2016 Review of Essential Fish Habitat (EFH) in the North Pacific Fishery Management Council's Fishery Management Plans

Summary Report
Final Review

October 2016

Table of Contents

List of Tables

List of Figures

1 Introduction

The Magnuson-Stevens Fishery Conservation and Management Act (MSA) requires regional Fishery Management Councils (Councils) to describe and identify Essential Fish Habitat (EFH) for all fisheries, and to minimize to the extent practicable the adverse effects of fishing on EFH. The MSA 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 Councils must describe 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 EHF. 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 could adversely affect EFH. Councils also have the authority to comment on Federal or state agency actions that could adversely affect habitat, including EFH, of managed species.

Each FMP contains the following EFH components:

1. EFH descriptions and identification
2. Fishing activities that may adversely affect EFH
3. Non-MSA 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 locations
8. Habitat Areas of Particular Concern (HAPC) identification
9. Research and information needs

The EFH final rule from 2002 establishes that Councils should identify the level (1-4) of information 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 described below:

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.

All of the current descriptions of EFH in the Council's FMPs are either Level 1, or do not reach the Level 1 threshold.

The EFH Final Rule requires that a "review and revision of EFH components" is completed every 5 years, and EFH provisions revised or amended, as warranted. The EFH Final Rule states that reviews should evaluate:

- Published scientific literature
- Unpublished scientific reports
- Information solicited from interested parties
- Previously unavailable or inaccessible data.

This is the second review of EFH in the North Pacific Fishery Management Council's groundfish FMPs. The first review was completed in 2010. The 2010 review contains much information about previous Council decisions regarding EFH; that information is not repeated here but is incorporated by reference. Based on this review, the Council will decide whether revisions to EFH or reevaluations of EFH management measures are necessary.

1.1 Background

The Council amended five of its FMPs (Bering Sea/Aleutian Island Groundfish, Gulf of Alaska Groundfish, BSAI crab, Scallop, and Salmon) in 2005 to address EFH requirements. The Arctic FMP was enacted in 2009, EFH for Arctic species was identified at that time. In 2005, the Council and NMFS developed an environmental impact statement (EIS) evaluating alternatives and environmental consequences of three actions: (1) describing and identifying EFH for fisheries managed by the Council; (2) adopting and approach for the Council to identify Habitat Areas of Particular Concern (HAPC, a subset of EFH); and (3) minimizing to the extent practicable the adverse effects of Council-managed fishing on EFH. The analysis concluded that there are long-term effects of fishing on benthic habitat features, and acknowledged that considerable scientific uncertainty remained regarding the consequences of such effects for the sustained productivity of managed species. Nevertheless, based on the analysis in the EIS, the Council concluded, and NMFS agreed, that the effects on EFH are minimal because there was 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 concluded, and NMFS agreed, that no Council-managed fishing activities would result in more than minimal and temporary adverse effects on EFH.

The Council initiated a review of EFH in all FMPs in 2010, except for the Arctic FMP which had recently been enacted. After review, the Council chose to initiate FMP amendments to revise EFH components in all five FMPs. The EFH Omnibus amendment package was completed and adopted in 2012.

Information relevant to management and mitigation of impacts to EFH is now published, annually, in the Stock Assessment and Fishery Evaluation (SAFE) reports (e.g., Zador 2015).

2 Approach

This report presents the 2016 review of EFH in the Council's FMPs. The review included evaluating new environmental and habitat data, developing new models to evaluate EFH, updating models to assess fisheries impacts on EFH, updating models to assess non-fishing impacts on EFH, identifying whether revisions to current EFH descriptions are needed or suggested, and assessing information gaps and research needs. This review follows the process developed in the first 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 Council meeting. This final report incorporates suggestions from the Council and its advisory bodies. This review fulfills the Council's responsibility to complete a 5-year review of EFH. Should the Council determine that revisions to EFH descriptions in the FMPs are appropriate, the Council could initiate an analysis to update the FMPs, including all the requisite analytical documents. If the Council determines that revisions to EFH descriptions are not necessary for one or more FMPs, then the existing definitions of EFH will remain as the legal descriptions.

2.1 Model-based Essential Fish Habitat definitions

Essential Fish Habitat descriptions consist of text descriptions and maps. In Alaska, most EFH descriptions for groundfish have been limited to qualitative statements on the distribution of adult life stages. While these are useful, they could be easily 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 this review, scientists at NMFS Alaska Region, the Alaska Fisheries Science Center, and academic researchers produced species distribution models of EFH for all major species of groundfish and invertebrates in the eastern Bering Sea, Aleutian Islands, and Gulf of Alaska (Appendices A, B, C). 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. From these, complementary distribution maps were generated that showed the location of EFH. Full descriptions of the models and model outputs are available in Appendix A-C, and are summarized here.

The species and life history stages of fishes and invertebrates examined to create model-based EFH definitions are shown in Table 1. 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 observer database (CIA Database). All data were divided into four seasons for analysis: fall (October-November), winter (December-February), spring (March-May), and summer (June-September).

2.1.1 Species distribution data

Data to describe species distribution were available at different scales, and with different coverage. FOCI’s ECODAAT database contains historical ichthyoplankton catches from across the entire eastern Bering Sea, from 1991 to 2013. These were collected during a number of different survey types with different objectives. Therefore, many different gear types have been used and samples were collected from a variety of depths in the water column. Samples were collected across all months and seasons of the year. Because of these disparities, data were combined across years for this analysis. Each species in the ECODAAT data was classified as either egg, larval, or juvenile (early stages because they were not settled to the benthos). These data were used for presence-only models where the number of presence observations in a species-life stage combination exceeded 50. An important caveat is that these data were not collected over the entire area of the eastern Bering Sea, but rather, typically, from a smaller regional survey grid, which should be considered when considering maps produced from these data.

Data were also collected during bottom-trawl surveys of the eastern Bering Sea ecosystem. These data were the most comprehensive, all collected from the summer season and surveys are conducted with a rigorous statistical design. The NMFS, AFSC has conducted standard bottom-trawl surveys in the BSAI and GOA since 1982. Details of the survey are available in Appendix A. All fishes and invertebrates captured were sorted either by species or into larger taxonomic groups and the total weight in the catch was determined. Catch per unit effort (CPUE) for each taxonomic group was calculated using the area swept. 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 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.

Table 1. 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					
Northern rockfish					
Shortraker rockfish		Sebastes sp. as a group			
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

Data from the catch-in-areas (CIA) observer database were used to model fishes caught in commercial catches during the non-summer seasons. Data from observed catches were combined across years for analysis. Presence of species in catches was used for MaxEnt (presence-only) models where the number of presence observations for a species exceeded 50. For most species, the distribution of catches was dependent on the distribution of fishing activity. This caveat should be considered when comparing to fishery-independent data.

2.1.2 Habitat-related data

Independent habitat-related data used for modeling included the standard suite of habitat variables typically collected on the bottom trawl surveys, as well as some derived and modeled variables. The suite of habitat variables is fully described in Appendix A.

These new models and new maps may 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 outlined below were provided to stock authors for their review and comment.

2.2 EFH review steps

The following steps have been used to complete and document this EFH review:

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 Scientific and Statistical Committee (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 were 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.

New data were also used to develop new models to assess the effects of fishing on EFH (§11). 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. 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 new methods and criteria are being developed and will be available to the Council in December 2016.

The NMFS Alaska Regional Office, Habitat Conservation Division (HCD) developed and contracted work to update non-fishing activities that may adversely affect EFH (§12). This analysis is presented to the Council at this meeting, including new EFH conservation recommendations where appropriate.

