ADVANCING ESSENTIAL FISH HABITAT DESCRIPTIONS AND MAPS FOR THE 2022 5-YEAR REVIEW

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PLAN TEAM MEETING

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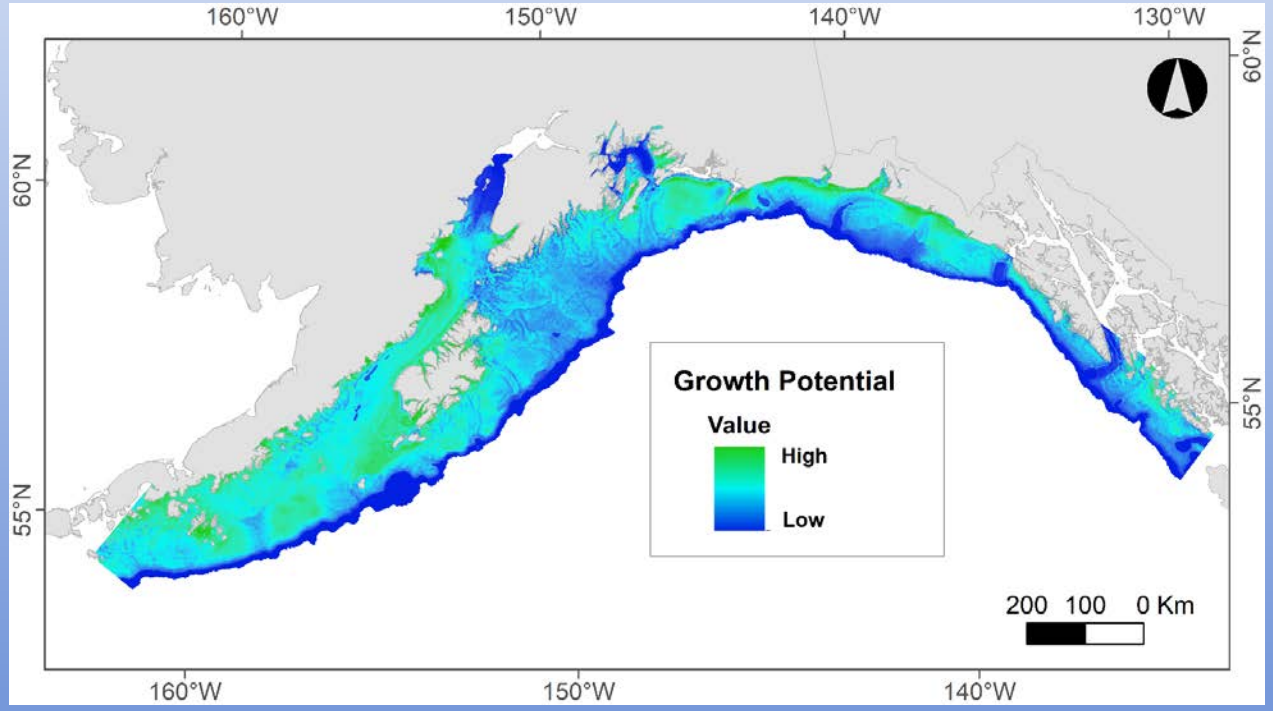

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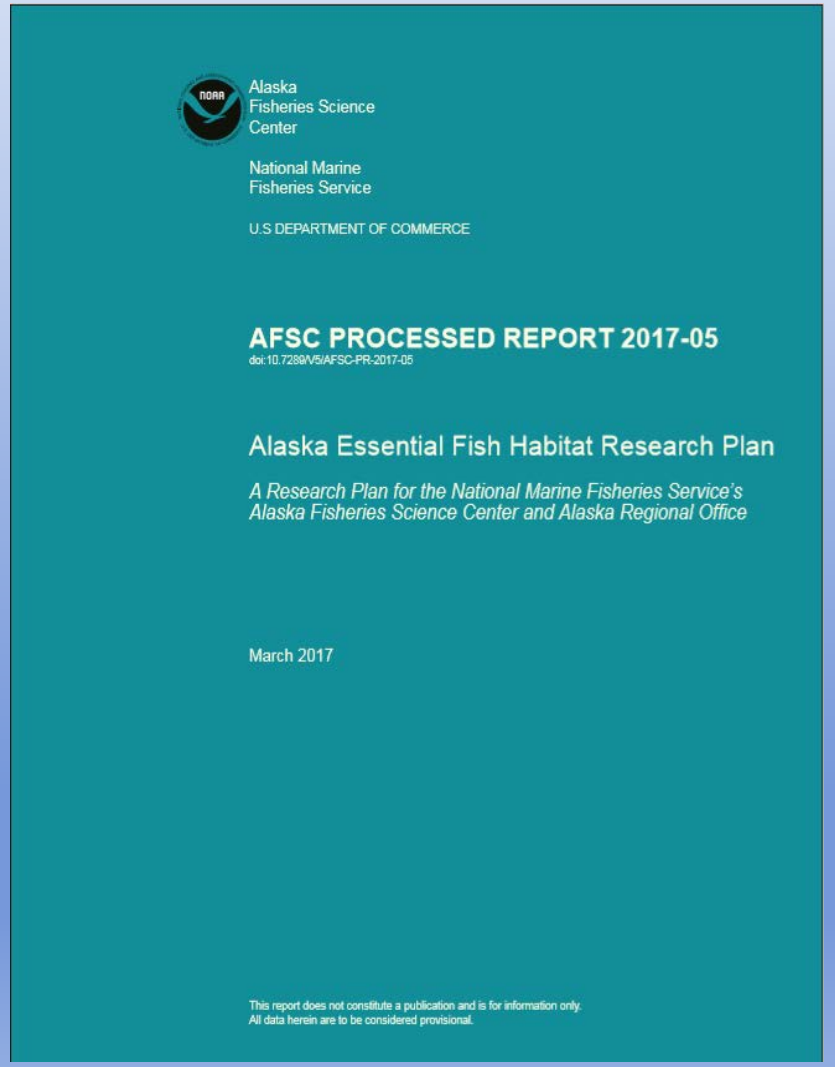
EFH RESEARCH



