

2022 Essential Fish Habitat (EFH) 5-Year Review

Component 1 Descriptions and Identification

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EFH Components of Fishery Management Plans

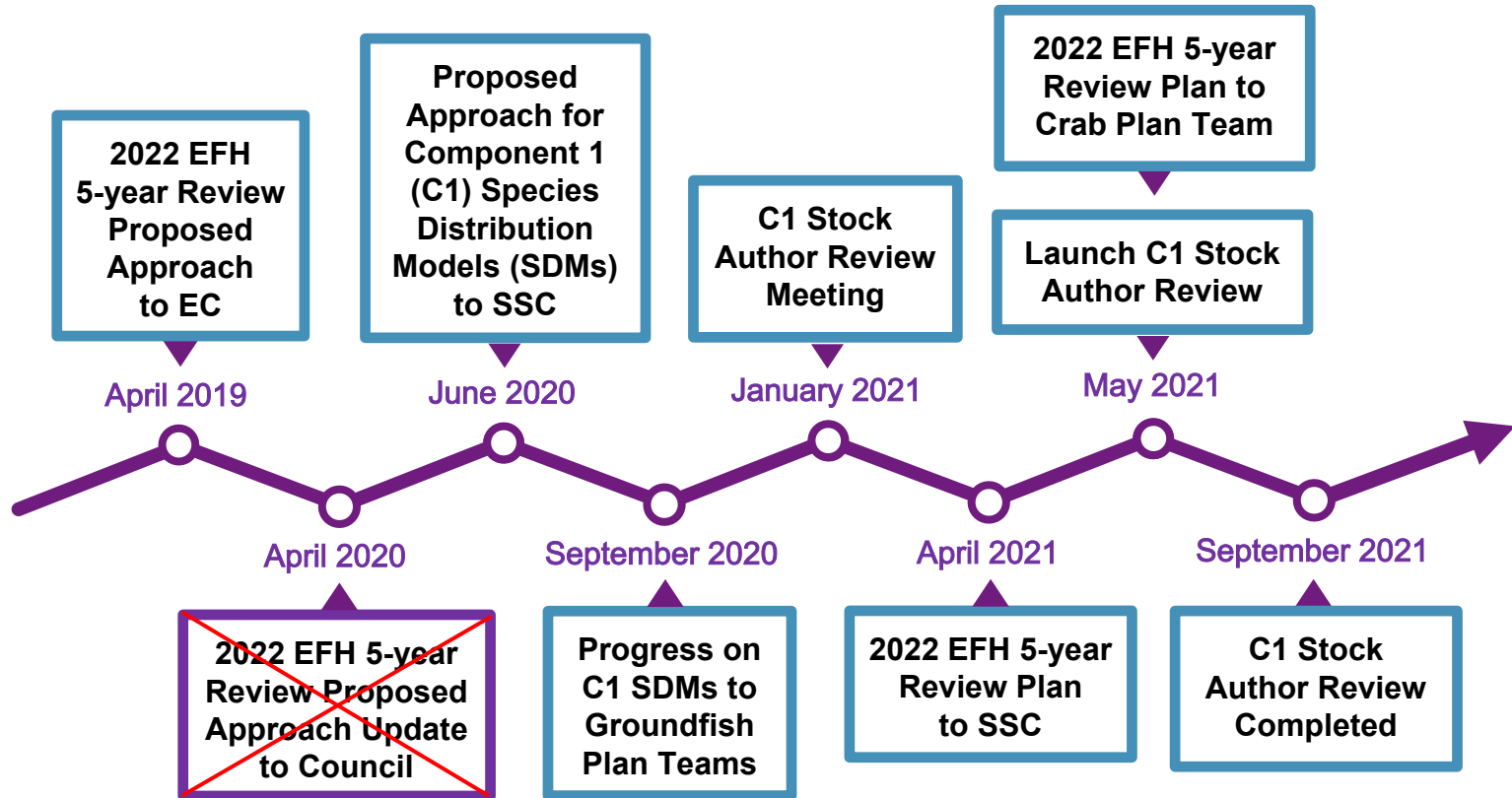
NMFS has prioritized the seven EFH components in bold for the 2022 EFH 5-year Review and will present **components 1 and 2** today:

- 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**

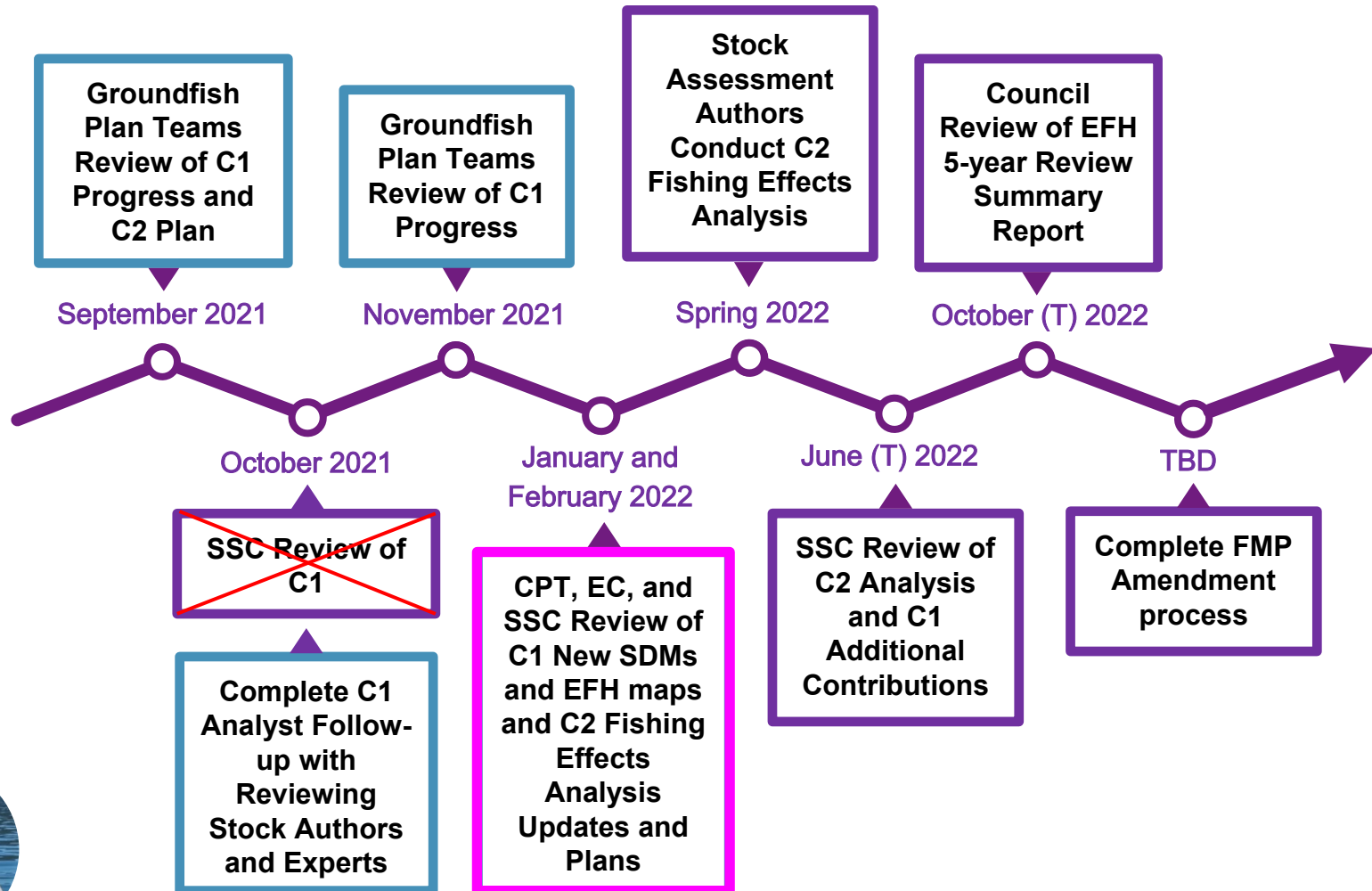
An EFH 5-Year Review Summary Report will be presented to the Council in October 2022 (T).



