

2022 Essential Fish Habitat (EFH) 5-Year Review

Component 1 Descriptions and Identification

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EFH Components of Fishery Management Plans

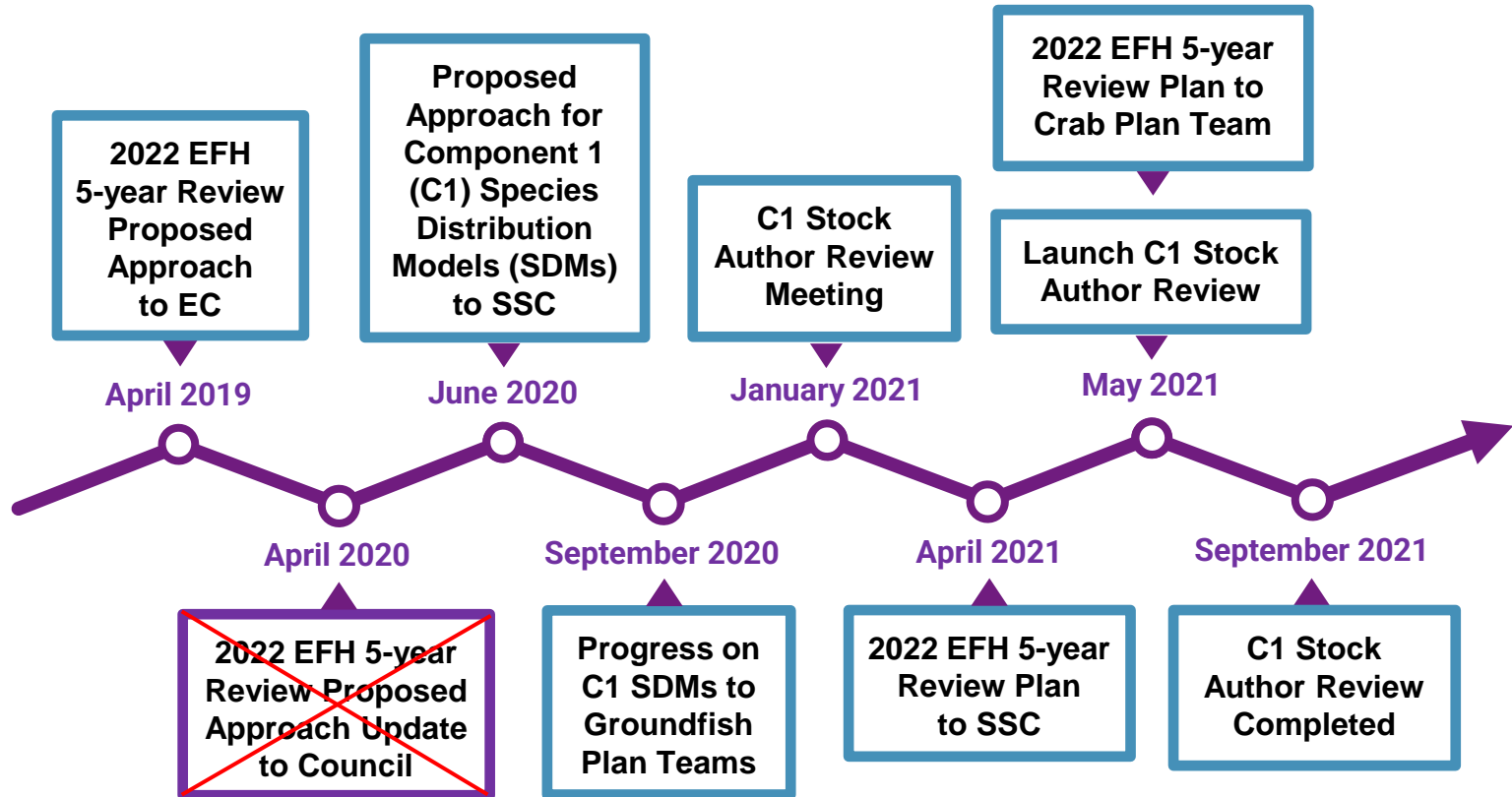
NMFS has prioritized the seven EFH components in bold for the 2022 EFH 5-year Review and will present [components 1 and 2](#) today:

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

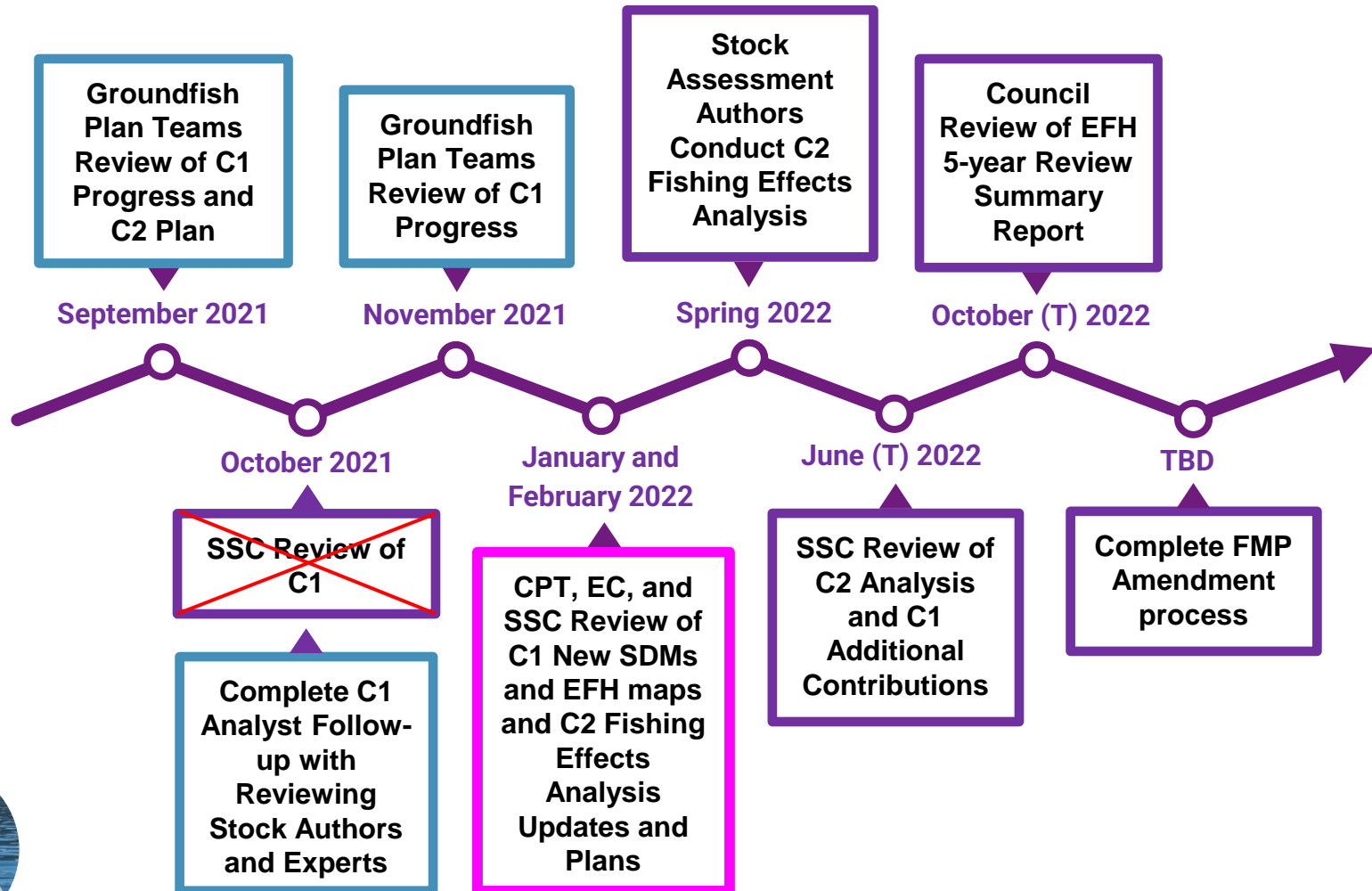
An EFH 5-Year Review Summary Report will be presented to the Council in October 2022 (T).



