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Essential Fish Habitat 5-year Review Final Summary Report

North Pacific 2023 Essential Fish Habitat 5-year Review

NOAA FISHERIES

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North Pacific 2023 Essential Fish Habitat 5-year Review

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Executive Summary

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

Federal regulations require that Councils and NMFS should review the EFH provisions of FMPs at least once every 5 years, and revise or amend EFH provisions as warranted based on best available science. All EFH components are evaluated in an EFH review and some components are emphasized, based on advances in information available to evaluate and, as a result, meaningfully update the FMPs. The 2023 EFH 5-year Review builds on the work from the previous EFH review, including the EFH roadmap, iterative review process, and using species distribution models to map EFH and the fishing effects model in the evaluation of fishing gear impacts to EFH.

In February 2023, NMFS provided the North Pacific Fishery Management Council (Council) with the draft summary report and supporting documents presenting new and best available science and information identified in the 2023 review. Based on this information, the Council initiated an analysis to amend the EFH provisions of five FMPs under review. In December 2023, the Council received the draft 2023 EFH 5-year Review Environmental Assessment and Omnibus EFH Amendments package and recommended final action to amend the FMPs. The Notice of Decision approving the EFH Amendments was published in July 2024.

This final summary report presents information that NMFS and Council staff developed to inform the Council's recommendation to revise the EFH provisions of five FMPs as a result of the 2023 EFH 5-year Review. We describe the process of the 2023 EFH 5-year Review, discuss each of the EFH components in detail, and provide an overview of revisions to the EFH information. Additional comprehensive analysis is provided in accompanying publications that focus on the new analysis conducted for EFH descriptions and identification, fishing effects to EFH, and non-fishing impacts to EFH.

The EFH regulations, EFH review process, and resulting science and information advancements, are vital to assist the Council and NMFS to conserve and enhance EFH, promote the long-term health of North Pacific marine ecosystems, and support sustainable fisheries and our Nation's economy.

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1 2023 EFH 5-year Review Process

The Magnuson-Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act) includes provisions concerning the identification and conservation of essential fish habitat (EFH). The Magnuson-Stevens Act (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 regional Fishery Management Councils (Councils) must describe and identify EFH in Fishery Management Plans (FMPs), minimize to the extent practicable the adverse effects of fishing on EFH, and identify other actions to encourage the conservation and enhancement of EFH. Federal agencies that authorize, fund, or undertake actions that may adversely affect EFH must consult with NMFS, and NMFS must provide conservation recommendations to federal and state agencies regarding actions that would adversely affect EFH. Councils also have the authority to comment on federal or state agency actions that would adversely affect the habitat, including EFH, of managed species.

Section 303(a)(7) of the MSA requires that FMPs describe and identify EFH based on the guidelines established by the Secretary of Commerce under section 305(b)(1)(A) of the MSA. NMFS established guidelines in Federal regulations at 50 CFR 600 Subparts J and K. Federal regulations at 50 CFR 600.815 require that each FMP contains the following ten EFH components:

1. Description and identification of EFH
2. Fishing activities that may adversely affect EFH
3. Non-Magnuson-Stevens Act fishing activities that may adversely affect EFH
4. Non-fishing activities that may adversely affect EFH
5. Cumulative impacts analysis
6. Conservation and enhancement
7. Prey species
8. Identification of habitat areas of particular concern (HAPC)
9. Research and information needs
10. Review and revision of EFH components of FMPs

To guide the review of EFH every 5 years, Federal regulations at 50 CFR 600.815(a)(10) state:

> *Councils and NMFS should periodically review the EFH provisions of FMPs and revise or amend EFH provisions as warranted based on available information. FMPs should outline the procedures the Council will follow to review and update EFH information. The review of information should include, but not be limited to, evaluating published scientific literature and unpublished scientific reports; soliciting information from interested parties; and searching for previously unavailable or inaccessible data. Council should report on their review of EFH information as part of the Annual Stock Assessment and Fishery Evaluation (SAFE) report prepared pursuant to §600.315(e). A complete review of all EFH information should be conducted as recommended by the Secretary, but at least once every 5 years.*

The 2023 EFH 5-year Review is the third review of EFH information in the FMPs by the NMFS and North Pacific Fishery Management Council (Council). Prior EFH 5-year reviews were completed in 2012, and 2018, where the objective is to evaluate and synthesize new information for each component, and determine whether changes to the FMPs are warranted. NMFS and the Council considered all EFH components for each FMP following the Council's EFH roadmap, including individual species EFH descriptions and identification, EFH conservation and enhancement recommendations for fishing and non-fishing effects on EFH, and identification of HAPCs. At the conclusion of an EFH 5-year review, a summary report is prepared that describes the review process and the results of review for all EFH components the Council elects to review and revise.

This final report is a summary of the process and information that NMFS and Council staff developed to inform the Council's recommendation to revise the EFH provisions of five FMPs as a result of the 2023 EFH 5-year Review. In the following chapters, we describe the 2023 EFH 5-year Review and discuss the EFH components in detail with an overview of revisions to the EFH information. Additional comprehensive analysis is provided in accompanying publications that focus on the new analysis conducted for EFH descriptions and identification, fishing effects to EFH, and non-fishing impacts to EFH.

As with the previous reviews, the 2023 review evaluates all EFH components in the Council's FMPs with respect to new information. The EFH review is primarily conducted by NMFS and Council staff using new information available since the completion of the previous review. Staff use information from published or unpublished scientific literature or scientific data and analytical methods that meet acceptable standards of scientific review, as directed in Federal regulations. Staff also noted, as part of this review, unpublished studies that are currently underway or under review, which may provide further insight on EFH in the future.

The Council's role with respect to the EFH review is to receive a draft summary report on the EFH review and decide whether any of the new information highlighted in the review warrants change to management (i.e., FMP amendments). Any change to the FMP text, no matter how minor, requires an FMP amendment. If, after reviewing the draft summary report, the Council chooses to update any EFH components in its FMPs, FMP amendments are prepared along with the appropriate analytical documents. The level of analysis (environmental assessment (EA), environmental impact statement (EIS), categorical exclusion (CE)) that is required to support the amendment(s) will vary depending on the impacts of the change. The 2005 EFH EIS (NMFS 2005) provided a comprehensive discussion of EFH in five FMPs. An EA was prepared for the 2012 and 2018 Omnibus EFH Amendment packages.

In February 2023, the Council received the draft summary report and supporting documents presenting the new and best available science and information identified in the 2023 EFH 5-year Review.[1] Based on this information, the Council initiated an analysis (EA) to incorporate the advancements in EFH information in five of the six FMPs under review.[2] In December 2023, the Council received the draft 2023 EFH Review EA and Omnibus EFH Amendments package and took final action to recommended that NMFS "[a]mend the Council's FMPs to incorporate the updated EFH information based on the new and best available science and information identified in the 2023 EFH 5-year Review"[3]. NMFS finalized the EA for the proposed amendments and issued its Notice of Availability in April 2024, providing additional

[1] C4 EFH 5-year Review, February 2023 https://meetings.npfmc.org/Meeting/Details/2975
[2] Council Motion, C4 EFH 5-year Review, February 2023 https://meetings.npfmc.org/Meeting/Details/2975
[3] Council Motion, C5 EFH FMP Amendments, December 2023 https://meetings.npfmc.org/Meeting/Details/3019

opportunity for public comment. NMFS published its Notice of Agency Decision in July 2024, approving the amendments, and responding to comments received (89 FR 58632, 7/19/2024).

The 2023 EFH 5-year Review builds on the work from the 2017 EFH 5-year Review, including the EFH roadmap, review process, and using species distribution models to map EFH and the Fishing Effects (FE) model in the evaluation of fishing effects to EFH. In this review, we evaluated new environmental and habitat data, improved the models to map EFH, updated the model to evaluate fisheries impacts on EFH, updated the assessment of non-fishing impacts on EFH, considered whether additional EFH conservation and enhancement measures were warranted, and assessed information gaps and research needs.

The following steps were used to complete and document the 2023 EFH 5-year Review (see Table 1 for more detail):

1. Evaluated new information available since the last EFH review and reviewed the text in the Council's six FMPs relating to the ten EFH components. Noted areas where changes to the EFH components may be warranted.
2. Conducted the analytical work to improve the components with new information.
3. Comprehensive review of the new information and analysis. Stock assessment authors were lead reviewers for the species which they assess, were provided the opportunity to review new analytical work for the EFH descriptions and identification (maps), and then conducted the EFH fishing effects evaluation. Other components were reviewed by NMFS Habitat Conservation Division (HCD) staff, or other qualified NMFS, Council, Alaska Department of Fish and Game (ADF&G), or other experts.
4. Consulted with the Plan Teams with respect to the stock assessment authors' review of EFH descriptions and maps, and fishing effects to EFH, as appropriate. Plan Teams were invited to provide recommendations to the Scientific and Statistical Committee (SSC) and the Council as to whether the individual species reviews were accurate and complete, and whether the available new information warranted revisions to EFH text in the FMPs. Plan Teams also had the opportunity to recommend to the Council additional management measures to conserve and enhance EFH.
5. Three comprehensive documents were developed to inform this EFH review and were available on the Council agenda for the February 2023 meeting[4]. These documents were subsequently published as National Oceanic and Atmospheric Administration (NOAA) Technical Memoranda:
    - Synthesis Report: Advancing Essential Fish Habitat Component 1 Descriptions and Maps for North Pacific Species (Pirtle et al. 2025)
    - 2022 Evaluation of Fishing Effects on Essential Fish Habitat (Zaleski et al. 2024)
    - Impacts to Essential Fish Habitat from Non-Fishing Activities in Alaska (Limpinsel et al. 2023)
6. In addition, for EFH component 1, descriptions and identification, four documents were developed, including three NOAA Technical Memoranda, that describe the EFH mapping

[4] C4 EFH 5-year Review, February 2023 https://meetings.npfmc.org/Meeting/Details/2975

methods, results, and the new maps available for the BSAI, GOA, Crab, and Arctic FMPs. These documents informed this EFH review and were available on the Council agenda for the February 2023 meeting[5]:

- Bering Sea Advancing Model-based EFH (Laman et al. 2022)
- Aleutian Islands Advancing Model-based EFH (Harris et al. 2022)
- Gulf of Alaska Advancing Model-based EFH (Pirtle et al. 2023)
- Arctic Advancing Model-based EFH (Marsh et al. 2023)

7. Prepared a draft EFH review summary report for the Council, including recommendations of whether changes to the FMPs are warranted. The draft 2023 EFH 5-year Review summary report was available on the Council agenda for the February 2023 meeting. Contents of the draft summary report included:
    a. Review of EFH components, documenting how the review was conducted, new information available relating to each component compared to the information that was currently in the FMP.
    b. Recommendations of possible changes to the EFH components in the FMPs under review.
8. Following this EFH review and the Council's decision to initiate FMP amendments[6], prepared amendments and any associated analysis to update EFH components in FMPs.
9. Prepared a final EFH review summary report.

Table 1. 2023 EFH 5-year Review timeline, major milestones, and supporting documents.

Date	Participants	Milestone
April 2019	Ecosystem Committee, Council	NMFS presented the EFH 5-year Review Proposed Approach (B2 EFH 2022 5-Year Review Approach).
April 2020	Council (*canceled*)	Review the EFH 5-year Review Proposed Approach and identify EFH components for potential revision (Proposed Approach to Reviewing EFH for the 2022 EFH 5-Year Review).
June 2020	Scientific and Statistical Committee (SSC)	NMFS presented a progress report on the EFH **component 1** species distribution model (SDM) approach to map EFH and provided an opportunity to engage, inform, and receive input from the SSC at this stage of the EFH review (D3 EFH Discussion Paper on Advancing EFH Descriptions and Maps for the 2022 5-year Review).
September 2020	Joint Groundfish Plan Teams	NMFS presented a progress report on the EFH **component 1** SDM approach (EFH presentation - Advancing EFH Habitat Descriptions and Maps for the 2022 5-year Review).
January 2021	Stock Assessment Authors	NMFS met with groundfish and crab stock assessment authors to explain the tools in development to provide new EFH information for their stocks for **components 1 and 7** and their role in reviewing this new information.
April 2021	Council, SSC	NMFS presented the planning document for the EFH 5-year review (originally scheduled April 2020) (B3 2022 Essential Fish Habitat 5-Year Review Plan).

[5] C4 EFH 5-year Review, February 2023 https://meetings.npfmc.org/Meeting/Details/2975
[6] Council Motion, C4 EFH 5-year Review, February 2023 https://meetings.npfmc.org/Meeting/Details/2975

Date	Participants	Milestone
May-Sept 2021	Stock Assessment Authors	Review of EFH **component 1** SDM methods and draft EFH maps, recommend updates to EFH maps, text descriptions, and other species' EFH information (e.g., **component 7** prey tables) in the FMPs.
September 2021	Joint Groundfish Plan Teams	NMFS presented a progress report on the EFH **component 1** SDM results, draft EFH maps, preliminary results from the Stock Assessment Author Review of this information, and an Introduction to EFH **component 2** fishing effects (Presentation to the Joint Groundfish Plan Team).
January 2022 & May 2022	Crab Plan Team	NMFS presented a progress report on the EFH **component 1** SDM results, draft EFH maps, preliminary results from the Stock Assessment Author Review of this information, and an Introduction to EFH **component 2** fishing effects (Component 1 Presentation, Component 2 Presentation). Launch the Fishing Effects (FE) Evaluation process for crab EFH (Presentation).
Jan 2022	Ecosystem Committee	NMFS presented an update on EFH **component 1** SDMs developed to map EFH and the EFH **component 2** FE model to evaluate fishing effects (Component 1 Presentation, Component 2 Presentation).
February 2022	SSC	NMFS presented the EFH **component 1** SDM models, draft EFH maps, and results of the Stock Assessment Author Review of this information, and the EFH **component 2** FE model proposed approach to initiate the FE evaluation process (SDM EFH Discussion Paper, Report of Stock Author Review of EFH Components 1 and 7, and Fishing Effects on EFH Discussion Paper).
April - July 2022	Stock Assessment Authors	Review FE model results and conduct the FE evaluation.
Sep 2022	Crab/Joint Groundfish Plan Teams	NMFS and Council staff presented the results of the FE evaluation and a supplemental analysis for the SDM models and EFH maps (Presentation to the Crab Plan Team and Presentation to the Joint Groundfish Plan Teams)
Oct 2022	Ecosystem Committee, SSC	NMFS and Council staff presented the results of the FE evaluation and a supplemental analysis for the SDM models and EFH maps (2022 Evaluation of Fishing Effects on Essential Fish Habitat, and Supplemental Analysis for the species distribution model ensemble EFH maps for the 2022 5-year Review)
February 2023	Council	Review draft 2023 EFH 5-year Review Summary Report with proposed updates to EFH components and, if appropriate*, initiate an analysis to amend the FMP EFH provisions (C4 EFH 5-year Review Summary Report). *Council initiated an analysis to amend the FMPs with new EFH information from the 2023 EFH 5-year Review (Council Motion).
Feb-September 2023	Council staff, NMFS Alaska Region (AKR)	NEPA analyses for potential FMP amendments.
October 2023	Council (*postponed*)	Initial Review of EFH FMP amendment analysis.
December 2023	Council	Initial Review of, and, if appropriate*, Final Action on EFH FMP amendments (C5 EFH FMP Amendments). *Council recommended final action to amend the FMPs with new EFH information from the 2023 EFH 5-year Review (Council Motion).
April 2024	NMFS AKR	Finalize the EA for the proposed amendments and issue Notice of Availability, providing additional opportunity for public comment.
July 2024	NMFS AKR	Publish Notice of Agency Decision, approving the amendments, and responding to comments received (89 FR 58632, 7/19/2024).

1.1 EFH in the Fishery Management Plans

The Council has EFH provisions to address the ten components in all six FMPs[7]:

- Groundfish of the Bering Sea and Aleutian Islands Management Area (BSAI FMP, NPFMC 2024a)
  - Sections 3.4, 3.5, and 4.2
  - Appendices D, E, F, and H
- Groundfish of the Gulf of Alaska (GOA FMP, NPFMC 2024b)
  - Section 3.4, 3.5, and 4.2
  - Appendices D, E, F, and H
- Bering Sea/Aleutian Islands King and Tanner Crabs (Crab FMP, NPFMC 2024c)
  - Section 8.1.6
  - Appendix F
- Fish Resources of the Arctic (Arctic FMP, NPFMC 2024d)
  - Chapter 4
  - Appendices A, B, C, D, E, and F
- Salmon Fisheries in the EEZ off Alaska (Salmon FMP, NPFMC 2024e)
  - Chapter 6
  - Appendix A
- Scallop Fishery off Alaska (Scallop FMP, NPFMC 2024f)
  - Section 4.6
  - Appendix D

1.2 History of EFH in Alaska

In 1998, the Council first amended five of its FMPs (BSAI, GOA, Crab, Salmon, and Scallop FMPs) (Table 2), following amendments made to the MSA to include EFH. The Council described EFH for its FMPs in 1999 with an EA that also outlined human-induced effects on EFH. In 2000, a legal challenge of the EFH provisions nation-wide resulted in a reevaluation of EFH information by all Councils. In 2005, the NMFS Alaska Region (AKR) and Council completed a more comprehensive EFH description and effects analysis in an EIS (2005 EFH EIS, NMFS 2005). Three EFH 5-year Reviews have been completed since the 2005 EFH EIS. This section describes the history of EFH in Alaska.

In 1999, a coalition of seven environmental groups and two fishermen's associations filed suit in the United States District Court for the District of Columbia to challenge NMFS' approval of EFH FMP amendments prepared by the Gulf of Mexico, Caribbean, New England, North Pacific, and Pacific Fishery Management Councils (American Oceans Campaign [AOC] et al. v. Daley et al., Civil Action No. 99-982-GK). The focus of the AOC v. Daley litigation was whether NMFS and the Council had adequately evaluated the effects of fishing on EFH and taken appropriate measures to mitigate adverse effects. In September 2000, the court upheld NMFS' approval of the EFH amendments under the MSA, but ruled that the EAs prepared for

[7] https://www.npfmc.org/library/fmps-feps/

the amendments violated the National Environmental Policy Act (NEPA). The court ordered NMFS to complete new and thorough NEPA analyses for each EFH amendment in question.

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

1. Describing and identifying EFH for fisheries managed by the Council.
2. Adopting an approach for the Council to identify HAPCs within EFH.
3. Minimizing to the extent practicable the adverse effects of Council-managed fishing on EFH.

The Council used an extensive public process to develop the alternatives for the 2005 EFH EIS, including numerous public meetings of the Council and its EFH Committee. The analysis indicated that there are long-term effects of fishing on benthic habitat features off Alaska, and acknowledged that considerable scientific uncertainty remains regarding the consequences of such habitat changes for the sustained productivity of managed species. Nevertheless, based on the best available scientific information, the EIS concluded that the effects on EFH are minimal because the analysis found no indication that continued fishing activities at the current rate and intensity would alter the capacity of EFH to support healthy populations of managed species over the long term. The analysis concluded that no Council-managed fishing activities have more than minimal and temporary adverse effects on EFH, which is the regulatory standard, in Federal regulations at 50 CFR 600.815(a)(2)(ii), to address the statutory requirement to minimize adverse effects to EFH under section 303(a)(7) of the MSA. Importantly, the Council initiated a variety of practicable management actions and precautionary measures to conserve and protect EFH.

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

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

It can be difficult to assess the impacts of changes to available habitat, whether due to fishing pressure, non-fishing anthropogenic activities, or the effects of changing climate or physical conditions, because the linkages between habitat preferences and abundance of managed species are largely unknown. The analyses of any new amendments initiated by the Council rely heavily on the 2005 EFH EIS, where these unknowns were discussed and characterized. This has been accomplished through subsequent EAs incorporating the 2005 EFH EIS by reference.

Each EFH 5-year review is a multi-year process. The Council and NMFS usually start the 5-year review process before the five-year period and it takes three to four years to complete due to anticipated long lead items and the Council and Secretary of Commerce approval process.

In 2010, the Council conducted its first EFH 5-year review and updated its EFH information for all FMPs. NMFS revised the EFH sections of five FMPs to address findings from the 2010 EFH Review and the EFH Omnibus Amendment package was approved in 2012. Updates included several species descriptions, changed the HAPC process to coincide with each EFH 5-year review, and revised EFH priorities. EFH descriptions were updated to include quantitative maps and text descriptions. Earlier descriptions of EFH in Alaska were identified by the Council as the distribution of species life stages and maps based on survey results and observed catch. The 2010 EFH 5-year Review focused on the following:

- Refine EFH descriptions for a small subset of managed species with new and more recent information;
- Analyze whether fishing effects may be impacting sensitive habitats of Bristol Bay red king crab, (Long-term Effects Index [LEI] model);
- Update the non-fishing impacts analysis, including advisory EFH conservation recommendations, with the most current level of information; and
- Identify skate egg deposition and recruitment sites as a habitat priority and initiate a call for proposals for candidate HAPC sites; noting that the amendment resulting from this was implemented through a separate process.[8]

In October 2012, NMFS implemented the 2010 EFH 5-year Review by approving Amendment 98 to the BSAI FMP, Amendment 90 to the GOA FMP, Amendment 40 to the Crab FMP, Amendment 15 to the Scallop FMP, and Amendment 1 to the Arctic FMP (77 FR 66564, 11/6/2012) (Table 2). Amendment 11 to the Salmon FMP occurred through separate action (77 FR 75570, 12/21/2012). The amendments revised the following EFH FMP components: (1) the EFH provisions for groundfish, crab, and scallop species or species complexes; (4) EFH conservation recommendations for non-fishing activities; (8) the timeline for considering HAPC proposals from three years to five years; and (9) the EFH research objectives. The EFH review concluded that no change to the 2005 conclusions on the evaluation of fishing effects on EFH was warranted based on a review of information from 2005 through 2010.

In 2015, the Council initiated its second review of EFH in all FMPs. The Council updated EFH information for five FMPs (83 FR 31340, 7/5/2018, Simpson et al. 2017). The following significant advancements resulted from the 2017 EFH 5-year Review:

- Introduced new data and species distribution models (SDMs) to describe and map EFH;
- Developed a new fishing effects (FE) model and updated the evaluation of fishing effects on EFH; and

[8] 80 FR 1378, 1/5/2015

- Updated the evaluation of non-fishing effects on EFH.

The SDMs developed for the 2017 Review resulted in Level 2 descriptions (habitat-related density or abundance) for some species' life stages in the BSAI, GOA, and Crab FMPs. However, most descriptions remained Level 1 descriptions (distribution), although several previously undescribed life stages of targeted species were described at Level 1 in the 2017 review. The Council also used the best available science and a new FE model to understand the effects of fishing on EFH. The Council updated the non-fishing impacts analysis, including EFH conservation recommendations, with the most recent information, including sections on ocean acidification, climate change, and ecosystem processes.

In May 2018, NMFS implemented the 2017 EFH 5-year Review by approving Amendment 115 to the BSAI FMP, Amendment 105 to the GOA FMP, Amendment 49 to the Crab FMP, Amendment 13 to the Salmon FMP, and Amendment 2 to the Arctic FMP (83 FR 31340) (Table 2). The amendments revised the following EFH FMP components: (1) the EFH provisions for groundfish, crab, salmon, and Arctic species or species complexes; (2) the FE model represents a substantial improvement from the LEI approach; and (4) EFH conservation recommendations for non-fishing activities. The EFH review concluded that no change to the 2005 conclusions on the evaluation of fishing effects on EFH was warranted based on a review of information from 2005 through 2015. While these analyses found no indication that continued fishing activities at the current rate and intensity would alter the capacity of EFH to support healthy populations of managed species over the long term, the Council has adopted, and NMFS has implemented, a number of management measures designed to reduce adverse impacts from fishing to habitat.

Table 2. History of EFH amendments to Council fishery management plans (FMPs).

Fishery Management Plan	EFH Amendment (Approval)
Groundfish of the Bering Sea and Aleutian Islands Management Area (BSAI FMP)	55 (1999), 78 (2006), 98 (2012), 104 (2015), 115 (2018)
Groundfish of the Gulf of Alaska (GOA FMP)	55 (1999), 73 (2006), 90 (2012), 105 (2018)
Bering Sea/ Aleutian Islands King and Tanner Crabs (Crab FMP)	8 (1999), 16 (2006), 40 (2012), 49 (2018)
Fish Resources of the Arctic (Arctic FMP)	1 (2012), 2 (2018), 3 (2024)
Salmon Fisheries in the EEZ off Alaska (Salmon FMP)	5 (1999), 7/8 (2006), 11 (2012), 13 (2018)
Scallop Fishery off Alaska (Scallop FMP)	5 (1999), 7/9 (2006), 15 (2012), 16 (2015)

1.3 EFH 5-year Review Roadmap

The ten EFH components are addressed in each of the Council's six FMPs. A description of the 2023 EFH 5-year Review work plan (2019) and prior review plans (2010, 2015) is included in Table 3. These plans are the strategic "roadmap" that the Council and NMFS follow for the ten EFH components in an EFH 5-year Review.

Table 3. EFH 5-year Review Roadmap for the ten EFH components of FMPs with plans launched in 2010, 2015, and 2019 (2023 Review).

EFH Component	**2010 Plan for EFH review**	**2015 Plan for EFH review**	**2019 Plan for EFH review**
1. Description and identification of EFH	Identify and evaluate new scientific literature, and information from other relevant sources, to see whether species-specific EFH description and identification, as written in the FMPs, is correct.	Identify and evaluate new scientific literature and other information. Develop new species distribution models (SDM) to create EFH maps for BSAI, GOA, and Crab FMPs. Evaluate new model-based maps for Salmon FMP and distribution maps for Arctic FMP from previous work. Plan Teams and SSC review methods. Stock assessment authors review EFH text descriptions and maps. SSC review and recommendations. If warranted, update FMPs with new information. Publish regional SDM EFH Reports.	Identify and evaluate new scientific literature and other information. Modernize the SDMs to include new ensemble methods and data to create new EFH maps for BSAI, GOA, Crab, and Arctic FMPs. Plan Teams and SSC review methods. Stock assessment authors review EFH text descriptions, models, and maps. SSC review and recommendations. If warranted, update FMPs with new information. Publish EFH Component 1 Synthesis Report and regional SDM EFH Reports.
2. Fishing activities that may adversely affect EFH	Evaluate the various inputs to the existing LEI model to compare with model inputs from 2004 (distribution of the trawl fisheries, species recovery rates, and gear changes in the fisheries that may affect habitat), in order to demonstrate whether the impacts analysis from the 2005 EIS is likely still valid, or whether it warrants revision.	Review impacts from fishing gears on EFH. Develop a new fishing effects (FE) model to update the prior LEI fishing effects model to examine impacts of fishing on habitat. SSC review FE model methods. SSC Subcommittee review and recommend EFH FE evaluation process. Stock assessment authors conduct EFH FE evaluation. SSC review and recommendations. If warranted, update FMPs with new information.	Update the FE model methods and include new data. Plan Teams and SSC review FE model methods. Stock assessment authors conduct EFH FE evaluation. SSC review and recommendations. If warranted, update FMPs with new information. Publish final EFH FE Evaluation Report.
3. Non-Magnuson-Stevens Act fishing activities that may adversely affect EFH	Review whether there have been changes in halibut and State water fisheries. Identify sources of new information that may shed light on analysis of the impact of these fishing activities.	Review changes to halibut and State water fisheries. Identify sources of new information that may shed light on analysis of the impact of these fishing activities. Review FMPs and evaluate against new information.	Review FMPs and evaluate against new information.

EFH Component	2010 Plan for EFH review	2015 Plan for EFH review	2019 Plan for EFH review
4. Non-fishing activities that may adversely affect EFH	Review whether there have been changes to non-fishing activities affecting habitat since the EFH analysis. Identify sources of new information that may shed light on analysis of the impact of non-fishing activities.	Review changes to non-fishing activities affecting EFH. Identify sources of new information that may shed light on analysis of the impact of non-fishing activities. Update EFH conservation recommendations (CRs) in the FMPs and add new sections on warming trends off Alaska, ocean acidification, and marine traffic, add a more thorough bibliography.	Review changes to non-fishing activities affecting EFH in Alaska. Identify sources of new information that may shed light on analysis of the impact of non-fishing activities. Update EFH CRs in the FMPs, including new climate-informed CRs.
5. Cumulative impacts analysis	Review cumulative impacts discussion in FMPs, and evaluate against new information.	Review cumulative impacts analysis discussion in FMPs, and evaluate against new information.	Review cumulative impacts analysis discussion in FMPs, and evaluate against new information.
6. Conservation and enhancement recommendations	Review EFH recommendations for fishing and non-fishing activities, review existing EFH conservation and enhancement measures, and evaluate against new information to determine whether updates are warranted.	Review EFH recommendations for fishing and non-fishing activities, review existing EFH conservation and enhancement measures, and evaluate against new information to determine whether updates are warranted.	Review EFH recommendations for fishing and non-fishing activities, review existing EFH conservation and enhancement measures, and evaluate against new information to determine whether updates are warranted.
7. Prey of EFH species	Review prey species information in the FMPs and evaluate against new information to determine whether updates are warranted.	Review prey species information in the FMPs and evaluate against new information to determine whether updates are warranted.	Review prey species information in the FMPs and evaluate against new information to determine whether updates are warranted.
8. Identification of habitat areas of particular concern (HAPC)	Summarize Council's progress on HAPC priorities. Based on species-specific review of EFH, stock assessment authors or Plan Teams may suggest candidate HAPC areas that could be considered by the Council in the next HAPC priority cycle.	Council determines whether to initiate a new call for HAPC proposals.	Council determines whether to initiate a new call for HAPC proposals.
9. Research and information needs	Identify research necessary to fill gaps in EFH knowledge, including recommendations.	Identify research necessary to fill gaps in EFH knowledge, including recommendations.	Identify research necessary to fill gaps in EFH knowledge, including recommendations.
10. Review and revision of EFH components of FMPs	Summary report represents EFH 5-year review.	Summary report represents EFH 5-year review.	Summary report represents EFH 5-year review.

1.4 Council Action

In February 2023, NMFS provided the Council with the draft summary report and supporting documents presenting the new and best available science and information identified in the 2023 EFH 5-year Review.[9] To complete the 2023 Review and decide if FMP amendments were warranted, the Council considered the following:

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

The Council initiated an analysis (EA) to incorporate the advancements in EFH information in five of six FMPs.[10]

In December 2023, the Council received the draft 2023 EFH Review EA and Omnibus EFH Amendments package and took final action to recommended that NMFS "[a]mend the Council's FMPs to incorporate the updated EFH information based on the new and best available science and information identified in the 2023 EFH 5-year Review"[11] (Table 4). The Council recommended the following amendments to the FMPs:

- Amendment 127 to the FMP for Groundfish of the Bering Sea and Aleutian Islands Management Area (BSAI FMP),
- Amendment 115 to the FMP for Groundfish of the Gulf of Alaska (GOA FMP),
- Amendment 56 to the FMP for Bering Sea/Aleutian Islands King and Tanner Crabs (Crab FMP),
- Amendment 3 to the FMP for Fish Resources of the Arctic Management Area (Arctic FMP), and
- Amendment 17 to the FMP for the Salmon Fisheries in the EEZ off Alaska (Salmon FMP).

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[9] C4 EFH 5-year Review, February 2023 https://meetings.npfmc.org/Meeting/Details/2975
[10] Council Motion, C4 EFH 5-year Review, February 2023 https://meetings.npfmc.org/Meeting/Details/2975
[11] Council Motion, C5 EFH FMP Amendments, December 2023 https://meetings.npfmc.org/Meeting/Details/3019

Table 4. Council action to amend FMPs based on the 2023 EFH 5-year Review.

EFH component	Council FMP	Recommended changes to the FMPs
1. Description and identification of EFH for individual species	BSAI FMP	Amend the FMP to update EFH descriptions and maps, including up to EFH Level 3 information on habitat-related vital rates. Add or revise the EFH text descriptions and add or replace the maps **for 41 species or species complexes**.
	GOA FMP	Amend the FMP to update EFH descriptions and maps, including up to EFH Level 3 information on habitat-related vital rates. Add or revise the EFH text descriptions and add or replace the maps **for 46 species or species complexes**.
	Crab FMP	Amend the FMP to update EFH descriptions and maps, including up to EFH Level 3 information on habitat-related vital rates. Add or revise the EFH text descriptions and add or replace the maps **for all five species**.
	Arctic FMP	Amend the FMP to update EFH descriptions and maps, including up to EFH Level 3 information on habitat-related vital rates. Add or revise the EFH text descriptions and add or replace the maps **for all three species**.
	Salmon FMP	Replace the distribution maps with the EFH maps **for all five species**.
2. Fishing activities that may adversely affect EFH	BSAI, GOA, and Crab FMPs	Update fishing effects (FE) information in the FMPs.
4. Non-fishing activities that may adversely affect EFH	BSAI, GOA, Crab, and Arctic FMPs	Revise the EFH appendices in the FMPs where conservation recommendations for non-fishing activities are described.
7. Prey of EFH species	BSAI, GOA, and Crab FMPs	Revise text or habitat description table information for two species of BSAI sharks, BSAI pollock, GOA Pacific cod, and BSAI red king crab.
9. Research and information needs	BSAI, GOA, Crab, and Arctic FMPs	Revise the EFH appendices with updated research and information needs.

NMFS finalized the EA for the proposed amendments and issued its Notice of Agency Decision in July 2024, responding to comments received and implementing the 2023 EFH 5-year Review by approving the amendments (89 FR 58632, 7/19/24). **In the following Chapters, we discuss the EFH components in detail with an overview of revisions to the EFH information as a result of the 2023 EFH 5-year Review.**

1.5 Ecosystem-based fisheries management approach to EFH

Ecosystem-based fisheries management (EBFM) is geographically specific, adaptive, accounting for ecosystem knowledge and uncertainties, considering multiple external influences, and striving to balance diverse societal objectives (NMFS 2024, Harvey et al. 2025), of which habitat science is a fundamental element (Peters et al. 2018). EBFM aims to maintain ecosystems in a healthy, productive, and resilient condition to support sustainable fisheries by accounting for ecosystem interactions and considerations. NMFS AKR strives for an EBFM approach to EFH, where habitat science is the foundation of consultations and information supporting EFH 5-year reviews; in turn, these habitat science advancements also support other EBFM information needs (Limpinsel et al. 2025, Pirtle et al. 2025).