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, breeding, 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 Component 1 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):

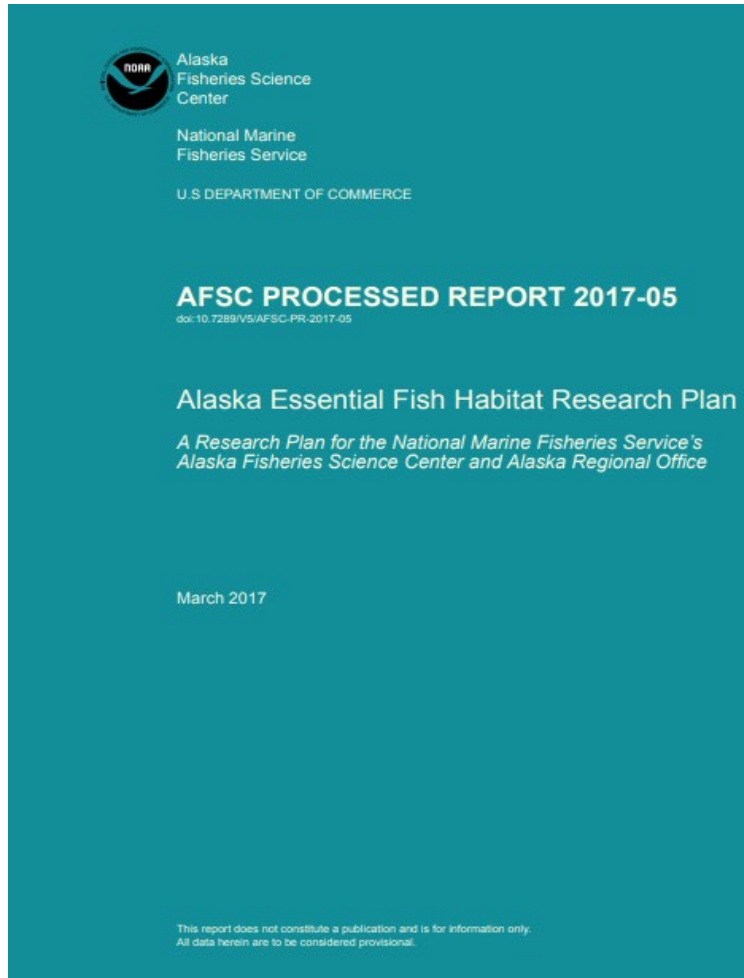
- EFH is the area inhabited by 95% of a species’ population.

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

- **SSC in June 2020 and Groundfish Plan Teams in September 2020** provided input on the proposed approach for new and revised EFH component 1 descriptions and maps (EFH June 2020 Discussion Paper).
 - Outcome: EFH analysts revised methods (e.g., introduce SDM ensembles, negative binomial SDM, and uncertainty map), leading to 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.
 - Outcome: EFH analysts responded to SSC and Plan Team input from 2020. SSC provided guidance for SSC review in October 2021 (now February 2022). CPT provided recommendations for the stock assessment author review process.
- **Groundfish Plan Teams in September 2021** provided input on EFH component 1 response plan for the SA Review and **in November 2021** reviewed the DRAFT Stock Author Review Report with the review response.
 - Outcome: EFH analysts completed their response to the SA Review (September – November) and finalized the SA Review Report.
- **SSC requested** a timeline of EFH component 1 review and input with analyst responses (**SSC October 2021, Discussion Paper Table A1.1 item 6a page 126**).

Discussion Paper Appendix 1: EFH component 1 analyst responses to requests and recommendations from SSC June 2020, Joint Meeting of the Groundfish Plan Teams (JGPT) September 2020, SSC April 2021, Crab Plan Team (CPT) May 2021, JGPT September 2021, SSC October 2021 (EFH agenda item not scheduled), and JGPT November 2021 (page 117).

Table A1.1 (2022 EFH 5-year Review)

Table A1.1. EFH component 1 analyst responses to requests and recommendations (item) by the Council’s Scientific and Statistical Committee (SSC), Joint meeting of the Groundfish Plan Teams (JGPT), and Crab Plan Team (CPT), provided in the minutes from meetings with an EFH agenda item scheduled or otherwise reported for review in 2020 and 2021, including (1) SSC June 2020, (2) JGPT September 2020, (3) SSC April 2021, (4) CPT May 2021, (5) JGPT September 2021, (6) SSC October 2021 (JGPT reporting to SSC; EFH agenda item not scheduled), and (7) JGPT November 2021.

Item	Description	Response
1: SSC June 2020 Meeting		
1a	SSC requested justification for selection of the final models using RMSE (root mean square error) or other skill testing metrics.	Methods describe how RMSE is used as an indicator of the best-performing model and model elimination steps are clear (see the Cross Validation and Skill Testing subsection of the Methods). To address overdispersion in the data, a negative binomial

Table A1.2 (2017 EFH 5-year Review; Discussion Paper Table A1.1 SSC request October 2021 item 6b)

Table A1.2. EFH component 1 (descriptions and identification) analyst responses to SSC’s request for “an overview of SSC recommendations from the 2017 EFH process and the degree to which these were addressed for the current EFH review cycle” ([Table A1.1 6b](#)). SSC minutes from the 2017 process include the following meetings: (1) February 2015⁴², (2) April 2016⁴³, (3) October 2016⁴⁴, (4) December 2016⁴⁵, and (5) April 2017⁴⁶.

Item	Description	Response
2: SSC April 2016 Meeting		
2	SSC reviewed an update to EFH designations based on the use of SDMs to define EFH. “SSC supports the use of SDMs for predicting species’ distributions . . . revisions to EFH definitions in the FMPs are warranted and the FMPs should be amended”. SSC acknowledged “there is still work to be done to allow this new	See items 2a-c relevant to EFH component 1.

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. **Report of SA EFH Component 1 Review Attachment 1** (SSC requested April and October 2021 Table A1.1 items 3b, 3j, 6d).
- Innovations of our approach to the SA review of EFH component 1 **strengthened the research products, process, and collaboration.**
 - We held an EFH Component 1 SA Review Summit in January 2021, to co-develop the process with SA reviewers.
 - 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.



Stock Assessment Author Review

- Results and Communication Summary [Attachment 1 Chapter 3](#).
- Completed September 1, 2021 with 100% engagement by reviewers, THANK YOU!!
- 32 SAs reviewed 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).
- We 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.
- We co-developed research recommendations for a future EFH 5-year Review.
- NMFS Tech Memos for the three regions 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

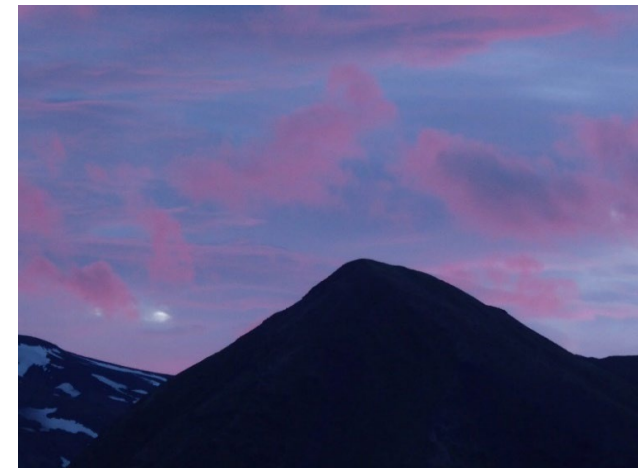


Advancing Model-based EFH for the 2022 5-year Review

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

Results by the Numbers:

- EFH for North Pacific Groundfishes; up to three life stages – 219 new and revised descriptions and maps:
 - 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 – 10 new and revised descriptions and maps:
 - 5 crab species in the Bering Sea
 - 2 crab species in the Aleutian Islands
 - Octopus in all three regions
- Advanced EFH information levels:
 - None to Level 1 (distribution)
 - Level 1 to Level 2 (habitat-related abundance)
 - Level 3 (habitat-related vital rates - *another first*)

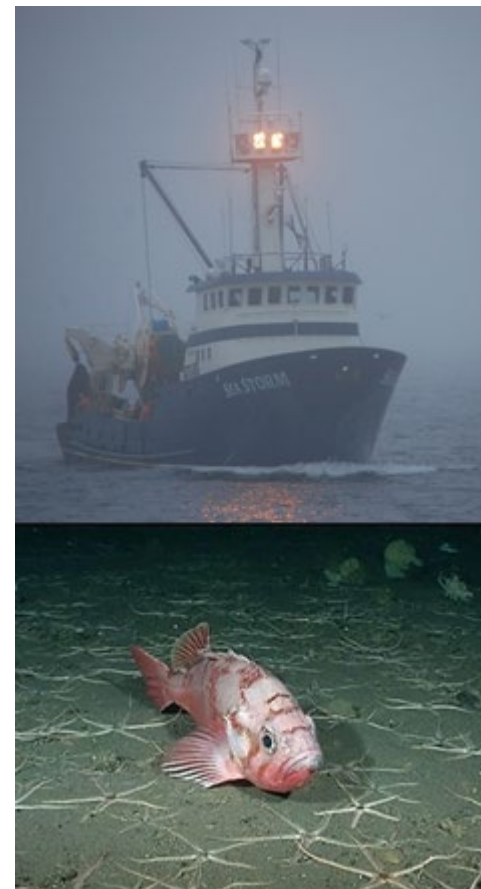


Advancing Model-based EFH for the 2022 5-year Review

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

Since the 2017 EFH 5-Year Review:

- 5 bottom trawl survey years added (2015-19)
- Nearshore surveys added to model settled early juvenile life stage in the GOA (*SSC encouraged June 2020; Table A1.1.1i page 119*)
- Updated terrain and ROMS covariates (*SSC supported June 2020; Table A1.1.1g*)
- Updated life stages and maturity schedules
- Modeling
 - Response variable = Numerical Abundance (*SSC supported June 2020; Discussion Paper Table A1.1.1f*)
 - 4th root transformed CPUE in 2017
 - Ensemble Modeling (*SSC suggested and supported June 2020; Table A1.1.1d.1e; JGPT supported September 2020 Table A1.1.2a*)
 - Added negative binomial GAM for overdispersion (*SSC recommended, suggested, and supported June 2020; Table A1.1.1b.1d.1f*)
 - Constituent model weighting by RMSE (*SSC suggested and supported June 2020; Table A1.1.1d.1f*)

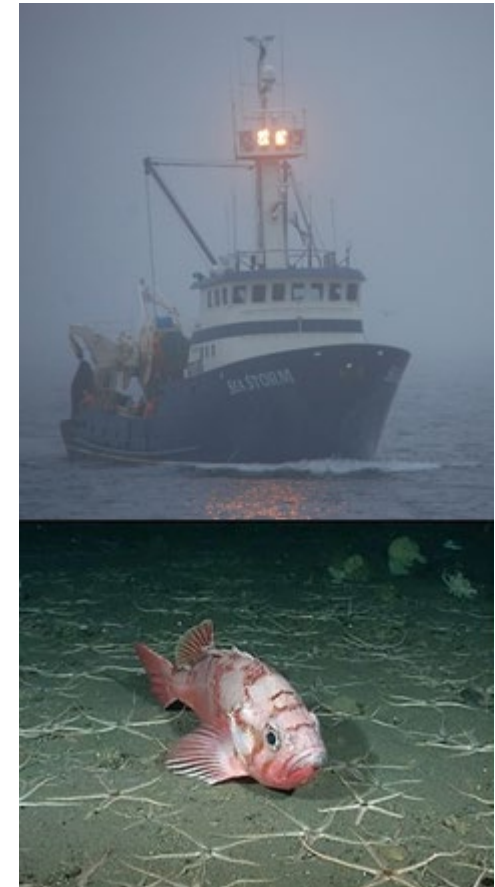


Advancing Model-based EFH for the 2022 5-year Review

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

Since the 2017 EFH 5-Year Review:

- Model uncertainty
 - k-fold cross validation and CV maps
(SSC recommended and supported June 2020; Table A1.1.1c.1f page 118)
- Skill testing among constituent SDMs
(SSC requested and supported June 2020; Table A1.1.1a.1f)
- EFH conditioned by 5% encounter probability
 - Change from absence threshold in 2017
- Advancing EFH Levels
 - Level 2 - abundance
 - Complementary log log (cloglog) abundance approximation (SSC supported June 2020; Table A1.1.1f)
 - Level 3 - vital rates
 - Enhance interpretation Level 1 and 2 maps (SSC supported and encouraged June 2020, Table A1.1.1h.1k)



SDM EFH Methods Overview and Comparison

2022 SDM Ensemble

Response Variable:

- 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 relatively 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

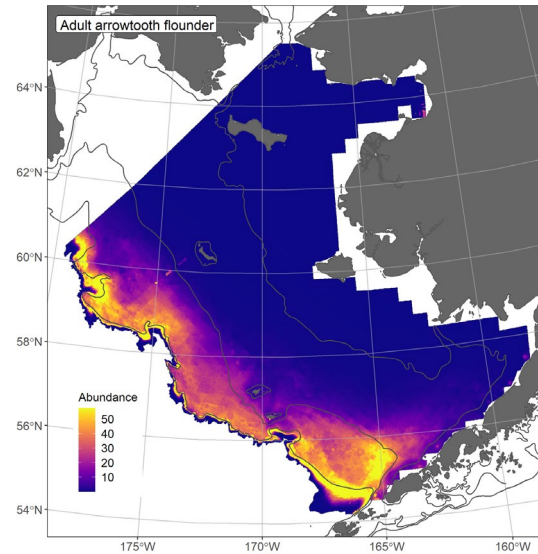
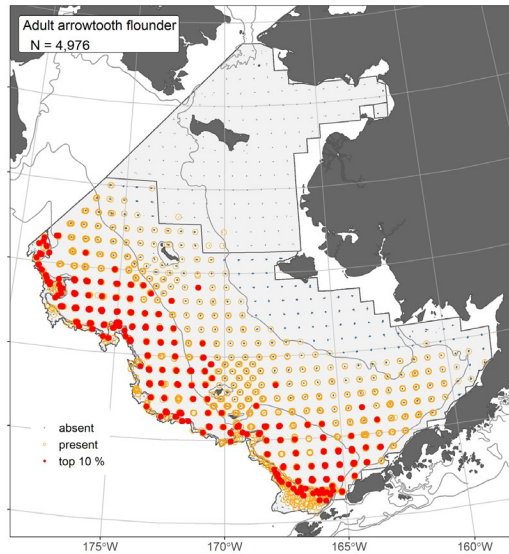


Mapping EFH from SDM ensembles:

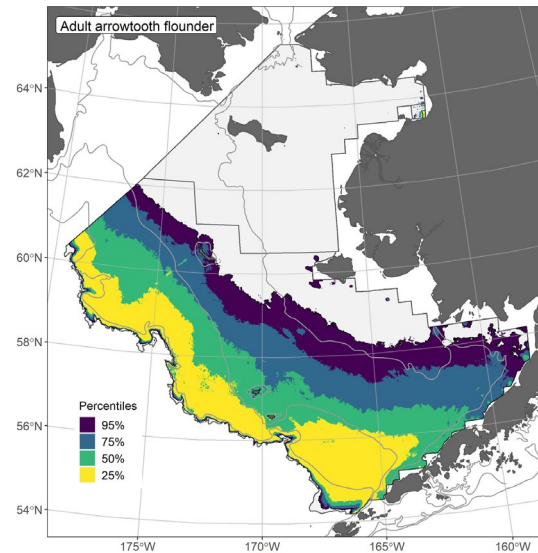
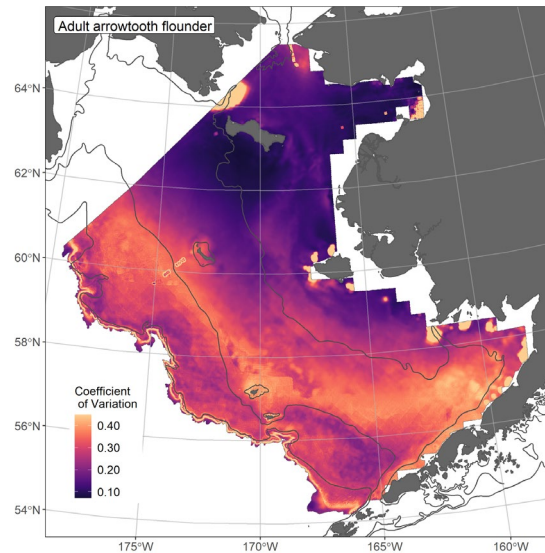
- EFH is the spatial domain containing 95% of occupied habitat for a species' life stage conditioned by encounter probability
- Additional EFH area percentiles: Upper 75% of occupied habitat; Upper 50% "Core EFH area" was applied to Fishing Effects Analysis in 2017 EFH 5-year Review; Upper 25% "EFH hot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