EFH research objectives to be accomplished by the next EFH 5-year Review (2022):

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).*

OUTLINE

Research

- Advancing EFH for North Pacific Species in Alaska (Laman et al.)
- First Model-based Arctic EFH (Marsh et al.)
- Juvenile Walleye Pollock Thermal Habitat (Laurel et al.)
- Individual-based Models to Advance EFH (Shotwell et al.)

Focus Questions

- How do we construct the ensemble?
- How do we map EFH Level 3 (habitat-related growth, survival, or reproduction)?

ADVANCING EFH FOR NORTH PACIFIC SPECIES IN ALASKA (*LAMAN et al.*)

Since the 2017 EFH Review:

- 5 bottom trawl survey years added (2015-19)
- Improved GOA bathymetry
- Introduced nearshore data and early juvenile life stage – None to Level 2
- Updated maturity schedules and redefined life stages
- Skill testing and model selection
- Modeling refinements – None and Level 1 to Level 2
- Habitat-linked growth potential – Level 3

SKILL TESTING AND MODEL SELECTION

2017 Review
(*a priori* assignment)

- Maxent
- hGAM
- GAM

2020 Laman et al.
(skill testing)

- Maxent
- hGAM
- GAM
- paGAM

2022 Review
(skill testing)

- Maxent
- hGAM
- GAM
- paGAM
- Negative binomial
- Ensemble

(cont'd) EVALUATING MODEL PERFORMANCE ("SKILL TESTING")

Root-mean-square-error

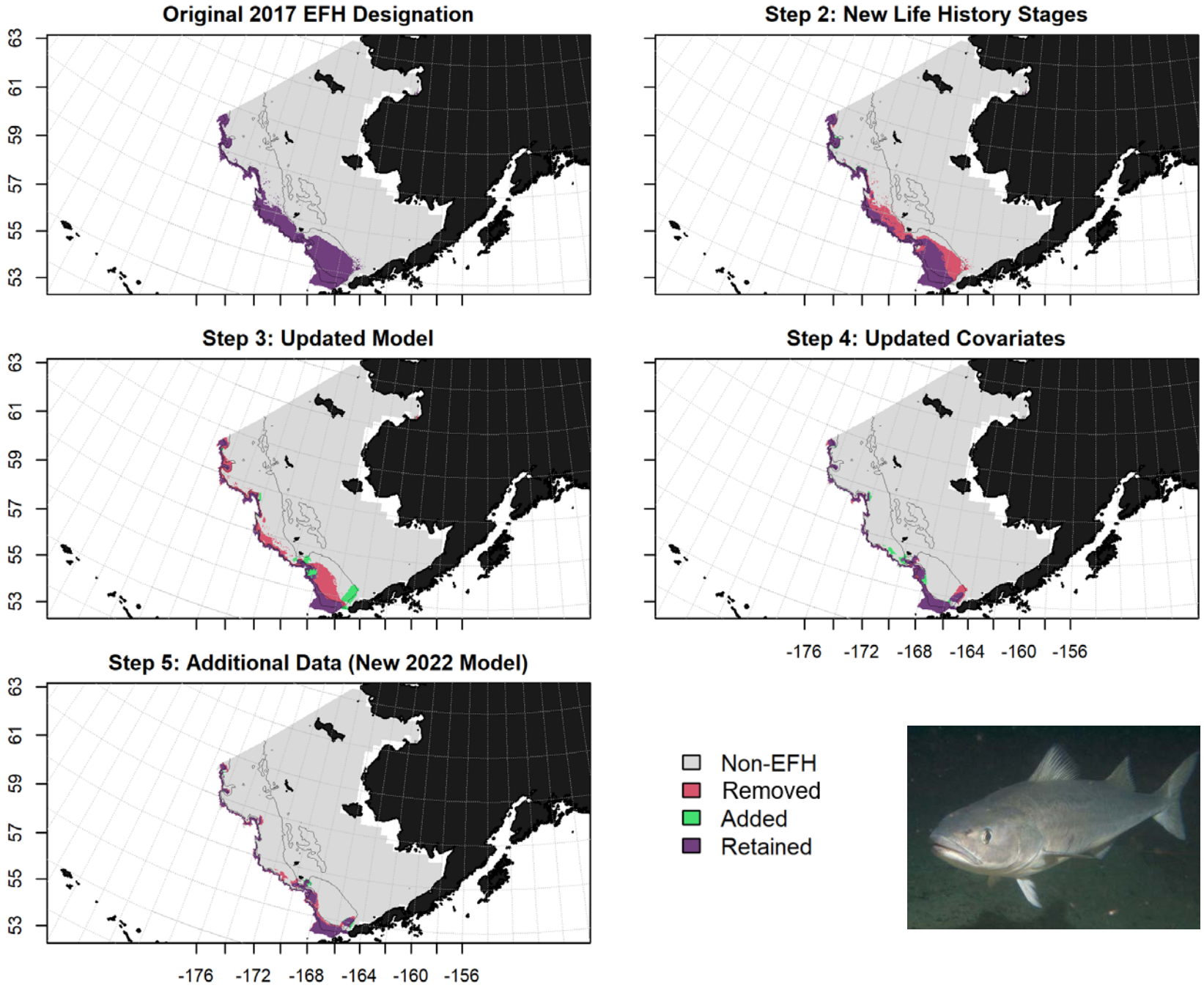
$$RMSE = \sqrt{\frac{\sum_i^{20} \sum_j^{n_i} \left(y_{ij} - x_{ij}\right)^2}{\sum_i^{20} n_i}}$$