Timeline – Progress to Date



Timeline – Progress and Next Steps



1. EFH Descriptions and Identification

“Essential fish habitat (EFH) means those waters and substrate necessary to fish for spawning, feeding, or growth to maturity.” (50 CFR 600.10)

Component 1: EFH descriptions and identification (maps)

- Fishery Management Plan (FMP) text and tables
- FMP maps based on species distribution models (SDMs) established in the 2017 Review and refined for 2022 Review.

EFH information levels

- **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]

New and revised EFH descriptions and maps for the 2022 Review

- EFH Levels 1 and 2 **Expanded** for GOA and BSAI Groundfish, BSAI Crab, and Arctic FMPs.
- EFH Level 3 **New** for GOA and BSAI Groundfish, and Arctic FMPs.



EFH Requirements

EFH Regulations:

600.815(a) “*Mandatory contents—(1) Description and identification of EFH—(i) Overview. FMPs must describe and identify EFH in text that clearly states the habitats or habitat types determined to be EFH for each life stage of the managed species. FMPs should explain the physical, biological, and chemical characteristics of EFH and, if known, how these characteristics influence the use of EFH by the species/life stage. FMPs must identify the specific geographic location or extent of habitats described as EFH. FMPs must include maps of the geographic locations of EFH or the geographic boundaries within which EFH for each species and life stage is found.*”

Alaska EFH EIS (2005):

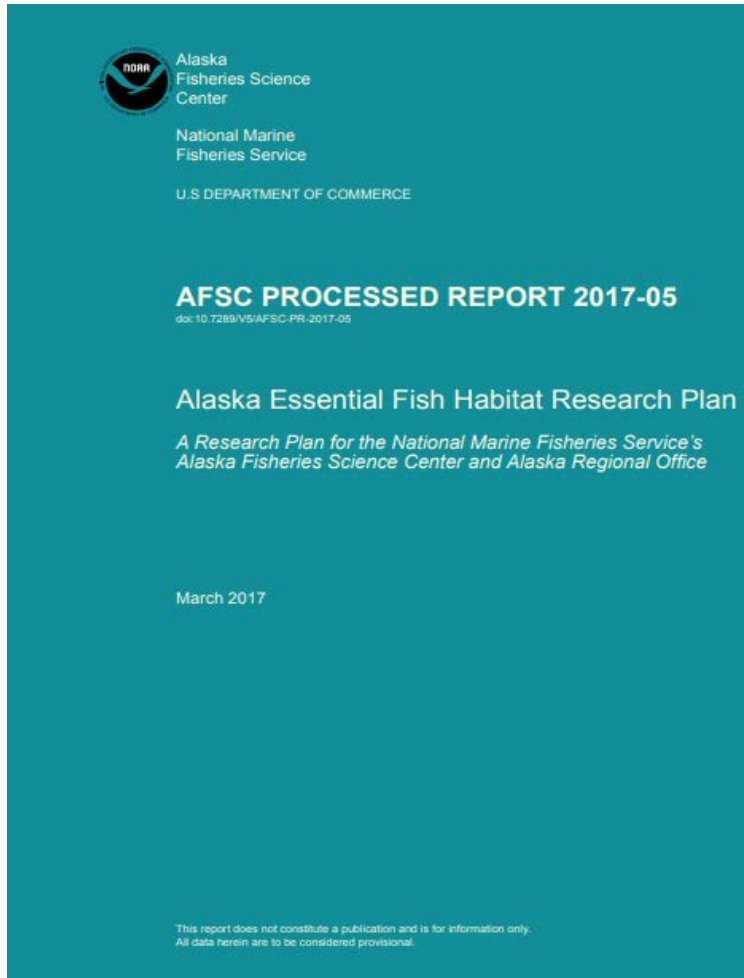
- EFH is the area inhabited by 95% of a species’ population.

SSC Guidance (2017 5-year Review):

- Map EFH areas from species distribution models (SDMs) using an area percentiles approach and use the “core EFH area” (upper 50% of EFH area) in the EFH Component 2 Fishing Effects Analysis.
- **SDM EFH mapping approach for the 2022 5-year Review** characterizes EFH for a species’ life stage as the spatial domain containing 95% of occupied habitat conditioned by encounter probability.



EFH Research Progress



Alaska EFH Research Plan objectives for progress by the 2022 EFH 5-year Review:

1. Develop EFH Level 1 information (distribution) for life stages and areas where missing.
2. Raise EFH level from Level 1 or 2 (habitat-related density or abundance) to Level 3 (habitat-related growth, reproduction, or survival rates).

Contributing Habitat Science

New Species Distribution Models (SDMs) and EFH Maps

Available for the February 2022 Meeting:

- Advancing Model-based EFH Descriptions and Maps for Groundfishes and Crabs (Laman et al. study)

Available for the June 2022 Meeting:

- First Model-based Arctic EFH (Marsh et al. study)
- Juvenile Walleye Pollock Thermal Habitat (Laurel et al. study)
- Individual-based Models to Advance EFH for Groundfish Pelagic Early Life History Stages (Shotwell et al. study)

All projects will provide new and revised EFH Level 1, 2, or 3 information, representing exciting progress on the Alaska EFH Research Plan objectives for the 2022 EFH 5-year Review.



Orientation to EFH Component 1 Documents

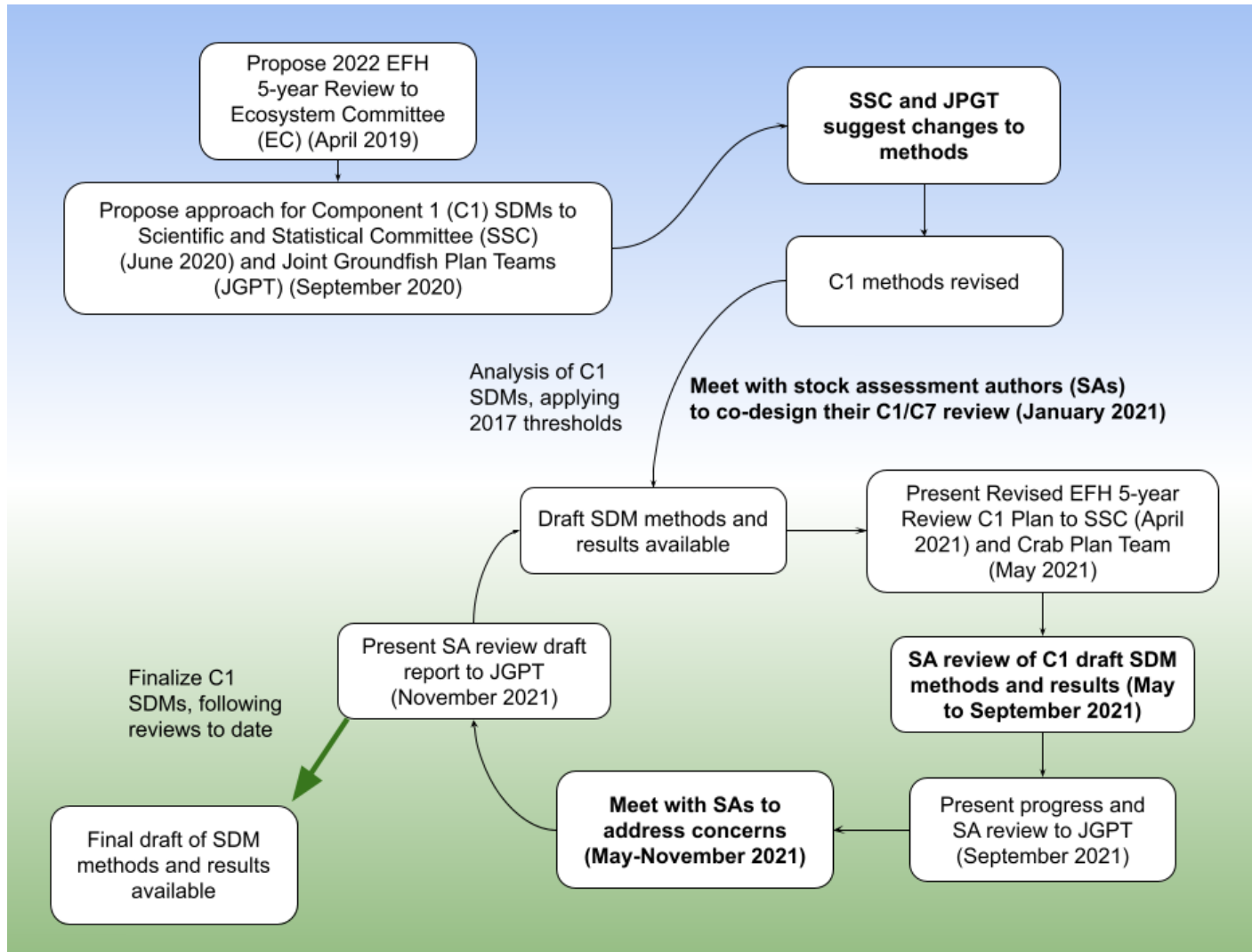
We have provided the **Discussion Paper on Advancing Model-based EFH Descriptions and Maps for the 2022 EFH 5-year Review** for this meeting.