2.2.1 EFH review next steps

If the Council decides that revisions to EFH definitions are necessary, changes to FMP text and appendices would be required. Those changes would be made with all appropriate analyses. Staff would use information from published and unpublished scientific literature or scientific data, as directed in the EFH Final Rule, assuming information meets acceptable standards of scientific review. If the Council determines that revisions to EFH descriptions are not necessary for one or more FMPs, then the existing definitions of EFH will remain as the legal descriptions.

Table **2**, below, shows a description and estimated timeline for review of each of the ten EFH components listed in the FMPs.

Table **3** presents a potential timeline for revising EFH in the Council's FMPs.

Table 2. Proposed tasks for revisions to EFH descriptions in the Council's Fishery Management Plans

EFH FMP Component	Plan For Review	Timeline
1. EFH descriptions and identification	Identify and evaluate new scientific literature and other information. Develop model-based EFH definitions. Stock assessment authors review models and outputs.	Complete.
2. Fishing activities that may affect EFH	Update fishing effects model. SSC review model and sample output.	SSC reviewed model in April 2016, new evaluation criteria in December 2016. Stock authors complete review in January 2016
3. Non MSA fishing activities that may affect EFH	Review changes to halibut and State water fisheries	Review if Council initiates FMP amendment
4. Non-fishing activities that may affect EFT	Contractor update non-fishing effects model.	Review at Council in December 2016
5. Cumulative impacts analysis	Review cumulative impacts analysis discussion in FMPs	Review if Council initiates FMP amendment
6. EFH conservation and enhancement recommendations	Review EFH recommendations for fishing and non-fishing activities and evaluate against new information to determine whether updates are warranted	Review after Council decision
7. Prey species list and locations	Review information on prey species and determine whether updates are warranted	
8. HAPC identification	Council determine whether to initiate a new call for HAPC proposals	Council discretion
9. Research and information needs	Identify research necessary to fill gaps in EFH knowledge	Ongoing

Table 3. Proposed timeline for amendments to redefine EFH in the Council's FMPs.

April 2016	Council meeting	Preliminary EFH Review 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	Council meeting	Review non-fishing effects at SSC, Ecosystem Committee, Advisory Panel and Council Review stock authors assessment of comprehensive map of EFH requested in April 2016 SSC review proposed Fishing Effects analysis methods and criteria
October 2016 – April 2017		Pending Council decision to revise EFH definitions, 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	Special joint GPT/CPT meeting	Plan Teams review proposed FMP amendments, if necessary Plan Teams review Fishing Effects results
April 2017	Council meeting	Review of FMP amendments and Fishing Effects results

2.2.2 EFH revisions

At the April 2016 meeting, the Council reviewed the new models to describe Essential Fish habitat and their outputs. The Council requested that stock authors review a single, comprehensive map of EFH for each species or age class. 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 Ecosystem Committtee (ECO), the Council may choose to revise EFH definitions in the Council's FMPs at the October 2016 meeting. Any changes to EFH descriptions in the FMPs will be accomplished with the appropriate analyses and process.

The EFH text description represents the legal description of EFH for each managed species. The Council's FMPs, must also include a map of EFH for each species. It is these descriptions that the agency uses to determine whether activities are likely to have detrimental impacts on 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. Comments from the stock assessment authors on the comprehensive map and description will be provided to the ECO, SSC, and AP for their review and comment before they are presented to the Council.

2.2.3 Adverse effects on EFH from fishing or non-fishing activities

The 2005 EFH EIS and 2010 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 review, the Council has taken management actions that may have changed the distribution or intensity of fishing.

For the 2016 review, the NMFS Alaska Region and academic contractors have developed a new model, based on a model applied in the northeast US, to assess the potential effects of federally-permitted fishing on EFH. The fishing effects model and sample outputs were reviewed by the SSC, ECO, AP, and Council at the April 2016 meeting. In April, the SSC approved the model and noted that new data may allow for a better assessment of effects. The SSC requested that new methods and criteria be developed to evaluate the effects of fishing on EFH. The proposed methods and criteria will be presented at the December 2016 Council meeting. If approved by the Council, the stock assessment authors will use the new methods and criteria in their assessment of fishing effects on EFH.

The 2005 EF EIS and 2010 review also examined the effects of non-fishing activities on EFH, and included a list of conservation recommendations designed to mitigate a range of activities that may have adverse impacts on EFH including: oil and gas exploration and development; vessel groundings damaging living habitats; spill of toxic substances (e.g., oil spill); introduction of exotic species; depositional fill; marine dredging; mineral extraction; and waste water discharges. For this review, non-fishing activities are again updated. This review 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.

2.2.4 EFH conservation and enhancement recommendations

Habitat conservation and enhancement recommendations address fishing and non-fishing threats to EFH and HAPCs. As part of the 2005 and 2010 EFH evaluations, the Council adopted a number of mitigation measures in the fisheries to provide additional protection to EFH. These measures were implemented in 2005, and include the designation of EFH habitat conservation areas and HAPC habitat conservation zones in the Gulf of Alaska and the Aleutian Islands. Additionally, in 2003 habitat conservation areas were implemented in the Bering Sea and in October 2009 the Council adopted a gear modification for the Bering Sea non-pelagic trawl flatfish fishery to reduce adverse impact to bottom habitats. Since 2010 additional HAPCs have been identified (see §3.1) and modifications to gear have been required (see §3.2) to reduce bottom habitat impacts.

EFH consultations occur for non-fishing activities that may adversely affect EFH. NMFS HCD conducts fishery resource reviews of all 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. NMFS AKR, annually, 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.

2.2.5 Habitat Areas of Particular Concern – HAPC

Essential Fish Habitat provisions provide a means for the Council to identify Habitat Areas of Particular concern (HAPC). HAPCs are areas of EFH that are rare, and may be ecologically important or sensitive to disturbance, and may require additional protections to prevent adverse impacts. 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. In 2010 the Council chose to align the HAPC process with the EFH 5-year review cycle. The HAPC process is initiated by Council action to establish priorities for HAPC consideration. The Council will issue a call for HAPC proposals, which 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. Proposals that meet the Council's priorities are reviewed for scientific and socioeconomic merit, and enforcement potential. After review, the Council identifies proposals for further public review and potential HAPC designation. A map of existing HAPC locations and the corresponding fishery management applications, including regulations, is available at https://alaskafisheries.noaa.gov/sites/default/files/hapc_ak.pdf.

3 Habitat-related FMP amendments since 2010 EFH review

A number of habitat-related FMP amendments have been put into place since the 2010 EFH review, although not all of them have dealt specifically with EFH.

3.1 Skate Habitat Areas of Particular Concern

In April 2010, the Council established skate nursery areas as a habitat priority type in conjunction with the 2010 EFH review, citing their rarity in the Bering Sea and important ecological function. The Alaska Fisheries Science Center (AFSC), then, presented a proposal in October 2010 specifying six, known locations of relatively high concentrations of skate eggs for several species of skates in the Bering Sea. After following established protocols, the Council initiated an analysis to amend the BSAI groundfish FMP to identify the six areas proposed by the AFSC as HAPC.

Amendment 104 to the BSAI groundfish FMP designated six areas with a total area of roughly 82 nm^2 of the Bering Sea with high concentrations of skate eggs as HAPCs and defined the boundaries of each area. There are no fishing restrictions associated with the Bering Sea skate HAPCs. While there may be as-yet-unknown concentrations of skate eggs in Alaskan waters, the Council only considered the six locations specified in the October 2010 proposal from the AFSC.

3.2 Gear modifications, Northern Bering Sea Research Area, St. Matthew Island Habitat Conservation Area

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 groundfish FMP, and additional blue king crab habitat conservation measures were taken as a joint amendment package for the BSAI groundfish FMP and BSAI king and tanner crab FMP.