- NMFS approaches the ten EFH components of FMPs from the geographic context of Alaska's five large marine ecosystems, defined by NOAA as the GOA, AI, EBS, northern Bering Sea and Chukchi Sea, and Beaufort Sea, and the fishery management areas, coastal communities, species, and habitats therein.

- The new SDM EFH component 1 maps are an improved foundation to meet our EFH mandates (Harris et al. 2024, Pirtle et al. 2025). The underlying SDMs are an advancement of habitat science that inform EBFM by supporting stock assessment (e.g., Ecosystem Socioeconomic Profiles; Shotwell et al. 2022), and understanding of how environmental variability affects habitat, recruitment, and spatial stock structure (e.g., Goldstein et al. 2020, Rooper et al. 2021, Barnes et al. 2022, Gibson et al. 2023, Goodman et al. 2024, Hart et al. 2025).
- The EFH component 2 fishing effects evaluation assesses the effects of fishing gear to EFH (Zaleski et al. 2024) and by extension is also currently used to provide an annual indicator to the Ecosystem Status Reports for the GOA, AI, and EBS[12]. An ecosystem approach to the fishing effects evaluation can be strengthened with additional research.
- The EFH component 4 Non-fishing Effects Report, supporting the consultation process for activities that may adversely affect EFH, takes an ecosystem approach in providing EFH conservation recommendations to these action agencies (Limpinsel et al. 2023). This report also includes climate-informed EFH conservation recommendations for the first time; change in ocean conditions is habitat change from a species perspective.
- Considering future directions to address EFH components 7 (prey species habitat), 5 (cumulative impacts), and 3 (non-MSA fishing effects) represent additional pathways where EFH conservation activities and habitat science have potential to improve NMFS mission effectiveness with respect to EBFM.
- EFH component 9 (research priorities) is driven by management information needs for habitat science innovations in alignment with an EBFM approach to meet the EFH mandates (Pirtle et al. 2024).
- EFH component 10 (review EFH information at least every 5-years) is a process where EFH information in the FMPs and new information is iteratively reviewed by the Council, including input from the public. As a result, the science supporting EFH information in the FMPs is current and these tools, such as SDMs and the FE model, can be applied as decision support for other EBFM information needs.[13]

2 Component 1: Descriptions and identification of EFH

Component 1 descriptions and identification of EFH consists of written summaries, tables, and maps in the FMPs and their appendices. The EFH regulations provide an approach to organize the information necessary to describe and identify EFH (50 CFR 600.815(a)(1)(iii)). When designating EFH, the Council should strive to describe and identify EFH information in the FMPs at the highest level possible (50 CFR 600.815(a)(1)(iii)(B))—

[12] NMFS Alaska Ecosystem Status Reports
[13] For example, SDMs developed by NMFS staff for Council's Bristol Bay red king crab closure areas analysis (C2, February 2024) https://meetings.npfmc.org/Meeting/Details/3029

- *Level 1:* Distribution data are available for some or all portions of the geographic range of the species.
- *Level 2:* Habitat-related densities or relative abundance of the species are available.
- *Level 3:* Growth, reproduction, or survival rates within habitats are available.
- *Level 4:* Production rates by habitat are available. [Not available at this time.]

For the 2023 EFH Review, new EFH component 1 information advances the species distribution model (SDM) EFH mapping approach of the 2017 Review and provides new and revised EFH maps (e.g., Figure 1) for the BSAI, GOA, Crab, and Arctic FMPs that include—

- New EFH Level 1, 2, and 3 descriptions and maps for life stages of groundfish in the Gulf of Alaska, Bering Sea, and Aleutian Islands, including settled early juveniles, subadults, and adults, for the GOA and BSAI FMPs.
- New EFH Level 2 and 3 descriptions and maps for up to five pelagic early life history stages of Pacific cod and sablefish in the Gulf of Alaska, including eggs, yolk-sac larvae, feeding larvae, pelagic early juveniles, and settling early juveniles for the GOA FMP.
- New EFH Level 2 descriptions and maps for life stages of crabs in the Bering Sea and Aleutian Islands, including subadults and adults combined for the Crab FMP.
- New EFH Level 1 and 3 descriptions and maps for Arctic cod, saffron cod, and snow crab life history stages, including larvae, settled early juveniles, juveniles, and adults for the Arctic FMP.

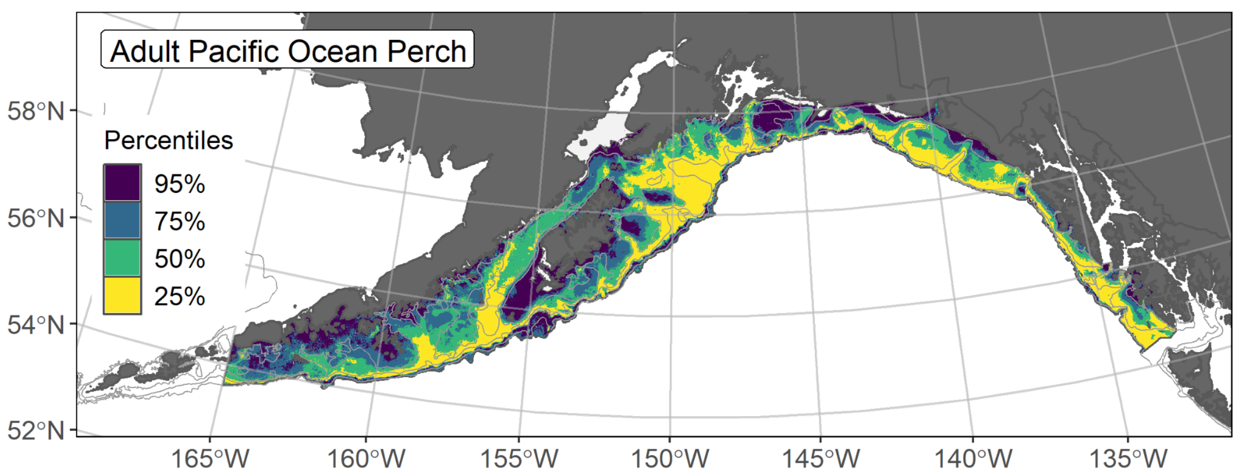

Figure 1. Essential fish habitat (EFH) map for adult Pacific ocean perch in the Gulf of Alaska. EFH is the area containing the top 95% of occupied habitat (defined as model estimated encounter probabilities greater than 5%) from an SDM ensemble fitted to adult Pacific ocean perch distribution and abundance in AFSC RACE-GAP summer bottom trawl surveys (1993–2019) with 50 m, 100 m, and 200 m isobaths indicated. Within the EFH map are the subareas of the top 25% (EFH hot spots), top 50% (core EFH area), and top 75% (principal EFH area) of habitat-related, ensemble-predicted numerical abundance.

The EFH descriptions represent the legal definitions of EFH for each target species and their life history stages and are provided in the Council's FMPs as text descriptions and maps. It is on the basis of these descriptions that evaluations are made by the agency about whether an activity is likely to impact EFH.

The studies contributing new EFH component 1 information for the 2023 Review for the BSAI, GOA, and Crab FMPs are introduced in section 2.1. Changes to the EFH descriptions available from these studies are in sections 2.4 (BSAI FMP), 2.5 (GOA FMP), and 2.6 (Crab FMP). The study contributing new EFH component 1 information for the Arctic FMP and changes to EFH descriptions from this study are in section 2.7 (Arctic FMP).

New EFH component 1 information was not developed for the Salmon and Scallop FMPs in the 2023 Review. Those FMPs are included in sections 2.8 and 2.9 to introduce recommended future directions for improving EFH information for species of salmon and scallops.

Section 2.2 summarizes the iterative review process by the stock assessment authors and other species experts, Plan Teams, Ecosystem Committee, and SSC. Section 2.3 is a summary of the new EFH component 1 information for the 2023 Review and highlights key advancements and recommended next steps. More information is available in *Synthesis Report: Advancing Model-Based Essential Fish Habitat Descriptions and Maps for North Pacific Species* (Synthesis Report, Pirtle et al. 2025), providing a synthesis of information developed for EFH component 1 leading up to the Council's February 2023 review[14]. Iterative versions of the report were presented to the Council and SSC as Discussion Papers in February 2022 and 2023, prior to publication as a NOAA Technical Memorandum.

2.1 New and revised EFH descriptions for the BSAI, GOA, and Crab FMPs

The study *Advancing Model-Based Essential Fish Habitat Descriptions for North Pacific Species* is described in detail in the Synthesis Report (Pirtle et al. 2025), a discussion paper reviewed by the Council in February 2023, and three regional NOAA Technical Memoranda (Harris et al. 2022, Laman et al. 2022, Pirtle et al. 2023). This study, hereafter referred to as ***ensemble study*** was funded by the Alaska EFH Research Plan (FY19-FY21) to refine the 2017 EFH 5-year Review SDM approach to mapping EFH for the summer distribution of groundfishes and crabs using AFSC RACE-GAP bottom trawl survey data to an SDM ensemble approach for the 2023 Review as a new foundation to mapping EFH component 1, including for additional species' life stages where currently missing. The *ensemble study* was guided by the Alaska EFH Research Plan (Sigler et al. 2017) research priority 1 to characterize habitat utilization and productivity using the best available scientific information to accomplish specific research objectives, following the 2017 EFH 5-year Review.

The *ensemble study* demonstrates a new SDM ensemble EFH approach for the 2023 EFH 5-year Review, where EFH is described and mapped for 31 North Pacific groundfish species in the Bering Sea (BS), 24 in the Aleutian Islands (AI), 41 in the GOA across up to three life stages. In addition, EFH is described and mapped for four crabs in the BS, two crabs in the AI, and one octopus in all three regions. The ensembles describing and mapping EFH in this study advance

[14] EFH Component 1 SDM EFH Discussion Paper, C4 EFH 5-year Review, February 2023 https://meetings.npfmc.org/Meeting/Details/2975

EFH information levels and refine EFH area maps for North Pacific species' life stages from none to Level 1 and from none or Level 1 to Level 2. This *ensemble study* also applies habitat-related vital rates from other studies to the SDMs to describe and map EFH Level 3 for the first time for eight species. The EFH descriptions and maps from this study comprise the bulk of new EFH component 1 information available for the 2023 EFH 5-year Review and also support the EFH component 2 fishing effects evaluation.

Their modeling strategy for the 2023 Review was to fit multiple habitat-based SDMs to fish and crab abundances, skill test among SDMs using the root-mean-square-error to indicate model performance (RMSE, Hastie et al. 2009), and incorporate the best performing models into an ensemble in R (R Core Team 2020). Ensemble models essentially average predictions across constituent models, making them more robust to overfitting and less sensitive to differences in predictive performance among constituents. For example, Rooper et al. (2017) found that ensembles performed better than the generalized linear or generalized additive models alone when predicting distributions of structure-forming invertebrates. The SDM ensemble EFH mapping approach of the 2023 EFH 5-year Review provided a universal SDM application across multiple FMPs and can be expanded to consider other constituent models in the future.

The *ensemble study's* approach to using SDM ensembles for mapping EFH is described in detail and contrasted with the SDM EFH approach of the 2017 EFH 5-year Review in the Methods section and Table 1 of the Synthesis Report (Pirtle et al. 2025) and February 2023 discussion paper[15]. Highlights from their study approach are developing several data updates and modeling refinements, introducing EFH Level 3, and advancing EFH information levels—

- Expanding the SDM approach from the 2017 5-year EFH Review to include up to five constituent SDMs in an ensemble that provides a robust modeling framework for future EFH Reviews (three SDMs were applied in 2017 and a single SDM was selected a priori for each species' life stage based on prevalence in the bottom trawl surveys).
- Refining our methodology by modeling numerical abundance instead of 4th root transformed CPUE facilitated skill testing (lowest cross-validated root mean square error; RMSE) to identify the best fitting models for inclusion and weighting in the ensemble and improved stakeholder interpretability of model results (i.e., predicting numbers of animals instead of a heavily derived abundance index).
- Incorporating new sources of species response data for the settled early juvenile life stage of groundfishes in the GOA from nearshore areas not previously modeled demonstrated for the first time that we could evaluate EFH for this critical life stage.
- Updating habitat covariates applied as independent predictors in the ensembles provided the opportunity to expand our observed temperature data set with an additional five years of AFSC RACE-GAP summer trawl survey bottom temperature observations, include recently modeled bottom temperature data from the coastal GOA regional ocean modeling system 3 km grid (applied to early juvenile SDMs only), update the GOA bathymetry and seafloor slope covariates, include additional derived seafloor terrain metrics in all regions, develop and include a seafloor rockiness metric for the AI and

[15] Methods section and Table 1 in EFH Component 1 SDM EFH Discussion Paper, C4 EFH 5-year Review, February 2023 https://meetings.npfmc.org/Meeting/Details/2975

GOA, and to incorporate the most recent substrate data in the Bering Sea.

- Enhancing existing data sets (both response and predictor variables) with the addition of five recent years of survey results from the AFSC RACE-GAP summer bottom trawl surveys (2015–2019) extended our temporal coverage in the EBS to 38 years (1982-2019), in the AI to 29 years (1991-2019), and to 27 years in the GOA (1993-2019).
- Updating length-based life stage definitions for North Pacific groundfish species in the SDM ensembles based on updated maturity schedules or life stages definitions documented in the recent scientific literature tailored our abundance predictions to the best available scientific information and increased the number of life stages we could model.
- Extending EFH to include settled early juvenile life stages allowed us to model this critical ontogenetic phase for North Pacific groundfish species in the EBS, AI, and GOA for the first time.

A total of 224 new and revised EFH descriptions and maps for the BSAI, GOA, and Crab FMPs are available for the 2023 EFH 5-year Review—

- New EFH Level 1 descriptions and maps for settled early juvenile life stages in the GOA FMP (11).
- New and revised EFH Level 2 descriptions and maps for the BSAI (114), GOA (75), and Crab (6) FMPs (195).
- New EFH Level 2 descriptions and maps for stock complexes as a proxy for member species where a model was not possible at this time for the BSAI (6) and GOA (4) FMPs (10).
- New EFH Level 3 descriptions maps for settled early juvenile life stages for the BSAI (2) and GOA (6) FMPs (8).

In comparing the 2017 SDMs and 2023 SDM ensembles, it is apparent that the type of model used in 2017 had a large effect on the performance metrics and calculated EFH areas (Pirtle et al. 2025, February 2023 Discussion Paper[16]). In the majority of cases, the performance metrics from the 2023 ensembles demonstrated clear improvements over the 2017 SDMs. The 2023 ensemble showed improvements—

- Lowest cross-validated root mean square error (RMSE) in 88% of models.
- Spearman's correlation (ρ) in 69% of models.
- Area under the receiver operating characteristic curve (AUC) in 52% of models.
- Poisson deviance explained (PDE) in 99% of models.
- In other cases, where clear improvement was not observed, the difference between the models was usually small, and in no instance was a decline observed across all metrics.

[16] Results Synthesis section and Appendix SDM Results Summaries in EFH Component 1 SDM EFH Discussion Paper, C4 EFH 5-year Review, February 2023 https://meetings.npfmc.org/Meeting/Details/2975

- Approximately 25% of ensembles in the present work predicted EFH areas larger by 100% or more; in almost all of these cases the 2017 SDM was hGAM.
- Approximately 18% of ensembles resulted in EFH areas that were smaller by at least half; in each of these cases the 2017 SDM was a MaxEnt model.

The SDM ensemble EFH mapping approach for the 2023 EFH 5-year Review provides several advantages. Certain classes of SDMs have tendencies to over- or under-predict distribution and abundance (i.e., MaxEnt and hGAM). Ensemble modeling essentially averages the predictions from multiple, best-performing constituent SDMs, which can provide abundance predictions that are more representative of habitat-related distribution and abundance than those produced by single SDMs in isolation. Due to the effect of moving from mapping EFH using single SDMs in 2017 to SDM ensembles in 2023, and barring large methods changes in future EFH mapping efforts, we expect that changes in future EFH maps should be less attributable to the underlying mapping methods so that changes in species distribution due to the environment or other impacts may be more easily detected.

In completing this body of work, and through the 2023 EFH 5-year Review process, they identified refinements and recommendations that could be considered for future EFH 5-year reviews. A Future Recommendations section is included in the Synthesis Report (Pirtle et al. 2025) and in each regional NOAA Technical Memorandum published by this study (Harris et al. 2022, Laman et al. 2022, Pirtle et al. 2023), which provides more detailed descriptions of the research and collaborative pathways the EFH component 1 analysts are recommending. These recommendations are summarized in greater details in the EFH Research Priorities section of this report (section 10.6).

This body of work is a significant advancement of the SDM approach for mapping EFH in the BSAI and GOA compared to the methods used in the 2017 EFH 5-year Review. In the present 5-year Review, EFH descriptions and maps are advanced for many groundfish and crab species in the BSAI and GOA, including new and revised EFH Level 1 and 2, and for the first time EFH Level 3 information. The ensemble approach applied here was an innovation over the 2017 EFH 5-year Review approach and, along with the other data and modeling refinements described, will provide a robust and flexible framework for the development of EFH descriptions and maps for future EFH 5-year Reviews. In addition, the ensembles described here provide valuable information that can be extended to stock assessment and other EBFM information needs in our region.

The *ensemble study* produced three NOAA Technical Memoranda detailing the regional methods, results, and future research and process recommendations (Harris et al. 2022, Laman et al. 2022, Pirtle et al. 2023). A manuscript, *Ensemble models mitigate bias in area occupied from commonly used species distribution models* (Harris et al. 2024), is a helpful contribution to the rapidly developing field of SDMs with applications to EFH and EBFM. It is a priority of NMFS to make available the SDM ensemble EFH code used to develop the new summer distribution EFH maps in the 2023 Review so that our methods are transparent, repeatable, and available to all stakeholders. EFH analysts have developed the Alaska Groundfish Essential Fish Habitat repository that is available on GitHub: https://github.com/alaska-groundfish-efh. Regular updates to this repository keep the R code (R Core Team 2020) and documentation current, as staff have subsequently developed SDMs using these methods as decision support for other Council actions[17].

2.1.1 GOA FMP pelagic early life history stages

A separate study *Developing a Novel Approach to Estimate Habitat-Related Survival Rates for Early Life History Stages using Individual-Based Models*, funded by the Alaska EFH Research Plan in FY18 and FY19 developed a novel approach to estimate habitat-related distribution, density, and survival rates for early life history stages of Pacific cod and sablefish, using individual-based models (IBMs) (hereafter, *IBM EFH study*).

The Alaska EFH Research Plan describes two pathways to advance to EFH Level 3 including, 1) using pre-existing vital rates, or 2) conducting additional laboratory and/or field studies to develop the required information (Sigler et al. 2017). Because the first option only currently exists for certain species and the second option can be very time-consuming and expensive, it is reasonable to consider alternative methods to describe and map EFH Level 3. This is particularly true for the pelagic early life history stages (PELS: eggs, larvae, pelagic early juveniles, and settling early juveniles), where limited survey data are available for most species to develop SDM EFH information and maps. IBM trajectory analysis can also identify pathways of connectivity between offshore pelagic ELHS and nursery habitats on the continental shelf, including locations where settlement may be more likely to occur and where it may not, which can refine EFH maps for settled early juvenile life stages of species with this life history strategy (e.g., Goldstein et al. 2021, Gibson et al. 2023).

SDM EFH Level 1 information was developed for the PELS of North Pacific groundfish species for the 2017 5-year Review (e.g., Laman et al. 2018). The *IBM EFH study* has developed a novel application of biophysical life-stage integrated IBMs to advance EFH information for PELS from Level 1 to Level 2 and Level 3, through case studies of Pacific cod and sablefish in the GOA Management Area, informed by spawning locations and a settled early juvenile stage SDM.

IBMs were developed for Pacific cod and sablefish as part of the North Pacific Research Board's Gulf of Alaska Integrated Ecosystem Research Program (GOAIERP). Results from these models were used to estimate variability in annual connectivity due to changes in the oceanic environment over 1996-2011 (Gibson et al. 2019, Hinckley et al. 2019). The *IBM EFH study* provided survival rate EFH maps for the PELS of these two species to demonstrate that IBM output can be used within the context of EFH. This new methodology may now be explicitly applied to other groundfish and crab species in Alaska where IBMs have been developed (e.g., walleye pollock, POP, red king crab, snow crab), including as a starting reference for other co-occurring species with similar early life history strategies.

Observed spawning locations set the origin of the egg life stage in the IBM at the start of the model run[18]. Settled early juvenile life history stage SDMs were developed for Pacific cod and sablefish and the IBMs use these maps to trigger settlement success once an individual reaches

[17] SDMs developed for e.g., C2 Bristol Bay red king crab closure areas analysis (February, 2024), available with the eAgenda for this meeting: https://meetings.npfmc.org/Meeting/Details/3029
[18] Data summarized for the winter fishery provided by S. Barbeaux, REFM, AFSC, Seattle, WA.

suitable benthic habitat during the early juvenile life stage at the end of the model run. EFH maps from this study are based on presence-absence of successful individuals in the IBM trajectory analysis:

- EFH Level 2 maps developed for Pacific cod and sablefish PELS by weighting the abundance results from individual years by an estimate of annual spawning stock biomass.
- EFH Level 3 maps developed by post-processing the model trajectories to calculate temperature-dependent survival and growth rates by life stage in the model domain.

New EFH component 1 descriptions and maps developed by this study were available to NMFS and the Council for consideration in the 2023 Review as part of the complete package of new information for the GOA FMP.

This study published one peer reviewed manuscript *Can seamounts in the Gulf of Alaska be a spawning ground for sablefish settling in coastal nursery grounds?* (Gibson et al. 2023), and another manuscript is in preparation *Individual-based models inform fishery management decision-support pathways for two groundfish with contrasting early life history phenologies* (Yeager et al. In Preparation).

2.2 Iterative Review

Since the 2017 Review, NMFS has worked to improve the EFH descriptions, focusing on foundational data and SDM improvements and where possible mapping EFH for species and life stages without an EFH map in 2017. During the 2023 Review process to date, the research contributing new information for EFH component 1 has been reviewed by the SSC, Ecosystem Committee, Plan Teams, stock authors, species experts, and other stakeholders in the Council's public process. EFH analysts have incorporated feedback from each of these reviews into revisions to the new SDM ensemble methods, EFH maps, and EFH component 1 reporting for the 2023 Review. This iterative review process is described in detail in the Synthesis Report (Pirtle et al. 2025). As some recommended improvements are not possible at this time without additional extensive research, input will inform priorities for the next iteration of EFH mapping, where continued incremental improvements will add value to EFH component 1. This section provides an overview of the stages of the iterative process by which NMFS and the Council have reviewed the EFH component 1 descriptions and maps for the 2023 Review—

- NMFS and the Council launched the 2023 EFH 5-year Review in April 2019 with a presentation by NMFS to the Ecosystem Committee of the preliminary plan for review of the ten EFH components in the Council's FMPs and proposed approach to advancing the SDM EFH mapping approach of the 2017 Review.
- The SSC in June 2020 and a joint meeting of the Groundfish Plan Teams (JGPT) in September 2020 provided input to NMFS on proposed methods and planned research to support the new EFH component 1 information.
- In January 2021, NMFS EFH component 1 analysts and senior stock assessment scientists convened a summit of stock assessment authors to co-develop the process for their review of EFH component 1, which was an innovation by NMFS of the 2023 EFH 5-year Review process.

- NMFS presented the 2023 EFH 5-year Review Plan to the SSC and Council[19]. The plan described the ten EFH components, work related to the components and the FMPs, and what types of new information will be included in the Summary Report. The SSC highlighted the importance of stock assessment author review in their minutes from April 2021: "The SSC considers consultation with assessment authors to be a critical link in evaluating model configuration and output, and was pleased to hear the EFH team was involving assessment authors early in the EFH review process." SSC provided additional guidance.
- The stock assessment author review of the draft SDM ensemble methods, results, EFH maps, and current EFH component 1 information in the FMPs occurred from May to September 1 2021. EFH analysts presented a response plan to address all reviewing assessment author concerns to the extent possible at this time to JGPT in September 2021.
- Between September 2021 and January 2022, EFH component 1 analysts worked with reviewing assessment authors to address their concerns, revised the draft methods, updated the results, and submitted three regional draft NOAA Technical Memoranda to the NMFS publication process.
- Stock assessment author review of the draft SDM ensemble methods, results, and EFH maps is discussed in detail in the Stock Assessment Author Review EFH Component 1 Report[20]. EFH analysts presented a draft of this report and how we worked with stock authors to address their review to the JGPT in November 2021. The Plan Teams thanked the EFH analysts for all that they had done over the past several months to address the stock author concerns reported in their review of the draft SDM methods and results for EFH component 1.
- EFH analyst responses to extensive SSC and Plan Team input on EFH component 1 from June 2020 through November 2021 are provided in the EFH Component 1 SDM EFH Discussion Paper.[21]
- EFH analysts presented the new draft EFH component 1 information available for the 2023 Review to the CPT and EC in January 2022 and to the SSC for review in February 2022.[22] In February 2022, SSC reviewed the revised SDM ensemble methods, updated draft results, and draft EFH maps, incorporating revisions from the stock author 2021 review addressing concerns to the extent possible at this time.
- In October 2022, by their request SSC reviewed an update to the EFH component 1 SDM ensemble EFH maps and how remaining stock author concerns have been addressed.[23] The question before the SSC at this review was whether the combination of the 2023 EFH SDM approach (component 1) and the Fishing Effects model (component 2) represent a reasonable scientific basis for evaluating whether the effects of fishing are

[19] B3 Planning for the EFH 5-year Review, April 2021 https://meetings.npfmc.org/Meeting/Details/1944
[20] Stock Assessment Author Review Report, D5 Essential Fish Habitat, February 2022 https://meetings.npfmc.org/Meeting/Details/2754
[21] Discussion Paper EFH Descriptions and Maps, D5 Essential Fish Habitat, February 2022 https://meetings.npfmc.org/Meeting/Details/2754
[22] D5 Essential Fish Habitat, February 2022 https://meetings.npfmc.org/Meeting/Details/2754
[23] D8 Essential Fish Habitat, October 2022 https://meetings.npfmc.org/Meeting/Details/2947

more than minimal and not temporary. SSC also provided future research recommendations for EFH component 1.

SSC input on EFH component 1 as an outcome of their October 2022 review:

- The SSC recommends the current EFH methodology and FE estimates as a reasonable basis for the determination of fishing impacts, and that no species needs to be elevated for mitigation due to fishing impacts. Based on the information provided, the SSC finds that the 2022 FE evaluation supports the continued conclusion that the adverse effects of fishing activity on EFH are minimal and temporary in nature.
- The SSC notes that both the current SDM approach to defining EFH and the FE model represent substantial methodological advances since the 2017 EFH review process. The SSC appreciates the substantial efforts by EFH component 1 and component 2 teams in advancing the EFH analysis in this cycle and incorporation of feedback from stock assessment authors and the SSC throughout the process.
- The SSC suggests consideration during the next 5-year EFH review cycle of whether subsequent evaluations should consider other life stages for which EFH has been defined.
- With respect to EFH research in the next 5-year review cycle the SSC had the following recommendations:
    - EFH SDM intercalibration of bottom trawl survey data with data from fixed gear surveys. While the SSC appreciated the description of the overlap between current EFH definitions and NMFS Longline Survey locations, the SSC notes that with the current discontinuation of the EBS slope bottom trawl survey and reduction in sampling of deeper strata within the GOA bottom trawl survey, information on species' occurrence and abundance in deeper habitats will become more important in the future.
    - Exploration of the extent to which fishery-dependent data can help inform future EFH SDM analyses, while highlighting the inherent problem of preferential sampling associated with fishery-dependent information.
    - Expansion of EFH definitions to other life stages and seasons where appropriate, based on available data to inform occurrence, abundance, and habitat associations.
    - The SSC refers EFH authors to its comments from February 2022 for further recommendations regarding future EFH evaluation.

2.3 EFH Component 1 Highlights as an Outcome of the 2023 5-year Review

- This EFH review focused on improving the SDM methods for mapping EFH. New SDM methods were developed by studies contributing new EFH information for the 2023 Review that has modernized the SDM EFH mapping approach of the 2017 Review to update the EFH text descriptions, maps, and information levels in the BSAI, GOA, Crab, and Arctic FMPs.
- The SDM ensemble approach is a foundational improvement to the single SDM method of 2017 for the BSAI, GOA, and Crab FMPs. In particular, NMFS identified that certain SDMs tend to under or over predict the area of occupied habitat. The SDM ensemble

helps mitigate that bias and provides a universal SDM application across multiple FMPs that can be expanded to consider additional constituent models in subsequent EFH Reviews.

- Some of the revised EFH maps have smaller or larger EFH areas than the 2017 EFH maps that stakeholders and reviewers may have become accustomed to for their species of interest. Moving from using single SDMs to SDM ensembles should reduce the magnitude of the change in EFH area attributable to modeling methods in future EFH mapping.
- The 2023 SDM ensemble EFH mapping approach has the potential to improve our ability to identify events in shifting species distributions due to climate change or other impacts to habitat, in particular when EFH is mapped over smaller time series (e.g., five year hindcasts) and with improved SDM forecasting methods (e.g., Rooper et al. 2021, Barnes et al. 2022).
- Research supporting future EFH 5-year reviews could develop methods if resources are available to add other data sources to the SDM ensembles for a subset of species life stages, where additional data would really add value to EFH maps.
- Habitat science is a critical element of EBFM. The new EFH maps are an improved foundation to meet the EFH mandates. The underlying SDMs are an advancement of habitat science that inform EBFM through several pathways (e.g., Goldstein et al. 2020, Rooper et al. 2021, Barnes et al. 2022, Shotwell et al. 2022, Gibson et al. 2023, Harris et al. 2024, Hart et al. 2025, Goodman et al. 2025).

2.4 EFH Descriptions for BSAI Groundfish Species

Amendment 127 to the Fishery Management Plan for Groundfish of the Bering Sea and Aleutian Islands Management Area (BSAI FMP) updated the EFH descriptions in this FMP as a result of the 2023 EFH 5-year Review.

This section summarizes the new and revised EFH descriptions available in the 2023 EFH 5-year Review to amend this information for groundfish species in the BSAI FMP. The BSAI FMP contains EFH component 1 information in Appendix D Life History Features and Habitat Requirements of Fishery Management Plan Species, and Appendix E Maps of Essential Fish Habitat.

The focus for EFH component 1 in the 2023 Review was to modernize the 2017 single SDM EFH mapping approach to an SDM ensemble approach as a new foundation to map EFH for the summer distribution of groundfishes using AFSC RACE-GAP summer bottom trawl survey data. Additional research is required to develop methods to potentially improve the 2017 maps for other seasons, which use fishery dependent data (demersal life stages) and data of limited spatial scale with respect to the BSAI Management Area (pelagic early life stages). The BSAI FMP contains summer distribution EFH maps from the 2023 Review. Additionally, the FMP contains EFH maps for fall, winter, and spring as available from the 2017 Review; EFH mapping efforts for the 2023 Review did not revise these other seasonal maps and they remain in the FMP.

The species, or species complex, and life history stages where an SDM EFH map was developed for the BSAI FMP in the 2017 and 2023 EFH reviews is provided, in order to compare the SDM methods and resulting EFH information levels possible (Table 5). The new SDM ensemble approach of the 2023 Review resulted in increased EFH information levels for most species' life stages included.

Table 5. Species, or species complex, and life history stages where an SDM EFH map was developed for the BSAI FMP in the 2017 and 2023 EFH 5-year reviews for the Aleutian Islands (AI) and the eastern and northern Bering Sea (BS). GAM = generalized additive model, hGAM = hurdle GAM, MaxEnt = maximum entropy model, and ensemble = an SDM ensemble including at most one presence-absence model, two GAMs (Poisson or negative binomial GAM and hGAM) and one MaxEnt, developed as a revised approach to mapping EFH for the 2023 Review.

