2022 EFH 5-Year Review Plan

Components 1 & 2

NMFS Alaska Region (AKRO) and Alaska Fisheries Science Center (AFSC)

Jodi Pirtle, AKRO, Habitat Conservation Division
Ned Laman, AFSC, Groundfish Assessment Program
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Jim Thorson, AFSC, Habitat and Ecological Processes Research Program

EFH Components of Fishery Management Plans

We have prioritized the six EFH components in bold and will present plans and progress for 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

April 2019 – 2022 EFH 5-year Review Proposed Approach to EC

April 2020 – ~~2022 EFH 5-year Review Proposed Approach Update to Council~~

June 2020 – Progress on Component 1 (C1) Species Distribution Models (SDMs) to SSC

September 2020 – Progress on C1 SDMs to Groundfish Plan Teams

January 2021 – C1 Stock Author Review Meeting

April 2021 – 2022 EFH 5-year Review Plan to SSC

May 2021 – 2022 EFH 5-year Review Plan to Crab Plan Team & Launch C1 Stock Author Review

September 2021 – C1 Stock Author Review Completed

Timeline – Plan for Next Steps

September 2021
Groundfish Plan Teams review of C1 & C2

October 2021
~~SSC Review of C1~~

February 2022
SSC Review of C1 & C2

Spring 2022
Stock Assessment Authors Conduct Fishing Effects (FE) Assessment (C2)

June (T) 2022
SSC review of FE Assessment

October (T) 2022
Council Review of EFH 5-year Review Summary Report

TBD
Complete FMP Amendment process

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

JODI PIRTLE[1], NED LAMAN[2], JIM THORSON[3]

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[3] Habitat and Ecological Processes Research (HEPR) Program, AFSC, Seattle, WA

1. EFH Descriptions and Identification

- EFH Definition: “those waters and substrate necessary to fish for spawning, feeding, or growth to maturity” (MSA EFH Regulations)

- Component 1: EFH descriptions and identification (maps)
  - FMP text and tables
  - FMP maps based on species distribution models (SDMs) established in 2017 and refined in 2022

- EFH information levels
  - Level 1 (distribution)
  - Level 2 (habitat-related densities or abundance)
  - Level 3 (habitat-related growth, reproduction, or survival rates)
  - Level 4 (production rates by habitat)

- In development for 2022 EFH 5-year Review:
  - EFH Level 2 *Expanded*
    - Groundfishes and Crabs in GOA, BSAI, and Arctic
  - EFH Level 3 *New*
    - Groundfishes in GOA, BSAI, and Arctic

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**."

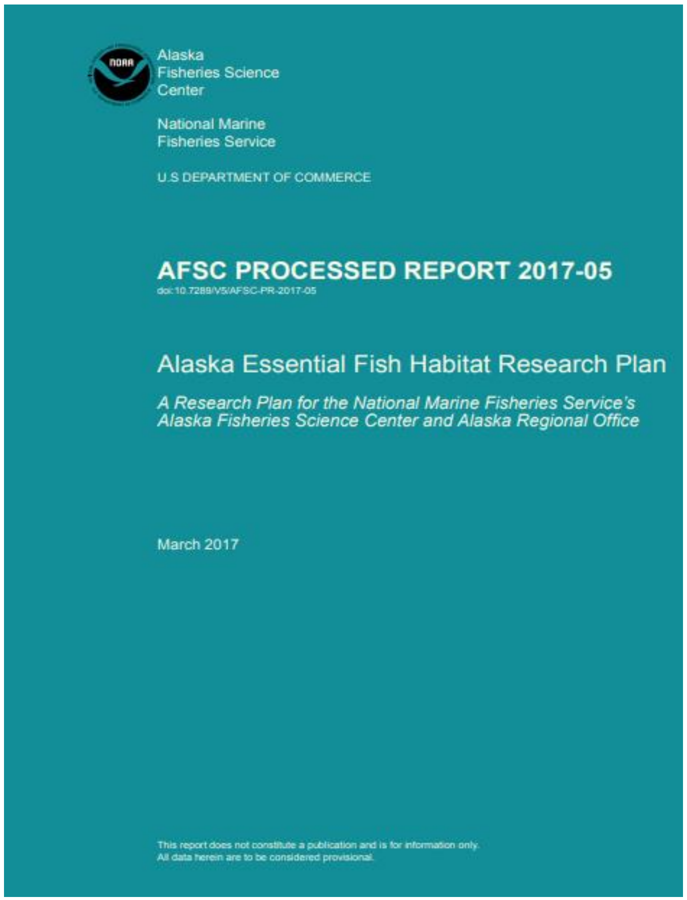
Alaska EFH (EFH EIS 2005):

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

SSC Guidance (2017):

- Map EFH areas using percentiles approach and use Core EFH area (upper 50% of population distribution) in the Fishing Effects Analysis (EFH Component 2).
- Our habitat-based modeling approach for the 2022 5-year Review characterizes EFH for life stages of species as the area circumscribing the top 95% of the SDM-predicted abundance conditioned to those locations with >5% encounter probabilities based on the predictions.

EFH RESEARCH



Alaska
Fisheries Science
Center

National Marine
Fisheries Service

U.S DEPARTMENT OF COMMERCE

AFSC PROCESSED REPORT 2017-05

doi:10.7289/V5/AFSC-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

This report does not constitute a publication and is for information only.
All data herein are to be considered provisional.

Alaska EFH Research Plan - objectives for progress 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).

Contributing Habitat Science

New Species Distribution Models and EFH Maps

- Advancing EFH for Groundfishes and Crabs in Alaska (Laman et al.)
- First Model-based Arctic EFH (Marsh et al.)

New Stock-specific EFH Tools

- Juvenile Walleye Pollock Thermal Habitat (Laurel et al.)
- Juvenile Shallow Water Flatfish Temperature Dependent Vital Rates (Hurst et al.)
- Individual-based Models to Advance EFH for Groundfish Pelagic Early Life History Stages (Shotwell et al.)

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

ADVANCING EFH FOR THE 2022 5-YEAR REVIEW
(Laman, Pirtle, Harris, Rooper, Hurst, Conrath)

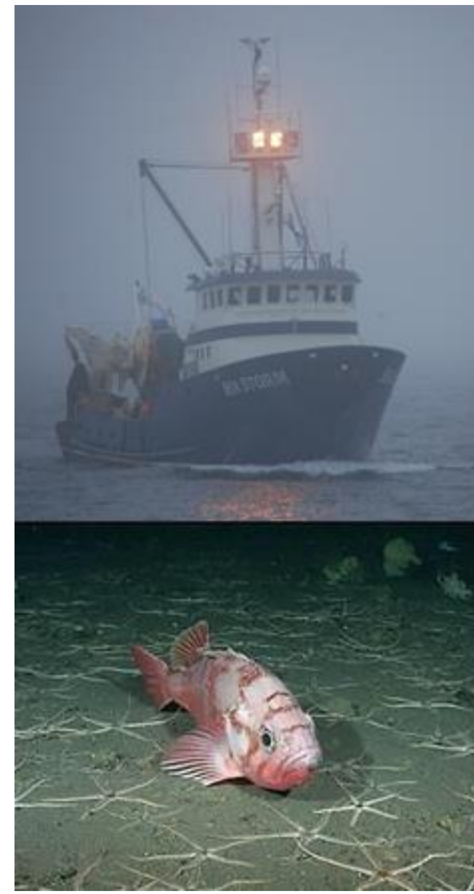
Since the 2017 EFH 5-Year Review:

- 5 bottom trawl survey years added (2015-19)
- Nearshore surveys added to model settled early juvenile life stage in the GOA
- Updated terrain and ROMS covariates
- Updated life stages and maturity schedules
- Modeling
  - Response variable = Numbers of fish (*SSC supported 6/20*)
    - 4th root transformed CPUE in 2017
  - Ensembling (*SSC suggested 6/20*)
    - Added negative binomial GAM for overdispersion
    - Constituent model weighting by RMSE

ADVANCING EFH FOR THE 2022 5-YEAR REVIEW
(Laman, Pirtle, Harris, Rooper, Hurst, Conrath)

Since the 2017 EFH 5-Year Review:

- Model uncertainty (*SSC supported 6/20*)
  - k-fold cross validation and CV maps
- Skill testing among constituent SDMs (*SSC supported 6/20*)
- EFH Maps conditioned by encounter probability
  - Change from absence threshold in 2017
- Advancing EFH Levels
  - Level 2 - abundance
    - Complementary log log (cloglog) abundance approximation (*SSC supported 6/20*)
  - Level 3 - vital rates
    - Enhance interpretation Level 1 and 2 maps *(SSC encouraged/suggested 6/20)*



ADVANCING EFH FOR THE 2022 5-YEAR REVIEW

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

Stock Assessment Author Review:

- Coordination meeting January 2021 to inform the community and co-develop the process
- Opportunity to review and provide input on:
    - FMP EFH text and maps for their stocks
    - Methods, draft ensemble results, and EFH maps *(new process in this EFH Review)*
- All 118 results chapters received stock author/expert review = 100% response
- High engagement and great ideas
- Constructive feedback for improving SDMs and EFH in the future
- Thank you for all of effort the reviewers brought to bear

ADVANCING EFH FOR THE 2022 5-YEAR REVIEW

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

Main Topics of Feedback from Stock Author Review:

1. **Looks Good** (e.g., "*maps are useful and informative*" "*AMAZING job all of you for putting all that together for all the stocks*" "*Wow--that is a truly impressive modeling effort. Congratulations*!").
   - **Response:** Thank you, we value your input, greatly appreciate your effort, and hope that this information is also useful to stock assessment.

