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Essential Fish Habitat 5-year Review

Summary Report

2010 through 2015

July 2017

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
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EXECUTIVE SUMMARY

The Magnuson-Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act) includes provisions concerning the identification and conservation of Essential Fish Habitat (EFH). The Magnuson-Stevens Act defines EFH as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity." The National Marine Fisheries Service (NMFS) and regional fishery management councils must describe and identify EFH in fishery management plans (FMPs), minimize to the extent practicable the adverse effects of fishing on EFH, and identify other actions to encourage the conservation and enhancement of EFH. Federal agencies that authorize, fund, or undertake actions that may adversely affect EFH must consult with NMFS, and NMFS must provide conservation recommendations to federal and state agencies regarding actions that would adversely affect EFH.

The 2005 Final Environmental Impact Statement (2005 EFH FEIS) for EFH in Alaska evaluates alternatives and environmental consequences for three actions: (1) describing and identifying EFH for fisheries managed by the Council; (2) adopting an approach for the Council to identify Habitat Areas of Particular Concern (HAPC) within EFH; and (3) minimizing to the extent practicable the adverse effects of Council-managed fishing on EFH. With respect to the description and identification of EFH, it was identified that the action could have indirect negative effects for the industries and other entities that may face requirements (for federally managed fishing activities) or recommendations (for non-fishing activities) that are designed to protect fish habitats.

The 2005 FEIS Final Rule requires 'a review and revision of EFH components' be completed every 5 years, and EFH provisions be revised or amended, as warranted, based on available information. In 2010, NMFS and the Council conducted an EFH 5-year review (2010 EFH Review). The Council and NMFS revised the EFH sections of its FMPs to address findings from the 2010 EFH Review and the EFH Omnibus Amendment package was completed and approved in 2012 (77 FR 66564, November 6, 2012). The 2010 EFH Review made the following main determinations:

- New and more recent information exists to refine EFH for a small subset of managed species.
- Certain fishing effects may be impacting sensitive habitats of Bristol Bay red king crab; however additional analysis is needed (Long-term Effects Index [LEI] model).
- The non-fishing impacts analysis, including advisory EFH Conservation Recommendations, should be updated with the most current level of information.
- Identify skate egg deposition and recruitment sites as Habitat Areas of Particular Concern.

This final summary report presents the 2015 EFH 5-year review (2015 EFH Review). In April 2017, the Council recommended amendments to revise EFH descriptions and maps in five FMPs (excludes FMP for the Scallop Fishery off Alaska). The associated EFH Omnibus Amendment package is being completed concurrently and is expected to be approved in 2017. NMFS and the Council made the following main determinations during the 2015 EFH Review:

- Refine EFH descriptions and maps for many managed species using more recent information and new methods.
- Use the best available science and a new Fishing Effects (FE) model to understand the effects of fishing on EFH. No changes in management with regard to fishing within EFH are recommended at this time.
- Update the non-fishing impacts analysis, including advisory EFH Conservation Recommendations, with the most recent information, including sections on ocean acidification, climate change, and ecosystem processes.

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1 Introduction

The Magnuson-Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act) includes provisions concerning the identification and conservation of Essential Fish Habitat (EFH). The Magnuson-Stevens Act defines EFH as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity." The National Marine Fisheries Service (NMFS) and regional fishery management councils must describe and identify EFH in fishery management plans (FMPs), minimize to the extent practicable the adverse effects of fishing on EFH, and identify other actions to encourage the conservation and enhancement of EFH. Federal agencies that authorize, fund, or undertake actions that may adversely affect EFH must consult with NMFS, and NMFS must provide conservation recommendations to federal and state agencies regarding actions that would adversely affect EFH. Fishery management councils also have the authority to comment on federal or state agency actions that would adversely affect the habitat, including EFH, of managed species.

Each of the North Pacific Fishery Management Council's (Council) FMPs contains the following EFH components:

1. EFH descriptions and identification
2. Fishing activities that may adversely affect EFH
3. Non-Magnuson-Stevens Act fishing activities that may adversely affect EFH
4. Non-fishing activities that may adversely affect EFH
5. Cumulative impacts analysis
6. EFH conservation and enhancement recommendations
7. Prey species list and any locations
8. Habitat Areas of Particular Concern (HAPC) identification
9. Research and information needs
10. Review EFH every 5 years

As clarification for component 10, the EFH Final Rule requires 'a review and revision of EFH components' be completed every 5 years, and EFH provisions be revised or amended, as warranted, based on available information. The Final Rule continues that the review should also evaluate:

- published scientific literature
- unpublished scientific reports
- information solicited from interested parties
- previously unavailable or inaccessible data.

This summary report documents the current 5-year review (2015 EFH Review). This is the Council's third review of EFH in the FMPs. Prior reviews were completed in 2005 and 2010. This 2015 EFH Review, completed in June 2017, describes the new information and analysis, and the Council decisions on EFH revisions, since the 2010 EFH Review.

The EFH Review is primarily conducted by NMFS and Council staff using new information available since the completion of the previous review. Staff use information from published or unpublished scientific literature or scientific data, as directed in the EFH Final Rule, that meets acceptable standards of scientific review. Staff have also noted, as part of this review, unpublished studies that are currently underway or whose results are under review, which may provide further insight on EFH in the future.

The Council's role with respect to the EFH Review is to receive a report on the review, and decide whether any of the new information from the last 5 years, highlighted in the review, warrants change to management (i.e., amendments to the FMPs). The Council considers all 10 EFH components for each FMP, including individual species EFH descriptions, EFH conservation and enhancement recommendations for fishing and non-fishing effects on EFH, and identification of HAPCs. Any change to the FMP text, no matter how minor, requires an FMP amendment.

Based on the 5-year review report, the Council may recommend FMP amendments to revise one or more EFH components within any of the six FMPs under review. The level of analysis (environmental assessment, environmental impact statement, categorical exclusion) that is required to support that amendment will vary depending on the impacts of the change. The 2005 EFH Environmental Impact Statement (2005 EFH EIS) provided a comprehensive discussion of EFH in the five FMPs. The 2010 Omnibus Amendment Environmental Assessment (EA) package analyzed inclusion of the then-new Arctic FMP and other FMP amendments.

This 2015 EFH Review included evaluating new environmental and habitat data, developing new models to describe EFH, updating models to evaluate fisheries impacts on EFH, updating assessment of non-fishing impacts on EFH, and assessing information gaps and research needs. This review follows the process developed in the 2010 EFH Review, and applies to all the Council's FMPs, including the Arctic. An initial review of this report was conducted by the Council's Ecosystem Committee (ECO), the Scientific and Statistical Committee (SSC), the Advisory Panel (AP), and the Council at the April 2016 and April 2017 Council meetings. This final report incorporates suggestions from the Council and its advisory bodies. This 2015 EFH Review fulfills the Council's responsibility to complete a 5-year review of EFH. Based on this review, the Council recommended updates to the EFH descriptions and maps in all of its FMPs, except the Scallop FMP.

The following general steps are used to complete and document the EFH 5-year review:

1. Evaluate new information available since the last EFH review and review the text in the Council's 6 FMPs (BSAI groundfish, GOA groundfish, BSAI King and Tanner crab, Scallop, Salmon, Arctic) relating to the 10 EFH components. Note areas where changes to the EFH components may be warranted.
    a. Stock assessment authors are the lead reviewers for EFH text and maps relating to the species or species complex which they assess.
    b. Other components are reviewed by NMFS Habitat Conservation Division (HCD) staff, or other qualified NMFS, Council, or other staff.
2. Consult with the Plan Teams with respect to the stock assessment authors' review of EFH text, and other EFH review components, if appropriate [1]. Plan Teams are invited to provide recommendations to the SSC and the Council as to whether the individual species reviews are accurate and complete, and whether the available new information warrants revisions to EFH text in the FMPs, or to Council management measures to protect and conserve EFH.

[1] Note, as there is no Salmon Plan Team, the review relies on the expertise of NMFS and ADF&G staff to review and provide recommendations on changes to the Salmon FMP.

3. Prepare EFH 5-year review summary report for Council. Include recommendations of whether changes to the FMPs are warranted. Report should be made available in advance to the public. Contents of Council summary report will include:
    a. Review of 10 EFH components, documenting how the review was conducted, what new information is available relating to each component, and whether it agrees or disagrees with the information that is currently in the FMP.
    b. Possible changes to the 10 EFH components in the six FMPs under review.
4. If the Council decides to initiate FMP amendments, prepare amendments and any associated analysis to update EFH components in FMPs. Note, any change to the FMP text (which includes all 10 EFH components) must be implemented through an FMP amendment. The degree of analysis require to implement the change will vary based on whether the proposed amendment is a substantive change (e.g., a change in the EFH description), or a technical one (e.g., minor changes to the life history information).

In addition to the general steps above, the 2015 EFH Review specifically included:

1. Compile and evaluate new information available to describe species distribution and habitat. These new data were used to develop model-based EFH definitions for the Eastern Bering Sea and Gulf of Alaska. Models were evaluated by the Council's SSC in October 2014.
2. Model outputs and EFH descriptions were evaluated by the stock assessment authors, as lead reviewers for EFH text related to species or species complexes.
3. Comments and recommendations from the stock authors were compiled in the initial report, and were reported to the ECO, SSC, AP, and Council in April 2016.
4. A single, comprehensive map for each species or life stage was created, according to the Council's request. The comprehensive map was reviewed by the stock authors. Recommendations from the stock authors on the comprehensive map are included in this final review report.
5. The ECO and SSC asked that NMFS add discussion to the non-fishing document pertaining to warming ocean trends off Alaska, ocean acidification, and marine vessel traffic (in the Arctic).
6. At the April 2017 Council meeting, the SSC requested that additional maps (other seasons and life stages; new Arctic snow crab adults) be appended to the Omnibus Amendment package.

The new models and new maps allow more qualitative, precise descriptions of EFH in the Council's FMPs, and meet the recommendation in the MSA to use the best available scientific information to define EFH. The outputs of these models (EFH maps) and other information were provided to stock authors for their review and comment.

Recent data were also used to develop new models to assess the effects of fishing on EFH. The models and sample output were provided to the stock assessment authors for review and comment in February 2016, and presented to the ECO, SSC, AP, and Council in April 2016 and December 2016. These new models use high resolution fishing data to estimate the proportion of EFH that is impacted by commercial fishing. The SSC recognized that these new data allow for more objective evaluations of the effects of fishing on EFH and recommended that new methods and criteria be developed to evaluate those potential effects.

The NMFS Alaska Regional Office, HCD developed and contracted work to update non-fishing activities that may adversely affect EFH. This analysis was presented to the Council at the December 2016 meeting, including new EFH conservation recommendations, where appropriate (NMFS 2017).

A timeline for the 2015 EFH Review and its resulting amendments is shown in Table 1.

Table 1. 2015 EFH Review timeline for amendments to redefine EFH in the Council's FMPs.

Month & Year	**Amendment**
September 2013	Overview of 2015 EFH review approach to Groundfish Plan Teams, including draft analytical concepts, and initial identification of potential data sets.
April 2016	Preliminary EFH Review Summary report for Council - Review model-based EFH definitions, fishing-effects model, and stock author comments and suggestions at SSC, Ecosystem Committee, Advisory Panel, and Council.
April 2014	Update to Council on 2015 EFH Review approach
September 2014	Preliminary update to Groundfish Plan Teams on fishing effects results and EFH description methodology, draft habitat priorities questionnaire. Coordinate with Crab, Scallop, Salmon, and Arctic leads and assessment authors.
October 2014	Council recommends that the timeline for the 2015 EFH Review be extended in order to accommodate incorporating new data sources and necessary SSC reviews into the fishing effects model and revised species distribution models.
January – February 2015	Stock assessment authors review EFH for target stocks under the 6 Council FMPs.
June 2015	Draft Summary Report available for Council Review. Council decision as to whether to initiate action based on report (e.g., initiate analysis of FMP amendments to implement EFH changes).
April 2016	Preliminary EFH Review Summary report for Council – Review model-based EFH definitions, fishing-effects model, and stock author comments and suggestions at SSC, Ecosystem Committee, Advisory Panel, and Council
October 2016	Review non-fishing effects at SSC, Ecosystem Committee, Advisory Panel and Council. Review stock author review of EFH maps requested in April 2016. SSC review proposed Fishing Effects analysis methods and criteria
October 2016 – April 2017	Pending Council decision to revise EFH definition, prepare amendments required to change FMP EFH descriptions for any of the Council's FMPs. Determine level of analysis required to support FMP Amendments.
March 2017	Plan Teams review proposed FMP amendments Plan Teams review Fishing Effects results
April 2017	Review of FMP amendments and Fishing Effects results Council votes to amend FMPs based on the 2015 EFH Review
July 2017	Final Summary Report, FMP amendments for EFH text description and map

1.1 Council action

The 2015 EFH Review has been completed and is documented in this summary report. The final recommendations contained within the review are summarized in Table 2. At the April 2017 Council meeting, the Council voted on final action to initiate FMP amendments. This motion passed 10-0 unanimously in support of modifications to the EFH language in the FMPs. The Council and NMFS staff are currently finalizing an EA to support the FMP amendments.

The Council considered the following during the 2015 EFH Review:

- Do the EFH descriptions and geographical distributions for individual species warrant revising in the FMP? Should the FMPs be revised to reflect new information on their life history, biological/ habitat/ predator-prey associations, or fishery?
- Is a new evaluation of the adverse effects of fishing on EFH needed?
- Should any new conservation measures be considered to mitigate adverse effects of fishing?
- Should the conservation and enhancement recommendations for non-fishing threats to EFH be revised in the FMPs?
- Is there a need to identify new HAPC priorities, and thus initiate a call for proposals for candidate sites to be considered for special management as HAPCs?
- Does the Council want to identify new directions for EFH research for the next 5 years?

The Council reviewed the draft summary report at the October 2016 Council meeting. Based on the review of the report and associated materials, the Council initiated amendments to revise EFH components in the five of the six Council FMPs. In April 2017, the Council recommended additional amendments to five FMPs as follows:

- Amendment 115 to the FMP for Groundfish of the Bering Sea and Aleutian Islands Management Area (BSAI FMP),
- Amendment 105 to the FMP for Groundfish of the Gulf of Alaska (GOA FMP),
- Amendment 49 to the FMP for Bering Sea/Aleutian Islands King and Tanner Crabs (Crab FMP),
- Amendment 13 to the FMP for the Salmon Fisheries in the EEZ off Alaska (Salmon FMP), and
- Amendment 2 to the FMP for Fish Resources of the Arctic Management Area (Arctic FMP).

Information relevant to management and mitigation of impacts to EFH is now published annually in the Ecosystem Considerations section of the Stock Assessment and Fishery Evaluation (SAFE) reports (e.g., Zador 2016). The FMP amendments would make the following changes to the FMPs:

1. BSAI FMP, GOA FMP, and Crab FMP: update EFH descriptions and replace existing maps in the FMPs with maps that represent the 95th percentile by season for each species and life stage, as available.
2. Salmon FMP: update EFH descriptions and replace existing marine EFH maps in the FMP with the model-based maps for each species and life stage, as available
3. Arctic FMP: update EFH descriptions for all species, as available and replace the existing map for snow crab.
4. All FMPs: update EFH conservation recommendations for non-fishing activities
5. No Action: HAPC process, EFH Research Priorities

Table 2. Council action on 2017 EFH 5-year Review Summary Report

EFH Component	***Council FMP***	***Recommended change***
EFH description of individual species	*BSAI Groundfish*	***Initiate amendments for all 22 species or complexes*** *whose habitat is described in the FMP, to revise some aspect of the EFH description and maps, as described in the summary report*
EFH description of individual species	*GOA Groundfish*	***Initiate amendments for all 23 species or complexes*** *whose habitat is described in the FMP, to revise some aspect of the EFH description and maps, as described in the summary report*
EFH description of individual species	*BSAI Crab*	***Initiate amendments for all 5 species or complexes*** *in the FMP, to revise general EFH and fishery information for each species, as described in the summary report (amendments to revise the evaluation of fishing effects conclusions are not initiated at this time, rather see discussion under evaluation of fishing effects)*
EFH description of individual species	*Scallop*	***No amendments are warranted at this time for the one species in the FMP***
EFH description of individual species	*Salmon*	***Initiate amendments for all 5 species*** *in the FMP, to revise some aspect of the EFH description and maps, as described in the summary report.*
EFH description of individual species	*Arctic*	***Initiate amendments for 2 of 3 species in the FMP****, to revise some aspect of the EFH descriptions; map updates are undergoing development.*
Fishing activities that may adversely affect EFH	*All Council FMPs*	***The FE model represents a substantial improvement from the LEI approach.*** *None of the stock assessment authors concluded that habitat reduction within the CEA for their species was affecting their stocks in ways that were more than minimal or not temporary. None of the authors recommended any change in management with regards to fishing within EFH.*
Non-fishing activities that may adversely affect EFH	*All Council FMPs*	***Initiate amendments to update EFH conservation recommendations for non-fishing activities.***
HAPC	*All FMPs*	***No action; status quo****. The Council may initiate a call for proposals at any time using the HAPC nomination process.*
Research and information needs	*All FMPs*	***No action, status quo.*** *Many of the Council and NMFS research questions are still valid and remain to be investigated.*

1.2 History of EFH in Alaska

In 1998, the Council first amended five of its FMPs (BSAI FMP, GOA FMP, Crab FMP, Scallop FMP, and Salmon FMP (Table 1) following amendments made to the Magnuson-Stevens Act to include EFH. In 1999, a coalition of seven environmental groups and two fishermen's associations filed suit in the United States District Court for the District of Columbia to challenge NMFS' approval of EFH FMP amendments prepared by the Gulf of Mexico, Caribbean, New England, North Pacific, and Pacific Fishery Management Councils (American Oceans Campaign [AOC] et al. v. Daley et al., Civil Action

No. 99-982-GK). The focus of the AOC v. Daley litigation was whether NMFS and the Council had adequately evaluated the effects of fishing on EFH and taken appropriate measures to mitigate adverse effects. In September 2000, the court upheld NMFS' approval of the EFH amendments under the Magnuson-Stevens Act, but ruled that the environmental assessments (EAs) prepared for the amendments violated the National Environmental Policy Act (NEPA). The court ordered NMFS to complete new and thorough NEPA analyses for each EFH amendment in question.

The Council and NMFS Alaska Region addressed the problems identified by the court by preparing an environmental impact statement (2005 EFH EIS, NMFS 2005). This 2005 EFH EIS serves as the baseline for subsequent reviews. In the 2005 EFH EIS, the Council and NMFS developed and evaluated alternatives and environmental consequences for three actions:

1. describing and identifying EFH for fisheries managed by the Council;
2. adopting an approach for the Council to identify HAPCs within EFH; and
3. minimizing to the extent practicable the adverse effects of Council-managed fishing on EFH.

The Council used an extensive public process to develop the alternatives for the 2005 EFH EIS, including numerous public meetings of the Council and its EFH Committee. The analysis indicated that there are long-term effects of fishing on benthic habitat features off Alaska, and acknowledged that considerable scientific uncertainty remains regarding the consequences of such habitat changes for the sustained productivity of managed species. Nevertheless, based on the best available scientific information, the EIS concluded that the effects on EFH are minimal because the analysis found no indication that continued fishing activities at the current rate and intensity would alter the capacity of EFH to support healthy populations of managed species over the long term. The analysis concluded that no Council-managed fishing activities have more than minimal and temporary adverse effects on EFH, which is the regulatory standard requiring action to minimize adverse effects under the Magnuson-Stevens Act. Importantly, the Council initiated a variety of practicable management actions and precautionary measures to conserve and protect EFH.

The 2005 EFH EIS reviewed the effects of fishing at the then-existing rate and intensity, and concluded that fishing would not affect the capacity of EFH to support the life history processes of any species. In other words, the effects of fishing on EFH were concluded to be no more than minimal. Since the analysis in the EIS, the Council has taken management actions that may have changed the distribution or intensity of fishing, including a suite of mitigation measures adopted by the Council to provide additional protection to EFH. The 5-year reviews evaluate changes to fishing distribution since the 2005 FH FEIS analysis, and stock assessment authors review changes in fishing activities and whether any such changes are likely to impact the conclusions of the FEIS for their species. If a change to the conclusions of the evaluation of fishing effects is indicated, this may be a higher priority action item for the Council.

The 2005 EFH EIS and 2010 EFH Review examined the effects of fishing on EFH, and concluded that fishing at the rates and intensity at those times did not affect the capacity of EFH to support the life history processes of any species. Since the analysis in the 2005 EFH EIS and 2010 EFH Review, the Council has taken management actions that may have changed the distribution or intensity of fishing.

The actions the Council and NMFS took in association with the 2005 EFH EIS resulted in FMP amendments to modify the existing EFH and HAPC designations and to implement additional measures to reduce the effects of fishing on EFH. Specific regulations and associated conservation areas are available on the NMFS Alaska Region web site.

A sixth FMP for Fish Resources of the Arctic was approved by the Secretary of Commerce in August 2009 (Table 3). A thorough assessment of EFH was included in the Arctic FMP.

It can be difficult to assess the impacts of changes to available habitat, whether due to fishing pressure, non-fishing anthropogenic activities, or the effects of changing climate or physical conditions, because the linkages between habitat preferences and abundance of managed species is largely unknown. The analyses of any new amendments initiated by the Council rely heavily on the 2005 EFH EIS, where these unknowns were discussed and characterized. This has been accomplished through EAs tiering from the FEIS (i.e. omnibus amendments), but can also be done by issuing a supplement to the EIS, addressing the new amendments.

Table 3 List of Council Fishery Management Plans and status of EFH 5-year reviews

Fishery Management Plan	EFH FMP Amendments
Groundfish of the Bering Sea and Aleutian Islands Management Area (BSAI Groundfish)	Approved: 1999, 2006, 2012 Proposed: 2017
Groundfish of the Gulf of Alaska (GOA Groundfish)	Approved: 1999, 2006, 2012 Proposed: 2017
Bering Sea/ Aleutian Islands King and Tanner Crabs (BSAI Crab)	Approved: 1999, 2006, 2012 Proposed: 2017
Scallop Fishery off Alaska (Scallop)	Approved: 1999, 2006, 2012
Salmon Fisheries in the EEZ off Alaska (Salmon)	Approved: 1999, 2006, 2012 Proposed: 2017
Fish Resources of the Arctic (Arctic)	Approved: 2009, 2012 Proposed: 2017

In 2010, the Council initiated the 2010 EFH Review for all FMPs, except for the Arctic FMP which had recently been enacted. After review, the Council chose to initiate FMP amendments to revise EFH components in five FMPs. The 2010 EFH EA amendment package was completed and adopted in 2012 (77 FR 66565, November 6, 2012).

In 2015, the Council initiated another review of EFH in all FMPs. During this 2015 EFH Review process, NMFS and its collaborators developed species distribution models to aid in updating EFH text and maps, developed a new model to evaluate the effects of fishing on EFH, and prepared an updated non-fishing activities report.

The 5-year review process typically begins at or before set intervals of every five years (e.g. 2010, 2015, 2020), but is usually started before the 5-year period and may not be completed within that same year due to anticipated long lead items and the Council and Secretary of Commerce approval process. Table 4 summarizes the 5-year review process and completion timeline since the 2005 EFH FEIS.

Table 4. Timeline to completion for 2005 EFH FEIS and subsequent 5-year reviews

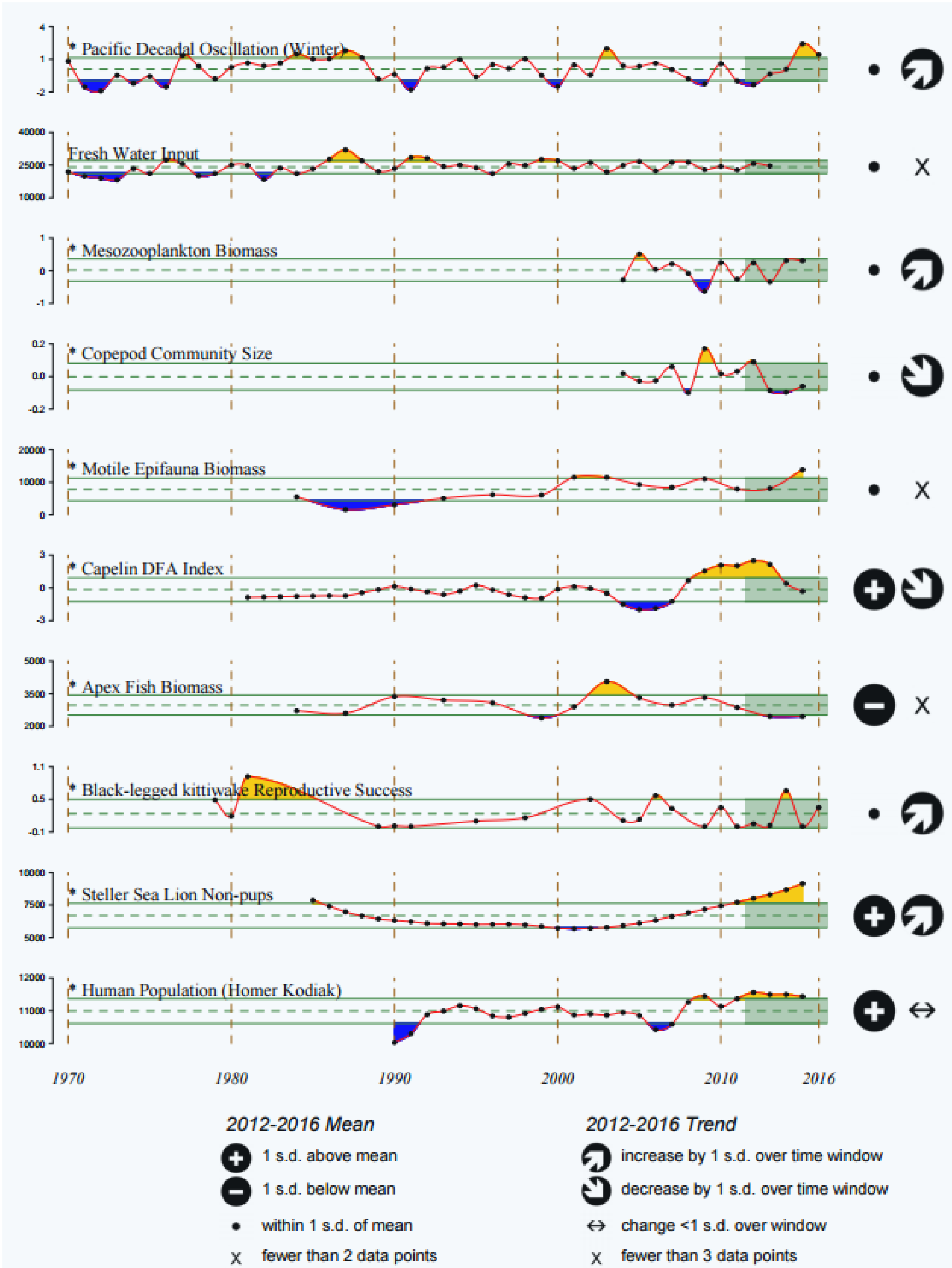
Document	Abbreviation	Process Began	Completed and Approved
2005 Final EIS for EFH in Alaska	2005 EFH FEIS	2001	2005
2010 EFH 5-year Review	2010 EFH Review	2010	2012
2015 EFH 5-year Review	2015 EFH Review	2013	2017

1.3 Environmental changes since 2005 EFH EIS and 2010 EFH Review

In order to better inform the 5-year review of EFH, this section discusses some of the changes that have occurred both in the North Pacific environment and habitat, including our understanding of that environment and our impact upon it in the last five years.
The Council's Ecosystem Considerations chapter of the Stock Assessment and Fishery Evaluation report (e.g. Zador 2016) provides a comprehensive overview of environmental conditions in the BSAI and GOA on an annual basis. Examples are shown here; however the annual ecosystem assessment provides the basis for understanding changes in the physical environment that may affect the review of EFH that is documented in this report. With respect to climate variability, the Bering Sea cold pool increased over the summers of 2007-2009, compared to the low values observed in 2000-2005, but was within the range of variability observed in recent decades. However, from 2014-2016, the Bering Sea was characterized by anomalously warm conditions for three consecutive years, and the cold pool was restricted to a small area in the Northern Bering Sea. The cold pool size and location may affect the distribution of some fish species, and may also affect stratification, production, and community dynamics in the Bering Sea.