Species/Complex	Region	Life Stage	SDM 2017	EFH Level 2017	SDM 2022	EFH Level 2022
Walleye pollock	AI	early juvenile	--	0	ensemble	3
		subadult	hGAM	2	ensemble	2
		adult	GAM	2	ensemble	2
	BS	early juvenile	--	0	ensemble	2
		subadult	GAM	2	ensemble	2
		adult	GAM	2	ensemble	2
Pacific cod	AI	subadult	GAM	2	ensemble	2
		adult	GAM	2	ensemble	2
	BS	early juvenile	--	0	ensemble	3
		subadult	GAM	2	ensemble	2
		adult	GAM	2	ensemble	2
Sablefish	AI	subadult	MaxEnt	1	ensemble	2
		adult	MaxEnt	1	ensemble	2
	BS	early juvenile	--	0	ensemble	2
		subadult	MaxEnt	1	ensemble	2
		adult	MaxEnt	1	ensemble	2
Yellowfin sole	BS	early juvenile	--	0	ensemble	2
		subadult	GAM	2	ensemble	2
		adult	GAM	2	ensemble	2
Greenland turbot	AI	subadult	MaxEnt	1	--	1
		adult	MaxEnt	1	ensemble	2
	BS	subadult	hGAM	2	ensemble	2
		adult	hGAM	2	ensemble	2

Species/Complex	Region	Life Stage	SDM 2017	EFH Level 2017	SDM 2022	EFH Level 2022
Kamchatka flounder	AI	subadult	GAM	2	ensemble	2
		adult	hGAM	2	ensemble	2
	BS	subadult	GAM	2	ensemble	2
		adult	hGAM	2	ensemble	2
Arrowtooth flounder	AI	early juvenile	--	0	ensemble	2
		subadult	GAM	2	ensemble	2
		adult	GAM	2	ensemble	2
	BS	early juvenile	--	0	ensemble	2
		subadult	GAM	2	ensemble	2
		adult	GAM	2	ensemble	2
Northern rock sole	AI	early juvenile	--	0	ensemble	2
		subadult	GAM	2	ensemble	2
		adult	GAM	2	ensemble	2
	BS	early juvenile	--	0	ensemble	2
		subadult	GAM	2	ensemble	2
		adult	GAM	2	ensemble	2
Flathead sole	AI	early juvenile	--	0	ensemble	2
		subadult	hGAM	2	ensemble	2
		adult	hGAM	2	ensemble	2
Flathead sole/Bering flounder complex						
Flathead sole	BS	early juvenile	--	0	ensemble	2
		subadult	GAM	2	ensemble	2
		adult	GAM	2	ensemble	2
Bering flounder	BS	subadult	--	0	ensemble	2
		adult	--	0	ensemble	2
Alaska plaice	BS	early juvenile	--	0	ensemble	2
		subadult	--	0	ensemble	2
		adult	GAM	2	ensemble	2
Other flatfish complex						
Butter sole	BS	all	--	0	ensemble	2
Deepsea sole	BS	all	--	0	ensemble	2
Dover sole	AI	subadult	MaxEnt	1	ensemble	2
	BS	adult	MaxEnt	1	ensemble	2
		subadult	MaxEnt	1	ensemble	2
		adult	MaxEnt	1	ensemble	2
English sole	AI	adult	--	0	ensemble	2

Species/Complex	Region	Life Stage	SDM 2017	EFH Level 2017	SDM 2022	EFH Level 2022
Longhead dab	BS	all	--	0	ensemble	2
Rex sole	AI	subadult	hGAM	2	ensemble	2
		adult	GAM	2	ensemble	2
	BS	early juvenile	--	0	ensemble	2
		subadult	hGAM	2	ensemble	2
		adult	hGAM	2	ensemble	2
Sakhalin sole	BS	subadult	--	0	ensemble	2
		adult	--	0	ensemble	2
Southern rock sole	AI	subadult	MaxEnt	1	ensemble	2
		adult	MaxEnt	1	ensemble	2
	BS	subadult	MaxEnt	1	--	1
		adult	MaxEnt	1	--	1
Starry flounder	BS	subadult	--	0	ensemble	2
		adult	--	0	ensemble	2
Pacific ocean perch	AI	early juvenile	--	0	ensemble	2
		subadult	hGAM	2	ensemble	2
		adult	GAM	2	ensemble	2
	BS	early juvenile	--	0	ensemble	2
		subadult	MaxEnt	1	ensemble	2
		adult	MaxEnt	1	ensemble	2
Northern rockfish	AI	subadult	MaxEnt	1	ensemble	2
		adult	GAM	2	ensemble	2
	BS	adult	MaxEnt	1	ensemble	2
Shortraker rockfish	AI	subadult	MaxEnt	1	ensemble	2
		adult	hGAM	2	ensemble	2
	BS	subadult	MaxEnt	1	ensemble	2
		adult	MaxEnt	1	ensemble	2
Rougheye/blackspotted rockfish	AI	subadult	--	0	ensemble	2
		adult	--	0	ensemble	2
	BS	subadult	--	0	ensemble	2
		adult	--	0	ensemble	2
Other rockfish complex						
Dusky rockfish	AI	subadult	MaxEnt	1	ensemble	2
		adult	MaxEnt	1	ensemble	2
	BS	adult	MaxEnt	1	--	1

Species/Complex	Region	Life Stage	SDM 2017	EFH Level 2017	SDM 2022	EFH Level 2022
Harlequin rockfish	AI	subadult	MaxEnt	1	--	1
		adult	MaxEnt	1	ensemble	2
Shortspine thornyhead	AI	subadult	MaxEnt	1	ensemble	2
		adult	hGAM	2	ensemble	2
	BS	subadult	MaxEnt	1	ensemble	2
		adult	MaxEnt	1	ensemble	2
Atka mackerel	AI	subadult	hGAM	2	ensemble	2
		adult	GAM	2	ensemble	2
	BS	adult	MaxEnt	1	ensemble	2
Skate complex						
Alaska skate	AI	subadult	MaxEnt	1	ensemble	2
		adult	MaxEnt	1	ensemble	2
	BS	subadult	GAM	2	ensemble	2
		adult	hGAM	2	ensemble	2
Aleutian skate	AI	subadult	MaxEnt	1	ensemble	2
		adult	MaxEnt	1	ensemble	2
	BS	subadult	hGAM	2	ensemble	2
		adult	MaxEnt	1	ensemble	2
Bering skate	AI	subadult	MaxEnt	1	--	1
		adult	MaxEnt	1	--	1
	BS	subadult	hGAM	2	ensemble	2
		adult	hGAM	2	ensemble	2
Big skate	BS	subadult	--	0	ensemble	2
Mud skate	AI	subadult	hGAM	2	ensemble	2
		adult	MaxEnt	1	ensemble	2
	BS	subadult	MaxEnt	1	ensemble	2
		adult	MaxEnt	1	ensemble	2
Whiteblotched skate	AI	subadult	--	0	ensemble	2
		adult	--	0	ensemble	2
	BS	subadult	--	0	ensemble	2
		adult	--	0	ensemble	2
Octopus						
Giant octopus	AI	all	hGAM	2	ensemble	2
	BS	all	MaxEnt	1	ensemble	2

2.4.1 Summary of EFH review for individual species

An overall summary of the review of EFH component 1 information in the BSAI FMP and new SDM EFH maps is provided by species with changes to the text descriptions, maps, and information levels in (Table 6). Section 2.4.2 lists the changes by species in the FMP.

Table 6. EFH review of BSAI FMP groundfish species, with changes to the existing EFH text, maps, and information levels. Key: yes = updated the EFH description based on new information; no = did not change due to insufficient information; and e/c = editorial changes or clarifications. Information level text describes any life stage additions and other changes, increases in available EFH information level, and necessary corrections.

Species/Complex	Text	Maps	Information Level 1-4
Walleye pollock	yes; e/c	yes	add settled early juvenile and increase to Level 2 in the Bering Sea and Level 3 in the Aleutian Islands; correct pelagic early juvenile to Level 1
Pacific cod	yes; e/c	yes	add Bering Sea settled early juvenile and increase to Level 3; correct larvae and pelagic early juvenile to Level 1
Sablefish	yes; e/c	yes	add Bering Sea settled early juvenile and increase to Level 2; increase subadult and adult to Level 2
Yellowfin sole	yes; e/c	yes	add Bering Sea settled early juvenile and increase to Level 2
Greenland turbot	yes; e/c	no/yes	no new SDM EFH map for Aleutian Islands subadult; increase Aleutian Islands adult to Level 2
Kamchatka flounder	yes; e/c	yes	correct subadult and adult to Level 2
Arrowtooth flounder	yes; e/c	yes	add settled early juvenile and increase to Level 2
Northern rock sole	yes; e/c	yes	add settled early juvenile and increase to Level 2; correct subadult and adult to Level 2
Flathead sole/Bering flounder complex	yes; e/c	yes	add Bering Sea subadult/adult complex map and increase to Level 2
Flathead sole	yes; e/c	yes	add settled early juvenile and increase to Level 2; correct pelagic early juvenile to Level 1
Bering flounder	yes; e/c	yes	add Bering Sea subadult and adult and increase to Level 2
Alaska plaice	yes; e/c	yes	add Bering Sea settled early juvenile and subadult and increase to Level 2
Other flatfish complex	yes; e/c	yes	add Aleutian Islands and Bering Sea subadult/adult complex maps and increase to Level 2
Butter sole	yes; e/c	yes	add Bering Sea subadult/adult and increase to Level 2
Deepsea sole	yes; e/c	yes	add Bering Sea subadult/adult and increase to Level 2

Species/Complex	Text	Maps	Information Level 1-4
Dover sole	yes; e/c	yes	increase subadult and adult to Level 2
English sole	yes; e/c	yes	add Aleutian Islands adult and increase to Level 2
Longhead dab	yes; e/c	yes	add Bering Sea subadult/adult and increase to Level 2
Rex sole	yes; e/c	yes	add Bering Sea settled early juvenile and increase to Level 2
Sakhalin sole	yes; e/c	yes	add Bering Sea subadult and adult and increase to Level 2
Southern rock sole	yes; e/c	yes/no	increase Aleutian Islands subadult and adult to Level 2; no new SDM EFH map for Bering Sea subadult and adult
Starry flounder	yes; e/c	yes	add Bering Sea subadult and adult and increase to Level 2
Pacific ocean perch	yes; e/c	yes	add settled early juvenile and increase to Level 2; increase Bering Sea subadult and adult to Level 2
Northern rockfish	yes; e/c	yes	increase Aleutian Islands subadult and Bering Sea adult to Level 2
Shortraker rockfish	yes; e/c	yes	increase Aleutian Islands subadult and Bering Sea subadult and adult to Level 2
Rougheye/blackspotted rockfish	yes; e/c	yes	combine species and increase subadult and adult to Level 2
Other rockfish complex	yes; e/c	yes	add Aleutian Islands subadult/adult complex map and increase to Level 2
Dusky rockfish	yes; e/c	yes/no	increase Aleutian Islands subadult and adult to Level 2; no new SDM EFH map for Bering Sea adult
Harlequin rockfish	yes; e/c	no/yes	no new SDM EFH map for Aleutian Islands subadult; increase Aleutian Islands adult to Level 2
Shortspine thornyhead	yes; e/c	yes	increase subadult and Bering Sea adult to Level 2; correct pelagic early juvenile to 0
Atka mackerel	yes; e/c	yes	increase Bering Sea adult to Level 2
Skate complex	yes; e/c	yes	add Aleutian Islands and Bering Sea subadult/adult complex maps and increase to Level 2
Alaska skate	yes; e/c	yes	increase Aleutian Islands subadult and adult to Level 2
Aleutian skate	yes; e/c	yes	increase Aleutian Islands subadult and adult to Level 2; increase Bering Sea adult to Level 2
Bering skate	yes; e/c	yes	no new SDM EFH maps for Bering Sea subadult and adult; Increase Aleutian Islands subadults and adults to Level 2

Species/Complex	Text	Maps	Information Level 1-4
Big skate	yes; e/c	yes	add Bering Sea subadult and increase to Level 2
Mud skate	yes; e/c	yes	increase Bering Sea subadult to Level 2; increase adult to Level 2
Whiteblotched skate	yes; e/c	yes	add subadult and adult and increase to Level 2
Octopus	yes; e/c	yes	Giant octopus is a single species representing the complex
Giant octopus	yes; e/c	yes	increase Bering Sea subadult/adult to Level 2

2.4.2 Description of changes to EFH text and maps

A description of the changes that are summarized in Table 6 is provided below for each individual species or species complex in the BSAI FMP.

Walleye Pollock

- Expand EFH text description and provide editorial changes
- Add SDM top contributing covariates informing habitat-related distribution and abundance
- Update life history and general distribution
- Add summer distribution map for settled early juveniles
- Update summer distribution maps for subadults and adults
- Correct pelagic early juveniles to Level 1
- Increase settled early juveniles to Level 2 in the Bering Sea and Level 3 in the Aleutian Islands

Pacific cod

- Expand EFH text description and provide editorial changes
- Add SDM top contributing covariates informing habitat-related distribution and abundance
- Update life history and general distribution
- Update literature
- Update summer distribution maps for subadults and adults
- Add summer distribution maps for settled early juveniles in the Bering Sea
- Correct pelagic early juveniles to Level 1
- Increase settled early juveniles to Level 3 in the Bering Sea

Sablefish

- Expand EFH text description and provide editorial changes
- Add SDM top contributing covariates informing habitat-related distribution and abundance
- Update life history and general distribution

- Update literature
- Update summer distribution maps for subadults and adults
- Add summer distribution maps for settled early juveniles in the Bering Sea
- Increase settled early juveniles in the Bering Sea to Level 2
- Increase subadults and adults to Level 2

Yellowfin sole

- Expand EFH text description and provide editorial changes
- Add SDM top contributing covariates informing habitat-related distribution and abundance
- Update summer distribution maps for subadults and adults
- Add summer distribution maps for settled early juveniles in the Bering Sea
- Increase settled early juveniles in the Bering Sea to Level 2

Greenland turbot

- Expand EFH text description and provide editorial changes
- Add SDM top contributing covariates informing habitat-related distribution and abundance
- Update summer distribution maps for subadults and adults
- Increase adults in the Aleutian Islands to Level 2

Kamchatka flounder

- Expand EFH text description and provide editorial changes
- Add SDM top contributing covariates informing habitat-related distribution and abundance
- Update summer distribution maps for subadults and adults
- Correct subadults and adults to Level 2

Arrowtooth flounder

- Expand EFH text description and provide editorial changes
- Add SDM top contributing covariates informing habitat-related distribution and abundance
- Update life history and general distribution
- Update literature
- Updates to habitat associations table
- Update summer distribution maps for subadults and adults
- Add summer distribution maps for settled early juveniles
- Increase settled early juveniles to Level 2

Northern rock sole

- Expand EFH text description and provide editorial changes
- Add SDM top contributing covariates informing habitat-related distribution and abundance

- Update summer distribution maps for subadults and adults
- Add summer distribution maps for settled early juveniles
- Increase settled early juveniles to Level 2
- Correct subadults and adults to Level 2

Flathead sole

- Expand EFH text description and provide editorial changes
- Add SDM top contributing covariates informing habitat-related distribution and abundance
- Update life history and general distribution
- Update literature
- Update summer distribution maps for subadults and adults
- Add summer distribution map for settled early juveniles
- Increase settled early juveniles to Level 2
- Correct pelagic early juvenile to Level 1

Bering flounder (Flathead sole/Bering flounder complex)

- Expand EFH text description and provide editorial changes
- Add SDM top contributing covariates informing habitat-related distribution and abundance
- Update life history and general distribution
- Update literature
- Add summer distribution map for subadults and adults in the Bering Sea
- Add subadult/adult species complex map and increase to Level 2 in the Bering Sea
- Increase subadults and adults in the Bering Sea to Level 2

Alaska plaice

- Expand EFH text description and provide editorial changes
- Add SDM top contributing covariates informing habitat-related distribution and abundance
- Update summer distribution maps for subadults and adults
- Add summer distribution map for settled early juveniles and subadults in the Bering Sea
- Increase settled early juveniles and subadults in the Bering Sea to Level 2

Other flatfish complex

- Expand EFH text description and provide editorial changes
- Add AI and BS subadult/adult complex maps, a compilation of SDM EFH maps for species in the complex, to account for EFH of unmapped species
- Increase species complex to Level 2

Butter sole

- Expand EFH text description and provide editorial changes

- Add SDM top contributing covariates informing habitat-related distribution and abundance
- Add summer distribution map for subadults/adults in the Bering Sea
- Increase Bering Sea subadult/adult to Level 2

Deepsea sole

- Expand EFH text description and provide editorial changes
- Add SDM top contributing covariates informing habitat-related distribution and abundance
- Update literature
- Add summer distribution map for subadults/adults in the Bering Sea
- Increase Bering Sea subadult/adult to Level 2

Dover sole

- Expand EFH text description and provide editorial changes
- Add SDM top contributing covariates informing habitat-related distribution and abundance
- Update summer distribution maps for subadults and adults
- Increase subadults and adults to Level 2

English sole

- Expand EFH text description and provide editorial changes
- Add SDM top contributing covariates informing habitat-related distribution and abundance
- Add summer distribution map for adults in the Aleutian Islands
- Increase adults in the Aleutian Islands to Level 2

Longhead dab

- Expand EFH text description and provide editorial changes
- Add SDM top contributing covariates informing habitat-related distribution and abundance
- Add summer distribution map for subadults/adults in the Bering Sea
- Increase Bering Sea subadult/adult to Level 2

Rex sole

- Expand EFH text description and provide editorial changes
- Add SDM top contributing covariates informing habitat-related distribution and abundance
- Add summer distribution map for Bering Sea settled early juveniles
- Update summer distribution maps for subadults and adults
- Increase settled early juveniles to Level 2

Sakhalin sole

- Expand EFH text description and provide editorial changes
- Add SDM top contributing covariates informing habitat-related distribution and abundance
- Add summer distribution map for Bering Sea subadults and adults
- Increase subadults and adults to Level 2

Southern rock sole

- Expand EFH text description and provide editorial changes
- Add SDM top contributing covariates informing habitat-related distribution and abundance
- No new EFH map for Bering Sea subadults and adults due to data limitations (no map change)
- Increase Aleutian Islands subadult and adult to Level 2

Starry flounder

- Expand EFH text description and provide editorial changes
- Add SDM top contributing covariates informing habitat-related distribution and abundance
- Add summer distribution map for Bering Sea subadults and adults
- Increase subadults and adults to Level 2

Pacific ocean perch

- Expand EFH text description and provide editorial changes
- Add SDM top contributing covariates informing habitat-related distribution and abundance
- Update life history and general distribution
- Update literature
- Update summer distribution maps for subadults and adults
- Add summer distribution map for settled early juveniles
- Increase Bering Sea subadult and adult to Level 2
- Increase settled early juveniles to Level 2

Northern rockfish

- Expand EFH text description and provide editorial changes
- Add SDM top contributing covariates informing habitat-related distribution and abundance
- Update literature
- Update summer distribution maps for subadults and adults
- Increase Aleutian Islands subadults to Level 2
- Increase Bering Sea adults to Level 2

Shortraker rockfish

- Expand EFH text description and provide editorial changes
- Add SDM top contributing covariates informing habitat-related distribution and abundance
- Update life history
- Update summer distribution maps for subadults and adults
- Increase subadults to Level 2
- Increase Bering Sea adults to Level 2

Rougheye/blackspotted rockfish

- Combine species in SDM ensemble EFH map by request of stock assessment author
- Expand EFH text description and provide editorial changes
- Add SDM top contributing covariates informing habitat-related distribution and abundance
- Update life history and general distribution
- Update literature
- Updates to habitat associations table
- Update summer distribution maps for subadults and adults with combined species maps
- Increase subadults and adults to Level 2

<u>Other rockfish complex</u>

- Expand EFH text description and provide editorial changes
- Add EFH map for the complex in the Aleutian Islands, a compilation of SDM EFH maps for species in the complex, to account for EFH of unmapped species
- Increase species complex to Level 2

Dusky rockfish

- Expand EFH text description and provide editorial changes
- Add SDM top contributing covariates informing habitat-related distribution and abundance
- Update summer distribution maps for subadults and adults
- No new SDM EFH map for Bering Sea adults due to data limitations (no map change)
- Increase Aleutian Islands subadults and adults to Level 2

Harlequin rockfish

- Expand EFH text description and provide editorial changes
- Add SDM top contributing covariates informing habitat-related distribution and abundance
- Update summer distribution maps for subadults and adults
- No new SDM EFH map for Aleutian Islands subadults due to data limitations (no map change)
- Increase Aleutian Islands adults to Level 2

Shortspine thornyhead rockfish

- Expand EFH text description and provide editorial changes
- Add SDM top contributing covariates informing habitat-related distribution and abundance
- Update literature
- Update summer distribution maps for subadults and adults
- Increase subadults to Level 2
- Increase Bering Sea adults to Level 2
- Correct pelagic early juveniles to 0 (insufficient information)

Atka mackerel

- Expand EFH text description and provide editorial changes
- Add SDM top contributing covariates informing habitat-related distribution and abundance
- Update literature
- Update life history and general distribution
- Update summer distribution maps for subadults and adults
- Increase Bering Sea adults to Level 2

Skate Complex

- Expand EFH text description and provide editorial changes
- Add EFH maps for the complex, a compilation of SDM EFH maps for species in the complex, to account for EFH of unmapped species
- Increase species complex to Level 2

Alaska skate

- Expand EFH text description and provide editorial changes
- Add SDM top contributing covariates informing habitat-related distribution and abundance
- Update summer distribution maps for subadults and adults
- Increase Aleutian Islands subadults and adults to Level 2

Aleutian skate

- Expand EFH text description and provide editorial changes
- Add SDM top contributing covariates informing habitat-related distribution and abundance
- Update summer distribution maps for subadults and adults
- Increase Aleutian Islands subadults to Level 2
- Increase adults to Level 2

Bering skate

- Expand EFH text description and provide editorial changes

- Add SDM top contributing covariates informing habitat-related distribution and abundance
- Update summer distribution maps for Aleutian Islands subadults and adults
- No new SDM EFH map for Bering Sea subadults and adults due to data limitations (no map change)
- Increase Aleutian Islands subadults and adults to Level 2

Big skate

- Expand EFH text description and provide editorial changes
- Add SDM top contributing covariates informing habitat-related distribution and abundance
- Add summer distribution map for Bering Sea subadults
- Increase Bering Sea subadults to Level 2

Mud skate

- Expand EFH text description and provide editorial changes
- Add SDM top contributing covariates informing habitat-related distribution and abundance
- Update summer distribution maps for subadults and adults
- Increase Bering Sea subadults to Level 2
- Increase adults to Level 2

Whiteblotched skate

- Expand EFH text description and provide editorial changes
- Add SDM top contributing covariates informing habitat-related distribution and abundance
- Add summer distribution maps for subadults and adults
- Increase subadults and adults to Level 2

<u>Octopus</u>

- Giant octopus is a single species representing the complex

Giant octopus

- Expand EFH text description and provide editorial changes
- Add SDM top contributing covariates informing habitat-related distribution and abundance
- Add summer distribution maps for subadult/adult
- Increase Bering Sea subadults/adults to Level 2

Sculpin

- Remove; sculpin are in the ecosystem component

Squid

- Remove; squid are in the ecosystem component

Forage fish

- Remove; forage fish are in the ecosystem component

Grenadier

- Remove; grenadier are in the ecosystem component

Table 7 lists the levels of EFH information available as a result of the 2023 EFH 5-year Review, for species and species complexes in the BSAI FMP.

Table 7. EFH information levels available by species or species complex and life history stage for groundfish in the BSAI FMP. Sebastes spp. pelagic early life stages are grouped.

Species/Complex	Egg	Larvae	Early Juvenile (Pelagic)	Early Juvenile (Settled)	Subadult	Adult
Walleye pollock	1	1	1	3	2	2
Pacific cod	0	1	1	3	2	2
Sablefish	0	0	0	2	2	2
Yellowfin sole	1	1	1	2	2	2
Greenland turbot	1	1	1	0	2	2
Kamchatka flounder	1	1	1	0	2	2
Arrowtooth flounder	1	1	1	2	2	2
Northern rock sole	0	1	1	2	2	2
Flathead sole/Bering flounder complex	0	0	0	0	2	
Flathead sole	1	1	1	2	2	2
Bering flounder	0	0	0	0	2	2
Alaska plaice	1	1	0	2	2	2
Other flatfish complex	1	1	1	0	2	
Butter sole	0	0	0	0	2	
Deepsea sole	0	0	0	0	2	
Dover sole	0	0	0	0	2	2
English sole	0	0	0	1	1	2
Longhead dab	0	0	0	0	2	
Rex sole	0	0	0	2	2	2
Sakhalin sole	0	0	0	0	2	2

Species/Complex	Egg	Larvae	Early Juvenile (Pelagic)	Early Juvenile (Settled)	Subadult	Adult
Southern rock sole	0	0	0	1	2	2
Starry flounder	0	0	0	1	2	2
Pacific ocean perch	1	1	1	2	2	2
Northern rockfish	1	1	1	0	2	2
Shortraker rockfish	1	1	1	0	2	2
Rougheye/blackspotted rockfish	1	1	1	0	2	2
Other rockfish complex	1	1	1	0	2	
Dusky rockfish	1	1	1	0	2	2
Harlequin rockfish	1	1	1	0	2	2
Shortspine thornyhead	0	0	0	0	2	2
Atka mackerel	1	1	1	0	2	2
Skate complex	1	1	--	1	2	
Alaska skate	0	0	--	0	2	2
Aleutian skate	0	0	--	0	2	2
Bering skate	0	0	--	0	2	2
Big skate	0	0	--	0	2	0
Mud skate	0	0	--	0	2	2
Whiteblotched skate	0	0	--	0	2	2
Octopus	0	0	--	0	0	
Giant octopus	0	0	--	0	2	

2.5 EFH Descriptions for GOA Groundfish Species

Amendment 115 to the Fishery Management Plan for Groundfish of the Gulf of Alaska (GOA FMP) updated the EFH descriptions in this FMP as a result of the 2023 EFH 5-year Review.

This section summarizes the new and revised EFH descriptions available in the 2023 EFH 5-year Review to amend this information for groundfish species in the GOA FMP. The GOA FMP contains EFH component 1 information in Appendix D Life History Features and Habitat Requirements of Fishery Management Plan Species, and Appendix E Maps of Essential Fish Habitat.

The focus for EFH component 1 in the 2023 Review was to modernize the 2017 single SDM EFH mapping approach to an SDM ensemble approach as a new foundation to map EFH for the summer distribution of groundfishes using AFSC RACE-GAP summer bottom trawl survey data. Additional research is required to develop methods to potentially improve the 2017 maps for other seasons, which use fishery dependent data (demersal life stages) and data of limited spatial scale with respect to the GOA Management Area (pelagic early life stages). The GOA FMP contains summer distribution EFH maps from the 2023 Review. Additionally, the FMP contains EFH maps for fall, winter, and spring as available from the 2017 Review; EFH mapping efforts for the 2023 Review did not revise these other seasonal maps and they remain in the FMP.

The species, or species complex, and life history stages where an SDM EFH map was developed for the GOA FMP in the 2017 and 2023 EFH reviews is provided, in order to compare the SDM methods and resulting EFH information levels possible (Table 8). The new SDM ensemble approach of the 2023 review resulted in increased EFH information levels for most species' life stages included.

Table 8. Species, or species complex, and life history stages where an SDM EFH map was developed for the GOA FMP in the 2017 and 2023 EFH 5-year reviews. GAM = generalized additive model, hGAM = hurdle GAM, MaxEnt = maximum entropy model, and ensemble = an SDM ensemble including at most one presence-absence model, two GAMs (Poisson or negative binomial GAM and hGAM) and one MaxEnt, developed as a revised approach to mapping EFH for the 2023 Review.

Species/Complex	Life Stage	SDM 2017	EFH Level 2017	SDM 2022	EFH Level 2022
Walleye pollock	early juvenile	--	0	MaxEnt	3
	subadult	GAM	2	ensemble	2
	adult	GAM	2	ensemble	2
Pacific cod	early juvenile	--	0	MaxEnt	3
	subadult	GAM	2	ensemble	2
	adult	GAM	2	ensemble	2
Sablefish	early juvenile	--	0	MaxEnt	3
	subadult	hGAM	2	ensemble	2
	adult	GAM	2	ensemble	2
Rex sole	early juvenile	--	0	MaxEnt	1
	subadult	hGAM	2	ensemble	2
	adult	GAM	2	ensemble	2
Flathead sole	early juvenile	--	0	MaxEnt	1
	subadult	GAM	2	ensemble	2
	adult	GAM	2	ensemble	2

Species/Complex	Life Stage	SDM 2017	EFH Level 2017	SDM 2022	EFH Level 2022
Arrowtooth flounder	early juvenile	--	0	MaxEnt	1
	subadult	GAM	2	ensemble	2
	adult	GAM	2	ensemble	2
Shallow water flatfish complex					
Alaska plaice	subadult	--	0	ensemble	2
	adult	hGAM	2	ensemble	2
Butter sole	subadult/adult	--	0	ensemble	2
English sole	early juvenile	--	0	MaxEnt	1
	subadult	--	0	ensemble	2
	adult	--	0	ensemble	2
Pacific sanddab	all	--	0	ensemble	2
Petrale sole	subadult	--	0	ensemble	2
	adult	--	0	ensemble	2
Northern/southern rock soles	early juvenile	--	0	MaxEnt	3
Northern rock sole	subadult	hGAM	2	ensemble	2
	adult	hGAM	2	ensemble	2
Sand sole	adult	--	0	ensemble	2
Slender sole	all	--	0	ensemble	2
Southern rock sole	subadult	hGAM	2	ensemble	2
	adult	GAM	2	ensemble	2
Starry flounder	early juvenile	--	0	MaxEnt	1
	subadult	--	0	ensemble	2
	adult	--	0	ensemble	2
Yellowfin sole	early juvenile	--	0	MaxEnt	3
	subadult	MaxEnt	1	ensemble	2
	adult	hGAM	2	ensemble	2
Deep water flatfish complex					
Dover sole	subadult	GAM	2	ensemble	2
	adult	GAM	2	ensemble	2
Pacific ocean perch	early juvenile	--	0	MaxEnt	3
	subadult	hGAM	2	ensemble	2
	adult	GAM	2	ensemble	2
Northern rockfish	subadult	MaxEnt	1	ensemble	2
	adult	hGAM	2	ensemble	2

Species/Complex	Life Stage	SDM 2017	EFH Level 2017	SDM 2022	EFH Level 2022
Dusky rockfish	subadult	MaxEnt	1	ensemble	2
	adult	hGAM	2	ensemble	2
Shortraker rockfish	subadult	MaxEnt	1	ensemble	2
	adult	hGAM	2	ensemble	2
Rougheye/blackspotted rockfish	subadult	--	0	ensemble	2
	adult	--	0	ensemble	2
Thornyhead rockfish					
Shortspine thornyhead	subadult	hGAM	2	ensemble	2
	adult	hGAM	2	ensemble	2
Other rockfish complex demersal subgroup					
Quillback rockfish	adult	--	0	ensemble	2
	all	MaxEnt	1	--	--
Yelloweye rockfish	subadult	MaxEnt	1	ensemble	2
	adult	MaxEnt	1	ensemble	2
Rosethorn rockfish	subadult	MaxEnt	1	ensemble	2
	adult	MaxEnt	1	ensemble	2
Other rockfish complex slope subgroup					
Greenstriped rockfish	all	MaxEnt	1	--	--
	adult	--	0	ensemble	2
Harlequin rockfish	subadult	MaxEnt	1	ensemble	2
	adult	hGAM	2	ensemble	2
Pygmy rockfish	all	MaxEnt	1	ensemble	2
Redbanded rockfish	subadult	hGAM	2	ensemble	2
	adult	MaxEnt	1	ensemble	2
Redstripe rockfish	subadult	MaxEnt	1	ensemble	2
	adult	MaxEnt	1	ensemble	2
Sharpchin rockfish	subadult	hGAM	2	ensemble	2
	adult	MaxEnt	1	ensemble	2
Silvergray rockfish	subadult	MaxEnt	1	ensemble	2
	adult	hGAM	2	ensemble	2
Atka mackerel	all	hGAM	2	--	--
	subadult	--	0	ensemble	2
	adult	--	0	ensemble	2

Species/Complex	Life Stage	SDM 2017	EFH Level 2017	SDM 2022	EFH Level 2022
Skate complex					
Alaska skate	subadult	MaxEnt	1	ensemble	2
	adult	MaxEnt	1	ensemble	2
Aleutian skate	subadult	hGAM	2	ensemble	2
	adult	MaxEnt	1	ensemble	2
Bering skate	subadult	MaxEnt	1	ensemble	2
	adult	MaxEnt	1	ensemble	2
Big skate	subadult	--	0	ensemble	2
	adult	--	0	ensemble	2
Longnose skate	subadult	--	0	ensemble	2
	adult	--	0	ensemble	2
Shark Complex					
Spiny dogfish	all	--	0	ensemble	2
Octopus					
Giant octopus	all	MaxEnt	1	ensemble	2

Table 9. Species and pelagic early life history stages where an IBM-based EFH map was developed for the GOA FMP.

Species	Egg	Larvae Yolk-sac	Larvae Feeding	Early Juvenile Pelagic	Early Juvenile Settling
Pacific cod	X	X	X	X	X
Sablefish	X	X	X	X	X

2.5.1 Summary of EFH review for individual species

An overall summary of the review of EFH component 1 information in the GOA FMP and new SDM EFH maps is provided by species with changes to the EFH text descriptions, maps, and information levels (Table 10). Section 2.5.2 lists the changes by species in the FMP.

Table 10. EFH review of GOA FMP groundfish species, with changes to the existing EFH text, maps, and information levels. Key: yes = updated the EFH description based on new information; no = did not change due to insufficient information; and e/c = editorial changes or clarifications. Information level text describes any life stage additions and other changes, increases in available EFH information level, and necessary corrections.