where

y_{ij} is the predicted numerical abundance,
x_{ij} is the observed numerical abundance at trawl station *j* in cross validation fold *i*, and
n_i is the number of trawl stations sampled in the *i*th fold

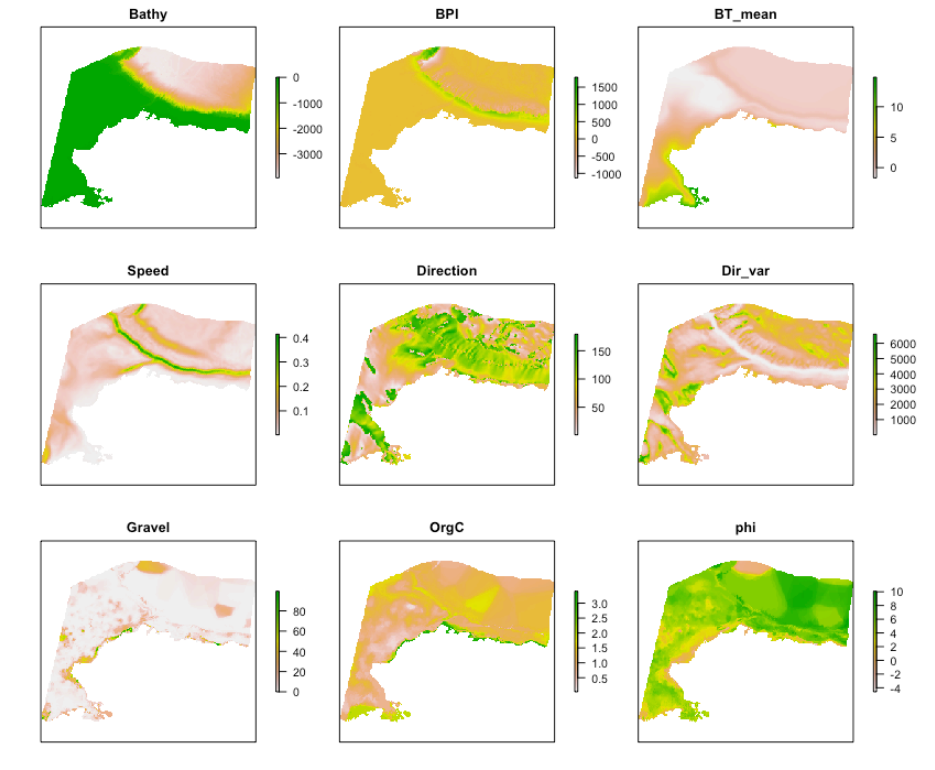
Evolution of EFH

A bridging example for adult sablefish in the eastern Bering Sea

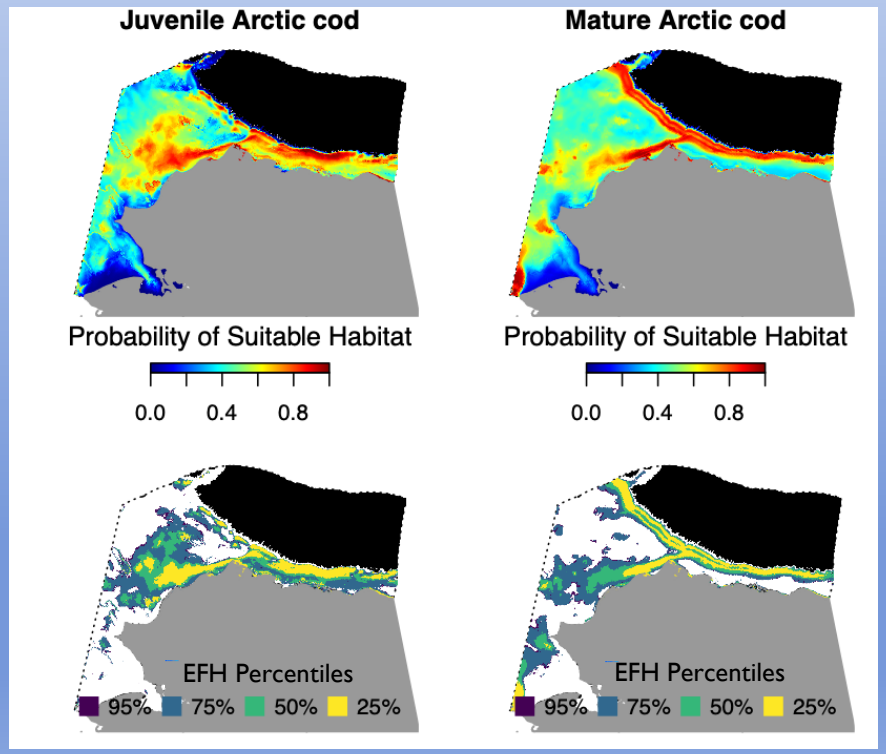


FIRST U.S. ARCTIC MODEL-BASED EFH (*MARSH et al.*)