3.3 Marmot Bay Tanner Crab Protection Area

Amendment 89 to the GOA GMP created the Marmot Bay Tanner Crab Protection Area in February 2014. This action prohibited directed fishing for groundfish using trawl gear year-round within the Marot Bay Area, with the exception of directed fishing for pollock using pelagic trawl gear. Amendment 89 also contained a provision to modify nonpelagic trawl gear used in the Central GOA directed flatfish fishery and revised technical specifications for the modified nonpelagic trawl gear in the BSAI flatfish fisheries.

4 Habitat Research

A general summary of EFH research undertaken by NOAA Fisheries follows. Importantly, these studies serve to compliment and augment existing AFSC research and their platforms.

4.1 NOAA Fisheries EFH Research

The NOAA Fisheries Alaska Regional Office (AKRO) coordinates the Alaska EFH Research Plan (Plan) with the AFSC to directly fund research in support of EFH management needs. Specifically, the Plan is used to forecast, coordinate, and fund fisheries research in response to emerging fisheries management needs. With the re-authorization of the MSA in 1996, an agreement was made between the AKRO and AFSC that foresaw that for EFH to be successful; 1) a coordinated effort was needed; 2) regional EFH allocations need to fund EFH research directly; and 3) EFH research projects address management needs. Subsequently, the AKRO and AFSC formulated a mechanism to better align scientific rationales and EFH.

The AFSC Habitat and Ecological Processes Research (HEPR) program develops scientific research that supports implementation of an ecosystem approach to fishery management. The HEPR program focuses on integrated studies that combine scientific capabilities and create comprehensive research on habitat and ecological processes. EFH research projects are tracked for completeness and a peer-reviewed literature bibliography is maintained at the HEPR website (http://www.afsc.noaa.gov/HEPR/efh.htm).

The Plan is revised every 5 years to update science priorities. Individual projects are funded through an internally-vetted, annual request for proposals (RFP). Proposals must be responsive to the Plan and its five priorities (below). Additionally, science and policy managers meet annually to identify any emerging priorities, and pressing issues.

EFH Research Priority Themes:

- Characterize habitat utilization and productivity; increase the level of information available to describe and identify EFH; apply information from EFH studies at regional scales;

- Assess sensitivity, impact, and recovery of disturbed benthic habitat;
- Validate and improve habitat impacts model; begin to develop geographic-based database for offshore habitat data;
- Map the seafloor ; and
- Assess coastal and marine habitats facing development.

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.

Since 2006, EFH directed and ARKO discretionary funds have contributed to more than 75 research projects totaling over $4.0M (Figure 1). The next 5-10 years of EFH research will be guided by findings in this Review and conceptualized in the upcoming 2017-2022 EFH Research Plan.

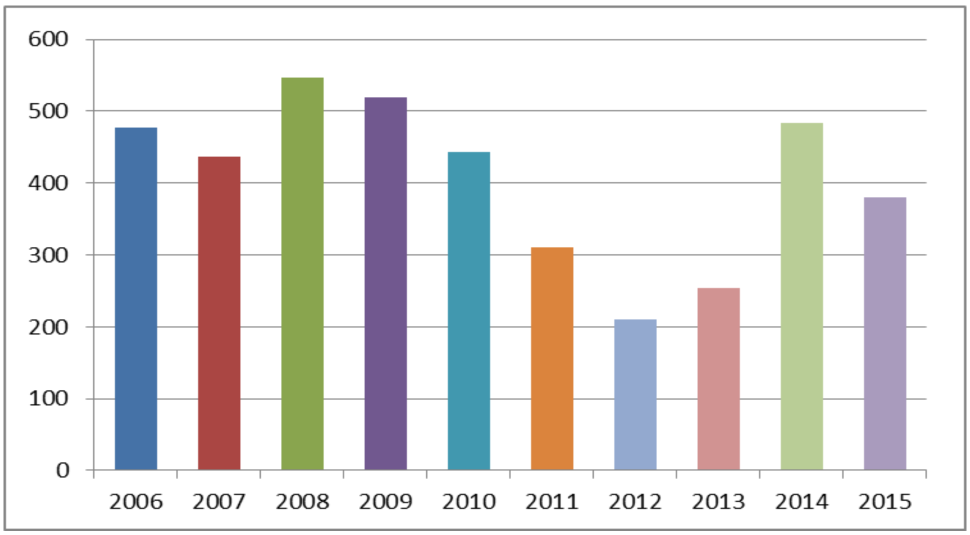

Figure 1. Essential Fish Habitat research allocations since 2006. In $ thousands.

5 EFH Descriptions for BSAI Groundfish species

Table 4 lists the species and species complexes for which EFH is currently identified in the BSAI Groundfish FMP. Essential Fish Habitat has not been defined for sharks, octopus, and the forage fish complex.

Table 4. Species and life history stages of BSAI groundfish with EFH descriptions

Species	Life history stages with EFH descriptions
Walleye pollock	Eggs, larvae, late juveniles/adults
Pacific cod	Larvae, late juveniles/adults
Sablefish	Larvae, late juveniles/adults
Yellowfin sole	Late juveniles/adults
Greenland turbot	Eggs, larvae, late juveniles/adults
Arrowtooth flounder	Late juveniles/adults
Kamchatka flounder	Late juveniles/adults
Northern rock sole	Larvae, late juveniles/adults
Alaska plaice	Eggs, late juveniles/adults
Rex sole	Late juveniles/adults
Dover sole	Late juveniles/adults
Flathead sole	Eggs, larvae, late juveniles/adults
Rockfish	Larvae
Pacific ocean perch	Late juveniles/adults
Northern rockfish	Adults
Shortraker rockfish	Adults
Blackspotted and rougheye rockfish	Late juveniles/adults
Dusky rockfish	Adults
Thornyhead rockfish	Late juveniles/adults
Atka mackerel	Eggs, larvae, adults
Squid species	Late juveniles/adults
Skates	Eggs, adults

Each stock assessment author was asked to review the current FMP text describing EFH for species or species complex for which they have responsibility. Authors were asked to review EFH text descriptions, level of EFH information (see §1), habitat information, and the list of literature. Authors suggested necessary changes and updates, if appropriate, for each life history stage and to suggest any information or literature available since the 2010 revision that should be included in the EFH description. Authors were also asked to review and update, if appropriate, the habitat association tables from the FMP. Finally, authors were asked to review the current maps of EFH in the FMP and compare them to the new maps produced from the models described in section 2.1 and conclude whether existing maps adequately depict EFH for their species, or whether updated maps better represented EFH. In some cases, existing maps are not available, or management has changed such that existing maps were inappropriate (e.g., species managed as complex rather than single species). In those cases, authors were asked to make that notation and make a recommendation to change EFH descriptions or maps. A summary of responses from the stock authors follows:

5.1 Pollock

- Minor updates to EFH description for Early Juveniles
- Minor updates life history and general distribution
- Updates to Literature
- Recommends use of updated maps to represent EFH
- Suggests Level 2 designation for pollock eggs, juveniles, and adults

5.2 Pacific cod

- Substantial changes to all life history stages of EFH description
- Substantial changes to EFH habitat information description
- Updates to literature
- Major changes to habitat association tables
- Recommends use of updated maps to represent EFH

5.3 Sablefish

- Substantive changes to EFH description for Larvae, no changes for other life history stages
- Substantive changes to EFH habitat information description for all life history stages
- Updates to literature
- No changes to habitat association tables
- Recommends use of updated map showing 25-50% predicted habitat to describe EFH