Arrowtooth Flounder Adults



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

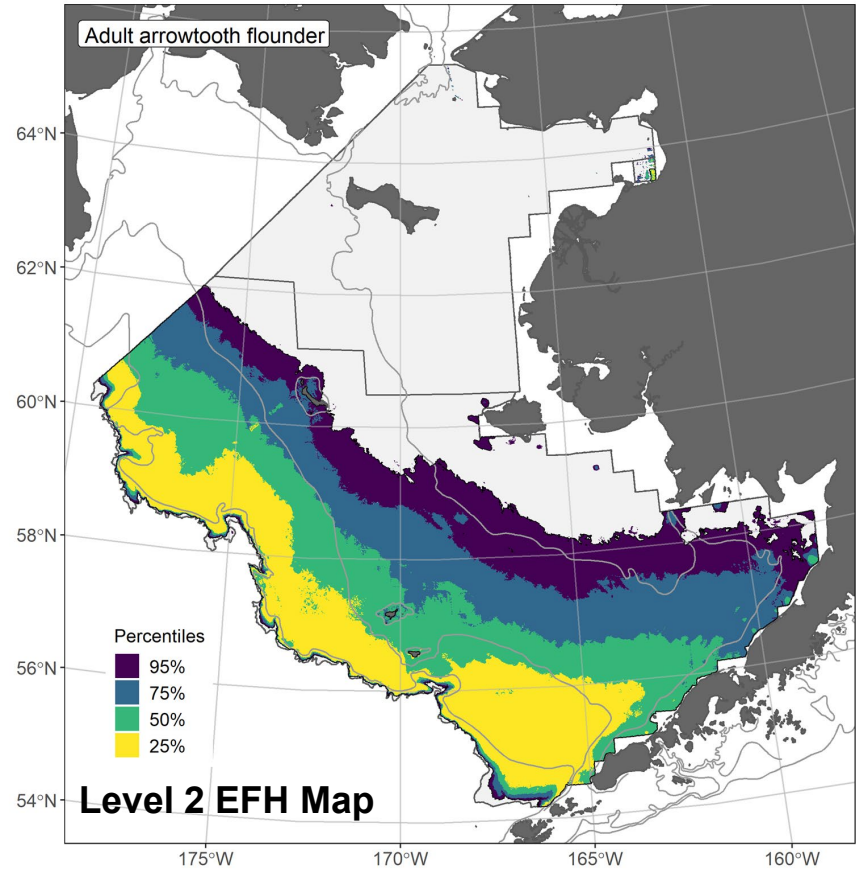
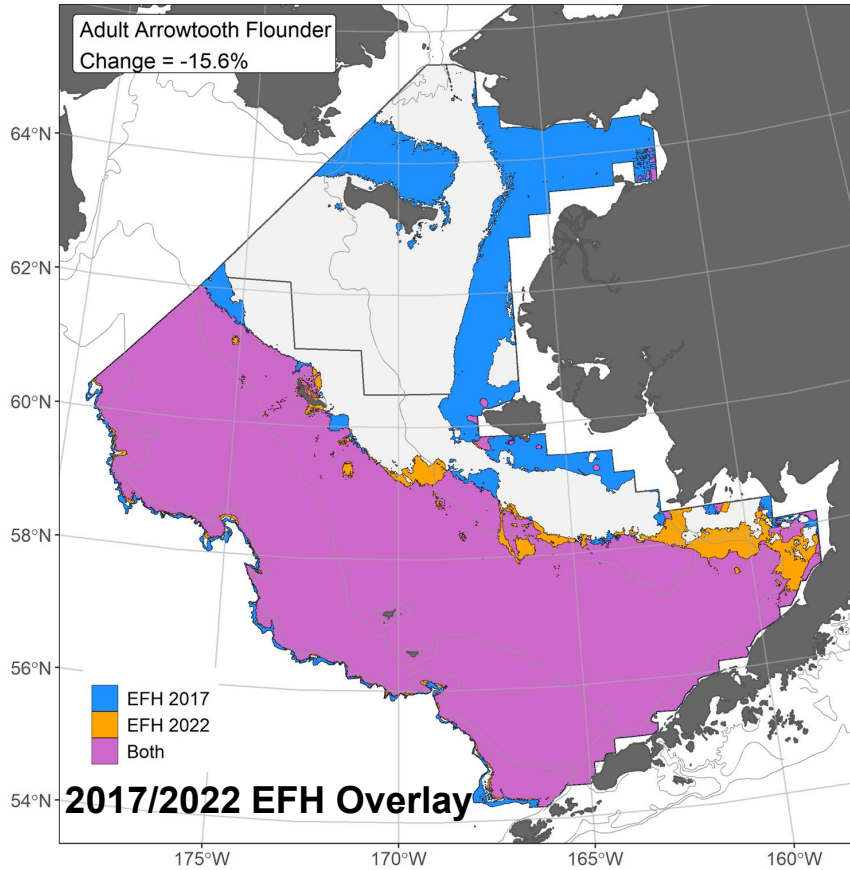