Arctic SDM-based EFH maps and descriptions for Arctic cod, saffron cod, and snow crab



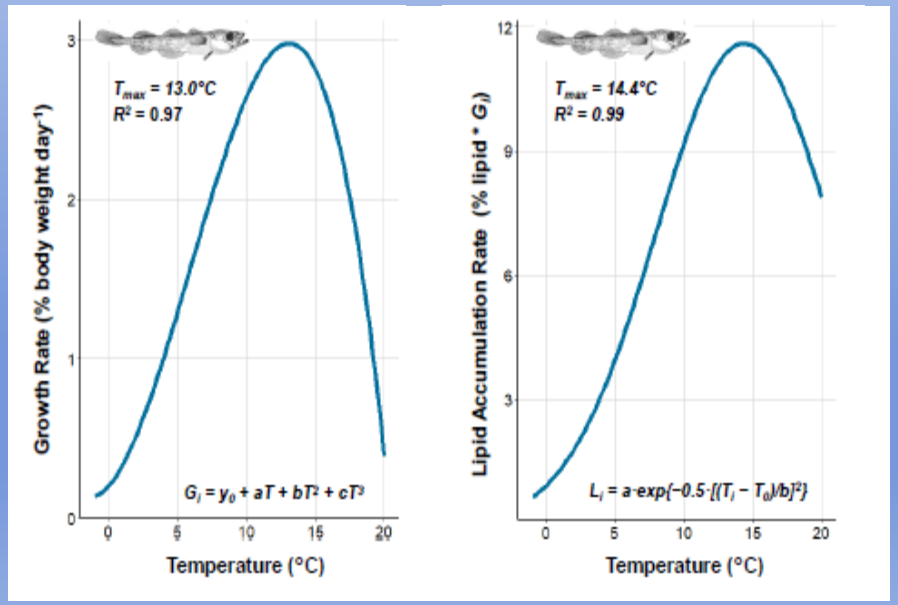
SDM covariates



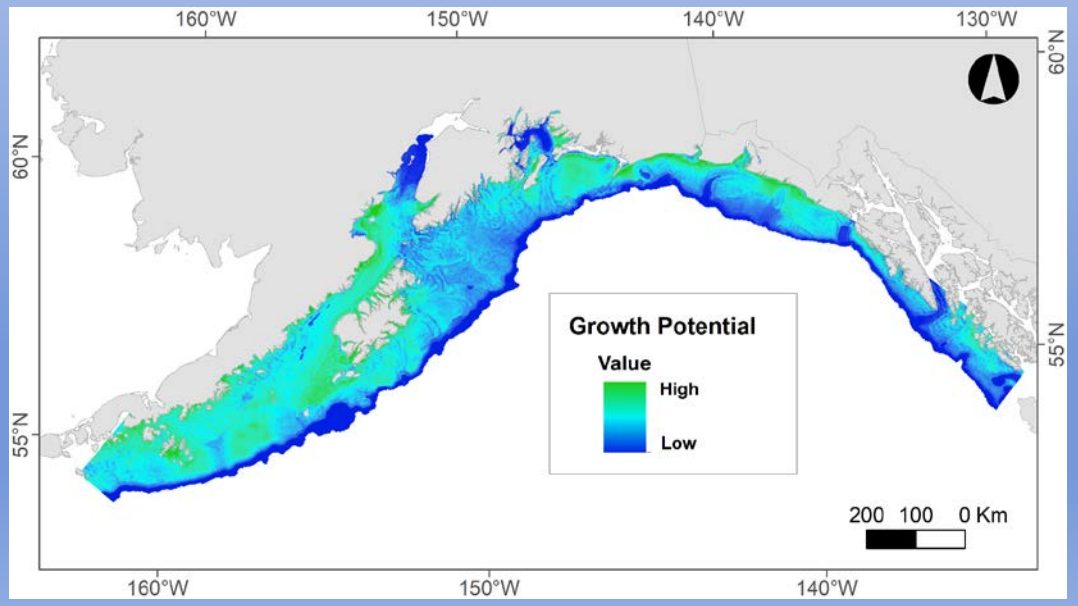
SDM maps and SDM-based EFH maps

LEVEL 3 EFH: THERMAL HABITAT FOR JUVENILE WALLEYE POLLOCK (*LAUREL et al.*)

- Early juvenile stage pollock (40-120 mm)
- Laboratory studies identified temperature-dependent growth and lipid accumulation (condition) rates for summer and winter
- Map is the product of summer growth rate and an SDM