2. **Add Data from Other Sources** (e.g., "*add longline survey data for sablefish*" "*this survey alone is ineffective for sleeper sharks... explore adding longline survey data*").
   - **Response:** Should be explored leading up to the next EFH 5-year Review. Ideas e.g., use crab maturity information to model crab life stages, add longline survey data (e.g., sablefish, shortrakers, sleeper sharks), add untrawlable habitat data. *Invitation for stock assessment scientists and others to work with HEPR to collaboratively develop EFH proposals for the next 5-year cycle.*

ADVANCING EFH FOR THE 2022 5-YEAR REVIEW

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

Main Topics of Feedback from Stock Author Review (con't):

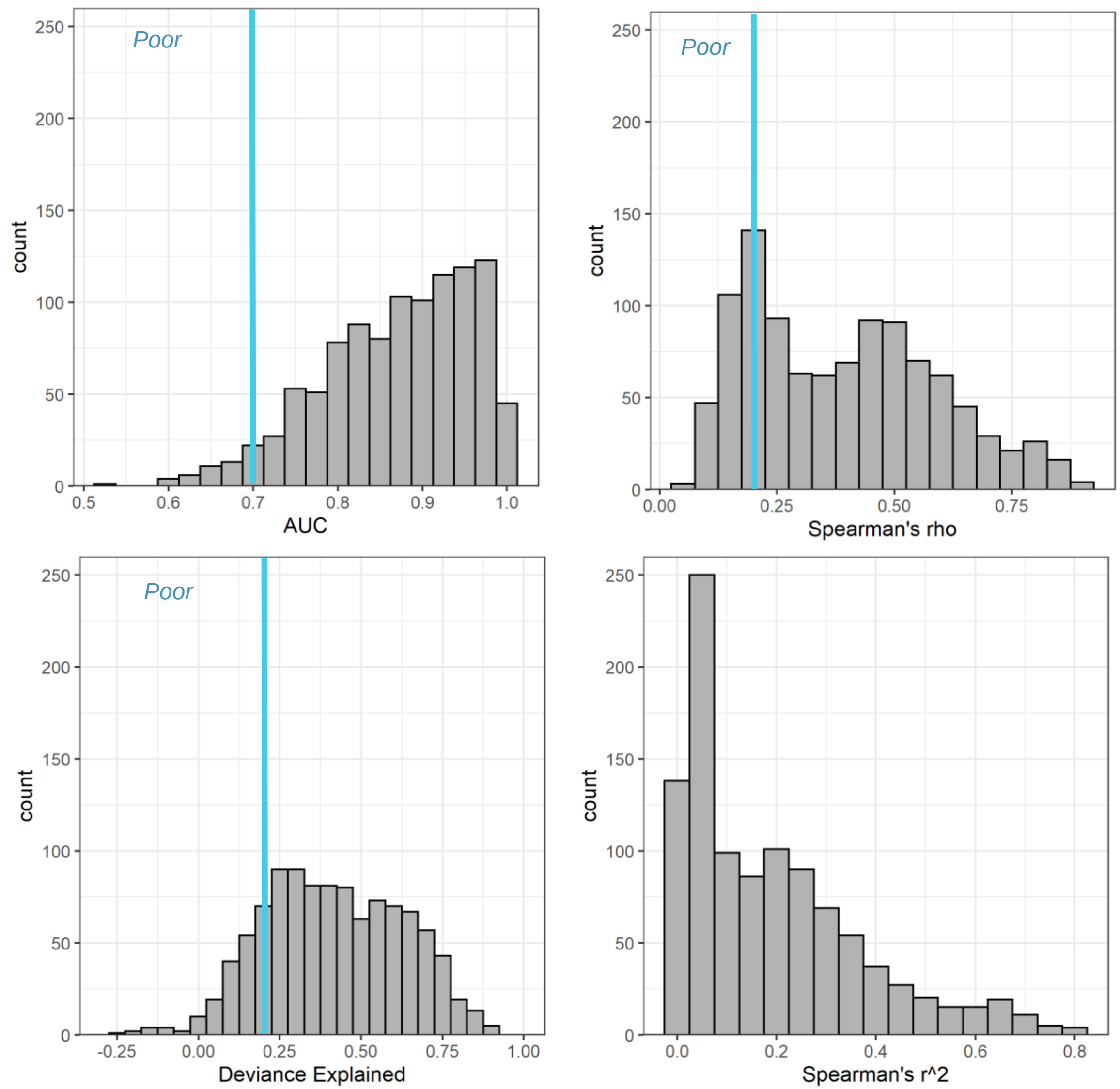
3. **Concerns of Model Performance** (e.g., *concern expressed over ensembles with low fit for specific species; recommendations to revisit our fit metric and to understand model performance more comprehensively)*
   - **Response:**
     - We added multiple common fit metrics (*rho*, AUC, Deviance Explained) to provide a more comprehensive interpretation of model performance and applied these to all species ensembles.
     - We are working with stock authors to diagnose issues.
     - We are considering alternative approaches for a small set of species (e.g., by addressing misbehaving SDMs in ensembles for species with an existing EFH map (i.e., GOA Atka mackerel) and by moving "boundary" species without previous EFH maps to be addressed in next 5-year cycle (e.g., sleeper sharks).

ADVANCING EFH FOR THE 2022 5-YEAR REVIEW

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

Ensemble Performance Fit Metrics:

- **AUC** (Hosmer and Lemeshow 2005)
- **Spearman's *rho***
- **Deviance Explained**
- **Spearman's r^2** (provided for stock assessment author review and replace by *rho* in future drafts)



ADVANCING EFH FOR THE 2022 5-YEAR REVIEW

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

Ensemble Performance Examples Key:

EBS Adult
Arrowtooth Flounder

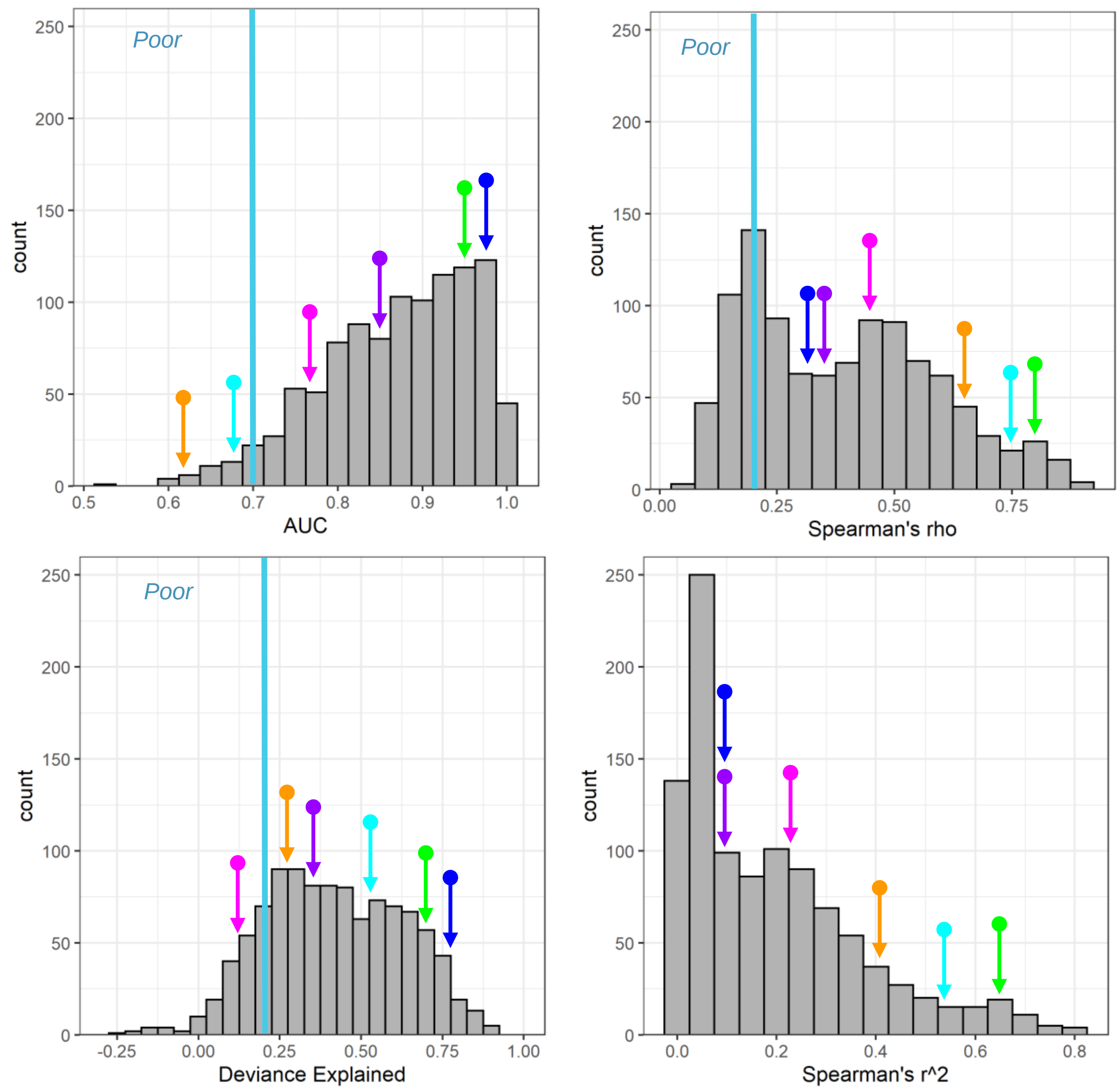
EBS Adult
Walleye Pollock

GOA Adult
Pacific cod

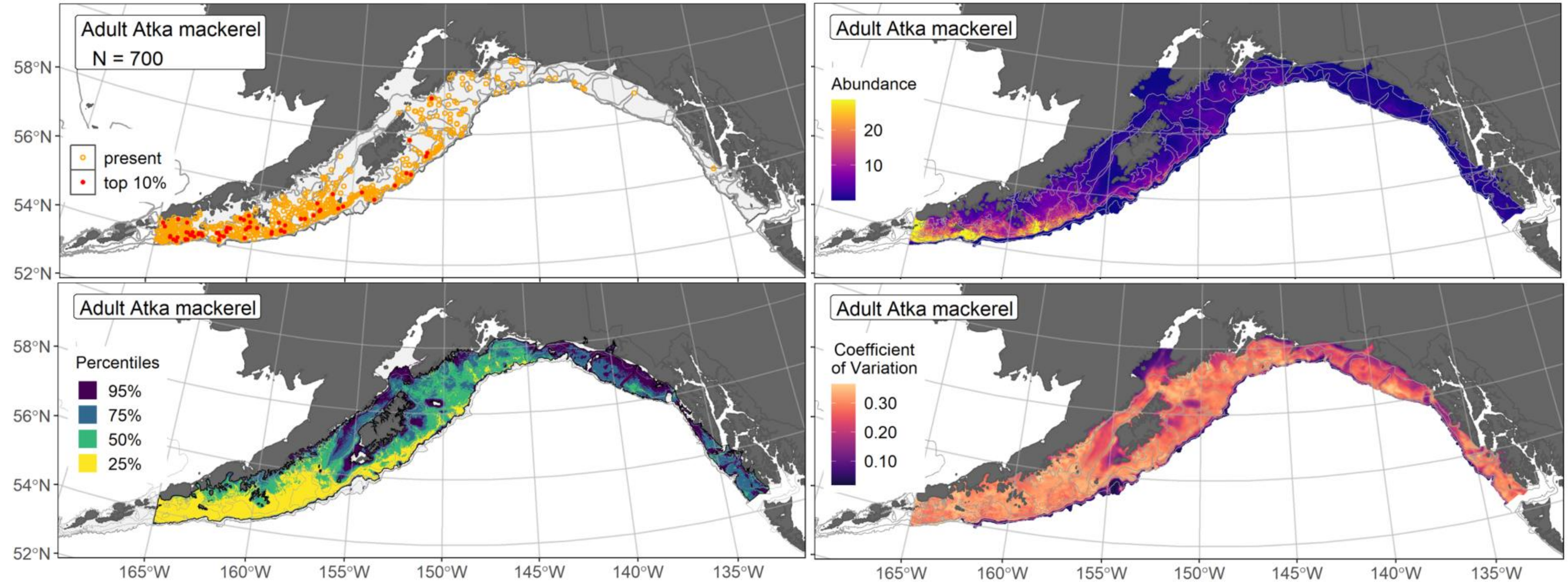
AI Adult
Pacific Ocean Perch

GOA Adult
Atka Mackerel

GOA Subadult
Shortraker Rockfish

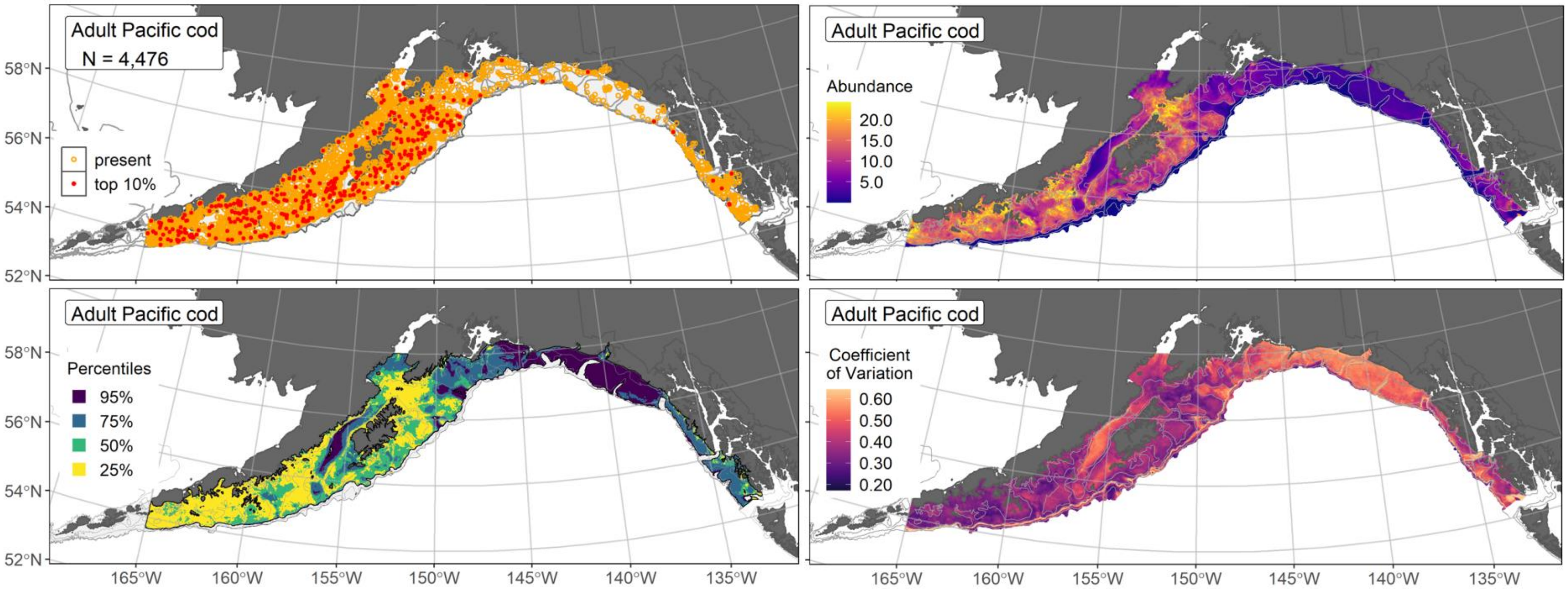


Atka mackerel adults: Catch, SDM, CV, EFH



- Constituent SDMs= *MaxEnt, presence-absence GAM, negative binomial GAM*
- Performance: Square of Spearman's rank correlation $r^2 = 0.11$ (provided for stock author review), Spearman's *rho* = 0.34, AUC = 0.85, Deviance Explained = 0.36
- "Core EFH area" is the upper 50th percentile (green on EFH map) of the total EFH area, which is the upper 95th percentile (purple on EFH map); Core EFH area is applied to the Fishing Effects Model Analysis (SSC Guidance, 2017).
  - Core EFH area 2017 = 33,000 km^2 and 2022 = 133,000 km^2

Pacific cod adults: Catch, SDM, CV, EFH

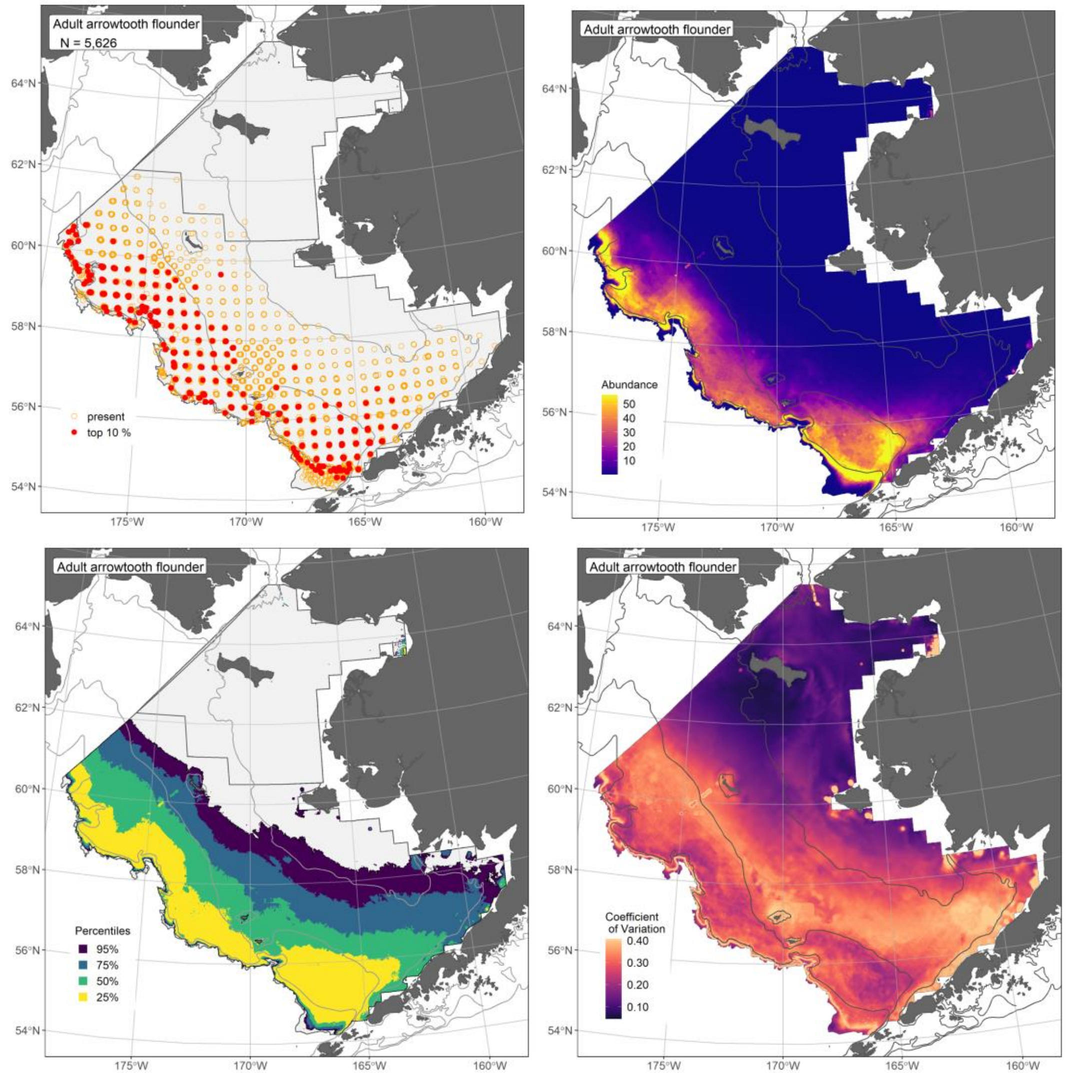


- Constituent SDMs = *MaxEnt, presence-absence GAM, negative binomial GAM*
- Performance: Square of Spearman's rank correlation $r^2 = 0.24$ (provided for stock author review), Spearman's *rho* = 0.49, AUC = 0.77, Deviance Explained = 0.16