Level 2 EFH Map

See the [Discussion Paper](#) results section



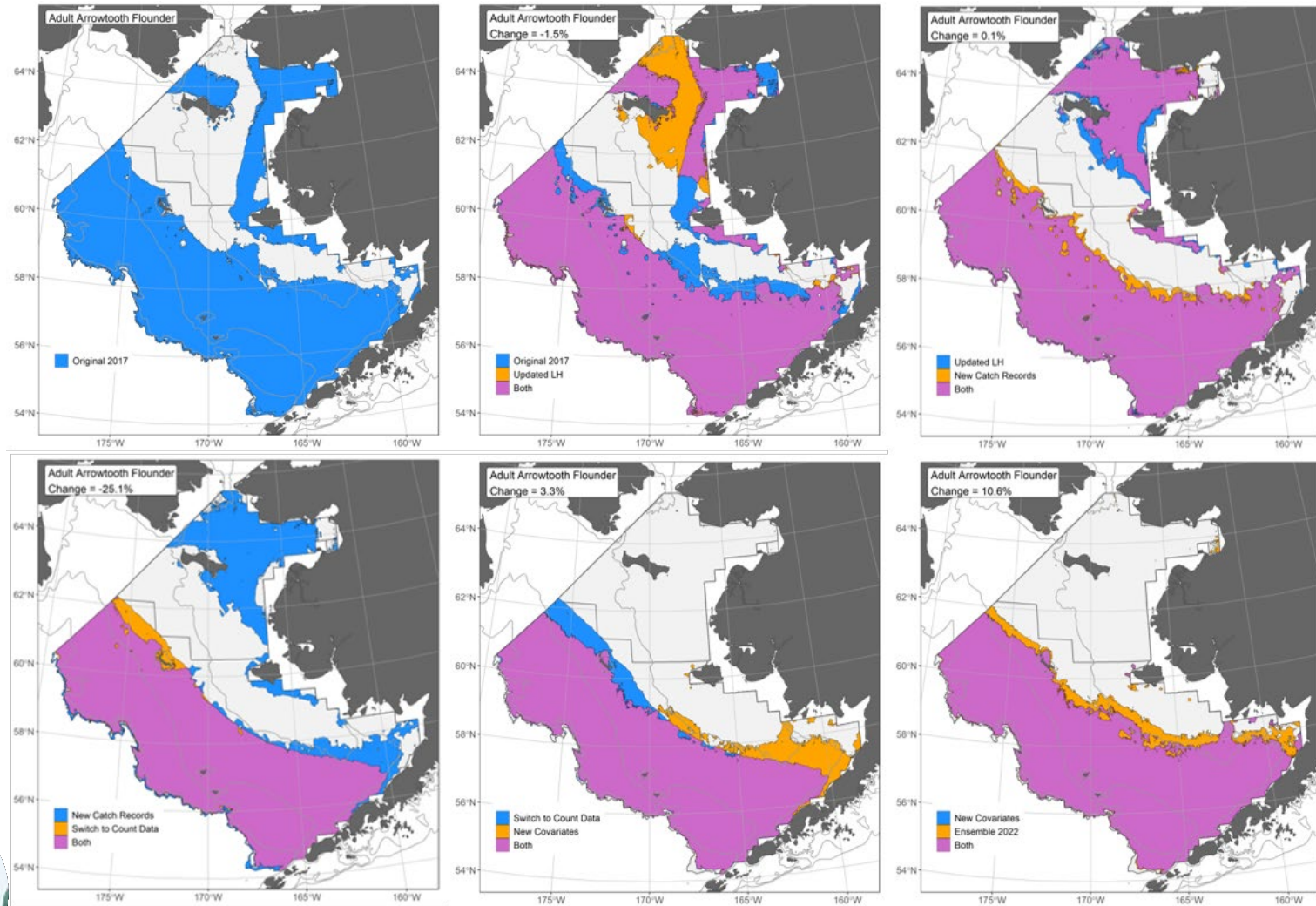
SDM EFH Comparison 2017 and 2022



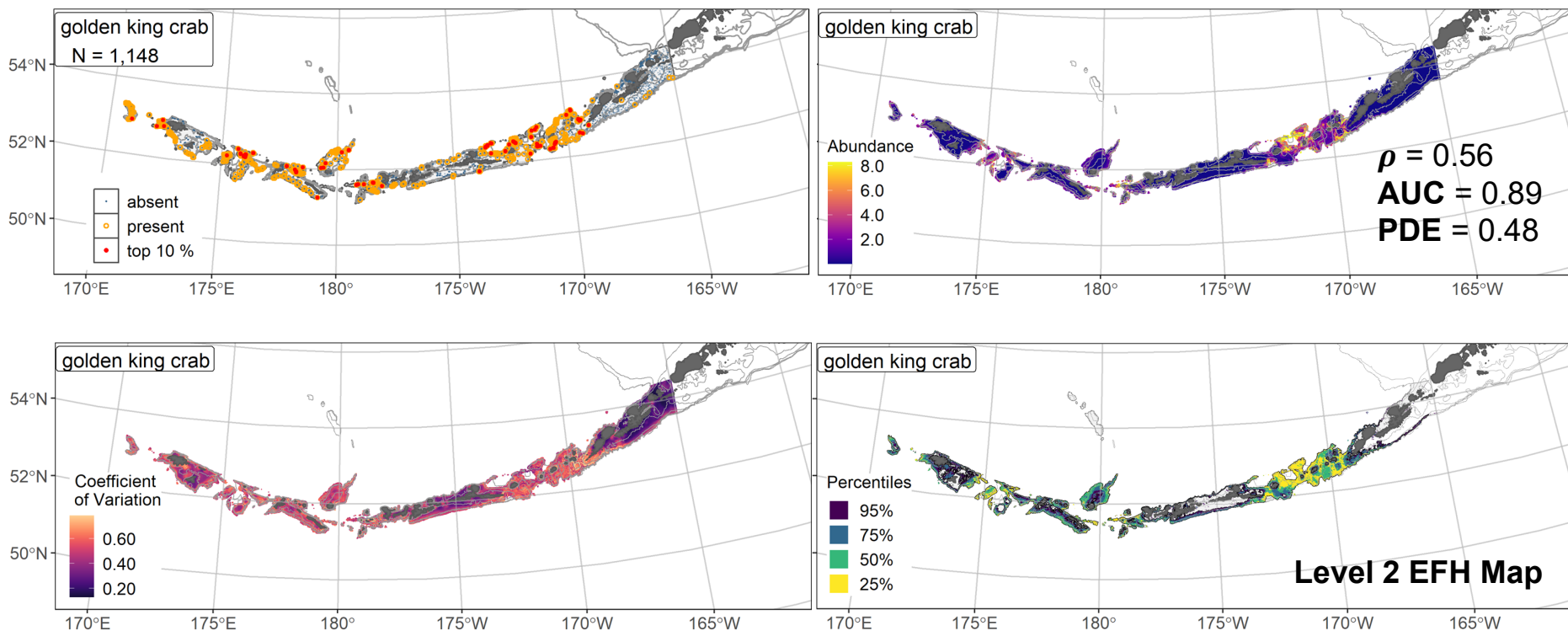
EFH Review	SDM Method	N	RMSE	ρ	AUC	PDE	EFH Area	Core EFH Area	% Change in Area
2017	GAM _{CPUE}	4,102	83.87	0.82	0.95	0.45	504,500	265,500	--
2022	Ensemble	4,976	26.88	0.81	0.96	0.63	425,700	224,000	-15.6%



EFH Area Bridging Sequence 2017 and 2022

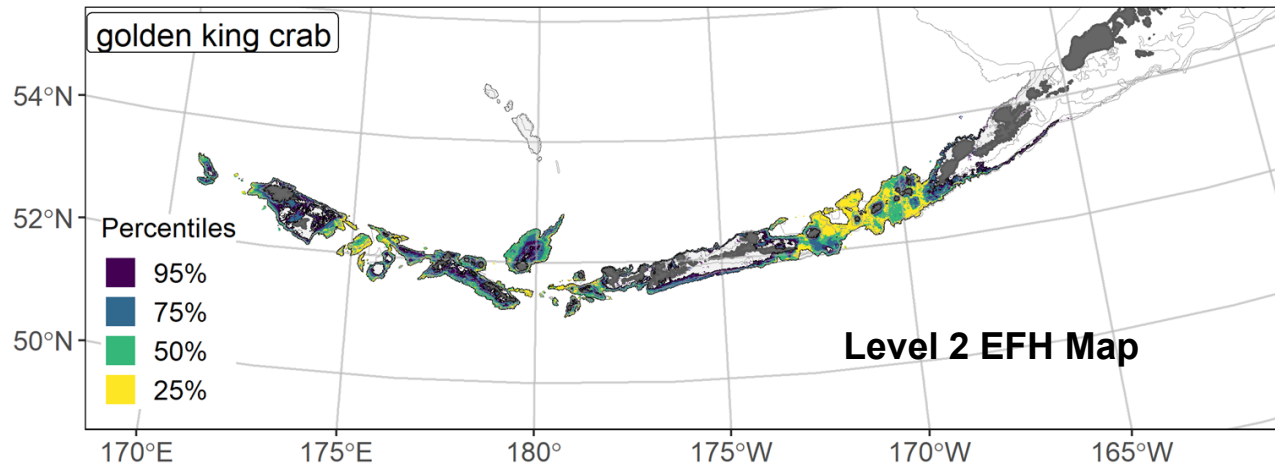
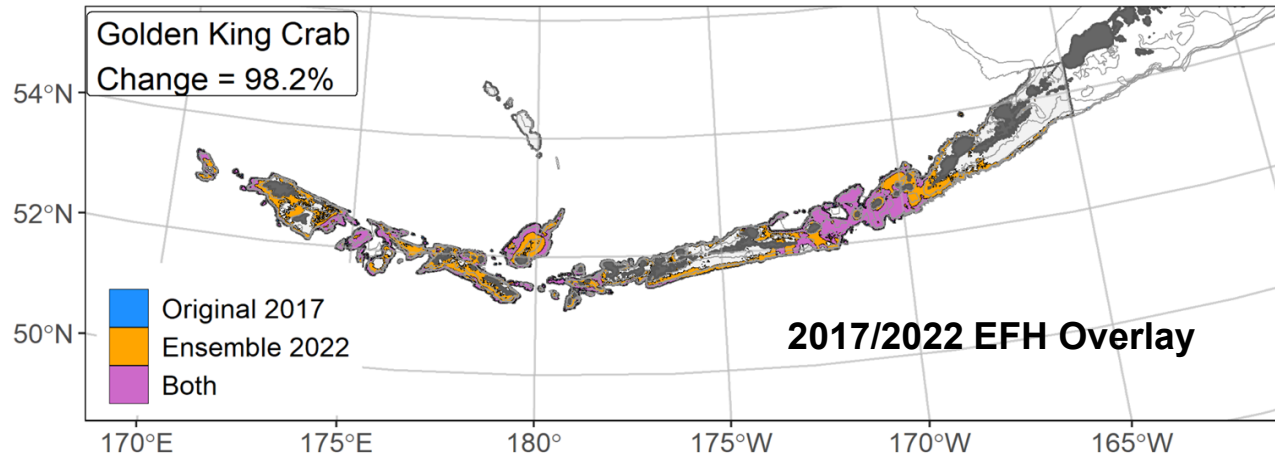


Golden King Crab



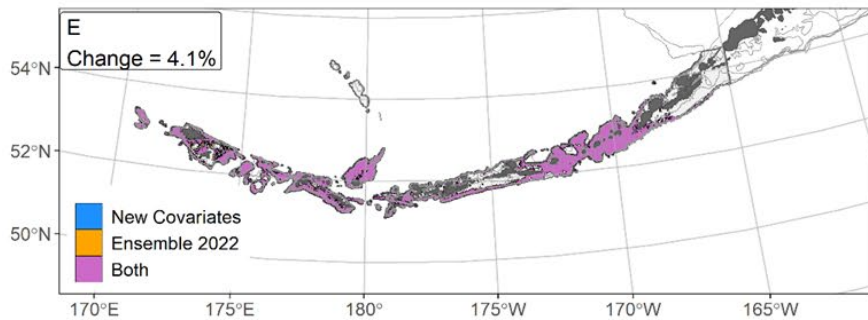
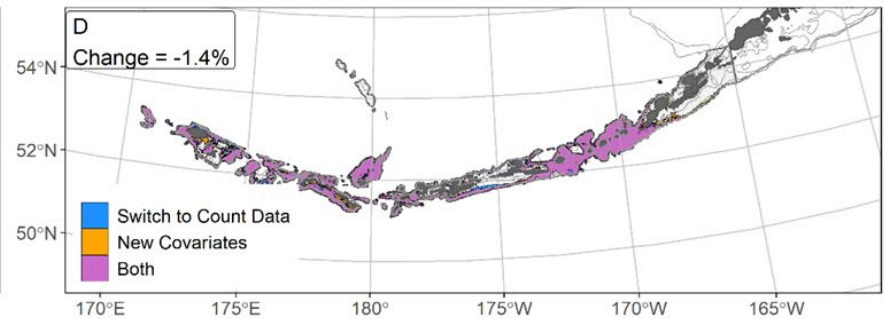
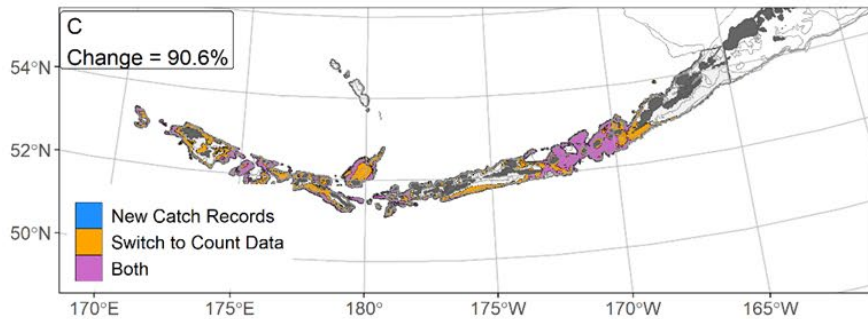
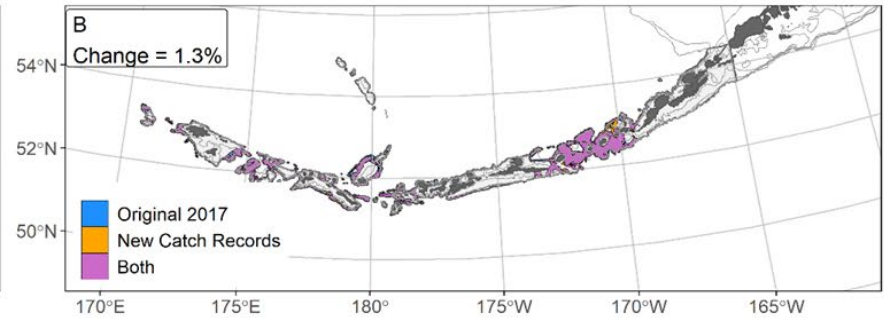
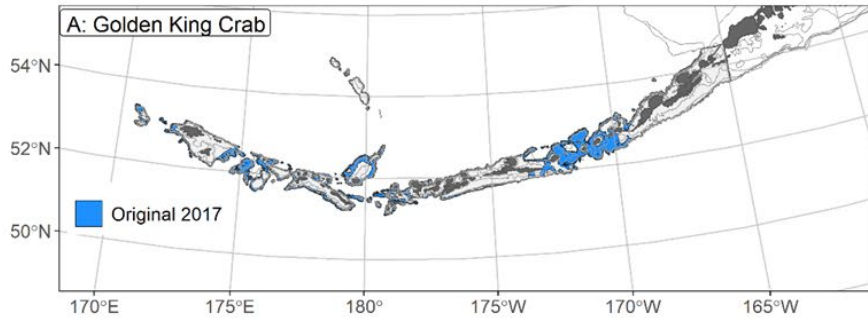
See the attached [Discussion Paper](#) on EFH Descriptions and Maps and the Aleutian Islands Tech Memo in review ([Discussion Paper Attachment 4](#)) for this Golden King Crab results example