AFSC staff developed a format for reporting various ecosystem indices over time, and comparing the most recent five years against the historical record for each indicator. During the 2010 review cycle, for almost all of the indices shown, the five year mean was within one standard deviation of the historical mean for the data set. This suggested that environmental conditions had not changed significantly from 2007-2011. However, from 2012-2016, the five year mean for many indicators in the Eastern Bering Sea, Aleutian Islands, and Gulf of Alaska are above or below one standard deviation of the historical mean. These differences may indicate a response to the warmer water in recent years (Zador et al. 2016).

Since 2010, the SAFE report has expanded and now provides Report Cards for three regions in the Aleutian Islands, two in the Gulf of Alaska, and one in the Bering Sea. These report cards provide information on ecosystem process and indicators on a yearly basis for the NPFMC. Figure 1 provides an example of the Gulf of Alaska report card for 2016.



Source: S. Zador, AFSC

Figure 1. Western Gulf of Alaska ecosystem assessment indicators

2 Roadmap to ten EFH components

Although the 10 EFH components are all addressed in each of the Council's FMPs, some components vary by FMP, and some are general across all the FMPs. Consequently, the format of the summary report is geared to minimize duplication, and groups related components together where appropriate. The following sections provide a roadmap to where, in this summary report, the review of each component may be found. A description of the 2010 and 2015 EFH Review plans for each of the 10 EFH components listed in the FMPs is included in Table 5.

2.1 EFH descriptions and identification

The review of EFH descriptions and identification for each managed species is described in this report by FMP, in Sections 4 through 9. For each individual species, the following information is contained within each FMP, and was reviewed for this report:

- *EFH description* – in text by life history stage, and illustrated on a map, along with an indication of the level of EFH information that is known for each life history stage of the species
- *General habitat information* – life history and general distribution; habitat, biological, and predator-prey associations; trophic information; upper size limit of juvenile fish
- *Fishery information* – description of directed fishery, evaluation of fishing effects (by any fishery) on species habitat
- *References* – references in the literature to learn more about species life history and habitat, persons to contact for further information

The EFH Final Rule establishes that fishery management councils should identify the level of information (1-4) that is available to describe EFH. As more information becomes available to describe EFH, the EFH description is noted at a higher level. The EFH levels are:

- *Level 1:* Distribution data are available for some or all portions of the geographic range of the species
- *Level 2:* Habitat-related densities of the species are available
- *Level 3:* Growth, reproduction, or survival rates within habitats are available
- *Level 4:* Production rates by habitat are available

Based on this review, the Council recommended changes to the EFH text descriptions and maps of EFH for most managed species, and changes to the available level of habitat information for many species' life history stages. Prior to this review, the descriptions of EFH in the Council's FMPs were either Level 1, or did not reach the Level 1 threshold due to insufficient information.

The EFH text description, by life history stage, represents the legal EFH description for each of the managed species. In the Council FMPs, that text description is also portrayed graphically on a map. It is on the basis of these descriptions that evaluations are made by the agency about whether an activity is likely to impact EFH. Stock assessment authors evaluated their species' EFH descriptions and seasonal and life-stage maps, as produced by the new models in January and February 2016, and a single, comprehensive map and description that was requested by the Council in May 2016. Section 3 describes the models used to create the EFH maps. Seasonal maps were eventually selected rather than a single full-year comprehensive species map due to differences in modeling methods. In turn, the Plan Teams have also provided recommendations to the SSC and the Council with respect to these new descriptions and new maps. Comments from the stock assessment authors on the comprehensive map and description were provided to the ECO, SSC, and AP for their review and comment before they were presented to the Council.

At the April 2016 meeting, the Council reviewed the new species distribution models to describe EFH and their outputs. Those maps were prepared and reviewed and approved by the stock assessment authors in May 2016. Based on their reviews, and input from the SSC, AP, and ECO, the Council chose to revise EFH definitions in the Council's FMPs at the October 2016 meeting.

In April 2017, the Council, through its advisory committees, decided that revisions to the FMPs were warranted, and recommended FMP amendments to implement these changes. The SSC requested that additional maps (other seasons and life stages) be appended to the FMPs. The Council determined that revisions to EFH descriptions in the Scallop FMP are not necessary at this time, and the existing definitions of scallop EFH will remain as the legal descriptions.

2.2 Fishing activities that may adversely affect EFH

For the 2015 EFH Review, the NMFS Alaska Region and academic contractors developed a new model to assess the potential effects of federally managed fishing on EFH. The proposed methods and criteria were presented and approved at the December 2015 Council meeting. The fishing effects model and sample outputs were reviewed by the SSC, ECO, AP, and Council at the April 2016 and December 2016 meetings; the SSC approved the model and noted that new data may allow for a better evaluation of effects. Stock assessment authors used the finalized methods and criteria in their assessment of fishing effects on EFH in 2017.

In Section 10, this report explains the new FE model and identifies how the model used in the 2005 EFH FEIS and 2010 EFH Review is compared against the new model. The model inputs include, among other things, the distribution and intensity of high resolution fishing data, additional habitat features, and habitat susceptibility and recovery rates. This demonstrates that the conclusions reached in the 2005 EFH EIS remains valid; however the new fishing effects model has advanced greatly from previous methods and represents the best current science.

2.3 Non-Magnuson-Stevens Act fishing activities that may adversely affect EFH

The effects of non-Magnuson-Stevens Act fishing activities are covered within the discussion of fishing effects on habitat in the 2005 EFH EIS and remain valid. Non-MSA fishing activities include State-parallel fisheries, State-water fisheries, and halibut fisheries managed by the International Pacific Halibut Commission (IPHC). The types of gear used by the non-MSA fisheries in Alaska are discussed in detail in the 2005 EFH EIS, as well as their distribution.

Overall the effects of State parallel and State-waters fisheries are not likely to be different than those discussed in the 2005 EFH EIS because of the nexus between the State harvest levels and fisheries restrictions and the Federal harvest levels and fisheries restrictions, and the ability to adjust the Federal fisheries if needed to mitigate impacts of the State fisheries. With regard to IPHC-managed halibut, commercial catch limits steadily declined from 2010 through 2014 and increased slightly in 2015, but overall the effects of halibut catch in all fisheries are not likely to be different than was analyzed in the 2005 EFH EIS because of the IPHC's process for setting the constant exploitation yield (CEY) and existing fishery restrictions. Therefore, the 2015 EFH Report does not provide additional analysis of the effects of non-MSA fishing activities on EFH.

Table 5. Five-year review plan for each of the 10 EFH components

EFH FMP Component	2010 Plan for EFH review	2015 Plan for EFH review
1. EFH Descriptions and Identification	Identify and evaluate new scientific literature, and information from other relevant sources, to see whether species-specific EFH description and identification, as written in the FMPs, is correct.	Identify and evaluate new scientific literature and other information. A newly developed model creates model-based EFH definitions. Stock assessment authors review models and outputs.
2. Fishing activities that may adversely affect EFH	Evaluate the various inputs to the existing LEI model to see how they compare with the model inputs from 2004 (a. distribution of the trawl fisheries, b. species recovery rates, c. gear changes in the fisheries that may affect habitat). This should demonstrate whether the impacts analysis from the 2005 EIS is likely to still be valid, or whether it warrants revision.	Review impacts from fishing gears on EFH. Develop a new fishing effects (FE) model to update the prior LEI fishing effects model to examine impacts of fishing on habitat. SSC review model design, implementation, parameters, and outputs.
3. Non-Magnuson-Stevens Act fishing activities that may adversely affect EFH	Review whether there have been changes in halibut and State water fisheries. Identify sources of new information that may shed light on analysis of the impact of these fishing activities.	Review changes to halibut and State water fisheries. Identify sources of new information that may shed light on analysis of the impact of these fishing activities.
4. Non-Fishing activities that may adversely affect EFH	Review whether there have been changes to non-fishing activities affecting habitat since the EFH analysis. Identify sources of new information that may shed light on analysis of the impact of non-fishing activities.	Review changes to non-fishing activities affecting EFH. Identify sources of new information that may shed light on analysis of the impact of non-fishing activities. Update EFH Conservation Recommendations; add new sections on warming trends off Alaska, ocean acidification and marine traffic (in the Arctic); and a more thorough bibliography.
5. Cumulative impacts analysis	Review cumulative impacts discussion in FMPs, and evaluate against new information.	Review cumulative impacts analysis discussion in FMPs, and evaluate against new information.
6. EFH Conservation and Enhancement Recommendations	Review EFH recommendations for fishing and non-fishing activities, and evaluate against new information to see whether updates are warranted.	Review EFH recommendations for fishing and non-fishing activities and evaluate against new information to determine whether updates are warranted.
7. Prey species list and any locations	Review prey species information and determine whether updates are warranted.	Review prey species information and determine whether updates are warranted
8. HAPC identification	Summarize Council's progress on HAPC priorities. Based on species-specific review of EFH, stock assessment authors or Plan Teams may suggest candidate HAPC areas that could be considered by the Council in the next HAPC priority cycle.	Council determines whether to initiate a new call for HAPC proposals.
9. Research and Information needs.	Review research and information needs, and determine whether updates to EFH research needs identified in the FMPs are warranted.	Identify research necessary to fill gaps in EFH knowledge. Stock Assessment authors recommended items to research for many EFH species.
10. Review EFH every 5 years.	Summary report represents EFH 5-year review.	Summary report represents EFH 5-year review.

2.4 Non-fishing activities that may adversely affect EFH

NMFS examines the effects of non-fishing activities on EFH and makes conservation recommendations designed to mitigate a range of activities that may have adverse impacts on EFH including: oil and gas exploration and development; vessel casualties that result in physical damage to living habitats or spill of toxic substances (i.e., oil spill); introduction of exotic species; depositional fill; marine dredging; mineral extraction; and waste water discharges. These conservation recommendations are included in the FMPs, and they have been reviewed by the staff of NMFS Alaska Region HCD. These recommendations are used by NMFS staff when consulting on effects to EFH by other agencies, and updating the FMPs to reflect the most recent recommendations may be a higher priority amendment for the Council to consider.

As part of the 2015 EFH Review, NMFS updated the report that evaluates the various non-fishing activities that may adversely affect EFH in Alaska, along with EFH conservation recommendations (NMFS 2017). The evaluation has a new format using an ecosystem approach, and incorporates EFH from terrestrial waters downstream to marine waters. This report is summarized in Section 11. This new report places more emphasis on estuarine and marine systems than previous reviews, and includes additional sections on ocean acidification and climate change, including expansion of marine transportation as increasingly ice-free Arctic waters become more favorable to shipping.

NMFS HCD conducts fishery resource reviews of all non-fishing activities, as necessary, that may adversely affect EFH. In some cases, NMFS and the action agency may enter into EFH Consultation, and an EFH Assessment may be required to provide science-based EFH Conservation Recommendations to conserve the biological value of EFH. Annually, NMFS AKR receives more than 1000 notices of activities that may affect EFH. Of these, approximately 30 may require EFH Consultation, and 3-5 of those enter expanded EFH Consultation, which receive a more detailed analysis. If these actions may adversely affect EFH that may impact a fishery, NMFS HCD brings these to the Council's attention through an established Council process to address non-fishing activities.

2.5 Cumulative impacts analysis

The cumulative effects of fishing and non-fishing activities on EFH were considered in the 2005 EFH EIS, but available information was not sufficient to assess how the cumulative effects of fishing and non-fishing activities influence the function of EFH on an ecosystem or watershed scale. As noted in the 2017 non-fishing effects report, the cumulative effects from multiple non-fishing anthropogenic sources are increasingly recognized as having synergistic effects that may degrade EFH and associated ecosystem processes that support sustainable fisheries. For fishing impacts to EFH, the FE model calculates habitat reductions at a monthly time step since 2003 and incorporates susceptibility and recovery dynamics, allowing for an assessment of cumulative effects from fishing activities for the first time. Cumulative impacts are considered throughout this summary report.

2.6 EFH conservation and enhancement recommendations

Habitat conservation and enhancement recommendations address fishing and non-fishing threats to EFH and HAPCs. NMFS conducts EFH consultations and makes conservation recommendations for non-fishing activities. Actions are hard to predict, since NMFS is not an action agency for non-fishing activities. However HCD acts to expand EFH consultation with recommendations for larger projects. This number remains fairly steady and is approximately 30 of the over 1,000 non-fishing activities reviewed by HCD.

As part of the evaluation of EFH, the Council adopted a number of mitigation measures in the fisheries to provide additional protection to EFH. Since the 2005 EFH EIS, and as a follow-up analysis from the 2010 EFH Review, the Council and NMFS have implemented several management changes to minimize impact on EFH.

EFH Habitat Conservation Measures (fishing)

In February 2005, the Council adopted several new closure areas to conserve EFH to minimize the effects of fishing on EFH and specifically address concerns about the impacts of bottom trawling on benthic habitat (particularly on coral communities). For example, in the Aleutian Islands, action was taken to prohibit all bottom trawling throughout the Aleutian Islands (totaling 277,100 nm^2). This created a suite of "open areas" for fishing to continue, while conserving EFH for select areas from bottom trawling. Further, a series of six discrete areas of especially high density coral and sponge habitat were closed to all bottom-contact fishing gear (longlines, pots, trawls). These "coral garden" areas, which total 110 nm^2, are essentially marine reserves. To improve monitoring and enforcement of the Aleutian Island closures, a vessel monitoring system is required for all fishing vessels in the Aleutian management area.

Other EFH conservation and protection measures include restricting or prohibiting bottom contact gears to 16 Named Alaska Seamounts (totaling 5,300 nm^2) in EEZ waters; an area commonly referred to as Bower's Ridge (totaling 5,330 nm^2); several slope areas containing corals throughout the Gulf of Alaska (totaling 2,100 nm^2); and identifying important habitat areas where concentrations of skate egg cases are found to exponentially high. Specifically, on January 5, 2015, NMFS approved Amendment 104 to the BSAI FMP to identify six areas of skate egg concentration as Habitat Areas of Particular Concern (HAPC; 80 FR 1378, January 9, 2015) and set a monitoring priority for these sites. Designating the six areas as HAPC highlighted the importance of early life stage histories for EFH conservation.

Gear Modifications

Starting in 2005, the AFSC Conservation Engineering Project has collaborated with the Bering Sea bottom trawl fleet, represented by The Groundfish Forum and the Best Use Cooperative, to identify modifications of trawl gear that reduce damage to seafloor habitat. Widely spaced elevating devices were developed that raised sweeps 2-4 inches above the seafloor with very little direct contact, instead of the continuous contact along the length of conventional sweeps. Cooperative research demonstrated reductions in effects on living structure animals on sand/mud substrates, while maintaining effective herding and capture of groundfish. The modification was also shown to substantially reduce mortality rates of Tanner, snow and red king crabs that encounter trawl sweeps. Field tests and workshops were conducted to develop practical implementation of these modifications, to identify related costs and handling issues and to propose useful definitions and enforcement measures.

In October 2009, the Council adopted a gear modification for the Bering Sea non-pelagic trawl flatfish fishery in order to reduce adverse impact to bottom habitat. Amendment 94 to the BSAI groundfish FMP, effective January 20, 2011, required the use of modified trawl gear in the Bering Sea flatfish nonpelagic trawl fishery to protect benthic habitat in a portion of the Bering Sea. A section of the Northern Bering Sea Research Area, identified as the Modified Gear Trawl Zone, was opened to targeted trawl fishing for any species. The boundary of the St. Matthew Island Habitat Conservation Area was modified to further protect blue king crab habitat. References to the Crab and Halibut Protection Zone were removed from the BSAI FMP, and additional blue king crab habitat conservation measures were taken as a joint amendment package for the BSAI FMP and Crab FMP.

In 2010, NMFS issued a final rule to implement Amendment 94 to the BSAI FMP (75 FR 61642, October 6, 2010). Amendment 94 (1) requires participants using nonpelagic trawl gear in the directed fishery for flatfish in the Bering Sea subarea to modify the trawl gear to raise portions of the gear off the ocean bottom, (2) changed the boundaries of the Northern Bering Sea Research Area to establish the Modified Gear Trawl Zone (MGTZ) and to expand the Saint Matthew Island Habitat Conservation Area, and (3) requires nonpelagic trawl gear to be modified to raise portions of the gear off the ocean bottom if used in any directed fishery for groundfish in the MGTZ. This action reduces potential adverse effects of nonpelagic trawl gear on bottom habitat, protects additional blue king crab habitat near St. Matthew Island, and allows for efficient flatfish harvest as the distribution of flatfish in the Bering Sea changes.

Marmot Bay Tanner Crab Protection Area

On January 16, 2014, NMFS issued regulations to implement Amendment 89 to the GOA FMP and to revise current regulations governing the configuration of modified nonpelagic trawl gear (79 FR 2794). This rule established a protection area in Marmot Bay, northeast of Kodiak Island, and closed that area to fishing with trawl gear except for directed fishing for pollock with pelagic trawl gear. The closure reduces bycatch of Tanner crab (Chionoecetes bairdi) in GOA groundfish fisheries. This rule also requires that nonpelagic trawl gear used in the directed flatfish fisheries in the Central Regulatory Area of the GOA be modified to raise portions of the gear off the sea floor. The modifications to nonpelagic trawl gear used in these fisheries reduce the unobserved injury and mortality of Tanner crab, and reduce the potential adverse impacts of nonpelagic trawl gear on bottom habitat. This rule also made a minor technical revision to the modified nonpelagic trawl gear construction regulations to facilitate gear construction for those vessels required to use modified nonpelagic trawl gear in the GOA and Bering Sea groundfish fisheries.

2.7 Prey species

Loss of prey may have an effect on EFH and managed species because the presence of prey makes waters and substrate function as feeding habitat. The major prey of managed species in the FMPs are reviewed in the individual species sections for each FMP. For example, the BSAI FMP and GOA FMP summarize this information in Appendix D Life History Features and Habitat Requirements of FMP species and Table D3 lists FMP species that are a predator of or prey to other FMP species. This information is updated as necessary when new information becomes available. Therefore, the 2015 EFH Report does not provide additional analysis of the effects of prey species.

2.8 HAPC identification

Section 12 provides a description of the Council’s HAPC identification process and existing HAPCs in Alaska. In April 2017, the Council considered initiating a HAPC proposal process to coincide with the ongoing review. Ultimately, the Council chose not to initiate the HAPC process; therefore, no calls for HAPC nominations through the proposal process will be initiated as part of the 2015 EFH Review. The Council noted that they had no information about any specific species or sites to warrant initiation of a HAPC process. The Council noted that should information arise the Council could initiate a HAPC process at any time in the future.

2.9 Research and information needs

Section 13 describes the review of research and information needs for EFH, as well as providing research recommendations for many of the individual FMP species. In conjunction with the 2015 EFH Review, NMFS published a new EFH Research Plan to guide the next several years of EFH research (Sigler et al. 2017).

2.10 Review EFH every 5 years

The final EFH component is to review EFH every 5 years. This summary report cumulatively documents the occurrence of this review since the 2005 EFH FEIS.

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3 Model-based Essential Fish Habitat descriptions

Sections 4 through 9 provide a summary of the review of EFH descriptions, which consist of text descriptions and maps, and recommendations for updating EFH descriptions based on new information and methods. In Alaska, most EFH descriptions for were limited to qualitative statements on the distribution of adult life stages. While these are useful, they could be refined by using species distribution models and available data from a variety of sources. Distribution models have been widely used in conservation biology and terrestrial systems to define the potential habitat for organisms of interest. Recently, species distribution models have been developed for coral and sponge species in the Eastern Bering Sea, Gulf of Alaska, and Aleutian Islands (Rooper et al. 2014, Sigler et al. 2015). Since the completion of the 2010 EFH review, substantial new data have been made available to describe habitat in the Large Marine Ecosystems (LMEs) around Alaska, and in some cases, the effects of habitat on abundance of species of interest.

For the 2015 EFH Review, scientists at NMFS Alaska Region, the Alaska Fisheries Science Center (AFSC), and academic researchers produced species distribution models of EFH for all major species of groundfish, crabs, and salmon in the eastern Bering Sea, Aleutian Islands, and Gulf of Alaska (Laman et al. 2017, Turner et al. 2017, and Echave et al. 2012). Models and text descriptions of EFH were generated for each species where data exists for egg, larval, juvenile, and adult life history stages in four seasons; fall (October-November), winter (December-February), spring (March-May), and summer (June-September). From these, complementary distribution maps were generated that showed the location of EFH.

The species and life history stages of fishes and invertebrates examined to create model-based EFH definitions are shown in Table 3. Data available for early life history stages (egg, larval, early juvenile) are primarily from the FOCI ECODAAT database. Summer distributions of juvenile and adult life history stages were modeled using the RACE eastern Bering Sea bottom trawl survey database (RACEBASE).

The seasonal adult distributions were modeled using commercial catch data from the catch-in-areas observer database (CIA Database) for the fall, winter, and spring seasons.

A new methodology to refine the geographic scope of EFH for Pacific salmon in marine waters off Alaska was developed by the AFSC. When the Council first identified salmon EFH, it designated all marine waters including the entire Exclusive Economic Zone (EEZ; 0 to 200 nm from shore) as EFH for each of the five species of Pacific salmon. In 2005, the Council recommended an improved analytical approach to identify EFH for most species of groundfish, crabs, and scallop, resulting in more refined EFH descriptions, but no changes were proposed to the existing description of marine salmon EFH as including the entire EEZ. Salmon EFH was identified broadly because (1) no systematic marine salmon survey exists off Alaska, (2) salmon are observed infrequently in offshore commercial fisheries for other species, and (3) the AFSC did not have the resources to analyze various data sources to determine whether it is possible to better define offshore salmon distributions and relative abundance.

In order to better define EFH within the U.S. EEZ for Pacific salmon found in Alaska (*Oncorhynchus* spp.), Echave et al. (2012) acquired catch, maturity, salinity, temperature, and station depth data for the Bering Sea and Gulf of Alaska from seven datasets. The objectives of this study were to 1) refine existing Level 1 EFH information by describing the presence/absence and geographic distribution of each species and life history of salmon, and 2) assess their Level 2 EFH habitat-specific densities. The influence of sea surface salinity (SSS), sea surface temperature (SST), and bottom depth on the distribution of Pacific salmon was analyzed. Very few significant associations between catch and the three tested environmental variables were found to exist, indicating little to no relationship between species distribution and the three measures of habitat condition; however, many patterns were still evident. This model resulted in improved EFH descriptions for salmon and new maps for salmon EFH.

3.1 Species distribution data

The modeling analyses included data collected during bottom-trawl surveys of the Aleutian Islands, Eastern Bering Sea, and Gulf of Alaska ecosystems. These data were the most comprehensive and useful of the three types of data analyzed, as they are all from the summer season and are conducted with a rigorous statistical design. The AFSC has conducted standard bottom-trawl surveys in these ecosystems since 1984 (von Szalay et al. 2016). The surveys are conducted on a 5 km by 5 km grid superimposed over the survey area. Each year of the survey a percentage of total grid cells are randomly chosen and a bottom trawl haul was placed within the 5 km X 5 km boundaries of the selected grid cell. Depending on the region, grid cells are chosen according to a stratified random sampling protocol and include a random mix both previously sampled and unsampled grid cells. For this analysis, AFSC bottom-trawl data were combined across years. The 1993 bottom-trawl survey was the first for which accurate temperature and depth data were available for calculating water-column properties used in the modeling.

All fishes and invertebrates captured during a survey tow were sorted either by species or into larger taxonomic groups and the total weight in the catch was determined. Catch per unit effort (CPUE; number·ha^{-1}) for each taxonomic group was calculated using the area swept which was computed from the net width for each tow multiplied by the distance towed recorded with a GPS. For some species both juvenile and adult sizes were captured during the bottom trawl survey. In these cases an approximate length at first maturity was used to partition the catches proportionally into juvenile and adult stages. For some species only a subset of years was used in the modeling due to taxonomic changes that have occurred throughout the time series. For example, dusky and dark rockfishes were considered one species prior to the 1996 survey, so only data from surveys beginning in this year were used to model these two species.

Data from the CIA observer database was used to model adult life history stages of fishes caught in commercial catches during the non-summer seasons. The CIA data was provided by Steve Lewis and John V. Olson (NMFS AKR). The data from observed hauls regardless of the type of fishing gear were combined across years for analysis. We used the observations of catch by species in the data for MaxEnt (presence-only) models where the number of presence observations in a species exceeded 50. All of these fish and invertebrates were assumed to be adult life history stages. Only the fall, winter, and spring seasons were considered, as the summer distributions were modeled using bottom trawl survey data.

An important caveat to the species distribution models developed using the CIA database is that for most species, the distribution of catches represents the distribution of fishing activity. So, instead of being a regular survey conducted over a regular grid, these observations are typically clustered around areas of high catches for target species. As such, they should be viewed with some caution compared to the bottom trawl survey distribution maps.