The **Discussion Paper** is an overview document **with five supporting attachments** that provide *additional details* on the *new and revised* model-based EFH descriptions and maps available for the 2022 EFH 5-year Review by the **Laman et al. study**:

1. Stock Assessment Author Review Report of EFH Components 1 and 7
2. EFH Area Comparison Maps (image files comparing 2017 and 2022 EFH areas)
3. EFH Descriptions and Maps for the Bering Sea (Tech Memo)
4. EFH Descriptions and Maps for the Aleutian Islands (Tech Memo)
5. EFH Descriptions and Maps for the Gulf of Alaska (Tech Memo)



Iterative Review Process



Iterative Review Process to Develop Methods

- **SSC in June 2020 and Groundfish Plan Teams in September 2020** provided input on proposed methods and plan for new and revised EFH component 1 descriptions and maps for the 2022 5-year Review (EFH June 2020 Discussion Paper)
 - Laman et al. study modified our approach, which led to improvements (e.g., introduce SDM ensembles, negative binomial SDM, and uncertainty map), and produced the first draft of SDM ensemble EFH methods and results for review.
- **SSC in April 2021 and Crab Plan Team (CPT) in May 2021** provided input on the 2022 EFH 5-year Review Plan.
 - Laman et al. study responded to the SSC and Plan Team input received in 2020 with an update on methods and draft results examples. SSC provided guidance for analysts to prepare for SSC review in October 2021 (now February 2022). CPT provided recommendations for the stock assessment author review process.
- **Stock Assessment Author Review occurred May – September 2021.**
 - See the [Discussion Paper Appendix 1 and Attachment 1](#) for the Laman et al. study's responses to input by the SSC, Plan Teams, and Stock Assessment Author Review.



Stock Assessment Author Review

- Iterative review by stock assessment authors (SA) and other experts is a critical element of an EFH 5-year Review for our region. **SA Review Process of EFH component 1 for the 2022 EFH 5-year Review [Attachment 1 Chapter 2](#)**.
- Innovations of our approach to the SA review of EFH component 1 **strengthened the research products, process, and collaboration**.
 - We collaborated with senior stock assessment scientists to hold an SA Summit in January 2021, to co-develop the process for the SA review of EFH component 1.
 - We included additional crab species expert reviewers; recommended by CPT.
 - SAs reviewed the complete draft SDM ensemble EFH methods and results.
 - We implemented the SA review of EFH component 1 with timing that allowed incorporation of reviewer feedback in the outcomes of this work.
- Launched the SA review in May 2021.
 - SAs reviewed the FMP EFH descriptions and maps from the 2017 5-year Review.
 - SAs reviewed draft SDM ensemble EFH methods and species results chapters with new and revised EFH descriptions and maps for the 2022 5-year Review.
- Completed September 1, 2021 with 100% engagement by 32 reviewers, THANK YOU!!

Stock Assessment Author Review

- **SA Review Results and Communication Summary [Attachment 1 Chapter 3](#).**
- Presented SA review response plan to the **Groundfish Plan Teams September 2021**.
- 32 SAs reviewed and provided input on 3 regional draft methods sections and 125 SDM ensemble EFH draft species results chapters with 1-3 life stages each, and the current FMP EFH descriptions and maps.
- 27 species (out of 60 species) received model re-runs as determined by our internal evaluation or by SA review (e.g., revise life stage breaks = 22 species; reevaluate ensemble constituents = 1 species; hold and revisit in the future = 3 species without an EFH description and map from 2017).
- Followed up with **all reviewers** who provided input as comments, questions, and concerns, and worked with (8) individual reviewers more closely, largely completed by November 1. Revisions were made available for reviewers upon request.
- Co-developed research recommendations for a future EFH 5-year Review.
- Presented the draft SA Review Report to the **Groundfish Plan Teams November 2021**. Final SA Review Report is Attachment 1.
- NMFS Technical Memoranda for the Bering Sea, Aleutian Islands, and Gulf of Alaska are in the publication process and available as [Attachments 3, 4, and 5](#).

Advancing Model-based EFH for the 2022 5-year Review

(Laman, Pirtle, Harris, Siple, Rooper, Hurst, Conrath)

Purpose:

- Describe and map EFH for federally managed North Pacific groundfish and crab species in the Bering Sea, Aleutian Islands, and Gulf of Alaska, using RACE GAP summer bottom trawl survey data and regional habitat covariates.
- Built on the species distribution modeling (SDM) approach introduced and accepted in the 2017 EFH 5-year Review.
- Guided by the Alaska EFH Research Plan.
 - Characterize habitat utilization and productivity.
 - Advance EFH information levels from none to Level 1 and from Levels 1 or 2 to Level 3.



2017 NMFS Tech Memos:

NOAA Technical Memorandum NMFS-AFSC-357
doi:10.7289/V5TM-AFSC-357

Model-based Essential Fish Habitat Definitions for Bering Sea Groundfish Species



NOAA Technical Memorandum NMFS-AFSC-360
doi:10.7289/V5TM-AFSC-360

Model-based Essential Fish Habitat Definitions for Aleutian Island Groundfish Species



NOAA Technical Memorandum NMFS-AFSC-373
doi:10.7289/V5TM-AFSC-373

Model-based Essential Fish Habitat Definitions for Gulf of Alaska Groundfish Species



Alaska
Fisheries Science
Center

National Marine
Fisheries Service

U.S. DEPARTMENT OF COMMERCE

AFSC PROCESSED REPORT 2017-05

doi:10.7289/V5AFSC-PR-2017-05

Alaska Essential Fish Habitat Research Plan

A Research Plan for the National Marine Fisheries Service's
Alaska Fisheries Science Center and Alaska Regional Office

March 2017

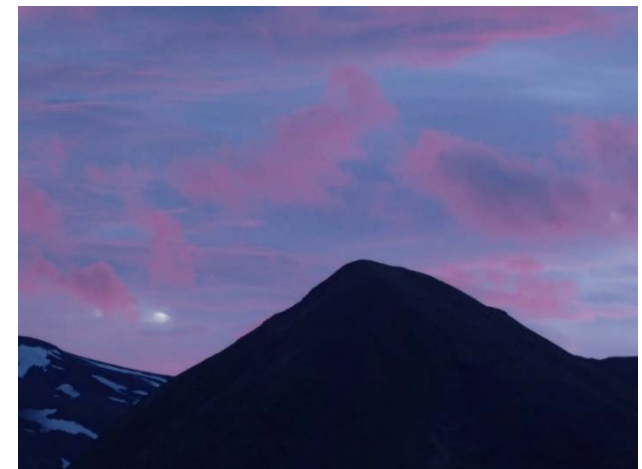


Advancing Model-based EFH for the 2022 5-year Review

(Laman, Pirtle, Harris, Siple, Rooper, Hurst, Conrath)

Results by the Numbers:

- EFH for North Pacific groundfish species, including up to three life stages:
 - 32 species in the Bering Sea
 - 25 species in the Aleutian Islands
 - 42 species in the Gulf of Alaska
 - 7 stock complexes (*a first*)
- EFH for invertebrates; all life stages combined:
 - 5 crab species in the Bering Sea
 - 2 crab species in the Aleutian Islands
 - 1 octopus species in all three regions
- Advanced EFH information levels for 211 species' life stages resulting in 229 new and revised EFH descriptions and maps:
 - None to Level 1
 - Level 1 to Level 2
 - Level 3 (*another first*)



SDM EFH Methods Overview and Comparison

2022 SDM Ensemble

Response Variable:

- Fish numerical abundance (1982-2019 catches)

Models:

- MaxEnt, paGAM, hGAM, Poisson GAM, Negative Binomial GAM
- All SDMs considered for the ensemble
- Skill testing with RMSE

Ensemble:

- Best performing SDMs retained

Performance Metrics: (applied to all)

- k-fold cross validation to generate RMSE and other fit metrics
- Spearman's correlation (ρ), AUC, Poisson Deviance Explained (PDE)

2017 SDM

Response Variable:

- 4th root transformed CPUE (1982-2014 catches)

Models:

- MaxEnt, hGAM, GAM
- One SDM selected *a priori*
- *New for 2022*

Ensemble:

- *New for 2022*

Performance Metrics:

- Applied based on SDM
- MaxEnt (AUC); GAMs (Deviance Explained)
- 80/20 training/testing, fit metrics examined for out of sample comparison



Advancing Model-based EFH for the 2022 5-year Review

(Laman, Pirtle, Harris, Siple, Rooper, Hurst, Conrath)

SDM Performance Metrics:

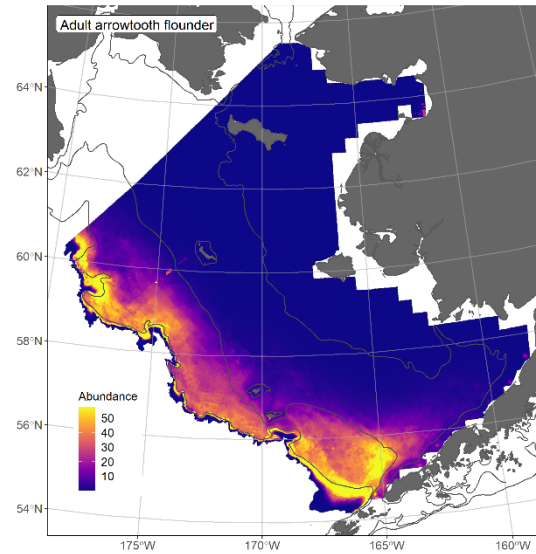
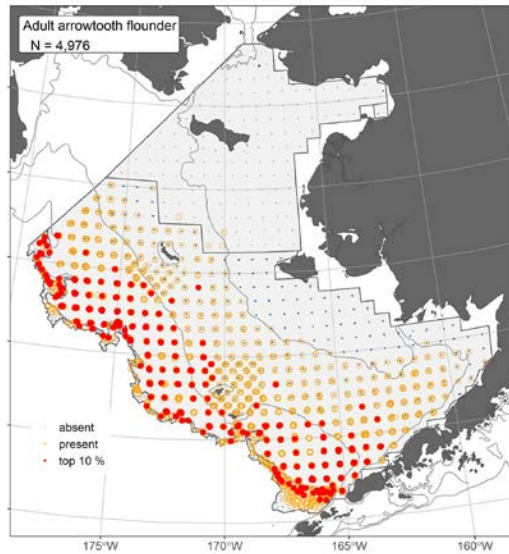
- Spearman's rank correlation coefficient (ρ)
 - distinguish between high and low abundance
- Area under the receiver operator characteristic curve (AUC)
 - discriminate presence absence
- Poisson Deviance Explained (PDE)
 - deviance explained by the ensemble assuming a Poisson distribution

Mapping EFH from SDM ensembles:

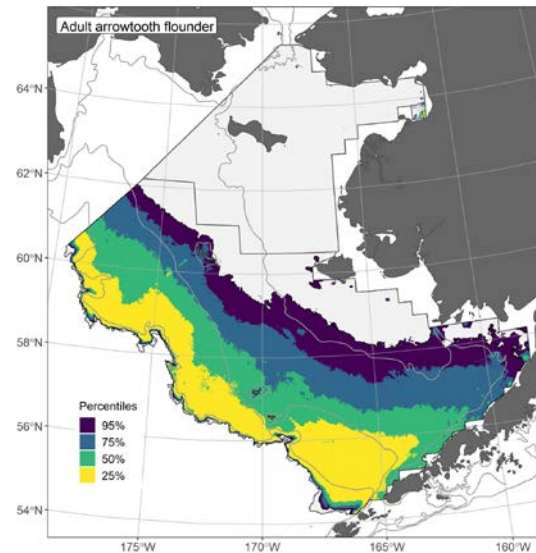
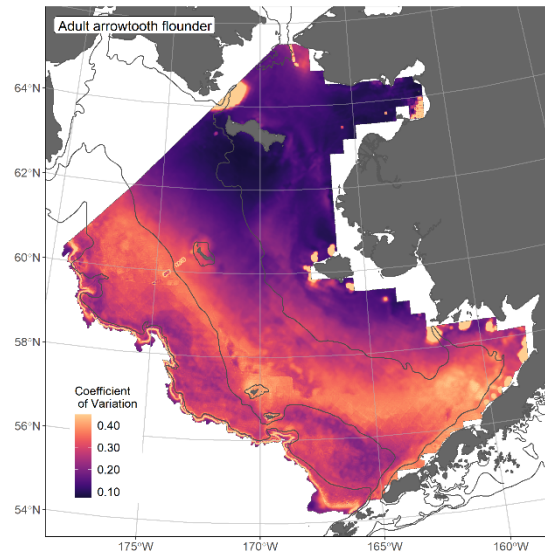
- EFH is the spatial domain containing 95% of occupied habitat for a species' life stage conditioned by encounter probability
- Additional EFH area percentiles: Upper 75% of occupied habitat; Upper 50% "Core EFH area" was applied to Fishing Effects Analysis in 2017 EFH 5-year Review; Upper 25% "EFH hot spots"