Arrowtooth flounder adults: Catch, SDM, CV, EFH

- Constituent SDMs = *MaxEnt, presence-absence GAM, hurdle GAM, Poisson GAM*

- Performance: Square of Spearman's rank correlation (provided for stock author review) r^2 = 0.66, Spearman's *rho* = 0.81, AUC = 0.96, Deviance Explained = 0.63



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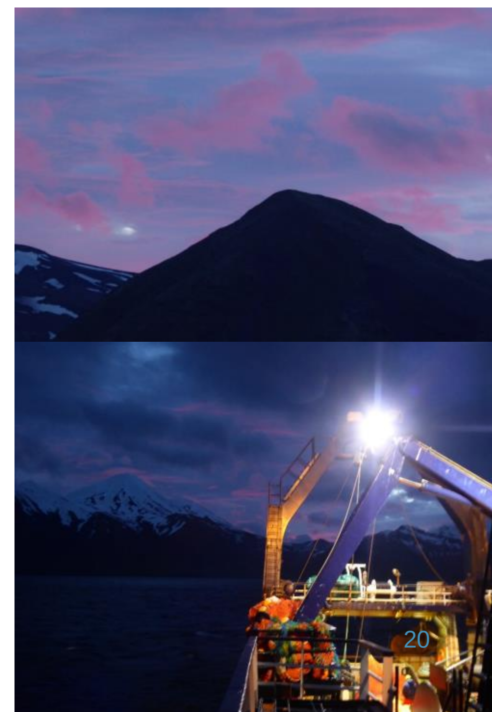
Discussion Papers:
EFH Component 1 Discussion Paper presented to SSC June 2020
EFH 5-year Review Discussion Paper presented to SSC April 2021



SDM EFH Methods Overview

2022 SDM

Response Variable

- Fish numerical abundance (1982-2019 catches)

Models

- MaxEnt, paGAM, hGAM, Poisson GAM, Negative binomial GAM
- Constituents applied comprehensively

Ensemble:

- Above constituent models included based on RMSE

Fit Metrics: (applied to all)

- k-fold cross validation to generate RMSE and other fit metrics
- Provided for Stock Author review of methods/results = Spearman's r^2
- Added based on Stock Author input to improve results communication = Spearman's *rho*, AUC, Deviance Explained

2017 SDM

Response Variable

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

Models

- MaxEnt, hGAM, GAM
- Selected *a priori*

Ensemble:

- (new for 2022)

Fit Metrics

- Applied based on model
- MaxEnt (AUC); GAMs (Deviance Explained)
- 80/20 training/testing data fit metrics examined for out of sample comparison
- Provided for Stock Author review = none

SSC MINUTES EFH COMPONENT 1 JUNE 2020 AND APRIL 2021

- **SSC suggested consideration of ensemble methods** that weight EFH prediction across candidate SDMs with similar out-of-sample predictive performance. (June 2020)
- **SSC supported continued exploration of alternative SDM approaches** across species, regions, and life stages (e.g., GAMs and MaxEnt models). (June 2020)
- **SSC supported the following:** Response variable of numerical abundance with area swept (effort) as an offset in the SDM; Out-of-sample skill testing for arbitrating among candidate SDMs; Cross-validation through repeated sampling of testing and training datasets; Use of the complementary log-log (cloglog) link to relate abundance to occurrence, which facilitates skill testing; Use of RMSE for skill testing. (June 2020)
- **SSC supported research permitting description of Level 3 EFH.** (June 2020)
- **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. (June 2020)
- Overall, the **SSC is supportive** of the use of this package of products for the advancement of EFH in the 2022 cycle, which will advance the objectives of the Alaska EFH research plan and lead to improved definitions of EFH in the BSAI, GOA, and Arctic. (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. (April 2021)

2. Evaluation of the Effects of Fishing

JOHN V. OLSON, Habitat Conservation Division, NMFS Alaska Region, Anchorage, AK

1. Overview of Fishing Effects model
2. Review methodology for Stock Assessment Authors to evaluate the effects of fishing on EFH
3. Input from GFPT on this process

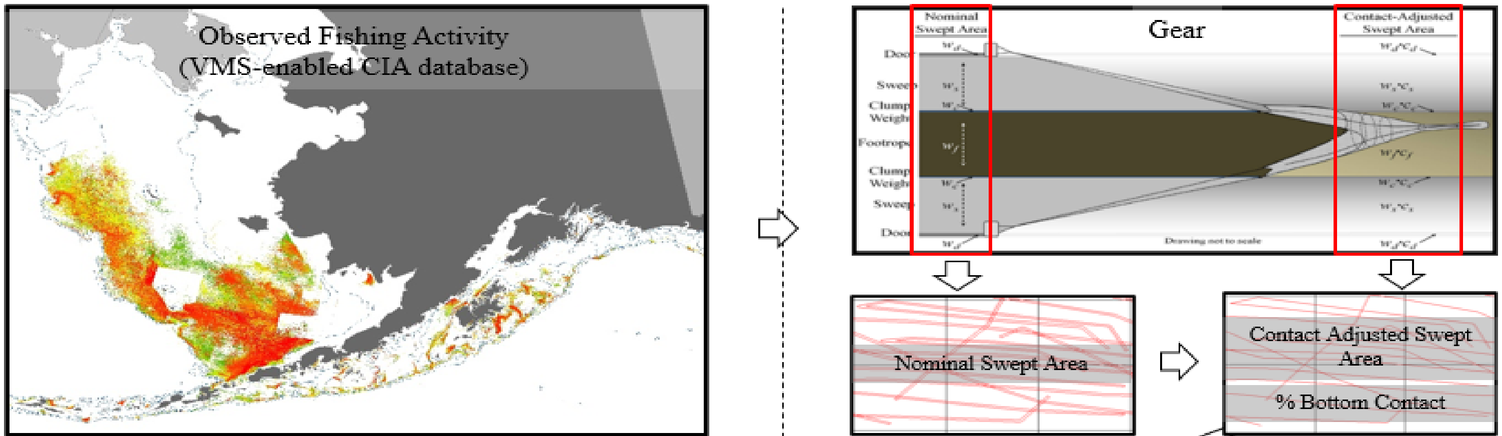
2015 EFH 5-year Review

During the 2015 (2017) EFH cycle, the NPFMC/SSC requested several updates to the LEI model to make the input parameters more intuitive and to draw on the best available data. In response to their requests, the Fishing Effects (FE) model was developed.

It is based on interaction between habitat impact and recovery, which depend on the amount of fishing effort, the types of gear used, habitat sensitivity, and substrate.

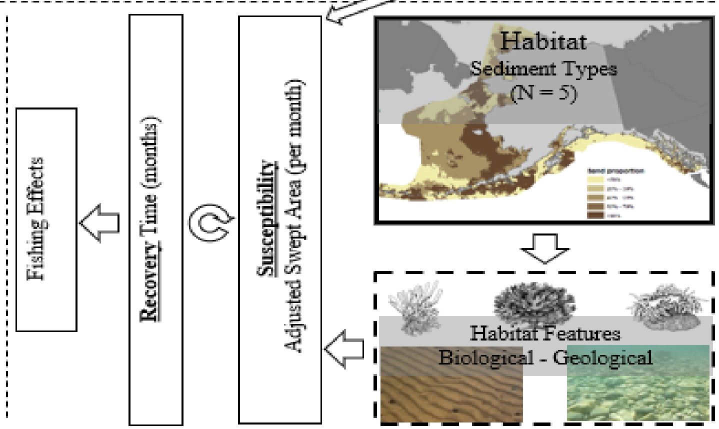
- The FE model is cast in a discrete time framework
- The FE model implements sub annual (monthly) tracking of fishing impacts and habitat disturbance.
- The FE model draws on VMS data and the Catch-in-Areas (CIA) database to use the best available spatial data of fishing locations and species targets.
- The FE model incorporates the extensive literature review from Grabowski (2014) to estimate susceptibility and recovery dynamics.