5.4 Yellowfin sole

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

5.5 *Greenland Turbot*

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

5.6 *Arrowtooth flounder*

- No changes to EFH description
- Minor changes 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

5.7 *Kamchatka flounder*

- No changes to EFH definition
- Changes to habitat association tables
- Recommends use of updated maps to represent EFH
- Recommends remain at Level 1

5.8 *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

5.9 *Alaska plaice*

- Updated EFH definition for larvae life stage
- Minor changes 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 remain at Level 1

5.10 *Rex sole*

- No changes to EFH definitions
- 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

5.11 *Dover sole*

- NO changes to EFH definitions
- 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

5.12 *Flathead sole*

- No changes to EFH definitions
- Minor change to life history and general distribution
- No changes to habitat and biological association table
- Update to literature
- Changes to habitat association tables
- Recommends use of updated maps to represent EFH

5.13 *Pacific Ocean perch*

- Minor changes to EFH definitions
- Changes to life history and general distribution
- Changes to habitat and biological associations text and table
- Updates to literature
- Changes to habitat association tables
- Recommends use of updated maps to represent EFH

5.14 *Northern rockfish*

- Minor changes to EFH definitions
- Changes to life history and general distribution
- Changes to habitat and biological associations text and table
- Updates to literature
- Changes to habitat association tables
- Recommends use of updated maps to represent EFH

5.15 *Shortraker rockfish*

- No changes to EFH definitions
- 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

5.16 *Blackspotted and rougheye rockfish*

- Changes to EFH definitions for larvae and adult life history stages
- Minor changes 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

5.17 *Dusky rockfish*

- No changes to EFH definitions
- Minor changes 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

5.18 *Thornyhead rockfish*

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

5.19 *Atka mackerel*

- Changes to EFH definition for eggs, larvae, late juvenile, and adult life history stages
- Major changes to life history and general distribution
- Major changes 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 2 for Atka mackerel adults, other levels remain the same

5.20 *Squid species*

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

5.21 *Skates*

- NO changes to EFH definitions
- Major changes to life history and general distribution
- Changes to relevant trophic information
- Changes to habitat and biological associations

- Updates to literature
- Changes to habitat association tables
- Recommends use of updated maps to represent EFH

5.22 *Sculpins*

- No changes to EFH definitions.
- No changes to life history and general distribution
- 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

Essential Fish Habitat is not currently defined for the following species and species groups.

5.23 Sharks

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

5.24 Octopus

- No changes to EFH definitions recommended. EFH remains undefined
- Major changes to life history and general distribution
- No changes to habitat and biological associations
- Updates to literature
- No changes to habitat association tables
- Recommends use of updated maps to represent EFH

5.25 Forage fish complex

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

5.26 Grenadiers

- Authors identified proposed EFH
- Added to habitat associations tables

At the April 2016 meeting, the Council requested that the stock assessment authors review a single, comprehensive map that depicted the total extent of EFH for each species, age class, or complex on an annual (rather than seasonal) basis as a graphic description of EFH. Single maps were prepared by NOAA AKR, HCD and AFSC staff and provided to the stock assessment authors in late April. Stock assessment authors reviewed the maps in May 2016, and all approved the single maps as comprehensive geographical depictions of EFH for their respective species. The proposed EFH maps for BSAI groundfish species are attached as Appendix D.

6 EFH Descriptions for GOA Groundfish species

Table 5 lists the species and species complexes for which EFH is currently identified in the GOA Groundfish FMP.

Table 5. Species and life history stages of GOA groundfish with EFH descriptions

Species	Life history stages with EFH descriptions
Walleye pollock	Eggs, larvae, late juveniles/adults
Pacific cod	Larvae, late juveniles/adults
Sablefish	Larvae, late juveniles/adults
Yellowfin sole	Late juveniles/adults
Northern rock sole	Larvae, late juveniles/adults
Southern rock sole	Larvae, late juveniles/adults
Alaska plaice	Eggs, larvae, late juveniles/adults
Rex sole	Eggs, larvae, late juveniles/adults
Dover sole	Eggs, larvae, late juveniles/adults
Flathead sole	Eggs, larvae, late juveniles/adults
Arrowtooth flounder	Larvae, late juveniles/adults
Pacific ocean perch	Late juveniles/adults
Northern rockfish	Larvae, late juveniles/adults
Shortraker rockfish	Larvae, late juveniles/adults
Blackspotted and rougheye rockfish	Larvae, late juveniles/adults
Dusky rockfish	Larvae, adults
Yelloweye rockfish	Larvae, juveniles/adults
Thornyhead rockfish	Larvae, late juveniles/adults
Atka mackerel	Eggs, larvae, adults
Squid species	Late juveniles/adults
Skates	Adults
Sculpin species	Juveniles/adults

Each stock assessment author was asked to review the current FMP text describing EFH for species or species complex for which they have responsibility. Authors were asked to review EFH text descriptions, level of EFH information (see §1), habitat information, and the list of literature. Authors suggested necessary changes and updates, if appropriate, for each life history stage and to suggest any information or literature available since the 2010 revision that should be included in the EFH description. Authors were also asked to review and update, if appropriate, the habitat association tables from the FMP. Finally, authors were asked to review the current maps of EFH in the FMP and compare them to the new maps produced from the models described in section 2.1 and conclude whether existing maps adequately depict

EFH for their species, or whether updated maps better represented EFH. In some cases, existing maps are not available, or management has changed such that existing maps were inappropriate (e.g., species managed as complex rather than single species). In those cases, authors were asked to make that notation and make a recommendation to change EFH descriptions or maps.

What follows is a summary of responses from the stock authors.

6.1 Pollock

- Changes to EFH definition for early juveniles
- Minor changes to life history and general distribution
- Updates to literature
- Recommends use of MaxEnt maps to describe EFH, with suggestions for edits

6.2 Pacific cod

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

6.3 Sablefish

- Change to the table showing essential fish habitat information levels currently available for GOA groundfish
- Changes to EFH definitions for eggs, larvae, early juveniles, late juveniles, and adults
- Major changes to life history and general distribution
- Major changes to relevant trophic information
- Changes to habitat and biological associations
- Updated literature
- Changes to habitat association tables
- Recommend use of MaxEnt maps to describe juvenile stage EFH, with 25% cutoff
- Recommend use of updated maps to describe adult stage EFH, integrated and include longline survey
- Recommend downgrade egg lifestage to “insufficient”, upgrade Early Juveniles to Level 1, Late juveniles to Level 2, adults to Level 2

6.4 Yellowfin sole

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

6.5 Southern rock sole

- Minor changes to life history and general distribution

- Minor changes to habitat and biological associations
- Updated literature
- Recommend use of updated maps to describe EFH

6.6 Alaska plaice

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

6.7 Rex sole

- Change to the table showing essential fish habitat information levels currently available for GOA groundfish
- Minor changes to life history and general distribution
- Updated literature
- Recommend use of updated maps to describe EFH

6.8 Dover sole

- Change to the table showing essential fish habitat information levels currently available for GOA groundfish, by life history stage
- Minor changes to life history and general distribution
- Updated literature
- Recommend use of updated maps to describe EFH

6.9 Flathead sole

- Change to the table showing essential fish habitat information levels currently available for GOA groundfish
- Reference for natural mortality rate used in recent stock assessments was updated
- Recommend use of updated maps to describe EFH

6.10 Arrowtooth flounder

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

6.11 Pacific Ocean perch

- Change to the table showing essential fish habitat information levels currently available for GOA groundfish
- Changes to EFH definitions for eggs, larvae, and early juveniles
- Changes to life history and general distribution
- Changes to relevant trophic information