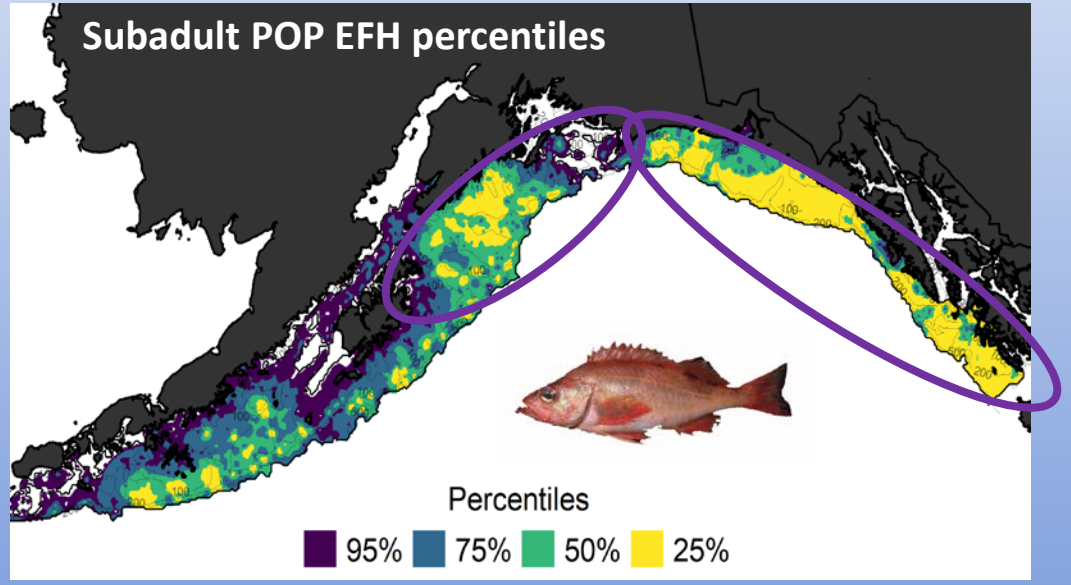


Vital rates as *f(temperature)*

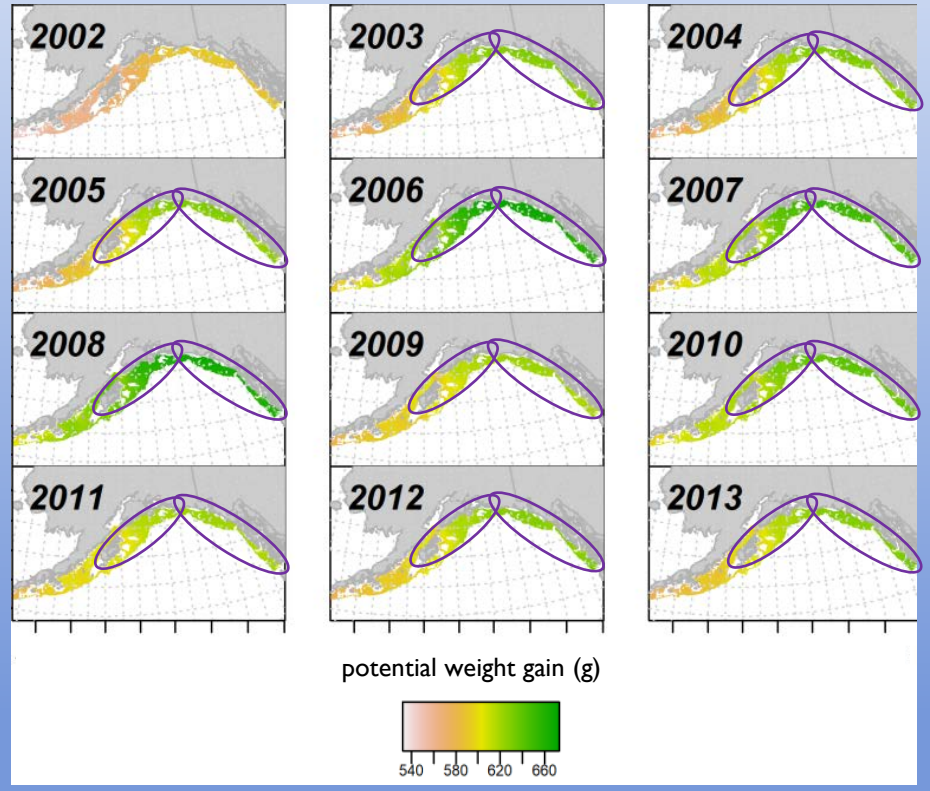


Habitat-related growth potential

LEVEL 3 EFH: CO-MAPPING TO LINK SDM PREDICTIONS WITH VITAL RATES FOR EFH MAPS (*LAMAN et al.*)



Areas with the top 25% of SDM-predicted abundance ("hot spots") roughly correspond to areas of perennially higher growth potential



