH throughout many coastal watersheds and estuaries. Historically, timber harvest in Alaska was not conducted under the current protective standards, and these past practices may have degraded EFH in some watersheds.

Potential Adverse Impacts

In both small and large watersheds there are many complex and important interactions between fish and forests (Northcote and Hartman 2004). Five major categories of silvicultural activities can adversely affect EFH if appropriate forestry practices are not followed: (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). Possible effects to EFH include the following (Northcote and Hartman 2004):

- Removal of the dominant vegetation and conversion of mature and old-growth upland and riparian forests to tree stands or forests of early seral stage;
- Reduction of soil permeability and increase in the area of impervious surfaces;
- Increase in erosion and sedimentation due to surface runoff and mass wasting processes, also potentially affecting riparian areas;
- Impaired fish passage because of inadequate design, construction, and/or maintenance of stream crossings;
- Altered hydrologic regimes resulting in inadequate or excessive surface and stream flows, increased streambank and streambed erosion, loss of complex instream habitats;
- Changes in benthic macroinvertebrate populations,
- Loss of instream and riparian cover;
- Increased surface runoff with associated contaminants (e.g., herbicides, fertilizers, and fine sediments) and higher temperatures;
- Alterations in the supply of large woody debris (LWD) and sediment, which can have negative effects on the formation and persistence of instream habitat features; and
- Excess debris in the form of small pieces of wood and silt, which can cover benthic habitat and reduce dissolved oxygen levels.

Recommended Conservation Measures

The following recommended conservation measures for silviculture/timber harvest should be viewed as options to avoid and minimize adverse impacts and promote the conservation, enhancement, and proper functioning of EFH. Additionally, management standards, guidelines, and best management practices are available from the Forest Service Region 10, the State of Alaska Division of Forestry, and forest plans for the Tongass and Chugach National Forests.

- Stream Buffers: For timber operations in watersheds with EFH, adhere to modern forest management practices and BMPs, including the maintenance of vegetated buffers along all streams to the extent practicable in order to reduce sedimentation and supply large wood.
- Estuary and Beach Fringe: For timber operations adjacent to estuaries or beaches, maintain vegetated buffers as needed to protect EFH.
- Watershed Analysis: A watershed analysis should be incorporated into timber and silviculture projects whenever practicable.
- Forest Roads: Forest roads can be a major cause of sediment into streams and road culverts can block or inhibit upstream fish passage. Roads need to be designed to minimize sediment transport problems and to avoid fish passage problems.

F.2.1.2 Pesticides

Pesticides are substances intended to prevent, destroy, control, repel, kill, or regulate the growth of undesirable biological organisms. Pesticides include the following: insecticides, herbicides, fungicides, rodenticides, repellents, bactericides, sanitizers, disinfectants, and growth regulators. More than 900 different active pesticide ingredients are currently registered for use in the United States and are formulated with a variety of other inert ingredients that may also be toxic to aquatic life. Legal mandates covering pesticides are the CWA and the Federal Insecticide, Fungicide, and Rodenticide Act. Water quality criteria for the protection of aquatic life have only been developed for a few of the currently used ingredients (EPA, Office of Pesticide Programs). While agricultural run-off is a major source of pesticide pollution in the lower 48 states, in Alaska, other human activities, such as fire suppression on forested lands, forest site preparation, noxious weed control, right-of-way maintenance (e.g., roads, railroads, power lines), algae control in lakes and irrigation canals, riparian habitat restoration, and urban and residential pest control are the most common sources of these substances.

Pesticides are frequently detected in freshwater and estuarine systems that provide EFH. 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 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, the number of pesticides documented in fish and their habitats has increased. In addition, pesticides may bioaccumulate in the ecosystem by retention in sediments and detritus, which are then ingested by macroinvertebrates, and which, in turn, are eaten by larger invertebrates and fish (Atlantic States Marine Fisheries Commission 1992).

Potential Adverse Impacts

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

Recommended Conservation Measures

The following recommended conservation measures regarding pesticides (including insecticides, herbicides, fungicides, rodenticides, repellents, bactericides, sanitizers, disinfectants, and growth regulators) should be viewed as options to avoid and minimize adverse impacts and promote the conservation, enhancement, and proper functioning of EFH.

- Incorporate integrated pest management and BMPs as part of the authorization or permitting process (Scott et al. 1999). If pesticides must be applied, consider area, terrain, weather, droplet size, pesticide characteristics, and other conditions to avoid or reduce effects to EFH.
- Carefully review labels and ensure that application is consistent with the product's directions.
- Avoid the use of pesticides within 500 linear feet and/or 1,000 aerial feet of anadromous fish bearing streams.
- For forestry vegetation management projects, establish a 35-foot pesticide-free buffer area from any surface or marine water body and require that pesticides not be applied within 200 feet of a public water source (Alaska Department of Environmental Conservation guidelines).
- Consider current and recent meteorological conditions. Rain events may increase pesticide runoff into adjacent water bodies. Saturated soils may inhibit pesticide penetration.
- Do not apply pesticides when wind speeds exceed 10 mph.
- Begin application of pesticide products nearest to the aquatic habitat boundary and proceed away from the aquatic habitat; do not apply towards a water body.

F.2.1.3 Urban and Suburban Development

Urban and suburban development is most likely the greatest non-fishing threat to EFH (NMFS 1998 a, 1998b). Urban and suburban development and the corresponding infrastructure result in four broad categories of impacts to aquatic ecosystems: hydrological, physical, water quality and biological (CWP 2003).

Potential Adverse Impacts

Potential impacts to EFH most directly related to general urban and suburban development discussed below are the watershed effects of land development, including stormwater runoff.

Other development-related impacts are discussed in later sections of this document, including dredging, wetland fill, and shoreline construction.

Development activities within watersheds and in coastal marine areas can impact EFH on both long and short timeframes. The Center for Watershed Protection (CWP) made a comprehensive review of the impacts associated with impervious cover and urban development and found a negative relationship between watershed development and 26 stream quality indicators (CWP 2003). The primary impacts include (1) the loss of hyporheic zones (the region beneath and next to streams where surface and groundwater mix), and riparian and shoreline habitat and vegetation; and, (2) runoff. Removal of riparian and upland vegetation has been shown to increase stream water temperatures, reduce supplies of LWD, and reduce sources of prey and nutrients to the water system. An increase in impervious surfaces in a watershed, such as the addition of new roads, buildings, 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 the shape of the hydrograph 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 where threats of impacts from urban and suburban development exist.