Species/Complex	Text	Maps	Information Level 1-4
Walleye pollock	yes; e/c	yes	add settled early juvenile and increase to Level 3; correct pelagic early juvenile to Level 1
Pacific cod	yes; e/c	yes	add egg and increase to Level 2; increase larvae to Level 2; add pelagic and settled early juvenile and increase to Level 3
Sablefish	yes; e/c	yes	add egg and increase to Level 2; increase larvae to Level 2; add pelagic and settled early juvenile and increase to Level 3
Rex sole	yes; e/c	yes	add settled early juvenile and increase to Level 1
Flathead sole	yes; e/c	yes	add settled early juvenile and increase to Level 1
Arrowtooth flounder	yes; e/c	yes	add settled early juvenile and increase to Level 1
Shallow water flatfish complex	yes; e/c	yes	add subadult/adult complex map and increase to Level 2
Alaska plaice	yes; e/c	yes	add subadult and increase to Level 2; correct pelagic early juvenile to Level 1
Butter sole	yes; e/c	yes	add subadult/adult and increase to Level 2
English sole	yes; e/c	yes	add settled early juvenile and increase to Level 1; add subadult and adult and increase to Level 2
Pacific sanddab	yes; e/c	yes	add subadult/adult and increase to Level 2
Petrale sole	yes; e/c	yes	add subadult and adult and increase to Level 2
Northern rock sole	yes; e/c	yes	add settled early juvenile (rock soles) and increase to Level 3; correct pelagic early juvenile to Level 1
Sand sole	yes; e/c	yes	add adult and increase to Level 2
Slender sole	yes; e/c	yes	add subadult/adult and increase to Level 2
Southern rock sole	yes; e/c	yes	add settled early juvenile (rock soles) and increase to Level 3; correct pelagic early juvenile to Level 1
Starry flounder	yes; e/c	yes	add settled early juvenile and increase to Level 1; add subadult and adult and increase to Level 2
Yellowfin sole	yes; e/c	yes	add settled early juvenile and increase to Level 3; increase subadult to Level 2; correct pelagic early juvenile to Level 1

Species/Complex	Text	Maps	Information Level 1-4
Deep water flatfish complex	yes; e/c	yes	Dover sole is a single species representing the complex
Dover sole	yes; e/c	yes	
Pacific ocean perch	yes; e/c	yes	add settled early juvenile and increase to Level 3
Northern rockfish	yes; e/c	yes	increase subadult to Level 2
Dusky rockfish	yes; e/c	yes	increase subadult to Level 2
Shortraker rockfish	yes; e/c	yes	increase subadult to Level 2
Rougheye/blackspotted rockfish	yes; e/c	yes	combine species and increase subadult and adult to Level 2
Thornyhead rockfish	yes; e/c	yes	Shortspine thornyhead is a single species representing the complex of two species with similar life histories
Shortspine thornyhead	yes; e/c	yes	correct pelagic early juvenile to Level 1
Other rockfish complex demersal subgroup	yes; e/c	yes	add subadult/adult complex map and increase to Level 2
Quillback rockfish	yes; e/c	yes	add adult and increase to Level 2 as previously subadult/adult were combined at Level 1
Yelloweye rockfish	yes; e/c	yes	increase subadult and adult to Level 2
Rosethorn rockfish	yes; e/c	yes	increase subadult and adult to Level 2
Other rockfish complex slope subgroup	yes; e/c	yes	add subadult/adult complex map and increase to Level 2
Greenstriped rockfish	yes; e/c	yes	add adult and increase to Level 2 as previously subadult/adult were combined at Level 1
Harlequin rockfish	yes; e/c	yes	increase subadult to Level 2
Pygmy rockfish	yes; e/c	yes	increase subadult/adult to Level 2
Redbanded rockfish	yes; e/c	yes	increase adult to Level 2
Redstripe rockfish	yes; e/c	yes	increase subadult and adult to Level 2
Sharpchin rockfish	yes; e/c	yes	increase adult to Level 2
Silvergray rockfish	yes; e/c	yes	increase subadult to Level 2
Atka mackerel	yes; e/c	yes	increase subadult and adult to Level 2 as previously subadult/adult were combined
Skate complex	yes; e/c	yes	add subadult/adult complex map and increase to Level 2
Alaska skate	yes; e/c	yes	increase subadult and adult to Level 2

Species/Complex	Text	Maps	Information Level 1-4
Aleutian skate	yes; e/c	yes	increase adult to Level 2
Bering skate	yes; e/c	yes	increase subadult and adult to Level 2
Big skate	yes; e/c	yes	add subadult and adult and increase to Level 2
Longnose skate	yes; e/c	yes	add subadult and adult and increase to Level 2
Shark Complex	yes; e/c	yes	Spiny dogfish is a single species representing the complex
Spiny dogfish	yes; e/c	yes	increase subadult/adult to Level 2
Octopus	yes; e/c	yes	Giant octopus is a single species representing the complex
Giant octopus	yes; e/c	yes	increase subadult/adult to Level 2

2.5.2 Description of changes for EFH text and maps

A description of the changes that are summarized in Table 10 is provided below for each individual species or species complex in the GOA FMP.

Walleye Pollock

- Expand EFH text description and provide editorial changes
- Add SDM top contributing covariates informing habitat-related distribution and abundance
- Update life history
- Add summer distribution map for settled early juveniles
- Update summer distribution maps for subadults and adults
- Correct pelagic early juveniles to Level 1
- Increase settled early juveniles to Level 3

Pacific cod

- Expand EFH text description and provide editorial changes
- Add SDM top contributing covariates informing habitat-related distribution and abundance
- Update life history and general distribution
- Update literature
- Update habitat association tables
- Add summer distribution maps for eggs, pelagic early juveniles, and settled early juveniles
- Update summer distribution maps for larvae, subadults, and adults
- Increase eggs and larvae to Level 2
- Increase pelagic and settled early juveniles to Level 3

Sablefish

- Expand EFH text description and provide editorial changes
- Add SDM top contributing covariates informing habitat-related distribution and abundance
- Update life history and general distribution
- Update literature
- Add summer distribution maps for eggs, pelagic early juveniles, and settled early juveniles
- Update summer distribution maps for larvae, subadults, and adults
- Increase eggs and larvae to Level 2
- Increase pelagic and settled early juveniles to Level 3

Rex sole

- Expand EFH text description and provide editorial changes
- Add SDM top contributing covariates informing habitat-related distribution and abundance
- Update literature
- Add summer distribution map for settled early juveniles
- Update summer distribution maps for subadults and adults
- Increase settled early juveniles to Level 1

Flathead sole

- Expand EFH text description and provide editorial changes
- Add SDM top contributing covariates informing habitat-related distribution and abundance
- Update life history and general distribution
- Update literature
- Add summer distribution map for settled early juveniles
- Update summer distribution maps for subadults and adults
- Increase settled early juveniles to Level 1

Arrowtooth flounder

- Expand EFH text description and provide editorial changes
- Add SDM top contributing covariates informing habitat-related distribution and abundance
- Update life history and general distribution
- Update literature
- Update habitat association tables
- Add summer distribution map for settled early juveniles
- Update summer distribution maps for subadults and adults
- Increase settled early juveniles to Level 1

<u>Shallow water flatfish complex</u>

- Expand EFH text description and provide editorial changes
- Add EFH map for the complex, a compilation of SDM EFH maps for species in the complex, to account for EFH of unmapped species
- Increase species complex to Level 2

Alaska plaice

- Expand EFH text description and provide editorial changes
- Add SDM top contributing covariates informing habitat-related distribution and abundance
- Add summer distribution map for subadults
- Increase subadults to Level 2
- Correct pelagic early juveniles to Level 1

Butter sole

- Expand EFH text description and provide editorial changes
- Add SDM top contributing covariates informing habitat-related distribution and abundance
- Add summer distribution maps for subadults and adults
- Increase subadults and adults to Level 2

English sole

- Expand EFH text description and provide editorial changes
- Add SDM top contributing covariates informing habitat-related distribution and abundance
- Add summer distribution maps for settled early juveniles, subadults, and adults
- Increase settled early juveniles to Level 1
- Increase subadults and adults to Level 2

Pacific sanddab

- Expand EFH text description and provide editorial changes
- Add SDM top contributing covariates informing habitat-related distribution and abundance
- Add summer distribution map for subadults/adults
- Increase subadults/adults to Level 2

Petrale sole

- Expand EFH text description and provide editorial changes
- Add SDM top contributing covariates informing habitat-related distribution and abundance
- Add summer distribution maps for subadults and adults
- Increase subadults and adults to Level 2

Northern rock sole

- Expand EFH text description and provide editorial changes
- Add SDM top contributing covariates informing habitat-related distribution and abundance
- Add summer distribution maps for settled early juveniles (northern and southern rock soles combined)
- Update summer distribution maps for subadults and adults
- Increase settled early juveniles to Level 3
- Correct pelagic early juveniles to Level 1

Sand sole

- Expand EFH text description and provide editorial changes
- Add SDM top contributing covariates informing habitat-related distribution and abundance
- Add summer distribution map for adults
- Increase adults to Level 2

Slender sole

- Expand EFH text description and provide editorial changes
- Add SDM top contributing covariates informing habitat-related distribution and abundance
- Add summer distribution map for subadults/adults
- Increase subadults and adults to Level 2

Southern rock sole

- Expand EFH text description and provide editorial changes
- Add SDM top contributing covariates informing habitat-related distribution and abundance
- Add summer distribution maps for settled early juveniles (northern and southern rock soles combined)
- Update summer distribution maps for subadults and adults
- Increase settled early juveniles to Level 3
- Correct pelagic early juveniles to Level 1

Starry flounder

- Expand EFH text description and provide editorial changes
- Add SDM top contributing covariates informing habitat-related distribution and abundance
- Add summer distribution maps for settled early juveniles, subadults, and adults
- Increase settled early juveniles to Level 1
- Increase subadults and adults to Level 2

Yellowfin sole

- Expand EFH text description and provide editorial changes
- Add SDM top contributing covariates informing habitat-related distribution and abundance
- Add summer distribution map for settled early juveniles
- Update summer distribution maps for subadults and adults
- Increase settled early juveniles to Level 3
- Increase subadults to Level 2
- Correct pelagic early juveniles to Level 1

<u>Deep water flatfish complex</u>

- Dover sole is a single species representing the complex

Dover sole

- Expand EFH text description and provide editorial changes
- Add SDM top contributing covariates informing habitat-related distribution and abundance
- Update summer distribution maps for subadults and adults

Pacific ocean perch

- Expand EFH text description and provide editorial changes
- Add SDM top contributing covariates informing habitat-related distribution and abundance
- Add summer distribution map for settled early juveniles
- Update summer distribution maps for subadults and adults
- Increase settled early juveniles to Level 3

Northern rockfish

- Expand EFH text description and provide editorial changes
- Add SDM top contributing covariates informing habitat-related distribution and abundance
- Update summer distribution maps for subadults and adults
- Increase subadults to Level 2

Dusky rockfish

- Expand EFH text description and provide editorial changes
- Add SDM top contributing covariates informing habitat-related distribution and abundance
- Update summer distribution maps for subadults and adults
- Increase subadults to Level 2

Shortraker rockfish

- Expand EFH text description and provide editorial changes

- Add SDM top contributing covariates informing habitat-related distribution and abundance
- Update summer distribution maps for subadults and adults
- Increase subadults to Level 2

Rougheye/blackspotted rockfish

- Combine species in SDM ensemble EFH map by request of stock assessment author
- Expand EFH text description and provide editorial changes
- Add SDM top contributing covariates informing habitat-related distribution and abundance
- Update literature
- Update summer distribution maps for subadults and adults with combined species maps
- Increase subadults and adults to Level 2

<u>Thornyhead rockfish complex</u>

- Dover sole is a single species representing the complex

Shortspine thornyhead rockfish

- Expand EFH text description and provide editorial changes
- Add SDM top contributing covariates informing habitat-related distribution and abundance
- Update summer distribution maps for subadults and adults
- Correct pelagic early juveniles to Level 1

<u>Other rockfish complex demersal subgroup</u>

- Expand EFH text description and provide editorial changes
- Add EFH map for the complex, a compilation of SDM EFH maps for species in the complex, to account for EFH of unmapped species
- Increase species complex to Level 2

Quillback rockfish

- Expand EFH text description and provide editorial changes
- Add SDM top contributing covariates informing habitat-related distribution and abundance
- Add summer distribution map for adults, as previously subadults and adults were combined at Level 1
- Increase adults to Level 2

Yelloweye rockfish

- Expand EFH text description and provide editorial changes
- Add SDM top contributing covariates informing habitat-related distribution and abundance
- Update summer distribution maps for subadults and adults

- Increase subadults and adults to Level 2

Rosethorn rockfish

- Expand EFH text description and provide editorial changes
- Add SDM top contributing covariates informing habitat-related distribution and abundance
- Update summer distribution maps for subadults and adults
- Increase subadults and adults to Level 2

<u>Other rockfish complex slope subgroup</u>

- Expand EFH text description and provide editorial changes
- Add EFH map for the complex, a compilation of SDM EFH maps for species in the complex, to account for EFH of unmapped species
- Increase species complex to Level 2

Greenstriped rockfish

- Expand EFH text description and provide editorial changes
- Add SDM top contributing covariates informing habitat-related distribution and abundance
- Add summer distribution map for adults, as previously subadults and adults were combined at Level 1
- Increase adults to Level 2

Harlequin rockfish

- Expand EFH text description and provide editorial changes
- Add SDM top contributing covariates informing habitat-related distribution and abundance
- Update literature
- Update summer distribution maps for subadults and adults
- Increase subadults to Level 2

Pygmy rockfish

- Expand EFH text description and provide editorial changes
- Add SDM top contributing covariates informing habitat-related distribution and abundance
- Update summer distribution map for subadults/adults
- Increase subadults and adults to Level 2

Redbanded rockfish

- Expand EFH text description and provide editorial changes
- Add SDM top contributing covariates informing habitat-related distribution and abundance
- Update summer distribution maps for subadults and adults

- Increase adults to Level 2

Redstripe rockfish

- Expand EFH text description and provide editorial changes
- Add SDM top contributing covariates informing habitat-related distribution and abundance
- Update summer distribution map for subadults and adults
- Increase subadults and adults to Level 2

Sharpchin rockfish

- Expand EFH text description and provide editorial changes
- Add SDM top contributing covariates informing habitat-related distribution and abundance
- Update summer distribution map for subadults and adults
- Increase subadults and adults to Level 2

Silvergray rockfish

- Expand EFH text description and provide editorial changes
- Add SDM top contributing covariates informing habitat-related distribution and abundance
- Update summer distribution map for subadults and adults
- Increase subadults and adults to Level 2

Atka mackerel

- Expand EFH text description and provide editorial changes
- Add SDM top contributing covariates informing habitat-related distribution and abundance
- Update literature
- Update life history and general distribution
- Add summer distribution map for subadults and adults, as previously subadults and adults were combined
- Increase subadult and adult to Level 2 as previously subadult/adult were combined

<u>Skate Complex</u>

- Expand EFH text description and provide editorial changes
- Add EFH maps for the complex, a compilation of SDM EFH maps for species in the complex, to account for EFH of unmapped species
- Increase species complex to Level 2

Alaska skate

- Expand EFH text description and provide editorial changes
- Add SDM top contributing covariates informing habitat-related distribution and abundance

- Update summer distribution maps for subadults and adults
- Increase subadults and adults to Level 2

Aleutian skate

- Expand EFH text description and provide editorial changes
- Add SDM top contributing covariates informing habitat-related distribution and abundance
- Update summer distribution maps for subadults and adults
- Increase adults to Level 2

Bering skate

- Expand EFH text description and provide editorial changes
- Add SDM top contributing covariates informing habitat-related distribution and abundance
- Update summer distribution maps for subadults and adults
- Increase subadults and adults to Level 2

Big skate

- Expand EFH text description and provide editorial changes
- Add SDM top contributing covariates informing habitat-related distribution and abundance
- Add summer distribution maps for subadults and adults
- Increase subadults and adults to Level 2

Longnose skate

- Expand EFH text description and provide editorial changes
- Add SDM top contributing covariates informing habitat-related distribution and abundance
- Add summer distribution maps for subadults and adults
- Increase subadults and adults to Level 2

<u>Shark Complex</u>

- Spiny dogfish is a single species representing the complex

Spiny dogfish

- Combine species in SDM ensemble EFH map by request of stock assessment author
- Expand EFH text description and provide editorial changes
- Add SDM top contributing covariates informing habitat-related distribution and abundance
- Update literature
- Update summer distribution maps for subadults and adults with combined species maps
- Increase subadults and adults to Level 2

Octopus

- Giant octopus is a single species representing the complex

Giant octopus

- Expand EFH text description and provide editorial changes
- Add SDM top contributing covariates informing habitat-related distribution and abundance
- Add summer distribution map for subadult/adult
- Increase subadults/adults to Level 2

Sculpin

- Remove; sculpin are in the ecosystem component

Squid

- Remove; squid are in the ecosystem component

Forage fish

- Remove; forage fish are in the ecosystem component

Grenadier

- Remove; grenadier are in the ecosystem component

Table 11 lists the levels of EFH information available as a result of the 2023 EFH 5-year Review, for species' life stages and species complexes for target species in the GOA FMP.

Table 11. EFH information levels available by species or species complex and life history stage for groundfish in the GOA FMP. Sebastes spp. pelagic early life stages are grouped.

Species/Complex	Egg	Larvae	Early Juvenile Pelagic	Early Juvenile Settled	Subadult	Adult
Walleye pollock	1	1	1	3	2	2
Pacific cod	0	1	1	3	2	2
Sablefish	0	1	1	3	2	2
Rex sole	1	1	0	1	2	2
Flathead sole	1	1	1	1	2	2
Arrowtooth flounder	1	1	1	1	2	2
Shallow water flatfish complex	1	1	1	1	2	
Alaska plaice	1	1	1	0	2	2

Species/Complex	Egg	Larvae	Early Juvenile Pelagic	Early Juvenile Settled	Subadult	Adult
Butter sole	0	0	0	0	2	
English sole	0	0	0	1	2	2
Pacific sanddab	0	0	0	0	2	
Petrale sole	0	0	0	0	2	2
Northern rock sole	1	1	1	3	2	2
Sand sole	0	0	0	0	0	2
Slender sole	0	0	0	0	2	
Southern rock sole	1	1	1	3	2	2
Starry flounder	0	0	0	1	2	2
Yellowfin sole	1	1	1	3	2	2
Deep water flatfish complex	1	1	0	0	0	0
Dover sole	1	1	0	0	2	2
Pacific ocean perch	1	1	1	3	2	2
Northern rockfish	1	1	1	0	2	2
Dusky rockfish	1	1	1	0	2	2
Shortraker rockfish	1	1	1	0	2	2
Rougheye/blackspotted rockfish	1	1	1	0	2	2
Thornyhead rockfish	0	0	1	0	2	2
Shortspine thornyhead	0	0	1	0	2	2
Other rockfish complex demersal subgroup	0	1	1	0	2	
Quillback rockfish	0	0	0	0	0	2
Yelloweye rockfish	0	0	0	0	2	2
Rosethorn rockfish	0	0	0	0	2	2
Other rockfish complex slope subgroup	0	1	1	0	2	
Greenstriped rockfish	0	0	0	0	0	2
Harlequin rockfish	0	0	0	0	2	2
Pygmy rockfish	0	0	0	0	2	

Species/Complex	Egg	Larvae	Early Juvenile Pelagic	Early Juvenile Settled	Subadult	Adult
Redbanded rockfish	0	0	0	0	2	2
Redstripe rockfish	0	0	0	0	2	2
Sharpchin rockfish	0	0	0	0	2	2
Silvergray rockfish	0	0	0	0	2	2
Atka mackerel	1	0	0	0	2	2
Skate complex	1	1	--	1	2	
Alaska skate	0	0	--	0	2	2
Aleutian skate	0	0	--	0	2	2
Bering skate	0	0	--	0	2	2
Big skate	0	0	--	0	2	2
Longnose skate	0	0	--	0	2	2
Shark Complex	0	0	--	0	0	
Spiny dogfish	0	0	--	0	2	
Octopus	0	0	--	0	0	
Giant octopus	0	0	--	0	2	

2.6 EFH Descriptions for BSAI King and Tanner Crab Species

Amendment 56 to the FMP for Bering Sea/Aleutian Islands King and Tanner Crabs (Crab FMP) updated the EFH descriptions in this FMP as a result of the 2023 EFH 5-year Review.

This section summarizes the new and revised EFH descriptions available in the 2023 EFH 5-year Review to amend this information for crab species in the Crab FMP. The Crab FMP contains EFH component 1 information in Appendix F Essential Fish Habitat and Habitat Areas of Particular Concern.

The focus for EFH component 1 in the 2023 Review was to modernize the 2017 single SDM EFH mapping approach to an SDM ensemble approach as a new foundation to map EFH for the summer distribution of crabs using AFSC RACE-GAP summer bottom trawl survey data. Additional research is required to develop methods to potentially improve the 2017 maps for other seasons, which use fishery dependent data. The Crab FMP contains summer distribution EFH maps from the 2023 Review. Additionally, the FMP contains EFH maps for fall, winter, and spring as available from the 2017 Review; EFH mapping efforts for the 2023 Review did not revise these other seasonal maps and they remain in the FMP.

The Crab FMP identifies five targeted species:

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

The species and life history stages where an SDM EFH map was developed for the Crab FMP in the 2017 and 2023 EFH 5-year reviews is provided, in order to compare the SDM methods and resulting EFH information levels possible (Table 12).

Table 12. Species and life history stages where an SDM EFH map was developed for the Crab FMP in the 2017 and 2023 EFH 5-year reviews for the Aleutian Islands (AI) and the eastern and northern Bering Sea (BS). GAM = generalized additive model, hGAM = hurdle GAM, MaxEnt = maximum entropy model, and ensemble = an SDM ensemble including at most one presence-absence model, two GAMs (Poisson or negative binomial GAM and hGAM) and one MaxEnt, developed as a revised approach to mapping EFH for the 2023 Review.

Species	Region	Life Stage	SDM 2017	EFH Level 2017	SDM 2023	EFH Level 2022
Blue king crab	BS	subadult/adult	hGAM	2	ensemble	2
Golden king crab	AI	subadult/adult	hGAM	2	ensemble	2
Red king crab	AI	subadult/adult	--	--	ensemble	2
Red king crab	BS	subadult/adult	hGAM	2	ensemble	2
Snow crab	BS	subadult/adult	GAM	2	ensemble	2
Tanner crab	BS	subadult/adult	GAM	2	ensemble	2

2.6.1 Summary of EFH review for individual species

An overall summary of the review of EFH information in the Crab FMP and new SDM EFH maps is provided by species with changes to the text descriptions, maps, and information levels (Table 13). Section 2.6.2 lists the changes by species in the FMP.

Table 13. EFH review of Crab FMP species, with changes to the existing EFH text, maps, and information levels. Key: yes = updated the EFH description based on new information; no = did not change due to insufficient information; and e/c = editorial changes or clarifications. Information level text describes any life stage additions and other changes, increases in available EFH information level, and necessary corrections.

Species	Text	Maps	Information Level 1-4
Blue king crab	yes; e/c	yes	correct subadult and adult to Level 2
Golden king crab	yes; e/c	yes	correct subadult and adult to Level 2
Red king crab	yes; e/c	yes	add Level 2 map for subadult/adult in Aleutian Islands; correct subadult and adult to Level 2
Snow crab	yes; e/c	yes	correct subadult and adult to Level 2
Tanner crab	yes; e/c	yes	correct subadult and adult to Level 2

2.6.2 Description of changes for EFH text and maps

A description of the changes that are summarized in Table 13 is provided below for species in the Crab FMP. Changes are listed comprehensively for all crab species, as differences in the recommended changes among species were minimal.

- Expand EFH text description and provide editorial changes
- Add SDM top contributing covariates informing habitat-related distribution and abundance
- Update life history
- Update summer distribution maps for subadults/adults
- Add Level 2 map for red king crab subadult/adult in Aleutian Islands
- Increase Aleutian Islands red king crab subadults/adults to Level 2
- Correct pelagic early juveniles to Level 1
- Correct subadults and adults to Level 2

Table 14 lists the levels of EFH information available as a result of the 2023 EFH Review, for target species in the Crab FMP. Revised EFH maps for BSAI crabs in the 2023 Review are Level 2 where subadult and adult life history stages were combined based on available species data. EFH was not mapped for other crab life stages at this time, although this may be possible for the next 5-year Review.

Table 14. EFH information levels available by species and life history stage for crabs in the Crab FMP.

Species	Egg	Larvae	Early Juvenile (Pelagic)	Early Juvenile (Settled)	Subadult	Adult
Blue king crab	inferred	0	1	0	2	
Golden king crab	inferred	0	0	0	2	
Red king crab	inferred	0	1	0	2	
Snow crab	inferred	0	0	0	2	
Tanner crab	inferred	0	0	0	2	

2.7 EFH Descriptions for Arctic Species

Amendment 3 to the FMP for Fish Resources of the Arctic Management Area (Arctic FMP) updated the EFH descriptions in this FMP as a result of the 2023 EFH 5-year Review.

This section summarizes the new and revised EFH descriptions available in the 2023 EFH 5-year Review to amend this information in the Arctic FMP. The Arctic FMP contains EFH component 1 information in section 4.1.3 Essential Fish Habitat, Appendix A EFH Text Descriptions, and Appendix B EFH Map Descriptions. EFH is only designated for targeted species of an FMP, however the Arctic FMP also identifies habitat descriptions for several ecosystem component species in Appendix D with habitat maps in Appendix E.

The Arctic FMP identifies three managed species:

- Arctic cod
- Saffron cod
- Snow crab

Arctic FMP EFH descriptions consist of text descriptions and maps for the three target species, Arctic cod, saffron cod, and snow crab. New SDM EFH maps were developed for several life stages of each Arctic FMP species by the University of Alaska Fairbanks (UAF) and NMFS AKR (Marsh et al. 2023). The study supporting these updates, *Model-Based Essential Fish Habitat Descriptions for Fish Resources of the Arctic Management Area*, was funded by the Bureau of Ocean Energy Management (BOEM). SDM EFH maps and information to support refined text descriptions for Arctic species represents a substantial update.

Prior to the 2023 EFH review, the Arctic FMP EFH maps were not based on SDMs, but rather survey presence-absence data presented as qualitative maps of distribution for several life stages combined (EFH Level 1). Due to the accelerated rate of climate change in the Arctic, there have been increased efforts to understand this dynamic region with many surveys occurring in recent years. This study developed SDM EFH maps for Arctic FMP species life stages, including Level 1 and Level 3 descriptions and maps, concurrently with the *ensemble study*, to advance Arctic species EFH descriptions and maps current with the state of science for the region (Table 15). In addition, this work compares the area of occupied habitat and habitat-related vital rates for species life stages in warm and cold years as a first step to consider climate change effects on EFH for Arctic species.

The Arctic Management Area includes the Chukchi and Beaufort Seas off Alaska, where ocean currents, wind, and the timing of ice melt largely influence productivity. As most biological surveys have occurred during the ice-free summers, SDM EFH was developed for the summer season. This study acquired several survey data sets where life stages of Arctic cod, saffron cod and snow crab were included and separated by life stage, including larval, early juvenile (age-0 or immature), subadult (juvenile or adolescent females and males), and mature (adult or mature females and males). They also assembled and developed a variety of ecologically meaningful habitat covariates (e.g., depth, seafloor terrain, sediment, currents, and temperature). SDMs (MaxEnt), used in a similar approach to the *ensemble study* in the 2023 Review, were developed for all life stages of all species where possible. This study also integrated SDMs with vital rates (temperature-dependent growth rate) for juvenile Arctic and saffron cods from published studies (Laurel et al. 2016) to map EFH Level 3 for these species and life stages.

Table 15. Species and life history stages where an SDM EFH map was developed for the Arctic FMP.

Species	Larvae	Early Juvenile	Juvenile	Adult
Arctic cod	X	X (age-0)	X	X (mature)
Saffron cod	X	X (age-0)	X	X (mature)
Snow crab	-	X (immature)	X (adolescent female, adolescent male)	X (mature female, mature male)

2.7.1 Summary of EFH review for individual species

An overall summary of the review of EFH component 1 information in the Arctic FMP and new SDM EFH maps is provided by species with changes to the EFH text descriptions, maps, and information levels (Table 16). Section 2.7.2 lists the changes by species in the FMP. There is currently no commercial fishing in the Arctic, so fishing effects were not evaluated.

Table 16. EFH review of Arctic species, with changes to the existing EFH FMP text, maps, and information levels. Key: yes = updated the EFH description based on new information; no = did not change due to insufficient information; and e/c = editorial changes or clarifications. Information level text describes any life stage additions and other changes, increases in available EFH information level, and necessary corrections.

Species	Text	Maps	Information Level 1-4
Arctic cod	yes; e/c	yes	add Level 1 text descriptions and maps for larvae, age-0, juvenile, and mature; add Level 3 text description and map for age-0
Saffron cod	yes; e/c	yes	add Level 1 text descriptions and maps for larvae, age-0, juvenile, and mature; add Level 3 text description and map for juvenile
Snow crab	yes; e/c	yes	add Level 1 text descriptions and maps for immature, adolescent female, adolescent male, mature female, and mature male

2.7.2 *Description of changes for EFH text and maps*

A description of the changes that are summarized in Table 16 is provided below for each individual species in the **Arctic** FMP.

Arctic cod

- Expand EFH text description and provide editorial changes
- Add SDM top contributing covariates informing habitat-related distribution and abundance
- Update life history and general distribution
- Update literature
- Update habitat association tables
- Add summer distribution maps for larvae, age-0, juvenile, and mature
- Increase eggs, larvae, and mature to Level 1
- Increase age-0 to Level 3

Saffron cod

- Expand EFH text description and provide editorial changes
- Add SDM top contributing covariates informing habitat-related distribution and abundance
- Update life history and general distribution
- Update literature
- Update habitat association tables
- Add summer distribution maps for larvae, age-0, juvenile, and mature
- Increase eggs, larvae, and mature to Level 1
- Increase age-0 to Level 3

Snow cod

- Expand EFH text description and provide editorial changes

- Add SDM top contributing covariates informing habitat-related distribution and abundance
- Update life history and general distribution
- Update literature
- Update habitat association tables
- Add summer distribution maps for immature, adolescent female, adolescent male, mature female, and mature male
- Increase immature, adolescent female, adolescent male, mature female, and mature male to Level 1

Table 17. EFH information levels available for species and life history stages of species in the Arctic FMP.

Species	Egg	Larvae	Early Juvenile (age-0, immature)	Juvenile (adolescent female, adolescent male)	Adult (mature female, mature male)
Arctic cod	1	1	3	1	1
Saffron cod	1	1	3	1	1
Snow crab	1	0	1	1	1

2.8 EFH Descriptions for Salmon Species

Amendment 17 to the FMP for the Salmon Fisheries in the EEZ off Alaska (Salmon FMP) updated the EFH descriptions in this FMP as a result of the 2023 EFH 5-year Review.

The Salmon FMP identifies five species of Pacific salmon:

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

2.8.1 Description of changes to the Salmon FMP

Salmon EFH refinements were not addressed in the 2023 Review. However, the Salmon FMP was amended to replace the Echave et al. 2012 marine habitat distribution maps with the Echave et al. 2012 EFH maps in Appendix A.

2.8.2 Recommendations for refining salmon EFH in the future

Salmon marine EFH was designated in 1998 as the whole Alaska EEZ. A new methodology to refine the geographic scope of EFH for Pacific salmon life history stages in marine waters off Alaska was developed by the AFSC in 2012 (Echave et al. 2012). Their quantitative model-based approach used the cumulative distribution frequency of survey catch per unit effort and maturity data (1964-2009) with three environmental covariates (sea surface salinity, sea surface temperature, and bottom depth) to estimate the habitat related distribution and density of all five Pacific salmon species for up to three marine life history stages (juvenile, immature, and mature). While their analysis considered salmon marine habitat in the whole Alaska EEZ, the resulting quantitatively-assessed EFH maps represented a more refined area. Appendix A of the Salmon FMP was amended following the 2017 EFH Review to include—

- Revisions to habitat descriptions,
- Updated habitat association tables,
- Added description and maps of salmon marine EFH from Echave et al. (2012), and
- EFH remained at Level 1 designation (although the analysis by Echave et al. (2012) estimated habitat-related density; Level 2 information).

Work is ongoing to update EFH information in the Salmon FMP. ADF&G routinely updates the Anadromous Waters Catalog[24], from which current EFH maps for salmon instream life history stages are derived. Salmon marine life history stage data, environmental data, and SDM methods have advanced since 2012. In progress studies by the University of Alaska Fairbanks (UAF) and NMFS (e.g., Hart et al. 2025) are applying updated data to modern SDMs, demonstrating new understanding of salmon marine habitat-related population structure. We recommend that refining salmon marine EFH is a priority for a future 5-year review. Resources will be required to support these updates.

2.9 EFH Descriptions for Scallop 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. However, only weathervane scallops are commercially harvested in Alaska, and it is the only scallop species for which EFH is described.

In the 2017 EFH Review, the Scallop Plan Team reviewed current definitions of EFH and concluded that no changes to the EFH definitions provided in the FMP were warranted at that time. For the 2023 EFH Review, the Scallop Plan Team did not recommend changes or updates.

3 Component 2: Fishing activities that may adversely affect EFH

As a result of the 2023 EFH 5-year Review, the BSAI, GOA, and Crab FMPs were updated where EFH fishing effects information is described.

For the 2023 EFH 5-year Review, the evaluation of fishing effects on EFH was performed for species of groundfish and crabs, including 27 AI species, 34 EBS species, and 42 GOA species. The methods and process for evaluating fishing effects were developed for the 2017 EFH 5-year Review with guidance from an SSC subcommittee. We used the 2017 methods and process for this review cycle and incorporated recommendations from the SSC February 2022 meeting. In this Section, we provide an overview of the FE evaluation, explain the updated FE model with

[24] ADF&G Anadromous Waters Catalog

changes from the 2017 iteration and brief descriptions of the model inputs, and describe the 2022 FE evaluation process and conclusions.

An updated fishing effects (FE) model was run using updated fishing effort data and the core EFH area (CEA) based on the new EFH component 1 SDM ensemble EFH maps. Stock assessment authors were asked to evaluate species-specific FE model results to determine if impacts to their species' habitat were more than minimal and not temporary. FE model results were assessed by stock assessment authors and species experts, and if the stock was below MSST, ≥ 10% of the CEA was disturbed by fishing gear, or if the stock assessment author chose to, an additional analysis was conducted to determine if the fishing effects to EFH were more than minimal and not temporary. To investigate the potential relationships between fishing effects and stock production, stock assessment authors examined trends in life history parameters and the amount of disturbed habitat in the CEA, identified as the upper 50th percentile of the cumulative distribution of ensemble predicted habitat-related abundance from the SDM EFH maps, for each species using the 2017 FE assessment methodology (NPFMC 2016).