Three types of distribution modeling were used for the bottom trawl survey data based on the frequency of occurrence for each species in the catch. For species that occurred in > 30% of bottom trawl hauls, a standard Generalized Additive Modeling (GAM) method was used to produce maps of predicted density. For species where frequency of occurrence was between 10% and 30% a hurdle model (Cragg 1971, Potts and Elith 2006) predicting spatial distribution of fishes was used. For species with < 10% frequency of occurrence, but > 50 presence observations, the MaxEnt methodology was used to develop suitable habitat models. For all models, separate training (80%) and testing (20%) data were randomly selected from the total available trawl hauls for assessing the performance of each type of modeling. The training and testing data sets were the same across all species for the analysis of bottom trawl survey data.

The maximum entropy (MaxEnt modeling method was used for estimating species distribution for commercial catch data in the CIA database (Phillips et al. 2006, Elith et al. 2011). It was implemented in R software using the dismo package. MaxEnt models use only presence observations and are based on raster grids of explanatory variables (habitat variables) and point observations of presence. As with the other models, separate training (80%) and testing (20%) data were randomly selected for MaxEnt model developed in order to assess model performance.

Table 6. Species and life history stages modeled for the eastern Bering Sea slope and shelf and Gulf of Alaska

Species	Eggs	Larvae	Early Juveniles	Late Juveniles	Adults
Pollock					
Pacific cod					
Sablefish					
Yellowfin sole					
Greenland turbot					
Arrowtooth flounder	Atheresthes sp. as a group				
Kamchatka flounder					
Southern rock sole					
Northern rock sole					
Alaska plaice					
Rex sole					
Dover sole					
Flathead sole					
Pacific Ocean Perch	Sebastes sp. as a group				
Northern rockfish					
Shortraker rockfish					
Blackspotted/rougheye rockfish					
Dusky rockfish					
Thornyhead rockfish					
Atka mackerel					
Great sculpin					
Yellow Irish lord					
Bigmouth sculpin					
Alaska skate					
Bering skate					
Aleutian skate					
Mud skate					
Pacific giant octopus					
Red king crab					
Blue king crab					
Tanner crab					
Snow crab					

No data available
Presence or presence/absence models
Density (CPUE) models

3.2 EFH Mapping Summary

Maps of EFH based on model predictions were developed for each species and life history stage. These maps were produced as population quantiles from predictions of the distribution of suitable habitat (for species where MaxEnt modeling was used) or predictions of the distribution of abundance (for species where CPUE was modeled using either a GAM or hurdle GAM). For each map of model predictions 300,000 points were randomly sampled from the raster surface. These values were then ordered by cumulative distribution and zero abundance values were removed. Four population quantiles were selected from these cumulative distributions (5%, 25%, 50% and 75%). These quantiles were then used as break points to translate the model predictions (maps of suitable habitat or abundance) to map the distribution of categories of the amount of the species abundance or suitable habitat. For example, if the 5% quantile of species A was 0.024 individuals/ha, this meant that 95% of the population occurred at values higher than 0.024. Similarly, a 75% quantile of species A at 2.1 individuals/ha meant that values above 2.1 represented the top 25% of the population proportion, or the predicted highest abundance areas. The four categories for each species, life history stage, and season were mapped to show the distribution of the areas containing 95%, 75%, 50% and 25% of the population. It is important to note that these values were chosen somewhat arbitrarily (except 95% which is the current definition of EFH in Alaska), and other values could be equally appropriate.

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4 EFH descriptions for BSAI Groundfish species

As part of the 2015 EFH Review, the Council recommended Amendment 115 to the FMP for Groundfish of the Bering Sea and Aleutian Islands Management Area (BSAI FMP). Amendment 115 would update the EFH descriptions in that FMP as described in this section.

4.1 What are the BSAI groundfish species?

Table 7 lists the species and species complexes for which EFH is currently identified in the BSAI FMP, and compares them to the species or species complexes that are assessed in the 2009 and 2016 SAFE reports.

Table 7. BSAI species or species complexes for which EFH is currently identified in the BSAI FMP, compared to species or species complexes that are assessed in the 2009 and 2016 SAFE reports

	Species or complexes for which EFH was identified in BSAI Groundfish FMP in 2005	**Species or complexes which are assessed in the 2009 SAFE report**	**Species or complexes which are assessed in the 2016 SAFE report**
Pollock	pollock	pollock (EBS, AI, Bogoslof)	pollock (EBS, AI, Bogoslof)
Pacific cod	pacific cod	pacific cod	pacific cod
Sablefish	sablefish	sablefish	sablefish
Flatfish	yellowfin sole	yellowfin sole	yellowfin sole
	greenland turbot	greenland turbot	greenland turbot
	arrowtooth flounder	arrowtooth flounder	arrowtooth flounder
			kamchatka flounder
	rock sole	northern rock sole	northern rock sole
	flathead sole	flathead sole	flathead sole
	alaska plaice	alaska plaice	alaska plaice
	rex sole	other flatfish	other flatfish
	dover sole		
Rockfish	Pacific ocean perch	Pacific ocean perch	Pacific ocean perch
	northern rockfish	northern rockfish	northern rockfish
			shortraker rockfish
	shortraker/ rougheye rockfish	shortraker/blackspotted/ rougheye rockfish	blackspotted/ rougheye rockfish
	yelloweye rockfish	other rockfish	other rockfish
	dusky rockfish		
	thornyhead rockfish		
Atka mackerel	atka mackerel	atka mackerel	atka mackerel
Squid	squid	squid	squids
Other species	octopus	octopus	octopus
	sharks	sharks	sharks
	sculpins	sculpins	sculpins
	skates	skates	skates
Forage fish	forage fish complex		
Unspecified species		grenadiers	

4.2 Summary of EFH review for individual species changes

Each stock assessment author was asked to review the current FMP text relating to EFH for the assessed species or species complex, based on new information that has become available since the 2010 EFH Review. The author completed a worksheet with some general questions about new habitat information, and recommendations on potential HAPC or EFH conservation recommendations. The author also revised the existing FMP text with recommended changes or updates. There are several components in the FMP that relate to EFH for each species:

- EFH description by life history stage, in text and in maps, including an indicator for how much habitat information is known about each life history stage
  - This is the legal description of EFH, based on which EFH consultations for fishing and non-fishing effects on EFH are held as directed by the Magnuson-Stevens Act
- General information about the life history and distribution of the species/complex, the fishery, relevant trophic information, and habitat and biological associations
- A literature section that cites references of where habitat information on the species/complex can be found, and a section listing contact people for more information on the species
- Conclusions from the evaluation of fishing effects on EFH for the species

Table 8 provides an overall summary of the EFH reviews by species. “Yes” indicates that the author has suggested updates to the text in the identified section. To further explain the summary table, the major changes recommended to the EFH text for each species are detailed in bulleted form in Section 4.3. The new literature on which the review of EFH is based is captured within the edited FMP text for each species. The BSAI Groundfish Plan Team also reviewed the stock assessment authors’ recommended changes, and provided recommendations for the SSC and the Council.

Table 8. EFH review of BSAI groundfish species, with recommended changes to the existing EFH FMP text

KEY: yes = author has recommended an update to the existing FMP text, based on new information
e/c = author has recommended editorial changes or clarifications to the existing FMP text
"–" = no changes to the existing text have been recommended

Species	Recommended changes to the FMP text – EFH description		
Name	**text**	**map**	**Changes to EFH level of information (Level 1-4)**
pollock	yes; e/c	yes	eggs, early & late juveniles, adults increase to level 2
pacific cod	yes; e/c	yes	larvae, early & late juveniles, adults increase to level 2
sablefish	yes; e/c	yes	larvae decrease to insufficient information
yellowfin sole	yes; e/c	yes	eggs, larvae, early juveniles increase to level 1
greenland turbot	e/c	yes	-
arrowtooth flounder	e/c	yes	-
kamchatka flounder	e/c	yes	-
northern rock sole	yes; e/c	yes	early juveniles increase to level 1
flathead sole	yes; e/c	yes	early & late juveniles, adults increase to level 2
alaska plaice	yes; e/c	yes	larvae increase to level 1
rex sole	e/c	yes	-
dover sole	e/c	yes	-
Pacific ocean perch	yes; e/c	yes	late juveniles, adults increase to level 2
northern rockfish	yes; e/c	yes	late juveniles, adults increase to level 2
shortraker rockfish	e/c	yes	-
blackspotted/ rougheye rockfish	yes; e/c	yes	late juveniles increase to level 1, adults increase to level 2
dusky rockfish	e/c	yes	-
thornyhead rockfish	e/c	yes	-
atka mackerel	yes; e/c	yes	late juveniles increase to level 1, adults increase to level 2
squid	e/c	yes	-
octopus	e/c	-	-
sharks	e/c	-	-
sculpins	e/c	yes	-
skates	e/c	yes	-
forage fish complex	e/c	-	-
grenadiers	e/c	-	-

4.3 Description of recommendations for EFH text for individual species

A description of the recommendations that are captured in the summary table (Table 8) is provided below for each individual species or species complex for which EFH is defined in the BSAI FMP.

Pollock

- Expanded on existing description for early juveniles
- Updates to life history and general distribution information
- Updates to Literature
- Recommends use of updated maps to represent EFH
- Suggests Level 2 designation for pollock eggs, juveniles, and adults

Pacific cod

- Updates to EFH descriptions for larvae, early juveniles, late juveniles, and adults
- Expanded on life history and general distribution, trophic, and habitat and biological associations information
- Updates to literature
- Updates to habitat association tables
- Recommends use of updated maps to represent EFH
- Recommends Level 2 for larvae, early juveniles, late juveniles, and adults

Sablefish

- Reduced EFH description for larvae due to insufficient information
- Expanded on life history and general distribution, trophic, and habitat and biological associations information
- Updates to literature
- No changes to habitat association tables
- Recommends use of updated map showing 25-50% predicted habitat to describe EFH
- Recommends Level downgrade for larvae; others remain unchanged

Yellowfin sole

- Add EFH definitions to eggs, larvae, early juvenile life stages.
- Updates to life history and general distribution
- Updates to habitat and biological associations
- Updates to literature
- Change to habitat association tables
- Recommends use of updated maps to represent EFH
- Recommends Level 1 for eggs, larvae, early juvenile life stages; others remain at Level 1

Greenland turbot

- No changes to EFH description
- Editorial update to EFH habitat information description
- Updates to literature
- Changes to habitat association tables
- Recommends use of updated maps to represent EFH

Arrowtooth flounder

- No changes to EFH description
- Update to life history and general distribution
- No changes to habitat or biological associations
- Updates to literature
- Changes to habitat association tables
- Recommends use of updated maps to represent EFH

Kamchatka flounder

- No changes to EFH description
- Changes to habitat association tables
- Recommends use of updated maps to represent EFH
- Recommends remain at Level 1 (likely refers to late juveniles and adults)

Northern rock sole

- Updated EFH definition for early juvenile life stage
- Minor changes to EFH habitat information description
- Minor changes to habitat associations
- Updates to literature
- Changes to habitat association tables
- Recommends use of updated maps to represent EFH
- Recommends remain at Level 1

Flathead sole

- Updated EFH description for early juvenile life stage
- Updates to EFH habitat information description
- Updates to habitat associations
- Updates to literature
- Changes to habitat association tables
- Recommends use of updated maps to represent EFH
- Recommends Level 1 upgrade for early juveniles; all others remain unchanged

Alaska plaice

- Updated EFH description for larvae life stage
- Updates to EFH habitat information description
- Updates to habitat and biological associations table
- Updates to literature
- Changes to habitat association tables
- Recommends use of updated maps to represent EFH
- Recommends Level 1 upgrade for larvae; others remain unchanged

Rex sole

- No changes to EFH descriptions
- No changes to EFH habitat information description
- No changes to habitat and biological association table
- No changes to literature
- Changes to habitat association tables
- Recommends use of updated maps to represent EFH

Dover sole

- No changes to EFH descriptions
- No changes to EFH habitat information description
- No changes to habitat and biological association table
- No changes to literature
- Changes to habitat association tables
- Recommends use of updated maps to represent EFH

Pacific ocean perch

- Editorial updates to EFH description
- Updates to life history and general distribution
- Updates to habitat and biological associations text and table
- Updates to literature
- Changes to habitat association tables
- Recommends use of updated maps to represent EFH
- Recommends Level 2 for late juveniles and adults; others remain unchanged

Northern rockfish

- Editorial update to EFH descriptions
- Updates to life history and general distribution
- Updates to habitat and biological associations text and table
- Updates to literature
- Changes to habitat association tables
- Recommends use of updated maps to represent EFH
- Recommends Level 2 for late juveniles and adults; others remain unchanged

Shortraker rockfish

- No changes to EFH descriptions
- No changes to life history and general distribution
- No changes to habitat and biological associations text and table
- No changes to literature
- Changes to habitat association tables
- Recommends use of updated maps to represent EFH

Blackspotted/rougheye rockfish

- Updates to EFH descriptions for larvae and adult life history stages
- Updates to life history and general distribution
- No changes to habitat and biological associations
- No changes to literature
- Changes to habitat association tables
- Recommends use of updated maps to represent EFH
- Recommends Level 1 for late juveniles and Level 2 for adults; others remain unchanged

Dusky rockfish

- No changes to EFH descriptions
- Editorial change to life history and general distribution
- No changes to habitat and biological associations
- No changes to literature
- Changes to habitat association tables
- Recommends use of updated maps to represent EFH
- Recommends remain at Level 1

Thornyhead rockfish

- Author suggests breaking out Thornyhead rockfish to longspine and shortspine Thornyhead rockfish
- No changes to EFH descriptions
- No changes to life history and general distribution
- Editorial changes to habitat and biological associations
- No changes to literature
- Recommends use of updated maps to represent EFH

Atka mackerel

- Updates to EFH descriptions for eggs, late juvenile, and adult life history stages
- Expanded on life history and general distribution information
- Updates to relevant trophic information
- No changes to habitat and biological associations
- Updates to literature
- Changes to habitat association tables
- Recommends use of updated maps to represent EFH
- Recommends Level 1 for late juveniles, Level 2 for adults; other levels remain the same

Squid

- No changes to EFH descriptions
- Changes to nomenclature
- Updates to life history and general distribution
- Updates to relevant trophic information
- Updates to habitat and biological associations
- Updates to literature
- Changes to habitat association tables

Octopus

- No changes to EFH descriptions. EFH remains undefined
- Expanded on life history and general distribution information
- No changes to habitat and biological associations
- Updates to literature
- No changes to habitat association tables

Sharks

- No changes to EFH descriptions. EFH remains undefined.
- Changes to nomenclature
- Updates to life history and general distribution
- Updates to relevant trophic information
- Updates to habitat and biological association
- Updates to literature
- Changes to habitat association tables
- No maps available to describe EFH for BSAI sharks

Sculpins

- No changes to EFH descriptions
- Editorial change to life history and general distribution information
- No changes to relevant trophic information
- No changes to habitat and biological associations
- No updates to literature
- Changes to habitat association tables
- Recommends use of updated maps to represent EFH

Skates

- No changes to EFH descriptions
- Expanded on life history and general distribution
- Updates to relevant trophic information
- Updates to habitat and biological associations
- Updates to literature
- Changes to habitat association tables
- Recommends use of updated maps to represent EFH

Forage fish

- Recommended identifying EFH for adult life history stage
- Updates to life history and general distribution for capelin and eulachon
- Editorial changes to relevant trophic information for capelin and eulachon
- No changes to habitat and biological associations
- Updates to literature
- Changes to habitat association tables

Grenadiers

- Authors identified proposed EFH
- Added to habitat associations tables

Table 9 lists the levels of EFH information available as a result of the 2015 EFH Review, for species and species complexes for which EFH is currently identified in the BSAI FMP. EFH has not been described for sharks due to insufficient information. EFH has not been described for grenadiers and the forage fish complex because they are ecosystem component species.

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

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

x Indicates insufficient information is available to describe EFH

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

2 Indicates quantitative data (density or habitat-related density) are available for the habitats occupied by a species or life stage

One juvenile stage exists – see Late Juveniles

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5 EFH descriptions for GOA Groundfish species

As part of the 2015 EFH Review, the Council recommended Amendment 105 to the FMP for Groundfish of the Gulf of Alaska (GOA FMP). Amendment 105 would update the EFH descriptions in that FMP as described in this section.

5.1 What are the GOA groundfish species?

Table 10 lists the species and species complexes for which EFH is currently identified in the GOA FMP, and compares them to the species or species complexes that are assessed in the 2009 and 2016 SAFE reports.

Table 10. GOA species or species complexes for which EFH is currently identified in the GOA FMP, compared to species or species complexes that are assessed in the 2009 and 2016 SAFE reports

	Species or complexes for which EFH was identified in GOA Groundfish FMP in 2005	**Species or complexes which are assessed in 2009 SAFE report**	**Species or complexes which are assessed in 2016 SAFE report**
Pollock	pollock	pollock	pollock
Pacific cod	pacific cod	pacific cod	pacific cod
Sablefish	sablefish	sablefish	sablefish
Flatfish	yellowfin sole	shallow water flatfish	shallow water flatfish
	rock sole		northern/southern rock sole
	Alaska plaice		
	dover sole	deep water flatfish	deep water flatfish
	greenland turbot		
	rex sole	rex sole	rex sole
	arrowtooth flounder	arrowtooth flounder	arrowtooth flounder
	flathead sole	flathead sole	flathead sole
Rockfish	Pacific ocean perch	Pacific ocean perch	Pacific ocean perch
	northern rockfish	northern rockfish	northern rockfish
	shortraker/ rougheye rockfish	shortraker/ other slope rockfish	shortraker rockfish
		blackspotted and rougheye rockfish	other slope rockfish
			rougheye/blackspotted rockfish
	dusky rockfish	pelagic shelf rockfish	dusky rockfish
	yelloweye rockfish	demersal shelf rockfish	demersal shelf rockfish
	thornyhead rockfish	thornyhead rockfish	thornyhead rockfish
Atka mackerel	atka mackerel	atka mackerel	atka mackerel
Skates	skates	skates	skates
Other species	squid	squid	squids
	octopus	octopus	octopus
	sharks	sharks	sharks
	sculpins	sculpins	sculpins
Forage fish	forage fish complex		forage fish complex
Unspecified species		grenadiers	

5.2 Summary of EFH review for individual species changes

Each stock assessment author was asked to review the current FMP text relating to EFH for the assessed species or species complex, based on new information that has become available since the 2010 EFH Review. The author completed a worksheet with some general questions about new habitat information, and recommendations on potential HAPC or EFH conservation recommendations. The author also revised the existing FMP text and maps with recommended changes or updates. There are several components in the FMP that relate to EFH for each species:

- EFH description by life history stage, in text and in maps, including an indicator for how much habitat information is known about each life history stage
  - This is the legal description of EFH, based on which EFH consultations for fishing and non-fishing effects on EFH are held as directed by the Magnuson-Stevens Act
- General information about the life history and distribution of the species/complex, the fishery, relevant trophic information, and habitat and biological associations
- A literature section that cites references of where habitat information on the species/complex can be found, and a section listing contact people for more information on the species
- Conclusions from the evaluation of fishing effects on EFH for the species

Table 11 provides an overall summary of the EFH reviews by species. "Yes" indicates that the author has suggested updates to the text in the identified section. To further explain the summary table, the major changes recommended to the EFH text for each species are detailed in bulleted form in Section 5.3. The new literature on which the review of EFH is based is captured within the edited FMP text for each species. The GOA Groundfish Plan Team also reviewed the stock assessment authors' recommended changes.

Table 11. EFH review of GOA Groundfish species, with recommended changes to the existing EFH FMP text

KEY: yes = author has recommended an update to the existing FMP text, based on new information
e/c = author has recommended editorial changes or clarifications to the existing FMP text
"–" = no changes to the existing text have been recommended

Species	Recommended changes to the FMP text – EFH description		
Name	**text**	**map**	**Changes to EFH level of information (Level 1-4)**
pollock	yes; e/c	yes	early & late juveniles, adults increase to level 2
pacific cod	yes; e/c	yes	early & late juveniles, adults increase to level 2
sablefish	yes; e/c	yes	eggs decrease to insufficient information, early juveniles increase to level 1, late juveniles & adults increase to level 2
yellowfin sole	e/c	yes	-
Southern rock sole	e/c	yes	-
Alaska plaice	e/c	yes	-
dover sole	yes; e/c	yes	late juveniles, adults increase to level 2
rex sole	yes; e/c	yes	late juveniles, adults increase to level 2
arrowtooth flounder	e/c	yes	-
flathead sole	yes; e/c	yes	early & late juveniles, adults increase to level 2
Pacific ocean perch	yes; e/c	yes	early juveniles increase to level 1
northern rockfish	e/c	yes	-
shortraker rockfish	e/c	yes	-
blackspotted/ rougheye rockfish	yes; e/c	yes	late juveniles increase to level 1
dusky rockfish	yes; e/c	yes	larvae decrease to insufficient information, late juveniles increase to level 1
other rockfish	yes; e/c	-	-
thornyhead rockfish	e/c	-	-

Species	Recommended changes to the FMP text – EFH description		
Name	text	map	Changes to EFH level of information (Level 1-4)
atka mackerel	yes; e/c	yes	larvae decrease to insufficient information
skates	yes; e/c	yes	-
octopus	e/c	-	-
sharks	e/c	-	-
sculpins	-	-	-
squid	e/c	-	-
forage fish complex	e/c	-	-

5.3 Description of recommendations for EFH text for individual species

A description of the recommendations that are captured in the summary table (Table 10) is provided below for each individual species or species complex for which EFH is defined in the GOA FMP. The authors' recommendations, if any, for EFH and HAPC conservation measures, and research needs, may be found in subsequent sections of this report.

Pollock

- Expanded on EFH description for early juveniles
- Updates to life history and general distribution
- Updates to literature
- Recommends use of MaxEnt maps to describe EFH, with suggestions for edits

Pacific cod

- Recommended updates to EFH descriptions for larvae, early juveniles, late juveniles, and adults
- Editorial changes to relevant trophic information
- Editorial changes to habitat and biological associations
- Changes to habitat association tables
- Recommends use of updated maps to describe EFH

Sablefish

- Changes to EFH descriptions for all life history stages
- Updates to life history and general distribution
- Updates to relevant trophic information
- Updates to habitat and biological associations
- Updated literature
- Changes to habitat association tables
- Recommends use of MaxEnt maps to describe juvenile stage EFH, with 25% cutoff
- Recommends use of updated maps to describe adult stage EFH, integrated and include longline survey
- Recommends downgrade egg life stage to "insufficient", upgrade early juveniles to Level 1, late juveniles to Level 2, and adults to Level 2

Yellowfin sole

- Editorial changes to life history and general distribution
- Updated table for habitat and biological associations

- Updated literature
- Recommends use of updated maps to describe EFH

Southern rock sole

- Editorial changes to life history and general distribution
- Editorial changes to habitat and biological associations
- Updated literature
- Recommends use of updated maps to describe EFH

Alaska plaice

- Updates to life history and general distribution
- Editorial changes to table for habitat and biological associations
- Updated literature
- Recommends use of updated maps to describe EFH

Dover sole

- Editorial changes to life history and general distribution
- Updated literature
- Recommend use of updated maps to describe EFH
- Recommends Level 2 upgrade for late juvenile and adult life history stages; others remain unchanged

Rex sole

- Editorial change to life history and general distribution
- Updated literature
- Recommends use of updated maps to describe EFH
- Recommends Level 2 upgrade for late juvenile and adult life history stages; others remain unchanged

Arrowtooth flounder

- Editorial change to life history and general distribution
- Updated literature
- Recommends use of updated maps to describe EFH

Flathead sole

- Editorial change to life history and general distribution
- Updated literature
- Recommend use of updated maps to describe EFH
- Recommends Level 2 upgrade for late juvenile and adult life history stages; others remain unchanged

Pacific ocean perch

- Updates to EFH descriptions for eggs, larvae, and early juveniles
- Updates to life history and general distribution
- Editorial changes to relevant trophic information
- Editorial changes to habitat and biological associations
- Updated literature
- Recommends use of updated maps to describe EFH
- Recommends Level 1 upgrade for early juvenile life history stage; others remain unchanged

Northern rockfish

- Editorial changes to life history and general distribution
- Updated literature
- Recommends use of updated maps to describe EFH

Shortraker rockfish

- Changes to habitat association tables
- Recommends use of updated maps to describe EFH

Rougheye/blackspotted rockfish

- Updates to EFH descriptions for larvae, late juveniles, and adults
- Updates to life history and general distribution
- Updated literature
- Recommends combining data for blackspotted and rougheye rockfish to create EFH maps for the complex rather than individual species maps
- Comment – combining species data may allow elevation to Level 2
- Recommends Level 1 upgrade for late juvenile life history stage

Dusky rockfish

- Updates to EFH descriptions for eggs and late juveniles
- Editorial change to introduction of section
- Editorial change to relevant trophic information
- Editorial change to habitat and biological associations
- Recommend use of updated maps to describe EFH
- Recommend using data other than trawl data
- Recommends "insufficient information" downgrade for larvae and Level 1 upgrade for late juveniles; other life history stages remain unchanged

Yelloweye rockfish

- Authors suggest defining EFH for Yelloweye and other Sebastes species as a species complex, as described in the *Other rockfish* section, below.