EFH Comparison 2017 versus 2022

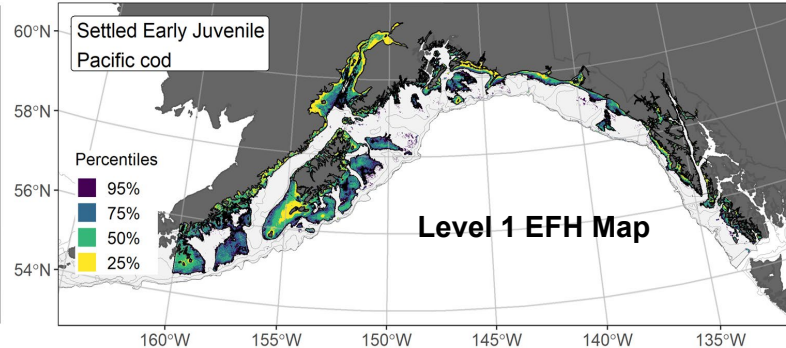
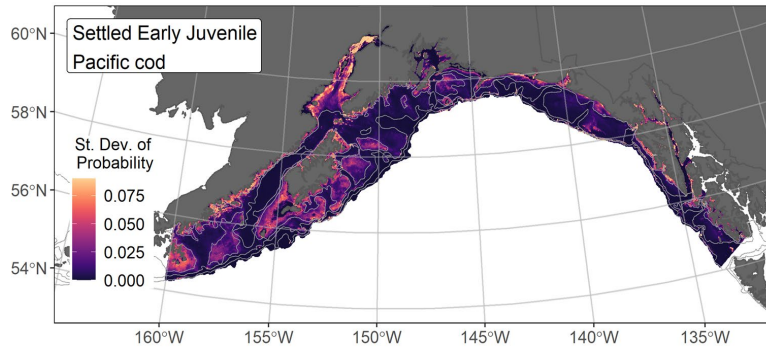
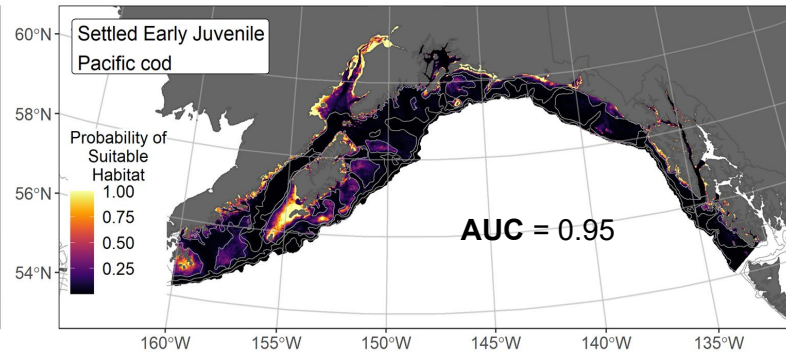
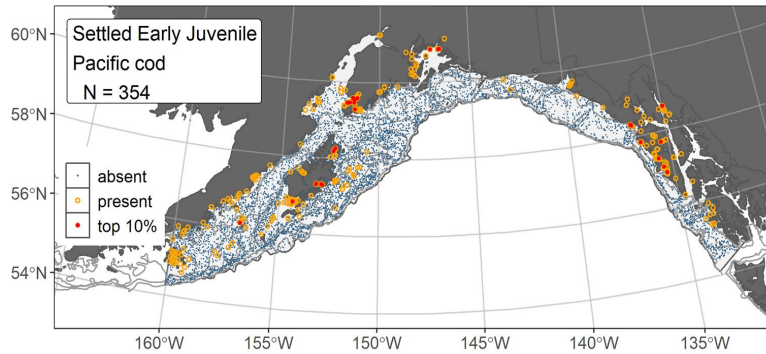


EFH Review	SDM Method	N	RMSE	ρ	AUC	PDE	EFH Area	Core EFH Area	% Change in Area
2017	hGAM _{CPUE}	956	6.28	0.56	0.88	-0.29	26,400	13,900	
2022	Ensemble	1148	6.19	0.56	0.89	0.48	52,300	27,600	98%

Golden King Crab Bridging Sequence

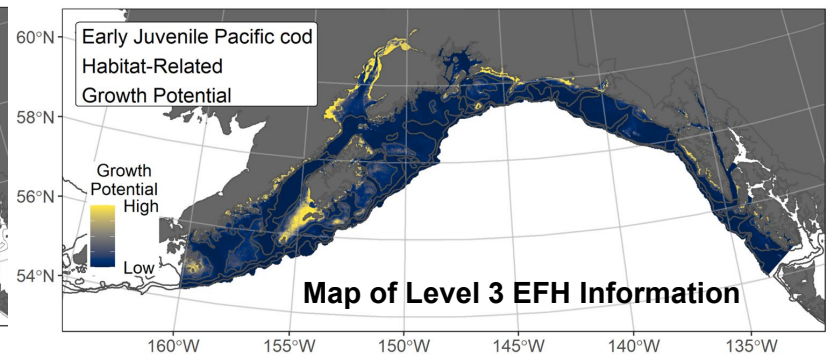
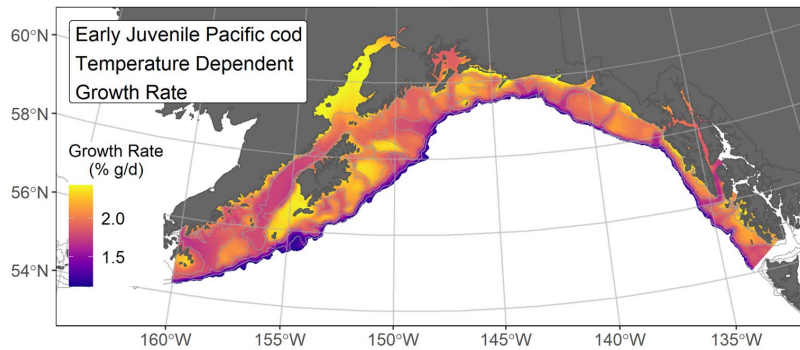
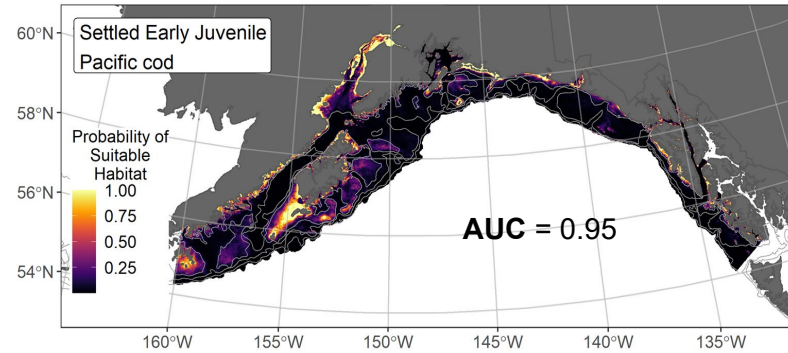