None of the stock assessment authors concluded that fishing effects on their species were more than minimal and not temporary, and therefore none recommended elevating their species to the Plan Teams and the SSC for possible mitigation to reduce fishing effects to EFH. A discussion paper reporting the stock assessment author FE evaluations was prepared for the SSC October 2022 meeting and presented to the Crab Plan Team and Joint Groundfish Plan Teams meetings in September 2022. The SSC found that the 2022 FE evaluation supports the continued conclusion that the adverse effects of fishing activity on EFH are minimal and temporary in nature. The discussion paper was updated after the October 2022 SSC meeting as the *2022 Evaluation of Fishing Effects on Essential Fish Habitat*, made available for the February 2023 Council meeting[25], and published as a NOAA Technical Memorandum (Zaleski et al. 2024). Stock assessment authors also provided future research recommendations (see section 10.6).

3.1 Fishing Effects Background

The EFH regulations base the evaluation of the adverse effects of fishing on EFH on a 'more than minimal and not temporary' standard (50 CFR 600.815). Gear contact from fishing operations may change the abundance or availability of certain habitat features (e.g., the presence of living or non-living habitat structures) used by managed fish species to accomplish spawning, breeding, feeding, and growth to maturity. These changes can reduce or alter the abundance, distribution, or productivity of that species, which in turn can affect the species' ability to "support a sustainable fishery and the managed species' contribution to a healthy ecosystem" (50 CFR 600.10). The outcome of this chain of effects depends on the characteristics of the fishing activities, the habitat, fish use of the habitat, and fish population dynamics. Conducting an analysis considering all relevant factors required the consolidation of information from a wide range of sources and fields of study to focus on the evaluation of the effects of fishing on EFH.

[25] C4 EFH 5-year Review, February 2023 https://meetings.npfmc.org/Meeting/Details/2975

The assessment of fishing effects on EFH is guided by the EFH regulations at 50 CFR 600.815(a)(2) and we highlight and summarize two here:

Fishing activities that may adversely affect EFH—

(i) *Evaluation.* Each FMP must contain an evaluation of the potential adverse effects of fishing on EFH designated under the FMP, including effects of each fishing activity regulated under the FMP or other Federal FMPs. … In completing this evaluation, Councils should use the best scientific information available, as well as other appropriate information sources. Councils should consider different types of information according to its scientific rigor. (Summarized)

(ii) *Minimizing adverse effects.* Each FMP must minimize to the extent practicable adverse effects from fishing on EFH, including EFH designated under other Federal FMPs. Councils must act to prevent, mitigate, or minimize any adverse effects from fishing, to the extent practicable, if there is evidence that a fishing activity adversely affects EFH in a manner that is more than minimal and not temporary in nature, based on the evaluation conducted pursuant to paragraph (a)(2)(i) of this section and/or the cumulative impacts analysis conducted pursuant to paragraph (a)(5) of this section. … FMPs must explain the reasons for the Council's conclusions regarding the past and/or new actions that minimize to the extent practicable the adverse effects of fishing on EFH. (Summarized)

During the 2017 EFH 5-year Review, NMFS contracted with Alaska Pacific University (APU) to develop the FE model to estimate benthic habitat disturbance from commercial fishing activities. Producing the FE model results was one step in a multilayered process to fulfill the requirements of FE evaluation set forth by EFH regulations.

3.2 Fishing Effects Model Description

Updates to the FE model were made in 2022 and were presented at the February 2022 SSC meeting. The full FE model description can be found in the 2022 Evaluation of Fishing Effects on Essential Fish Habitat (Zaleski et al. 2024).

3.2.1 Model input parameters

FE model input parameters are described in detail in Zaleski et al. 2024. This summary focuses on the following parameters:

- Fishing effort
- Gear parameters
- Habitat categorization
- Susceptibility and recovery

Fishing effort is derived from VMS data automatically collected onboard nearly all commercial fishing vessels in the North Pacific. It is based on the NMFS AKR’s catch-in-areas (CIA) database which contains spatial data of all fishing activities in the North Pacific. Each VMS path is truncated to reflect only fishing activity and not steaming; this includes both observed and unobserved paths, where the observed paths are truncated based on observer records and unobserved paths are truncated using a filtering process to identify likely fishing activity based on the vessel's speed and location. See Section 3.3.3 for discussion on using only observed trips versus using both observed and unobserved trips. During the 2017 EFH Review, both observed and unobserved fishing effort data were included.

Gear parameters are the input parameters relating to different fishing gears used in the FE model. They are the nominal width of the gear and the contact adjustment, which is the assumed direct contact of the gear to benthic habitat. For example, non-pelagic trawls have bottom contact adjustments of 1.0 (full contact, with consideration for gear width) while longline gear will have a smaller proportion of bottom contact compared to their VMS footprint. All the gear parameters used in the FE model can be found in the Gear Parameter Table (Appendix 2, Zaleski et al. 2024). Following an SSC recommendation from February 2022, NMFS AKR in-season management personnel reviewed the fishery definitions in the Gear Parameter Table and their edits were incorporated.

Habitat categorization uses sediment type as a proxy for habitat types. The 2017 FE model used over 250,000 sediment records for the BSAI and GOA. The 2022 FE model added more sediment data including dbSEABED[26]. Spatial models of habitat features may improve habitat categorization (e.g., Rooper et al. 2014). Future updates may include spatial models of habitat features into the FE model workflow. However, sediment-based categories are the best available science for this iteration.

Susceptibility is the proportion of habitat disturbed if contacted by fishing gear while **recovery** is the proportion of disturbed habitat that transitions to undisturbed habitat from one time step to the next. Susceptibility is based on both the underlying habitat and the gear type. Recovery is based on the sediment assuming different recovery dynamics for different sediment classes. For a single fishing activity the proportion of habitat impacted within a grid cell and time step is the product of the swept area ratio, contact adjustment, and susceptibility. Both susceptibilities and recovery values used here are drawn from the Grabowski et al. (2014) global meta-analysis of benthic susceptibility and recovery. They are parameterized for 26 habitat features (e.g., sponges, macroalgae, and boulder piles) and, for susceptibility, by each gear-habitat combination. See the 2022 Evaluation of Fishing Effects on Essential Fish Habitat for the supplementary susceptibility and recovery tables (Appendix 3, Zaleski et al. 2024).

3.2.2 Sensitivity analysis

During initial development of the model, the contact adjustment, susceptibility, and recovery parameters were chosen to include random variables from uniform distributions with the intent that running multiple iterations of the model would allow for estimation of uncertainty. The key source of uncertainty unaccounted for in this stochastic approach is either 1) potential bias in the parameter estimates, or 2) misspecification of model parameters. To evaluate these potential uncertainties, we ran several versions of the FE model to find the minimum and maximum estimates of habitat disturbance. This involved fixing certain model parameters or omitting them to find representative estimates for "fishing footprint", "benthic footprint", and "impacted footprint". The ranges of estimated habitat disturbance, as well as the footprint results,

[26] http://instaar.colorado.edu/~jenkinsc/dbseabed/

are reported in Table 2 of the 2022 Evaluation of Fishing Effects on Essential Fish Habitat (Zaleski et al. 2024).

3.3 Fishing Effects Model Changes

As stated above, the FE model was updated between the 2017 and 2022 iterations. Intuitive updates include adding 5 more years of VMS track data, updating sediment and habitat information, and, when applying the FE model outputs to species-specific CEAs, using the new SDM ensemble maps. There were also changes to the model that were more than applying the best available science. This section will review code correction to the FE model, the added habitat feature to incorporate longer recovery times, and the comparison of VMS data from observed trips or from all trips. The third topic did not result in changes to the model, but it had sparked interest in a potential change and was discussed by the SSC during the February 2022 meeting.

3.3.1 Fishing effects model code correction

The 2017 FE model was developed and is run on a combination of Python and R code. The 2017 EFH 5-year Review was the initial implementation of the model, and, since 2017, APU has made various updates and improvements with an aim toward flexibility and efficiency. In 2018, an error was discovered in the 2017 model code that transposed the susceptibility for trawl and longline gears. Because susceptibility is generally higher for trawls than longlines, the effect was an underestimation of impacts from trawls and an overestimation of impacts from longlines. The total footprint of trawling throughout the North Pacific is much greater than the footprint of longlines, so the net effect of transposing the susceptibilities result was an underestimation of habitat disturbance (Figure 2), with the largest difference evident in the Bering Sea. The differences between the outputs in Figure 2 due to the correction made to properly attribute susceptibility to trawl and longline, as well as updates to the Gear Parameter Table. APU’s FE model code is available upon request.

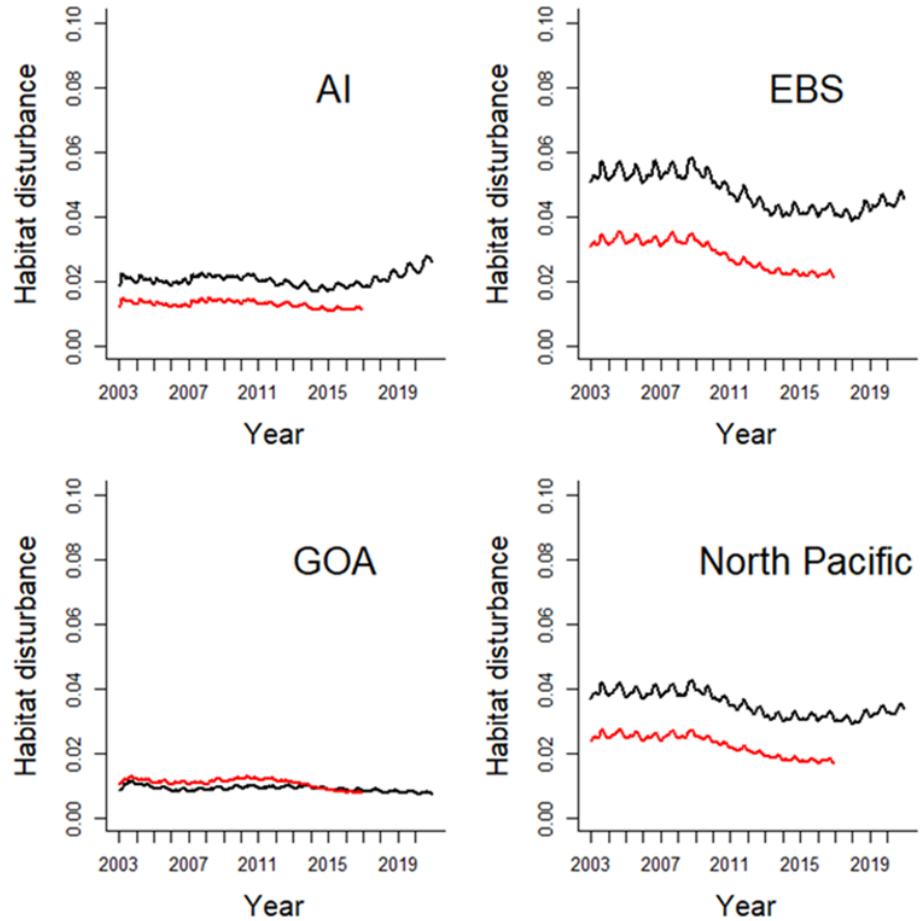

Figure 2. Comparison of 2017 (red lines) and 2022 (black lines) fishing effects (FE) model outputs among subregions and the North Pacific at large.

3.3.2 Incorporation of longer recovery times

During the 2017 EFH Review, it was noted deep-sea corals may have underestimated recovery times that incorrectly reflect results of recent studies. To include these long-lived/slow recovering corals, the SSC suggested adding an additional habitat category for rocky and cobble habitats > 200 m depth where these long-lived corals were likely to be found. Video analysis of transects from three NMFS AI cruises in 2003-2004 indicated that corals have the highest density at depths of 400 to 700 m with bedrock or cobbles substrates, moderate to very high roughness, and slopes greater than 24 percent. To be precautionary, a new habitat feature for the long-lived corals was defined as cobble or boulder habitats deeper than 300 m. The long-lived corals were assigned a mean recovery time of 10 - 50 years and identified as “deep/rocky” habitats.

3.3.3 Comparison of VMS data: all versus observed-only

During the 2017 EFH review, both observed and unobserved fishing effort data were included in the analysis. However, visual examination of the unobserved fishing activity in the CIA database revealed that the VMS filtering was likely overestimating fishing activity by identifying and labeling other activities like travel between fishing locations as active fishing. As a consequence, including unobserved data likely leads to an overestimation of fishing impacts, however excluding it results in an underestimation (Figure 3). For the current review, the FE model was run using the full VMS data and the observed-only VMS data to provide a comparison for each species-specific model output. The reported model results in the 2022 Evaluation of Fishing Effects on Essential Fish Habitat use both observed and unobserved fishing data per the SSC's request.

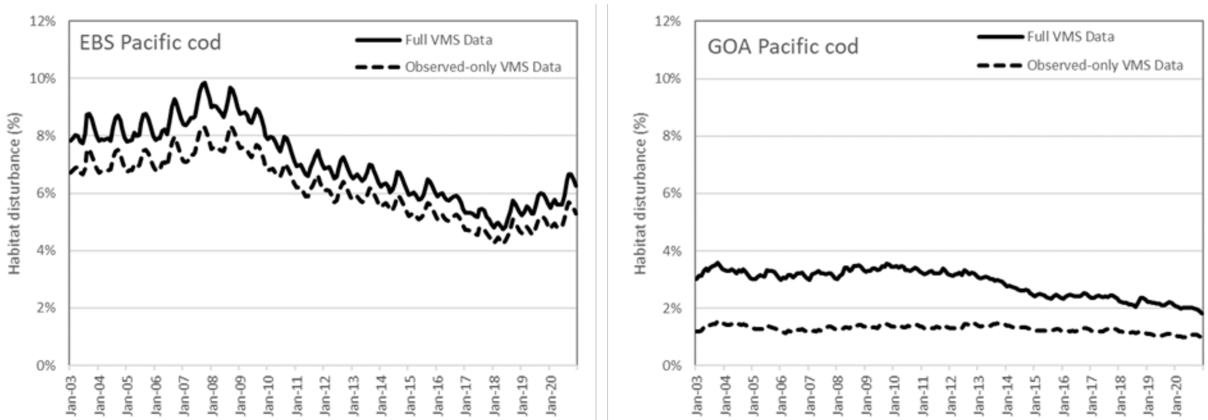

Figure 3. Estimated core EFH area (CEA) disturbance (%) for EBS Pacific cod (left) and GOA Pacific cod (right) using both observed and unobserved VMS data (solid line) and observed-only VMS data (dashed line). Both time series data sets were provided to stock assessment authors for the EFH Fishing Effects Evaluation.

3.4 Stock Assessment Author Fishing Effects Evaluation Process

We requested stock assessment authors assess the impacts of commercial fishing on EFH in Alaska and launched the evaluation process once the FE model runs were completed in April 2022. In 2016, an SSC subcommittee developed the evaluation process for assessment authors to meet the requirements of EFH component 2[27]. This process was used for the 2023 EFH 5-year Review, with adjustments based on the February 2022 SSC review and some improvements. To investigate the potential relationships between fishing effects and stock production, the assessment authors had the opportunity to examine trends in life history parameters and the amount of disturbed habitat in the CEA for each species they assess, as appropriate.

The 2022 FE model was run using the upper 50th percentile CEA from the summer distribution SDM ensemble EFH maps for adults or combined life stages, representing EFH Level 2 information of habitat-related abundance at the population level. We requested assessment authors conduct additional analyses for their stocks in three situations: if their stock is below the minimum stock size threshold (MSST), if the estimated habitat disturbed by fishing in the CEA was ≥ 10%, and/or if they preferred a qualitative analysis of the effects of fishing on their species' habitat rather than the quantitative assessment. The third option was prompted by the SSC during the February 2022 meeting to address assessment author concerns on species with

[27] D1 EFH Fishing Effects Proposed Methods for Analysis, December 2016
https://meetings.npfmc.org/Meeting/Details/474

data limitations. The SSC subcommittee noted that the 10% threshold does not preclude stock assessment authors from completing the evaluation for levels of habitat disturbance less than 10%, so assessment authors were not limited to these situations to perform additional analyses if other data suggested that impacts may be affecting the population.

During the launch of the stock assessment author evaluation process, assessment authors were provided FE model results in the forms of maps, time series graphs, and time series spreadsheets to run any correlative analyses. They were also provided with SDM EFH maps and additional SDM information including comparisons of CEA between the two mapping iterations. They were provided a Google Form (2022 FE Assessment Questionnaire) so that we could receive their input on any analyses run, any concerns with the FE model or data limitations related to the SDM EFH maps, as requested by the SSC, and whether the species should be elevated for possible mitigation from fishing impacts based on their evaluation. They were also provided an opportunity to recommend EFH research activities and raise habitat concerns that would be appropriate for the HAPC process. Details of the full 2022 FE Assessment Questionnaire and stock assessment author evaluation process are included in the 2022 Evaluation of Fishing Effects on Essential Fish Habitat (Appendix 4, Zaleski et al. 2024).

3.5 Fishing Effects Model Results and Evaluations

Due to the extensive nature of the FE model results and subsequent stock assessment author evaluation, the 2022 Evaluation of Fishing Effects on Essential Fish Habitat (Zaleski et al. 2024) presents the results in the following order, which we will summarize below:

- FE model results and summary of stock assessment author concerns
- Species with data limitations and the path forward
- Species with ≥ 10% CEA disturbed

The 2022 Evaluation of Fishing Effects on Essential Fish Habitat also reports the additional assessment author analyses (whether a qualitative or quantitative assessment was provided) for the species with ≥ 10% CEA disturbed in the Results section, and the full assessment author evaluations for all species in the last appendix to that discussion paper. **Ultimately no stock assessment authors recommended to elevate their species for possible mitigation to reduce fishing effects to EFH.**

3.5.1 Fishing effects model results and summary of stock assessment author concerns

FE model results were presented for all species or species complexes in the BSAI, GOA, and Crab FMPs. While the stock assessment authors were provided time series data for each of their species, ranging from 2003 to 2020, the reported results focused on estimates of percent habitat disturbance for December 2020. Those estimates ranged from 0% to 24.8%, using the full VMS data in the FE model. Out of the 103 species with FE results, 16 species had estimates ≥ 10% CEA disturbed, which we list in Section 3.5.3; all others were below 10%, though that did not preclude assessment authors from performing further analyses.

We received 87 responses in the Google Form and via email for individual species and/or stock complexes. Their full responses are provided in the 2022 Evaluation of Fishing Effects on

Essential Fish Habitat. As part of the Google Form, stock assessment authors were able to highlight concerns with data limitations in producing the SDM maps or the FE model. The assessment authors ranked their concerns as *no concern, low (1), medium (2),* or *high (3)* and provided a field to explain. There were 53 responses with *no concern* for the SDM EFH maps and 52 responses with *no concern* and 14 blank responses for the FE model. FE model concerns were reported and ranked low (n = 7), medium (n = 10), and high (n = 4). Some species had 2+ SAs providing feedback and are reflected in those numbers. Concerns with the FE model were under the following themes:

- the SDM EFH maps used for the FE results,
- life history considerations,
- differences between the FE analysis regions and stock management areas,
- regional FE results undervaluing fishing impacts in smaller areas and/or time spans,
- using stock complexes undervaluing fishing impacts to individual species, and
- different measures of FE on not only habitat but fisheries bycatch.

When presented to the SSC in October 2022, the SSC found that the current EFH evaluation methodology is appropriate for the 2023 5-year Review, and they offered recommendations for the next review cycle (SSC Report, October 2022). The SSC noted appreciation for incorporation of feedback from stock assessment authors and the SSC through the process. The SSC encouraged further consideration of what products or areas of research are necessary to satisfy EFH regulatory requirements as compared to what would benefit fishery management more generally. With regard to FE concerns, the SSC recommended:

- consideration during the next 5-year EFH Review cycle of whether subsequent FE evaluations should consider other life stages for which EFH has been defined,
- reporting of species-specific habitat disturbance from the FE model by major gear classes, and
- continued consideration of long-lived benthic habitat features and the extent to which current definitions of depth distribution and recovery times within the FE model are appropriate, and whether they can be refined in the future given available data.

3.5.2 Species with data limitations

Part of the evaluation process for the stock assessment authors was to make a determination if the species should be elevated for mitigation measures against fishing impacts. In all cases, none of the stock assessment authors elevated their species for mitigation measures, though insufficient information to make the decision was noted for nine species. The crab species identified as having insufficient information were AI golden king crab, EBS red king crab, EBS snow crab, and EBS Tanner crab. EBS Tanner crab is the only crab species with an estimated habitat disturbance ≥ 10%. At the September 2022 Crab Plan Team meeting, no resolution was determined for addressing the data limitation concerns. The Crab Plan Team continued this discussion at their meeting in May 2023.

The groundfish species identified as having insufficient information were GOA spiny dogfish and four rockfish species in the GOA Other rockfish complex slope subgroup: greenstriped rockfish, pygmy rockfish, redbanded rockfish, and silvergray rockfish. In order to address the data concerns with GOA spiny dogfish, we recommended combining subadult and adult life history stages for a new EFH map. The resulting estimate of habitat disturbance using the CEA from the combined life stages EFH map did not exceed 10% and no further action was needed. For the GOA Other rockfish complex slope subgroup, we recommended evaluating FE at the individual level for the species not flagged (harlequin rockfish, redstripe rockfish, and sharpchin rockfish), and evaluating FE at the complex level as proxy for all other rockfish species in the slope subgroup. For each species and the species complex subgroup results, no further action was needed. We presented these recommendations to the SSC in October 2022 and they concurred those solutions were an appropriate path forward for this iteration of the EFH 5-year Review. The SSC concluded: *"The SSC supports EFH and FE evaluation for species complexes or by combining data across species' life history stages as necessary to adequately determine EFH and evaluate fishing effects"* (SSC Report, October 2022).

3.5.3 Species with ≥ 10% CEA disturbed

There were 103 species with fishing impacts to EFH assessed for the 2023 EFH 5-year Review. Of those, 16 reached the threshold of ≥ 10% CEA disturbed (Table 18). Stock assessment authors provided both quantitative and qualitative assessments for these species and none were elevated for possible mitigation, though the EBS Tanner crab assessment author concluded there was insufficient information to make the decision to elevate or not elevate for this stock.

During the 2017 EFH 5-year Review, no species had estimated habitat disturbance that was ≥ 10%. Given the changes to the SDM EFH maps and the FE model since 2017, we ran comparisons to identify what changes may have led to the 16 species with ≥ 10% CEA disturbance for the 2023 EFH 5-year Review (Table 18). This was accomplished by comparing estimates of 50% CEA disturbance at November 2016 (the terminal month of the 2017 FE model run) to estimates of 50% CEA disturbance at December 2020, using the 2017 and 2022 CEAs and the corrected 2022 FE model. We found that nine species exceeded the ≥ 10% threshold due to the FE model correction and updates. Two species exceeded the ≥ 10% threshold due to SDM EFH map changes. Three species exceeded the ≥ 10% threshold due to an increase in fishing effort within their CEAs. There were two species without 2017 SDM maps so they did not have comparison results.

Table 18. Species list with an estimated percent core EFH area (CEA) disturbance ≥ 10%. Atka mackerel and giant octopus (bold) were the species where stock assessment authors (SAs) preferred a qualitative assessment due to data limitation concerns.

Species (All EBS)	% CEA disturbed (2022)	SA completed FE assessment?	Elevated for mitigation?	Cause for exceeding 10%
Arrowtooth flounder	10.3%	Yes	No	SDM EFH map
Atka mackerel	**24.8%**	**Yes (Qualitative)**	**No**	**FE model**
Blackspotted/Rougheye rockfish complex	19.9%	Yes	No	*No 2017 SDM*
Giant octopus	**13.5%**	**Yes (Qualitative)**	**No**	**SDM EFH map**
Dover sole	18.8%	Yes	No	FE model
Rex sole	12.0%	Yes	No	FE model
Northern rockfish	14.9%	Yes	No	FE model
Pacific ocean perch	12.8%	Yes	No	FE model
Sablefish	12.4%	Yes	No	Increased fishing
Shortraker rockfish	11.5%	Yes	No	Increased fishing
Shortspine thornyhead rockfish[a]	11.4%	Yes	No	Increased fishing
Aleutian skate	20.3%	Yes	No	FE model
Bering skate	11.1%	Yes	No	FE model
Mud skate	19.0%	Yes	No	FE model
Whiteblotched skate	20.8%	Yes	No	*No 2017 SDM*
Tanner crab	10.9%	Yes	Insufficient Information	FE model

[a] Shortspine thornyhead rockfish represent the Other rockfish complex but are the only representative species for the EBS region.

4 Component 3: Non-MSA fishing activities that may adversely affect EFH

The EFH review considers any fishing activities that are not managed under the MSA that may affect EFH. The effects of non-MSA fishing activities are covered within the discussion of fishing effects on habitat in the 2005 EFH EIS and remain valid. Non-MSA fishing activities include State-parallel fisheries, State-water fisheries, and halibut fisheries managed by the International Pacific Halibut Commission (IPHC) under the Northern Pacific Halibut Act of 1982. The types of gear used by the non-MSA fisheries in Alaska are discussed in detail in the 2005 EFH EIS, as well as their distribution.

Overall the effects of State parallel and State-waters fisheries on EFH are not likely to be substantially different than those discussed in the 2005 EFH EIS because of the nexus between the State harvest levels and fisheries restrictions and the Federal harvest levels and fisheries restrictions, and the ability to adjust the Federal fisheries if needed to mitigate impacts of the State fisheries. With regard to IPHC-managed halibut, the halibut spawning biomass and catch limits were particularly high in the late 1990s, then entered a period of gradual decline during the period when the 2005 EFH EIS was analyzed. The decline continued through 2010, then entered a period of relative stability that continued through 2022. To determine annual catch limits, IPHC reviews stock assessments that includes data on halibut mortality estimates from all sources, including mortalities from directed and non-directed fishing. From this information, IPHC determines a Total Constant Exploitation Yield (TCEY) for the coast-wide stock and apportions catch limits to each of ten regulatory areas. Overall, the effects of halibut fishery are not likely to be substantially different than was analyzed in the 2005 EFH EIS. Therefore, additional analysis or changes to the information in the FMPs for this component were not recommended for the 2023 EFH 5-year Review.

5 Component 4: Non-fishing activities that may adversely affect EFH

As a result of the 2023 EFH 5-year Review, the FMP EFH appendices were revised, where conservation recommendations for non-fishing activities are described.

Federal regulations require FMPs to identify activities other than the act of fishing that may adversely affect EFH (50 CFR 600.815(a)(4)). Non-fishing activities that may adversely affect EFH are diverse and highly variable but include broad categories of sources. Impacts include, but are not limited to excavation in wetlands and watersheds; dredging in rivers, estuaries or coastal zones; armoring shorelines; impoundments or damming streams or rivers; discharge of polluted waters or hazardous materials; introduction of invasive species; and the conversion of aquatic habitat that may eliminate, diminish, or disrupt aquatic ecology and EFH.

The Non-Fishing Impacts Report was first provided in 2005 EFH EIS, Appendix G (NMFS 2005). During the EFH 5-year reviews, NMFS re-examines the science surrounding potential impacts from non-fishing (anthropogenic) activities on EFH (Component 4). NMFS AKR HCD has previously updated the Report in 2011 and 2017 (Limpinsel et al. 2018).

This most recent review is presented in *Impacts to Essential Fish Habitat from Non-Fishing Activities Report, 2018-2023* (Non-Fishing Impacts Report)[28] published as a NOAA Technical Memorandum (Limpinsel et al. 2023). The report's overall purpose is to inform EFH consultations, provide practical conservation recommendations and reduce adverse impacts to EFH and fish while promoting environmentally responsible development. AKR HCD uses the report as a reference document when providing consultations. Other Federal and State action agencies, as well as project proponents, use the report as a reference to better understand EFH, and to design and inform their own EFH assessments in consultation with NMFS. Other organizations, academia, and the public also reference the report to gain understanding of how anthropogenic impacts influence EFH and fish.

[28] C4 EFH 5-year Review, February 2023 https://meetings.npfmc.org/Meeting/Details/2975

5.1 Review Approach and Summary of Findings

Here we present a brief summary of the contents and updates that NMFS made to the Non-Fishing Impacts Report for the 2023 EFH 5-year Review. Much of the original report language and topics remain relevant today, however there have been substantial improvements to the science, technology, and data analysis related to non-fishing impacts. The scientific literature has greatly improved our understanding of the issues. All chapters have been updated to provide the most recent literature and reference seminal papers.

- Chapter 1, Introduction: The introduction provides a discussion of the report's purpose – to guide understanding of the potential adverse effects of non-fishing activities on EFH and provide conservation recommendations to avoid and minimize those effects; a brief history of MSA; EFH; a description of EFH attributes; a review of the EFH consultations process; the role of the NPFMC in the consultation process; tools to support EFH consultations; and an overview of Ecosystem-based Fisheries Management.
- Chapter 2, Climate Change: Climate change is now recognized as an anthropogenic impact and a principle influence that exacerbates all other types of impacts. This chapter discusses how changing atmospheric and oceanic conditions alter EFH across riverine, estuarine and marine systems, and offers conservation recommendations targeting the reduction of methane emissions from petroleum extraction facilities.
- Chapter 3, Watersheds: Previous versions of the report presented wetlands and forests, and streams and rivers in two separate chapters. For 2023, the two chapters are combined into one to capture the full ecosystem functions supporting EFH for Pacific salmon and associated downstream habitat. An often-unrecognized characteristic of watersheds is the relationship between landscape geology and ground and surface water regimes. Chapter updates for 2023 better represent the connection between ground and surface water regimes and how those processes support Pacific salmon overwinter and rearing survival.
- Chapter 4, Estuaries and Nearshore: Sources of potential impacts to EFH in estuarine and nearshore habitat are identified and updated in this version. Impacts are associated with activities such as dredging, the discharge of dredged and fill material, onshore seafood processing waste, infrastructure development and utilities, invasive species, flood control and shoreline stabilization, log transfer facilities, water intake and discharge, aquaculture, energy development, and habitat restoration projects. Recommended conservation measures for each potential source of impact inform project development and proactively mitigate project effects.
- Chapter 5, Offshore: The current science and technology of oil spill response strategies, mechanisms and toxicology of fishes is expanded, cited and relevant recommendations are included.
- Chapters 3-5, Physical, Chemical and Biological Properties Sections: Ecosystem processes from headwater streams to the continental shelf influence the characteristics of EFH attributes. Each of the chapters now includes better updated descriptions of the more widely understood processes and properties across watersheds, nearshore and estuaries, and offshore marine systems.

5.2 Outreach on Non-fishing Effects to EFH

AKR HCD routinely informs stakeholders and the public of EFH consultation requirements through EFH consultation training sessions, posting of NMFS official comment letters, and by making information readily accessible on the AKR EFH website[29]. Continuing these outreach activities provides up-to-date science and any changes in suggested conservation measures within the Non-Fishing Impacts Report.

AKR HCD regularly invites federal, state, tribal, academic, and any interested organizations to attend EFH trainings. These are targeted to the audience and address how the MSA and associated EFH provisions are applied when actions may adversely affect EFH. Trainings may also detail what is required of a federal action agency should they determine their activity may adversely affect EFH resources. In addition, our trainings provide updated resources for the audience, including the Non-Fishing Impacts Report, and introduction to the Alaska EFH Mapper, Nearshore Fish Atlas of Alaska, and the Alaska ShoreZone Mapper tools that we develop and make available as resources for EFH consultations and other habitat science information needs.

AKR HCD also posts correspondence for actions where NMFS has offered comments and conservation recommendations to conserve and enhance EFH. These letters give action agencies, project proponents and the public, examples as to what NMFS may specifically offer as EFH conservation recommendations. Posting occurs on the Environmental Consultation Organizer (ECO) platform[30].

6 Component 5: Cumulative impacts analysis

To the extent practicable, FMPs should analyze how cumulative impacts of fishing and non-fishing activities influence the function of EFH on an ecosystem or watershed scale. The cumulative effects of fishing and non-fishing activities on EFH were considered in the 2005 EFH EIS, but available information was not sufficient to assess how the cumulative effects of fishing and non-fishing activities influence the function of EFH on an ecosystem or watershed scale. As noted in all versions of the Non-Fishing Impacts Report, the cumulative effects from multiple non-fishing anthropogenic sources are recognized as having synergistic effects that may degrade EFH and associated ecosystem processes that support sustainable fisheries (Limpinsel et al. 2023). For fishing impacts to EFH, the FE model calculates habitat reductions at a monthly time step since 2003 and incorporates susceptibility and recovery dynamics, allowing for an assessment of cumulative effects from fishing activities, for the first time in the 2017 EFH 5-year Review, and updated in the 2023 Review. Additionally, the cumulative impacts of fishing activities are evaluated in the Supplemental Information Report (SIR) to the Alaska Groundfish Fisheries Programmatic Environmental Impact Statement. Cumulative impacts are considered throughout this summary report and in the analytical documents produced for the 2023 EFH 5-year Review.

[29] https://alaskafisheries.noaa.gov/habitat/efh
[30] https://www.fisheries.noaa.gov/resource/tool-app/environmental-consultation-organizer-eco

7 Component 6: Conservation and enhancement

FMPs must identify actions to encourage the conservation and enhancement of EFH, including recommended options to avoid, minimize, or compensate for adverse impacts. Habitat conservation and enhancement recommendations address fishing and non-fishing threats to EFH and HAPC. NMFS conducts EFH consultations and makes conservation recommendations for non-fishing activities. Since NMFS is not an action agency for non-fishing activities, actions are hard to predict. However, NMFS acts to expand EFH consultation via EFH conservation and enhancement recommendations in particular for larger projects. For the 2023 EFH 5-year Review, NMFS revised the EFH conservation recommendations for non-fishing activities in the Non-Fishing Impacts Report (Limpinsel et al. 2023) under EFH component 4 and updated the FMPs with this information.

As part of the evaluation of EFH, the Council has adopted a number of mitigation measures in the fisheries to provide additional protection to EFH. Since the 2005 EFH EIS, the Council and NMFS have implemented several management measures to minimize impacts to EFH. New information was available from the FE model and FE evaluations to understand fishing effects on EFH for the 2023 5-year Review and the FMPs were updated with this information.