- Changes to habitat and biological associations
- Updated literature
- Recommend use of updated maps to describe EFH

6.12 Northern rockfish

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

6.13 Shortraker rockfish

- No changes
- Changes to habitat association tables
- Recommend use of updated maps to describe EFH

6.14 Blackspotted and rougheye rockfish

- Change to the table showing essential fish habitat information levels currently available for GOA groundfish
- Changes to EFH definitions for larvae, late juveniles, and adults
- Minor changes to life history and general distribution
- Updated literature
- Authors recommend combining data for blackspotted and rougheye rockfish to create EFH maps for the complex rather than individual species maps
- Combining species data may allow elevation to Level 2

6.15 Dusky rockfish

- Updated table showing EFH information levels currently available for GOA groundfish
- Changes to EFH definitions for eggs and late juveniles
- Minor changes to introduction of section
- Minor changes to relevant trophic information
- Minor changes to habitat and biological associations
- Updated literature
- Changes to habitat association tables
- Recommend use of updated maps to describe EFH
- Recommend using data other than trawl data
- Recommend remain at Level 1

6.16 Yelloweye rockfish

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

6.17 Thornyhead rockfish

- Changes to habitat association tables

6.18 Other rockfish

- Included in the table showing EFH information levels currently available for GOA groundfish
- Added EFH definitions for larvae, early & late juveniles, and adults
- Recommended including other rockfish stock complex in the EFH
    - Authors presented four alternatives for methods to describe EFH for the *Sebastes* sp. complex
- Expressed concerns over using model based EFH descriptions
- 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

6.19 Atka mackerel

- Included larvae in table showing EFH information levels currently available for GOA groundfish
- Revised EFH definitions for larvae
- Major changes to life history and general distribution
- Changes to relevant trophic information
- Changes to table for habitat and biological associations
- Updated literature
- Changes to habitat association tables
- Insufficient information to model EFH for the GOA

6.20 Squid species

- Updated scientific names
- Major changes to life history and general distribution
- Changes to relevant trophic information
- Changes to habitat and biological associations
- Updated literature
- Changes to habitat association tables

6.21 Skates

- Changed EFH definition for adults
- Changed introduction for skate complex
- Major changes to life history and general distribution
- Changes to relevant trophic information
- Changes 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

6.22 Sculpin species

- No changes

6.23 Sharks

- Updated scientific name of spiny dogfish (*Squalus suckleyi*)
- Major changes to life history and general distribution
- Changes to relevant trophic information
- Changes to habitat and biological associations
- Updated table for shark habitat and biological associations
- Updated literature
- Changes to habitat association tables
- No EFH maps
- Recommend remain at Level 1

6.24 Forage fish complex

- Updated EFH information levels currently available for GOA groundfish
- Changed EFH definition for adults
- Minor changes to life history and general distribution
- Minor changes to relevant trophic information
- Updated literature
- Changes to habitat association tables
- No maps to describe EFH

6.25 Grenadiers

- Included in the table showing EFH information levels currently available for GOA groundfish
- Included EFH definition for adults
- Added 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

6.26 Octopus

- Created habitat association tables

At the April 2016 meeting, the Council requested that the stock assessment authors review a single, comprehensive map that depicted the total extent of EFH for each species, age class, or complex on an annual (rather than seasonal) basis as a graphic description of EFH. Single maps were prepared by NOAA AKR, HCD and AFSC staff and provided to the stock assessment authors in late April. Stock assessment authors reviewed the maps in May 2016, and all approved the single maps as comprehensive geographical depictions of EFH for their respective species, with some recommendations on the models used to create those maps. The proposed EFH maps for BSAI groundfish species are attached as Appendix E.

7 EFH Descriptions for BSAI King and Tanner crab species

The BSAI king and Tanner crab FMP applies to commercial fisheries for red king crab, blue king crab, golden (or brown) king crab, Tanner crab, and snow crab.

Stock assessment authors were asked to review the current FMP text describing EFH for species or species complex for which they have responsibility. Authors were asked to review EFH text descriptions, level of EFH information (see §1), habitat information, and the list of literature. Authors suggested necessary changes and updates, if appropriate, for each life history stage and to suggest any information or literature that should be included in the EFH description. Authors were also asked to review and update, if appropriate, the habitat association tables from the FMP. Finally, authors were asked to review the current maps of EFH in the FMP and compare them to the new maps produced from the models described in section 2.1 and conclude whether existing maps adequately depict EFH for their species, or whether updated maps better represented EFH.

- Authors suggest major revisions to descriptions of habitat types, general life history, and habitat descriptions for all crab species
- Recommend use of updated maps to describe EFH
- Major revisions to habitat and biological associations
- Updates to habitat and diet tables
- Major revisions to fishery descriptions
- Major revisions to descriptions of EFH for red king crab larvae
- Major revisions to descriptions of EFH for blue king crab larvae
- Revisions to habitat association table
- Revisions to predator/prey associations table

At the April 2016 meeting, the Council requested that the stock assessment authors review a single, comprehensive map that depicted the total extent of EFH for each species, age class, or complex on an annual (rather than seasonal) basis as a graphic description of EFH. Single maps were prepared by NOAA AKR, HCD and AFSC staff and provided to the stock assessment authors in late April. Stock assessment authors reviewed the maps in May 2016, and all approved the single maps as comprehensive geographical depictions of EFH for their respective species. The proposed EFH maps for BSAI groundfish species are attached as Appendix F.

8 EFH Descriptions for Scallop FMP species

All scallop stocks off the coast of Alaska are covered under the Scallop FMP, including weathervane scallops, rock scallops, pink scallops, and spiny scallops. Only weathervane scallops are commercially harvested in Alaska, and it is the only scallop species for which EFH is described.

The chairman of the NPFMC 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 existing EFH map for weathervane scallops is attached as Appendix G.

9 EFH Descriptions for Salmon FMP species

The salmon species managed with the Salmon FMP include Chinook salmon, chum salmon, coho salmon, pink salmon, and sockeye salmon. Existing EFH was reviewed by a "review team" that consisted of scientists from the NOAA/AFSC and ADFG. As with other FMPs, the review team was asked to review EFH text descriptions, level of EFH information (see §1), habitat information, and the list of literature. Authors suggested necessary changes and updates, if appropriate, for each life history stage and to suggest any information or literature available since the 2010 revision that should be included in the EFH description. The team was also asked to review and update, if appropriate, the habitat association tables from the FMP. Finally, the team was asked to review the current maps of EFH in the FMP and compare them to the new maps produced from the models described in section 2.1 and conclude whether existing maps adequately depict EFH for their species, or whether updated maps better represented EFH.

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

The proposed EFH maps for salmon species are attached as Appendix H.

10 EFH Descriptions for Arctic FMP species

The Arctic FMP describes EFH for Arctic cod, saffron cod, and snow crab.

Each stock assessment author was asked to review the current FMP text describing EFH for species or species complex for which they have responsibility. Authors were asked to review EFH text descriptions, level of EFH information (see §1), habitat information, and the list of literature. Authors suggested necessary changes and updates, if appropriate, for each life history stage and to suggest any information or literature available since the 2010 revision that should be included in the EFH description. Authors were also asked to review and update, if appropriate, the habitat association tables from the FMP. Finally, authors were asked to review the current maps of EFH in the FMP and compare them to the new maps produced from the models described in section 2.1 and conclude whether existing maps adequately depict EFH for their species, or whether updated maps better represented EFH. In some cases, existing maps are not available, or management has changed such that existing maps were inappropriate (e.g., species managed as complex rather than single species). In those cases, authors were asked to make that notation and make a recommendation to change EFH descriptions or maps.

What follows is a summary of responses from the stock authors.