- Implement BMPs for sediment control during construction and maintenance operations (USEPA 1993).
- Avoid using hard engineering structures for shoreline stabilization and channelization when possible.
- Encourage comprehensive planning for watershed protection, and avoid or minimize filling and building in coastal and riparian areas affecting EFH.
- Where feasible, remove obsolete impervious surfaces from riparian and shoreline areas, and reestablish water regime, wetlands, and native vegetation.
- Protect and restore vegetated buffer zones of appropriate width along streams, lakes, and wetlands that include or influence EFH.
- Manage stormwater to replicate the natural hydrologic cycle, maintaining natural infiltration and runoff rates to the maximum extent practicable.
- Where instream 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.
- Use the best available technologies in upgrading wastewater systems to avoid combined sewer overflow problems and chlorinated sewage discharges into rivers, estuaries, and the ocean.
- Design and install proper wastewater treatment systems.
- Where vegetated swales are not feasible, install and maintain oil/water separators to treat runoff from impervious surfaces in areas adjacent to marine or anadromous waters.

F.2.1.4 Road Building and Maintenance

Roads and trails have always been part of man's impact on his environment (Luce and Crowe 2001). Federal, state, and local transportation departments devote huge budgets to construction and upgrading of roads. As in other places, roads play an important part in access and thus are vital to the economy of Alaska (Connor 2007).

Potential Adverse Impacts

Today's road design construction and management practices have improved from the past. Roads however, still have a negative effect on the biotic integrity of both terrestrial and aquatic ecosystems (Trombulak and Frissell 2000), and the effects of roads on aquatic habitat can be profound. Potential adverse impacts to aquatic habitats resulting from existence of roads in watersheds include (1) increased surface erosion, including mass wasting events, and 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 invasive species; and (6) changes in channel configuration; and (7) the concentration and introduction of polycyclic aromatic hydrocarbons, heavy metals and other pollutants.

Recommended Conservation Measures

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

- Roads should be sited to avoid sensitive areas such as streams, wetlands, and steep slopes to the extent practicable.
- Build bridges rather than culverts for stream crossings when possible. If culverts are to be used, they should be sized, constructed, and maintained to match the gradient and width of the stream, so as to accommodate design flood flows; they should be large enough to provide for migratory passage of adult and juvenile fishes.
- Design bridge abutments to minimize disturbances to stream banks and place abutments outside of the floodplain whenever possible.
- Specify erosion control measures in road construction plans.
- Avoid side casting of road materials on native surfaces and into streams.
- Use only native vegetation in stabilization plantings.
- Use seasonal restrictions to avoid impacts to habitat during species critical life history stages (e.g., spawning and egg development periods).
- Properly maintain roadway and associated stormwater collection systems.
- Limit roadway sanding and the use of deicing chemicals during the winter to minimize sedimentation and introduction of contaminants into nearby aquatic habitats.

F.2.2 <u>Riverine Activities</u>

F.2.2.1 Mining

Mining within riverine habitats may result in direct and indirect chemical, biological, and physical impacts to habitats within the mining site and surrounding areas during all stages of operations. On site mining activities include exploration, site preparation, mining and milling, waste management, decommissioning or reclamation, and abandonment (NMFS 2004, American Fisheries Society 2000). Mining and its associated activities have the potential to cause adverse effects to EFH from exploration through post-closure. The operation of metal, coal, rock quarries, and gravel pit mines in upland and riverine areas 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, are designed to control and manage these changes to the landscape to avoid and minimize impacts. However, while environmental regulations may avoid, limit, control, or offset many potential impacts, mining will, to some degree, always alter landscapes and environmental resources (National Research Council 1999). (Additional information on mining impacts in the marine environment is covered later in this synthesis.)

F.2.2.1.1 Mineral Mining

Mining and mineral extraction activities take many forms, such as commercial and recreational suction dredging, placer, open pit and surface mining, and contour operations. The process for mineral extraction involves exploration, mine development, mining (extraction), processing and reclamation.

Potential Adverse Impacts

The potential adverse effects of mineral mining on fish populations and EFH are well documented (Farag et al. 2003, Hansen et al. 2002, Brix et al. 2001, Goldstein et al. 1999) and depend on the type, extent, and location of the activities. Impacts associated with the extraction of material from within or near a stream or river bed may include (1) alteration in channel morphology, hydraulics, lateral migration and natural channel meander; (2) increases in channel incision and bed degradation; (3) disruption in pre-existing balance of suspended sediment transport and turbidity; (4) direct impacts to fish spawning and nesting habitats (redds), juveniles, and prey items; (5) simplification of in-channel fluvial processes and LWD deposition; (6) altered surface and ground water regimes and hydro-geomorphic and hyporheic processes; and (7) destruction of the riparian zone during extraction operations. Additional impacts may include mining-related pollution, acid mine drainage, habitat fragmentation and conversion, altered temperature regimes, reduction in oxygen concentration, the release of toxic materials (NMFS 2008), and additional impacts to wetland and riverine habitats. Many of these types of impacts have been previously introduced in the document. The additional discussion that follows is intended to round out the discussion of impacts that have not been previously introduced.

Recommended Conservation Measures

The following measures are adapted from recommendations in Spence et al. (1996), NMFS (2004), and Washington Department of Fish and Wildlife (2009). These conservation recommendations for mineral mining should be viewed as options to avoid and minimize adverse impacts and promote the conservation, enhancement, and proper functioning of EFH.

- To the extent practicable, avoid mineral mining in waters, water sources and watersheds, riparian areas, hyporheic zones, and floodplains providing habitat for federally managed species.
- Schedule necessary in-water activities when the fewest species/least vulnerable life stages of federally managed species will be present.
- Minimize spillage of dirt, fuel, oil, toxic materials, and other contaminants into EFH. Prepare a spill prevention plan if appropriate.
- Treat and test wastewater (acid neutralization, sulfide precipitation, reverse osmosis, electrochemical, or biological treatments) and recycle on site to minimize discharge to streams.
- Minimize the effects of sedimentation on fish habitat, using methods such as contouring, mulching, construction of settling ponds, and sediment curtains. Monitor turbidity during operations, and cease operations if turbidity exceeds predetermined threshold levels.
- If possible, reclaim, rather than bury, mine waste that contains heavy metals, acid materials, or other toxic compounds to limit the possibility of leachate entering groundwater.
- Restore natural contours and use native vegetation to stabilize and restore habitat function to the extent practicable. Monitor the site to evaluate performance.
- Minimize the aerial extent of ground disturbance and stabilize disturbed lands to reduce erosion.
- For large scale mining operations, stochastic models should be employed to make predictions of ground and surface hydrologic impacts and acid generating potential in mine pits and tailing impoundments.

F.2.2.1.2 Sand and Gravel Mining

In Alaska, riverine sand and gravel mining is extensive and can involve several methods: 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.