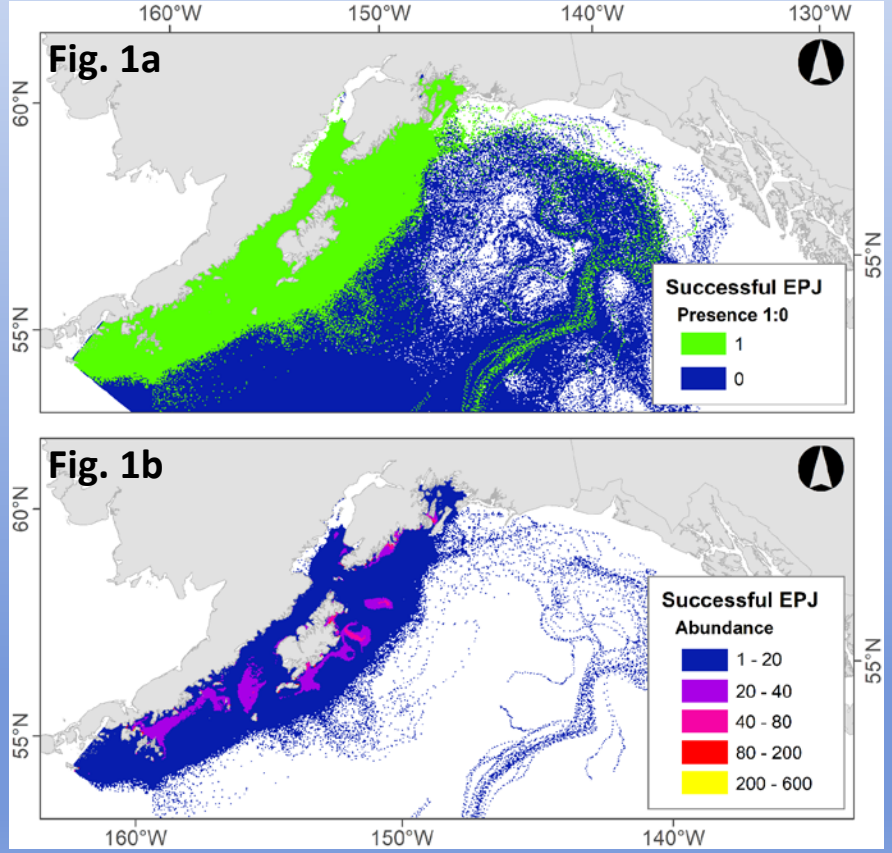
Temperature-dependent subadult POP summer growth

INDIVIDUAL-BASED MODELS (IBM) TO ADVANCE EFH (*SHOTWELL et al.*)

EFH Level 1: Initial IBM run will create the presence/absence map – life stage trajectory of survivors (**Fig. 1a**).

EFH Level 2: Model trajectories are post-processed with spatially-explicit spawning biomass information to create the relative abundance map. (similar to **Fig. 1b**).

EFH Level 3: Trajectories are further post-processed with vital rates to create maps of habitat-related survival and growth potential.



GOA IBMs for Sablefish and Pacific cod

Pacific cod successful epipelagic juveniles

QUESTIONS AND TOPICS FOR DISCUSSION

FOCUS QUESTIONS

1. For the ensemble, what criteria should we use for inclusion (when do we drop a constituent) and how do we weight the models (equal or skill-based weighting)?
2. Is there a preference for co-mapping or map products (SDM*vital rate) when combining Level 2 EFH maps with Level 3 vital rates?

ADDITIONAL TOPICS

- How best can we incorporate and visualize uncertainty in mapping EFH?
- What is the best format and timing to communicate results of EFH projects to the Stock Authors for review?
- How can this EFH research support stock assessment and EBFM?

THANK YOU

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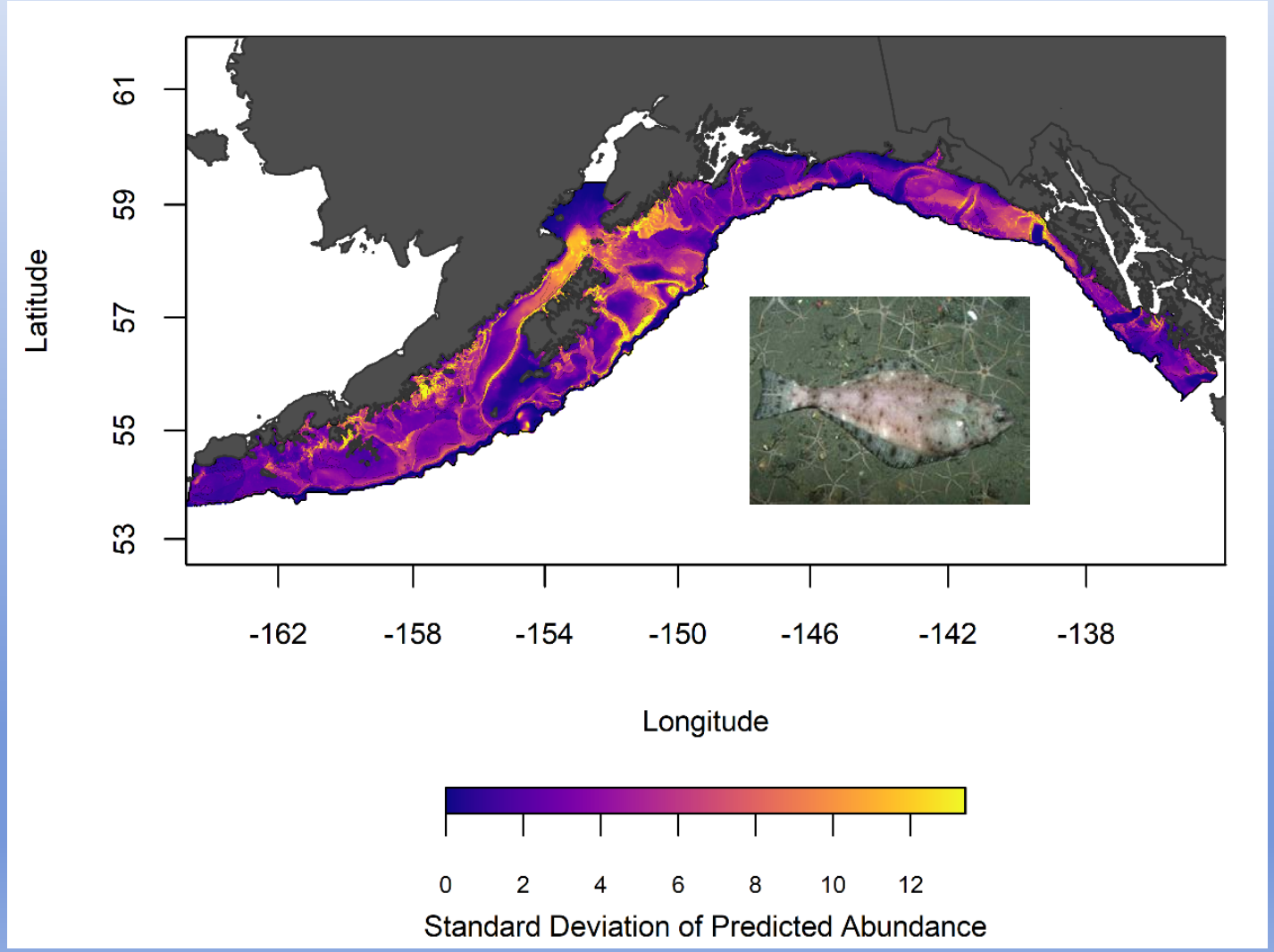
MAPPING EFH UNCERTAINTY