- 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
- No changes to maps
- Created and revised habitat association tables for Arctic species

The existing EFH maps and text descriptions for Arctic species are attached as Appendix I.

11 Fishing effects on EFH

11.1 Fishing effects modeling

The 2005/2010 EFH EIS 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. The specific index, termed 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). Distributions of LEIs for each class of habitat feature (epifaunal prey, infaunal prey, biological structures, and physical structures) 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.

During the 2015 EFH cycle, the NPFMC 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 25km^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. For example, an impact rate can be defined as 25% habitat disturbed per month.
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 with VMS-Obs-UnObs-Lines (provided by Analytical Team, NOAA Fisheries Alaska Region) to use the best available spatial data of fishing locations. The CIA database provides line segments representing locations of individual tows or other bottom contact fishing activities. The LEI model in comparison, used endpoint only representations of fishing activity. The use of the CIA database provides more accurate allocation of fishing effort among grid cells.
4. The FE model incorporates the extensive literature review conducted by the New England Fisheries Management Council (NEFMC 2011) to estimate susceptibility and recovery dynamics. A consequence of this change is that the FE model splits habitat into 26 unique features rather than the four of the LEI model. Typical outputs of the FE model will average over all 26 features, or aggregate them into Biological or Geological features. However, the FE model is designed to be flexible to produce output based on any single habitat feature or unique combination of features.

11.1.1 Fishing Effects Vulnerability Assessment

In previous EFH EIS 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. A summary section discusses whether those changes might substantially affect our perception of the effects of fishing on EFH for Alaska managed species.

For the 2015 EFH EIS review, we have incorporated a more empirical literature review method to assess the effects of fishing on habitat. This vulnerability assessment and associated literature review was developed over an approximately two-year period by members of the New England Fishery Management Council's Habitat Plan Development Team while developing the Swept Areas Seabed Impacts (SASI) model and has since been modified for use in the North Pacific. The assessment serves two related purposes: (1) a review of the habitat impacts literature relevant to fishing gears and seabed types, and (2) a framework for organizing and generating quantitative susceptibility and recovery parameters for use in the SASI model. The vulnerability assessment only considers adverse (vs. positive) effects and effects on habitat associated with the seabed (vs. the seabed and the water column). This bounding does not preclude the possibility of positive impacts from fishing on seabed structures or fauna, nor is it intended to indicate that the water column is not influential habitat for fish. The former is possible, and the latter is likely. However, as per the EFH Final Rule, only adverse effects are considered and, because fishing gears do not substantively alter the water column, effects from fishing on the pelagic water column are assumed to be negligible.

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 SASI model outputs can be conducted to better evaluate the vulnerability of a particular species' essential habitat components to fishing gear effects.

Contact and vulnerability-adjusted area swept, a proxy for the degree of adverse effect, is calculated by conditioning a nominal area swept value, indexed across units of fishing effort and primary gear types, by the nature of the fishing gear impact, the susceptibility of benthic habitats likely to be impacted, and the time required for those habitats to return to their pre-impact functional value. The various components of the SASI approach fit together as described in NEFMC (2011).

11.1.2 Gear impacts literature review

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. 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 by each study. In addition to identifying gear types and features, the database included fields to code 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 a form (Figure 2).

Most studies were read and coded by a single team member initially, and then the coding was reviewed by one or more additional team members at a later time. The database is intended to serve as a legacy product, so some features are coded but not used in the current analysis. The long-term intention is to create new records in the database as additional gear impacts studies are published. Tables 1 and 2 contain examples of gear-specific susceptibility and recovery scores.

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.

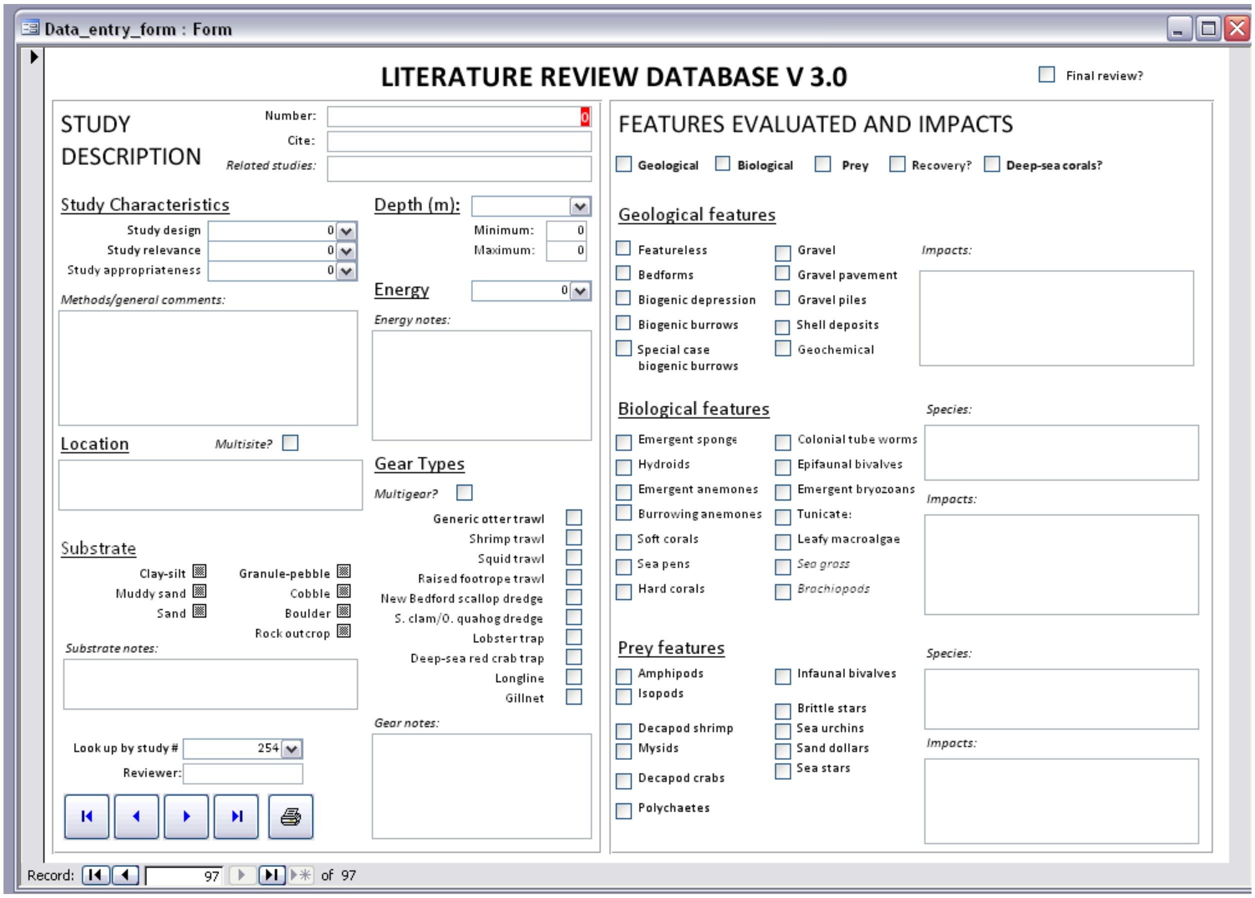

Figure 2. Literature review database form. Data field descriptions provided in NEFMC (2011).

11.1.3 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 EIS 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 26 habitat features which can be grouped into biological or geological features. These 26 habitat features were drawn from the literature review describe 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 spatial 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.

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. Thus, each point was attributed as present or absent for each sediment category. We then used an indicator Kriging algorithm (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. We set a probability threshold of 0.5 to indicate presence/absence of each sediment category. Thus, 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, we used the sediment proportions from the nearest 5 km grid cell.