Potential Adverse Impacts

Primary impacts associated with riverine sand and gravel mining activities include (1) turbidity plumes and re-suspension of sediment and nutrients, (2) removal of spawning habitat, and (3) alteration of channel morphology. These often lead to secondary impacts including: (1) alteration of migration patterns; (2) physical and thermal barriers to upstream and downstream migration; (3) increased fluctuation in water temperature; (4) decrease in dissolved oxygen; (5) high mortality of early life stages; (6) increased susceptibility to predation; (7) loss of suitable habitat (Packer et al. 2005); (8) decreased nutrients (from loss of floodplain connection and riparian vegetation); and (9) decreased food production (loss of invertebrates) (Spence et al. 1996).

Recommended Conservation Measures

The following recommended conservation measures for sand and gravel mining are adapted from NMFS (2004) and OWRRI (1995). They should be viewed as options to avoid and minimize adverse impacts to EFH due to sand and gravel mining and promote the conservation, enhancement, and proper functioning of EFH.

- To the extent practicable, avoid sand/gravel mining in waters, water sources and watersheds, riparian areas, hyporheic zones and floodplains providing habitat for federally managed species.
- 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.
- If operations in EFH cannot be avoided, design, manage, and monitor sand and gravel mining operations to minimize potential direct and indirect impacts to living marine resources and habitat. For example, minimize the areal extent and depth of extraction.
- Include restoration, mitigation, and monitoring plans, as appropriate, in sand/gravel extraction plans.
- Implement seasonal restrictions to avoid impacts to habitat during species critical life history stages.

F.2.2.2 Organic and Inorganic Debris

Organic and inorganic debris, and its impacts to EFH, extend beyond riverine systems into estuarine coastal and marine systems. To reduce duplication, impacts to other systems are also addressed here.

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. In riverine systems, the physical structure of LWD provides cover for managed species, creates habitats and microhabitats (e.g., pools, riffles, undercut banks, and side channels), retains gravels, and helps maintain underlying channel structure (Abbe and Montgomery 1996, Montgomery et al. 1995, Ralph et al. 1994, Spence et al. 1996). LWD also plays similar role in salt marsh habitats (Maser and Sedell 1994). In benthic ocean habitats, LWD enriches local nutrient availability as deep-sea wood borers convert the wood to fecal matter, providing terrestrially-based carbon to the ocean food chain (Maser and Sedell 1994). When deposited on coastal shorelines, macrophyte wrack creates microhabitats and provides a food source for aquatic and terrestrial organisms such as isopods and amphipods, which play an important role in marine food webs.

Conversely, inorganic flotsam and jetsam debris can negatively impact EFH. Inorganic marine debris is a problem along much of the coastal United States, 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 water outfalls, 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 purposes (e.g., active beach log harvests, garden mulch, and fertilizer). However, the presence of organic debris is important for maintaining aquatic habitat structure and function.

Potential Adverse Impacts

The removal of organic debris from natural systems can reduce habitat function, adversely impacting habitat quality. Reductions in LWD 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. In rivers and streams of the Pacific Northwest, the historic practice of removing LWD to improve navigability and facilitate log transport has altered channel morphology and reduced habitat complexity, thereby negatively affecting habitat quality for spawning and rearing salmonids (Koski 1992, Sedell and Luchessa 1982).

Beach grooming and wrack removal can substantially alter the macrofaunal community structure of exposed sand beaches (Dugan et al. 2000). Species richness, abundance, and biomass of macrofauna associated with beach wrack (e.g., sand crabs, isopods, amphipods, and polychaetes) are higher on ungroomed beaches than on those that are groomed (Dugan et al. 2000). The input and maintenance of wrack can strongly influence the structure of macrofauna communities, including the abundance of sand crabs (*Emerita analoga*) (Dugan et al. 2000), an important prey species for some managed species of fish.

Recommended Conservation Measures

The recommended conservation measures for organic debris removal are listed below. They should be viewed as options to avoid and minimize adverse impacts and promote the conservation, enhancement, and proper functioning of EFH.

- Encourage the preservation of LWD whenever possible, removing it only when it presents a threat to life or property.
- 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.
- Educate landowners and recreationalists about the benefits of maintaining LWD.
- Localize beach grooming practices, and minimize them whenever possible.
- Advise gardeners to only harvest dislodged, dead kelp and leave live, growing kelp (whether dislodged or not).

F.2.2.2.2 Inorganic Debris

Inorganic debris in the marine environment is a chronic problem along much of the U.S. coast, resulting in littered shorelines and estuaries with varying degrees of negative effects to coastal ecosystems. 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. It generally enters waterways indirectly through rivers and storm drains or by direct ocean dumping. Ocean-based sources of debris also create problems for managed species. These include discarded or lost fishing gear (NMFS 2008), and galley waste and trash from commercial merchant, fishing, military, and other vessels.

Potential Adverse Impacts

Land and ocean sourced inorganic marine debris is a very diverse problem, and adverse effects to EFH are likewise varied. Floating or suspended trash can directly affect managed species 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 that leach from plastics can 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 can continue to cause environmental problems. Plastics and other materials with a large surface area can 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

Pollution prevention and improved waste management can occur through regulatory controls and best management practices. The recommended conservation measures for minimizing inorganic debris listed in the section below should be viewed as options to avoid and minimize adverse impacts and promote the conservation, enhancement, and proper functioning of EFH.

- Encourage proper trash disposal, particularly in coastal and ocean settings, and participate in coastal cleanup activities.
- Advocate for local, state, and national legislation that rewards proper disposal of debris.
- Encourage enforcement of regulations addressing marine debris pollution and proper disposal.
- Provide resources and technical guidance for development of studies and solutions addressing the problem of marine debris.
- Educate the public on the impact of marine debris and provide guidance on how to reduce or eliminate the problem.
- Implement structural controls that collect and remove trash before it enters nearby waterways.
- Consider the use of centrifugal separation to physically separate solids and floatables from water in combined sewer outflows.
- Encourage the development of incentives and funding mechanisms to recover lost fishing gear.

- Require all existing and new commercial construction projects near the coast to develop and implement refuse disposal plans.

F.2.2.3 Dam Operation

Dams provide sources of hydropower, water storage, and flood control. Construction and operation of dams can affect basic hydrologic and geomorphic function including the alteration of physical, biological, and chemical processes that, in turn, can have effects on water quality, timing, quantity, and alter sediment transport.