Fishing Effects (FE) Model Overview

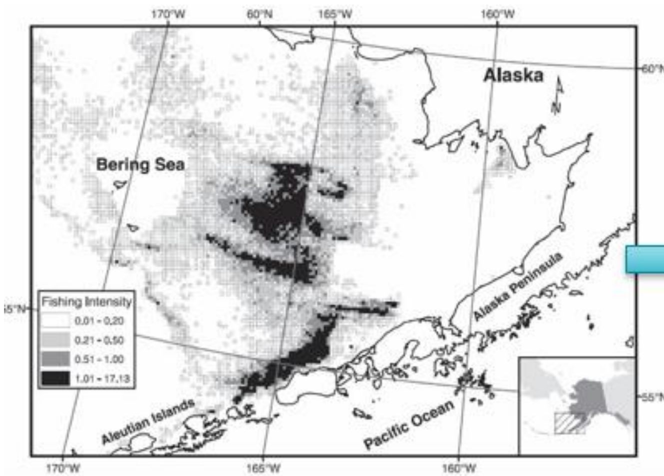


$$H_{t+1} = H_t(1 - I'_t) + h_t\rho'_t$$

H: habitat undisturbed from fishing
h: habitat disturbed from fishing
I': monthly impact rate
ρ': monthly recovery rate

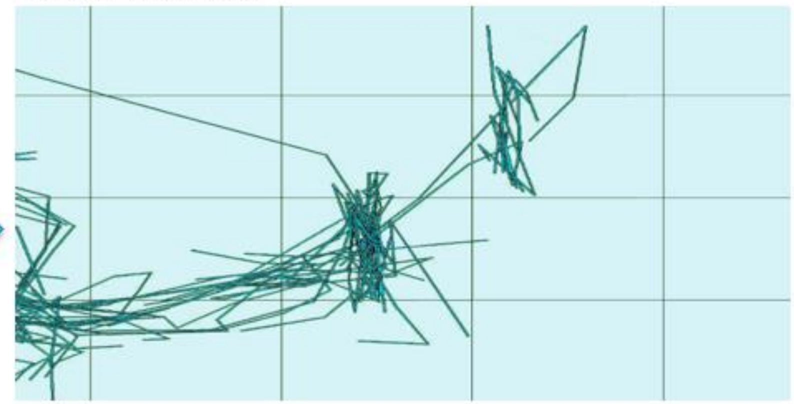


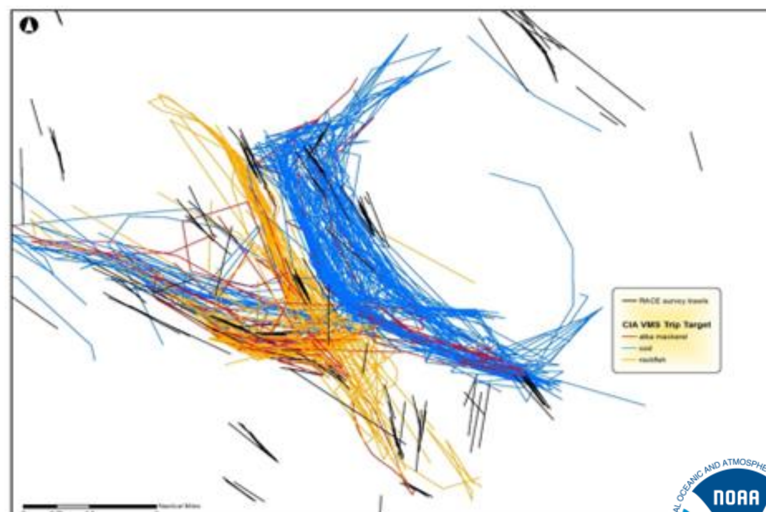
Using VMS to Increase Spatial Resolution



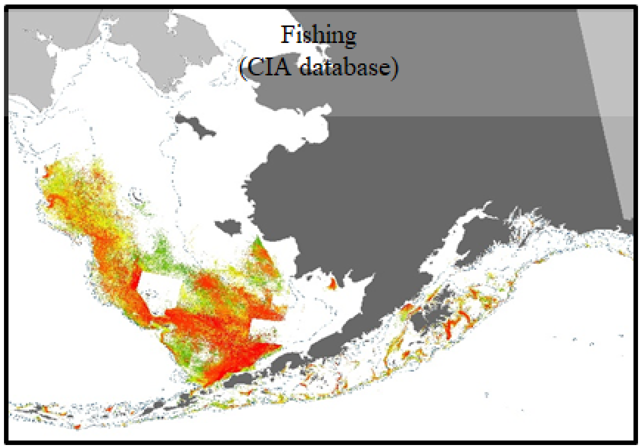
2005/2010 EFH analyses - endpoint only

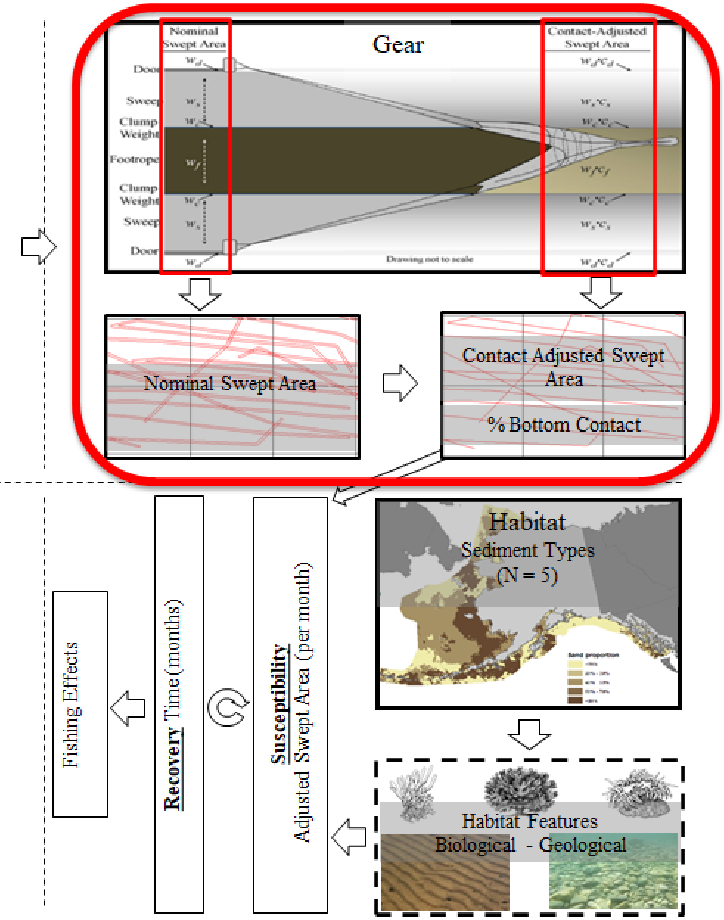
2015 VMS 30min ping rate





FE - Gear Descriptions & Bottom Contact

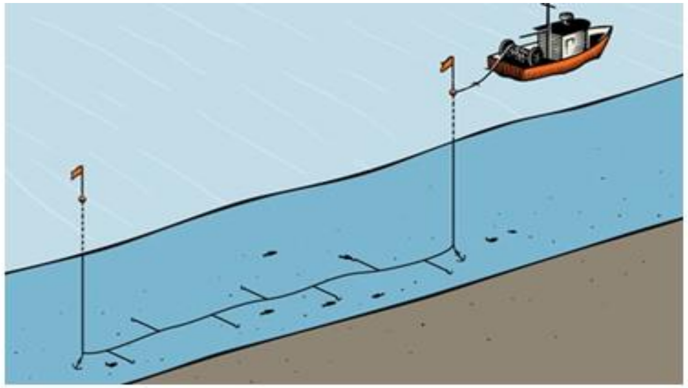




$$H_{t+1} = H_t(1 - I'_t) + h_t\rho'_t$$

H: habitat undisturbed from fishing
h: habitat disturbed from fishing
I': monthly impact rate
ρ': monthly recovery rate