Further, the FE model and EFH FE evaluation are tools for determining whether past EFH conservation and enhancement measures are sufficient to maintain minimal and temporary impacts to EFH and to look at the cumulative effects of all fishery management measures on EFH. The Council reviewed the 2022 FE analysis, the stock assessment author's independent FE evaluations, and public comment in concluding that no additional measures were required at this time. At any time, with new information and specific need, the Council can initiate action to conserve and enhance EFH. For example, the Council is currently considering an action to protect Tanner crab habitat in the GOA[31].

7.1 Existing Conservation and Enhancement Measures

Since 2005, the Council has adopted several closure areas to conserve EFH, to minimize the effects of fishing on EFH, and specifically address concerns about the impacts of bottom trawling on benthic habitat (particularly on coral communities). All of the area closures in Figure 4 are explained on the NMFS AKR website[32].

Northern Bering Sea Research Area: In 2008, NMFS implemented Amendment 89 to the BSAI FMP, which established habitat conservation measures that prohibit nonpelagic trawl gear in certain waters of the Bering Sea subarea and the Northern Bering Sea Research Area (73 FR 43362, 7/25/08). The action provides protection to bottom habitat from the potential effects of nonpelagic trawling.

Aleutian Islands Habitat Protection Areas and Aleutian Islands Coral Habitat: The Council and NMFS prohibit all bottom trawling throughout the Aleutian Islands (totaling 277,100 nm^2). This created a suite of "open areas" for fishing to continue, while conserving EFH for select areas from bottom trawling. Further, a series of six discrete areas of especially high-

[31] D2 GOA Tanner Crab Protections, April 2025 https://meetings.npfmc.org/Meeting/Details/3080
[32] https://www.fisheries.noaa.gov/resource/tool-app/habitat-conservation-area-maps

density coral and sponge habitat were closed to all bottom-contact fishing gear (longlines, pots, trawls). These “coral garden” areas, which total 110 nm^2, are essentially marine reserves. To improve monitoring and enforcement of the Aleutian Island closures, a vessel monitoring system is required for all fishing vessels in the Aleutian management area.

Marmot Bay Tanner Crab Protection Area: In January 2014, NMFS issued regulations to implement Amendment 89 to the GOA FMP and to revise current regulations governing the configuration of modified nonpelagic trawl gear (79 FR 2794, 1/16/2014). This rule established a protection area in Marmot Bay, northeast of Kodiak Island, and closed that area to fishing with trawl gear except for directed fishing for pollock with pelagic trawl gear. The closure reduces bycatch of Tanner crab (*Chionoecetes bairdi*) in GOA groundfish fisheries. This rule also requires that nonpelagic trawl gear used in the directed flatfish fisheries in the Central Regulatory Area of the GOA be modified to raise portions of the gear off the sea floor. The modifications to nonpelagic trawl gear used in these fisheries reduce the unobserved injury and mortality of Tanner crab, and reduce the potential adverse impacts of nonpelagic trawl gear on bottom habitat. This rule also made a minor technical revision to the modified nonpelagic trawl gear construction regulations to facilitate gear construction for those vessels required to use modified nonpelagic trawl gear in the GOA and Bering Sea groundfish fisheries.

HAPC: The Council has enacted a number of HAPCs as shown in Figure 5 and Table 19. Other EFH conservation and enhancement measures include restricting or prohibiting bottom contact gears to 16 Named Alaska Seamounts (totaling 5,300 nm^2) in EEZ waters; an area commonly referred to as Bower’s Ridge (totaling 5,330 nm^2); several slope areas containing corals throughout the Gulf of Alaska (totaling 2,100 nm^2); and identifying important habitat areas where concentrations of skate egg cases are found to exponentially high. Specifically, in January 2015, NMFS approved Amendment 104 to the BSAI FMP to identify six areas of skate egg concentration as HAPC (80 FR 1378, 1/9/2015) and set a monitoring priority for these sites. Designating the six areas as HAPC highlighted the importance of early life stage histories for EFH conservation. This action followed the 2010 EFH 5-year Review as a separate regulatory process (NMFS 2012).

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

In October 2009, the Council recommended a gear modification for the Bering Sea non-pelagic trawl flatfish fishery in order to reduce adverse impact to bottom habitat. Amendment 94 to the BSAI groundfish FMP, effective January 20, 2011, required the use of modified trawl gear in the Bering Sea flatfish nonpelagic trawl fishery to protect benthic habitat in a portion of the

Bering Sea. A section of the Northern Bering Sea Research Area, identified as the Modified Gear Trawl Zone, was opened to targeted trawl fishing for any species. The boundary of the St. Matthew Island Habitat Conservation Area was modified to further protect blue king crab habitat. References to the Crab and Halibut Protection Zone were removed from the BSAI FMP, and additional blue king crab habitat conservation measures were taken as a joint amendment package for the BSAI FMP and Crab FMP.

In 2010, NMFS issued a final rule to implement Amendment 94 to the BSAI FMP (75 FR 61642, 10/6/2010). Amendment 94 (1) requires participants using nonpelagic trawl gear in the directed fishery for flatfish in the Bering Sea subarea to modify the trawl gear to raise portions of the gear off the ocean bottom, (2) changed the boundaries of the Northern Bering Sea Research Area to establish the Modified Gear Trawl Zone (MGTZ) and to expand the Saint Matthew Island Habitat Conservation Area, and (3) requires nonpelagic trawl gear to be modified to raise portions of the gear off the ocean bottom if used in any directed fishery for groundfish in the MGTZ. This action reduces potential adverse effects of nonpelagic trawl gear on bottom habitat, protects additional blue king crab habitat near St. Matthew Island, and allows for efficient flatfish harvest as the distribution of flatfish in the Bering Sea changes.

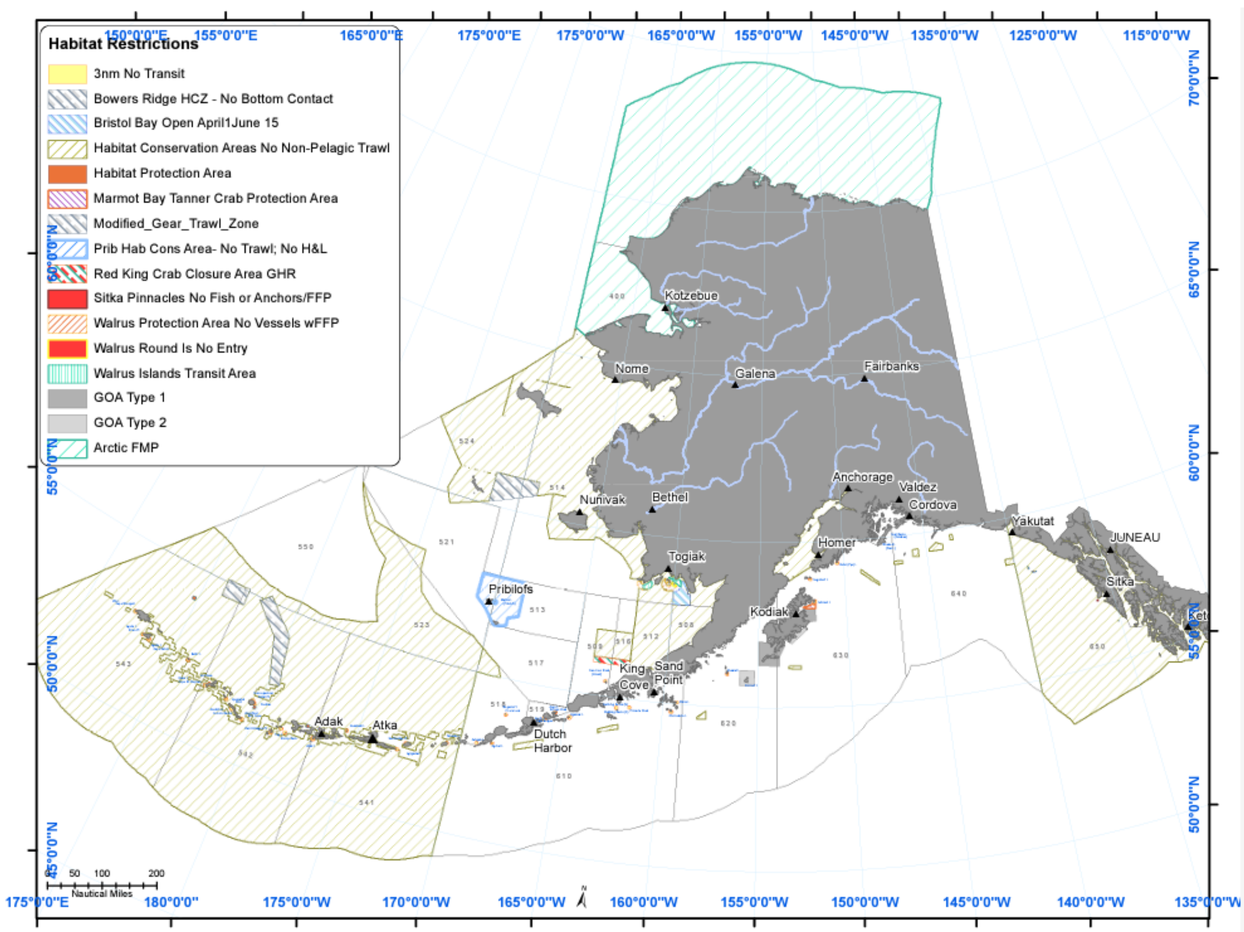

Figure 4. Map of Habitat Restriction Areas off Alaska.

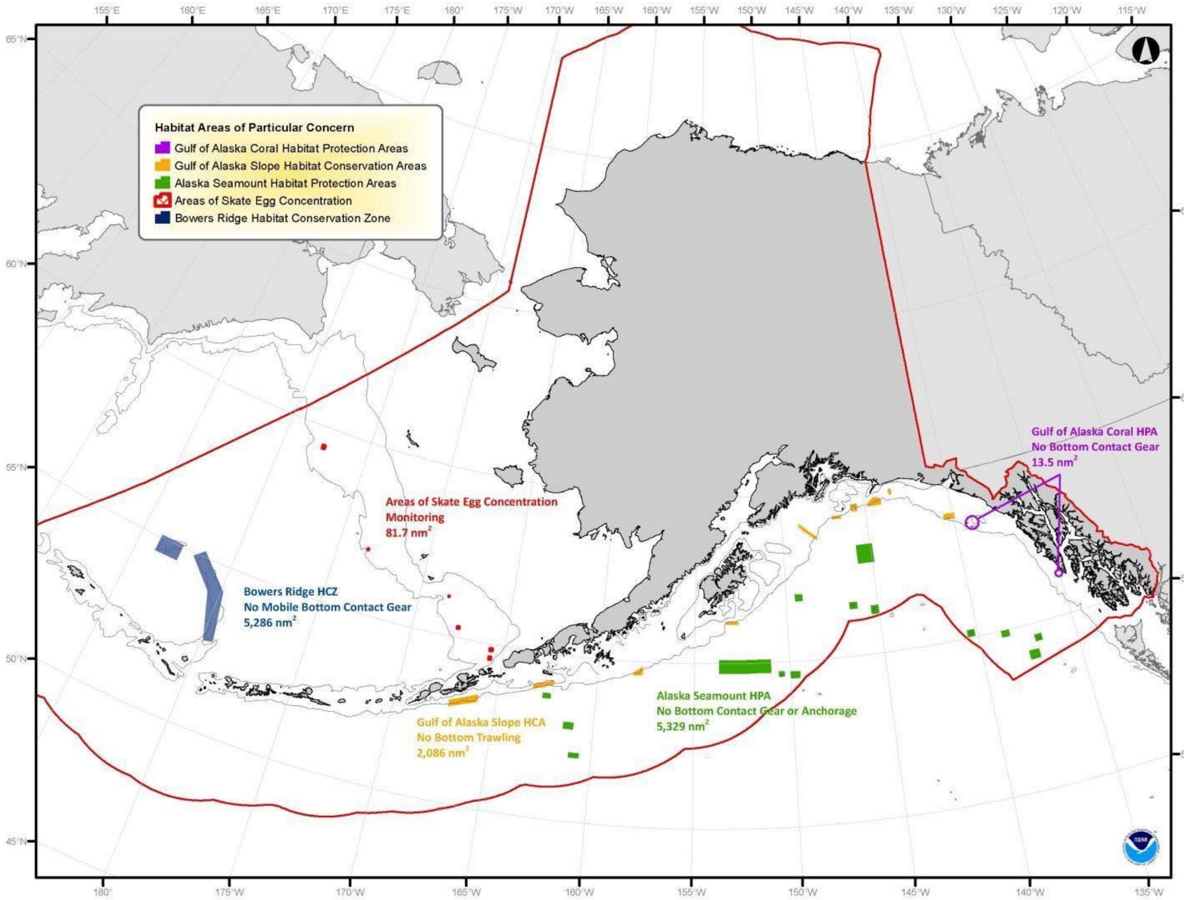

Figure 5. Map of Habitat Areas of Particular Concern in the EEZ off Alaska.

Table 19. Summary of existing habitat protection areas and habitat conservation zones.

HAPC	Individual HAPCs	Total Area Size	Fishery Management Application	Specific Regulation
Alaska Seamount Habitat Protection Areas	Dickens Seamount Denson Seamount Brown Seamount Welker Seamount Dall Seamount Quinn Seamount Giacomini Seamount Kodiak Seamount Odessey Seamount Patton Seamount Chirikof & Marchand Seamounts Sirius Seamount Derickson Seamount Unimak Seamount Bowers Seamount	5,300 nm^2	No federally permitted vessel may fish with bottom contact gear[i]. 50 CFR 679.22(a)(12)	Federal Register 50 CFR Part 679 Volume 71, No.124 Wednesday, June 28, 2006 http://www.fakr.noaa.gov/frules/71fr36694.pdf

HAPC	Individual HAPCs	Total Area Size	Fishery Management Application	Specific Regulation
Bowers Ridge Habitat Conservation Zone	Bowers Ridge Ulm Plateau	5,330 nm^2	No federally permitted vessel may fish with mobile bottom contact gear [ii]. 50 CFR 679.22(a)(15)	Same as above
Gulf of Alaska Coral Habitat Protection Areas	Cape Ommaney 1 Fairweather FS1 Fairweather FS2 Fairweather FN1 Fairweather FN2	14 nm^2	No federally permitted vessel may fish with bottom contact gear [iii]. 50 CFR 679.22(b)(9)	Same as above
Gulf of Alaska Slope Habitat Conservation Areas	Yakutat Cape Suckling Kayak Island Middleton Island east Middleton Island west Cable Albatross Bank Shumagin Island Sanak Island Unalaska Island	1,892 nm^2	No federally permitted vessel may fish with nonpelagic trawl gear [iv]. 50 CFR 679.22(b)(10)	Same as above
Skate Nursery Areas	Bering 1 Bering 2 Bristol Pribilof Zhemchug Pervenets	81.7 nm^2	Monitoring Priority	Federal Register Vol. 80, No.6 Friday, January 9, 2015 http://alaskafisheries.noaa.gov/frules/80fr1378.pdf

8 Component 7: Prey species

As a result of the 2023 EFH 5-year Review, the BSAI, GOA, and Crab FMPs were updated with new prey species information for two species of BSAI sharks, BSAI pollock, GOA Pacific cod, and BSAI red king crab.

The definition of EFH includes waters and substrate necessary to fish for feeding. A loss of prey may have an adverse effect on EFH and managed species because the presence of prey makes waters and substrate function as feeding habitat. Actions that reduce the availability of a major prey species or their habitat may be considered adverse effects on EFH. Therefore, it is necessary to know what habitats the prey of EFH species are utilizing. FMPs should list the major prey species for the species in the fishery management unit and discuss the location of prey species habitat (50 CFR 600.815(a)(7)). Adverse effects on prey species and their habitats may result from fishing and non-fishing activities.

8.1 Prey Component in FMPs

Each FMP for groundfish in the BSAI and the GOA management areas and for BSAI crab includes text on prey species. In both the BSAI and GOA groundfish FMPs, prey information is included in Appendix D under each species' sections on Relevant Trophic Information in text and Habitat and Biological Associations in table form. There is also Table D.3 Summary of predator and prey associations for BSAI groundfish that includes what the fish species are predators to at each life history stage. Similar to the groundfish FMPs, prey information can be found in the Crab FMP in Appendix F under each species' habitat descriptions in sections on Relevant Trophic Information and Habitat and Biological Associations. Appendix F also includes Table 2-3 Summary of predator and prey associations for BSAI crab species. This information, however, does not include the habitat associations of prey species, which may be possible to develop for a future EFH 5-year review.

For the 2023 EFH 5-year Review, stock assessment authors had the opportunity to review and recommend updates to the prey species life history information and tables in the FMPs. We received recommended updates specific to prey information for four species or species complexes (Table 20).

Table 20. Stock assessment author recommendations provided during their review of Component 7 for the 2023 EFH 5-year Review.

FMP	Species	Summary of changes
BSAI Groundfish	Shark complex	• Update salmon shark trophic information text • Update juvenile and adult Pacific sleeper shark prey list in habitat description table
BSAI Groundfish	Walleye pollock	• Update trophic information text
GOA Groundfish	Pacific cod	• Update trophic information text • Update juvenile and adult prey list in habitat description table
BSAI Crab	Red king crab	• Update juvenile prey list in habitat description table

8.2 Prey Information Update

Work is underway to improve prey species information. Here we outline two projects that are building information and resources on prey species habitat and ecosystem connections.

Nearshore Fish Atlas of Alaska (NFAA): The NFAA is a database and ongoing record of the distribution, relative abundance, and habitat use of nearshore fishes in Alaska curated by NMFS (Johnson et al. 2012)[33]. Shallow, nearshore waters are some of the most productive habitats in Alaska and the most vulnerable to human disturbance. Using a beach seine as the primary sampling method, more than 100 fish species in a variety of nearshore habitats have been documented throughout Alaska in an effort to identify EFH. This collection was expanded in 2020 with 25 new fish survey data sets from seven organizations, including and not limited to an

[33] https://www.fisheries.noaa.gov/alaska/habitat-conservation/nearshore-fish-atlas-alaska

additional 3,800 beach seine hauls (total 5,154) and 768 nearshore trawls (total 1,017) from 1995-2018. A peer-reviewed manuscript from the NFAA expansion study demonstrated an SDM method to map EFH and habitat of EFH species' prey at spatial scales relevant to nearshore species habitat associations (Grüss et al. 2021), which could be applied to develop information for a future EFH 5-year review. The NFAA—

- provides a quick reference for identifying species in areas designated for development or impacted by human disturbance (e.g., oil spill);
- provides data for resource managers to identify EFH for FMP species and habitat of EFH species' prey in nearshore habitats;
- provides data for resource managers to prepare biological opinions for ESA species; and
- allows resource managers to track long-term and large-scale changes in fish distribution and habitat use that may result from impacts to nearshore habitats.

2022 AFSC Forage Species Congress: A team of AFSC and AKR staff led a steering committee in early 2022 to host a Forage Species Congress. Forage species are a group of prey species, including herring, capelin, eulachon, shrimp, juvenile fishes, and juvenile invertebrates, that are important food sources to FMP species. The goal was to improve our state of knowledge regarding forage species in Alaska's large marine ecosystems and integrate research efforts across programs. Prior to the Congress, the steering committee identified the following objectives:

- Identify species and species groups that serve important ecosystem roles as forage in Alaska large marine ecosystems;
- Assess forage-related research efforts regarding these species at the AFSC and other institutions;
- Identify major scientific goals for forage research across the AFSC and associated knowledge gaps, and identify paths to improve data collection, analysis, and information-sharing; and
- Provide specific recommendations to Center leadership regarding (1) important ecological and management questions that could be addressed in the next 5-7 years and (2) organization of cross-program forage research.

The Forage Species Congress was held as a two-day event in late March and early April 2022. Drawing from the discussions during presentations and small break-out groups, the steering committee is in the process of providing a summary and future research priorities on forage species to be published as a NOAA Technical Memorandum. Information from the Forage Species Congress may inform a future EFH 5-year review.

8.3 Future Research for Prey of EFH Species

A more comprehensive review and update of EFH component 7 information in the FMPs can be accomplished by engaging with prey species experts in addition to the stock assessment author reviews, to update the prey species information in the FMPs. A first step is to identify and evaluate data gaps in prey species information such as predator-prey relationships, prey distribution, and prey habitat associations. Advancing information for EFH species' prey will, among other management applications, assist NMFS to provide better-informed conservation recommendations in EFH consultations.

EFH component 7 information in the FMPs is categorized as—

- Nearshore: the species utilizes the nearshore marine environment during a key part of its life cycle (e.g., spawning, rearing); and
- Offshore: the species' entire life cycle takes place in the offshore marine environment.

The nearshore marine environment in Alaska is known as some of the most productive fisheries habitat in North America (Arimitsu and Piatt 2008) and is nursery habitat for many FMP species (e.g., gadids, Abookire et al. 2007; flatfishes, Hurst 2016; sablefish Coutré et al. 2015; crabs, Loher and Armstrong 2000; and Pacific salmon, Miller et al. 2016). The productivity of this habitat and the proximity to human development make nearshore prey species habitat the most likely to be affected through direct impacts from human activities (Limpinsel et al. 2023).

In order to advance nearshore habitat and prey species information for the next EFH 5-year review, NMFS included objectives in the revision to the Alaska EFH Research Plan (Pirtle et al. 2024), following the 2023 EFH Review (EFH component 9, Chapter 10).

9 Component 8: Identification of habitat areas of particular concern

Habitat Areas of Particular Concern (HAPC) are important tools for fishery managers. The HAPC process requires the consideration of adverse effects to sensitive and rare habitat areas exposed to stress from fishing or developmental activities. The Council works closely with NMFS, stakeholders, and the public to identify HAPCs and to prepare conservation measures, as needed. The current HAPCs off Alaska are described in section 7.1.

FMPs should identify specific types or areas of habitat within EFH as HAPC based on one or more of the following considerations: importance of ecological function, habitat sensitivity to human-induced degradation, whether development activities are or will be stressing the habitat, and rarity of the habitat. In 2010, the Council outlined its HAPC evaluation criteria[34] and determined that as part of its HAPC process, areas nominated for inclusion must meet at least two of the four considerations, one of which must be the rarity consideration. If the Council chooses to identify a specific habitat type for HAPC consideration, they will solicit nominations. Nominations are reviewed by the SSC and other Council advisory bodies. If an area is designated as HAPC, the Council can determine whether additional management measures should be recommended for that area. The Council can initiate a HAPC process at any time, should a specific need and information arise. This section provides a description of the Council's HAPC identification process.

9.1 Overview

HAPCs are subsets of EFH that highlight specific sites with extremely important ecological functions and/or areas that are especially vulnerable to human-induced degradation

[34] https://www.npfmc.org/wp-content/PDFdocuments/conservation_issues/HAPC/HAPC_eval_210.pdf

(Figure 5). EFH provisions provide a means for the Council to identify HAPCs (50 CFR 600.815(a)(8)) within FMPs. EFH is designated for the managed species identified in the Council's six FMPs. HAPCs are areas within EFH that are rare and are either ecologically important, sensitive to disturbance, or may be stressed. Specific to fishery actions, HAPC are a site-specific management tool for federally managed species that may require additional protection from adverse fishing effects.

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

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

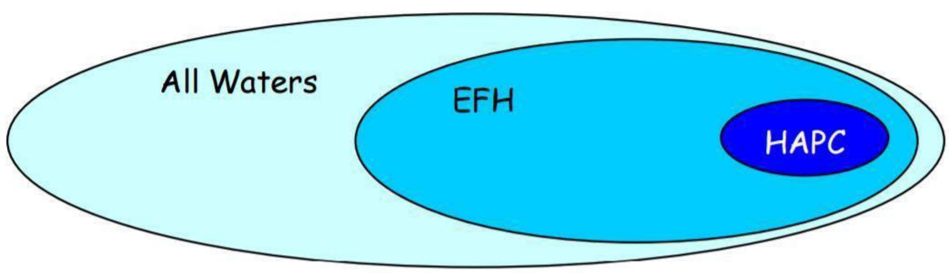

Figure 6. General categories of fish habitat as they relate to the management of federal fisheries in the U.S. EEZ, including all waters, essential fish habitat (EFH), and habitat areas of particular concern (HAPC).

9.2 HAPC Process

HAPCs are those areas of special importance that may require additional protection from adverse effects. 50 CFR 600.815(a)(8) provides that FMPs should identify specific types or areas of habitat within EFH as habitat areas of particular concern based on one or more of the following considerations. However, the Council would consider HAPC that meet at least two of four considerations:

(i) The importance of the ecological function provided by the habitat;

(ii) The extent to which the habitat is sensitive to human-induced environmental degradation;

(iii) Whether, and to what extent, development activities are, or will be, stressing the habitat type; and

(iv) The rarity of the habitat type

Rarity is a mandatory criterion of all Council HAPC proposals.

The HAPC process is initiated when the Council sets management priorities. A subsequent request, or call, for HAPC proposals is issued. A call for proposals is announced during a Council meeting, published in the Federal Register, and advertised in the Council newsletter and other media such as the Council's website[35]. Scientific and technical information on habitat distributions, gear effects, fishery distributions, and economic data are accessible to the public. For example, NMFS AKR's website has a number of valuable tools for assessing habitat distributions, understanding ecological importance, and assessing impacts[36]. Information on EFH distribution, living substrate distribution, fishing effort, catch and bycatch data, gear effects, known or estimated recovery times of habitat types, prey species, and freshwater areas used by anadromous fish is provided in the 2005 EFH EIS (NMFS 2005). The public would be advised of the rating criteria with the call for proposals.

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

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

A socioeconomic review of proposals is conducted by Council or agency economists for socioeconomic impact. The MSA states that EFH measures are to minimize impacts on EFH "to the extent practicable," thus socio-economic considerations have to be balanced against expected ecological benefits at the earliest point in the development of measures. NMFS' Final Rule for developing EFH plans states specifically that FMPs should "identify a range of potential new

[35] https://www.npfmc.org/
[36] https://www.fisheries.noaa.gov/about/alaska-regional-office

actions that could be taken to address adverse effects on EFH, include an analysis of the practicability of potential new actions, and adopt any new measures that are necessary and practicable" (50 CFR 600.815(a)(2)(ii)). In contrast to a process where the ecological benefits of EFH or HAPC measures are the singular initial focus and a later step is used to determine practicability, this approach would consider practicability simultaneously. Proposals are rated as to the extent they identify affected fishing communities and the potential effects on those communities, employment, and earnings in the fishing and processing sectors and the related infrastructure, to the extent that such information is readily available to the public. Management and enforcement provides input during the review to evaluate general management cost and enforceability of individual proposals.

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

9.2.1 Council evaluation criteria for HAPC proposals

The EFH provisions indicate that the Council should identify HAPCs based on one or more of four considerations. The Council has decided as part of its HAPC process, in the FMPs, that HAPCs in Alaska must meet at least two of the four considerations, of which at least one should be the 'rarity' consideration. Proposals are evaluated by the Plan Teams and the SSC based on how they compare against these four considerations. In order to address concerns during a previous HAPC proposal process about how the considerations are to be interpreted, the Council has adopted the following revised HAPC criteria evaluation process (Table 21), which will be used in evaluating submitted proposals nominating HAPC sites.

Table 21. Revised HAPC criteria evaluation process.

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

Factor →	Rarity	Ecological Importance	Sensitivity	Level of Disturbance (applicable to activities other than fishing)
	occurs to some extent in 1 or 2 regions.	provides refugia or substrates for spawning and foraging.	within 10 years. Effects considered temporary, however may be more than minimal.	Short term effects evident.
3	Habitat unique and occurs in discrete areas within only one region.	Complex habitat condition and substrate serve as refugia, concentrate prey, and/or are known to be important for spawning.	Habitat is highly sensitive and slow to recover; exceeds 10s of years. Effects will persist and more than minimal.	Habitat is or will be severely stressed or disturbed by development. Cumulative impacts require consideration from long term effects.

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

9.2.2 Data Certainty Factor and HAPC Ranking System

The Data Certainty Factor (DCF) determines the level of information known to describe and assess the HAPC (Table 22). The DCF is used to determine if information is adequate prior to taking further action. Thus, a HAPC proposal with a high criteria score and a low DCF is to be highlighted (flagged) as a potential candidate for HAPC and for further consideration as a research priority. The DCFs are color coded according to their weight to provide a visual way of informing the criteria scores, i.e., proposal scores with a DCF of 3 are color coded green, scores with a DCF of 2 are color coded yellow, and scores with a DCF of 1 are color coded red.

Table 22. Data Certainty Factors used during proposed HAPC evaluation.

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

HAPC ranking formula provides a color-coded score (sum of criteria scores) to further the proposal along within the immediate HAPC Process. A high ranked HAPC with a DCF of 3 (score color coded green) has a high criteria score and information exists to assess the site. The overall HAPC Proposal Rank is the additive HAPC Criteria Score supplemented with Data Certainty Factor (Table 23).

Table 23. Example evaluation of HAPC proposals.

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

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

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

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

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

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

9.3 History of HAPC Nominations in Alaska

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

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

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

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

The Council received 23 HAPC proposals from six different organizations[37]. The proposals were reviewed by the Plan Teams, and by staff to consider management, enforcement, and socioeconomic issues.

Ultimately, the Council identified a range of alternatives, staff completed an analysis, and the Council established several new HAPCs (71 FR 36694, 6/28/2006). In December 2004, the Council removed one of the proposed HAPC locations near Dixon Entrance for corals within the GOA. The Council became aware that a portion of the Dixon Entrance HAPC lies in disputed waters over which both the United States and Canada claim jurisdiction. Because of territorial concerns, the Council directed staff to remove the Dixon Entrance option from the HAPC consideration. However, the 2005 HAPC review process resulted in the implementation of several HAPC designations in the Gulf of Alaska and the Aleutian Islands in 2006—

- Aleutian Islands Coral Habitat Protection Area,
- Aleutian Islands Habitat Conservation Area,
- Alaska Seamount Habitat Protection Area,
- Gulf of Alaska Coral Habitat Protection Area, and,
- Gulf of Alaska Slope Habitat Conservation Area.

[37] https://alaskafisheries.noaa.gov/sites/default/files/analyses/hapcea102005.pdf

Management measures for these HAPCs were implemented in August 2006.

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

In April 2009, the SSC recommended that the Council consider permanently changing the timeline for consideration of HAPC priorities and candidate sites to align it with the EFH 5-year reviews. In 2010 the Council chose to align the HAPC process with the EFH 5-year review cycle. However, the Council can initiate the HAPC process at any time if a specific need arises.

The next, and most recent, HAPC process was initiated in June 2009 when the Council considered whether to set priorities for identifying HAPCs and re-solicit for HAPC proposals. The Council opted to synchronize the timing of the two actions so that the results from the 2010 EFH 5-year Review could be considered in setting HAPC priorities, and the HAPC proposal cycle that might result. The Council can still initiate the HAPC process at any time if a specific need arises.

In April 2010, the Council identified skate egg deposition and recruitment sites (skate nurseries) as a habitat priority, and initiated a call for proposals for candidate HAPC sites in conjunction with the completion of the 2010 EFH 5-year Review. Any analysis and amendments resulting from the call for proposals were to be implemented through a separate process (NMFS 2012).

In October 2010, the Council selected a HAPC proposal from AFSC for further analysis. The Council reviewed several versions of the analysis and refined the alternatives options before selecting five distinct skate egg deposition sites as HAPC. NMFS staff selected distinct sites where egg cases recruit and are vulnerable to fishing gear contacting the seafloor: egg case prongs (or horns) become entangled in or recruit onto the gear. These sites are discrete areas near the shelf/slope break that serve as important spawning and embryonic development areas for skate species (80 FR 1378, 1/9/2015). In February 2020, the Ecosystem Committee received a report from AFSC researchers on the research conducted on skate nursery areas over the last 17 years and concluded, based on the information provided, that updates to the skate egg concentration HAPCs were not warranted at this time.

In April 2017, the Council considered initiating a HAPC process to coincide with the ongoing, 2017 EFH 5-year Review. Ultimately, the Council chose not to initiate the HAPC process and to maintain status quo; therefore, no calls for HAPC nominations through the proposal process were initiated as part of the 2017 EFH 5-year Review. The Council noted at final action that they had no information about any specific species or sites to warrant initiation of a HAPC process. A map of existing HAPC locations (Figure 5) and the corresponding fishery management applications (Table 19) are provided and available on NMFS AKR's website[38].

[38] https://media.fisheries.noaa.gov/dam-migration/hapc-ak-akr.pdf

9.4 2023 EFH 5-year Review and HAPC Consideration

Currently, the HAPC cycle is designated to be considered by the Council in conjunction with EFH 5-year reviews, or initiated at any time by the Council. During the 2022 FE evaluation, potential, future HAPC recommendations for the Crab FMP were suggested by individual stock assessment authors and endorsed by the Crab Plan Team for possible consideration (Table 24).

Table 24. HAPC recommendations for the Crab FMP from stock assessment authors during the 2022 FE evaluation.

Species	Recommendations
SMBKC/ PIBKC	Activities such as dredging which could remove or substantially alter cobble and shell hash habitat. Any such activities near the Pribilof Islands, St. Matthew Island, or St. Lawrence Island should be evaluated for their potential impact on these important benthic nursery habitats for blue king crab.
WAIRKC	Habitat disturbance is quite high on Petrel Bank, north of Semisopochnoi Island. While the overall spatial scale of this high disturbance area is small relative to the Aleutian Island chain and effects of this disturbance are unknown for WAIRKC populations, it may have significant ecological importance for [red king crab]. Most of the historical WAIRKC stock catch came from the Petrel Bank area; however, the most recent industry-cooperative survey (2016) indicated very low [red king crab] abundance with reduced spatial distribution in this area, likely caused by recruitment failure.