Potential Adverse Impacts (adapted from NMFS 2008)

The effects of dam construction and operation on fish and aquatic habitat include (1) complete or partial upstream and downstream migratory impediment; (2) water quality and flow pattern alteration; (3) alteration to distribution and function of ice, sediment, and nutrient budgets; (4) alterations to the floodplain, including riparian and coastal wetland systems and associated functions and values; and (5) thermal impacts. Dam construction and operations can impede or block anadromous fish passage and other aquatic species migration in streams and rivers. Unless proper fish passage structures or devices are operational, dams can either prevent access to productive upstream spawning and rearing habitat or can alter downstream juvenile migration. Turbines, spillways, bypass systems, and fish ladders also affect the quality and quantity of EFH available for salmon passage in streams and rivers (Pacific Fishery Management Council [PFMC] 1999). The construction of a dam can fragment habitat, resulting in alterations to both upstream and downstream biogeochemical processes.

Recommended Conservation Measures (adapted from NMFS 2008)

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

- Avoid construction of new dam facilities, where possible.
- Construct and design facilities with efficient and functional upstream and downstream adult and juvenile fish passage which ensures safe, effective, and timely passage.
- Operate dams within the natural flow fluctuations rates and timing and, when possible, mimic the natural hydrograph, allow for sediment and wood transport, and consider and allow for natural ice function. Monitor water flow and reservoir flow fluctuation.
- Understand longer term climatic and hydrologic patterns and how they affect habitat; plan project design and operation to minimize or mitigate for these changes.
- Use seasonal restrictions for construction, maintenance, and operation of dams to avoid impacts to habitat during species' critical life history stages.
- Develop and implement monitoring protocols for fish passage.
- Retrofit existing dams with efficient and functional upstream and downstream fish passage structures.
- Construct dam facilities with the lowest hydraulic head practicable for the project purpose. Site the project at a location where dam height can be reduced.
- Downstream passage should prevent adults and juveniles from passing through the

turbines and provide sufficient water downstream for safe passage.

- Coordinate maintenance and operations that require drawdown of the impoundment with state and federal resource agencies to minimize impacts to aquatic resources.
- Develop water and energy conservation guidelines for integration into dam operation plans and into regional and watershed-based water resource plans.
- Encourage the preservation of LWD, whenever possible.
- Develop a sediment transport and geomorphic maintenance plan to allow for peak flow mimicking that will result in sediment pulses through the reservoir/dam system and allow high flow geomorphic processes.

F.2.2.4 Commercial and Domestic Water Use

An increasing demand for potable water, combined with inefficient use of freshwater resources and natural events (e.g., droughts) have led to serious ecological damage worldwide (Deegan and Buchsbaum 2005). 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). Groundwater supplies 87 percent of Alaska's 3,500 public drinking water systems. Ninety percent of the private drinking water supplies are groundwater. Each day, roughly 275 million gallons of water derived from aquifers, which directly support riverine systems, are used for domestic, commercial, industrial, and agricultural purposes in Alaska (Groundwater Protection Council 2010). Surface water sources serve a large number of people from a small number of public water systems (e.g., Anchorage and several southeastern communities).

Potential Adverse Impacts

The diversion of freshwater for domestic and commercial uses can affect EFH by (1) altering natural flows and the process associated with flow rates, (2) altering riparian habitats by removing water or by submersion of riparian areas, (3) removing the amount and altering the distribution of prey bases, (4) affecting water quality, and (5) entrapping fishes. Water diversions can involve either withdrawals (reduced flow) or discharges (increased flow).

Recommended Conservation Measures

These conservation measures for commercial and domestic water use should be viewed as options to avoid and minimize adverse impacts from commercial and domestic water use and promote the conservation, enhancement, and proper functioning of EFH.

- Design water diversion and impoundment projects to create flow conditions that provide for adequate fish passage, particularly during critical life history stages. Avoid low water levels that strand juveniles and dewater redds. Incorporate juvenile and adult fish passage facilities on all water diversion projects (e.g., fish bypass systems). Install screens at water diversions on fish-bearing streams, as needed.
- Maintain water quality necessary to support fish populations by monitoring and adjusting water temperature, sediment loads, and pollution levels.
- Maintain appropriate flow velocity and water levels to support continued stream functions. Maintain and restore channel, floodplain, riparian, and estuarine conditions.

- Where practicable, ensure that mitigation is provided for unavoidable impacts to fish and their habitat.

F.2.3 Estuarine Activities

A large portion of Alaska's population resides near the state's 33,904-mile coastline (NOAA 2010). The dredging and filling of coastal wetlands for commercial and residential development, port, and harbor development directly removes important wetland habitat and alters the habitat surrounding the developed area. Physical changes from shoreline construction can result in secondary impacts such as increased suspended sediment loading, shading from piers and wharves, as well as introduction of chemical contamination from land-based human activities (Robinson and Pederson 2005). Even development projects that appear to have minimal individual impacts can have significant cumulative effects on the aquatic ecosystem (NMFS 2008).

F.2.3.1 Dredging

The construction of ports, marinas, and harbors typically involves dredging sediments from intertidal and subtidal habitats to create navigational channels, turning basins, anchorages, and berthing docks. Additionally, periodic dredging is used to maintain the required depths after sediment is deposited into these facilities. Dredging is also used to create deepwater navigable channels or to maintain existing channels that periodically fill with sediments. (Impacts from dredging from marine mining are also addressed later.)

Potential Adverse Impacts

Dredging activities can adversely affect benthic and water-column habitat. The environmental effects of dredging on managed species and their habitat can include (1) direct removal/burial of organisms; (2) turbidity and siltation, including light attenuation from turbidity; (3) contaminant release and uptake, including nutrients, metals, and organics; (4) release of oxygen consuming substances (e.g., chemicals and bacteria); (5) entrainment; (6) noise disturbances; and (7) alteration to hydrodynamic regimes and physical habitat.

Recommended Conservation Measures

The recommended conservation measures for dredging are listed in the following section. They should be viewed as options to avoid and minimize adverse impacts and promote the conservation, enhancement, and proper functioning of EFH.

- Avoid new dredging in sensitive habitat areas to the maximum extent practicable.
- Reduce the area and volume of material to be dredged to the maximum extent practicable.
- Avoid dredging and placement of equipment used in conjunction with dredging operations in special aquatic sites and other high value habitat areas.
- Implement seasonal restrictions to avoid impacts to habitat during species critical life history stages (e.g., spawning season, egg, and larval development period).
- Utilize BMPs to limit and control the amount and extent of turbidity and sedimentation.

- 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.
- Prior to dredging, test sediments for contaminants as per U.S. Environmental Protection Agency (EPA) and U.S. Army Corps of Engineers (USACE) requirements.
- Provide appropriate compensation for significant impacts (short-term, long-term, and cumulative) to benthic environments resulting from dredging.
- Identify excess sedimentation in the watershed that prompts excessive maintenance dredging activities, and implement appropriate management actions, if possible.