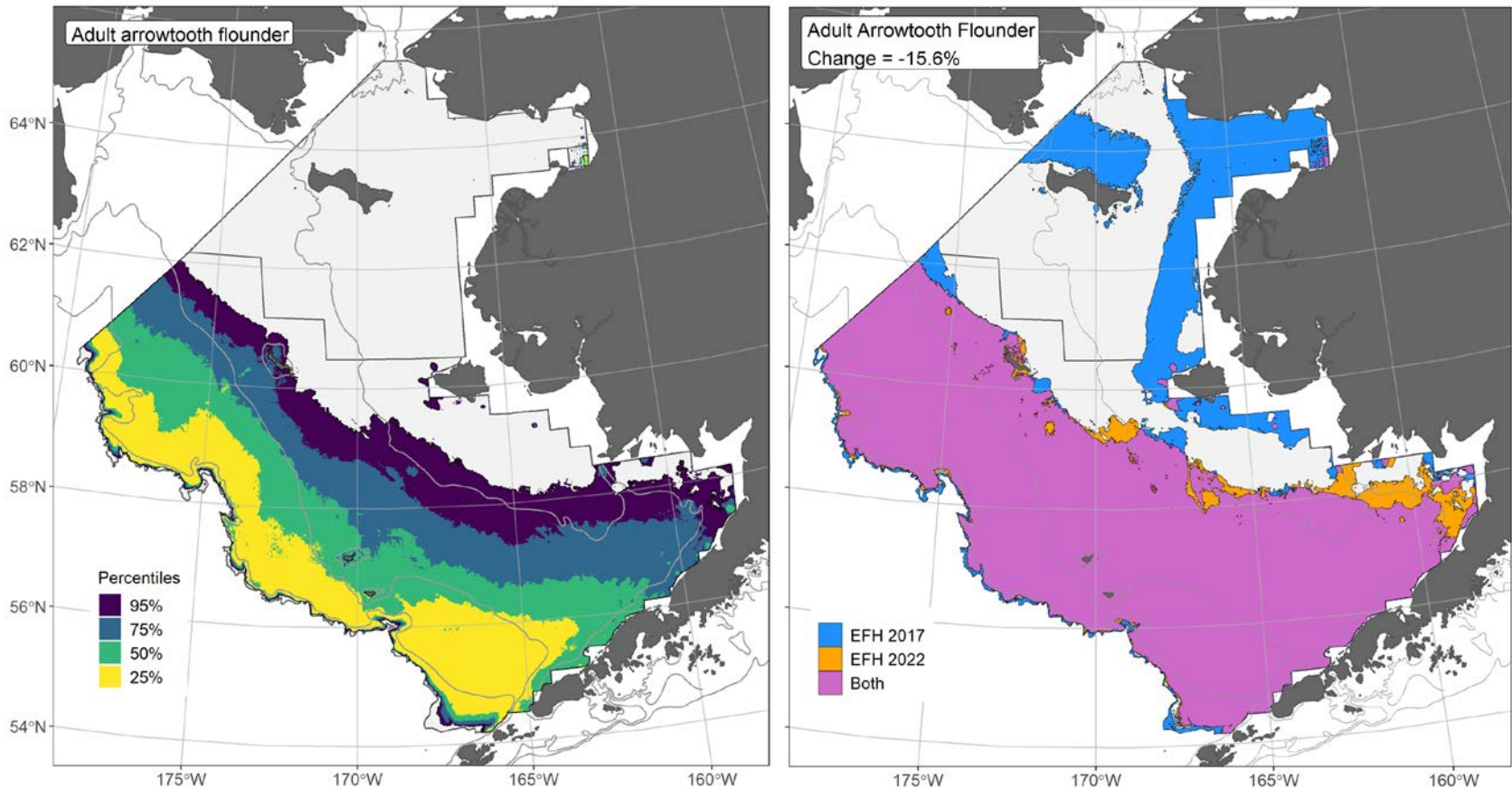
Arrowtooth Flounder Adults



$\rho = 0.81$
AUC = 0.96
PDE = 0.63



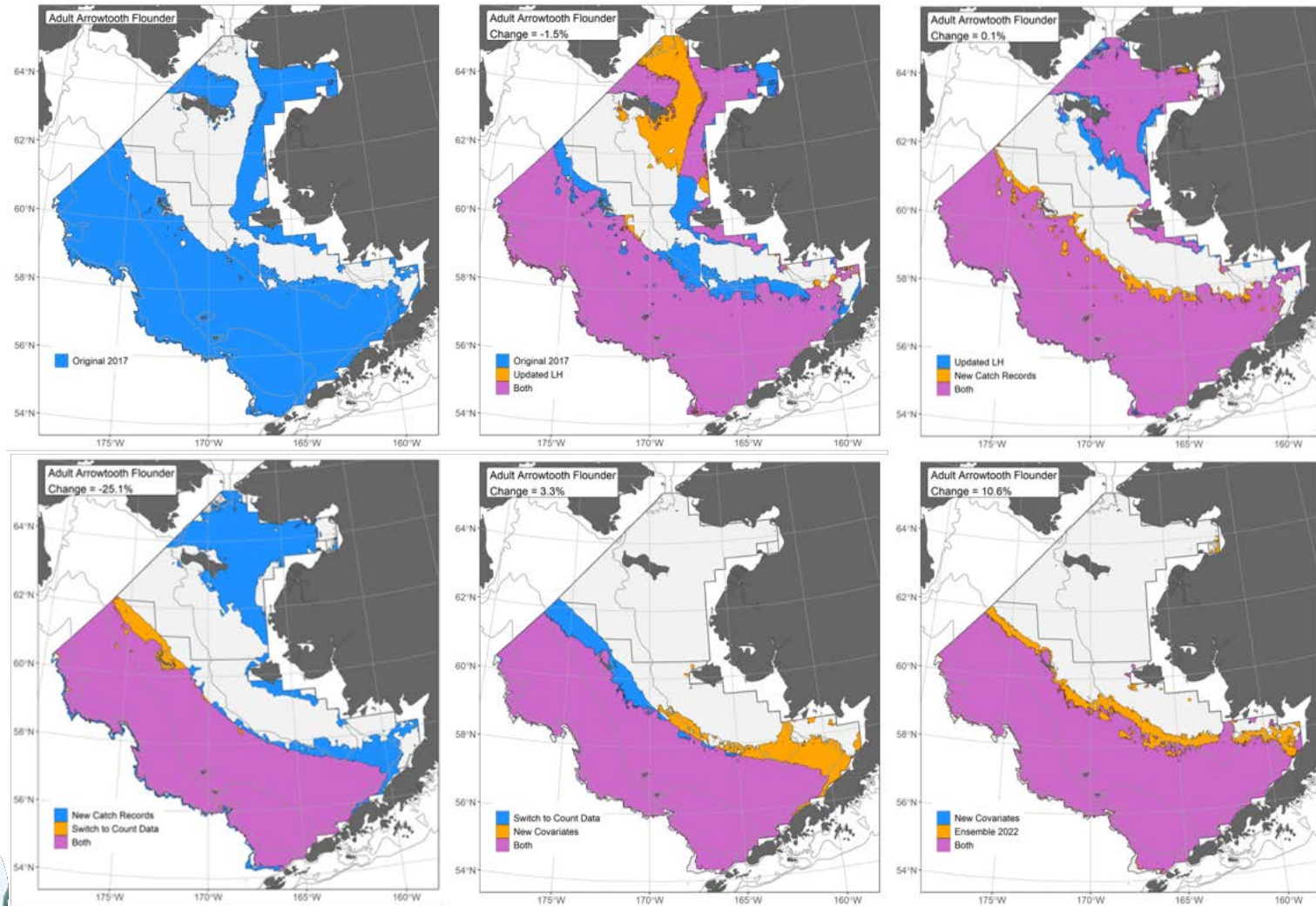
SDM EFH Comparison 2017 and 2022



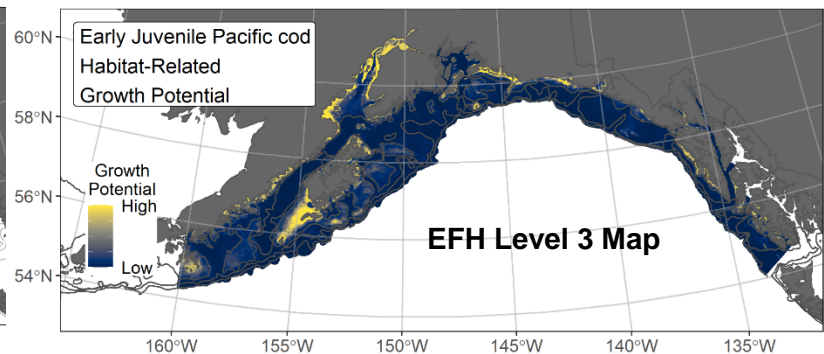
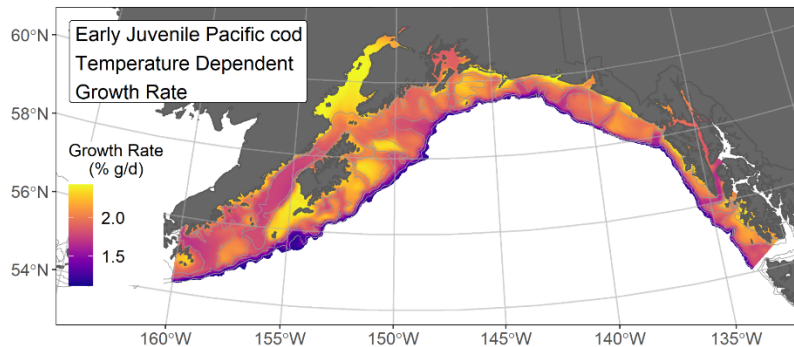
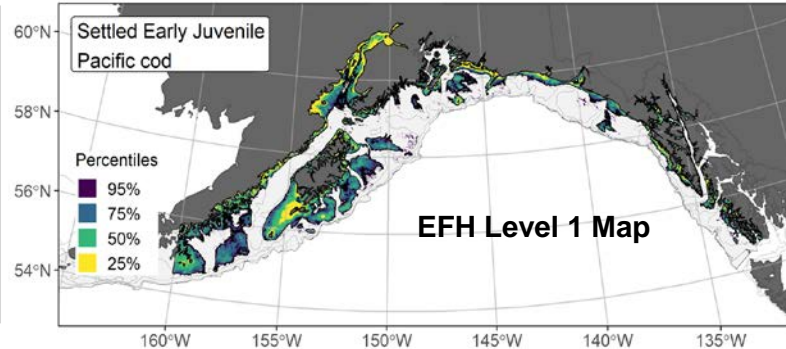
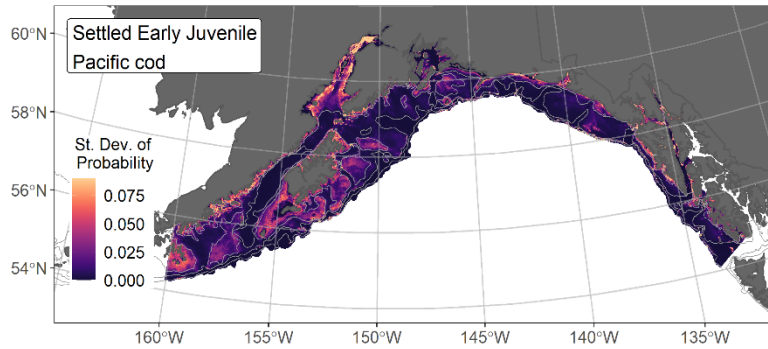
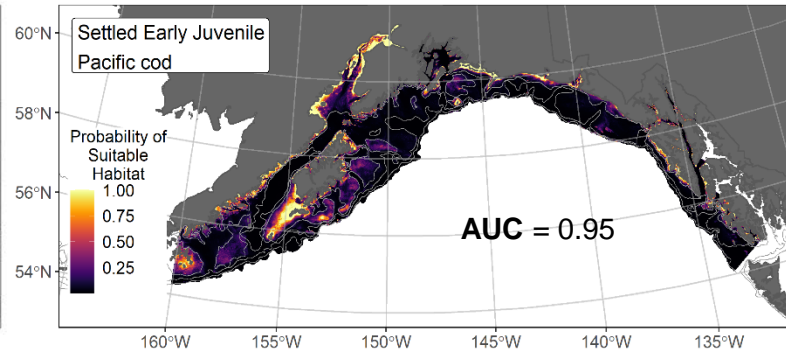
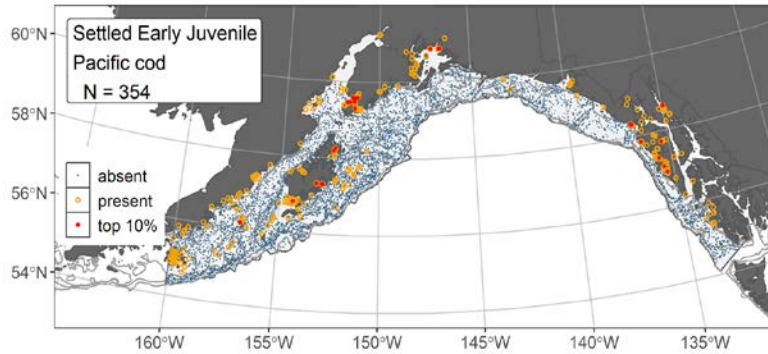
EFH Review	SDM Method	N	RMSE	ρ	AUC	PDE	EFH Area	Core EFH Area	% Change in Area
2017	GAM _{CPUE}	4,102	83.87	0.82	0.95	0.45	504,500	265,500	--
2022	Ensemble	4,976	26.88	0.81	0.96	0.63	425,700	224,000	-15.6 %



EFH Area Bridging Sequence 2017 and 2022



Pacific Cod Settled Early Juveniles



Conclusions

- Accomplished Alaska EFH Research Plan objectives.
- Incorporated reviews and guidance from SSC, Plan Teams, stock authors, species experts, and other stakeholders.
- SDM ensemble was an improvement over single SDM approach of 2017 EFH 5-year Review.
 - Reduced model-dependent prediction bias
 - Performance metrics were improved overall
 - Robust modeling framework
- A total of 229 new or revised EFH Level 1, 2, or 3 descriptions and maps are available for 211 individual species' life stages and 7 stock complexes in 3 FMPs.
- Extend to stock assessment and other EBFM
 - ESPs (e.g., Shotwell et al. in review), groundfish recruitment processes (e.g., Goldstein et al. 2020), future distribution changes related to climate (e.g., Rooper et al. 2021).



Future Research Directions

- Future Research Directions:
 - Data
 - Model crab life stages (immature/mature)
 - Incorporate other data sets (e.g., longline surveys, fisheries data, or optical surveys)
 - Explore additional or new environmental variables
 - Modeling
 - Explore classes of SDMs
 - Focus on data-limited species
 - Execute SDMs on reduced temporal scales
- Future EFH Process Recommendations:
 - Timely review
 - Automation
 - Reproducible code
 - Automated reports
 - Working Group