- Discussion Topic: How best can we incorporate and visualize uncertainty in mapping EFH?
- Example: Arrowtooth flounder standard deviation of predicted abundance among *k*-fold replicates.



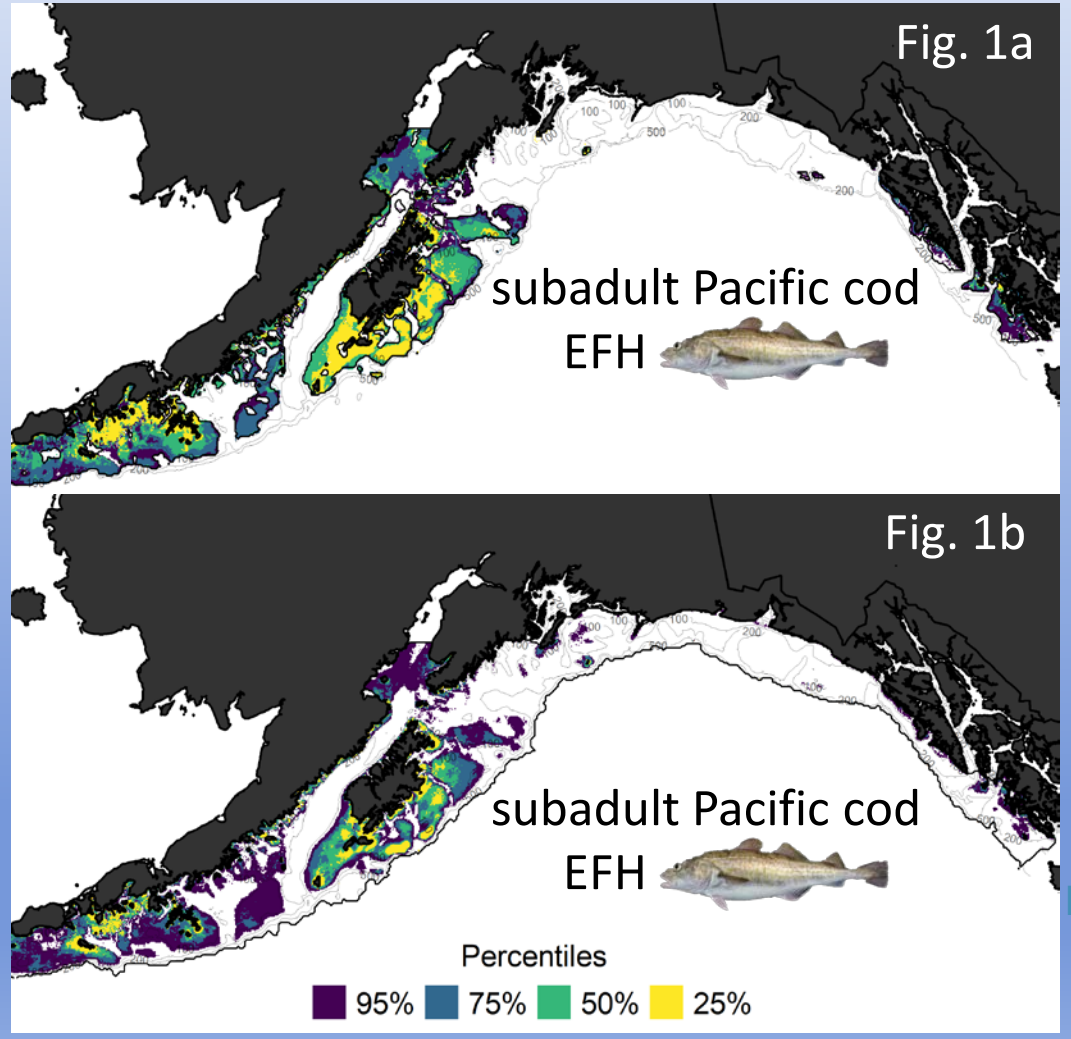
CONSTRUCTING EFH FROM SDM

2017 SDM EFH:

- Minimum threshold for presence
- Values ≤ minimum abundance or probability considered absent
- Fig. 1a