F.2.3.2 Material Disposal and Filling Activities

Material disposal and filling activities can directly remove important habitat and alter the habitat surrounding the developed area. The discharge of dredged materials or the use of fill material in aquatic habitats can result in 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 (adapted from NMFS 2008)

The disposal of dredged material can reduce the suitability of water bodies for managed species and their prey by (1) reducing floodwater retention in wetlands; (2) reducing nutrients uptake and release; (3) decreasing the amount of detrital input, an important food source for aquatic invertebrates (Mitsch and Gosselink 1993); (4) habitat conversion through alteration of water depth or substrate type; (5) removing aquatic vegetation and preventing natural revegetation; (6) impeding physiological processes to aquatic organisms (e.g., photosynthesis, respiration) caused by increased turbidity and sedimentation (Arruda et al. 1983, Cloern 1987, Dennison 1987, Barr 1993, Benfield and Minello 1996, Nightingale and Simenstad 2001a); (7) directly eliminating sessile or semi-mobile aquatic organisms via entrainment or smothering (Larson and Moehl 1990, McGraw and Armstrong 1990, Barr 1993, Newell et al. 1998); (8) altering water quality parameters (i.e., temperature, oxygen concentration, and turbidity); and (9) releasing contaminants such as petroleum products, metals, and nutrients (USEPA 2000a).

Recommended Conservation Measures

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

- Avoid disposing dredged material in wetlands, submerged aquatic vegetation and other special aquatic sites whenever possible.
- Test sediment compatibility for open-water disposal per EPA and USACE requirements.
- Ensure that disposal sites are properly managed and monitored to minimize impacts associated with dredge material.
- Where long-term maintenance dredging is anticipated, acquire and maintain disposal sites for the entire project life.

- Encourage beneficial uses of dredged materials.

F.2.3.2.2 Fill Material

Like the discharge of dredged material, the discharge of fill material to create upland areas can remove productive habitat and eliminate important habitat functions.

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 for the discharge of fill material should be viewed as options to avoid and minimize adverse impacts and promote the conservation, enhancement, and proper functioning of EFH.

- Federal, state, and local resource management and permitting agencies should address the cumulative impacts of fill operations on EFH.
- Minimize the areal extent of any fill in EFH, or avoid it entirely.
- Consider alternatives to the placement of fill into areas that support managed species.
- Fill should be sloped to maintain shallow water, photic zone productivity; allow for unrestricted fish migration; and provide refugia for juvenile fish.
- In marine areas of kelp and other aquatic vegetation, fill (including artificial structure fill reefs) should be designed to maximize kelp colonization and provide areas for juvenile fish to find shelter from higher currents and exposure to predators.
- Fill materials should be tested and be within the neutral range of 7.5 to 8.4 pH.

F.2.3.3 Vessel Operations, Transportation, and Navigation

In Alaska, the growth in coastal communities is putting demands on port districts to increase infrastructure to accommodate additional vessel operations for cargo handling and marine transportation. Port expansion has become an almost continuous process due to economic growth, competition between ports, and significant increases in vessel size. In addition, increasing boat sales have put more pressure on improving and building new harbors, an important factor in Alaska because of the limited number of roads.

Potential Adverse Impacts

Activities associated with the expansion of port facilities, vessel/ferry operations, and recreational marinas can directly and indirectly impact EFH. Impacts include (1) loss and conversion of habitat; (2) altered light regimes and loss of submerged aquatic vegetation; (3) altered temperature regimes; (4) siltation, sedimentation, and turbidity; (5) contaminant releases; and, (6) altered tidal, current, and hydrologic regimes.

Recommended Conservation Measures

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

- Locate marinas in areas of low biological abundance and diversity.
- Leave riparian buffers in place to help maintain water quality and nutrient input.
- Include low-wake vessel technology, appropriate routes, and BMPs for wave attenuation structures as part of the design and permit process.
- 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.
- Locate mooring buoys in water deep enough to avoid grounding and to minimize the effects of prop wash.
- Use catchment basins for collecting and storing surface runoff to remove contaminants prior to delivery to any receiving waters.
- Locate facilities in areas with enough water velocity to maintain water quality levels within acceptable ranges.
- Locate marinas where they do not interfere with natural processes so as to affect adjacent habitats.
- To facilitate movement of fish around breakwaters, breach gaps and construct shallow shelves to serve as “fish benches,” as appropriate.
- Harbor facilities should be designed to include practical measures for reducing, containing, and cleaning up petroleum spills.

F.2.3.4 Invasive Species

Introductions of invasive species into estuarine, riverine, and marine habitats have been well documented (Rosecchi et al. 1993, Kohler and Courtenay 1986, Spence et al. 1996) 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 be spread via shipping, recreational boating, aquaculture, biotechnology, and aquariums. The introduction of nonindigenous organisms to new environments can have many severe impacts on habitat (Omori et al. 1994).

Invasive aquatic species that are considered high priority threats to Alaska’s marine waters include: Atlantic salmon (*Salmo salar*), green crab (*Carcinus maenas*), Chinese mitten crab (*Eriocheir sinensis*), signal crayfish (*Pacifastacus leniuaculus*), zebra mussels (*Dreissena polymorpha*), New Zealand mudsnail (*Potamopyrgus antipodarum*), saltmarsh cordgrass

(*Spartina alterniflora*), purple loosestrife (*Lythrum salicaria*), and tunicates (*Botrylloides violaceus* and *Didemnum vexillum*).[1]

Potential Adverse Impacts

Invasive species can create five types of negative effects on EFH: (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 for invasive species should be viewed as options to avoid and minimize adverse impacts and promote the conservation, enhancement, and proper functioning of EFH.

- 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.
- Adhere to regulations and use best management practices outlined in the State of Alaska Aquatic Nuisance Species Management Plan (Fay 2002).
- Encourage vessels to perform a ballast water exchange in marine waters to minimize the possibility of introducing invasive estuarine species into similar habitats.
- Discourage vessels that have not performed a ballast water exchange from discharging their ballast water into estuarine receiving waters.
- Require vessels brought from other areas over land via trailer to clean any surfaces that may harbor non-native plant or animal species (e.g., propellers, hulls, anchors, fenders).
- Treat effluent from public aquaria displays and laboratories and educational institutes using non-native species before discharge.
- Encourage proper disposal of seaweeds and other plant materials used for packing purposes when shipping fish or other animals.
- Undertake a thorough scientific review and risk assessment before any non-native species are introduced.

F.2.3.5 Pile Installation and Removal (From NMFS 2005)

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 or vibratory hammers.

[1] http://www.adfg.state.ak.us/special/invasive/invasive.ph

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). Fish injuries associated directly with pile driving are poorly studied, but include rupture of the swim bladder and internal hemorrhaging (CalTrans 2001, Abbott and Bing-Sawyer 2002, Stadler pers. obs. 2002). Sound pressure levels (SPLs) 100 decibels (dB) above the threshold for hearing are thought to be sufficient to damage the auditory system in many fishes (Hastings 2002).