Pacific Cod Settled Early Juveniles

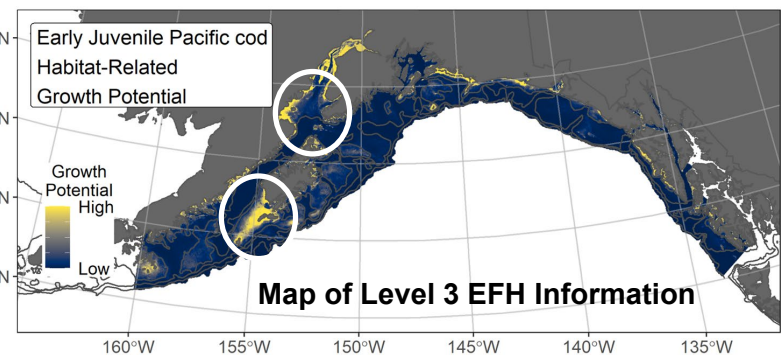
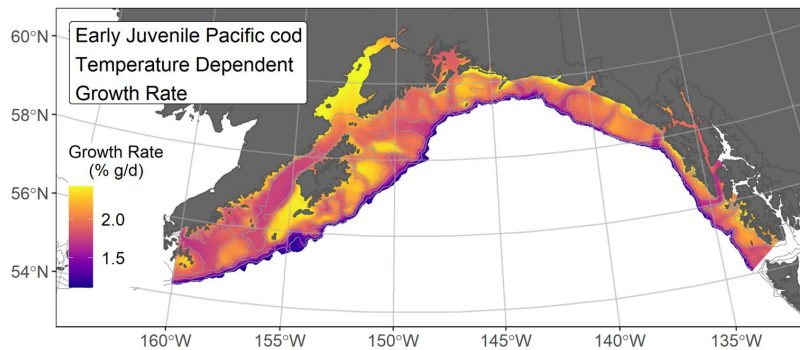
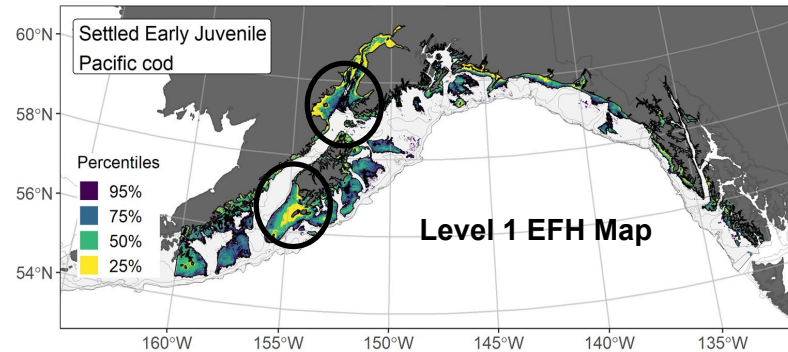
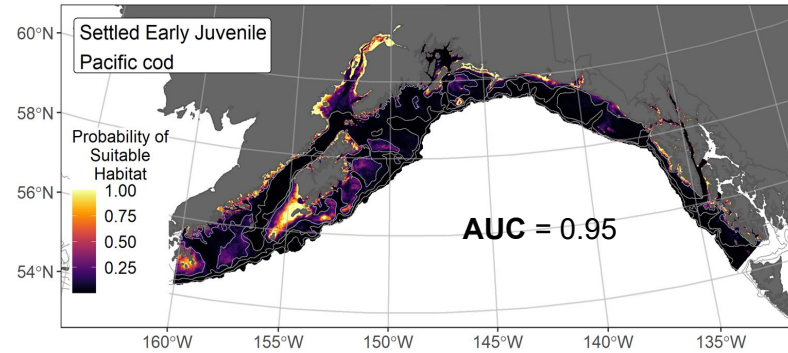


See the attached [Discussion Paper](#) on EFH Descriptions and Maps and the Gulf of Alaska Tech Memo in review ([Discussion Paper Attachment 5](#)) for this Pacific cod results example

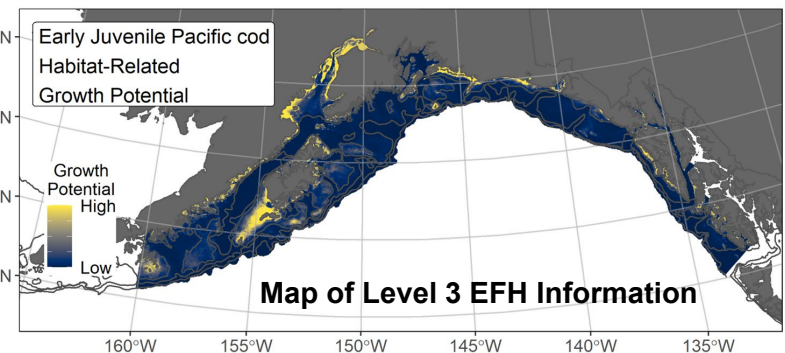
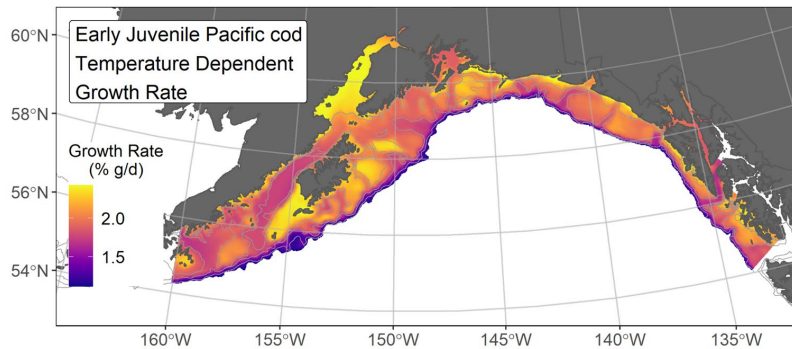
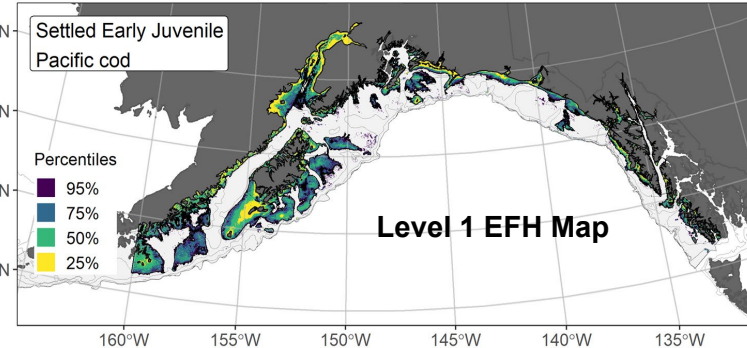
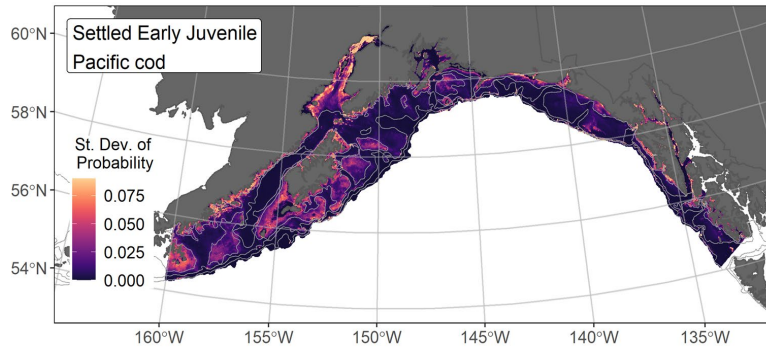
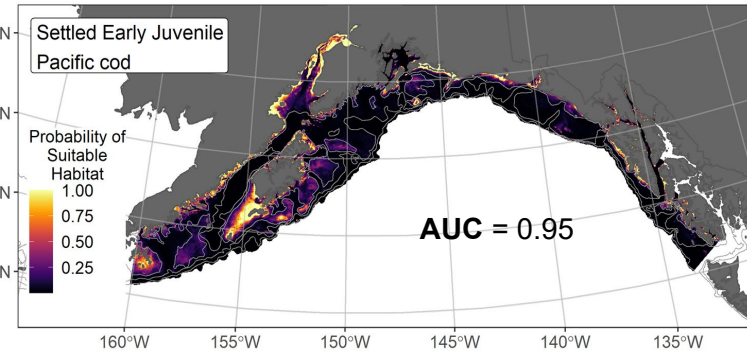
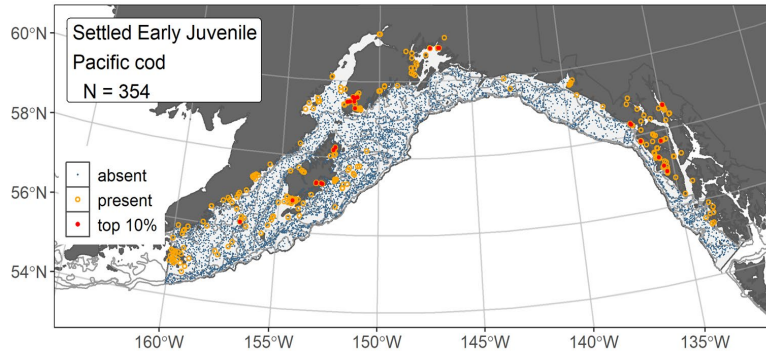
Pacific Cod Settled Early Juveniles