Bottom Contact Adjustment



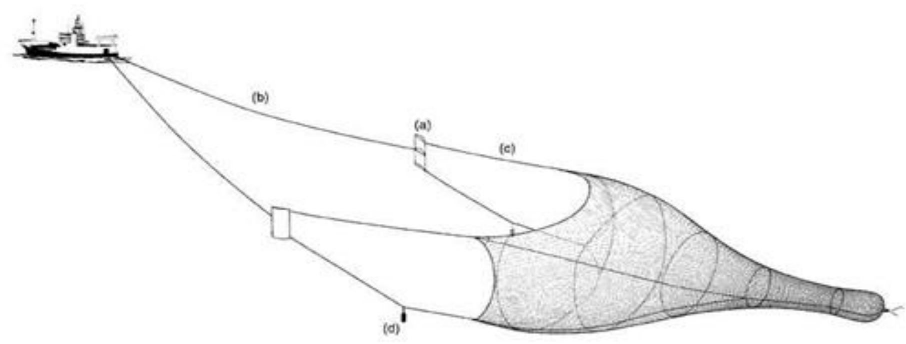


Figure 10. Single boat pelagic trawl

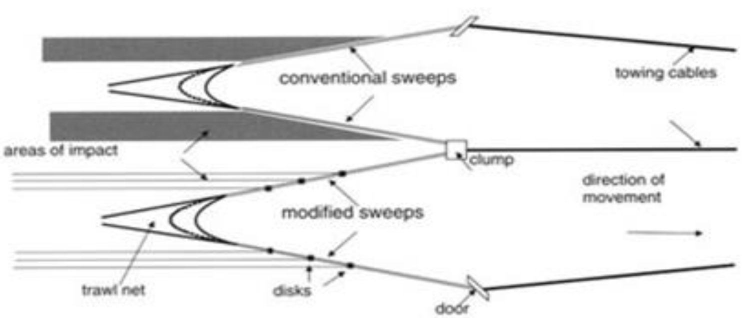


Figure 1

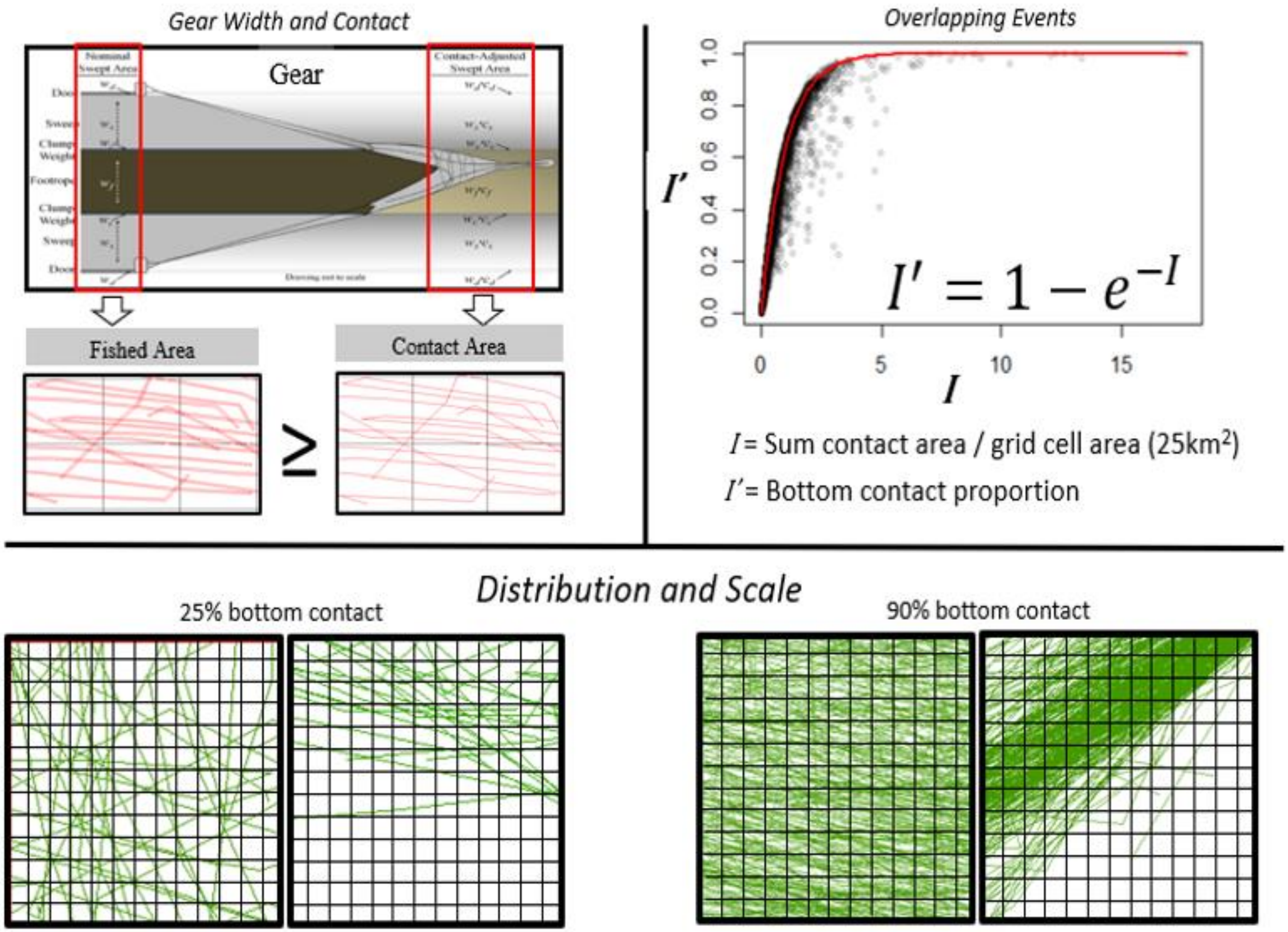
Diagram of the twin trawl system, complete with sweeps (conventional and modified), towed simultaneously behind a vessel and used to test whether raised trawl sweeps reduce flatfish herding. Actual total width was approximately 250 m. Shaded areas represent the area of contact with the seafloor.

Gear Descriptions by Vessel Class, Target

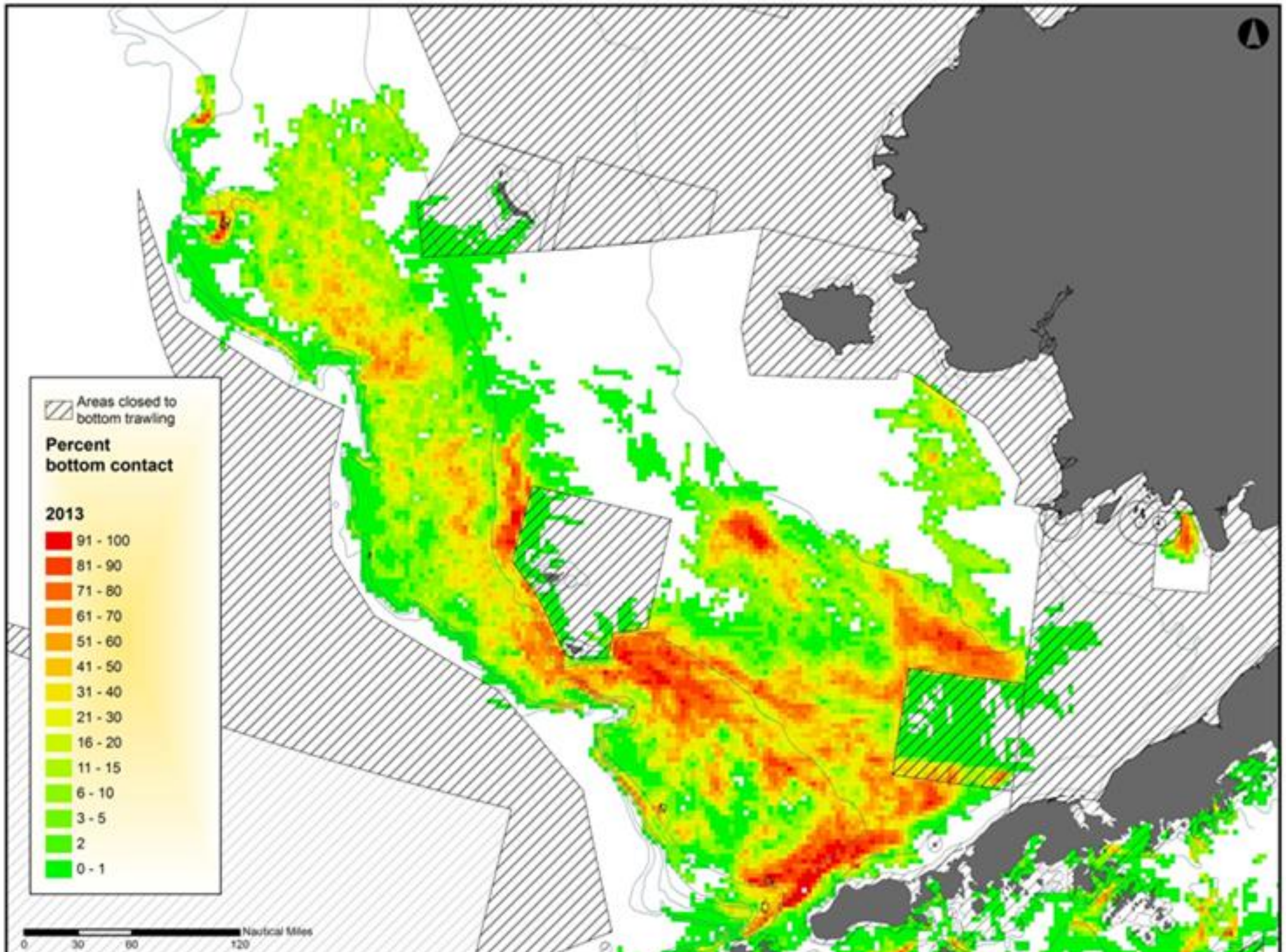
Fishery	Vessel type	Area	Gear	Target1	Target2	Vessel Length (ft)	Season	Depth Range (fath.)	Nom Width (m)
GOA Pollock Pelagic Trawl Sand Point	CV	GOA	PTR	P	all others	<75			50
GOA Pollock Pelagic Trawl	CV	GOA	PTR	P	all (but K, S)	≥75			75
GOA Slope Rockfish Pelagic Trawl	CV	GOA	PTR	K	S	≥75			75
GOA Slope Rockfish Pelagic Trawl	CP	GOA	PTR	K	W	all			100
GOA PCod Bottom Trawl Inshore	CV	GOA	NPT	C	B, P	≥75			90
GOA Deepwater Flatfish Bottom Trawl	CV	GOA	NPT	D	W, X	≥75			90
GOA Shallowwater Flatfish Bottom Trawl	CV	GOA	NPT	H	all others	≥75			90
GOA PCod Bottom Trawl Sand Point	CV	GOA	NPT	C	all others	<75			55
GOA Deepwater Flatfish Bottom Trawl CP	CP	GOA	NPT	D, W	X	all			193
GOA Shallowwater Flatfish/Cod Bottom Trawl CP	CP	GOA	NPT	H, C	L, all others	all			193
GOA Slope Rockfish Bottom Trawl CP	CP	GOA	NPT	K	S	all			75
BS Pollock Pelagic Trawl (incl Mothership)	CV	BS	PTR	P	B, all others	<125 ≥300	A	≥90	62
BS Pollock Pelagic Trawl (incl Mothership)	CV	BS	PTR	P	B, all others	<125 ≥300	A	60-90	58
BS Pollock Pelagic Trawl (incl Mothership)	CV	BS	PTR	P	B, all others	<125 ≥300	A	<60	50
BS Pollock Pelagic Trawl (incl Mothership)	CV	BS	PTR	P	B, all others	<125 ≥300	B	≥90	77
BS Pollock Pelagic Trawl (incl Mothership)	CV	BS	PTR	P	B, all others	<125 ≥300	B	60-90	73
BS Pollock Pelagic Trawl (incl Mothership)	CV	BS	PTR	P	B, all others	<125 ≥300	B	<60	64
BS Pollock Pelagic Trawl	CV	BS	PTR	P	B, all others	125-151	A	≥90	93
BS Pollock Pelagic Trawl	CV	BS	PTR	P	B, all others	125-151	A	60-90	87
BS Pollock Pelagic Trawl	CV	BS	PTR	P	B, all others	125-151	A	<60	75
BS Pollock Pelagic Trawl	CV	BS	PTR	P	B, all others	125-151	B	≥90	115