Thornyhead rockfish

- Changes to habitat association tables

Other rockfish

- Added to the table showing EFH information levels currently available for GOA groundfish
- Added EFH descriptions for all life history stages
- Recommended including other rockfish stock complex in the EFH descriptions
    - Authors presented four alternative methods to describe EFH for the Sebastes species complex
- Expressed concerns over using model based EFH descriptions
    - Developed 9 new EFH descriptions for various life stages of other rockfish within this complex
- Requested that the Council provide guidance to the EFH authors on how to proceed with defining EFH for the complex
- Changes to habitat associations tables
- Recommend combining individual species maps to represent EFH for the "other rockfish" complex
- Recommend "other rockfish" at Level 1

Atka mackerel

- Revised EFH description for larvae
- Expanded on life history and general distribution
- Editorial change to relevant trophic information
- Updates to table for habitat and biological associations
- Updated literature
- Changes to habitat association tables
- Insufficient information to model EFH for the GOA
- Recommends downgrade from Level 1 to "insufficient" for larvae; other life history stages remain unchanged

Skates

- Update to EFH definition for adults
- Updated introduction for skate complex
- Expanded on life history and general distribution
- Update to relevant trophic information
- Updates to habitat and biological associations
- Updated table for habitat and biological associations
- Updated literature
- Changes to habitat association tables
- Recommend use of updated maps to describe EFH

Octopus

- Created habitat association tables

Sharks

- Updated scientific name of spiny dogfish (*Squalus suckleyi*)
- Expanded on life history and general distribution
- Updates to relevant trophic information
- Updates to habitat and biological associations
- Updated habitat and biological associations table
- Updated literature
- Changes to habitat association tables
- No maps to describe EFH

Sculpins

- No changes

Squid

- Updated nomenclature
- Expanded on life history and general distribution
- Updates to relevant trophic information
- Editorial change habitat and biological associations

Forage fish

- Update to life history and general distribution for capelin and eulachon
- Editorial changes to relevant trophic information
- Updated literature
- Changes to habitat association tables
- No maps to describe EFH

Grenadiers

- Added to the table showing EFH information levels currently available for GOA groundfish
- Added EFH descriptions
- Added new section on grenadiers including:
    - Life history and general distribution
    - Relevant trophic information
    - Habitat and biological associations
    - Literature
- Created habitat association tables
- No maps to describe EFH

Table 12 lists the levels of EFH information available as a result of the 2015 EFH Review, for species and species complexes for which EFH is currently identified in the GOA FMP. EFH has not been described for sharks due to insufficient information. EFH has not been described for grenadiers and the forage fish complex because they are ecosystem component species.

Table 12. EFH information levels currently available for GOA groundfish by life history stage

Species	Eggs	Larvae	Early Juveniles	Late Juveniles	Adults
Walleye pollock	1	1	2	2	2
Pacific cod	x	1	2	2	2
Sablefish	x	1	1	2	2
Yellowfin sole	1	1	2	2	2
Northern rock sole	1	1	2	2	2
Southern rock sole	1	1	1	2	2
Alaska plaice	1	1	2	2	2
Dover sole	1	1	x	2	2
Rex sole	1	1	x	2	2
Arrowtooth flounder	1	1	1	2	2
Flathead sole	1	1	2	2	2
Pacific ocean perch	*Sebastes* spp. early life stages grouped 1			1	1
Northern rockfish				2	2
Shortraker rockfish				2	2
Blackspotted/rougheye rockfish				1	1
Dusky rockfish				1	1
Yelloweye rockfish				1	1
Other Rockfish (sharpchin, harlequin)	1	x	x	1	1
Thornyhead rockfish	x	x	2	2	2
Atka mackerel	1	x	x	1	1
Skates	1	x	1	2	2
Octopuses	x	x	x	x	2
Sharks	x	x	x	x	x
Sculpins	x	x		x	2
Squids	x	x	x	1	1
Forage fish complex	x	x	x	x	x
Grenadiers	x	x	x	x	x

x Indicates insufficient information is available to describe EFH

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

2 Indicates quantitative data (density or habitat-related density) are available for the habitats occupied by a species or life stage

One juvenile stage exists – see Late Juveniles

6 EFH descriptions for BSAI king and Tanner crab species

As part of the 2015 EFH Review, the Council recommended Amendment 49 to the FMP for Bering Sea/Aleutian Islands King and Tanner Crabs (Crab FMP). Amendment 49 would update the EFH descriptions in that FMP as described in this section.

6.1 What are the BSAI crab species?

The managed species currently identified in the Crab FMP, and which were reviewed as part of this process, are the following:

- Red king crab
- Blue king crab
- Golden king crab
- Tanner crab
- Snow crab

6.2 Summary of EFH review for individual species changes

Crab biologists and stock assessment authors were asked to review the current FMP text and maps relating to EFH for the assessed species, based on new information that has become available in the five years since EFH was last evaluated. The author or crab biologist completed a worksheet with some general questions about new habitat information available since the 2010 EFH Review, and recommendations on potential HAPC or EFH conservation recommendations. The author or crab biologist also reviewed the existing FMP text and maps with recommended changes or updates. There are several components in the FMP that relate to EFH for each species:

- EFH description by life history stage, in text and in maps, including an indicator for how much habitat information is known about each life history stage
    - o This is the legal description of EFH, based on which EFH consultations for fishing and non-fishing effects on EFH are held as directed by the Magnuson-Stevens Act
- General information about the life history and distribution of the species/complex, the fishery, relevant trophic information, and habitat and biological associations
- A literature section that cites references of where habitat information on the species/complex can be found, and a section listing contact people for more information on the species
- Conclusions from the evaluation of fishing effects on EFH for the species

Table 13 provides an overall summary of the 2015 EFH Review by species. To further explain the summary table, the updates recommended to the EFH text are detailed in bulleted form in Section 6.3. The BSAI Crab Plan Team also reviewed the stock assessment authors' recommended changes.

During the 2015 EFH Review, crab biologists and stock assessment authors were provided information at the stock level rather than domain-wide, as requested by the Crab Plan Team in 2016. They evaluated fishing effects on EFH for crab stocks using the recently developed FE model, and determined that the conclusions in the existing FMP are valid. These efforts satisfy recommendations made by the Crab Plan Team during the 2010 EFH Review; there had been previous concern that the methodology used in the 2005 and 2010 LEI analyses did not adequately capture actual impacts of fishing on crab populations.

Table 13. EFH review of BSAI crab species, with recommended changes to the existing EFH FMP text

KEY: yes = author has recommended an update to the existing FMP text, based on new information
e/c = author has recommended editorial changes or clarifications to the existing FMP text
"–" = no changes to the existing text have been recommended

Species	Recommended changes to the FMP text – EFH description		
Name	**Text**	**Map**	**Changes to EFH level of information (Level 1-4)**
Red king crab	yes; e/c	yes	early juveniles increase to 1
Blue king crab	yes; e/c	yes	early juveniles increase to 1
Golden king crab	e/c	yes	-
Tanner crab	e/c	yes	-
Snow crab	e/c	yes	-

6.3 Description of 2017 recommendations for EFH text for crab species

A description of the recommendations that are captured in the summary table (Table 13) is provided below for each individual species for which EFH is defined in the Crab FMP. Authors suggest editorial revisions to descriptions of habitat types, general life history, and habitat descriptions for all crab species.

- Updates to relevant trophic information
- Recommend use of updated maps to describe EFH
- Updates to habitat and biological associations
- Updates to habitat and diet tables
- Editorial revisions to fishery descriptions
- Updates to EFH description for red king crab early juveniles
- Updates to EFH description for blue king crab early juveniles
- Recommend Level 1 for early juvenile red king crab and blue king crab; other life stages remain unchanged
- Updates to habitat association table
- Updates to predator/prey associations table

Table 14 lists the levels of EFH information available as a result of the 2015 EFH Review, for species in which EFH is currently identified in the Crab FMP. An "x" means that insufficient information is available to determine EFH for the life stage and a "1" means information is available to determine the general distribution area of EFH.

Table 14. EFH information levels currently available for BSAI crab, by life history stage.

BSAI Crab Species	Egg	Larvae	Early Juvenile	Late Juvenile	Adult
Red king crab	inferred	x	1	1	1
Blue king crab	inferred	x	1	1	1
Golden king crab	inferred	x	x	1	1
Tanner crab	inferred	x	x	1	1
Snow crab	inferred	x	x	1	1

7 EFH descriptions for Scallop FMP species

In this 2015 EFH Review, the Scallop Plan Team reviewed current definitions of EFH and concluded that no changes to the EFH definitions provided in the FMP are warranted at this time. The Scallop FMP is available at the North Pacific Fishery Management Council website.

7.1 What are the Scallop FMP species?

All scallop stocks off the coast of Alaska are covered under the Scallop FMP, including weathervane scallops (*Patinopecten caurinus*), rock scallops (*Crassadoma gigantean*), pink scallops (*Chlamys rubida*), and spiny scallops (*C. hastata*, *C. behringiana*, and *C. albida*). However, only weathervane scallops are commercially harvested in Alaska, and it is the only scallop species for which EFH is described.

7.2 Summary of EFH review

The weathervane scallop stock assessment author was asked to review the current FMP text relating to EFH for the assessed species or species complex, based on new information that has become available in the five years since EFH was last evaluated. The author completed a worksheet with some general questions about new habitat information available since the 2010 EFH Review, and recommendations on potential HAPC or EFH conservation recommendations. The author also revised the existing FMP text with recommended changes or updates. There are several components in the FMP that relate to EFH for each species:

- EFH description by life history stage, in text and in maps, including an indicator for how much habitat information is known about each life history stage
    - This is the legal description of EFH, based on which EFH consultations for fishing and non-fishing effects on EFH are held as directed by the Magnuson-Stevens Act
- General information about the life history and distribution of the species/complex, the fishery, relevant trophic information, and habitat and biological associations
- A literature section that cites references of where habitat information on the species/complex can be found, and a section listing contact people for more information on the species
- Conclusions from the evaluation of fishing effects on EFH for the species

Discussion with scallop management biologists is ongoing and it is likely that confidential scallop harvest data will be integrated into the FE model during 2017 or 2018. It is anticipated that the Scallop FMP will be updated in the 2020 EFH Review.

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8 EFH descriptions for Salmon FMP species

As part of the 2015 EFH Review, the Council recommended Amendment 13 to the FMP for Salmon Fisheries in the EEZ off Alaska (Salmon FMP). Amendment 13 would update the EFH descriptions in that FMP as described in this section.

8.1 What are the Salmon FMP species?

The managed species identified in the Salmon FMP are the following:

- Chinook salmon
- Chum salmon
- Coho salmon
- Pink salmon
- Sockeye salmon

8.2 Summary of EFH review for individual species changes

Because management of salmon is deferred to the State of Alaska, and there is no Council Salmon Plan Team, NMFS and Alaska Department of Fish and Game (ADF&G) salmon experts were asked to provide the EFH review for salmon. They were asked to review the current FMP text relating to EFH for the assessed species or species complex, based on new information that has become available since the 2010 EFH Review. The authors also revised the existing FMP text with recommended changes or updates. There are several components in the FMP that relate to EFH for each species:

- EFH description by life history stage, in text and in maps, including an indicator for how much habitat information is known about each life history stage
    - This is the legal description of EFH, based on which EFH consultations for fishing and non-fishing effects on EFH are held as directed by the Magnuson-Stevens Act
- General information about the life history and distribution of the species/complex, the fishery, relevant trophic information, and habitat and biological associations
- A literature section that cites references of where habitat information on the species/complex can be found, and a section listing contact people for more information on the species
- Conclusions from the evaluation of fishing effects on EFH for the species

Table 15 provides an overall summary of the 2017 EFH review for salmon species. “Yes” indicates that the author has suggested updates to the text in the identified section. To provide further detail on the summary table, the major changes recommended to the EFH text are detailed in bulleted form below the table.

Table 15. EFH review of Salmon species, with recommended changes to the existing EFH FMP text

KEY: yes = author has recommended an update to the existing FMP text, based on new information
e/c = author has recommended editorial changes or clarifications to the existing FMP text
"–" = no changes to the existing text have been recommended

Species	Recommended changes to the FMP text – EFH description		
Name	**Text**	**Map**	**Changes to EFH level of information (Level 1-4)**
Chinook salmon	yes; e/c	yes	-
Chum salmon	yes; e/c	yes	-
Coho salmon	yes; e/c	yes	-
Pink salmon	yes; e/c	yes	-
Sockeye salmon	yes; e/c	yes	-

8.3 2012 Salmon EFH Refinement

A new methodology to refine the geographic scope of EFH for Pacific salmon in marine waters off Alaska was developed by the AFSC in 2012. When the Council first identified EFH in 1998 it designated all marine waters including the entire Exclusive Economic Zone (EEZ; 0 to 200 nm from shore) as EFH for each of the five species of Pacific salmon. In 2005, the Council recommended an improved analytical approach to identify EFH for most species of groundfish, crabs, and scallop, resulting in more refined EFH descriptions, but no changes were proposed to the existing description of marine salmon EFH as including the entire EEZ. Salmon EFH was identified broadly because (1) no systematic marine salmon survey exists off Alaska, (2) salmon are observed infrequently in offshore commercial fisheries for other species, and (3) the AFSC did not have the resources to analyze various data sources to determine whether it is possible to better define offshore salmon distributions and relative abundance.

NMFS had been criticized repeatedly for the breadth of EFH designations. EFH for salmon in marine waters is particularly broad, not only off Alaska[2] but also off the west coast[3] and New England[4]. Identifying EFH so broadly greatly reduces the potential utility of EFH designations for management purposes, and also reduces the credibility of the EFH program nationwide. Developing a methodology to refine the way salmon EFH is designated off Alaska enables the Council to amend its Salmon FMP accordingly. This approach may also be applicable for other regions identifying EFH for salmon or other highly migratory species.

In order to better define EFH within the U.S. EEZ for Pacific salmon found in Alaska (*Oncorhynchus* spp.), Echave et al. (2012) acquired catch, maturity, salinity, temperature, and station depth data for the Bering Sea and Gulf of Alaska from seven datasets. The objectives of this study were to 1) refine existing Level 1 EFH information by describing the presence/absence and geographic distribution of each species and life history of salmon, and 2) assess their Level 2 EFH habitat-specific densities. The influence of sea surface salinity (SSS), sea surface temperature (SST), and bottom depth on the distribution of Pacific salmon was analyzed. Very few significant associations between catch and the three tested environmental

[2] Fishery Management Plan For The Salmon Fisheries In The EEZ Off Alaska
[3] Identification of Essential Fish Habitat for Pacific Salmon
[4] Essential Fish Habitat Description - Atlantic salmon (Salmo salar)

variables were found to exist, indicating little to no relationship between species distribution and the three measures of habitat condition; however, many patterns were still evident.

By calculating and mapping the coincidence of the 95% range of each environmental variable (SSS, SST, depth) for each of the five species at each maturity stage, the updated EFH descriptions reduce the area of designated EFH for Pacific salmon by 71.3% on average (Echave et al. 2012). Juvenile salmon EFH generally consisted of the water over the continental shelf within the Bering Sea extending north to the Chukchi Sea, and over the continental shelf throughout the Gulf of Alaska and within the inside waters of the Alexander Archipelago. Immature and mature Pacific salmon EFH included nearshore and oceanic waters, often extending well beyond the shelf break, with fewer areas within the inside waters of the Alexander Archipelago and Prince William Sound.

This was the first time that salmon data sets from multiple surveys, agencies, and years were accumulated and formatted for Pacific salmon distribution and habitat analysis. This analysis summarized catches > 420,000 Pacific salmon sampled during 5,280 surface trawl and purse seine events in the Alaska EEZ from 1964 to 2009. Distribution was plotted for each salmon species and life history within the Alaska EEZ. To better describe salmon EFH, additional detailed habitat preference analysis was performed with available biophysical data from approximately 84% of the events. The methodology and associated results were presented at the Alaska Marine Science Symposium numerous times and scientifically peer reviewed.

8.4 Summary of EFH review for Pacific Salmon

As described above, the new methodology allows the Council to refine areas identified as EFH for marine life history stages of the Pacific salmon species. At initial review for the 2010 EFH Review for Pacific Salmon (February 2011), the Council postponed amendments to EFH descriptions for the Salmon FMP. The Council chose to delay because the new methodology for describing EFH for all five species of Pacific salmon was not completed. Since that time the Echave et al. 2012 methodology was peer reviewed and consideration of the Salmon EFH provisions were scheduled to begin during to the next 5-year EFH review cycle in 2015 (i.e. this review).

Unlike other FMPs, the Salmon FMP lacks a Salmon plan team, so 5-year reviews are provided by salmon experts. For the 2015 EFH Review, the proposed salmon EFH descriptions were reviewed by NMFS, the AFSC, and ADF&G. As with other FMPs, the subject matter experts were asked to review EFH text descriptions, level of EFH information, habitat information, and the list of literature. In 2015, these subject matter experts suggested necessary changes and updates, if appropriate, for each life history stage and to suggest any information or literature available since the 2010 EFH Review that should be included in the EFH description. The team review and updated, where appropriate, the habitat association tables from the FMP. In addition, the team reviewed the current maps of EFH in the FMP and compared them to the new maps produced from the models described in Echave et al. (2012). They were asked to conclude whether existing maps adequately depict EFH for their species, or whether updated maps better represented EFH.

In March 2016, the Salmon EFH Review team members met to discuss final recommendations to the Salmon FMP habitat information, EFH descriptions, and to choose to recommend adopting the new marine EFH descriptions from the Salmon Tech Memo 236 (Echave et al. 2012). The review team unanimously supported the adoption of the maps accompanying Tech Memo 236 with the provision that a disclaimer appears below each map stating that the salmon distributions are based on intermittent survey data, only documented occurrences, and should not be used to infer EEZ wide species distribution and density. Moreover, the team agreed that the salmon habitat association tables reviewed are appropriate. The review team unanimously agreed that the EFH rank for salmon remains at a Level 1 designation.

The review team made the following recommendations:

- EFH remains at Level 1 designation
- Revisions to habitat descriptions
- Updated habitat association tables
- Adopt the summary information and maps in Echave et al. 2012 (EFH described with GAMs) to describe marine EFH for salmon

9 EFH Descriptions for Arctic FMP Species

As part of the 2015 EFH Review, the Council recommended Amendment 2 to the FMP for Fish Resources of the Arctic Management Area (Arctic FMP). Amendment 2 would update the EFH descriptions in that FMP as described in this section.

9.1 What are the Arctic FMP species?

The managed species identified in the Arctic FMP are the following:

- Arctic cod
- Saffron cod
- Snow crab

9.2 Summary of EFH review for individual species changes

The stock assessment author was asked to review the current FMP text relating to EFH for the assessed species or species complex, based on new information that has become available since the 2010 EFH Review. The author completed a worksheet with some general questions about new habitat information, and recommendations on potential HAPC or EFH conservation recommendations. There is currently no commercial fishing in the Arctic, so fishing effects were not evaluated. The author also reviewed the existing FMP text and maps with recommended changes or updates. There are several components in the FMP that relate to EFH for each species:

- EFH description by life history stage, in text and in maps, including an indicator for how much habitat information is known about each life history stage
    - o This is the legal description of EFH, based on which EFH consultations for fishing and non-fishing effects on EFH are held as directed by the Magnuson-Stevens Act
- General information about the life history and distribution of the species/complex, the fishery, relevant trophic information, and habitat and biological associations
- A literature section that cites references of where habitat information on the species/complex can be found, and a section listing contact people for more information on the species

Table 16 provides an overall summary of the EFH reviews by species. To further explain the summary table, the updates recommended to the EFH text are detailed in bulleted form below.

Table 16. EFH review of Arctic species, with recommended changes to the existing EFH FMP text

KEY: yes = author has recommended updates to the existing FMP text, based on new information
e/c = author has recommended editorial changes or clarifications to the existing FMP text
"–" = no changes to the existing text have been recommended

Species	**Recommended changes to the FMP text – EFH description**		
Name	**text**	**map**	**Changes to EFH level of information (Level 1-4)**
Arctic cod	yes; e/c	-	-
Saffron cod	yes; e/c	-	-
Snow crab	yes; e/c	yes	-

What follows is a summary of responses from the stock author:

- Author identified new information to describe EFH for Arctic and saffron cod eggs and larvae
- Author identified new information to describe benthic distribution of adult Arctic and saffron cod
- Snow crab EFH map updated to include waters from shoreline to the 100 m contour
- Created and revised habitat association tables for Arctic species

During the 2016 stock author review, it was noted that no new EFH Description Maps would be created for Arctic cod, saffron cod, or snow crab in Arctic waters. However, the SSC noted that there is likely new information for Arctic crab and fish populations that would assist in the EFH Review. Almost simultaneously, NMFS gained great opportunity to advance a partnership with Alaska Sea Grant to address EFH species distributions in the Arctic. Species, habitat attributes, such as sediments, and oceanographic data are being assessed in a model. NMFS plans to complete refinements to EFH for cod and crab species by the fall of 2017. Newly described EFH in the Arctic will then be fully vetted back through the SSC and Council process in the near future, or as directed by the Council.

10 Fishing effects on EFH

10.1 Fishing Effects Background

The Council is required to minimize adverse effects of fishing on EFH that are more than minimal and not temporary in nature. Scientists from AFSC developed the Long-term Effects Index (LEI) for the purpose of analyzing the effects of fishing activities on EFH (Fujioka 2006). The 2005 EFH FEIS concluded that no Council-managed fishing activities have more than minimal and temporary adverse effects on EFH. Nonetheless, the Council initiated a variety of practicable and precautionary measures to conserve and protect EFH.

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

The CIE panel's reports included the following findings:

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

In the 2010 EFH Review, NMFS reviewed the status of the LEI model with work done both within and outside the ASFC but found there was little new information to update the model as structured.

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

This section describes the model improvements and where fishing intensity, habitat categorization, modeling methods, susceptibility and recovery of features, and corals are discussed relative to the FE model.

10.2 Compilation of new information affecting input parameters to the analysis of fishing effects on EFH

The purpose of the following section is to review this research with respect to the elements of the fishing effects evaluation from the previous analysis and to examine how these elements may have changed. This section details the inputs to the fishing effects model. A summary section discusses whether those changes might substantially affect our perception of the effects of fishing on EFH for Alaska managed species.

10.2.1 Fishing Effects Vulnerability Assessment

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

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

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

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

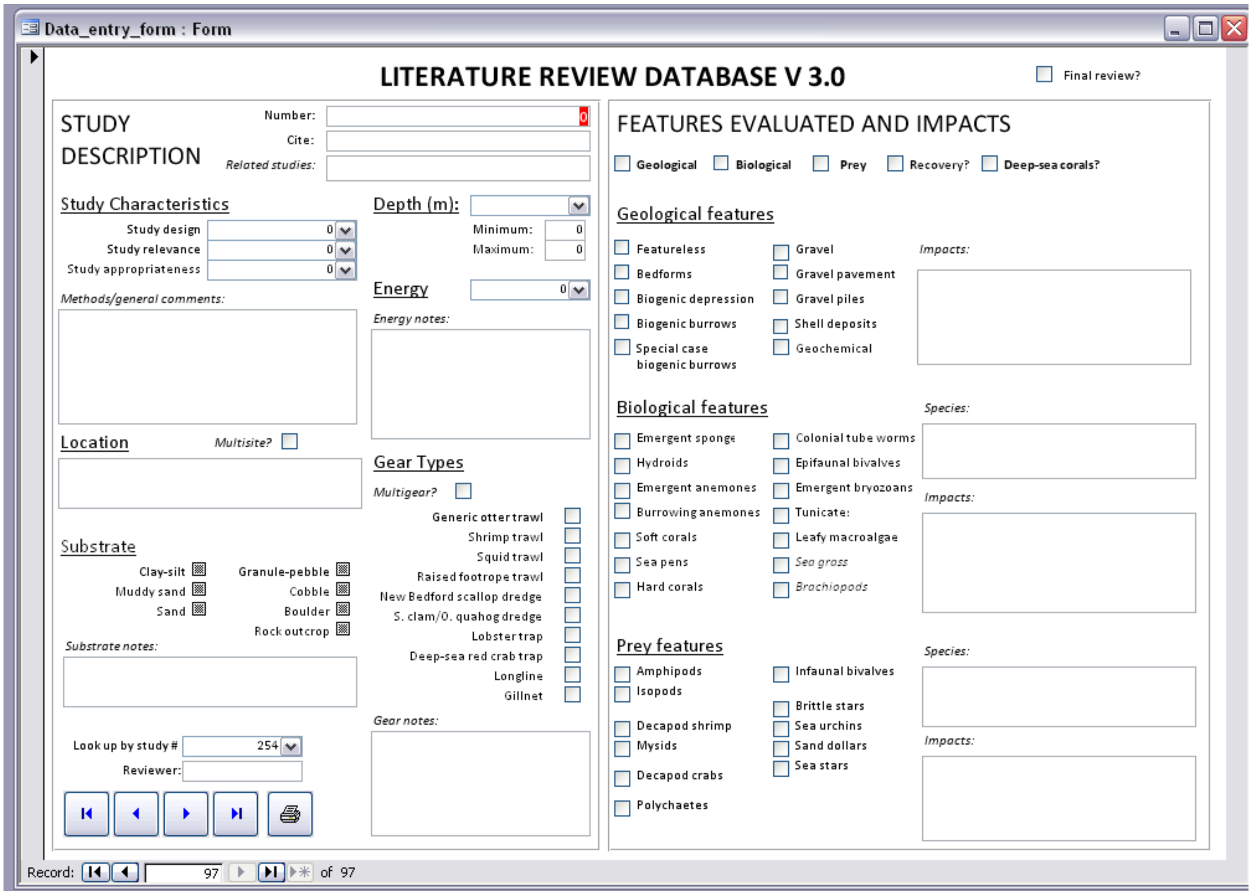

Figure 2. Literature review database form. Data field descriptions provided in Grabowski et al. (2014)

As a model parameterization tool, the vulnerability assessment quantifies both the magnitude of the impacts that result from the physical interaction of fish habitats and fishing gears, and the duration of recovery following those interactions. This vulnerability information from this database has been modified to condition area swept (i.e. fishing effort) in the FE model via a series of susceptibility and recovery parameters.

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

10.2.2 Habitat categorization

The FE and LEI model both consider habitat impacts and recovery at the level of habitat features, where habitat is the sum total of all habitat features. Aside from structural differences between models (i.e. continuous vs discrete time), both LEI and FE treat habitat features in the same way, just define them differently. The 2005 EFH FEIS analyzed approximately 2,000 sediment point data and divided Bering Sea habitat types into 4 sediment types – sand, mixed sand and mud, and mud. Additional categories were added for the slope below 200 m depth and the northern shelf. The ability to classify habitats in the Aleutian Islands and Gulf of Alaska was highly constrained due to the lack of comprehensive sediment distribution data, so the RACE survey strata, split into shallow, deep, and slope were used. The LEI model defined four broad habitat features: infaunal prey, epifaunal prey, biological structure, and physical structure. The FE model, in contrast, defines 27 habitat features which can be grouped into biological or geological features. These 27 habitat features were drawn from the literature review described above. The FE model, however, is flexible to produce results over any combination of habitat features, if for example a specific subset of habitat features was important for a specific species.