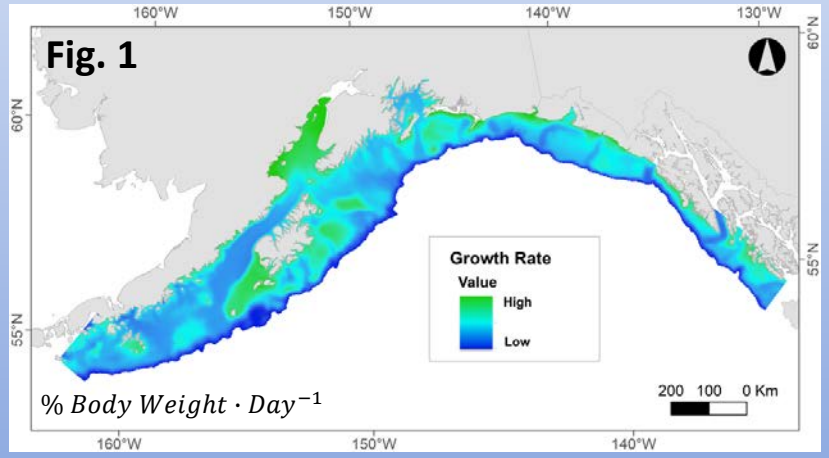
2022 SDM EFH:

- Cumulative distribution function
- Fig. 1b

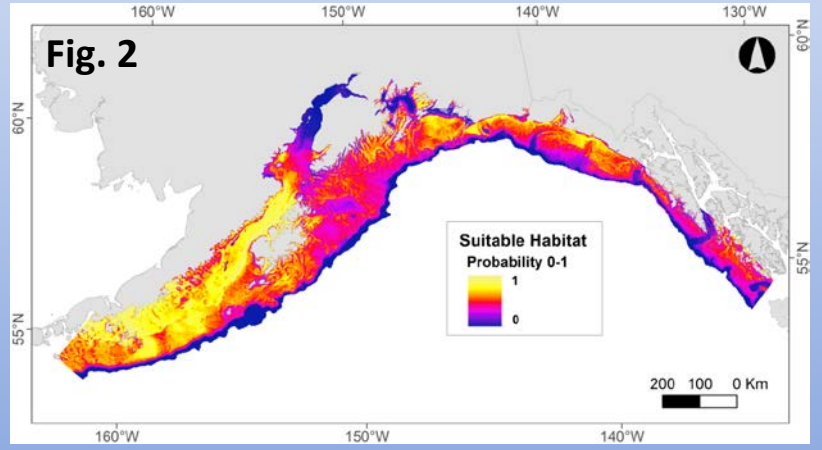


INTEGRATING VITAL RATES AND SDM TO MAP EFH LEVEL 3

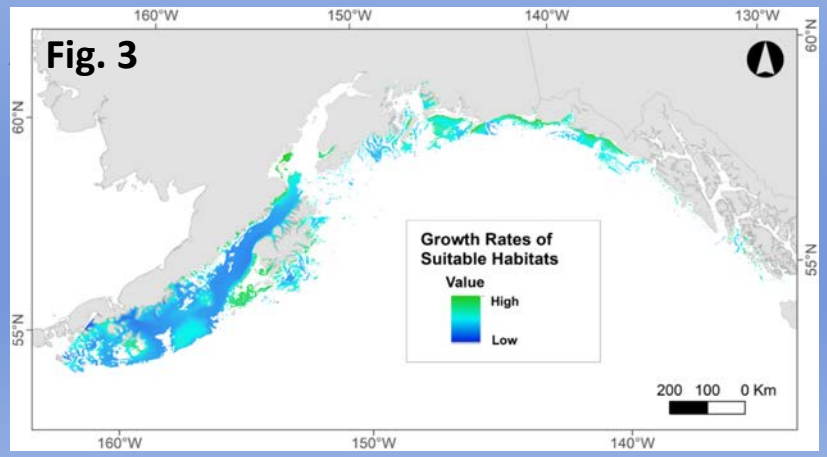
Early Juvenile Walleye Pollock (40-120 mm)



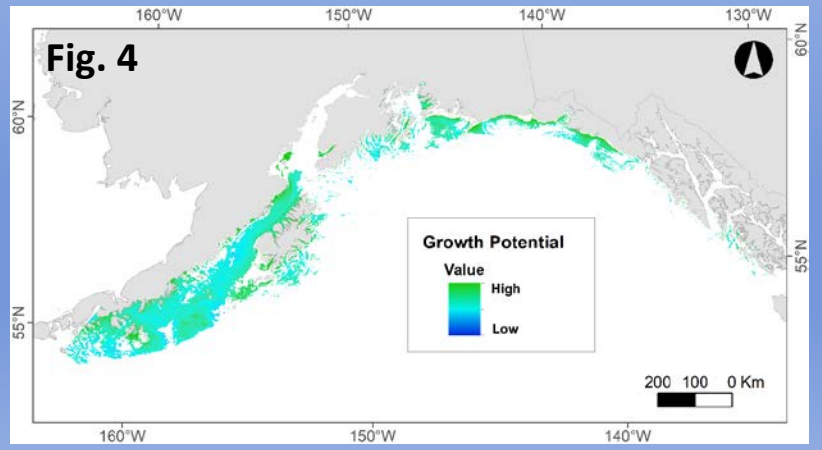
Temperature-dependent growth rate



Early juvenile pollock habitat suitability



Growth rates of suitable habitat (co-mapping)



Habitat-related growth potential (product)