The type and intensity of the sounds produced during pile driving depend on a variety of factors, including 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. A key difference between the sounds produced by impact hammers and those produced by vibratory hammers is the responses they evoke in fish. The differential responses to these sounds are due to the differences in the duration and frequency of the sounds.

Systems using air bubbles have been successfully designed to reduce the adverse effects of underwater SPLs on fish. 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 for pile driving should be viewed as options to avoid and minimize adverse impacts and promote the conservation, enhancement, and proper functioning of EFH.

- 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.

If the first measure is not possible, then the following measures regarding pile driving should be incorporated when practicable to minimize adverse effects:

- Drive piles during low tide when they are located in intertidal and shallow subtidal areas.
- Use a vibratory hammer when driving hollow steel piles.
- Implement measures to attenuate the sound should SPLs exceed the 180 dB (re: 1 μPa) threshold.
- Surround the pile with an air bubble curtain system or air-filled coffer dam.
- Use a smaller hammer to reduce sound pressures.
- Use a hydraulic hammer if impact driving cannot be avoided.

- Drive piles when the current is reduced 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 (see earlier). 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 in Alaska 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 for pile removal should be viewed as options to avoid and minimize adverse impacts and promote the conservation, enhancement, and proper functioning of EFH.

- Remove piles completely rather than cutting or breaking them off, if they are structurally sound.
- 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:
    - When practicable, remove piles with a vibratory hammer.
    - Remove the pile slowly to allow sediment to slough off at, or near, the mudline.
    - The operator should first hit or vibrate the pile to break the bond between the sediment and the pile.
    - Encircle the pile, or piles, with a silt curtain that extends from the surface of the water to the substrate.
- Complete each pass of the clamshell to minimize suspension of sediment if pile stubs are removed with a clamshell.
- Place piles on a barge equipped with a basin to contain attached sediment and runoff water after removal.

- 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 (from NMFS 2005)

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).

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, (3) introduction of contaminants into the marine environment, and (4) activities associated with the use and operation of the facilities (Nightingale and Simenstad 2001b).

Recommended Conservation Measures

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

- Use upland boat storage whenever possible to minimize need for overwater structures.
- 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.
- Design piers, docks, and floats to be multiuse facilities to reduce the overall number of such structures and to limit impacted nearshore habitat.
- Incorporate measures that increase the ambient light transmission under piers and docks.
    - Maximize the height and minimize the width to decrease the shade footprint.
    - Use reflective materials on the underside of the dock to reflect ambient light.
    - Use the fewest number of pilings necessary to support the structures.
    - 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.
- 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.
- Locate floats in deep water to avoid light limitation and grounding impacts to the intertidal or shallow subtidal zone.
- Maintain at least 1 foot (0.30 meter) of water between the substrate and the bottom of the float at extreme low tide.
- Conduct in-water work when managed species and prey species are least likely to be impacted.
- To the extent practicable, avoid the use of treated wood timbers or pilings.

- Mitigate for unavoidable impacts to benthic habitats.

F.2.3.7 Flood Control/Shoreline Protection (from NMFS 2005)

Structures designed to protect humans from flooding events can result in varying degrees of change in the physical, chemical, and biological characteristics of shoreline and riparian habitat. These structures also can 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 in between that are in equilibrium with the prevailing climatic, hydrographic, geological, and biological features of the coast. These systems normally drain through 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 may include 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 the flow of freshwater, annual renewal of sediments and nutrients, and the formation of new marshes. Water controls within the marsh can intercept and carry away freshwater drainage, thus blocking freshwater from flowing across seaward portions of the marsh, or conversely increase the speed of runoff of freshwater to the bay or estuary. This can result in lowering the water table, which may permit saltwater intrusion into the marsh, and create migration barriers for aquatic species. In deeper channels where anoxic conditions prevail, large quantities of hydrogen sulfide may be produced that are toxic to marsh grasses and other aquatic life (NMFS 2008). Acid conditions of these channels can also result in release of heavy metals from the sediments.

Long-term effects of shoreline protection structures on tidal marshes include land subsidence (sometimes even submergence), soil compaction, conversion to terrestrial vegetation, greatly reduced invertebrate populations, and general loss of productive wetland characteristics (NMFS 2005). Alteration of the hydrology of coastal salt marshes can reduce estuarine productivity, restrict suitable habitat for aquatic species, and result in salinity extremes during droughts and floods (NMFS 2008). Armoring shorelines to prevent erosion and to maintain or create shoreline real estate can reduce 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 for flood and shoreline protection should be viewed as options to avoid and minimize adverse impacts and promote the conservation, enhancement, and proper functioning of EFH.

- Avoid or minimize the loss of coastal wetlands as much as possible.
- Do not dike or drain tidal marshlands or estuaries.
- Wherever possible, use soft in lieu of “hard” shoreline stabilization and modifications.
- Ensure that the hydrodynamics and sedimentation patterns are properly modeled and that the design avoids erosion to adjacent properties when “hard” shoreline stabilization is deemed necessary.
- Include efforts to preserve and enhance fishery habitat to offset impacts.
- Avoid installing new water control structures in tidal marshes and freshwater streams.
- Ensure water control structures are monitored for potential alteration of water temperature, dissolved oxygen concentration, and other parameters.
- Use seasonal restrictions to avoid impacts to habitat during critical life history stages.
- Address the cumulative impacts of development activities in the review process for flood control and shoreline protection projects.
- 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 (from NMFS 2005)

Rivers, estuaries, and bays were historically the primary ways to transport and store logs in the Pacific Northwest, and log storage continues in some tidal areas today. Using estuaries and bays and nearby uplands for storage of logs is common in Alaska, with most log transfer facilities (LTFs) found in Southeast Alaska and a few located in Prince William Sound. LTFs are facilities that are constructed wholly or in part in waterways and used to transfer commercially harvested logs to or from a vessel or log raft, or for consolidating logs for incorporation into log rafts (USEPA 2000b). LTFs may use a crane, A-frame structure, conveyor, slide or ramp to move logs from land into the water. Logs can also be placed in the water at the site by helicopters.

Potential Adverse Impacts

Log handling and storage in the estuaries and intertidal zones can result in modification of benthic habitat and water quality degradation within the area of bark deposition (Levings and Northcote 2004). EFH may be physically impacted by activities associated with LTFs. LTFs may cause shading and other indirect effects similar in many ways to those of floating docks and other over-water structures (see earlier).