Pacific Cod Settled Early Juveniles



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).
 - SSC noted the “immense progress in EFH modeling and hopes that these analyses will be considered in stock assessments and analyses supporting stock assessments, particularly habitat suitability and how it may pertain to recruitment and spawning locations. At a minimum, these efforts should be able to contribute to the stock assessment process and ongoing EBFM efforts, including through the ESPs” (June 2020, Table A1.1 item 1I).



Future Research Directions

- Data
 - Modeling 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 in addition to GAMs
 - Improve SDMs for data-limited species
 - Explore SDMs on different temporal scales
- Process Recommendations:
 - Timely review
 - Reproducible code
 - Automated reports
 - Working Group



THANK YOU



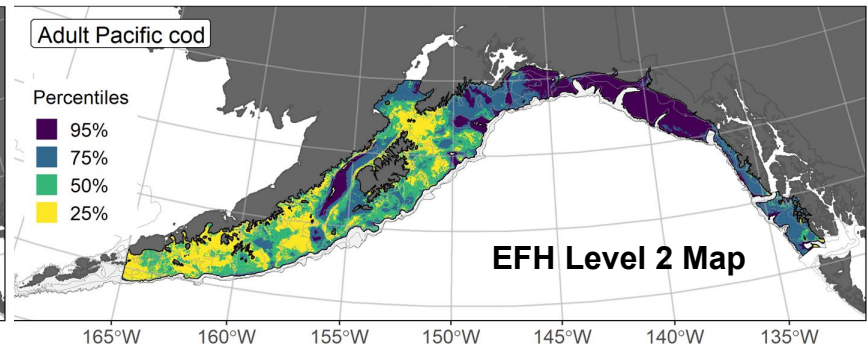
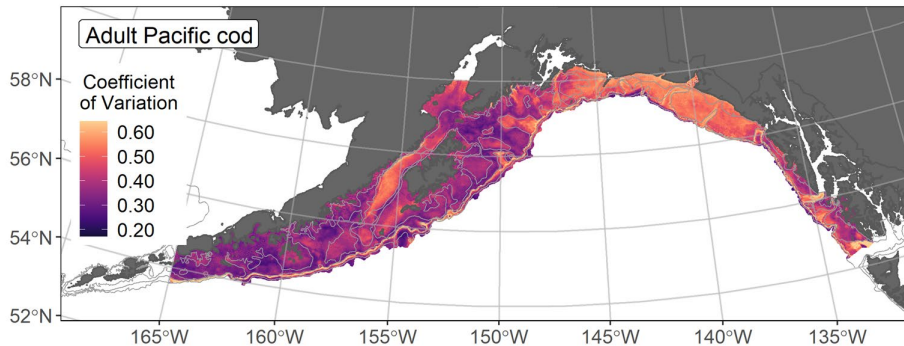
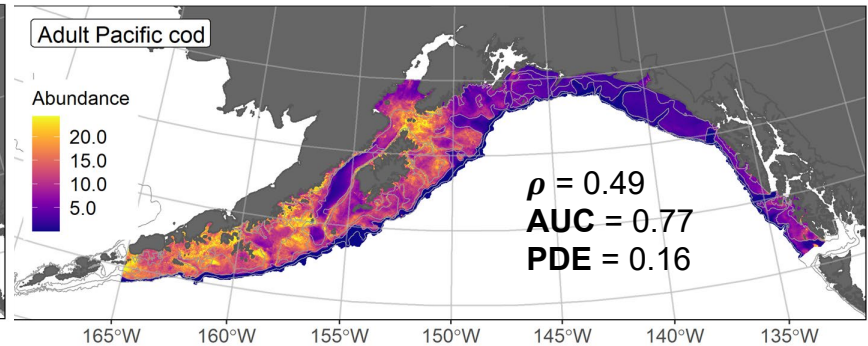
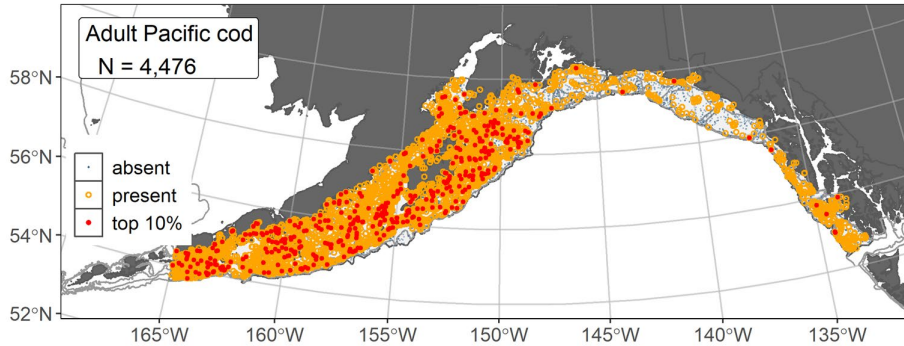
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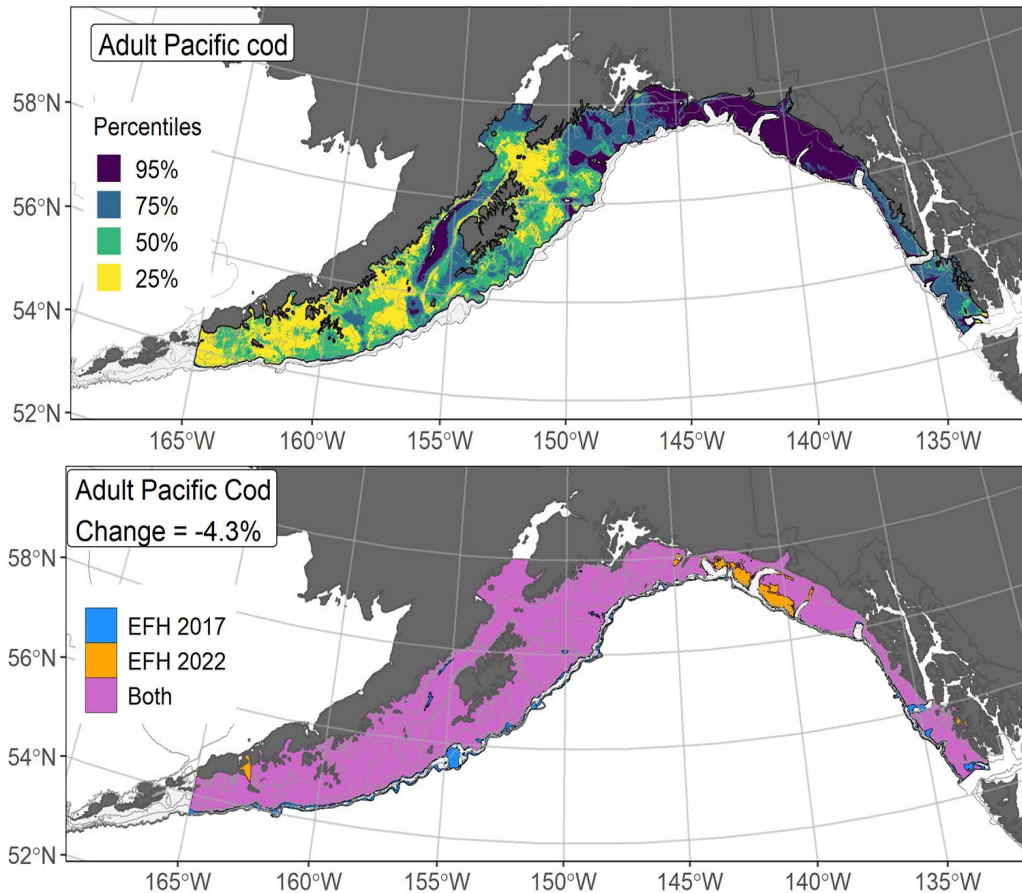
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Pacific Cod Adults



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