THANK YOU



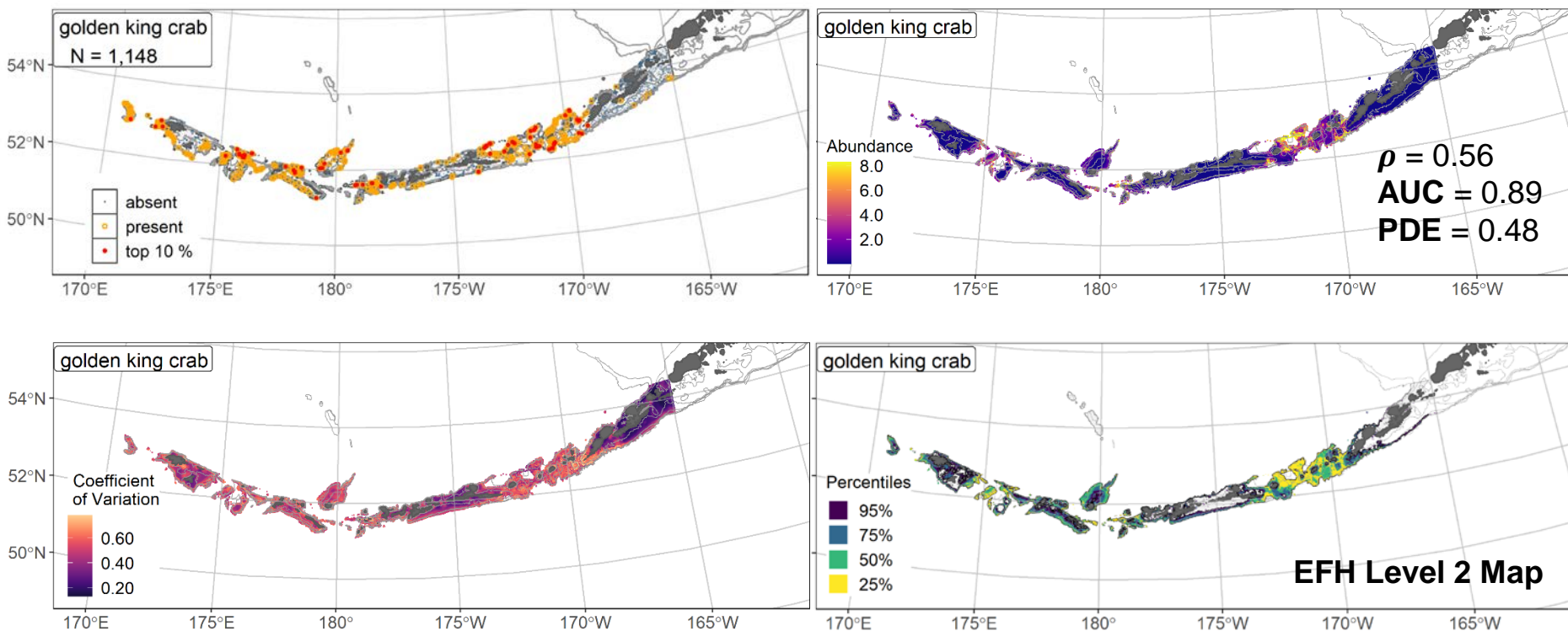
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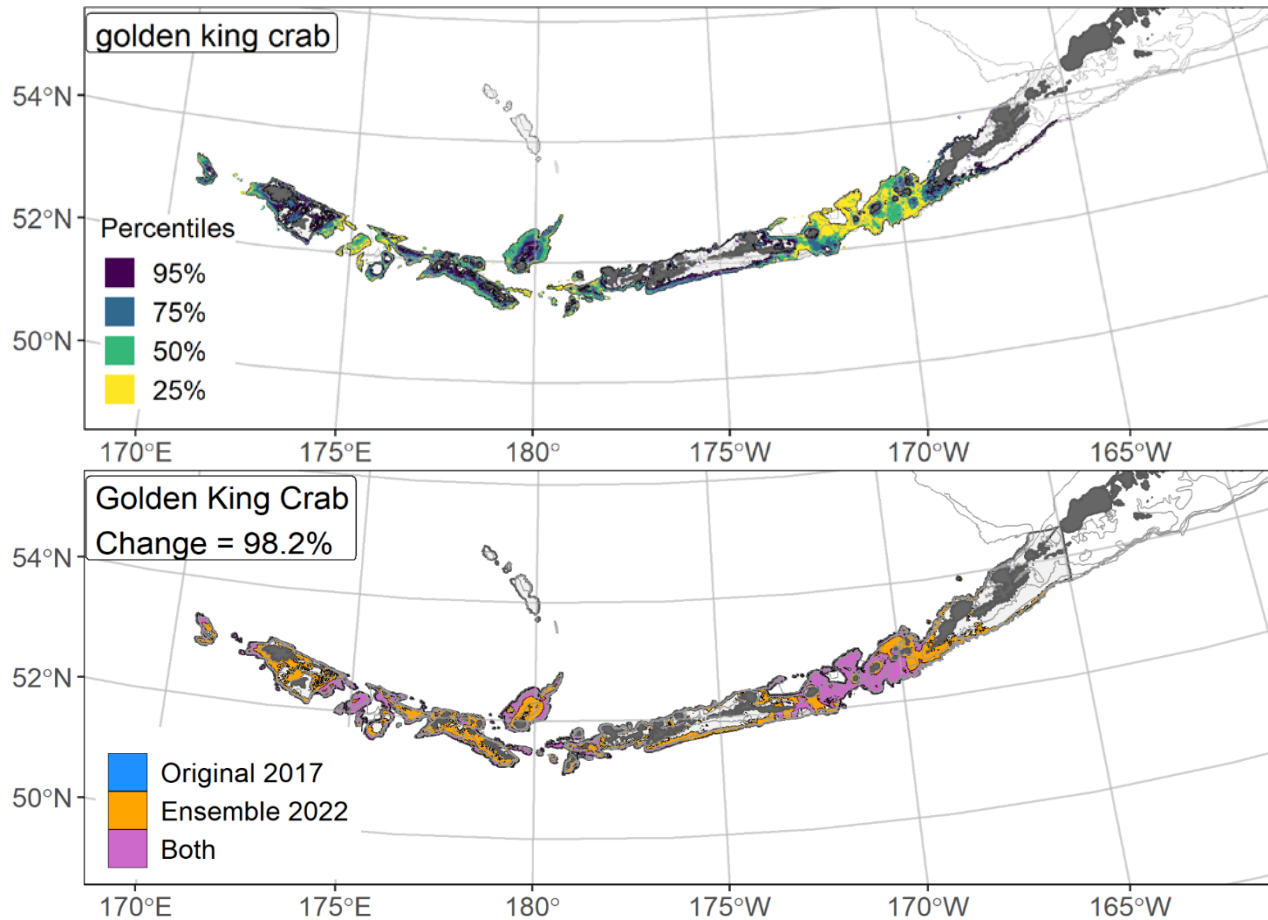
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Golden King Crab



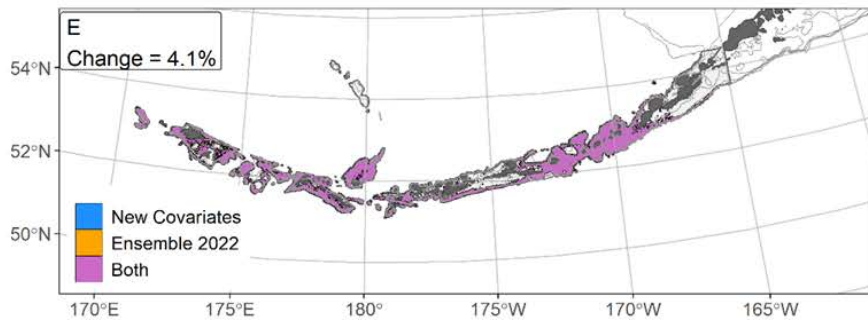
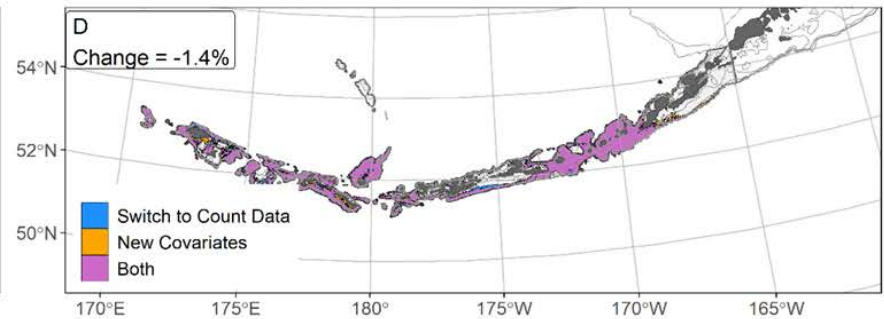
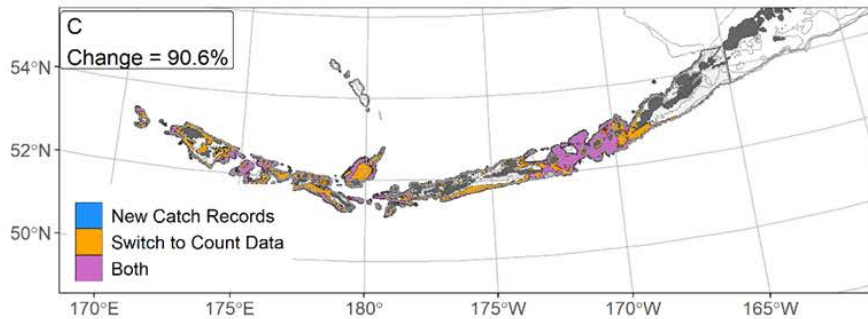
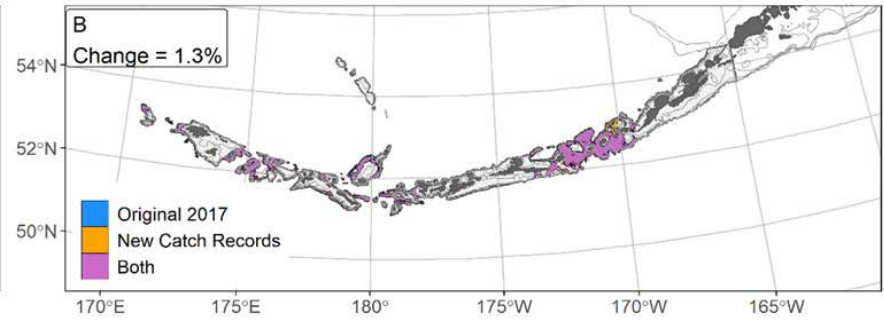
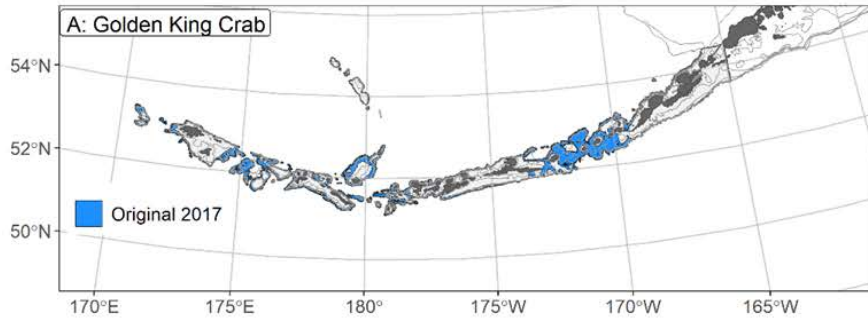
See the [Discussion Paper](#) on EFH Descriptions and Maps for the Golden King Crab results example and the Aleutian Islands Tech Memo ([Discussion Paper Attachment 4](#)).