During the 2023 EFH 5-year Review, the Council chose to maintain status quo with respect to HAPC, and therefore, did not initiate a call for HAPC nominations through the proposal process.

10 Component 9: Research and information needs

As a result of the 2023 EFH 5-year Review, the FMP appendices were revised with updated research and information needs (e.g., GOA FMP Appendix H section 8.4).

FMPs should identify recommendations for research that the Council and NMFS view as necessary to improve descriptions and identification of EFH, evaluate impacts to EFH, and develop EFH conservation and enhancement measures (50 CFR 600.815(a)(9)). During each EFH 5-year review, NMFS identifies information gaps and research recommendations. These recommendations inform the Alaska EFH Research Plan, EFH research priorities in the FMPs, and habitat science development for the next, and future, EFH 5-year reviews and other fishery management information needs. This section summarizes the review and update of EFH component 9 in the 2023 EFH 5-year Review.

In addition to the EFH pathways (50 CFR 600.815), NMFS has identified habitat research priorities through other processes. In 2008, the NMFS Science Board recognized the need to improve habitat science. They identified goals, including supplementing stock assessments with ecosystem considerations, improving the descriptions of EFH, and reducing habitat uncertainty. To address these goals, scientists and fishery managers developed the Habitat Assessment Improvement Plan (HAIP) (NMFS 2010). Progress on the goals of the HAIP, the Habitat Assessment Prioritization for Alaska Stocks (McConnaughey et al. 2017), and recommendations for how to integrate EFH and EBFM (Peters et al. 2018), following the first issuance of the NMFS EBFM Policy and Road Map (NMFS 2016a, 2016b), continue to influence NMFS habitat priorities.

Further, the National Standard guidelines of the MSA (50 CFR 600.305) contain several provisions to facilitate the incorporation of EBFM into federal fisheries management. National Standard 2 requires NMFS to conserve and manage fishery resources based upon the best available scientific information.

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

10.1 History of the Alaska EFH Research Plan

10.1.1 Timeline and Process

Previous Alaska EFH Research Plans have guided research to meet EFH mandates in Alaska since 2005. A new EFH Research Plan revises and supersedes these earlier plans, and similar to previous plans, is expected to guide the next several years of research developing new EFH information to support management needs. Revisions of the Alaska EFH Research Plan occurs at the conclusion of an EFH 5-year review. These reviews summarize the status of research contributing new EFH information, which then provides a basis for determining future research directions for a revised research plan. At the conclusion of the 2023 EFH 5-year Review, NMFS published an updated Alaska EFH Research Plan to guide the next several years of EFH research (Pirtle et al. 2024) (section 10.3).

Historic timeline of the Alaska EFH Research Plan (Plan):

- 1996 – EFH research funding began;
- 2006 – First Plan is published (AFSC 2006);
- 2012 – Plan is revised based on the 2010 EFH 5-year Review (Sigler et al. 2012); and
- 2017 – Plan is revised based on the 2017 EFH 5-year Review (Sigler et al. 2017).

10.1.2 2017 Alaska EFH Research Plan

The 2017 Alaska EFH Research Plan (Sigler et al. 2017)) guided research development for the 2023 EFH 5-year Review. The 2017 Plan included five long-term research goals:

- characterize habitat utilization and productivity,
- assess habitat sensitivity and recovery,
- validate and improve fishing impacts model,
- map the seafloor, and
- assess coastal habitats facing development.

The 2017 Plan also identified two near-term research objectives:

> *Objective 1: Develop EFH Level 1 information (distribution) for life history stages and areas where missing.*
>
> *Objective 2: Raise EFH information from Level 1 or 2 (habitat-related densities or abundance) to Level 3 (habitat-related growth, reproduction or survival rates).*

Objective 2 also called for fishery researchers to collaborate with model developers to incorporate new and existing data into regional models, and initiated a process to fund multi-year studies for the first time. NMFS funded several projects since the 2017 EFH 5-year Review under the 2017 Alaska EFH Research Plan to address these timely objectives and provide new information to update EFH component 1 in the 2023 Review and support other EBFM decision support needs.

10.2 EFH Research Since the 2005 EFH EIS

This section provides a general summary of EFH research in Alaska that NMFS has undertaken under the EFH Research Plans, beginning in 2006. Additional studies eliciting habitat information have also been documented in the individual species reviews.

EFH research is coordinated through an annual EFH Research Proposal Process by NMFS AKR HCD and AFSC Habitat and Ecological Processes Research (HEPR) Program. AKR and AFSC conduct a science review of the proposals and assign each a score based on review criteria. After review, the AKR HCD's Assistant Regional Administrator and their Deputy meet to prioritize proposals that show scientific merit, address management emphasis areas, and meet the timely objectives of the Alaska EFH Research Plan. Prioritized proposals are considered for funding, as allocations allow. Prioritized proposals are also submitted to other sources of funding such as the NOAA Fisheries Office of Habitat Conservation's EFH Innovation and Advancement Funds.

EFH as a management pathway benefits from directed research advancing science supporting prioritized information needs. The Alaska EFH Research Plan and proposal review process by AKR and AFSC allows EFH research to undergo peer-review scrutiny, a process implemented first in Alaska. EFH research has struggled from a lack of adequate funding and capacity to address enormous unknowns, such as seafloor mapping and high-resolution marine habitat delineations on the scale of Alaska's five large marine ecosystems. However, this deficiency should not overshadow the exceptional EFH research progress that has been funded in Alaska.

For example, we are currently the only region having developed and applied ensemble species distribution models, to describe and map up to EFH Level 2 (habitat-related abundance), vital rates from laboratory studies to describe and map EFH Level 3 (habitat-related vital rates). We are also currently the only region able to undertake such a comprehensive evaluation of fishing effects to EFH cumulatively, over time, as we are able to do using our CIA database with our FE model and evaluation process. Our methods supporting EFH information development are published in top journals in the field (e.g., Laurel et al. 2016, Copeman et al. 2017, Laman et al. 2018, Smeltz et al. 2019, Rooper et al. 2021, Barnes et al. 2022, Harris et al. 2024) and our work has contributed to other fishery management information needs such as stock assessment (e.g., Shotwell et al. 2022) and spatial management[39]. We are grateful to our research community and to NMFS and the Council for their continued support.

10.2.1 Projects NMFS has funded under the Alaska EFH Research Plan, 2005-2022

On average (2006-2022), NMFS spends $425,000 annually on EFH research projects in Alaska (Figure 7). Note that while not all marine habitat research is funded through the EFH funding process, this section focuses on projects funded by NMFS with EFH funds from the AKR, AFSC, and the Office of Habitat Conservation. We report NMFS funding for research projects supporting the development of new EFH information through 2022, the final year supporting the 2023 EFH 5-year Review. In recent years, the following funding has been available for EFH research (Figure 7). Funded projects address major research themes (Figure 8). Project results are described in annual reports and the peer-reviewed literature. Study results have contributed extensively to EFH information available for 5-year reviews and a wealth of habitat science supporting other fishery management information needs. The specific research projects that NMFS has funded and conducted for advancing EFH information in the North Pacific since the 2005 EFH FEIS is listed in Table 25.

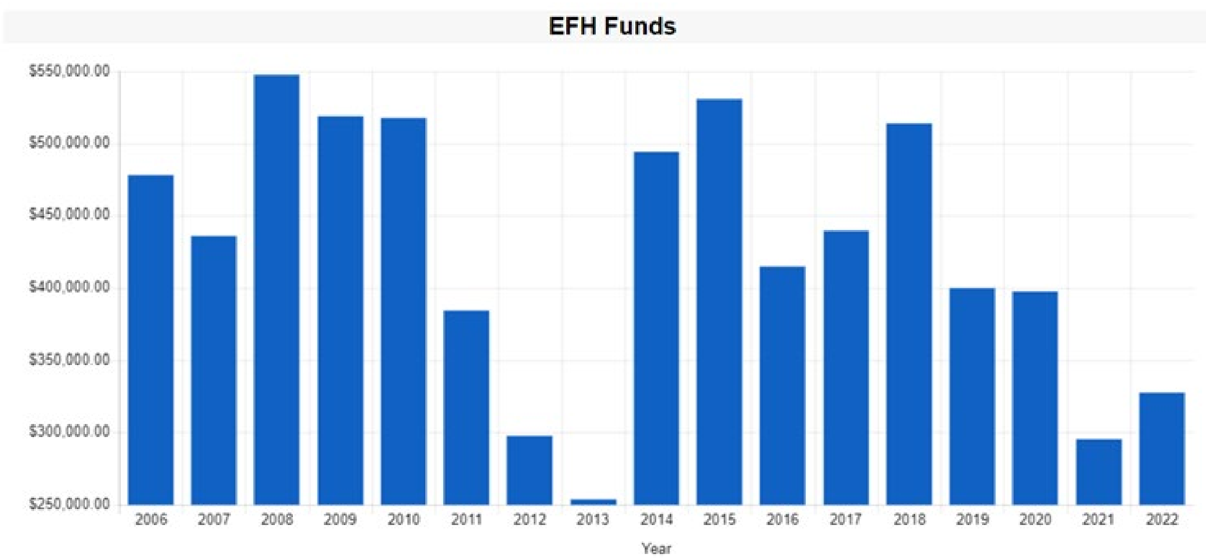

Figure 7. NMFS Alaska EFH Research Plan funding 2006-2022.

[39] For example, SDMs developed by NMFS staff for Council's Bristol Bay red king crab closure areas analysis (C2, February 2024) https://meetings.npfmc.org/Meeting/Details/3029

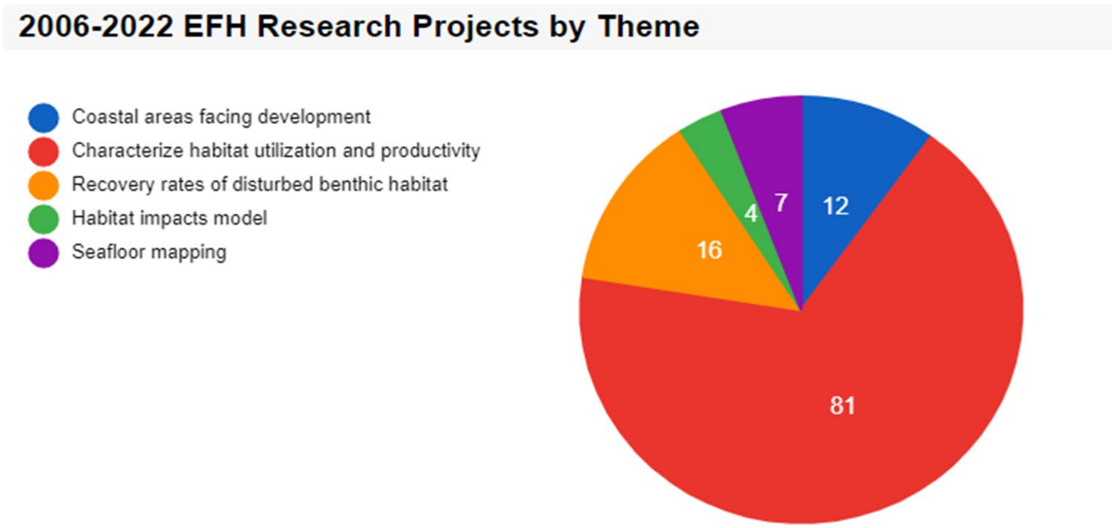

Figure 8. NMFS Alaska EFH Research Plan count of projects funded by research theme 2006-2022.

Table 25. Alaska EFH Research Plan projects funded by NMFS from 2006 through 2022 and resulting publications.

Year(s) Funded	Project Title (when funded)	Publication (complete citation) or *Principal Investigators (if no publication)*
2006	Mapping Long Term Equilibrium Impacts of Fishing and Evaluation of Impacts of Fishing on Fish Condition, Fish Distribution, and Fish Diet	*Aydin, Grieg, Hermann, Hollowed, Ianelli, Rose, Spencer, Stockhausen, Wilderbuer*
2006	Modify trawls to reduce fishing impacts / Better characterize fishing's footprint	ROSE, C. 2006. Development and evaluation of trawl groundgear modifications to reduce damage to living structure in soft bottom areas. Available NOAA Alaska Fisheries Science Center 7600 Sand Point Way NE, Seattle WA 98115.
2006	Assessment of critical habitats for juvenile Pacific cod	LAUREL, B. J., A. W. STONER, C. H. RYER, T. P. HURST, and A. A. ABOOKIRE. 2007. Comparative habitat associations in juvenile Pacific cod and other gadids using seines, baited cameras and laboratory techniques. J. Exp. Mar. Biol. Ecol. 351:42–55.
2006/07	Habitat effects on growth and condition of northern rock sole	HURST, T.P., ABOOKIRE A.A., KNOTH B. 2010. Quantifying thermal effects on contemporary growth variability to predict responses to climate change in northern rock sole (*Lepidopsetta polyxystra*) Can. J. Fish. Aquat. Sci. 67: 97–107.
2006	Essential Fish Habitat Requirements For Skate Nurseries	HOFF, G. R. 2010. Identification of skate nursery habitat in the eastern Bering Sea. Mar. Ecol. Prog. Ser. 403:243–254.
2006	Convene a workshop to plan for the development of a habitat data inventory system for the AFSC	*Heifetz, McConnaughey, Olson*
2006	Essential Fish Habitat - Overwinter habitat use and energy dynamics of juvenile capelin, eulachon, and Pacific herring	*Vollenweider, Hudson, Heintz*
2006	Juvenile Rockfish Habitat Utilization	ECHAVE, K. B., J. L. PIRTLE, J. HEIFETZ, AND S. K. SHOTWELL. In press. Cautious considerations for using multiple covariate distance sampling and seafloor terrain for improved estimates of rockfish density. Mar Ecol Prog Ser. accepted November, 2022.
2006	Nearshore Essential Fish Habitat-Seasonal Fish Use, Mapping, GIS Database	JOHNSON, S. W., A. D. NEFF, J. F. THEDINGA, M. R. LINDEBERG, and J. M. MASELKO. 2012. Atlas of nearshore fishes of Alaska: a synthesis of marine surveys from 1998 to 2011. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-239, 261 p.
2006	Food habits and small scale habitat utilization of Atka mackerel in the Aleutian Islands, Alaska	RAND, K.M., and S.A. LOWE. 2011. Defining essential fish habitat for Atka mackerel with respect to feeding within and adjacent to Aleutian Islands trawl exclusion zones. Mar. Coastal Fish. 3:21-31.
2006	Log transfer facilities	*Miller, Shaw, Rice, Hudson*
2007	Habitat Specific Production of Pacific Ocean Perch in the Aleutian Islands	BOLDT, J.L. and C.N. ROOPER. 2009. An examination of links between feeding conditions and energetic content of juvenile Pacific ocean perch in the Aleutian Islands. Fishery Bulletin 107:278–285.
2007	Recovery of a sessile invertebrate of the Bering Sea shelf from trawling	ROSE C.S., E. MUNK C.F. HAMMOND, A. STONER. 2010. Cooperative Research to Reduce the Effects of Bering Sea Flatfish Trawling on Seafloor Habitat and Crabs. AFSC Quarterly Report (January February March 2010). 1–6.
2007	Temporal dynamics of habitat use in juvenile Pacific cod	LAUREL, B.J., C.H. RYER, B. KNOTH, and A.W. STONER. 2009. Temporal and ontogenetic shifts in habitat use of juvenile Pacific cod (Gadus macrocephalus). J. Exp. Mar. Biol. Ecol. 377:28–35.

Year(s) Funded	Project Title (when funded)	Publication (complete citation) or *Principal Investigators (if no publication)*
2007	Mapping and Fish Utilization of Coastal Habitats Vulnerable to Disturbance from Development and Climate Change	*Johnson, Thedinga, Lindeberg, Harris*
2007	Juvenile Pacific ocean perch habitat utilization	*Malecha, Gray, Lunsford*
2007	Habitat Influence on Rearing Condition and Overwinter Survival of Juvenile Capelin (*Mallotus villosus*)	*Vollenweider, Hudson, Heintz, Calvert*
2007	Biological parameters to estimate the recovery of disturbed benthic habitat in Alaska, study A: Coral growth	*Stone, Andrews, Lehnert, France*
2007	Biological parameters to estimate the recovery of disturbed benthic habitat in Alaska, study C: Coral genetics	*Stone, Andrews, Lehnert, France*
2008	Nearshore Fish and Habitat Assessment	JOHNSON, S. W., A. D. NEFF, J. F. THEDINGA, M. R. LINDEBERG, and J. M. MASELKO. 2012. Atlas of nearshore fishes of Alaska: a synthesis of marine surveys from 1998 to 2011. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-239, 261 p.
2008	Productivity, habitat utilization and recruitment dynamics of Pacific cod	LAUREL, B. J., C. H. RYER, B. KNOTH, and A. W. STONER. 2009. Temporal and ontogenetic shifts in habitat use of juvenile Pacific cod (Gadus macrocephalus). J. Exp. Mar. Biol. Ecol. 377:28–35.
2008	Contrasting predation intensity and distribution in two rock sole nursery areas	RYER, C. H., B. J. LAUREL, and A. W. STONER. 2010. Testing the shallow water refuge hypothesis in flatfish nurseries. Mar. Ecol. Prog. Ser. 415:275-282.
2008	Physical and temporal aspects of pollock spawning habitat utilization	BACHELER, N. M., L. CIANNELLI, K. M. BAILEY, and J. T. DUFFY-ANDERSON. 2010. Spatial and temporal patterns of walleye pollock (*Theragra chalcogramma*) spawning in the eastern Bering Sea inferred from egg and larval distributions. Fish. Oceanogr. 19(2):107–120.
2008	Habitat characterization and utilization of early benthic phase red king crab	*Persselin, Stoner, Foy, Eckert*
2008	Habitat Influence on Rearing Condition and Overwinter Survival of Juvenile Capelin	*Vollenweider, Hudson, Heintz, Calvert*
2008	Rockfish abundance and diurnal habitat associations on isolated rocky habitat in the eastern Bering Sea	ROOPER, C. N., G. R. HOFF, and A. De ROBERTIS. 2010. Assessing habitat utilization and rockfish (*Sebastes* spp.) biomass on an isolated rocky ridge using acoustics and stereo image analysis. Can. J. Fish. Aquat. Sci. 67:1658–1670.
2008	Characterization of Benthic Infauna Community for Modeling Essential Fish Habitat in the Eastern Bering Sea	YEUNG, C., M-S. YANG, and R. A. McCONNAUGHEY. 2010. Polychaete assemblages in the south-eastern Bering Sea: Linkage with groundfish distribution and diet. J. Mar. Biol. Assoc. U-K. 90:903–917.
2008	Juvenile slope rockfish habitat distribution	*Malecha, Gray, Lunsford, Clausen*
2009	New Methodology to Describe EFH for Salmon in Marine Waters	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. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-236, 104 p.
2009	Recovery of deep water sponges and sea whips from bottom trawling	MALECHA, P., HEIFETZ J. 2019. Long-term effects of bottom trawling on large sponges in the Gulf of Alaska. Cont. Shelf Res. 150: 18–26.
2009	Invertebrate colonization of PMEL moorings	*Zimmermann, Floering, Van Syoc, Stabeno*

Year(s) Funded	Project Title (when funded)	Publication (complete citation) or *Principal Investigators (if no publication)*
2009	Recruitment and response to damage of an Alaskan gorgonian coral	*Malecha, Shotwell, Ammann*
2009	Nearshore Fish Assemblages in the Arctic: Establishment of Monitoring Sites in a Rapidly Changing Environment from Energy Development and Climate Change	JOHNSON, S. W., THEDINGA, J. T., NEFF, A. D., HOFFMAN, C. A. 2010. Fish fauna in nearshore waters of a barrier island in the western Beaufort Sea, Alaska. NOAA Tech. Memo. NMFS-AFSC-210.
2009	Contrasting predation intensity and distribution in two rock sole nursery areas: a principle factor controlling nursery productivity - Component A	RYER, C. H., B. J. LAUREL, and A. W. STONER. 2010. Testing the shallow water refuge hypothesis in flatfish nurseries. Mar. Ecol. Prog. Ser. 415:275–282.
2009	Characterization of Benthic Infauna Community for Modeling Essential Fish Habitat in the Eastern Bering Sea - Reduced plan	YEUNG, C., M-S. YANG, and R. A. McCONNAUGHEY. 2010. Polychaete assemblages in the south-eastern Bering Sea: Linkage with groundfish distribution and diet. J. Mar. Biol. Assoc. U-K. 90:903–917.
2009	Assessing the physical and temporal aspects of pollock spawning habitat utilization in Shelikof Strait, Gulf of Alaska	DOUGHERTY, A., K. BAILEY, T. VANCE, and W. CHENG. 2012. Underlying causes of habitat-associated differences in size of age-0 walleye pollock (*Theragra chalcogramma*) in the Gulf of Alaska. Mar. Biol. 159:1733–1744.
2009/10	Productivity, habitat utilization and recruitment dynamics of Pacific cod	LAUREL, B. J., KNOTH, B. A., & RYER, C. H. (2016). Growth, mortality, and recruitment signals in age-0 gadids settling in coastal Gulf of Alaska. ICES J. Mar. Sci. 73(9): 2227–2237.
2009	Characterize habitat utilization and productivity for rockfish species	ROOPER, C. N., G. R. HOFF, and A. De ROBERTIS. 2010. Assessing habitat utilization and rockfish (Sebastes spp.) biomass on an isolated rocky ridge using acoustics and stereo image analysis. Can. J. Fish. Aquat. Sci. 67:1658–1670.
2009	Natural and man-made disturbance of eelgrass beds in northern southeastern Alaska: damage and recovery	HARRIS, P. M., A. D. NEFF, and S. W. JOHNSON. 2012. Changes in eelgrass habitat and faunal assemblages associated with coastal development in Juneau, Alaska, 47 p. U.S. Dep. Commer., NOAA Tech. Mmeo. NMFS-AFSC-240, 47 p.
2009	Contrasting predation intensity and distribution in two rock sole nursery areas: a principle factor controlling nursery productivity - Component B	RYER, C. H., B. J. LAUREL, and A. W. STONER. 2010. Testing the shallow water refuge hypothesis in flatfish nurseries. Mar. Ecol. Prog. Ser. 415:275–282.
2009	Utilization of nearshore habitat by fishes in Nushagak and Togiak Bays (Bristol Bay)	*Ormseth, Norcross, Holladay*
2009	Nearshore Fish Assemblages in Coastal Areas Facing Development in Southcentral Alaska	JOHNSON, S. W., J. F. THEDINGA, A. D. NEFF, P. M. HARRIS, M. R. LINDEBERG, J. M. MASELKO, and S. D. RICE. 2010. Fish assemblages in nearshore habitats of Prince William Sound, Alaska. Northwest Sci. 84:266–280.
2010/11/14	Recruitment and response to damage of an Alaskan gorgonian coral	*Malecha, Shotwell, Amman (in prep)*
2010	Collection of field data to support modeling bottom trawling impacts and subsequent recovery rates of sponges and corals in the Aleutian Islands, Alaska	ROOPER, C. N., M. E. WILKINS, C. S. ROSE, and C. COON. 2011. Modeling the impacts of bottom trawling and the subsequent recovery rates of sponges and corals in the Aleutian Islands, Alaska. Cont. Shelf Res. 31:1827–1834.
2010	Reproductive ecology of the red tree coral (*Primnoa pacifica*)	WALLER, R. G., R. P. STONE, J. JOHNSTONE, and J. MONDRAGON. 2014. Sexual reproduction and seasonality of the Alaskan red tree coral, *Primnoa pacifica*. PLoS ONE 9(4): e90893. doi:10.1371/journal.pone.0090893.
2010	Nearshore Fish Assemblages in Coastal Areas Facing Development in Upper Cook Inlet and Prince William Sound, Alaska	THEDINGA, J.F., S.W. JOHNSON, and A.D. NEFF. 2011. Diel differences in fish assemblages in nearshore eelgrass and kelp habitats in Prince William Sound, Alaska. Environ. Biol. Fishes 90:61–70.

Year(s) Funded	Project Title (when funded)	Publication (complete citation) or *Principal Investigators (if no publication)*
2010	Northern Bering Sea habitat suitability for benthic-feeding flatfishes	YANG, M-S., and C. YEUNG. 2013. Habitat-associated diet of some flatfish in the southeastern Bering Sea. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-246,151 p.
2010	Identification of high relief living structures in the Gulf of Alaska slope areas	ROOPER, C., M. SIGLER, G. HOFF, R. P. STONE, and M. ZIMMERMANN. 2013. Determining the distributions of deep-sea corals and sponges throughout Alaska. AFSC Quarterly Report Feature (October-November-December 2013) 4 p.
2010	Reproductive Biology of Pacific Sand Lance near Juneau, Alaska: Spawn Timing and Location, and Larval Distribution	*Harris*
2010	Recruitment, post-settlement processes and habitat utilization by Tanner crab *Chionoecetes bairdi*	RYER, C. H., W. C. LONG, M. L. SPENCER, and P. ISERI. 2015. Depth distribution, habitat associations, and differential growth of newly settled southern Tanner crab (*Chionoecetes bairdi*) in embayments around Kodiak Island, Alaska. Fish. Bull., U.S. 113:256–269. DOI:10.7755/FB.113.3.3.
2010	Seasonal habitat use and overwintering habits of juvenile Pacific cod (*Gadus macrocephalus*) in coastal nursery areas	*Knoth, Conrath, Urban, Laurel, Worton*
2011	Determinants of juvenile Tanner crab growth from different nursery embayments	RYER, C. H., W. C. LONG, M. L. SPENCER, and P. ISERI. 2015. Depth distribution, habitat associations, and differential growth of newly settled southern Tanner crab (*Chionoecetes bairdi*) in embayments around Kodiak Island, Alaska. Fish. Bull., U.S. 113:256–269. DOI:10.7755/FB.113.3.3.
2011	The role of benthic habitat in larval rock sole settlement dynamics	*Laurel, Stoner*
2011	Quantifying flatfish habitat quality in the eastern Bering Sea by infauna prey density	YANG, M-S., and C. YEUNG. 2013. Habitat-associated diet of some flatfish in the southeastern Bering Sea. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-246,151 p.
2011	Collection of seafloor imagery during AFSC bottom trawl surveys	ROOPER, C. N., M. E. WILKINS, C. S. ROSE, and C. COON. 2011. Modeling the impacts of bottom trawling and the subsequent recovery rates of sponges and corals in the Aleutian Islands, Alaska. Cont. Shelf Res. 31:1827–1834.
2011	Coastal fishes of Alaska: A synthesis of over a decade of nearshore marine surveys	JOHNSON, S. W., A. D. NEFF, J. F. THEDINGA, M. R. LINDEBERG, and J. M. MASELKO. 2012. Atlas of nearshore fishes of Alaska: a synthesis of marine surveys from 1998 to 2011. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-239, 261 p.
2011	Low-cost multibeam mapping to support habitat based groundfish assessment and deepwater coral research in the Gulf of Alaska	T.C. WEBER, C. ROOPER, J. BUTLER, D. JONES, AND C. WILSON. 2013. Seabed classification for trawlability determined with a multibeam echo sounder on Snakehead Bank in the Gulf of Alaska. Fish. Bull., U.S. 111(1): 68–77. PIRTLE, J.L., T.C. WEBER, C.D. WILSON, AND C.N. ROOPER. 2015. Assessment of trawlable and untrawlable seafloor using multibeam-derived metrics. Methods Oceanogr. 12: 18–35. doi.org/10.1016/j.mio.2015.06.001
2012	Seasonal distribution and habitat use of managed fish species in Upper Cook Inlet, Alaska	*Lindeberg, Eagleton, Saupe*
2012	The role of benthic habitat in larval rock sole settlement dynamics - Yr 2 of 2	LAUREL, B. J., A. J. BASILIO, C. DANLEY, C. H. RYER, and M. SPENCER. 2015. Substrate preference and delayed settlement in northern rock sole larvae *Lepidopsetta polyxystra*. Mar. Ecol. Prog. Ser. 519:183–193. DOI: 10.3354/meps11090.

Year(s) Funded	Project Title (when funded)	Publication (complete citation) or *Principal Investigators (if no publication)*
2012	Determinants of juvenile Tanner crab growth from different nursery embayments	COPEMAN, .L, RYER, C., SPENCER, M., OTTMAR, M., ISERI, P., SREMBA, A., WELLS, J., PARRISH, C. (2018) Benthic enrichment by diatom-sourced lipid promotes growth and condition in juvenile Tanner crabs around Kodiak Island, Alaska. Mar Ecol Prog Ser 597:161–178. https://doi. org/ 10. 3354/ meps1 2621
2012	Essential fish habitats of juvenile Pacific cod, yellowfin sole, and northern rock sole along the Alaska Peninsula	HURST, T.P. 2016. Shallow-water habitat use of Bering Sea flatfishes along the central Alaska Peninsula. Journal of Sea Research 111:37–46. Special Issue-Proceedings of International Flatfish Symposium. doi: 10.1016/j.seares.2015.11.009 HURST, T.P., D.W. COOPER, J.T. DUFFY-ANDERSON, AND E. FARLEY. 2015. Contrasting coastal and shelf nursery habitats of Pacific cod in the southeastern Bering Sea. ICES J. Mar. Sci. 72:515–527. doi: 10.1093/icesjms/fsu141
2012/13	Otolith Microchemical Fingerprinting: Assessing Juvenile Pacific Cod Habitat Utilization in the Gulf of Alaska	MATTA, M. E., MILLER, J. A., SHORT, J. A., HELSER, T. E., HURST, T. P., RAND, K. M., AND ORMSETH, O. A. 2019. Spatial and temporal variation in otolith elemental signatures of age-0 Pacific cod (*Gadus macrocephalus*) in the Gulf of Alaska. Deep-Sea Res. Pt. II 165:268–279. 10.1016/j.dsr2.2017.08.015
2012	Reproductive ultrastructure of red tree corals from Tracy Arm Fjord, Southeast Alaska: delving deeper into recovery dynamics	WALLER, R. G., R. P. STONE, J. JOHNSTONE, and J. MONDRAGON. 2014. Sexual reproduction and seasonality of the Alaskan red tree coral, *Primnoa pacifica*. PLoS ONE 9(4): e90893. doi:10.1371/journal.pone.0090893.
2012	A photographic guide to nearshore, marine fishes of Alaska: a beach seiner's handbook	JOHNSON, S. W., A. D. NEFF, and M. R. LINDEBERG. 2015. A handy field guide to the nearshore marine fishes of Alaska. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-293, 211 p.
2013	Refining EFH descriptions and assessing effects of fishing on EFH in preparation for NPFMC's 2015 EFH 5-year review	T. SCOTT SMELTZ, BRADLEY P. HARRIS, JOHN V. OLSON, AND SURESH A. SETHI. A seascape-scale habitat model to support management of fishing impacts on benthic ecosystems. Can, J. Fish. Squat. Sci. 76(10): 1836–1844. https://doi.org/10.1139/cjfas-2018-0243.
2013	Bathymetry and substrate compilation from smooth sheet charts	ZIMMERMANN, M., and J. L. BENSON. 2013. Smooth sheets: How to work with them in a GIS to derive bathymetry, features and substrates. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-249, 52 p.
2013	Simulation modeling of sustainable removals of Primnoa in the Gulf of Alaska based on field studies of size structure and recruitment rates	*Rooper, Etnoyer, Stone*
2013	Essential fish habitats of juvenile Pacific cod, yellowfin sole, and northern rock sole along the Alaska Peninsula	HURST, T.P., N. FERM, J.A. MILLER, R.A. HEINTZ, AND E.V. FARLEY. 2018. Spatial variation in potential and realized growth of juvenile Pacific cod in the Southeast Bering Sea. Mar. Ecol. Prog. Ser. 590:171–185. doi: 10.3354/meps12494 FERM, N.C., J.T. DUFFY-ANDERSON, T.P. HURST. 2021. Foraging habits and dietary overlap of juvenile yellowfin sole and northern rock sole in a Bering Sea coastal nursery. Fish. Bul., U.S. 120:1–12. doi: 10.7755/FB.120.1.1
2013	The distribution and productivity of commercially important rockfish species in coral and sponge habitats of the Gulf of Alaska	CONRATH CL, ROOPER CN, WILBORN RE, KNOTH BA, JONES DT. 2019. Seasonal habitat use and community structure of rockfish in the Gulf of Alaska. Fish. Res. 219, https://doi.org/10.1016/j.fishres.2019.105331