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

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

10.2.3 Modeling Methods

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

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

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

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

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

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

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

10.3 Fishing Effects Model Description

The Fishing Effects (FE) model is conceptualized as an iterative model tracking habitat transitions between disturbed and undisturbed states. We let represent the proportion of habitat disturbed by fishing activities, and represent the proportion of habitat undisturbed by fishing activities. Terminology may vary slightly according to context, but in general, we will treat “undisturbed”, “showing no effect of fishing” or other similar terms as equivalent. In this model, habitat that has had no historic fishing is equivalent to disturbed habitat that has fully recovered. Likewise, we will treat terms such as “disturbed”, “affected by fishing", or "impacted" as equivalent. The two habitat states H and h are mutually exclusive and complete,

$$H + h = 1 \tag{1}$$

The FE model considers transition between H and h in monthly discrete time steps, t. Thus, H_t is undisturbed habitat and h_t is disturbed habitat at time t. In implementation of the model, $t = 1$ represents January 2003 when using the complete CIA dataset. H transitions into h from one month to the next through fishing impacts and h transitions into H through recovery. We let I'_t represent the proportion of H that transitions to h by fishing impacts from month t to month $t + 1$, and ρ'_t as the proportion of h that recovers to H over the same time step. As a time-varying model, both I'_t and ρ'_t can vary from month to month. Thus, H_{t+1} is the is the sum of non-impacted H_t and recovered h_t. Conversely, h_{t+1} is the sum of impacted H_t and non-recovered h_t,

$$\begin{aligned} H_{t+1} &= H_t(1 - I'_t) + h_t\rho'_t \\ h_{t+1} &= H_t I'_t + h_t(1 - \rho'_t) \end{aligned} \tag{2}$$

These state transitions are run independently within 5 km x 5 km grid cells across the complete domain of the model in a spatially explicit tracking of H and h through time. In implementation of the model, we only track H since h can easily be back calculated through Eq. 1. Each grid cell is characterized by the proportion of five sediment types within it: mud, sand, granule/pebble, cobble, and boulder. For example, a grid cell may be 50% sand and 50% mud, or 10% mud, 80% sand, and 10% cobble, or any other combination of sediment types that sums to 100%. Sediment types are assumed to be uniformly spread throughout each grid cell based on their proportion, thus this model does not consider spatial structure of sediment within a grid cell. H and h, then are tracked not only within grid cells, but also within sediment classes. Let the subscripts t, i, s represent time (month), grid cell, and sediment class respectively. Let a • represent summations across a given index. Thus, the total undisturbed habitat in a given cell is the sum of undisturbed habitat for each sediment times the proportion of sediment with the grid cell, $\varphi_{i,s}$, across all five sediment types (note the sediment proportion remains constant across all time periods),

$$H_{t,i,\bullet} = \sum_{s=1}^{5} H_{t,i,s}\,\phi_{i,s} \tag{3}$$

For example, if a grid cell was composed of 10% mud, 80% sand, and 10% cobble, with H of 90%, 60%, and 100% for mud, sand and cobble respectively, the total undisturbed percent of the grid cell would be 67%. If the total undisturbed area within each grid cell is the quantity of interest, we simply need to multiply $H_{t,i,\bullet}$ times the total area of the grid cell, A_i. The area for most grid cells will be 25 km^2 (5 km X 5 km), however, some grid cells will have smaller areas when they are located at the edge of the domain or along coastlines.

10.3.1 Fishing Impacts

The proportion of undisturbed habitat that transitions to disturbed habitat as a result of fishing impact, I', is calculated as the exponentiation of the impact rate, I (for a discussion on this conversion, see Section Expectation of impact rate),

$$I' = 1 - e^{-I} \tag{4}$$

In the FE model implementation, the parameter I is indexed across grid cells, i, time periods, t, sediment classes, s, and gear types, g. We sum across n gear types to calculate an impact rate for each grid, time period, and sediment combination. For the remainder of the model discussion, we will omit the *i* and *t* indexing as all parameters are unique to grid cell and time period unless otherwise stated.

$$I_{s,\bullet} = \sum_{g=1}^{n} I_{s,g} \tag{5}$$

The impact rate for each gear-sediment combination, $I_{s,g,}$ is calculated as the product of the gear specific fishing effort, f_g and the gear-sediment susceptibility $q_{s,g,}$

$$I_{s,g} = f_g q_{s,g} \tag{6}$$

f_g is a measure of the total bottom contact by each gear type as a proportion of the total grid cell area. It can range from zero, indicating no bottom contact by a gear type, to proportions greater than or equal one, indicating that the total bottom contact area was greater than or equal the area of the grid cell. Proportions exceeding one may occur because f_g is summed across all individual tows of the same gear type within a cell regardless of possible overlap. When $f_g \geq 1$, it does not necessarily mean that the entire grid cell has been contacted by fishing gear, but only that the sum of bottom contact by individual tows is greater than or equal to the grid area. For example, we can consider the two following hypothetical (and unlikely) scenarios both resulting in $f_g = 1$. In the first scenario, one tow may contact the entire grid cell, resulting in 100% contact by one vessel. In the second scenario, 10 vessels may contact the same 10% area of the grid cell, in which case $f_g = 10 \times 0.1 = 1$. Although, $f_g = 1$ in both scenarios, the actual percent of ground contact differs. f_g is calculated for each gear as the nominal area swept by fishing gear, A_g, multiplied by contact adjustment, c_g. Nominal area swept is the door-to-door area of a tow not accounting for the degree to which the components of a tow actually touch the sea floor. The contact adjustment, then, is the proportion of the nominal area swept in contact with the sea floor. Because we assume a uniform distribution of sediment within a grid cell, f_g is not indexed over sediment, and is assumed to be spread proportionally among all sediments within a grid cell. Nominal areas are calculated for each tow, *x*, within a grid cell and are summed over *n* tows within gear types. Since f_g is measured as a proportion and A_g is an area, we need to divide by the total area of a grid cell, A_i,

$$f_g = \frac{c_g \sum_{x=1}^{n} A_{g,x}}{A_i} \tag{7}$$

10.3.2 Estimate of Susceptibility

Susceptibility, $q_{s,g,}$ is the proportion of habitat affected by bottom contact with fishing gear. We index it over *s* and *g* because we assume differing susceptibilities for gear-sediment combinations. Within each sediment class is a defined set of geological and biological habitat features that are associated with that type of sediment. The susceptibility for a gear-sediment combination is the average of the susceptibility of all habitat features within a gear-sediment combination. Habitat features definitions and their susceptibility were based on a literature review conducted for the SASI model. In a few cases, the SASI model split habitat feature susceptibility between high and low energy systems. In these cases, we selected the low energy susceptibility. Habitat feature susceptibilities were not estimated as absolute values, but were classified into four ranges: 0: 0-10%; 1: 10-25%; 2: 25-50%; 3: >50%.

To calculate an average susceptibility for each gear-sediment combination, we first randomly selected a susceptibility for each habitat feature within its range of susceptibilities for a given gear-sediment combination. We then computed the mean of these randomly selected habitat feature susceptibilities to get an average susceptibility for each gear-sediment combination. In the initial implementation of the FE model, random susceptibility values were generated once then used throughout the model. In future version of the model, random susceptibilities may be generated for each time step and/or grid cell.

10.3.3 Recovery

Recovery, $\rho'_{s,}$ is the proportion of disturbed habitat, *h*, that transitions to undisturbed habitat, *H*, from one time step to the next. It is indexed over sediment, *s*, assuming differing recovery dynamics for different sediment classes. ρ' is calculated as the exponentiation of the negative recovery rate, ρ_s subtracted from one,

$$\rho'_s = 1 - e^{-\rho_s} \tag{8}$$

ρ_s is defined as the inverse of recovery time,

$$\rho_s = \frac{1}{\tau_s} \tag{9}$$

where τ_s is the average number of years it takes for habitat in a sediment class to recover from a disturbed to an undisturbed state. In the implementation of the model, we divide ρ_s by twelve to convert years to months (equivalent to multiplying τ_s by twelve) to align with the monthly time step of the present FE model implementation. Similar to susceptibility, ρ_s is calculated by averaging across all habitat features within a sediment class. However, we first average recovery times, τ, using the recovery times published for the SASI model. We then convert average recovery times to recovery rate, ρ_s using Eq. 9. Unlike the SASI model, which estimates a recovery time for each gear-sediment-habitat feature combination, the FE model does not account for differing recovery times when habitat is impacted by different gear types (i.e., recovery dynamics are independent of impact source). Thus, when using the SASI values, we used their sediment-habitat features values for only, regardless of what gear caused the disturbance. In a few cases, the SASI recovery values differed for high and low energy systems. In these cases, low energy values were used. Also, like susceptibility, recovery times were classified into four ranges: 0: < 1 year; 1: 1 – 2 years; 2: 2 – 5 years; 3: >5 years.

To calculate an average recovery time for each sediment class, we first randomly selected a recovery time for each habitat feature within its range of recoveries for a given sediment. We then computed the mean of these randomly selected habitat feature recoveries to get an average recovery time for each sediment class. We bounded class 3 to a maximum of ten years for recovery. In the initial implementation of the FE model, we generated random recoveries once, then subsequently used these values throughout the model. In future versions of the model, we may generate random recoveries for each time step and/or each grid cell. Additionally, it is worth noting, that in the current method of converting from yearly recovery rates to monthly recovery rates, we are assuming the recovery rate to be spread uniformly throughout the year. It is possible in future versions of the model to consider recovery rates that are seasonal or differ among months.

10.3.4 Expectation of Impact Rate

We used Eq. 4 to convert impact rate, I to a proportion I' representing the proportion of undisturbed habitat that converts to disturbed habitat each time step. While I itself is measured as a proportion, it is calculated within each grid cell for each gear type by summing across the impacted area for each tow and dividing by the grid area. Because we sum across tows, regardless of whether or not they overlap, the value I can exceed one. Using an untransformed I in the model would be problematic, as this could lead to estimations of disturbed area that exceed the total area of the grid cell. Eq. 4 solves this problem as the transformed I' is bounded between zero and one.

We can motive this particular transformation by imagining a grid cell to be composed of *N* discrete habitat units. We will consider an example with only one gear and sediment type in the grid cell. We will let n be the number of impacted habitat units impacted by fishing as summed across individual tows. Thus n is the product of I and N,

$$n = IN \tag{10}$$

Note that n can exceed N if $I > 1$. Given only I as a measure of fishing activity, we don't know how much of the habitat was actually impacted. For example, if we imagine $N = 100$ discrete habitat units in a grid cell and $I = 1$, then n = 100. We don't know if all 100 units were impacted in the grid cell or if the same 10 units were impacted by 10 different tows ($I = 0.1$, for 10 tows). We can model this scenario by treating the impact of each unique tow a sampling from N discrete habitat features. For a habitat feature to be "sampled" means that it gets disturbed by fishing. We sample with replacement because each tow can disturb a habitat feature that has already been disturbed by another tow. We can think of n as the number of times we take a sample with replacement of one from N. This assumes that there are n independent tows each with $I = 1/N$. Thus, each habitat feature has a $1/N$ probability of disturbance for each tow. Because a habitat feature can be repeatedly impacted, the probability of disturbance for each unit remains constant over all n tows. So, for any habitat feature, $X_{i,}$ the probability of being impacted k times follows a Binomial distribution, **Bin**(n, $1/N$), with the probability mass function,

$$f(k;n,\frac{1}{N}) = \Pr(X_i = k) = \binom{n}{k}\frac{1}{N}^k\ (1-\frac{1}{N})^{n-k} \tag{11}$$

Using Eq. 11, we can calculate the probability of a habitat feature not impacted over n tows,

$$\Pr(X_i = 0) = (1-\frac{1}{N})^n \tag{12}$$

Thus, the probability of a habitat feature being impacted is,

$$\Pr(X_i > 0) = 1 - \Pr(X_i = 0) = 1 - (1-\frac{1}{N})^n \tag{13}$$

We can treat each X_i as a Bernoulli trail with the expectation of being impacted,

$$\mathbb{E}[X_i] = 1 - (1-\frac{1}{N})^n \tag{14}$$

The expected proportion of impact I' across the entire grid cell will then be the sum of expected impacts for each habitat feature divided by N,

$$\frac{1}{N}\sum_{i=1}^{N}\mathbb{E}\,[X_i] = \frac{1}{N}N\mathbb{E}[X_i] = 1 - (1-\frac{1}{N})^n \tag{15}$$

While Eq. 15 models the grid cell and impact in discrete units, this processes can be modeled across a continuous surface by letting $N \to \infty$ and substituting IN for n using Eq. 10,

$$I' = \lim_{N\to\infty} 1 - \left(1-\frac{1}{N}\right)^{IN} = 1 - e^{-I} \tag{16}$$

We can interpret I' as the expected habitat disturbance, given an impact rate of I. Certainly, true measures of actual non-overlapping ground contact disturbance will vary about the expected value depending on how much overlap there is among tows. Likewise, we can anticipate higher variance as I increases, as greater impact will allow for greater variance in overlap patterns. We also note that the assumption of n independent tows each with $I = 1/N$, is almost certainly not met. Within a tow, impacts are not independent, and cannot be modeled as a sample with replacement since we know that individual tows do not overlap themselves (even where individual tows do intersect themselves, the area of the overlap is not counted twice). If a grid cell contained just one tow with an impact rate of $I = 0.25$, we know that the true proportion impacted is 25%. Using Eq. 16, however, we would estimate $I' = 1 - \exp(-0.25) = 0.22$, a difference of ~0.03. This difference is small, and in general, $I' \approx I$ for low values of I (Figure 3). For grid cell containing only a single tow, I will generally be small, as the width of a tow (max < 300 m) is small compared to the area of a typical grid cell (25 million sq. ~m). At greater values where we would expect multiple tows within a grid cell, I and I' do diverge considerably.

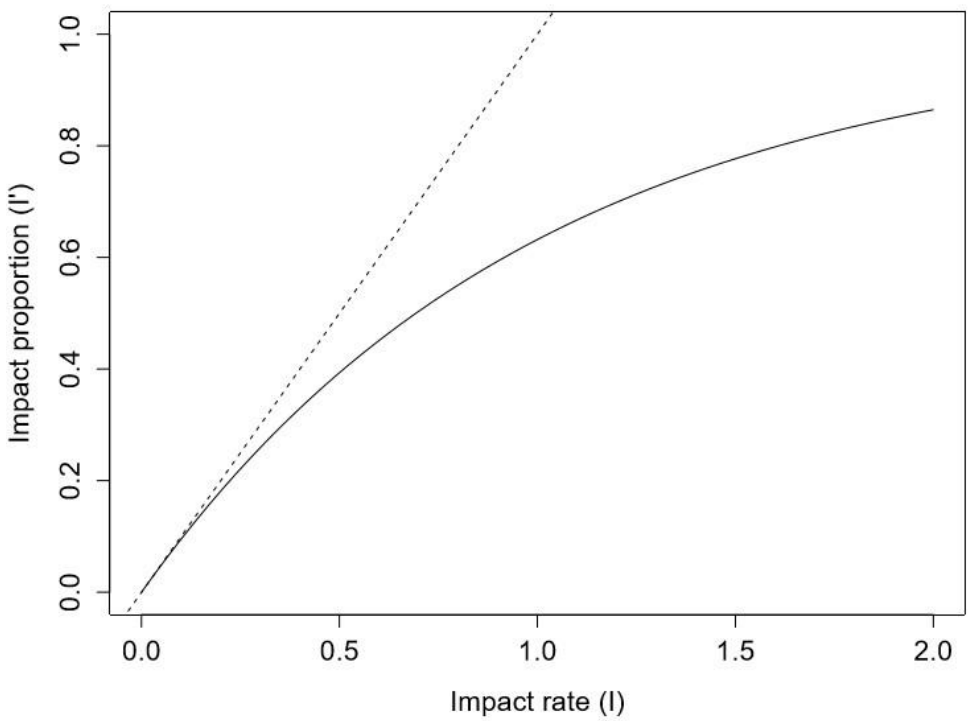

Figure 3. Comparison of I' *to* I*. The 1:1 relationship is represented by the dashed line.* I' *and* I *values remain relatively similar to about 0.2 before they begin to diverge.*

10.3.5 Calculation of Fishing Effort

Fishing effort, f_g is calculated for each cell, month, and gear type using the CIA data set. The CIA dataset was provided as a polyline feature class representing individual tows from January 2003 through June 2015. Nominal widths were joined to each fishing event in the CIA dataset based on the following attributes: vessel type, subarea, gear, target species, vessel length, season (date), and grid cell depth. Buffers were created around the polylines based on the nominal gear with (ArcMap v 10.2.1). Square buffer ends were used to ensure the area swept did not exceed the extent of the polyline as well as to increase the efficiency of subsequent spatial operations by reduced the number of vertices compared to a rounded buffer. The buffered tows were then intersected with the 5 km grid creating a nominal area swept for individual tows within each cell. Each of these nominal areas were multiplied by a contact adjustment to calculate total ground contact. Ground contacts for each FE model gear type were summed over each grid cell and month and divided by the grid cell area to calculate f_g.

10.3.6 Corals

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

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

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

- Determine the distribution, abundance, and diversity of sponge and deep-sea coral in Alaska (and their distribution relative to fishing activity);
- Compile and interpret habitat and substrate maps for the Alaska region;
- Determine deep-sea coral and sponge associations with species regulated by fishery management plans (especially juveniles) and the contribution of deep-sea coral and sponge ecosystems to fisheries production;
- Determine impacts of fishing by gear type and test gear modifications to reduce impacts;
- Determine recovery rates of deep-sea coral and sponge communities in Alaska from disturbance or mortality; and
- Establish a long-term monitoring program to determine the impacts of climate change and ocean acidification on deep-coral and sponge ecosystems.

At the October 2016 Council meeting, the SSC supported the use of the FE model as a tool for assessing the effects of fishing on EFH. In response to public comment, however, the SSC raised concern that the longest recovery time incorporated into the model (10 years) may not capture the recovery needed for long-lived species like some hard corals that live on rocky substrate at deep depths. The authors of the model explained that recovery is addressed in the model as an exponential decay function and that 10 years is a recovery to 50% of original coral biomass; a site would recover to 80% of the original biomass after 34 years in the absence of further damage or removals. However, to further address these concerns, a deep and rocky substrate habitat category was added using published information from Stone (2014). This study was focused on the central Aleutian Islands, but is the most comprehensive source of information on corals in Alaska. Results indicate that corals have the highest density and depths of 400-700m, on bedrock or cobbles, with moderate to very high roughness, and slopes greater than 10 percent.

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

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

10.3.7 Impacts Assessment Methods

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

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

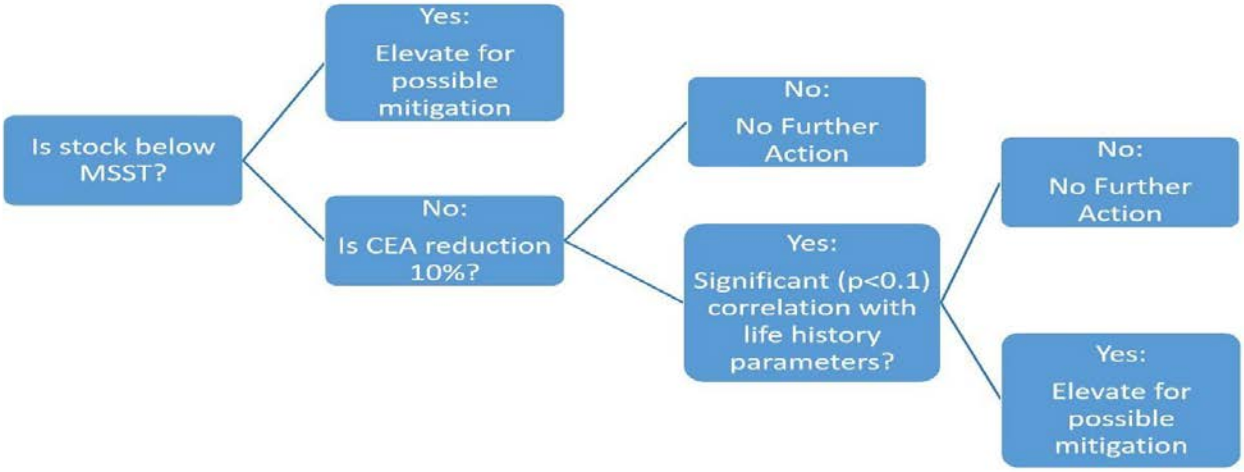

Figure 4. Three-tiered method to evaluate effects of fishing on Essential Fish Habitat in Alaska.

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

To investigate the potential relationships between fishing effects and stock production, the stock assessment authors examined trends in life history parameters and the amount of disturbed habitat in the "core EFH Area" (CEA) for each species. The CEA is identified as the predicted 50 percent quantile threshold of suitable habitat or summer abundance (Laman et al. 2017, Turner et al. 2017, Rooney et al., In Press). Stock assessment authors evaluated whether 10 percent or more of the CEA was impacted by commercial fishing in November 2016 (the end of the time series). The 10 percent threshold was selected based on the assumption that impacts to less than 10 percent of the CEA means than more than 90 percent of the CEA (top 50 percent of suitable habitat or summer abundance) was undisturbed, and therefore represented minimal disturbance. If 10 percent or more of the CEA was impacted, the stock assessment authors examined indices of growth-to-maturity, spawning success, breeding success, and feeding success to determine whether there are correlations between those parameters and the trends in the proportion of the CEA impacted by fishing. If a correlation exists, positive or negative, stock assessment authors determined whether the correlation is significant at a p-value of 0.1. If a significant correlation was found, stock assessment authors used their expert judgement to determine whether there is a plausible connection to reductions in EFH as the cause. Stock assessment authors identified the correlation, and the significance in their reports.

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

10.4 Conclusions about the effects of Federally-managed fishing on EFH

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

The previous EFH analyses, as well as the CIE review, indicated the need for improved fishing effects model parameters. With the FE model, our ability to analyze fishing effects on habitat has grown exponentially. Vessel Monitoring System data provides a much more detailed treatment of fishing intensity, allowing better assessments of the effects of overlapping effort and distribution of effort between and within grid cells. The development of literature-derived fishing effects database has increased our ability to estimate gear-specific susceptibility and recovery parameters. The distribution of habitat types, derived from increased sediment data availability, has improved. The combination of these parameters has greatly enhanced our ability to estimate fishing impacts.

In April 2016, the SSC recommended that new methods and criteria be developed to evaluate whether the effects of fishing on EFH are more than minimal and not temporary. Criteria were developed by NMFS and researchers at Alaska Pacific University, and reviewed by the Council and its advisory committees in 2016, and the stock assessment authors in 2017. In April 2017, based on the analysis with the FE model, the Council concurred with the Plan Team consensus that the effects of fishing on EFH do not currently meet the threshold of more than minimal and not temporary, and mitigation action is not needed at this time.

While these analyses found no indication that continued fishing activities at the current rate and intensity would alter the capacity of EFH to support healthy populations of managed species over the long term, the Council acknowledges that scientific uncertainty remains regarding the consequences of habitat alteration for the sustained productivity of managed species. Consequently, the Council has adopted, and NMFS has implemented, a number of management measures designed to reduce adverse impacts to habitat. These actions are described in Section 2.6.

11 Non-fishing effects on EFH

11.1 Background

Non-fishing activities that may adversely affect EFH are diverse and highly variable[1]. For example, changes in regional climate patterns alter sea ice distribution and sea surface temperatures, which have had a significant influence on EFH attributes that support federally managed fisheries. Other specific activities include the various phases of oil and gas exploration, development and production. Other actions associated actions may result from harbor construction, navigation channel dredging, or fills and armoring near shore zones to support infrastructure. The cumulative effects from multiple anthropogenic sources are also increasingly recognized as having synergistic effects that degrade EFH. NMFS Alaska Region HCD staff reviewed Appendix G of the 2005 EFH FEIS. Appendix G describes non-fishing activities and offers EFH conservation recommendations by activity type. NMFS has updated Appendix G and produced a report on the Impacts to Essential Fish Habitat from Non-fishing Activities in Alaska with each 5-year review.

11.2 Review Approach and Summary of Findings

The non-fishing effects report is a comprehensive document that evaluates the impacts of non-fishing activities on EFH, and identifies EFH conservation recommendations for each of these activities. An abbreviated version of Appendix G was included in each of the Council's FMPs. In the 2015 EFH Review process, HCD staff reviewed the report and concluded many of the existing impact categories and associated mitigation recommendations remained relevant. However, it was also determined that better representation of the EFH attributes such as ecosystem processes that provide water quality and quantity, and support trophic dynamics, needed to be presented and discussed in the context, scale and scope of Alaska's fisheries resources. It was also recognized that the emerging influence of climate change and associated cumulative impacts needed to be presented as a non-fishing impact. The current science and technology of oil spill response strategies, mechanisms and toxicology has also been expanded and relevant recommendations have been included.

Non-fishing activities that may affect EFH span a multitude of subjects and life stages of fish. To address this, HCD contracted with UAF Dr. Chris Maio to conduct a cumulative impacts assessment in Alaska: *Geospatial Datasets Applicable to an Essential Fish Habitat Nonfishing Vulnerability Assessment: Norton Sound, Alaska, June 2015*. Initially a large area was planned; however reality of costs and scale brought the effort to access Norton Sound, Alaska only. This effort includes a GIS spatial planning component linked to fish and fish habitat information, and sources of anthropogenic effects, such a point source pollution, development, and fill actions. A copy of this report is available at https://alaskafisheries.noaa.gov/habitat/efh. Future applications are being explored to assess these types of actions for more areas facing human-induced activities, such as Lower Cook Inlet, the Arctic, or Southeast Alaska. A consideration not to be overlooked is cost and dedication to selecting assessments for major community areas or those areas facing large scale development.

In 2005, Appendix G of the EFH FEIS fulfilled the requirement to describe non-fishing activities that may have adverse effects on EFH and identify actions to encourage the conservation and enhancement of EFH. In 2010, NMFS HCD staff reviewed the original non-fishing activities evaluation in Appendix G of the FEIS and as abbreviated in the FMPs, and based on more recent scientific literature specific to Alaska, updated the analysis of each activity's potential to result in adverse impacts on EFH and recommended conservation measures to avoid, minimize, or compensate for adverse effects on EFH, as needed.

In 2017, NMFS HCD staff reviewed non-fishing activities from the 2011 report and concluded that much of the information remains relevant and requires simple updating. A new chapter presents a simple discussion of how climate change is influencing fisheries in Alaska. New introductions to chapters 3 through 6, were presented to illustrate the current scale and scope of EFH attributes in Alaska, but also our understanding of ecosystem processes the support various aspects of EFH, at the watershed and offshore scale. The body of literature addressing our current understanding of oil and gas development and spill response and response strategies has improved, so that section in chapter 6 was completely revised. The final non-fishing activities report (Limpinsel et al. 2017) is available online through the Alaska Fisheries website.