Fishery	Vessel type	Area	Gear	Target1	Target2	Vessel Length (ft)	Season	Depth Range (fath.)	Gear mod[1]	Nom Width (m)	L
AI Pcod Bottom Trawl mothership	CV	AI	NPT	C	all others	>250 (or Processor M)				75	
AI Pcod Bottom Trawl	CV	AI	NPT	C	all others	<99				55	
AI Pcod Bottom Trawl	CV	AI	NPT	C	all others	≥99				90	
AI Atka and Rockfish Bottom Trawl	CP	AI	NPT	A	K, all others	all				100	
AI Pollock		AI	PTR	P	all					100	
GOA PCod Pot		GOA	POT	C	all others					5.6	
BSAI Pcod Pot		BSAI	POT	C	all others					5.6	
BSAI Sablefish Pot		BSAI	POT	S	T					5.6	
GOA Sablefish Pot (few, but future) can combine BS for now		GOA	POT	S	T					5.6	
GOA Sablefish Longline		GOA	HAL	S	T					2	
GOA SE Demersal Shelf Rock Longline		GOA	HAL	K						2	
GOA Halibut longline		GOA	HAL	I						2	
GOA Pcod Longline		GOA	HAL	C	all others					2	
BSAI Pcod Longline		BSAI	HAL	C	all others					2	
BSAI Sabelfish/ Greenland Turbot Longline		BSAI	HAL	S	T					2	
BSAI Halibut longline		BSAI	HAL	I						2	
PCod Jig (also rockfish and halibut)		GOA	JIG	C	all others					0.2	

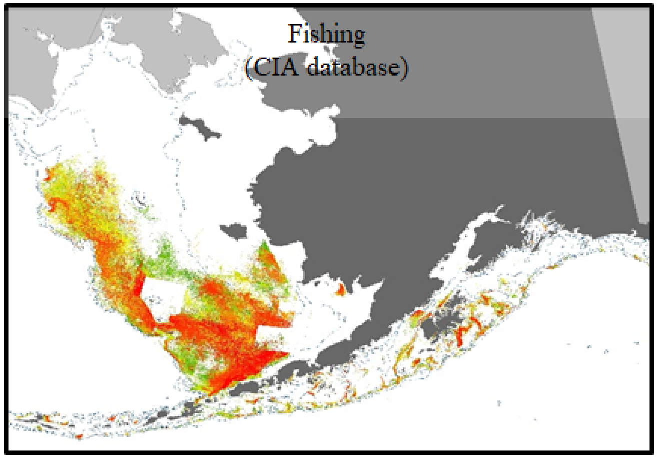
Defining Fishing Gear Footprint

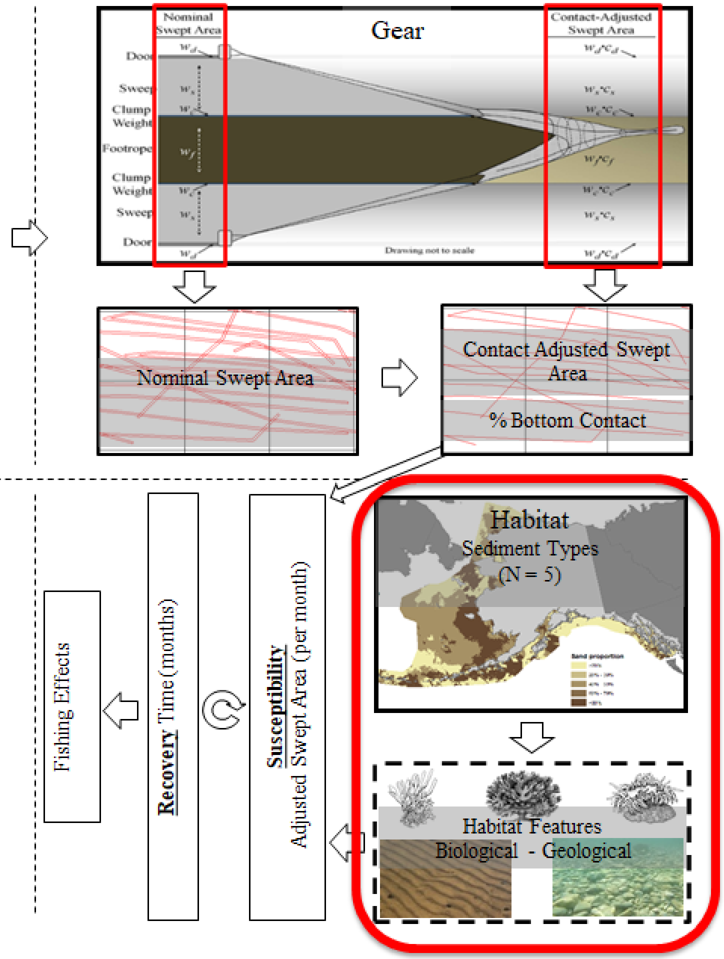


Initial Bottom Contact Percentages



FE - Habitat Features

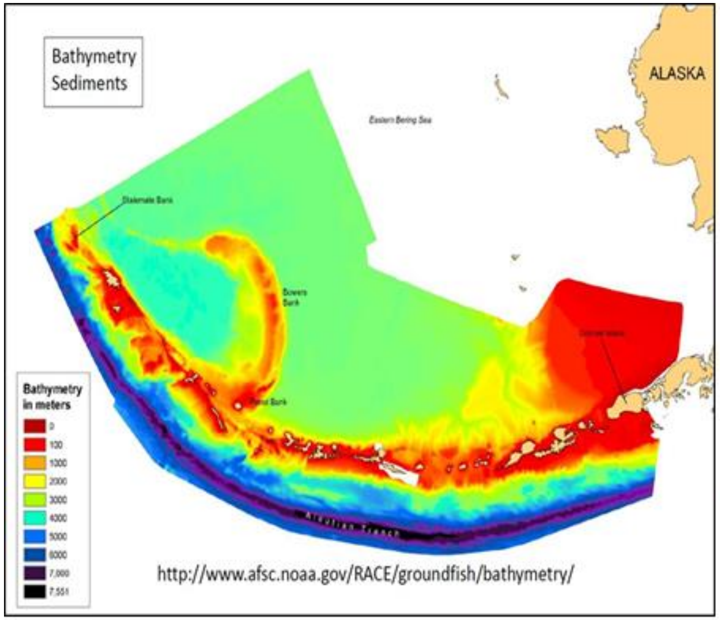


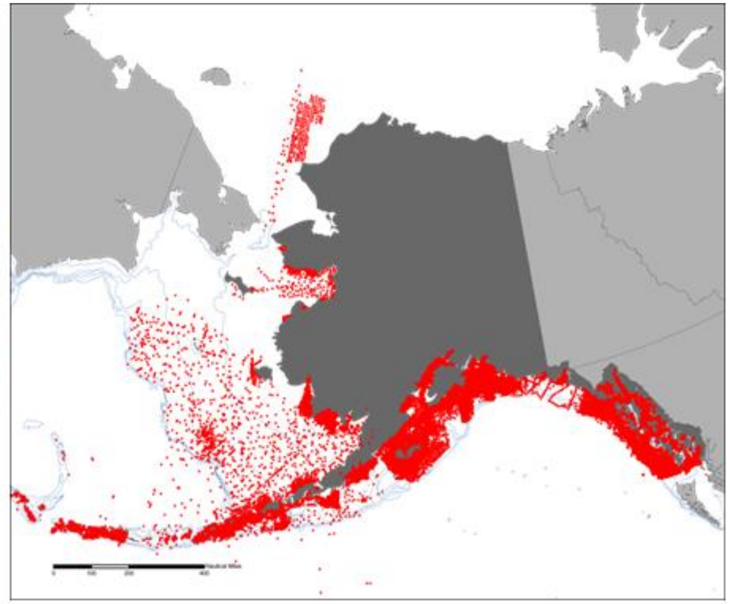


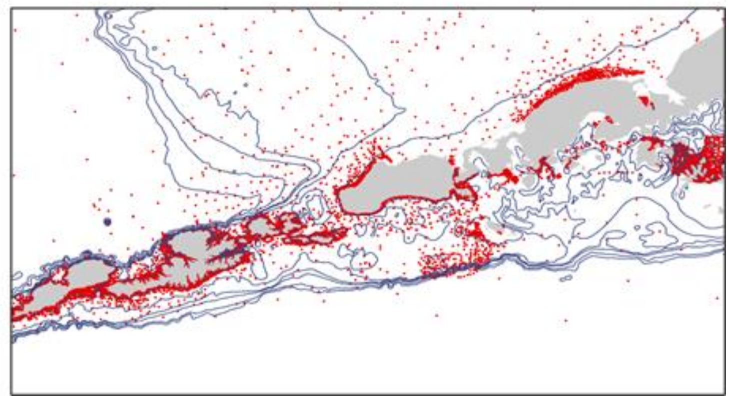
$$H_{t+1} = H_t(1 - I'_t) + h_t\rho'_t$$