11.1.3 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 $\bullet$ 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, $\phi_{i,s}$, 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 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.

11.2 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,

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

11.3 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.

11.4 Recovery

Recovery, ρ'_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,

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

$\boldsymbol{\rho_s}$ 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 he 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.

11.5 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 of 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, $\mathbf{Bin}(n, 1/N)$, 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 $\boldsymbol{n}$ 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 $\boldsymbol{X_i}$ 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 (Fig. 1). 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.

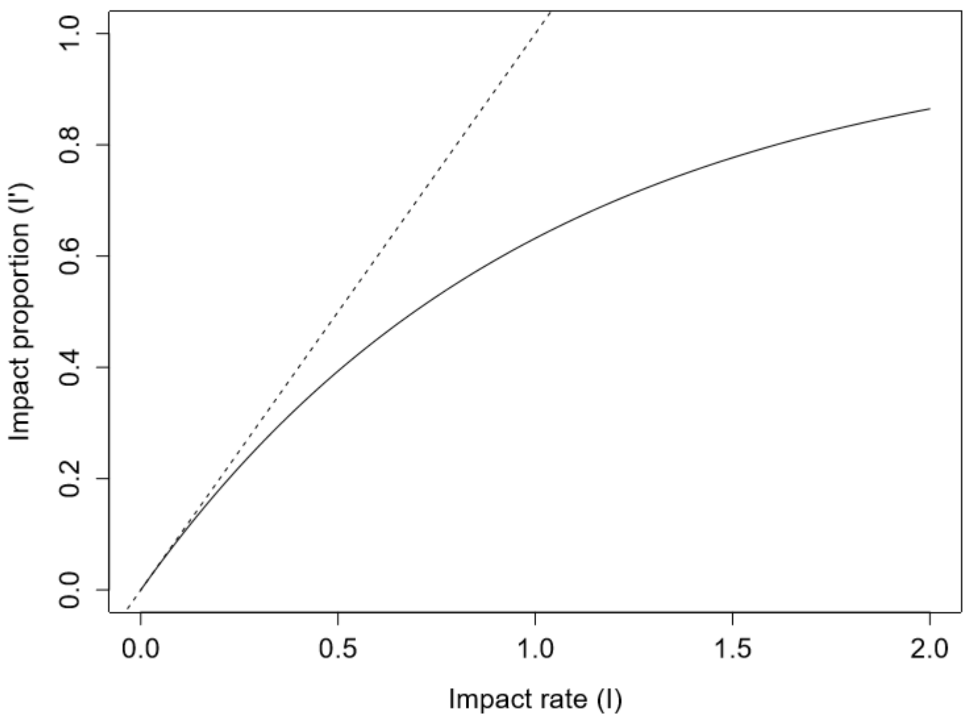

Figure 3. Comparison of I′ to I. The 1:1 relationship is represented by the dashed line. I' and I values remain relatively similar to about 0.2 before they begin to diverge. This represents the fact that as more total fishing occurs in a region, there is a higher probability that the fishing activities will overlap thus decreasing the proportion of area impacted relative to fishing effort.

11.6 Calculation of fishing effort

Fishing effort, f_g is calculated for each cell, month, and gear type using the CIA data set. The CIA data set 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 (Table 5): 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.

11.6.1 Recommended conclusions about the impact of new information on the effects of fishing analysis

Previous EFH analyses, as well as a review by the Center for Independent Experts in 2004, 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 are being developed and will be reviewed by the Council in December, 2017 for potential implementation in January – February, 2017.

12 Non-fishing effects on EFH

12.1 Background

Non-fishing activities that may adversely affect EFH are diverse[1]. Example activities include harbor construction, navigation channel dredging, fill for near shore development and infrastructure, oil and gas exploration and production facilities, shoreline stabilization, exotic species introduction, and fish processing waste-water. The NOAA Fisheries Alaska Region Habitat Conservation Division staff (HCD) is charged with reviewing non-fishing activities and offers EFH Conservation Recommendations by activity type, as appropriate. HCD bi-annually informs the Council of actions that may be of concern for their review. These are generally large scale projects that may impact a Council-regulated fishery, or are politically or economically controversial.

12.2 Review Approach and Summary of Findings

The review of non-fishing activities focused on 2005 EFH EIS Appendix G and the 2010 EFH Review document *Non-fishing Activities that May Adversely Affect EFH*. These documents evaluated the impact of non-fishing activities on EFH and identified EFH conservation and enhancement recommendations by activity type. An abbreviated summary has been included in each of the Council's FMPs. This review evaluates impacts to EFH from wetlands, through estuaries, and into marine waters. Updates also include an ocean acidification and climate change discussion. The non-fishing activity effects analysis is attached as Appendix F. For each activity, staff reviewed the potential for adverse impacts to EFH. If potential for EFH existed, staff recommended conservation measures designed to avoid, minimize, or compensate for those adverse effects.

12.3 Conclusions

A review by NMFS HCD provides new information and new conservation recommendations for consideration. Updates to this section provide the Council, Federal agencies, the public, and other NMFS staff a starting point to assess whether non-fishing actions may adversely affect EFH and ways to avoid, minimize, or mitigate for any effects. This document will be regularly updated and made available to the public online.

[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 affects on fish habitat is extensive. Appendix G 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].

12.4 New Direction and Future Considerations

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 application to assess these types of actions for more areas facing human-induced activities, such as Lower Cook Inlet, the Arctic, or SE Alaska. A major consideration not to be overlooked is cost and dedication to selecting assessments for major community areas or those areas facing large scale development.

13 HAPC recommendations

Habitat areas of particular concern (HAPCs) are areas within essential fish habitat (EFH) that may require additional protection from adverse effects. The EFH guidelines provide that HAPCs may be identified as specific types or areas of habitat within EFH, based on one or more of the following four considerations:

1. The importance of the ecological function provided by the habitat.
2. The extent to which the habitat is sensitive to human-induced environmental degradation.
3. Whether, and to what extent, development activities are, or will be, stressing the habitat type.
4. The rarity of the habitat type.

For application under the NPFMC HAPC Process, HAPCs must meet at least two of the four HAPC considerations above, including rarity of the habitat type.

The Council formally revised its approach to designate HAPCs by adopting a site-based approach in 2005. A 2010 HAPC Process document (https://alaskafisheries.noaa.gov/sites/default/files/hapc_process092010_0.pdf) details how the Council identifies priorities and initiates a public call for HAPC nominations. Proposed sites are reviewed by the Plan Teams and staff for ecological merit, socioeconomic, management, and enforcement impacts. Unique to this review is a Data Certainty Factor (DCF) calculation to notify analysts of data availability. More simply, since the HAPC Process calls for public and science involvement, the DCF allows a pubic idea to be supplemented with best available science. In this manner, a HAPC could be identified by the public, science, or management. Based on this combined review, the Council may advance various HAPC proposals for further analysis. The Council may then design specific management measures, if needed, for each HAPC.

A map of existing HAPC locations and corresponding fishery management applications, including regulations, is at https://alaskafisheries.noaa.gov/sites/default/files/hapc_ak.pdf
No new HAPC's are being considered at this time. The Council, at its discretion, can choose to initiate the HAPC process at any time.