11.3 New EFH Conservation Recommendations

Non-fishing activities are already subject to a variety of regulations and restrictions under federal, state and local laws that would help minimize and avoid adverse effects of non-fishing activities on EFH. Therefore, the recommendations are general in nature and may overlap with certain existing standards for specific development activities. They are meant to highlight options to avoid, minimize, or compensate for adverse impacts and promote the conservation and enhancement of EFH. All of the suggested measures are not necessarily applicable to any one project or activity and are not binding on any action agency or permit applicant. Subject-specific recommendations are advisory and serve as proactive conservation measures that would help minimize and avoid adverse effects of these non-fishing activities on EFH.

Table 16 identifies changes to the non-fishing activities document, including new EFH conservation recommendations that resulted from the 2015 EFH Review. The Council has initiated FMP amendments to add these conservation recommendations to each of the FMPs.

Table 17. Summary of 2017 Updates to the Non-fishing Activities Document

Activity, Ecosystem Processes and/or EFH Attributes	**New Chapters, Sections, Information or EFH Conservation Recommendations in the 2017 review. Previously existing sections with no changes from 2011, to Chapter Sections or EFH Recommendations, appear in italics**.
Chapter 1 – Section 1.4 Introduction: Purpose of the Document	**New Section** At the request of the Council, Ecosystem Committee, Section 1.4 was added to explain how this report is compliant with and dovetails into other NOAA marine policy, directives and action plans. • NOAA Mission: Science, Service, and Stewardship: Responsibility for the stewardship of the nation's ocean and living marine resources and their habitat. • NOAA Strategic Plan: Presents commitment to represent marine ecosystems, our nation's coastline and marine resources, focusing on human wellbeing and sustainable fisheries. • NOAA Organizational Structure, Mission and Statutory Authority: Puts in motion a science-based, organizational structure to manage the nation's coastlines, oceans, atmosphere, and marine resources. • Alaska Fisheries Science Center (AFSC) Plan: Supports the need for continued scientific research to support EFH and sustainable fisheries. • AFSC Annual Guidance Memo: Reviews its scientific programs and focuses on those platforms that meet or exceed NOAA Fisheries mission critical goals. • Alaska EFH Research Plan: Coordinates Alaska EFH, Research Plan (Plan) with Science Center to fund research in support of EFH management needs.
Chapter 2 – Sections 2.1 – 2.3 Climate Change & Ocean Acidification (CC & OA)	**New Chapter and Sections** • At the request of the Council, present NOAA's current understanding of CC & OA. AKR-HCD framed the discussion in the context of marine ecosystem processes and fisheries. • What is climate change and ocean acidification. • Basic atmospheric and oceanic carbon chemistry. • Recent projections from the Intergovernmental Panel on Climate Change (IPCC). • Metrics: Easily identified evidence versus not easily identified evidence. • Evidence of change in Alaska's Large Marine Ecosystems (LME). • Gulf of Alaska: Regime shifts and sea surface warming. • Bering Sea: Trophic dynamics and fish distributions. • Arctic: Atmosphere and ocean circulation, and sea ice declines • Potential adverse impacts • Conservation recommendations
Chapter 3 – Sections 3.1 – 3.3 Woodlands and Wetlands	**New Introduction and Sections** Introduction and Current Condition Alaska Metrics – Wetlands and Woodlands Physical, Biological and Chemical Processes Ecosystem Functions and Bio-chemical Processes
Chapter 3 – Section 3.4	**Previously Existing Sections**
Upland Activities	Existing recommendations are adequate. Minor editorial comments New subject references and information provided.
Silviculture	Existing recommendations are adequate. Minor editorial comments New subject references and information provided.
Pesticides	Existing recommendations are adequate. Minor editorial comments New subject references and information provided.
Urban & Suburban Development	Existing recommendations are adequate. Minor editorial comments New subject references and information provided.

Activity, Ecosystem Processes and/or EFH Attributes	New Chapters, Sections, Information or EFH Conservation Recommendations in the 2017 review. Previously existing sections with no changes from 2011, to Chapter Sections or EFH Recommendations, appear in italics.
Transportation Infrastructure	Existing recommendations are adequate. Minor editorial comments New subject references and information provided.
Chapter 4 – Sections 4.1 – 4.3 Headwaters, Streams, Rivers and Lakes	**New Introduction and Sections** Introduction and Current condition Alaska Metrics – Streams and Rivers Physical, Biological and Chemical Processes Ecosystem Functions and Bio-chemical Processes Hyporheic EFH Headwater EFH Organic Nutrient Marine Derived Nutrient Riparian Zones Hydrology and Water Surface and Groundwater Regimes Channel Morphology
Chapter 4 – Section 4.4	**Previously Existing Sections**
Mining	Existing recommendations are adequate. Minor editorial comments New subject references and information provided.
Mineral Mining	Existing recommendations are adequate. Minor editorial comments New subject references and information provided.
Sand and Gravel	Existing recommendations are adequate. Minor editorial comments New subject references and information provided.
Organic and Inorganic Debris	Existing recommendations are adequate. Minor editorial comments New subject references and information provided.
Organic Debris Removal	Existing recommendations are adequate. Minor editorial comments New subject references and information provided.
Inorganic Debris	Existing recommendations are adequate. Minor editorial comments New subject references and information provided.
Dam Construction and Removal	Existing recommendations are adequate. Minor editorial comments New subject references and information provided.
Commercial – Domestic Water	Existing recommendations are adequate. Minor editorial comments New subject references and information provided.
Chapter 5 – Sections 5.1 – 5.3 Estuaries and Nearshore Zones	**New Introduction and Sections** Introduction and Current Condition Alaska Metrics – Estuaries and Nearshore Zones Regional Coastal Ecosystems Southeast and Gulf of Alaska Aleutian Islands Bering Sea Arctic Physical, Biological and Chemical Processes Nearshore Fish Nurseries Estuarine Processes Terrestrial Carbon and Nitrogen Ecosystem Functions and Bio-chemical Processes
Chapter 5 – Section 5.4	**Previously Existing Sections**

Activity, Ecosystem Processes and/or EFH Attributes	New Chapters, Sections, Information or EFH Conservation Recommendations in the 2017 review. Previously existing sections with no changes from 2011, to Chapter Sections or EFH Recommendations, appear in italics.
Dredging	Existing recommendations are adequate. Minor editorial comments New subject references and information provided.
Material Disposal	Existing recommendations are adequate. Minor editorial comments New subject references and information provided.
Disposal or Dredged Material	Existing recommendations are adequate. Minor editorial comments New subject references and information provided.
Discharge of Fill Material	Existing recommendations are adequate. Minor editorial comments New subject references and information provided.
Vessel Operations	Existing recommendations are adequate. Minor editorial comments New subject references and information provided.
Invasive Species	Existing recommendations are adequate. Minor editorial comments New subject references and information provided.
Pile Installation and Removal	Existing recommendations are adequate. Minor editorial comments New subject references and information provided.
Pile Driving	Existing recommendations are adequate. Minor editorial comments New subject references and information provided.

1 Non-fishing activities (or developmental activities) information is compiled by NOAA, other Federal agencies, academia, and environmental consulting firms. The amount of this type of information as compared to information used to address fishing effects on fish habitat is extensive. The 2017 report addresses those activities most likely to reduce the quantity and/or quality of EFH. It is not meant to provide a conclusive review and analysis of the impacts of all potentially detrimental activities; rather it highlights notable threats and provides information to determine if further examination of a proposed activity is necessary. Subject-specific EFH Conservation Recommendations are advisory and serve as proactive conservation measures that would help minimize and avoid adverse effects of these fishing activities on EFH. Site-specific EFH Conservation Recommendations will be prepared per activity and as necessary during EFH Consultation [see: CFR 50 Part 600 Subpart K].

11.4 Outreach

NMFS HCD staff routinely informs stakeholders and the public of EFH consultation requirements through EFH Consultation training sessions, posting of NMFS official comment letters, and by making information readily accessible on the NMFS Website Essential Fish Habitat information page. HCD updated its "EFH Frequently Asked Questions" section of the website in May 2017.

EFH training occurs every couple of years or as specifically requested by interested parties. Specifically, NMFS invites federal, state, tribal, academic, and any interested consulting firms to attend EFH workshops. These discussions address how the Magnuson-Stevens Act, and associated EFH provisions, are applied to federal agencies, including NMFS, and their actions that may adversely affect EFH. A summary of fisheries management explains NMFS role to manage healthy, sustainable fish stocks using a rigorous, public management process through the North Pacific Fishery Management Council. The training further details what is required of a federal action agency should they determine their activity may adversely affect EFH resources.

NMFS posts correspondence for actions where NMFS has offered comment to conserve EFH. NMFS' official comment letters give the public and natural resource developers, working with EFH, an idea as to what NMFS may specifically offer as EFH Conservation Recommendations. Posting occurs on the Essential Fish Habitat Consultations page on the Alaska Fisheries web site.

NMFS has presented the recommendations for non-fishing activities update several times, including at the May 2016 National EFH Summit in Annapolis, Maryland. At the December 2016 Council meeting in Anchorage, NMFS presented the updated recommendations in front of the Council, Ecosystem Committee, Science and Statistical Committee, and at an evening meeting for the general public. Attendees were primarily agency (NOAA and U. S. Army Corps of Engineers), academia, or non-governmental organization representatives. NMFS continued this public outreach by presenting the non-fishing activities update at the March 2017 American Fisheries Society Alaska Chapter meeting in Fairbanks, and April 2017 Western Alaska Interdisciplinary Science Conference in Dutch Harbor.

These many sources facilitate public access to use NMFS information for their decision making. Additionally, NMFS has contacted several of the resource development groups that provided comment on the non-fishing EFH conservation recommendations in the past (i.e., during the process culminating in the 2005 EFH FEIS), to inform them that changes to the recommendations. Some of the organizations that have been contacted include the Resource Development Council, Alaska Miners Association, Alaska Oil and Gas Association, and Alaska Forest Association. Comments from these and other stakeholders are considered by the Council and NMFS prior to finalizing the Impacts to Essential Fish Habitat from Non-fishing Activities in Alaska Report.

12 HAPC recommendations

HAPCs are important tools for fishery managers. The HAPC process requires the consideration of adverse effects to sensitive and rare habitat areas exposed to stress from fishing or developmental activities. The Council works closely with NMFS, stakeholders, and the public to identify HAPCs and to prepare conservation measures, as needed.

12.1 Overview

HAPCs are subsets of EFH that highlight specific sites with extremely important ecological functions and/or areas that are especially vulnerable to human-induced degradation (see Figure 5). EFH provisions provide a means for the Council to identify HAPCs (50 C.F.R. 600.815(a)(8)) within FMPs. EFH is designated for the managed species identified in the Council's six FMPs (BSAI and GOA groundfish, Crab, Scallop, Salmon, and Arctic). HAPCs are areas within EFH that are rare and are either ecologically important, sensitive to disturbance, or may be stressed. Specific to fishery actions, HAPC are a site specific management tool for federally managed species that may require additional protection from adverse fishing effects.

Although the identification of HAPC is not required by statute or regulatory guidelines, the Council has a formalized process identified within its FMPs for selecting HAPCs. The HAPC process is initiated by Council action to establish priorities for HAPC consideration. Under this process, the Council periodically considers whether to set a habitat priority. If so, the Council initiates a request for proposals (RFP) for HAPC candidate areas that meet the specific priority habitat. HAPC proposals may be submitted by any member of the public, including fishery management agencies, other government agencies, scientific and educational institutions, non-governmental organizations, communities, and industry groups.

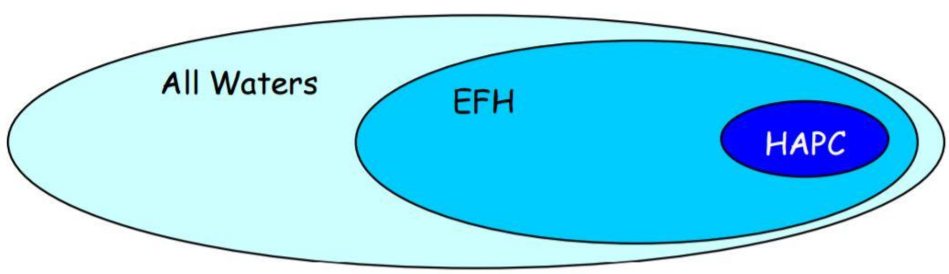

Figure 5. Venn diagram representing general categories of fish habitat as they relate to the management of federal fisheries in the U.S. EEZ.

12.2 HAPC nomination background

Proposals that meet the Council's priorities are reviewed for scientific and socioeconomic merit, and enforcement potential. This information is then presented to the SSC and AP, the Enforcement and Ecosystem Committees if necessary, and to the Council, which may choose to select HAPC proposals for a full analysis and subsequent implementation. The Council may also modify proposed HAPC sites and management measures during its review, or request additional stakeholder input and technical review. After review, the Council identifies proposals for further public review and potential HAPC designation.

In 2005, the Council revised its approach to designation of HAPC by adopting a site-based approach rather than habitat types, as had been the practice. The 2005 HAPC nomination process was initiated in October 2003. NMFS and the Council set the priorities of seamounts and undisturbed coral beds outside of core fishing areas important as rockfish or other species habitat as priority sites for identification as HAPC and for additional conservation measures. Seamounts may have unique ecosystems, may contain endemic species, and may thus be sensitive to disturbance. Some deep-sea coral sites may provide important habitat for rockfish and other species and may be particularly sensitive to some fishing activities. The Council evaluated alternatives to designate HAPC sites and take action, where practicable, to conserve these habitats from adverse effects of fishing. For the initial 2003-2004 HAPC process, the Council identified two specific priority areas for HAPC proposals:

- Seamounts in the exclusive economic zone (EEZ), named on National Oceanic and Atmospheric Administration (NOAA) charts, that provide important habitat for managed species.
- Largely undisturbed, high-relief, long-lived hard coral beds, with particular emphasis on those located in the Aleutian Islands, which provide habitat for life stages of rockfish or other important managed species.

Additionally, nominations were required to be based on best available scientific information and must include the following features:

- Sites must have likely or documented presence of FMP rockfish species.
- Sites must be largely undisturbed and occur outside core fishing areas.

The Council received 23 HAPC proposals from six different organizations as listed on the Alaska Fisheries website. The proposals were reviewed by the Plan Teams, and by staff to consider management, enforcement, and socioeconomic issues.

Ultimately, the Council identified a range of alternatives, staff completed an analysis, and the Council established several new HAPCs (71 FR 36694, June 28, 2006). In December 2004, the Council removed one of the proposed HAPC locations near Dixon Entrance for corals within the GOA. The Council became aware that a portion of the Dixon Entrance HAPC lies in disputed waters over which both the United States and Canada claim jurisdiction. Because of territorial concerns, the Council directed staff to remove the Dixon Entrance option from the HAPC consideration. However, the 2005 HAPC review process resulted in the implementation of several HAPC designations in the Gulf of Alaska and the Aleutian Islands in 2006: Aleutian Islands Coral Habitat Protection Area; Aleutian Islands Habitat Conservation Area; Alaska Seamount Habitat Protection Area; Gulf of Alaska Coral Habitat Protection Area; and, Gulf of Alaska Slope Habitat Conservation Area. Management measures for these HAPCs were implemented in August 2006.

In 2006-2007, the Council considered whether to initiate a HAPC proposal process during discussion related to Bering Sea Habitat Conservation. The Council considered whether to set a HAPC priority for Bering Sea skate nurseries and/or Bering Sea canyons. A summary of available research on these subjects was prepared and presented. Following public input and Plan Team and SSC review, the Council determined that it would be premature to initiate a call for proposals as there were no identified conservation concerns at that time

In April 2009, the SSC recommended that the Council consider permanently changing the timeline for consideration of HAPC priorities and candidate sites to align it with the EFH 5-year review. In 2010 the

Council chose to align the HAPC process with the EFH 5-year review cycle. However, the Council can initiate the HAPC process at any time if a specific need arises.

The next, and most recent, HAPC process was initiated in June 2009 when the Council considered whether to set priorities for identifying HAPCs and resolicit for HAPC proposals. The Council opted to synchronize the timing of the two actions so that the results from the five-year review can be considered in setting HAPC priorities, and the HAPC proposal cycle that might result. However, the Council can initiate the HAPC process at any time if a specific need arises.

In April 2010, the Council set a habitat priority (skate nurseries) and issued a request for HAPC proposals in conjunction with the completion of its 2010 EFH Review process. In October 2010, the Council selected a HAPC proposal from the AFSC to forward on for further analysis. The Council reviewed several versions of the analysis and refined the alternatives options before selecting five distinct skate egg deposition sites as HAPC. NMFS staff selected distinct sites where egg cases recruit and are vulnerable to fishing gear contacting the seafloor: egg case prongs (or horns) become entangled in or recruit onto the gear. These sites are discrete areas near the shelf/slope break that serve as important spawning and embryonic development areas for skate species (80 FR 1378, January 9, 2015).

12.3 2015 EFH Review and HAPC Consideration

In April 2017, the Council considered initiating a HAPC process to coincide with the ongoing review. Ultimately, the Council chose not to initiate the HAPC process and to maintain status quo; therefore, no calls for HAPC nominations through the proposal process will be initiated as part of the 2015 EFH Review. The Council noted at final action that they had no information about any specific species or sites to warrant imitation a HAPC process. The Council noted that should information arise the Council could initiate a HAPC process at any time in the future. Thus, the Council voted unanimously to not initiate any additional conservation or management recommendation for HAPC within the EFH described for all managed species in any of the FMPs. There will be no change to the status quo management of the current HAPC areas as part of this review; however, the Council can initiate a HAPC process at any time. A map of existing HAPC locations (Figure 6) and the corresponding fishery management applications (Table 18), including regulations, is available at alaskafisheries.noaa.gov.

Had the Council selected to initiate a HAPC process, the Council would have invited calls for HAPC nominations through a proposal process that focuses on specific sites consistent with the HAPC priorities designated by the Council. The proposal process is necessary for the Council to designate HAPCs sites and to consider management measures, if needed, to be applied to a habitat feature or features in a specific geographic location. The feature(s), as identified on a map or chart, must meet the considerations established in Federal regulations, and address identified problems for an FMP species. Proposals must provide clear, specific, and adaptive management objectives. Evaluation and development of HAPC management measures, where appropriate, would be guided by the EFH Final Rule.

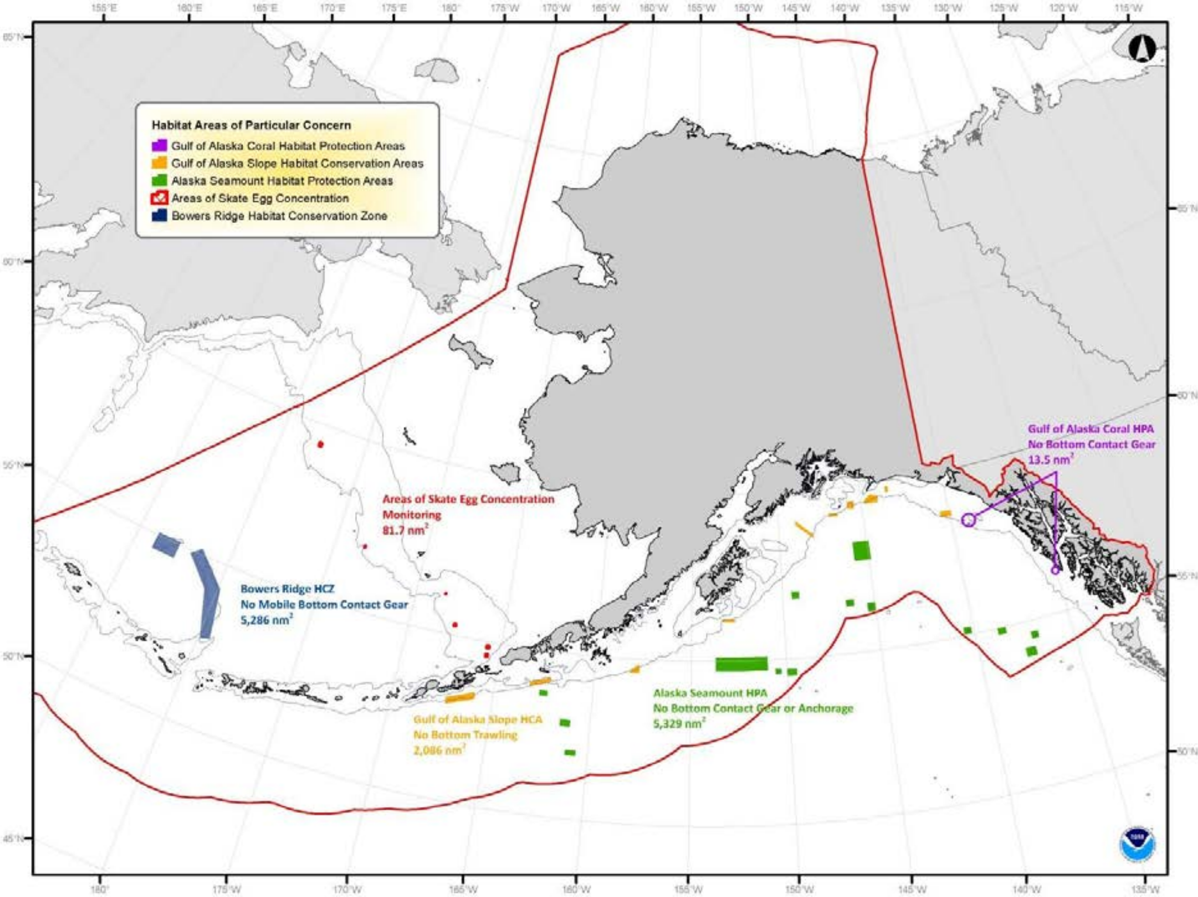

Figure 6. Map of Habitat Areas of Particular Concern in the EEZ off Alaska.

Table 18. Summary of existing habitat protection areas and conservation zones.

HAPC	Individual HAPC's	Total Area Size	Fishery Management Application	Specific Regulation
Alaska Seamount Habitat Protection Areas	Dickens Seamount Denson Seamount Brown Seamount Welker Seamount Dall Seamount Quinn Seamount Giacomini Seamount Kodiak Seamount Odessey Seamount Patton Seamount Chirikof & Marchand Seamounts Sirius Seamount Derickson Seamount Unimak Seamount Bowers Seamount	5,300 nm^2	No federally permitted vessel may fish with bottom contact gear[i]. 50 CFR 679.22(a)(12)	Federal Register 50 CFR Part 679, Volume 71, No.124 Wednesday, June 28,2006
Bowers Ridge Habitat Conservation Zone	Bowers Ridge Ulm Plateau	5,330 nm^2	No federally permitted vessel may fish with mobile bottom contact gear [ii]. 50 CFR 679.22(a)(15)	Same as above
Gulf of Alaska Coral Habitat Protection Areas	Cape Ommaney 1 Fairweather FS1 Fairweather FS2 Fairweather FN1 Fairweather FN2	14 nm^2	No federally permitted vessel may fish with bottom contact gear [iii]. 50 CFR 679.22(b)(9)	Same as above
Gulf of Alaska Slope Habitat Conservation Areas	Yakutat Cape Suckling Kayak Island Middleton Island east Middleton Island west Cable Albatross Bank Shumagin Island Sanak Island Unalaska Island	1,892 nm^2	No federally permitted vessel may fish with nonpelagic trawl gear [iv]. 50 CFR 679.22(b)(10)	Same as above
Skate Nursery Areas	Bering 1 Bering 2 Bristol Pribilof Zhemchug Pervenets	81.7 nm^2	Monitoring Priority	Federal Register Volume 80, No. 6, Friday, January 09, 2015

12.4 HAPC Process

HAPCs are those areas of special importance that may require additional protection from adverse effects. 50 CFR 600.815(a)(8) provides that 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; however, the Council would have consider HAPCs that meet at least two of the four considerations below:

(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

Rarity is a mandatory criterion of all Council HAPC proposals.

The HAPC process is initiated when the Council sets management priorities. A subsequent request, or call, for HAPC proposals is issued. Any member of the public may submit a HAPC proposal. Potential contributors may include fishery management agencies, other government agencies, scientific and educational institutions, non-governmental organizations, communities, and industry groups. A call for proposals is announced during a Council meeting, published in the Federal Register, and advertised in the Council newsletter and other media such as the Council's website. Scientific and technical information on habitat distributions, gear effects, fishery distributions, and economic data are accessible to the public. For example, NMFS' Alaska Region website has a number of valuable tools for assessing habitat distributions, understanding ecological importance, and assessing impacts. Information on EFH distribution, living substrate distribution, fishing effort, catch and bycatch data, gear effects, known or estimated recovery times of habitat types, prey species, and freshwater areas used by anadromous fish is provided in the 2005 EFH FEIS. The public would be advised of the rating criteria with the call for proposals.

Proposals need to be received by the deadline established for the call for proposals. Council staff would screen proposals to determine consistency with Council priorities, HAPC criteria, and general adequacy. Staff presents a preliminary report of the screening results to the Council. The Council will determine which of the proposals will be forwarded for the next review step: scientific, socioeconomic, and enforcement review. The Council could then refer selected proposals to the Plan Teams (Gulf of Alaska groundfish; Bering Sea/Aleutian Islands groundfish; Bering Sea/Aleutian Islands crab; and scallop; and salmon (currently dissolved). The Plan Teams evaluate the proposals for ecological merit.

A scientific review by the SSC is also necessary because past experience has shown that there will always be some level of scientific uncertainty in the design of proposed HAPCs and how they meet their stated goals and objectives. Some of this uncertainty may arise because the public will not have access to all relevant scientific information. Recognizing time and staff constraints, however, the staff cannot be expected to fill all the information gaps of proposals. The Council considers data limitations and uncertainties when weighing the efficacy of precautionary strategies for conserving and enhancing HAPCs while maintaining sustainable fisheries. The review panels may highlight available science and information gaps that may have been overlooked or are not available to the submitter of the HAPC proposal.

A socioeconomic review of proposals is conducted by Council or agency economists for socioeconomic impact. The Magnuson-Stevens Act states that EFH measures are to minimize impacts on EFH “to the extent practicable,” thus socio-economic considerations have to be balanced against expected ecological benefits at the earliest point in the development of measures. NMFS’ Final Rule for developing EFH plans states specifically that FMPs should “identify a range of potential new actions that could be taken to address adverse effects on EFH, include an analysis of the practicability of potential new actions, and adopt any new measures that are necessary and practicable” (50 CFR 600.815(a)(2)(ii)). In contrast to a process where the ecological benefits of EFH or HAPC measures are the singular initial focus and a later step is used to determine practicability, this approach would consider practicability simultaneously. Proposals are rated as to the extent they identify affected fishing communities and the potential effects on those communities, employment, and earnings in the fishing and processing sectors and the related infrastructure, to the extent that such information is readily available to the public. Management and enforcement provides input during the review to evaluate general management cost and enforceability of individual proposals.