Recommended Conservation Measures

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

The physical, chemical, and biological impacts of LTF operations can be substantially reduced by adherence to appropriate siting and operational constraints. Adherence to the Alaska Timber Task Force (ATTF) operational and siting guidelines and BMPs in the National Pollutant Discharge Elimination System (NPDES) General Permit 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. The following conservation measures reflect those guidelines.[2]

- 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.
- 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).
- Do not store logs in the water if they will ground at any time or shade sensitive aquatic vegetation such as eelgrass.
- Avoid siting log-storage areas and LTFs in sensitive habitat and areas important for specified species, as required by the ATTF guidelines.
- Site log storage areas and LTFs in areas with good currents and tidal exchanges.
- Use land-based storage sites where possible.

F.2.3.9 Utility Line, Cables, and 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, and other utilities. 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 direct impacts occur during construction, 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 due to ground clearing and construction.

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 and

[2] See also http://www.fs.fed.us/r10/TLMP/F_PLAN/APPEND_G.PDF.

release of contaminants; (4) changes in hydrology; and; (5) destruction of vertically complex hard bottom habitat (e.g., hard corals and vegetated rocky reef).

Recommended Conservation Measures

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

- Align crossings along the least environmentally damaging route.
- 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 intertidal zone.
- Store and contain excavated material on uplands.
- Backfill excavated wetlands with either the same or comparable material capable of supporting similar wetland vegetation, and at original marsh elevations.
- Use existing rights-of-way whenever possible.
- Bury pipelines and submerged cables where possible.
- Remove inactive pipelines and submerged cables unless they are located in sensitive areas (e.g., marsh, reefs, sea grass).
- Use silt curtains or other barriers to reduce turbidity and sedimentation whenever possible.
- Limit access for equipment to the immediate project area. Tracked vehicles are preferred over wheeled vehicles.
- Limit construction equipment to the minimum size necessary to complete the work.
- Conduct construction during the time of year when it will have the least impact on sensitive habitats and species.
- Suspend transmission lines beneath existing bridges or conduct directional boring under streams to reduce the environmental impact.
- For activities on the Continental Shelf, implement the following to the extent practicable:
    - Shunt drill cuttings through a conduit and either discharge the cuttings near the sea floor, or transport them ashore.
    - Locate drilling and production structures, including pipelines, at least 1 mile (1.6 kilometers) from the base of a hard-bottom habitat.
    - Bury pipelines at least 3 feet (0.9 meter) beneath the sea floor whenever possible.
    - Locate alignments along routes that will minimize damage to marine and estuarine habitat.

F.2.3.10 Mariculture

Productive embayments are often used for commercial culturing and harvesting operations. These locations provide protected waters for geoduck, oyster, and mussel culturing. In 1988, Alaska passed the Alaska Aquatic Farming Act (AAF Act) which is designed to encourage establishment and growth of an aquatic farming industry in the state. The AAF 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. Aquatic farm permits are issued by the Alaska Department of Natural Resources (ADNR).

Potential Adverse Impacts

Shellfish aquaculture tends to have less impact on EFH than finfish aquaculture because the shellfish generally are not fed or treated with chemicals (OSPAR Commission 2009). Adverse impacts to EFH by mariculture operations include (1) risk of introducing undesirable species and disease; (2) physical disturbance of intertidal and subtidal areas; (3) impacts on estuarine food webs, including disruption of eelgrass habitat (e.g., dumping of shell on eelgrass beds, repeated mechanical raking or trampling, and impacts from predator exclusion netting, though few studies have documented impacts). Hydraulic dredges used to harvest oysters in coastal bays can cause long-term adverse impacts to eelgrass beds by reducing or eliminating the beds (Phillips 1984).

Recommended Conservation Measures

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

- Site mariculture operations away from kelp or eelgrass beds.
- Do not enclose or impound tidally influenced wetlands for mariculture.
- Undertake a thorough scientific review and risk assessment before any non-native species are introduced.
- 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.
- Provide appropriate mitigation for the unavoidable, extensive, or permanent loss of plant communities.
- Ensure that mariculture facilities, spat, and related items transported from other areas are free of nonindigenous species.

F.2.4 Coastal/Marine Activities

F.2.4.1 Point-Source Discharges

Point source pollutants are generally introduced via some type of pipe, culvert, or similar outfall structure. These discharge facilities typically are associated with domestic or industrial activities, or in conjunction with collected runoff from roadways and other developed portions of the coastal landscape. Waste streams from sewage treatment facilities and watershed runoff may be combined in a single discharge. Point source discharges introduce inorganic and organic contaminants into aquatic habitats, where they may become bioavailable to living marine resources.

Potential Adverse Impacts (adopted from NMFS 2008)

The Clean Water Act (CWA) includes important provisions to address acute or chronic water pollution emanating from point source discharges. Under the NPDES program, most point-source discharges are regulated by the state or EPA. While the NPDES program has led to ecological improvements in U.S. waters, point sources continue to introduce pollutants into the aquatic environment, albeit at reduced levels.

Determining the fate and effect of natural and synthetic contaminants in the environment requires an interdisciplinary approach to identify and evaluate all processes sensitive to pollutants. This is critical as adverse effects may be manifested at the biochemical level in organisms (Luoma 1996) in a manner particular to the species or life stage exposed. Exposure to pollutants can inhibit (1) basic detoxification mechanisms, e.g., production of metallothioneins or antioxidant enzymes; (2) disease resistance; (3) the ability of individuals or populations to counteract pollutant-induced metabolic stress; (4) reproductive processes including gamete development and embryonic viability; (5) growth and successful development through early life stages; (6) normal processes including feeding rate, respiration, osmoregulation; and (7) overall Darwinian fitness (Capuzzo and Sassner 1977; Widdows et al. 1990; Nelson et al. 1991; Stiles et al. 1991; Luoma 1996; Thurberg and Gould 2005).

Recommended Conservation Measures

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

- Locate discharge points in coastal waters well away from shellfish beds, sea grass beds, corals, and other similar fragile and productive habitats.
- Reduce potentially high velocities by diffusing effluent to acceptable velocities.
- Determine baseline benthic productivity by sampling before any construction activity.
- Provide for mitigation when degradation or loss of habitat occurs.
- Institute source-control programs that effectively reduce noxious materials.
- Ensure compliance with pollutant discharge permits, which set effluent limitations and/or specify operation procedures, performance standards, or BMPs.
- Treat discharges to the maximum extent practicable.
- Use land-treatment and upland disposal/storage techniques where possible.
- Avoid siting pipelines and treatment facilities in wetlands and streams.

F.2.4.2 Seafood Processing Waste—Shoreside and Vessel Operation

Seafood processing is conducted throughout much of coastal Alaska. Processing facilities may be vessel-based or located onshore (ADEC 2010a). 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, recreational fish cleaning at marinas and small harbors can produce a large quantity of fish waste.