14 Conclusions and Council action

The 2016 review of EFH in the Council's FMPs has been completed and is documented in this summary report. An analysis of the effects of non-fishing activities on EFH will be provided to the Council in December 2016, and analysis of the effects of fishing on EFH can be provided on either the current definitions of EFH, or new definitions should the Council choose to redefine EFH based on the most recent information. At this point, the Council's primary decision is to determine whether, based on the information presented in this report, revisions to any of the Council's FMPs are warranted. Any revisions would require FMP amendments and the requisite analyses to comply with NEPA and RFA requirements and EO 12866. The Council could also, at this point, consider whether to initiate a new HAPC proposal cycle and identify priorities and initiate a call for proposals for specific sites for HAPC nomination. The questions before the Council at this meeting can be summarized as follows:

1. Are revisions to EFH definitions in any of the Council's FMPs warranted?
2. Is there a need to identify HAPC priorities and initiate a call for proposals for candidate HAPC sites?
3. Does the Council wish to identify new priorities for EFH research for the next five years?

Upcoming decisions for the Council include:

1. Is a new evaluate of the effects of fishing activities on EFH necessary?
2. Are new management measures to avoid adverse effects of fishing on EFH necessary?

Table 6, below, summarizes information presented in this report to facilitate the Council's decisions.

Table 6. Summary of recommendations from stock authors and review of information available to redefine EFH in the Council's FMPs

EFH component	Council FMP	Recommendations and information
EFH descriptions of individual species or complexes	BSAI Groundfish	• **Amendments are recommended for all species or complexes** • **All stock authors recommended use of updated maps to describe EFH**
	GOA Groundfish	• **Amendments are recommended for all species or complexes except for sculpins** • **All stock authors recommend use of updated maps to describe EFH except for sculpins** • **Recommendations to combine some species into complexes to describe EFH** • **New information available to describe EFH for species for which EFH has not been described**
	BSAI Crab	• **Amendments are recommended for all species or complexes** • **Revisions to habitat and biological associations** • **Recommend use of updated maps to describe EFH**
	Scallop	• **No changes to EFH are warranted**
	Salmon	• **Amendments recommended for all species or complexes** • **Recommend use of updated maps to describe EFH**
	Arctic	• **Amended descriptions for Arctic and saffron cod eggs and larvae** • **Amended distribution of Arctic and saffron cod** • **No changes to existing maps**

		• **New habitat association tables for Arctic species**
Fishing activities that may adversely affect EFH	All Council FMPs	• **Updated fishing effects (FE) model available to describe impact rates and recovery rates over specific spatial and temporal scales** • **New method to evaluate effects of fishing on EFH proposed by SSC**
Non-fishing activities that may adversely affect EFH	All Council FMPs	• **Report available in December 2016** • **Update at Council discretion**
HAPC identification	Potentially all Council FMPs	• **Update at Council discretion**
Research and information needs	Potentially all FMPs	• **Research priority objectives from 2010 have largely been met** • **Update at Council discretion**

15 Preparers

15.1 Preparation of document

Steve A. MacLean – Council staff
Matt Eagleton – NOAA AKR HCD
John V. Olson – NOAA AKR HCD

15.2 Review of groundfish species EFH

Coordinated by Sandra Lowe, Dan Ito, Phil Rigby, Jon Heifetz
Reviews by Steve Barbeaux, Liz Conners, Martin Dorn, Angie Greig, Dana Hanselman, Jim Ianelli, Libby Logerwell, Susanne McDermott, Carey McGillard, Chris Lundsford, Sandy Neidetcher, Olav Ormseth, Kim Rand, Cara Rodgeveller, Kalei Shotwell, Paul Spencer, Ingred Spies, William Stockhausen, Grant Thompson, Jack Turnock, Cindy Tribuzio, Tom Wilderbuer

15.3 Review of crab species EFH

Coordinated by Robert Foy
Reviews by Chris Long, Doug Pengilly, Lou Rugolo, Kathy Swiney, Jack Turnock, Jie Zheng, Matt Eagleton,

15.4 Review of scallop species EFH

Quin Smith – ADF&G Commercial Fisheries, Chairman NPFMC Scallop Plan Team

15.5 Review of salmon species EFH

Ed Farley, Andrew Grey, Joe Orsi, John Joyce, Matt Eagleton

15.6 Review of fishing effects

Bradley Harris, John V. Olson, Scott Smeltz, Craig Rose, Suresh Sethi

15.7 Review of non-fishing effects

Doug Limpinsel, Matt Eagleton, Jeanne Hanson. Also, Erika Ammann, Sean Egan, Charelene Felkley, Cindy Hartmann-Moore, Seanbob Kelly, Linda Shaw, Susan Walker, Amy Whit (Azura lead)

15.8 EFH Workgroup

Name	Agency	Title
Matthew Eagleton	NMFS / HCD	EFH Coordinator
Steve MacLean	NPFMC	Council Coordinator
John Olson	NMFS / HCD	EFH Analytical Expert
Mike Sigler	NMFS / AFSC	HEPR Program Leader BSAI Plan Team
Dan Ito	NMFS / AFSC	Deputy Division Chief, REFM
Jim Ianelli	NMFS / AFSC	GOA Plan Team Chair
Dana Hanselman Grant Thompson	NMFS / AFSC	BSAI Plan Team Co-Chairs
Brad Harris Suresh Sethi Craig Rose Scott Smeltz	Alaska Pacific University	Fishing Effects Model Authors
Chris Rooper Jodi Pirtle	NMFS / AFSC	EFH Description Model Authors
Gretchen Harrington	NMFS / NEPA	NEPA Coordinator
Brandee Gerke	NMFS / SF	SF Analyst
Jon Heifetz	NMFS / AFSC	GOA Plan Team
Ed Farley	NMFS / AFSC	Pacific Salmon
Robert Foy	NMFS / AFSC	BSAI Crab Team GOA Groundfish Plan Team
Bradley Harris	Alaska Pacific University	Scallop Plan Team
Libby LogerwelL	NMFS / AFSC	Arctic
John Lepore	NOAA GC	General Counsel

16 References

Echave, K., M. Eagleton, E. Farley, and J. Orsi. 2012. A refined description of essential fish habitat for Pacific salmon within the U.S. Exclusive Economic Zone in Alaska. U.S. De. Commer., NOAA Tech. Memo. NMFS-AFSC-236, 104 p.

Laman, E.A., C.N. Rooper, S. Rooney, K. Turner, D. Cooper, and M. Zimmerman. 2015. Model-based Essential Fish Habitat Definitions or Eastern Bering Sea Groundfish Species. U.S. Dep. Commer., NOAA Tech Memo. NMFS-AFSC-XXXX, XXp.

National Marine Fisheries Service (NMFS), 2005. Final Environmental Impact Statement for Essential Fish Habitat Identification and Conservation in Alaska. March 2005. NMFS PO Box 21668, Juneau, AK 99801

New England Fishery Management Council (NEFMC) 2011. The Swept Area Seabed Impact (SASI) approach: a tool for analyzing the effects of fishing on essential fish habitat. New England Fishery Management Council report. Newburyport, MA.

North Pacific Fishery Management Council (NPFMC). 2010. Essential Fish Habitat (EFH) 5-year Review for 2010. Final Summary Report. Anchorage, AK

Rooney, S., K. Turner, E.A. Laman, C.N. Rooper, D. Cooper, and M. Zimmerman. 2015. Model-based Essential Fish Habitat definitions for Gulf of Alaska Groundfish Species. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-XXX, XXX p.

Turner, K., C.N. Rooper, S. Rooney, E. Laman, D. Cooper, and M. Zimmerman. 2015. Model-based Essential Fish Habitat Definitions for Aleutian Islands Groundfish Species. U.S. Dp. Commer., NOAA Tech. Memo. NMFS-AFSC-XXX, XXX p.

Zador, S. (ed). 2015. Ecosystem Considerations 2015 Status of Alaska's Marine Ecosystems. NOAA, AFSC, REFM. Seattle, WA.