The reviewers rank proposals by using the HAPC criteria established by the Council, described in more detail below.

12.4.1 Evaluation criteria for HAPC proposals

The EFH provisions indicate that the Council should identify HAPCs based on one or more of four considerations. The Council has decided as part of its HAPC process, in the FMPs, that HAPCs in Alaska must meet at least two of the four considerations, of which at least one should be the ‘rarity’ consideration. Proposals are evaluated by the Plan Teams and the SSC based on how they compare against these four considerations. In order to address concerns during the last HAPC proposal process about how the considerations are to be interpreted, the Council has adopted the following revised HAPC criteria evaluation process (Table 19), which will be used in evaluating submitted proposals nominating HAPC sites.

Table 19. Revised HAPC criteria evaluation process

Factor EFH Final Rule consideration	**Rarity** The rarity of the habitat type	**Ecological Importance** The importance of the ecological function provided by the habitat	**Sensitivity** The extent to which the habitat is sensitive to human induced environmental degradation	**Level of Disturbance (applicable to activities other than fishing)** Whether and to what extent development activities are or will be stressing the habitat type
0	Habitat[1] common throughout the Alaska regions: Gulf of Alaska, Bering Sea, Aleutian islands, and Arctic	Habitat does not provide any ecological associations[2].	Habitat resilient (not sensitive).	Habitat not subject to developmental stress.
1	Habitat less frequent and occurs to some extent in 2 or more regions.	Habitat provides little structure[3] or refugia. Foraging and spawning areas do not exist.	Habitat somewhat sensitive and quickly recovers; 1-5 years. Effects considered temporary.	Habitat is or will be exposed to minimal disturbance from development.
2	Habitat unique, less frequent, and occurs to some extent in 1 or 2 regions.	Habitat exhibits structure and provides refugia or substrates for spawning and foraging.	Habitat sensitive and recovery wit within 10 years. Effects considered temporary, however may be more than minimal.	Habitat is or will be stressed by activities. Short term effects evident.

Factor EFH Final Rule consideration	**Rarity** The rarity of the habitat type	**Ecological Importance** The importance of the ecological function provided by the habitat	**Sensitivity** The extent to which the habitat is sensitive to human induced environmental degradation	**Level of Disturbance (applicable to activities other than fishing)** Whether and to what extent development activities are or will be stressing the habitat type
3	Habitat unique and occurs in discrete areas within only one region.	Complex habitat condition and substrate serve as refugia, concentrate prey, and/or are known to be important for spawning.	Habitat is highly sensitive and allow to recover; exceeds 10s of years. Effects will persist and more than minimal.	Habitat is or will be severely stressed or disturbed by development. Cumulative impacts require consideration from long term effects.

[1] Habitat includes living (infauna, epifauna, megafauna, etc.) and non-living substrate (rock, cobble, gravel, sand, mud, silt, etc.) as well as pelagic waters important to managed species.
[2] Ecological associations are those associations where the habitat provides for reproductive traits (i.e. spawning and rearing aggregations) and foraging areas; areas necessary for survival of the species. Associations include habitat complexity (features, structures, etc.) and habitat associations (provide refugia, spawning substrates, concentrate prey, etc.). Ecological importance is not to be applied across all waters or substrates.
[3] 'Structure' refers to three-dimensional structure.

12.4.2 Data Certainty Factor

A Data Certainty Factor (DCF) was added to help determine the level of information known to describe and assess the HAPC (Table 19). The DCF is used to determine if information is adequate prior to taking further action. Thus, a HAPC proposal with a high criteria score and a low DCF is to be highlighted (flagged) as a potential candidate for HAPC and for further consideration as a research priority. The DCFs are color coded according to their weight to provide a visual way of informing the criteria scores, i.e., proposal scores with a DCF of 3 are color coded green, scores with a DCF of 2 are color coded yellow, and scores with a DCF of 1 are color coded red.

Table 20 Data Certainty Factors (DCF) used during HAPC evaluation

Weight	Data Certainty
3	Site-specific habitat information is available.
2	Habitat information can be inferred or proxy conditions allow for information to be reliable.
1	Habitat information does not exist; neither by inference or proxy.

12.4.3 HAPC Ranking System

HAPC ranking formula provides a color coded score (sum of criteria scores) to further the proposal along within the immediate HAPC Process. A high ranked HAPC with a DCF of 3 (score color coded green) has a high criteria score and information exists to assess the site. The overall HAPC Proposal Rank is the additive HAPC Criteria Score supplemented with Data Certainty Factor (Table 21).

Table 21. Example evaluation of HAPC proposals

HAPC Evaluation	Proposal A	Proposal B	Proposal C
Rarity	0	2	3
Ecological Importance	2	1	3
Sensitivity	2	3	3
Stress	n/a	n/a	2
Criteria Total (+)	4	6	11
Data Certainty Factor	3	3	1
HAPC Proposal Rank (=)	**4**	**6**	**11**

The top scoring proposals within each color category could then be forwarded for further consideration with the additional information that red high criteria scores may warrant consideration as a research priority and may not be an appropriate candidate for HAPC until further research is conducted.

Staff provides the Council with a summary of the ecological, socioeconomic, and enforcement reviews. The Council selects which proposal(s) go forward for analysis for possible HAPC designation. If the Council determined, through the HAPC identification process defined in the Council FMPs, that HAPCs in Alaska must be geographic sites that are rare, and must meet one of three other considerations: provide an important ecological function, be sensitive to human-induced degradation, or be stressed by development activities the Council could initiate a rulemaking process to establish the HAPC in Federal Regulation. The Council may modify the proposed HAPC sites and management measures.

Each proposal received and/or considered by the Council has one of three possible outcomes:

- The proposal could be accepted, and, following review, the concept from the proposal could be analyzed in a NEPA document for HAPC designation.
- The proposal could be used to identify an area or topic requiring more research, which the Council would request from NMFS or another appropriate agency.
- The proposal could be rejected.

The Council may set up a stakeholder process, as appropriate, to obtain additional input on proposals. The Council may obtain additional technical reviews as needed from scientific, socioeconomic, and management experts. Staff would prepare a NEPA analysis and other analyses necessary under applicable laws and Executive Orders. After the Council receives a summary of public comments and they would take final action on HAPC selections and management alternatives. The Council may periodically review the efficacy of existing HAPCs and allow for input on new scientific research.

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13 Research and information needs

Recently revised, National Standard 1 guidelines of the Magnuson-Stevens Act (2016) add several provisions to facilitate the incorporation of ecosystem-based fisheries management (EBFM) into federal fisheries management. National Standard 2 of the Magnuson-Stevens Act requires NMFS to conserve and manage fishery resources based upon the best available scientific information.

To meet these mandates, NMFS research must identify habitats that contribute most to the survival, growth and productivity of managed fish species and determine science-based measures to best manage and conserve these habitats from adverse effects of human activities.

Section 13.1 identifies the EFH research plan that was outlined in the 2005 EFH EIS, and which is included in five of the Council's FMPs (excludes Arctic). The Council considers revising or updating these research priorities during the 5-year review process.

To inform any recommendations on other EFH research priorities, Section 13.2 identifies the current habitat research priorities for NMFS and the Council. Section 13.4 identifies research needs that were identified in each of the individual species reviews.

Long-term EFH research themes include:

- Characterize habitat utilization and productivity
- Validate and improve habitat impacts model
- Sensitivity, impact and recovery of disturbed benthic habitat
- Low-cost seafloor mapping
- Coastal areas facing development

NMFS' EFH Research Plan timeline:

- 1996 – EFH research funding began
- 2006 – First 5-year EFH Research Plan published
- 2012 – Revised EFH Research Plan based on 5-year EFH review
- 2017 – Revise EFH Research Plan based on latest 5-year EFH review

Previous EFH Research Plans (Figure 7; AFSC 2006, Sigler et al. 2012) for Alaska have guided research to meet EFH mandates in Alaska since 2005. A new EFH Research Plan revises and supersedes these earlier plans, and similar to previous plans, is expected to guide the next several years of EFH research. Revisions of the EFH research plan (Sigler et al. 2012, Sigler et al. 2017) are timed to match required EFH 5-year reviews. These reviews summarize the status of EFH research, which then provides a basis for determining future research directions (i.e., revised research plan).

13.1 Research since the 2005 EFH FEIS and 2010 EFH Review

This section provides a general summary of habitat research that has been undertaken by NOAA Fisheries and the North Pacific Research Board, two of the primary research agencies for marine research in Alaska, in the last 5-10 years. Additional studies eliciting habitat information have also been documented in the individual species reviews. From 2005 to 2015, EFH research was conducted as single-year research projects. However, in a few instances, research was accomplished by highlighting a priority for more than year. This approach appeared to work, however clear objectives were absent and priorities seemed to change within the funding year. Eventually, this inconsistent application frustrated many researchers and a new Plan now offers to set clearer direction.

13.1.1 NMFS EFH Research

EFH Research Planning is coordinated through the AFSC, the AFSC Habitat and Ecological Processes Research (HEPR) Core Team, the Council, and the Alaska Region, HCD. NMFS Alaska Region has an annual EFH Research Proposal Process. In recent years, the following funding has been available for EFH research (Figure 8):

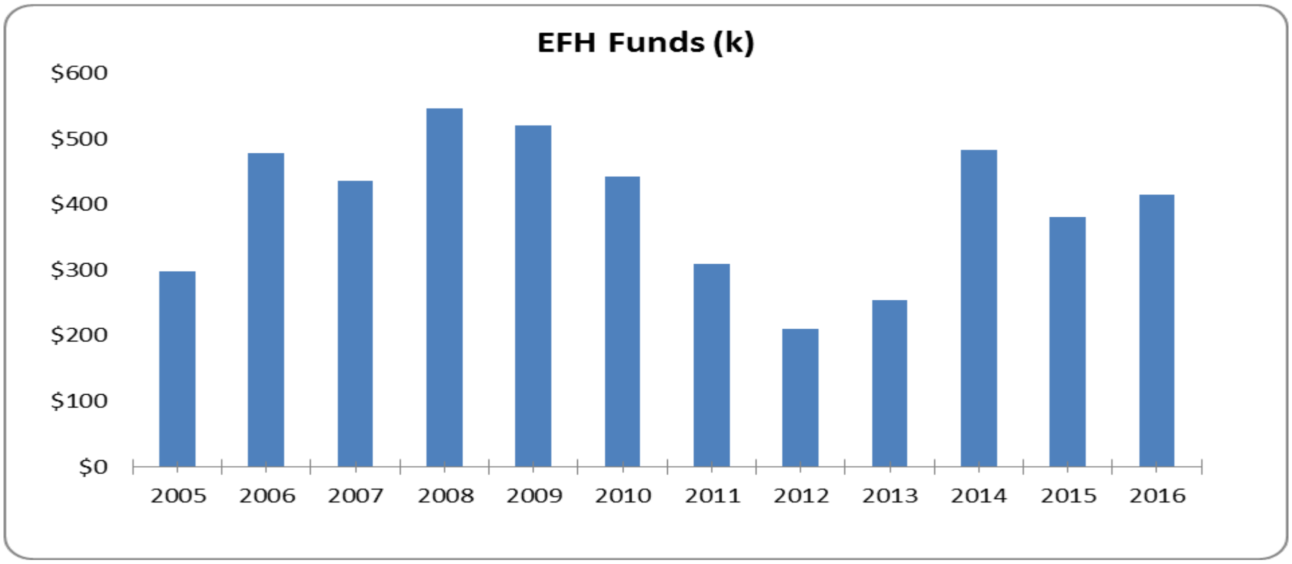

Figure 7. NMFS EFH Research Plan Funding, 2005-2016

Proposals undergo scientific review (scoring and ranking) by the HEPR Program. After review, the Acting Regional Administrator for the Habitat Conservation Division, the Regional EFH Coordinator, and the HEPR Team Lead meet to prioritize proposals that show scientific merit, address management emphasis areas, and meet priorities in the Plan. Prioritized proposals are considered for funding, as EFH allocations allow.

Specific research has been done on EFH and habitat by the Alaska Fisheries Science Center since the 2005 EFH FEIS, and is described below.

13.1.1.1 Projects funded under the EFH research plan, 2005-2017

EFH research needs are 1) to identify habitats that contribute most to the survival, growth, and productivity of managed fish and shellfish species; and 2) to determine how to best manage and protect these habitats from human disturbance and environmental change.

Research projects are selected through a competitive AFSC request for proposal process based on research priorities from the EFH Research Implementation Plan for Alaska. Annually, approximately $500,000 is spent annually on EFH research projects. Funded projects address major research themes

(Figure 9). Project results are described in annual reports and the peer-reviewed literature ([HEPR: Essential Fish Habitat]). Study results contribute to existing EFH data sets.

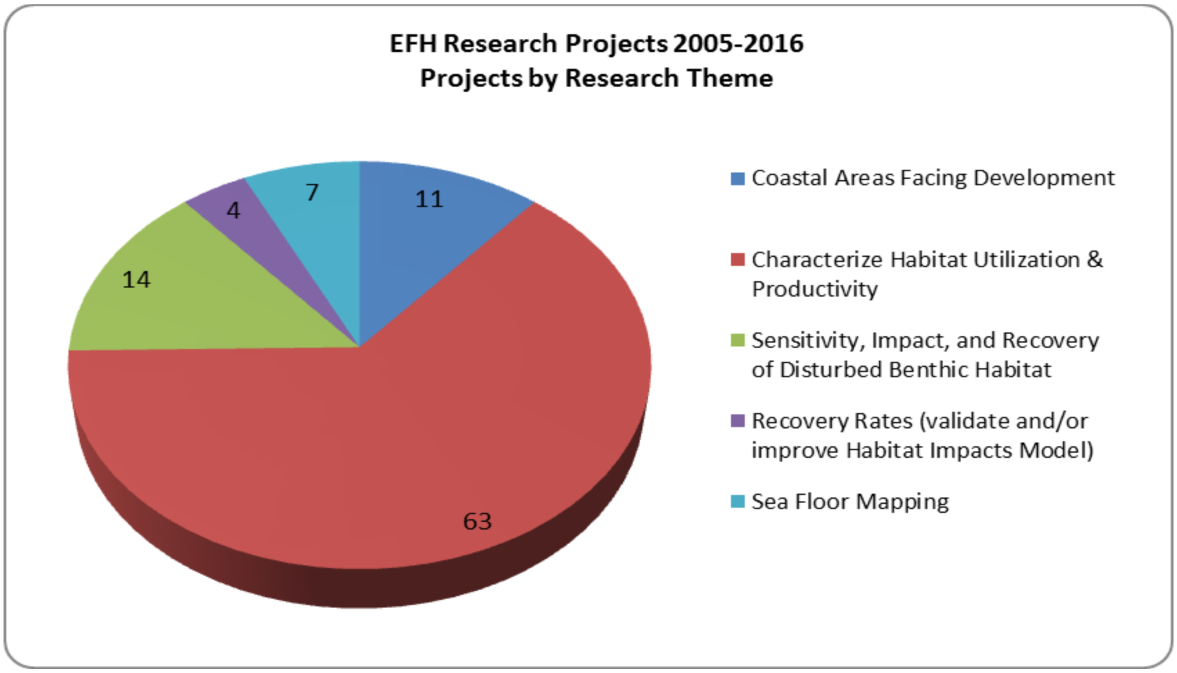

Figure 8. EFH research themes funded from the Research Plan, 2005-2016

EFH benefits from research directed to address effects from fishing and other anthropogenic activities. The EFH Research Plan and project review by AFSC HEPR allows EFH research to undergo peer-review scrutiny, a process implemented only in Alaska. EFH research struggles from a lack of adequate funding to address enormous unknowns, such as seafloor mapping and marine habitat delineations on the Alaska scale. However, this deficiency should not overshadow the exceptional research EFH has funded. A few highlights include:

- A better understanding of Atka mackerel spawning behaviors
- Bering Sea seafloor substrate mapping
- Coral recovery and growth studies
- Gear modification research
- Shoreline mapping and fish distributions
- Fishing effects and habitat impact recovery modeling

The next 5 years of EFH research will be guided by and conceptualized in the 2017-2022 EFH Research Plan. The new plan, described below, considers the research needs identified in this 2015 EFH Review Summary Report.

The 2015 EFH Review demonstrated a large advance in EFH information, in particular by substantially refining EFH maps for fish and crab species (Fisheries Leadership and Sustainability Forum 2016). The refinement occurred through an analysis to determine the environmental influences on species distributions and used this information to refine the EFH maps. These maps provide EFH level 2 information (habitat-related densities) for the adult life stage for many FMP species and EFH level 1 information (habitat distribution) for the juvenile life stages of some FMP species. These maps also provide a solid foundation for the next five years of EFH research.

Specific EFH research objectives are to be accomplished in the next five years, that is, by the next EFH update. These objectives are more focused than the 5 long-term research goals and describe specific tasks to accomplish in the next five years.

1. Develop EFH level 1 information (distribution) for life stages and areas where missing.
2. Raise EFH level from level 1 or 2 to 3.

Objective 1: Develop EFH level 1 maps. The purpose of the first EFH research objective is to develop maps where information is available for analysis, but this information has not yet been analyzed. One area with information available is settlement stage juveniles in the Gulf of Alaska, Bering Sea and Aleutian Islands. Currently, many juvenile stage maps have been developed; this analysis would separate settlement and later stage juveniles (i.e., separate the juvenile stages based on length into early (settlement) and late juveniles, where practical (e.g., Pacific cod). Likewise, information is available for early life stages and adults of fish and crab species in the northern Bering, Chukchi and Beaufort seas, but has not been analyzed. The goal is to analyze all of these data sets to develop EFH level 1 maps.

Objective 2: Raise EFH level from level 1 or level 2 to level 3. Habitat-related densities are available for the juvenile and adult life stages of many species listed in the GOA FMP and BSAI FMP. The next step is to incorporate habitat-related growth, survival and reproductive rates into the EFH maps. In some cases, this incorporation also is possible for level 1 species.

First, growth, survival or reproductive rates are available for several species. This information often was collected during laboratory studies (e.g., growth response to temperature of four gadid species [Laurel et al., 2015]). In these cases, analysis methods similar to those applied for the level 1 and level 2 maps could be applied to create level 3 maps. Second, additional laboratory and/or field studies could be conducted and this new information used to create level 3 EFH maps. The performance objective for the number of species with level 3 information examined through new studies after 5 years is 8-10 (assuming 2-3 years to conduct a study, 2-3 related species examined in each study and 1-2 studies conducted simultaneously). To accomplish research objective 2, the primary research approach is to build integrated lab, field, and modeling studies, with the purpose of mapping, for example, the growth potential of the studied fish and crab species (level 3 EFH).

Differences between the 2017 and 2012 EFH Research Plans are listed below.

1. Provides clearer direction to researchers seeking resolution than cannot occur within a year.
2. A directed focus to achieve species research to describe EFH at Level 3.
3. Functional responses will be incorporated into a model and EFH level 3 information mapped. The study components (lab and/or field components and the modeling) will be explicitly tied together, explained in the proposal, and then reported.
4. New Plan includes a 5 year performance objective to examine and advance EFH to Level 3 for 8 to 10 life history stages of EFH species.
5. Principle investigators are to consult with habitat modelers beforehand and describe a plan for incorporating data.
6. Commitment of $350,000 annually for EFH planning purposes.

13.2 EFH research priorities

The 2005 EFH FEIS identified a research approach for EFH related to minimizing fishing impacts, including research objectives, questions, activities, and a time frame. The four research objectives that are defined below have largely been met by the Council in the time period since the 2005 EFH FEIS. With respect to the research questions, many of these are still valid, and remain to be investigated. The Council may wish to consider either deleting the objectives from the FMP, and retaining the remainder of the research priority section, or perhaps developing new objectives for EFH research.

The Council reviewed these research priorities and decided that they did not need to be revised for this 2015 EFH Review.

13.2.1 EFH research priority language in the FMPs

Objectives

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

Research Questions

Reduce impacts. Does the closure effectively restrict higher-impact trawl fisheries from a portion of the GOA slope? Is there increased use of alternative gears in the GOA closed areas? Does total bottom trawl effort in adjacent open areas increase as a result of effort displaced from closed areas? Do bottom trawls affect these benthic habitats more than the alternative gear types? What are the research priorities? Are fragile habitats in the AI affected by any fisheries that are not covered by the new EFH closures? Are sponge and coral essential components of the habitat supporting FMP species?

Benthic habitat recovery. Did the habitat within closed areas recover or remain unfished because of these closures? Do recovered habitats support more abundant and healthier FMP species? If FMP species are more abundant in the EFH protection areas, is there any benefit in yield for areas that are still fished without EFH protection?

Research Activities

- Fishing effort data from observers and remote sensing would be used to study changes in bottom trawl and other fishing gear activity in the closed (and open) areas. Effects of displaced fishing effort would have to be considered. The basis of comparison would be changes in the structure and function of benthic communities and populations, as well as important physical features of the seabed, after comparable harvests of target species are taken with each gear type.
- Monitor the structure and function of benthic communities and populations in the newly closed areas, as well as important physical features of the seabed, for changes that may indicate recovery of benthic habitat. Whether these changes constitute recovery from fishing or just natural variability/shifts requires comparison with an area that is undisturbed by fishing and otherwise comparable.
- Validate the LEI model and improve estimates of recovery rates, particularly for the more sensitive habitats, including coral and sponge habitats in the Aleutian Islands region, possibly 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.

Research Time Frame

Changes in fishing effort and gear types should be readily detectable. Biological recovery monitoring may require an extended period if undisturbed habitats of this type typically include large or long-lived organisms and/or high species diversity. Recovery of smaller, shorter-lived components should be apparent much sooner.

13.2.2 Council research priorities for habitat and EFH

The following three Council-related EFH Priorities were listed in the Council's recent review of 2017-2022 Research Priorities.

1. Evaluate efficacy of habitat closure areas and habitat recovery. Establish a scientific research and monitoring program to understand the degree to which impacts on habitat, benthic infauna, etc., have been reduced within habitat closure areas, and to understand how benthic habitat recovery of key species is occurring. (This is an objective of EFH research approach for the Council FMPs). This research is considered important for near term planning. Action is partially underway.
2. Investigate skate egg concentration areas as EFH and HAPC. Skate conservation and skate egg concentration areas remain a priority for EFH and HAPC management within Council and NMFS research plans. This research is considered important for near term planning. No action is currently being taken.
3. Develop a GIS relational database for habitat, to include a historical time series of the spatial intensity of interactions between commercial fisheries and habitat. Such a time series are needed to evaluate the impacts of changes in fishing effort and type on EFH. This research is considered strategic and evaluation is underway.

13.3 2015 EFH Review research priorities identified by species

As part of the 2015 EFH Review, each stock assessment author provided a stock-specific evaluation of EFH research needs. Table 22 identifies these needs by species and FMP. These research needs could be used by the SSC and the Council in refining the Council’s research priorities which are disseminated to NPRB, NMFS, and other agencies. Additionally, these research needs will also likely be used by NMFS in developing research priorities for the 2017-2022 funding cycle. Although it is not proposed that this list of information should be included in the FMPs, it may be used by the Council in the development of the overall annual research priorities.

Table 22. Stock-specific research notes from stock authors

Bering Sea/ Aleutian Island Species	Research Notes from Stock Author
pollock	The current understanding of habitat preference for walleye pollock in the Aleutian Islands is limited. The bottom trawl survey is likely not a good estimate for pollock distribution and abundance in the Aleutian Islands. Small-scale acoustic surveys show the pollock are associated with the shelf break and the majority of walleye pollock in the Aleutians would not be available to a summer bottom trawl survey (Barbeaux and Fraser 2007). To understand EFH for AI walleye pollock, more acoustic survey work needs to be conducted in the Aleutian Islands. Accompanying this work would be additional research on acoustic species identification would need to be completed to differentiate walleye pollock aggregations from Pacific ocean perch and other rockfish species. Studies to determine the impacts of environmental conditions such as temperature regime and gyre strength on AI walleye pollock are needed.
Pacific cod	Improved consistency for 'size at age' to identify life history stages.
sablefish	Given the high movement rates and widespread distribution of Alaska Sablefish, it is unlikely that fine-scale habitat preferences exist for Alaska Sablefish (Hanselman et al. 2015). Little is known about actual spawning locations for Alaska Sablefish and that would be useful to guide further determination of which habitat is essential. There is limited information on the distribution and habitat requirements of eggs, larvae, and late juveniles. There is insufficient information on early juveniles. In general, little is known about the early juvenile stage distribution, habitat requirements, and interaction with other components of the ecosystem. Planktonic larvae have been found up to 500 km from shore, usually in upper water column (neuston), but little is known of the distribution of Alaska Sablefish until they are about 3 years old and appear in fishery and surveys. Studies to understand the recruitment dynamics of Alaska Sablefish as they relate to habitat are being conducted during the GOA Integrated Ecosystem Project but may need to continue after that Project concludes.
yellowfin sole	The EFH analysis has shown that there are some localized areas of higher habitat reduction in the Bering Sea and has estimated their cumulative effect on flatfish life history traits. However, there is limited information available on the distributions of eggs, larvae, juveniles or adults in these disturbed versus undisturbed areas necessary to contrast the success or failures in the breeding, feeding and growth to maturity of Bering Sea flatfish. Studies to provide and analyze this information are needed. In addition, information on the distribution and habitat requirements of eggs, larvae and newly metamorphosized juveniles and the variability of their stage duration are needed.
greenland turbot	Recruitment and survival processes controlled by environmental conditions are not fully understood and the distribution of early juvenile stages are mostly unknown. Climate change will likely impact this species substantially since it appears that larvae and/or juvenile survival may be positively correlated with the size of the cold-pool and overall shelf conditions (Barbeaux et al. 2016). Further research on habitat requirements of sub-adults and ontogenetic migration within this species and the impacts of climate on these processes and necessary habitat conditions are needed.
arrowtooth flounder	More information about the location and behavior associated with spawning and the distribution of larvae and early juvenile stages would be helpful for determining EFH for arrowtooth flounder in the Bering Sea and Aleutian Islands. Modeling studies of early life history of arrowtooth flounder have been performed for the Gulf of Alaska (Stockhausen, W. AFSC, pers. comm)
kamchatka flounder	The EFH analysis has shown that there are some localized areas of higher habitat reduction in the Bering Sea and has estimated their cumulative effect on flatfish life history traits. However, there is limited information available on the distributions of eggs, larvae, juveniles or adults in these disturbed versus undisturbed areas necessary to contrast the success or failures in the breeding, feeding and growth to maturity of Bering Sea flatfish. Studies to provide and analyze this information are needed. In addition, information on the distribution and habitat requirements of eggs, larvae and newly metamorphosized juveniles and the variability of their stage duration are needed.