EFH Comparison 2017 versus 2022

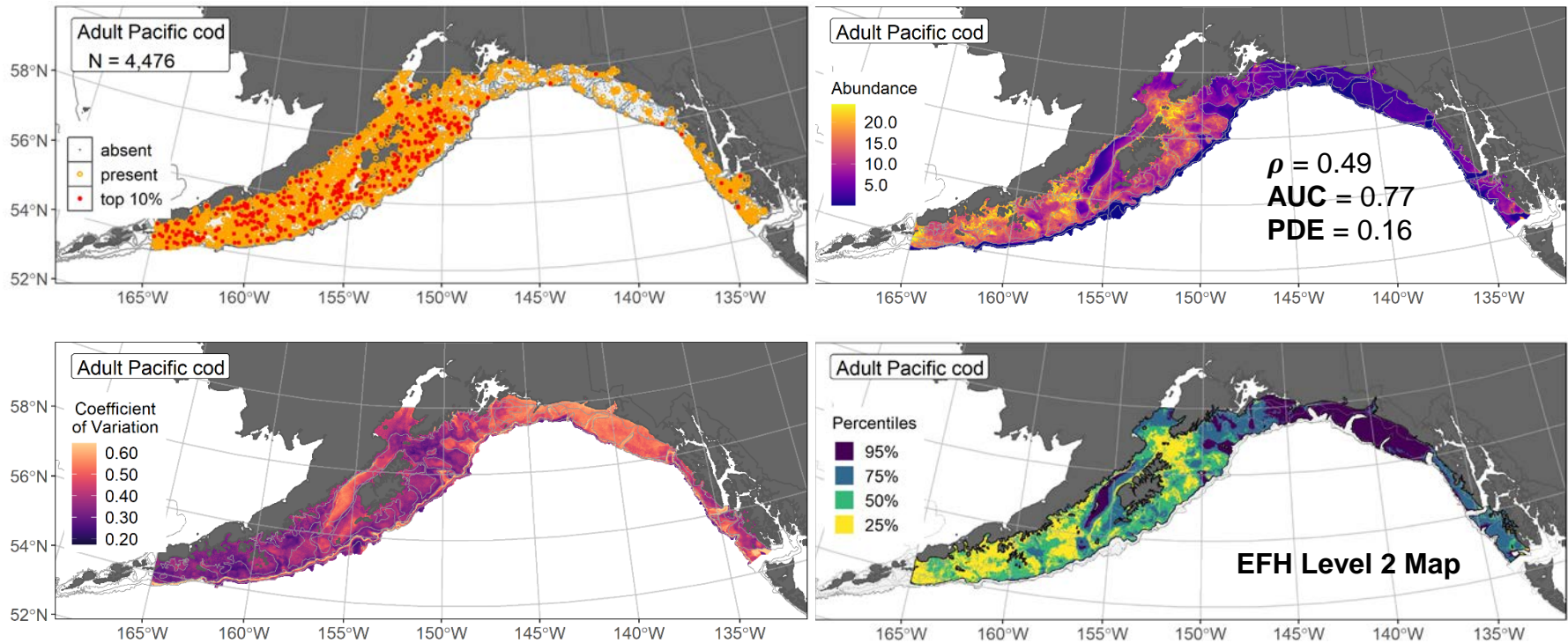


EFH Review	SDM Method	N	RMSE	ρ	AUC	PDE	EFH Area	Core EFH Area	% Change in Area
2017	hGAM _{CPUE}	956	6.28	0.56	0.88	-0.29	26,400	13,900	
2022	Ensemble	1148	6.19	0.56	0.89	0.48	52,300	27,600	98%

Golden King Crab Bridging Sequence

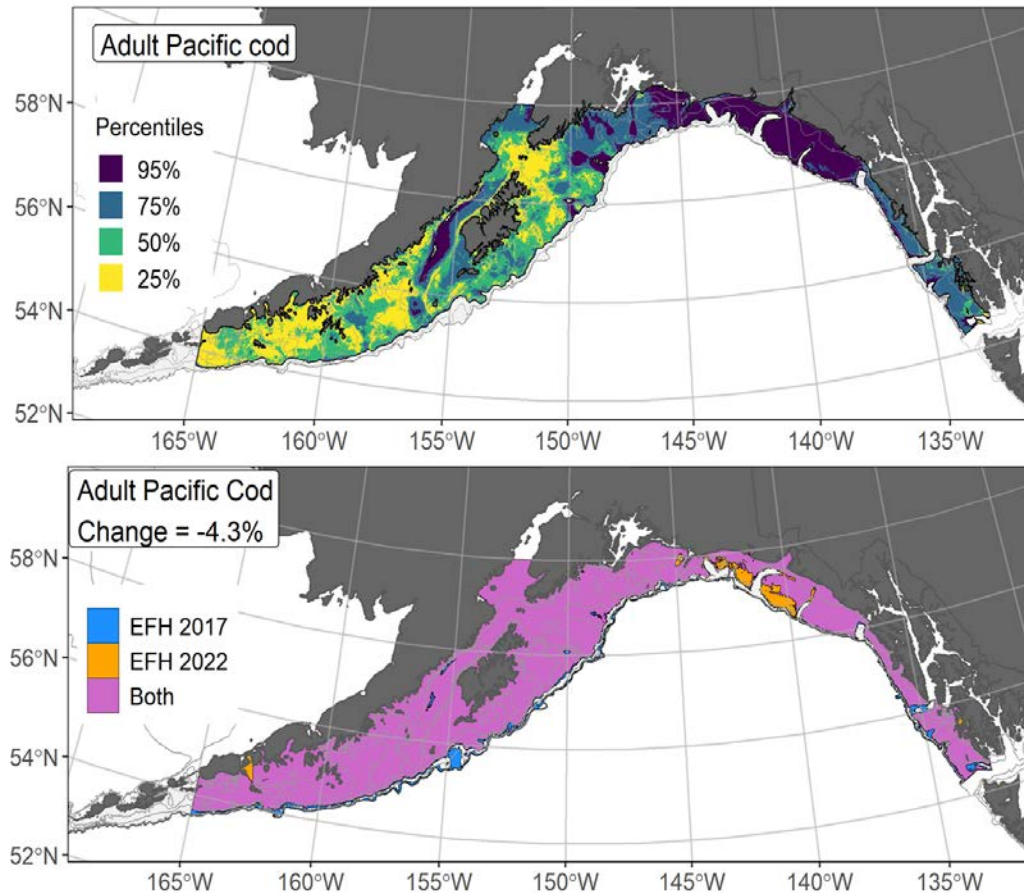


Pacific Cod Adults



See the [Discussion Paper](#) on EFH Descriptions and Maps for the Pacific cod results example and the Gulf of Alaska Tech Memo ([Discussion Paper Attachment 5](#)).

SDM EFH Comparison 2017 and 2022



EFH Review	SDM method	N	RMSE	ρ	AUC	PDE	EFH area (km ²)	Core EFH area (km ²)	% Change in area
2017	GAM _{CPUE}	3,753	96.1	0.49	0.76	-0.35	295,900	155,700	
2022	Ensemble	4,476	71.0	0.49	0.77	0.16	265,900	140,000	-4.3%

EFH Area Bridging Sequence 2017 and 2022