Pollutants of concern from seafood processing wastewater are primarily components of the biological wastes generated by processing raw seafood into a marketable form, chemicals used to maintain sanitary conditions for processing equipment and fish containment structures, and refrigerants (ammonia and freon) that may leak from refrigeration systems used to preserve seafood (ADEC 2010b). Biological wastes include fish parts (e.g., heads, fins, bones, entrails); and chemicals, which are primarily disinfectants that must be used in accordance with EPA specifications.

Potential Adverse Impacts

Seafood processing operations have the potential to adversely affect EFH through the discharge of nutrients, chemicals, fish byproducts, and “stickwater” (water and entrained organics originating from the draining or pressing of steam-cooked fish products). Seafood processing discharges influence nutrient loading, eutrophication, and anoxic and hypoxic conditions significantly influencing marine species diversity and water quality (Theriault et al. 2006, Roy Consultants 2003, Lotze et al. 2003). Although fish waste is biodegradable, fish parts that are ground to fine particles may remain suspended for some time, thereby overburdening habitats from particle suspension (NMFS 2005). Scum and foam from seafood waste deposits can also occur on the water surface and/or increase turbidity. Turbidity decreases light penetration into the water column, reducing primary production. In addition, stickwater takes the form of a fine gel or slime that can concentrate on surface waters and move onshore to cover intertidal areas.

Recommended Conservation Measures

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

- To the maximum extent practicable, base effluent limitations on site-specific water quality concerns.
- Encourage the use of secondary or wastewater treatment systems where possible.
- Do not allow designation of new zones of deposit for fish processing waste and instead seek disposal options that avoid an accumulation of waste.
- Promote sound recreational fish waste management through a combination of fish-cleaning restrictions, public education, and proper disposal of fish waste.
- Encourage alternative uses of fish processing wastes.
- Explore options for additional research.
- Monitor biological and chemical changes to the site of processing waste discharges.

F.2.4.3 Water Intake Structures/Discharge Plumes

Withdrawals of riverine, estuarine, and marine waters are common for a variety of uses such as 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) degrading water quality, (4) operation and maintenance, and (5) construction-related impacts.

Recommended Conservation Measures

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

- 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.
- Design intake structures to minimize entrainment or impingement.
- Design power plant cooling structures to meet the best technology available requirements as developed pursuant to section 316(b) of the CWA.
- Regulate discharge temperatures so they do not appreciably alter the ambient temperature to an extent that could cause a change in species assemblages and ecosystem function in the receiving waters.
- Avoid the use of biocides (e.g., chlorine) to prevent fouling where possible.
- Treat all discharge water from outfall structures to meet state water quality standards at the terminus of the pipe.

F.2.4.4 Oil and Gas Exploration, Development, and Production

Two agencies, the Bureau of Ocean Energy Management and the Bureau of Safety and Environmental Enforcement are responsible for regulating oil and gas operations on the Outer Continental Shelf (OCS). The ADNR Division of Oil and Gas exercises similar authority over State waters (ADNR 1999). Offshore petroleum exploration, development, and production activities have been conducted in Alaska waters or on the Alaska OCS since the 1960s (Kenai Peninsula Borough 2004). 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.

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, and can cause an assortment of physical, chemical, and biological disturbances

(NMFS 2005, Helvey 2002). (Some of these disturbances are listed below; however, not all of the potential disturbances in this list apply to every type of activity.)

- 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 for oil and gas exploration and development should be viewed as options to avoid and minimize adverse impacts and promote the conservation, enhancement, and proper functioning of EFH:

- Avoid the discharge of produced waters into marine waters and estuaries.
- Avoid discharge of muds and cuttings into the marine and estuarine environment.
- To the extent practicable, avoid the placement of fill to support construction of causeways or structures in the nearshore marine environment.
- As required by federal and state regulatory agencies, encourage the use of geographic response strategies that identify EFH and environmentally sensitive areas.
- Evaluate potential impacts to EFH that may result from activities carried out during the decommissioning phase of oil and gas facilities.
- Vessel operations and shipping activities should be familiar with Alaska Geographic Response Strategies which detail environmentally sensitive areas of Alaska’s coastline.

F.2.4.5 Habitat Restoration and 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 adequate shelter from predators 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 fish stocks by increasing or improving ecological structure and functions. Habitat restoration and enhancement may include, but is not limited to, improvement of coastal wetland tidal exchange or reestablishment of natural hydrology; dam or berm removal; fish passage barrier removal or modification; road-related sediment source reduction; natural or artificial reef, substrate, or 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; and improvements to feeding, shade or refuge, spawning, and rearing areas that are essential to fisheries.

Potential Adverse Impacts

The implementation of restoration and 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 removal feeding opportunities, (4) indirect effects from construction phase of the activity (5) direct disturbance or removal of native species, and (6) temporary or permanent habitat disturbance.

Recommended Conservation Measures

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

- Use BMPs to minimize and avoid potential impacts to EFH during restoration activities.
  - Use turbidity curtains, hay bales, and erosion mats.
  - Plan staging areas in advance, and keep them to a minimum size.
  - Establish buffer areas around sensitive resources.
  - Remove invasive plant and animal species from the proposed action area before starting work. Plant only native plant species.
  - Establish temporary access pathways before restoration activities.
- Avoid restoration work during critical life stages for fish such as spawning, nursery, and migration.
- Provide adequate training and education for volunteers and project contractors to ensure minimal impact to the restoration site.
- Conduct monitoring before, during, and after project implementation.
- To the extent practicable, mitigate any unavoidable damage to EFH.
- Remove and, if necessary, restore any temporary access pathways and staging areas used.
- 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.

F.2.4.6 Marine Mining

Mining activities, which are also described in Sections 3.1.1 and 3.1.2 of the EFH EIS (NMFS 2005), can lead to the direct loss or degradation of EFH for certain species. Offshore mining, such as the extraction of gravel and gold in the Bering Sea, can increase turbidity, and resuspension of organic materials could impact eggs and recently hatched larvae in the area. Mining large quantities of beach gravel can also impact turbidity, and may significantly affect the transport and deposition of sand and gravel along the shore, both at the mining site and down-current (NMFS 2005).

Potential Adverse Impacts

Impacts from mining on EFH include both physical impacts (i.e., intertidal dredging) and chemical impacts (i.e., additives such as flocculates) (NMFS 2005). Physical 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.

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.

- To the extent practicable, avoid mining in waters containing sensitive marine benthic habitat, including EFH (e.g., spawning, migrating, and feeding sites).
- Minimize the areal extent and depth of extraction to reduce recolonization times.
- Monitor turbidity during operations, and cease operations if turbidity exceeds predetermined threshold levels.
- Monitor individual mining operations to avoid and minimize cumulative impacts.
- 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).
- Deposit tailings within as small an area as possible.

F.2.5 References

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