Year(s) Funded	Project Title (when funded)	Publication (complete citation) or *Principal Investigators (if no publication)*
2014	Ground truth the presence and abundance of coral habitat on the eastern Bering Sea slope both inside and outside canyon areas	*Rooper, Sigler, Hoff*
2014	Examining the effects of offshore marine mining activities on Norton Sound red king crab habitat	*Olson, Foy, Harris*
2014	Optimal thermal habitats of gadids in Alaskan waters	COPEMAN LA, LAUREL BJ, SPENCER M, SREMBA A. 2017. Temperature impacts on lipid allocation among juvenile gadid species at the Pacific Arctic-Boreal interface: an experimental laboratory approach. Mar. Ecol. Prog. Ser. 566:183–198. https:// doi. org/ 10.3354/ meps1 2040.
2014	Bathymetry and substrate compilation from smooth sheets: Gulf of Alaska and Norton Sound	ZIMMERMANN, M., and M. M. PRESCOTT. 2014. Smooth sheet bathymetry of the central Gulf of Alaska. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-287, 54 p. PRESCOTT, M. M., and M. ZIMMERMANN. 2015. Smooth sheet bathymetry of Norton Sound. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-298, 23 p.
2014	High prey availability defines juvenile flatfish habitat quality in the eastern Bering Sea	YEUNG, C., and M.-S. YANG. 2014. Habitat and infauna prey availability for flatfishes in the northern Bering Sea. Polar Biol. 37:1769–1784.
2014	Coral and Sponge diversity along the EBS slope with a focus on Pribilof and Zhemchug Canyons	SIGLER, M. F., C. N. ROOPER, G. R. HOFF, R. P. STONE, R. A. McCONNAUGHEY, and T. K. WILDERBUER. 2015. Faunal features of submarine canyons on the eastern Bering Sea slope. Mar. Ecol. Prog. Ser. 526:21–40. DOI: 10.3354/meps11201.
2014	Matching pieces of the puzzle: validating the reproductive ecology of red tree corals in Gulf of Alaska habitats with extensive studies in shallow water	*Stone, Waller*
2015	Effects of offshore marine mining activities on Norton Sound Red King crab	BALDWIN-SCHAEFFER, M. A. 2018. Acoustic Assessment of Natural and Mining-induced Benthic Features in Turbid, Shallow Waters. PhD Thesis, Alaska Pacific University.
2015	Examining the effects of offshore marine mining activities on Norton Sound red king crab habitat - phase 2	*Olson, Foy, Harris, Boswell*
2015	Defining EFH for Alaska groundfish species, using species distribution modeling	LAMAN, E. A., C. N. ROOPER, S. C. ROONEY, K. A. TURNER, D. W. COOPER, and M. ZIMMERMANN. 2017. Model-based essential fish habitat definitions for Bering Sea groundfish species. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-357, 265 p. TURNER, K., C. N. ROOPER, E. A. LAMAN, S. C. ROONEY, D. W. COOPER, and M. ZIMMERMANN. 2017. Model-based essential fish habitat definitions for Aleutian Island groundfish species. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-360, 239 p. ROONEY, S., C. N. ROOPER, E. LAMAN, K. TURNER, D. COOPER, and M. ZIMMERMANN. 2018. Model-based essential fish habitat definitions for Gulf of Alaska groundfish species. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-373, 370 p.
2015	Bathymetry compilation: Eastern Bering Sea slope	ZIMMERMANN, M., and M. M. PRESCOTT. 2018. Bathymetry and canyons of the Eastern Bering Sea slope. Geosciences 8(5):184. https://doi.org/10.3390/geosciences8050184
2015	Improving based model EFH definitions for Gulf of Alaska groundfish species using combined species distribution models with high-resolution regional habitat metrics	PIRTLE, J. L., S. K. SHOTWELL, M. ZIMMERMANN, J. A. REID and N. GOLDEN. 2019. Habitat suitability models for groundfish in the Gulf of Alaska. Deep Sea Res. II. 165:303-321. https://doi.org/10.1016/j.dsr2.2017.12.005

Year(s) Funded	Project Title (when funded)	Publication (complete citation) or *Principal Investigators (if no publication)*
2015	Optimal thermal habitats of FMP crab species in relation to the Bering Sea cold pool	COPEMAN, L. A., C. H. RYER, L. B. EISNER, J. M. NIELSEN, M. L. SPENCER, P. J. ISERI, and M. L. OTTMAR. 2021. Decreased lipid storage in juvenile Bering Sea crabs (*Chionoecetes* spp.) in a warm (2014) compared to a cold (2012) year on the southeastern Bering Sea. Polar Biol. 44:1883-1901. https://doi.org/10.1007/s00300-021-02926-0
2015	Physiological response of red tree coral to low pH scenarios in the laboratory	ROSSIN, A.M., WALLER, R.G., STONE, R.P. 2019. The effects of in-vitro pH decrease on the gametogenesis of the red tree coral, *Primnoa pacifica*. PLoS ONE 14(4): e0203976. https://doi.org/10.1371/journal.pone.0203976
2015	Estimating rockfish abundance as a function of habitat in the Gulf of Alaska	JONES, D. T., C. N. ROOPER, C. D. WILSON, P. D. SPENCER, D. H. HANSELMAN, and R. E. WILBORN. 2021. Estimates of availability and catchability for select rockfish species based on acoustic-optic surveys in the Gulf of Alaska. Fish. Res. 236:105848. https://doi.org/10.1016/j.fishres.2020.105848
2016	Expansion and validation of the EFH fishing effects model	SMELTZ, T. S., B. P., HARRIS, J. V. OLSON, AND S. A. SETHI. 2019. A seascape-scale habitat model to support management of fishing impacts on benthic ecosystems. Can. J. Fish. Aquat. Sci. 76(10): 1836–1844. https://doi.org/10.1139/cjfas-2018-0243
2016	Bathymetry compilation: Southeast Alaska	*Zimmermann*
2016	Thermal habitat requirements of Bering Sea flatfishes	*Hurst, Ryer, Laurel*
2016	Predicting changes in habitat for groundfishes under future climate scenarios using species distribution modeling	ROOPER, C. N., I. ORTIZ, A. J. HERMANN, N. LAMAN, W. CHENG, K. KEARNEY and K. AYDIN. 2020. Predicted shifts of groundfish distribution in the Eastern Bering Sea under climate change, with implications for fish populations and fisheries management. ICES J. Mar. Sci. 78(1): 220–234. https://doi.org/10.1093/icesjms/fsaa215
2016	Quality of two juvenile flatfish habitats during warm and cold periods in the eastern Bering Sea. I. The Warm Year	YEUNG, C., and D. W. COOPER. Contrasting the variability in spatial distribution of two juvenile flatfishes in relation to thermal stanzas in the eastern Bering Sea. ICES J. Mar. Sci. 77(3): 953–963. https://doi.org/10.1093/icesjms/fsz180
2016	Physiological response of red tree corals to low pH scenarios in the laboratory	ROSSIN, A.M., WALLER, R.G., STONE, R.P. 2019. The effects of in-vitro pH decrease on the gametogenesis of the red tree coral, *Primnoa pacifica*. PLoS ONE 14(4): e0203976. https://doi.org/10.1371/journal.pone.0203976
2017	A pilot study for assessing deep-sea corals and sponges as nurseries for fish larvae in the western Gulf of Alaska	ROOPER, C. N., M. ZIMMERMANN, and M. M. PRESCOTT. 2017. Comparison of modeling methods to predict the spatial distribution of deep-sea coral and sponge in the Gulf of Alaska. Deep Sea Res. I 126:148–161. http://dx.doi.org/10.1016/j.dsr.2017.07.002
2017	Using habitat characteristics and prey abundance to predict distribution, abundance, and condition of groundfish in the Gulf of Alaska	SIMONSEN, K.A., P.H. RESSLER, AND C.N. ROOPER. Does prey abundance influence predator distribution? Perspectives from a study of Gulf of Alaska groundfish. *(in prep)*
2017	Juvenile flatfish habitat in the northern Bering Sea	YEUNG, C., L. A. COPEMAN, M. E. MATTA, and M.-S. YANG. 2021. Latitudinal variation in the growth and condition of juvenile flatfishes in the Bering Sea. Est. Coast. Shelf Sci. 258:107416. https://doi.org/10.1016/j.ecss.2021.107416
2017/18/19	Optimal overwintering thermal habitat of juvenile walleye pollock (*Gadus chalcogrammus*) from the Gulf of Alaska	*Copemen et al. (in prep)*

Year(s) Funded	Project Title (when funded)	Publication (complete citation) or *Principal Investigators (if no publication)*
2017/18/19	Essential fish habitat of flatfish early life stages in the Chukchi Sea	COOPER, D, CIECIEL, K., COPEMAN, L. EMELIN, P. LOGERWELL, E., FERM, N. LAMB, J., LEVINE, R., AXLER, K., WOODGATE, R., BRITT, L., LAUTH, R., LAUREL, B., ORLOV, A. 2023. Pacific cod or tikhookeanskaya treska (*Gadus macrocephalus*) in the Chukchi Sea during recent warm years: Distribution by life stage and age-0 diet and condition. Deep Sea Research II. 208:105241
2018/19	Developing a novel approach to estimate habitat-related survival rates for early life history stages using individual-based models	GIBSON, G. A., STOCKHAUSEN, W. T., S. K. SHOTWELL, A. L. DEARY, J. L. PIRTLE, K. O. COYLE, AND A. J. HERMANN. 2023. Can seamounts in the Gulf of Alaska be a spawning ground for sablefish settling in coastal nursery grounds? Fish. Res. 261:106625. YEAGER, M., SHOTWELL, S.K., STOCKHAUSEN, W.T., GIBSON, G.A., AND PIRTLE, J.L. *In prep.* Individual-based models inform fishery management decision-support pathways for two groundfish with contrasting early life history phenologies.
2018/19	A unified nearshore catch database to refine juvenile EFH models and maps for Alaska	GRÜSS, A., J. L. PIRTLE, J. T. THORSON, M. R. LINDEBERG, A. D. NEFF, S. G. LEWIS and T. E. ESSINGTON. 2021. Modeling nearshore fish habitats using Alaska as a regional case study. Fish. Res. 238:105905.
2018	Is nearshore habitat essential to overwintering young of the year Pacific cod?	*Kastelle, Helser, Litzow, Laurel (in prep)*
2018	Spatial variation in early juvenile flatfish growth and condition in relation to thermal phases in the eastern Bering Sea Shelf	YEUNG, C., L. A. COPEMAN, M. E. MATTA, and M.-S. YANG. 2021. Latitudinal variation in the growth and condition of juvenile flatfishes in the Bering Sea. Est. Coast. Shelf Sci. 258:107416. https://doi.org/10.1016/j.ecss.2021.107416
2018	Age effects on thermal habitat requirements on commercial flatfishes	*Hurst, Copeman (in prep)*
2019/20/21	Advancing EFH species distribution modeling descriptions and methods for the North Pacific Fishery Management Plan species	HARRIS, J., LAMAN, E. A., PIRTLE, J. L., SIPLE, M. C., ROOPER, C. N., HURST, T. P., and CONRATH, C. L. 2022. Advancing Model-Based Essential Fish Habitat Descriptions for North Pacific Species in the Aleutian Islands. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-458, 406 p. https://doi.org/10.25923/ffnc-cg42 LAMAN, E.A., PIRTLE, J.L., HARRIS, J., SIPLE, M.C., ROOPER, C.N., HURST, T.P., and CONRATH, C.L. 2022. Advancing Model-Based Essential Fish Habitat Descriptions for North Pacific Species in the Bering Sea. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-459, 538 p. https://doi.org/10.25923/y5gc-nk42 PIRTLE, J.L., LAMAN, E.A., HARRIS, J., SIPLE, M.C., ROOPER, C.N., HURST, T.P., CONRATH, C.L., et al. 2023. Advancing model-based essential fish habitat descriptions for North Pacific species in the Gulf of Alaska. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-468, 541 p. https://doi.org/10.25923/ygdf-5f65 HARRIS, J., PIRTLE, J. L., LAMAN, E. A., SIPLE, M. C., AND THORSON, J. T. 2024. An ensemble approach to species distribution modelling reconciles systematic differences in estimates of habitat utilization and range area. J. Appl. Ecol. 61: 351–364. https://doi.org/10.1111/1365-2664.14559

Year(s) Funded	Project Title (when funded)	Publication (complete citation) or *Principal Investigators (if no publication)*
2019/20 *Funded by BOEM	Model-based essential fish habitat descriptions for Fish Resources of the Arctic Management Area	MARSH, J., PIRTLE, J.L., AND MUETER, F.J. In review. Model-Based Essential Fish Habitat Descriptions for Fish Resources of the Arctic Management Area. NOAA Technical Memorandum.
2019	Spatial variation in early juvenile flatfish growth and condition in relation to habitat quality the Bering Sea	YEUNG, C., L. A. COPEMAN, M. E. MATTA, and M.-S. YANG. 2021. Latitudinal variation in the growth and condition of juvenile flatfishes in the Bering Sea. Est. Coast. Shelf Sci. 258:107416. https://doi.org/10.1016/j.ecss.2021.107416
2019	Modeling nearshore fish habitats using Alaska as a regional case study.	GRÜSS, A., J. L. PIRTLE, J. T. THORSON, M. R. LINDEBERG, A. D. NEFF, S. G. LEWIS and T. E. ESSINGTON. 2021. Modeling nearshore fish habitats using Alaska as a regional case study. Fish. Res. 238:105905. https://doi.org/10.1016/j.fishres.2021.105905
2019	Dynamic models inform species responses to climate change in high latitude systems	BARNES, C. L., T. E. ESSINGTON, J. L. PIRTLE, C. N. ROOPER, E. A. LAMAN, K. K. HOLSMAN, K. Y. AYDIN, AND J. T. THORSON. 2022. Climate-informed models benefit hindcasting but present challenges when forecasting species-habitat associations. Ecography: e06189 https://doi.org/10.1111/ecog.06189
2020	Evaluating seasonal habitat use and movements by juvenile age-1+ Pacific cod in the Gulf of Alaska	*Rooney, Laurel, Holsman (in prep)*
2020	Nearshore essential habitats of juvenile flatfish in the eastern and northern Bering Sea.	YEUNG, C., L. A. COPEMAN, M. E. MATTA, and M.-S. YANG. 2021. Latitudinal variation in the growth and condition of juvenile flatfishes in the Bering Sea. Est. Coast. Shelf Sci. 258:107416. https://doi.org/10.1016/j.ecss.2021.107416
2020/21/22	Condition indicators for Pacific Cod and Walleye Pollock from the eastern Bering Sea	*Hoff, Hachn, Helser, Britt, Rooper, Boldt (in prep)*
2020	Using drones to update and enhance essential fish habitat eelgrass/substrate maps	*Miller (in prep)*
2020	Pilot project using eDNA metabarcoding to improve nearshore consultations and EFH maps and descriptions.	LARSON, W., BERRY, P., MASELKO, J., OLSON, J., AND BAETSCHER, D. 2021. Leveraging eDNA metabarcoding to characterize nearshore fish communities in Southeast Alaska: Do habitat and tide matter? bioRxiv doi: https://doi.org/10.1101/2021.10.28.466160
2020	Spatio-temporal environmental covariates to refine salmon EFH within the Bering and Chukchi seas of the U.S. EEZ.	HART, L. K. G, CUNNINGHAM, C. J., YASUMIISHI, E. M., MUETER, F. J., THORSON, J. T., PIRTLE, J. L., and DIMOND, J. A. 2025. Species distribution models estimate time-varying juvenile salmon distributions in the north- and southeastern Bering Sea. Can. J. Fish. Aquat. Sci. 82: 1–13. https://doi.org/10.1139/cjfas-2024-0137
2021/22	Defining essential habitats for juvenile FMP crab species (*Chionoecetes* spp.): the importance of bottom temperature and diatom flux in defining juvenile crab abundance and condition across a warming Bering Sea	COPEMAN, OTTMAR, RYER, KRISTIANSEN. *In prep.* Temperature-dependent survival and growth of early juvenile Bering Sea snow crab (*Chionoecetes opilio*) and Tanner crab (*Chionoecetes bairdi*): implications for optimal crab thermal habitat in a rapidly warming Alaska Arctic. COPEMAN, COOPER, NIELSEN, KRISTIANSEN, STOWELL, OTTMAR. *In prep.* The importance of bottom temperature and diatom flux in defining juvenile crab condition across a warming Bering Sea: linking ecosystem metrics to predict optimal juvenile crab habitat.
2021	Acoustic and image-based habitat classification in the Gulf of Alaska using machine learning	*Williams, Rooper (in prep)*

Year(s) Funded	Project Title (when funded)	Publication (complete citation) or *Principal Investigators (if no publication)*
2021	Developing a submersible eDNA autosampler: a DNA “net” that can be deployed remotely with no selectivity bias	*Larson, Neumann, Pochardt, Maselko, Olson, Levi, Selker, Udell (in prep)*
2022	Predictive distribution models to support flexible management of Bering Sea crab fisheries: a combined modeling, field, and laboratory approach	RYZNAR, E., LITZOW, M. 2024. Predicting the distribution of red king crab bycatch in Bering Sea flatfish trawl fisheries. Fisheries Research. 279:107158. HOWARD, R., CIANNELLI, L., RYZNAR, R., LITZOW, M. *In review.* Sex- and maturity-specific distributions of eastern Bering Sea snow crab (*Chionoecetes opilio*). RYZNAR, E., LITZOW, M. A. *In review*. fisheries-dependent model of Bering Sea red king crab distribution in the data-poor season. Submitted to Can. J. Fish. Aquat. Sci. HARDISON, S., FEDEWA. E., MUETER, F., LITZOW, M., et al. *In prep.* A hybrid species distribution – movement model to refine seasonal estimates of Bristol Bay red king crab distribution. ZACHER, L., A. NAULT, V. VANEK, AND B. DALY. *In prep.* Tagging reveals seasonal patterns in movement of male Bristol Bay red king crab.
2022	Accounting for trophic relationships in Essential Fish Habitat designation	*Siple, Nielsen, Andrews, Siddon, Eisner (in prep)*

10.3 New Alaska EFH Research Plan

AKR HCD and AFSC HEPR led a process to develop an update to the Alaska EFH Research Plan, following the 2023 EFH 5-year Review. The new plan guides research supporting EFH information development for the next EFH 5-year review. The plan was published as a NOAA Technical Memorandum (Pirtle et al. 2024).

Prior plans have offered changes over time in how research proposals are solicited and funded. The previous plan (Sigler et al. 2017) introduced a new process to submit, review, and fund multi-year proposals that conduct field- and laboratory-based process research and then synthesize these to provide EFH mapping products (termed "multi-year proposals"). The benefits of this multi-year approach were realized with the studies supporting the 2023 EFH 5-year Review. This multi-year process was retained in the updated plan with improvements in communicating the process and expectations.

Prior Alaska EFH Research Plans have consistently had the same five core, long-term research goals, and have differed primarily by providing specific objectives with guidance on emphasis areas. These long-term goals were modernized in the new plan, while largely maintaining their intent—

1. Characterize habitat utilization and productivity at regional scales;
2. Assess sensitivity, impact, and recovery of disturbed benthic habitat;
3. Improve modeling and validation of human impacts on marine habitat;
4. Improve information regarding habitat and seafloor characteristics;
5. Assess coastal and marine habitats facing human development.

During the 2023 EFH 5-year Review, input from Council bodies, stock assessment scientists, and EFH analysts (section 10.4), assisted AKR and AFSC to develop the new, timely objectives that are intended to advance EFH information for the next 5-year review and future reviews. The new plan includes three objectives with recommendations for areas of emphasis in data and methods development:

- *Objective 1: Improve EFH information for targeted species and life stages.*
    - Including, by incorporating additional field data and alternative data sources; identifying demographic processes driving variation over time; and further improving methods to integrate monitoring and process research.
- *Objective 2: Improve fishing effects assessment.*
    - Encouraging, additional methods development to assess fishing impacts to EFH, including by extending the FE model currently applied to the EFH FE evaluation in the 2023 EFH 5-year Review; and new methods development to identify the cumulative effects of fishing and non-fishing human activities to EFH.
- *Objective 3: Improve understanding of nearshore habitat and forage species.*
    - Recommending, expanded efforts to understand habitat utilization and productivity of nearshore environments for EFH species (e.g., early life history stages) and their prey species. Improved understanding of nearshore habitats is

also intended to support the EFH non-fishing effects consultations that are done near areas with human development.

Full descriptions of the long-term goals and research objectives are available in the updated Alaska EFH Research Plan (Pirtle et al. 2024). This information was included in the updates to the FMP appendices, following the conclusion of the 2023 EFH 5-year Review (e.g., GOA FMP Appendix H section 8.4).

10.4 Research Priorities Identified During the 2023 EFH 5-year Review

In this section we summarize the research recommendations received by Council bodies, stock assessment scientists, and EFH analysts during the 2023 EFH 5-year Review that informed the revised EFH research and information needs in the FMPs and the Alaska EFH Research Plan (Pirtle et al. 2024), as a result of the 2023 EFH 5-year Review.

10.4.1 Stock assessment author and species expert reviewer recommendations

As part of the 2023 EFH 5-year Review, each stock assessment author provided evaluations of EFH research needs for FMP species and provided recommendations (Table 26, Table 27, Table 28). These species-specific recommendations were included in the update to the EFH research sections in the appendices of the BSAI, GOA, and Crab FMPs. These recommendations can be used by the SSC and the Council in refining the Council's research priorities, which are updated and disseminated to NMFS, ADF&G, NPRB, and other agencies. Additionally, these recommendations are useful to NMFS in developing research priorities for the Alaska EFH Research Plan annual request for proposals, following the 2023 EFH 5-year Review.

Table 26. Stock assessment author research recommendations for Bering Sea/Aleutian Island groundfish species. These include focus areas of research and identify data sources for future EFH map iterations.

Bering Sea / Aleutian Island Species	Research Recommendations by Stock Assessment Authors
arrowtooth flounder	Incorporate other data sources like longline survey and IPHC survey data to supplement the slope bottom trawl survey. When evaluating FE, referencing habitat specificity variables in the climate vulnerability assessment and the habitat assessment prioritization for Alaska stocks could allow for a more targeted approach.
Atka mackerel	Further stratification of data in time and space may allow for patterns to become apparent at local scales.
blackspotted/ rougheye rockfish complex	Continue research on observing and modeling stock densities in untrawlable grounds, particularly in the Aleutian Islands and Bering Sea slope.
flathead sole-Bering flounder complex	Investigate impacts to the habitat/environment on early life history and recruitment distribution.
Greenland turbot	Incorporate AFSC longline survey data in addition to the bottom trawl survey data. They also suggested forming a small team to reevaluate life stage breaks and look at spatially varying growth differences.

Bering Sea / Aleutian Island Species	Research Recommendations by Stock Assessment Authors
Kamchatka flounder	Incorporate AFSC longline survey data in addition to the bottom trawl survey data.
northern rock sole	Northern rock sole have exhibited changes in growth over time, so length-based categories may need to be addressed.
northern rockfish	Continue research on observing and modeling stock densities in untrawlable grounds, particularly in the Aleutian Islands and Bering Sea slope.
other flatfish complex	Group life history stages by age rather than length where possible.
other rockfish complex	Incorporate AFSC longline survey data.
Pacific ocean perch	Continue research on observing and modeling stock densities in untrawlable grounds, particularly in the Aleutian Islands and Bering Sea slope.
sablefish	Incorporate longline survey data in future EFH analyses. Gather more data on life history patterns and habitat utilization: spawning locations, larval dispersal, juvenile nursery areas, and/or ontogenetic movement patterns. Utilize FE model outputs for areas aside from the regional requirements.
shortraker rockfish	Incorporate other data sources like longline survey and IPHC survey data to supplement the slope bottom trawl survey. When evaluating FE, referencing habitat specificity variables in the climate vulnerability assessment and the habitat assessment prioritization for Alaska stocks could allow for a more targeted approach.

Table 27. Stock assessment author research recommendations for Gulf of Alaska groundfish species. These include focus areas of research and identify data sources for future EFH map iterations.

Gulf of Alaska Species	Research Notes from Stock Assessment Authors
arrowtooth flounder	Incorporate other data sources like longline survey and IPHC survey data to supplement the slope bottom trawl survey. When evaluating FE, referencing habitat specificity variables in the climate vulnerability assessment and the habitat assessment prioritization for Alaska stocks could allow for a more targeted approach.
Atka mackerel	Explore EFH over different time blocks representing different environmental conditions, and also regulations in place over the time series.
blackspotted/ rougheye rockfish complex	Incorporate AFSC longline survey data as additional species distribution data.
Dover sole	The length-stage definitions should be revisited and future maps and descriptions should try to account for subregional growth and size-at-age differences.
dusky rockfish	Prioritize research into fishery location data and early life history information. Include fishery observer data for additional species distribution data.
flathead sole	Research impacts of environmental indicators such as temperature on growth and/or distribution of recruits, since we don't see these in the surveys.
northern rockfish	Research early life history. Incorporate stakeholder/fleet understanding of fish locations.
other rockfish complex, demersal subgroup	ADF&G currently uses their ROV surveys to assess and manage this stock in the EGOA and recommend incorporating data from those surveys into the SDM ensemble framework.

Gulf of Alaska Species	Research Notes from Stock Assessment Authors
other rockfish complex, slope subgroup	Research should include data from the AFSC and IPHC longline surveys, the GOA rockfish fishery data, and underwater images from untrawlable habitats in future EFH mapping efforts for these rockfish species.
greenstriped rockfish	Incorporate AFSC longline survey data and IPHC survey data as additional species distribution data.
harlequin rockfish	Incorporate GOA fishery data to more accurately represent the spatial extent of the population.
pygmy rockfish	Incorporate GOA fishery data for additional distribution data.
silvergray rockfish	Incorporate AFSC longline survey data and IPHC survey data as additional species distribution data.
redbanded rockfish	Incorporate both longline survey indices and length data when available.
rex sole	Reevaluate the length categories for subadults and adults with regard to regional and temporal growth differences.
sablefish	Incorporate longline survey data into the SDM. Collect data to better understand spawning areas (requires winter sampling) and ELH [early life history] habitat preferences. Develop a better understanding of connectivity among management units within the Alaska-wide sablefish population, particularly the dynamics of juvenile fish and how they utilize the EBS shelf.
Shark complex	(Note: only spiny dogfish maps were advanced by EFH analysts, however Pacific sleeper shark maps were reviewed and the SA provided the research recommendation below.)
Pacific sleeper shark	Research the spatial distribution of length data collected during surveys.
spiny dogfish	Incorporate the AFSC and IPHC longline surveys, with their length data, as additional data sources.
shortraker rockfish	Incorporate AFSC longline survey data as additional species distribution data.

Table 28. Stock assessment author research recommendations for Bering Sea/Aleutian Island crab species. These include focus areas of research and identify data sources for future EFH map iterations.

Bering Sea & Aleutian Island Crab	Research Notes from Stock Assessment Authors
Blue king crab	Explore using FE model outputs for smaller areas within the EFH regions such as known nursery habitats where blue king utilize cobble and shell hash. Map early benthic life stages. Research female spawning and juvenile habitat needs.
Golden king crab	Incorporate observer data from the fishery and pot survey in the eastern portions of the grounds.
Red king crab	Model immature and mature crab separately. Model FE for different seasons. Explore using FE model outputs in smaller areas of interest within the EFH regions such as important spawning areas and molting areas. Research female distributions, critical spawning habitat, and movement outside of the summer months.
Snow crab	Model immature and mature crab separately. Explore using FE model outputs in smaller spatial and temporal results.
Tanner crab	Research immediate and longer-term responses to nearby fishing effects (effects of increased sediment load in the water column on respiration, fishing effects on prey abundance and quality, fishing effects on predator distributions).

10.4.2 EFH component 1 analysts' recommendations

The NMFS EFH component 1 analysts provided a set of future research recommendations. As they developed their modeling approaches for the present work and participated in multiple peer and expert reviews in a variety of venues, they identified recommendations that could be considered for future EFH 5-year reviews. The complete list of these recommendations is incorporated into the three regional NOAA Technical Memoranda in the regional future recommendations chapters, Synthesis Report (Pirtle et al. 2025), and the February 2023 discussion paper[40], which provides more detailed descriptions of the pathways that the EFH component 1 analysts recommend. These recommendations are in three categories (Table 29):

1. Prioritize and improve EFH for select species,
2. Increase the scope and applicability of EFH research, and
3. Improve process and communication.

Table 29. Summary of EFH analyst recommendations to advance research to improve EFH descriptions and identification (component 1) and continue to improve the EFH 5-year review process.

Area of research	Improvement/advancement	Taxa with potential EFH improvement
Prioritize and improve EFH for select species	Leverage existing species distribution data to expand spatial scope and improve predictions in existing EFH maps	Subset of species where higher-quality EFH information is needed
	Leverage environmental data	All (especially species where higher-quality EFH information is needed)
	Improve life history information with best available science to the extent that the available survey data sets can handle this	All (especially crab species)
	Expand and improve existing SDM EFH mapping to include species and life stages in the nearshore (e.g., at appropriate spatial resolutions)	Many EFH species and their prey that inhabit nearshore habitats
	Develop methodology for combining disparate datasets (e.g., survey/gear intercalibration)	Subset of species where higher-quality EFH information is needed
	Develop process studies to inform EFH descriptions and maps (e.g., vital rates, movement, population dynamics)	All

[40] EFH Component 1 SDM EFH Discussion Paper, C4 EFH 5-year Review, February 2023 https://meetings.npfmc.org/Meeting/Details/2975

Area of research	Improvement/advancement	Taxa with potential EFH improvement
	Consider diverse constituent models and/or other techniques such as joint species distribution models (jSDM)	Subset of species where higher-quality EFH information is needed; especially those with EFH level 1 information only
Increase scope and applicability of EFH research	Describe prey species habitat (EFH component 7)	Most groundfish, especially those with diets more specialized on forage
	Expand to EFH Levels 3 and 4	All
	Continue to advance and apply dynamic SDM methods in development to map and forecast shifts in EFH and spatial stock structure to improve climate responsive approaches to EFH and EBFM	All
Improve process and communication	Communicate confidence in EFH designations/boundaries	All
	Develop thresholds for mapping EFH with SDMs and SDM EFH applied to the EFH component 2 Fishing Effects Evaluation (e.g., thresholds applied), through research and an expert work group, and communicate this guidance to the SSC prior to the launch of the next EFH 5-year Review. One-two SSC members may be interested in joining this team.	All
	Add more opportunities for communication and continually improve communication	All
	Streamline workflows and reproducibility.	All

10.4.3 Scientific and Statistical Committee recommendations

The SSC provided research recommendations for future EFH 5-year reviews, during their reviews of EFH components 1 and 2 at their February 2022 and October 2022 meetings.

SSC research recommendations for the next EFH 5-year review (October 2022):

- EFH SDM intercalibration of bottom trawl survey data with data from fixed gear surveys (e.g., as applicable to a subset of species where inclusion of additional species data has high potential to improve EFH information).
- Exploration of the extent to which fishery-dependent data can help inform future EFH SDM analyses, while highlighting the inherent problem of preferential sampling associated with fishery-dependent information.
- Expansion of EFH definitions to other life stages and seasons where appropriate, based on available data to inform occurrence, abundance, and habitat associations.

- Reporting of species-specific habitat disturbance from the FE model by major gear classes would be beneficial in considering habitat impacts in a strategic manner.
- The SSC refers EFH authors to its comments from February 2022 for further recommendations regarding future EFH evaluation.

SSC provided these specific recommendations to guide the next EFH 5-year review (February 2022):

- SDM modeling is a rapidly evolving field, including the development of joint species distribution models. Although the analysts applied state-of-the-art approaches, the SSC suggests that the [Alaska] EFH Research Plan should consider an in-depth review of available approaches, including considerations of joint SDMs.
- The SSC encourages further efforts to identify ways in which the EFH information can contribute to the stock assessment process through ESPs and other ‘on-ramps’.
- The current EFH definitions focus on summer survey data only and provide a much-improved snapshot of summer distributions. The SSC supports recommendations to extend the analyses in the future to use fishery-dependent data, longline surveys, acoustic surveys, etc., to both enhance maps of summer distributions and to define EFH at other times of the year where possible, building on the approach developed during the 2017 Review. However, the SSC notes that this type of intercalibration exercise will require careful consideration of the relative catchability among different gear types, the spatial distribution of effort, and targeting behavior in the case of fishery-dependent data.
- The SSC previously encouraged, and the discussion paper recommends, the move toward a more dynamic definition of EFH, for example in time blocks, which would require careful consideration of the time frames used for defining EFH. The SSC recommends that both longer-term average EFH and EFH under contrasting conditions for those species whose distribution is known to be linked to changing ocean conditions be considered in the next 5-year review.
- The SSC appreciates the move to life stage specific models for almost all groundfish stocks and encourages the team to prioritize life stage specific models for crab species based on available maturity data.
- The SSC supports a recommendation brought forward by the CPT and in public testimony to consider mapping EFH by management area for separate stocks within an FMP area. One example is red king crab in the Bering Sea, which consists of three distinct stocks.
- The SSC encourages the analysts to consider objective approaches to eliminate isolated areas where the model suggests elevated abundances that are not supported by any occurrences in the data and are spatially separated from the main distributional areas.
- The SSC appreciates the inclusion of the PR-AUC as an additional criterion for evaluating the SDM models as it provides useful information on model performance with respect to the presence of a species, particularly for relatively uncommon species. The SSC suggests including the PR-AUC and species prevalence as routine criteria in future model updates.

- The SSC encourages the analysts to explore options that account for both abundance and uncertainty in the definition of EFH.
- The SSC encourages the analysts to provide general comparisons of the abundances estimated in the EFH SDMs and those estimated in the stock assessments.
- The SSC supports the additional recommendations in "Table 18 of the discussion paper" (Table 29) and highlights the following priorities:
  - Further development of methods to combine multiple surveys to make full use of available data and to expand coverage beyond any one survey region.
  - Development of process studies to advance EFH descriptions to Level 3 and possibly [Level] 4, if appropriate. The SSC suggests that the [Alaska] EFH Research Plan consider a case study for the development of Level 4 EFH description for at least one species / life stage to better understand the information and methods needed to advance to Level 4.
  - The SSC suggests adding (additional oceanographic covariates to the SDMs) variables that are indicative of frontal structures, which often aggregate prey and their predators. The SSC further suggests exploring the use of variables that reflect the vertical structure of the water column.
  - Inclusion of alternative data sources such as longline survey data, fishery-dependent data, acoustic data and other sources.

11 Preparers and Persons Consulted

Preparation of Summary Report

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Review of groundfish species EFH descriptions, maps, and fishing effects evaluation

- Coordinated by Sandra Lowe and Chris Lunsford (AFSC),
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- BSAI and GOA Groundfish Plan Teams (NPFMC, AKR, AFSC, and ADFG).

Review of crab species EFH descriptions, maps, and fishing effects evaluation

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Review of non-fishing effects to EFH

- Doug Limpinsel, Charlene Felkley, Sean McDermott, Jodi Pirtle, Seanbob Kelly, Stefanie Coxe, Linda Shaw, Molly Zaleski, Gretchen Harrington, Ellen Ward, Sean Eagan, John Olson, Matt Eagleton (AKR HCD).

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