Bering Sea/ Aleutian Island Species	Research Notes from Stock Author
northern rock sole	The EFH analysis has shown that there are some localized areas of higher habitat reduction in the Bering Sea and has estimated their cumulative effect on flatfish life history traits. However, there is limited information available on the distributions of eggs, larvae, juveniles or adults in these disturbed versus undisturbed areas necessary to contrast the success or failures in the breeding, feeding and growth to maturity of Bering Sea flatfish. Studies to provide and analyze this information are needed. In addition, information on the distribution and habitat requirements of eggs, larvae and newly metamorphosized juveniles and the variability of their stage duration are needed.
southern rock sole	The EFH analysis has shown that there are some localized areas of higher habitat reduction in the Bering Sea and has estimated their cumulative effect on flatfish life history traits. However, there is limited information available on the distributions of eggs, larvae, juveniles or adults in these disturbed versus undisturbed areas necessary to contrast the success or failures in the breeding, feeding and growth to maturity of Bering Sea flatfish. Studies to provide and analyze this information are needed. In addition, information on the distribution and habitat requirements of eggs, larvae and newly metamorphosized juveniles and the variability of their stage duration are needed.
flathead sole	More information on flathead sole habitat preferences would be useful to improve our understanding of EFH, particularly in localized areas of higher habitat reduction. Better habitat mapping of the Bering Sea and Aleutian Islands would provide information for survey stratification and the extent of trawlable and untrawlable habitat. There is limited information on the distribution and habitat requirements of eggs, larvae, and late juveniles. There is insufficient information on early juveniles. In general, little is known about the early juvenile stage distribution, habitat requirements, and interaction with other components of the ecosystem. Little is known of the distribution of flathead sole until they are about 2 years old and appear in fishery and surveys. Flathead sole catchability appears to vary with temperature and with the extent of the cold pool. Further studies on the linkage between temperature and flathead sole habitat preferences are needed.
alaska plaice	The EFH analysis has shown that there are some localized areas of higher habitat reduction in the Bering Sea and has estimated their cumulative effect on flatfish life history traits. However, there is limited information available on the distributions of eggs, larvae, juveniles or adults in these disturbed versus undisturbed areas necessary to contrast the success or failures in the breeding, feeding and growth to maturity of Bering Sea flatfish. Studies to provide and analyze this information are needed. In addition, information on the distribution and habitat requirements of eggs, larvae and newly metamorphosized juveniles and the variability of their stage duration are needed.
rex sole	More information on Bering Sea rex sole habitat preferences at different life stages and seasons would be useful to improve our understanding of EFH, particularly in localized areas of higher habitat reduction. Studies to determine impacts of environmental indicators such as temperature regime on rex sole are needed. More information on Aleutian Islands rex sole habitat preferences at different life stages and seasons would be useful to improve our understanding of EFH, particularly in localized areas of higher habitat reduction. Studies to determine impacts of environmental indicators such as temperature regime on rex sole are needed.
dover sole	More information on Bering Sea Dover sole habitat preferences at different life stages and seasons would be useful to improve our understanding of EFH, particularly in localized areas of higher habitat reduction. Studies to determine impacts of environmental indicators such as temperature regime on Dover sole are needed. More information on Aleutian Islands Dover sole habitat preferences at different life stages and seasons would be useful to improve our understanding of EFH, particularly in localized areas of higher habitat reduction. Studies to determine impacts of environmental indicators such as temperature regime on Dover sole are needed.
Pacific ocean perch	Research on the densities of rockfish in untrawlable and trawlable habitats are ongoing and should remain a priority. The results of this research should help in estimating the proportion of POP in untrawlable grounds, and thus improve stock assessments. Estimates of densities in untrawlable grounds can be obtained from acoustic and optical sampling gear, and much of the field work to date using these sampling tools has focused on the GOA (where the GOA acoustic survey provides a sampling platform). Extending these field sampling of untrawlable habitats to the Aleutian Islands and the EBS slope would improve the BSAI stock assessment.

Bering Sea/ Aleutian Island Species	**Research Notes from Stock Author**
northern rockfish	Research on the densities of rockfish in untrawlable and trawlable habitats are ongoing and should remain a priority. The results of this research should help in estimating the proportion of northern rockfish in untrawlable grounds, and thus improve stock assessments. Estimates of densities in untrawlable grounds can be obtained from acoustic and optical sampling gear, and much of the field work to date using these sampling tools has focused on the GOA (where the GOA acoustic survey provides a sampling platform). Extending this field sampling of untrawlable habitats to the Aleutian Islands and the EBS slope would improve the BSAI stock assessment.
shortraker rockfish	More information is needed on habitat use of various life stages of shortraker rockfish in the BSAI. Information on the distribution and habitat use of the various life-history stages would improve our knowledge of stock productivity and population dynamics. Also, efforts should be made to estimate population abundance in “trawlable” and “untrawlable” habitats, and their relative trends over time. A concern with our trawl surveys is that we implicitly assume the trawlable habitats (where we have data) are equivalent to the untrawlable habitats.
rougheye rockfish & Blackspotted rockfish	Research on the densities of rockfish in untrawlable and trawlable habitats are ongoing and should remain a priority. The results of this research should help in estimating the proportion of blackspotted/rougheye rockfish in untrawlable grounds, and thus improve stock assessments. Estimates of densities in untrawlable grounds can be obtained from acoustic and optical sampling gear, and much of the field work to date using these sampling tools has focused on the GOA (where the GOA acoustic survey provides a sampling platform). Extending this field sampling of untrawlable habitats to the Aleutian Islands and the EBS slope would improve the BSAI stock assessment.
dusky rockfish	AI only- More information on Aleutian Islands dusky rockfish habitat preferences at different life stages and seasons would be useful to improve our understanding of EFH, particularly in localized areas of higher habitat reduction. Studies to determine impacts of environmental indicators such as temperature regime on dusky rockfish are needed.
yelloweye rockfish	No specific research items.
harlequin rockfish	More information on Aleutian Islands harlequin rockfish habitat preferences at different life stages and seasons would be useful to improve our understanding of EFH, particularly in localized areas of higher habitat reduction. Studies to determine impacts of environmental indicators such as temperature regime are needed.
thornyhead rockfish (shortspine)	More information on Bering Sea shortspine thornyhead habitat preferences at different life stages and seasons would be useful to improve our understanding of EFH, particularly in localized areas of higher habitat reduction. Studies to determine impacts of environmental indicators such as temperature regime are needed.
atka mackerel	More information on Atka mackerel habitat preferences would be useful to improve our understanding of EFH, particularly in localized areas of higher habitat reduction. Better habitat mapping of the Aleutian Islands would provide information for survey stratification and the extent of trawlable and untrawlable habitat. There is limited information on the distribution and habitat requirements of eggs, larvae, and late juveniles. There is insufficient information on early juveniles. In general, little is known about the early juvenile stage distribution, habitat requirements, and interaction with other components of the ecosystem. Planktonic larvae have been found up to 800 km from shore, usually in upper water column (neuston), but little is known of the distribution of Atka mackerel until they are about 2 years old and appear in fishery and surveys. Studies to determine the impacts of environmental indicators such as temperature regime on Atka mackerel are needed.
squid	No research items identified.

Bering Sea/ Aleutian Island Species	Research Notes from Stock Author
octopus	More information on Bering Sea octopus habitat preferences at different life stages and seasons would be useful to improve our understanding of EFH, particularly in localized areas of higher habitat reduction. There is limited information on the seasonal or spatial distribution and habitat requirements of mating adults, females incubating eggs, planktonic paralarvae, or benthic juveniles. Little is known about the breeding season, growth rates, and time to maturity for octopus populations in the Bering Sea. Much more would need to be known in order to determine impacts of environmental indicators such as temperature regime on octopus. More information on Aleutian Islands octopus habitat preferences at different life stages and seasons would be useful to improve our understanding of EFH, particularly in localized areas of higher habitat reduction. There is limited information on the seasonal or spatial distribution and habitat requirements of mating adults, females incubating eggs, planktonic paralarvae, or benthic juveniles. Little is known about the breeding season, growth rates, and time to maturity for octopus populations in the Aleutian Islands. Much more would need to be known in order to determine impacts of environmental indicators such as temperature regime on octopus.
sharks *Pacific sleeper shark* *spiny dogfish* *salmon shark*	Species are quite different from one another and subject to severe data limitations for the stock assessments and assessment of EFH. Pacific sleeper shark are a large species and difficult to study. To date, no mature Pacific sleeper sharks have been observed on any AFSC surveys and data to assess EFH is limited. Thus, it is not possible to know what habitats the adults inhabit. Juveniles occur in many areas, both survey and fishery, and multiple gear types. However, given the large size and highly mobile nature of the animal, it is difficult to discern if any specific habitat is essential. Neonates have not been encountered, thus nursery areas have not been identified. EFH for the life history stages of spiny dogfish are also unknown. Near term females have been observed in some bays in Alaska, but neonates have not been encountered. Adults are highly migratory and habitat use is unknown. Salmon shark are a pelagic species, with little data available from AFSC surveys or fisheries to inform EFH analyses. Further, this species is highly migratory and likely spends a significant portion of time outside of Alaskan waters.
sculpins (Great, Yellow Irish Lord, Bigmouth)	There is a need for research on sculpin habitat utilization throughout their life history stages. It is also not known whether bottom trawling negatively impacts the habitat of adult sculpins.
skates (Alaska, Bering, Aleutian, Mud)	Bering Sea skate EFH research priorities include: Determine how adult Alaska skates are using nursery areas (e.g. are nursery areas visited once or multiple times? Is there a seasonal pattern to deposition of eggcases in nursery areas?; Determine ontogenetic patterns in habitat use by Alaska skates, i.e. juvenile vs adult use of EBS shelf habitats; Determine the effects of bottom contact gear on embryos and eggcases in known nursery areas. Aleutian Islands skate EFH research priorities include: Identify nursery areas for skates (particularly whiteblotched, Alaska, and Aleutian skates) in the Aleutian Islands and associated habitat characteristics (e.g. depth, sediment type); Identify the potential for movement of skates within the Aleutian Islands (e.g. through conventional or satellite tagging).
forage fish complex	No research items identified.
grenadiers	Despite their abundance, giant grenadier <15 years old are nearly absent from surveys. Their habitat use from the larval stage through their appearance on the continental slope at ~ age 15 is unknown. It is not possible to tag grenadiers and track their movements and habitat use because they experience 100% mortality when brought to the surface. Therefore, it is unknown they use the water column or if they migrate during any life phases. Over 90% of giant grenadier caught in surveys are females and there is very little data on where males are distributed, but it is thought they reside in deeper waters (>1,000 m), at least during the summer months when survey occur. Information is needed for early life stages.

Gulf of Alaska Species	Research Notes from Stock Author
pollock	In general, little is known about the pollock juvenile stage distribution, habitat requirements, and interaction with other components of the ecosystem. For example, it is unclear whether pollock during the juvenile stage temporarily adopt a more demersal distribution, and if so, what are the habitat requirements of this stage. Studies to determine the impacts of environmental factors on pollock growth and maturation are needed. Pollock fisheries in the GOA use mostly mid-water trawls. Studies of bottom contact with mid-water trawls have been conducted in the eastern Bering Sea, but not in the Gulf of Alaska, where the range of bottom types is different and smaller mid-water trawls are used. Studies specific to the Gulf of Alaska are needed.
Pacific cod	The current understanding of habitat preference for Pacific cod by life stage in the Gulf of Alaska is limited. More information on ontogenetic preferences and requirements of GOA Pacific cod would be useful to improve our understanding of GOA Pacific cod EFH. In addition, a better understanding of the differences in GOA Pacific cod survey selectivity and availability between trawlable and untrawlable habitat would substantially enhance our understanding of fishery impacts on Pacific cod EFH. Studies to determine the impacts of environmental conditions such as temperature regime and gyre strength on GOA Pacific cod are needed.
sablefish	Given the high movement rates and widespread distribution of Alaska Sablefish, it is unlikely that fine-scale habitat preferences exist for Alaska Sablefish (Hanselman et al. 2015). Little is known about actual spawning locations for Alaska Sablefish and that would be useful to guide further determination of which habitat is essential. There is limited information on the distribution and habitat requirements of eggs, larvae, and late juveniles. There is insufficient information on early juveniles. In general, little is known about the early juvenile stage distribution, habitat requirements, and interaction with other components of the ecosystem. Planktonic larvae have been found up to 500 km from shore, usually in upper water column (neuston), but little is known of the distribution of Alaska Sablefish until they are about 3 years old and appear in fishery and surveys. Studies to understand the recruitment dynamics of Alaska Sablefish as they relate to habitat are being conducted during the GOA Integrated Ecosystem Project but may need to continue after that Project concludes.
yellowfin sole	No research items identified.
arrowtooth flounder	Research on whether arrowtooth flounder are broadcast or batch spawners would be helpful. It would also be informative to know the role of arrowtooth flounder, if any, in the pelagic zone.
northern rock sole	Difficult to consistently differentiate southern rock sole from northern rock sole. As such, the analysis to determine the seasonal distribution of southern rock sole was done on the combined Lepidopsetta spp. Future sampling efforts should include genetic analysis to better determine misidentification of the two species by the observer and survey programs and to better understand the composition of the unknown category.
southern rock sole	See northern rock sole
flathead sole	More information on flathead sole habitat preferences would be useful to improve our understanding of EFH, particularly in localized areas of higher habitat reduction. Better habitat mapping of the GOA would provide information for survey stratification and the extent of trawlable and untrawlable habitat. There is limited information on the distribution and habitat requirements of eggs, larvae, and late juveniles. There is insufficient information on early juveniles. In general, little is known about the early juvenile stage distribution, habitat requirements, and interaction with other components of the ecosystem. Little is known of the distribution of flathead sole until they are about 2 years old and appear in fishery and surveys. Studies to determine the impacts of environmental indicators such as temperature regime on GOA flathead are needed.
alaska plaice	No research items identified.

Gulf of Alaska Species	Research Notes from Stock Author
rex sole	More information on rex sole habitat preferences would be useful to improve our understanding of EFH, particularly in localized areas of higher habitat reduction. Better habitat mapping of the GOA would provide information for survey stratification and the extent of trawlable and untrawlable habitat. There is limited information on the distribution and habitat requirements of eggs, larvae, and late juveniles. There is insufficient information on early juveniles. In general, little is known about the early juvenile stage distribution, habitat requirements, and interaction with other components of the ecosystem. Little is known of the distribution of rex sole until they are about 2 years old and appear in fishery and surveys. Studies to determine whether rex sole grow faster in some areas than in other areas and what habitat attributes may contribute to these differences would be useful as well.
dover sole	More information on Dover sole habitat preferences would be useful to improve our understanding of EFH. Better habitat mapping of the GOA would provide information for survey stratification and the extent of trawlable and untrawlable habitat. There is limited information on the distribution and habitat requirements of eggs, larvae, and late juveniles. There is insufficient information on early juveniles. In general, little is known about the early juvenile stage distribution, habitat requirements, and interaction with other components of the ecosystem. Little is known of the distribution of Dover sole until they are about 3 years old and appear in fishery and surveys.
Pacific ocean perch	More information on POP habitat preferences, particularly by season, would be useful to improve our understanding of EFH, particularly in localized areas of higher habitat reduction. Adults are found primarily offshore on the outer continental shelf and the upper continental slope in depths of 150-420 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 of ~300-420 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. Better habitat mapping of the Gulf of Alaska would also be desirable and would provide information for survey stratification and the extent of trawlable and untrawlable habitat, a concern that is applicable to most rockfish species in the GOA. The distribution and habitat requirements during the early life history stages of GOA POP are limited. 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 ~2 months later. The eggs hatch internally, and parturition (release of larvae) occurs in April-May. Information on early life history is very sparse, especially for the first year of life. POP larvae are thought to be pelagic and drift with the current, and oceanic conditions may sometimes cause advection to suboptimal areas (Ainley et al. 1993) resulting in high recruitment variability. There is also insufficient information on distribution and habitat requirements of early juveniles. In general, little is known about the early juvenile stage distribution, habitat requirements, and interaction with other components of the ecosystem until they are about 2 years old and appear in fishery and surveys. Studies to determine the impacts of environmental indicators such as temperature regime on POP are needed.

Gulf of Alaska Species	Research Notes from Stock Author
northern rockfish	More information on northern rockfish habitat preferences would be useful to improve our understanding of EFH, particularly in localized areas of higher habitat reduction. Previous studies have identified the highest concentrations of northern rockfish in the NMFS bottom trawl surveys are associated with relatively rough bottom on shallow rises or banks on the outer continental shelf at depths of about 75-150 m (Clausen and Heifetz 2002), which is consistent with the CEA resulting here. However, better habitat mapping of the Gulf of Alaska would provide information for survey stratification and the extent of trawlable and untrawlable habitat, a concern that is also discussed in the research priorities for northern rockfish stemming from highly variable and uncertain bottom trawl survey abundance estimates (Hulson et al. 2015). The distribution and habitat requirements of GOA northern rockfish larvae are unknown. Like other Sebastes species, northern rockfish are presumed to be ovoviviparous with internal fertilization, although, larval northern rockfish cannot be unequivocally identified to species at this time, even using genetic techniques, so information on larval distribution and length of the larval stage is unknown. There is also insufficient information on distribution and habitat requirements of early juveniles. In general, little is known about the early juvenile stage distribution, habitat requirements, and interaction with other components of the ecosystem until they are about 2 years old and appear in fishery and surveys. Studies to determine the impacts of environmental indicators such as temperature regime on northern rockfish are needed.
shortraker rockfish	More information on shortraker rockfish habitat preferences would be useful to improve our understanding of EFH, particularly in localized areas of higher habitat reduction. There is little to no information on larval, post-larval, or juvenile shortraker rockfish, especially juveniles. Genetic techniques were used to identify a small number of post-larval shortraker rockfish from samples collected in epipelagic waters far offshore in the GOA, which is the only documentation of habitat for this life stage. No data exist on when juvenile fish become demersal in the GOA; in fact, few specimens of juvenile shortraker rockfish <35 cm fork length (FL) have ever been caught in this region, so information on this life stage is virtually absent. Studies are needed to locate and sample these young fish before their habitat requirements can be determined. In general, little is known about the distribution, habitat requirements, and interaction with other components of the ecosystem of shortraker rockfish < 35 cm FL, the smallest size they begin to appear in the fishery and surveys. Although more is known about adult fish, the specifics of their habitat requirements need further research and would be useful to improve our understanding of EFH, particularly in localized areas of higher habitat reduction. For example, does a relationship exist between adult shortraker rockfish and Primnoa coral, and if so, to what degree of importance? More research needs to be done on the bottom habitat of the major fishing grounds to describe what biota are found on these grounds, and on what impact bottom trawling has on these biota.
blackspotted rockfish	See rougheye rockfish
rougheye rockfish	More information on RE/BS rockfish habitat preferences would be useful to improve our understanding of EFH, particularly in localized areas of higher habitat reduction. There is little to no information on larval, post-larval, or juvenile RE/BS rockfish. No data exist on when juvenile rockfish become demersal in the GOA. Studies are needed to locate and sample these young fish before their habitat requirements can be determined. In general, little is known about the distribution, habitat requirements, and interaction with other components of the ecosystem of RE/BS rockfish prior to when they begin to appear in the fishery and surveys. Although more is known about adult fish, the specifics of their habitat requirements need further research and would be useful to improve our understanding of EFH, particularly in localized areas of higher habitat reduction. More research needs to be done on the bottom habitat of the major fishing grounds to describe what biota are found on these grounds, and on what impact bottom trawling has on these biota.
dusky rockfish (dark)	More information on dusky rockfish habitat preferences would be useful to improve our understanding of EFH, particularly in localized areas of higher habitat reduction. A better understanding of what particular biota is preferred may help understand impacts of bottom disturbance by fishing gear. Improved knowledge of juvenile habitat requirements would help us understand the habitat requirements of different life stages thus improving our ability to evaluate the effects of fishing.

Gulf of Alaska Species	Research Notes from Stock Author
thornyhead rockfish (shortspine)	More information on shortspine thornyhead habitat preferences would be useful to improve our understanding of EFH, particularly in localized areas of higher habitat reduction. Unlike rockfish in the genus Sebastes, which retain fertilized eggs internally and release hatched, fully developed larvae, thornyheads spawn a bi-lobed mass of fertilized eggs which floats in the water column. Once the pelagic egg masses hatch, larval and juvenile thornyheads spend far more time in a pelagic life stage than the young of year rockfish in the genus Sebastes. Shortspine thornyhead juveniles spend 14-15 months in a pelagic phase. Shortspine thornyhead juveniles tend to settle into relatively shallow benthic habitats between 100 and 600 m and then migrate deeper as they grow. Studies to determine the impacts of environmental indicators such as temperature regime, especially during the egg, larval, and juvenile stage, are needed.
black rockfish	No research items identified. Completed by ADF&G.
Other rockfish Yelloweye greenstriped harlequin pygmy quillback redbanded redstriped rosethorn silvergray sharphin	More information on OR/DSR habitat preferences would be useful to improve our understanding of EFH, particularly in localized areas of higher habitat reduction. There is limited information on the distribution and habitat requirements of eggs, larvae, and late juveniles. There is insufficient information on early juveniles. In general, little is known about the early juvenile stage distribution, habitat requirements, and interaction with other components of the ecosystem. Planktonic larvae have been found up to 800 km from shore, usually in upper water column (neuston), but little is known of the distribution of OR/DSR until they are about 2 years old and appear in fishery and surveys. Studies to determine the impacts of environmental indicators such as temperature regime on OR/DSR are needed.
atka mackerel	More information on Atka mackerel habitat preferences would be useful to improve our understanding of EFH, particularly in localized areas of higher habitat reduction. There is limited information on the distribution and habitat requirements of eggs, larvae, and late juveniles. There is insufficient information on early juveniles. In general, little is known about the early juvenile stage distribution, habitat requirements, and interaction with other components of the ecosystem. Planktonic larvae have been found up to 800 km from shore, usually in upper water column (neuston), but little is known of the distribution of Atka mackerel until they are about 2 years old and appear in fishery and surveys. Studies to determine the impacts of environmental indicators such as temperature regime on Atka mackerel are needed.
squid	No research items identified.
octopus	More information on Gulf of Alaska octopus habitat preferences at different life stages and seasons would be useful to improve our understanding of EFH, particularly in localized areas of higher habitat reduction. There is limited information on the seasonal or spatial distribution and habitat requirements of mating adults, females incubating eggs, planktonic paralarvae, or benthic juveniles. In general, little is known about the breeding season, growth rates, and time to maturity for octopus populations in the Gulf of Alaska. Much more would need to be known in order to determine impacts of environmental indicators such as temperature regime on octopus.
sharks Pacific sleeper shark spiny dogfish salmon shark	Species are quite different from one another and subject to severe data limitations for the stock assessments and assessment of EFH. Pacific sleeper shark are a large species and difficult to study. To date, no mature Pacific sleeper sharks have been observed on any AFSC surveys and data to assess EFH is limited. Thus, it is not possible to know what habitats the adults inhabit. Juveniles occur in many areas, both survey and fishery, and multiple gear types. However, given the large size and highly mobile nature of the animal, it is difficult to discern if any specific habitat is essential. Neonates have not been encountered, thus nursery areas have not been identified. EFH for the life history stages of spiny dogfish are also unknown. Near term females have been observed in some bays in Alaska, but neonates have not been encountered. Adults are highly migratory and habitat use is unknown. Salmon shark are a pelagic species, with little data available from AFSC surveys or fisheries to inform EFH analyses. Further, this species is highly migratory and likely spends a significant portion of time outside of Alaskan waters.
sculpins Great sculpin Yellow Irish Lord Bigmouth sculpin	There is a need for research on sculpin habitat utilization throughout their life history stages. It is also not known whether bottom trawling negatively impacts the habitat of adult sculpins.

Gulf of Alaska Species	Research Notes from Stock Author
Skates *Alaska skate* *Bering skate* *Aleutian skate*	Gulf of Alaska skate EFH research priorities Identify nursery areas for skates (particularly big and longnose skates) in the Gulf of Alaska and associated habitat characteristics (e.g. depth, sediment type). Identify the potential for movement of skates (particularly big and longnose skates) within the Gulf of Alaska (e.g. through conventional or satellite tagging).
forage fish complex	No research items identified.
grenadiers	Despite their abundance, giant grenadier <15 years old are nearly absent from surveys. Their habitat use from the larval stage through their appearance on the continental slope at ~ age 15 is unknown. It is not possible to tag grenadiers and track their movements and habitat use because they experience 100% mortality when brought to the surface. Therefore, it is unknown they use the water column or if they migrate during any life phases. Over 90% of giant grenadier caught in surveys are females and there is very little data on where males are distributed, but it is thought they reside in deeper waters (>1,000 m), at least during the summer months when survey occur. Information is needed for early life stages.

Bering Sea & Aleutian Island Crab	Research Notes from Stock Authors
Red king crab	The stock assessment author suggests that additional analysis is required for Bristol Bay red king crab to adequately assess potential changes needed for this stock.
Blue king crab	No research items identified.
Golden king crab	No research items identified.
Tanner crab	No research items identified.
Snow crab	No research items identified.

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14 Future Directions

Activities are in progress to evaluate and validate habitat for species and stocks to meet habitat information needs for future EFH Reviews. Highlights include the following:

- separate demersal early juvenile stage and late juvenile stage models and maps to improve EFH Level 1 and 2 information for groundfish species in an FMP, resulting in greater resolution of EFH for life stages that occupy nearshore habitats;
- improved EFH Level 1 and 2 information for crab stocks;
- model-based EFH maps and improved EFH information for Arctic species;
- integrated 2-3 year studies to determine EFH Level 3 information for species life stages (Sigler et al. 2017; Alaska Essential Fish Habitat Research Plan); and
- validation of the fishing effects model.

In addition, Habitat Assessment Prioritization for the Alaska Region of NMFS was completed in 2017 following a national framework for prioritizing habitat assessments regionally (www.st.nmfs.noaa.gov). This process provided two lists of Alaska stocks prioritized for habitat assessments, including—

- stock assessments that would most benefit from habitat assessments, and
- stocks for which habitat assessments will most advance EFH.

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Review of groundfish species EFH

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Review of crab species EFH

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Review of scallop species EFH

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Review of salmon species EFH

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Review of Arctic species EFH

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Review of early life stage histories

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Review of fishing effects

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