H: habitat undisturbed from fishing
h: habitat disturbed from fishing
I': monthly impact rate
ρ': monthly recovery rate

Bathymetry & Sediment

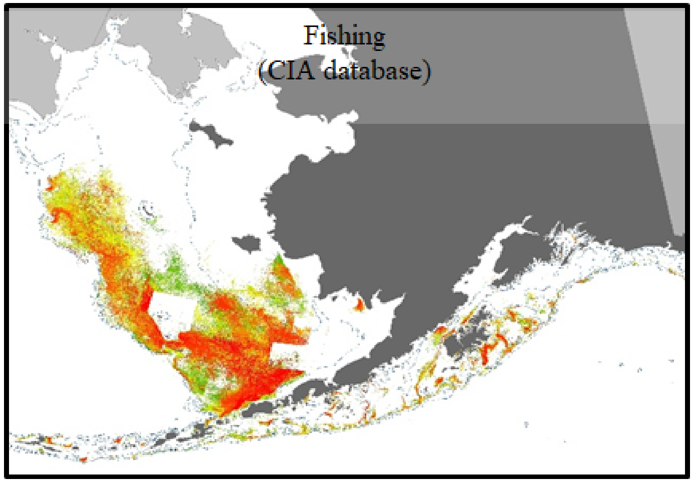


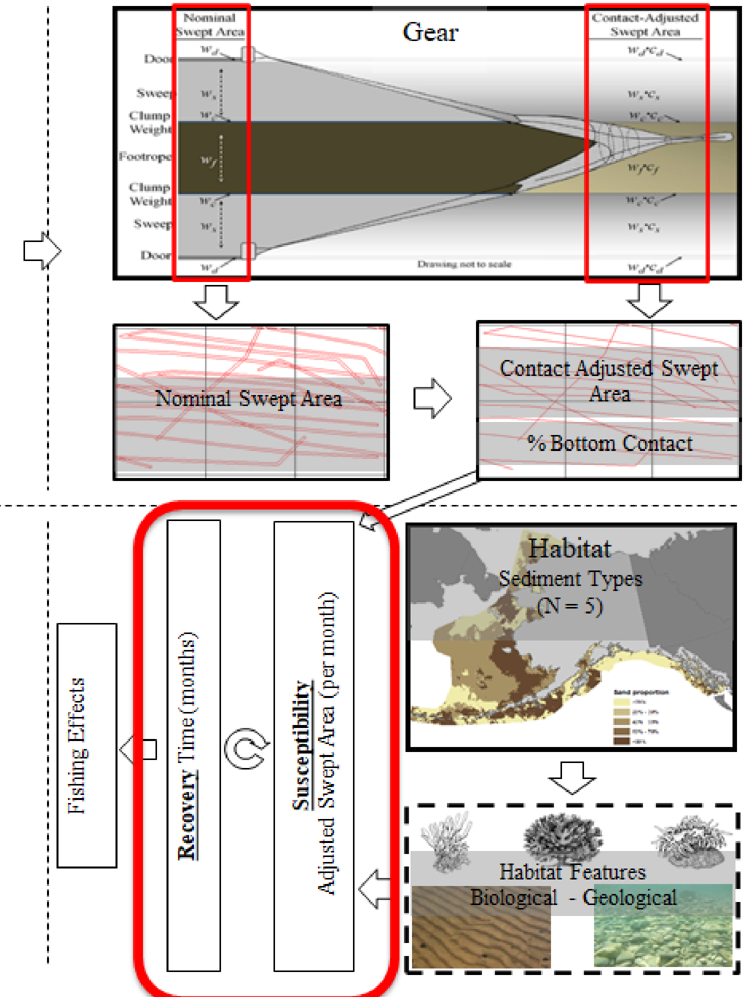




250,000+ points with 6,000+ sediment descriptions coded into 5 sediment classes: Mud, Sand, Granule/Pebble, Cobble, Boulder

FE - Susceptibility & Recovery Dynamics





$$H_{t+1} = H_t(1 - I'_t) + h_t \rho'_t$$

H: habitat undisturbed from fishing
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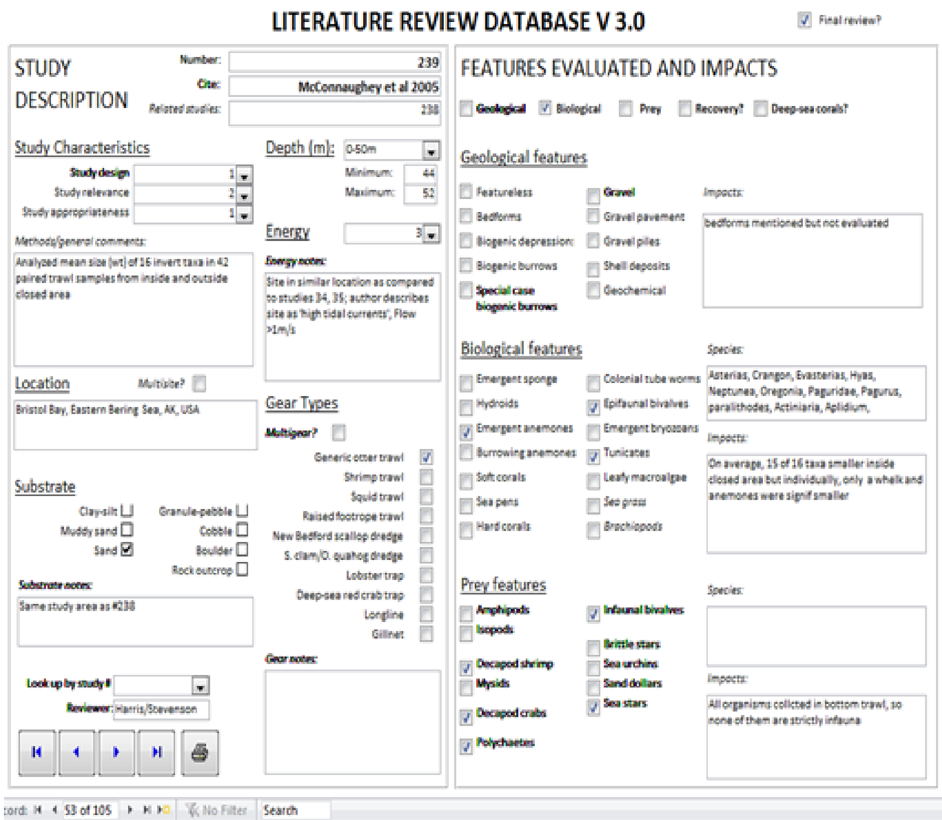
I': monthly impact rate
ρ': monthly recovery rate

Framework for Literature Review

Assessing the Vulnerability of Marine Benthos to Fishing Gear Impacts

JONATHAN H. GRABOWSKI,[1] MICHELLE BACHMAN,[2] CHAD DEMAREST,[3] STEVE EAYRS,[4] BRADLEY P. HARRIS,[5] VINCENT MALKOSKI,[6] DAVID PACKER,[7] and DAVID STEVENSON[8]
[1]Marine Science Center, Northeastern University, Nahant, Massachusetts, USA
[2]New England Fishery Management Council, Newburyport, Massachusetts, USA
[3]NOAA/NMFS Northeast Fisheries Science Center, Woods Hole, Massachusetts, USA
[4]Gulf of Maine Research Institute, Portland, Maine, USA
[5]Department of Environmental Science, Alaska Pacific University, Anchorage, Alaska, USA
[6]Massachusetts Division of Marine Fisheries, New Bedford, Massachusetts, USA
[7]NOAA National Marine Fisheries Service, Highlands, New Jersey, USA
[8]NOAA Northeast Regional Office, Gloucester, Massachusetts, USA

"develop a framework for generating and organizing quantitative susceptibility (based on percent loss of structural habitat from a single interaction with the gear) and recovery (i.e., the time required for recovery of lost structure) parameters for each biological (e.g., sponges, ascidians, mollusks) and geological (e.g., mud burrows, sand ripples, cobble, and boulder piles) feature common to the following five substrates: mud, sand, granule–pebble, cobble, and boulder"



Grabowski, J. H., M. Bachman, C. Demarest, S. Eayrs, B. P. Harris, V. Malkoski, D. Packer, and D. Stevenson. 2014. Assessing the vulnerability of marine benthos to fishing gear impacts. Reviews in Fisheries Science & Aquaculture 22:142-155.

Susceptibility & Recovery of Habitat Features

The susceptibility and recovery rates for both biological taxa and geological features are averaged across all features with substrate types (mud, sand, gravel-pebble, cobble, boulder). These rates are similar to the recovery rates in Hiddink et al (2017) for each substrate type, and are representative for substrate types at the scale of the model rather than individual features.

Susceptibility

Feature Class	Feature	Mud	Sand	Gran-Peb	Cobble	Boulder
G	Bedforms		2			
G	Biogenic burrows	2	2			
G	Biogenic depressions	2	2			
G	Boulder, piled					2
G	Boulder, scattered, in sand					0
G	Cobble, pavement				1	
G	Cobble, piled				3	
G	Cobble, scattered in sand				1	
G	Granule-pebble, pavement			1		
G	Granule-pebble, scattered, in sand			1		
G	Sediments, suface/subsurface	2	2			
G	Shell deposits		1	1		
B	Amphipods, tube-dwelling	1	1			
B	Anemones, actinarian			2	2	2
B	Anemones, cerianthid burrowing	2	2	2		
B	Ascidians		2	2	2	2
B	Brachiopods			2	2	2
B	Bryozoans			1	1	1
B	Corals, sea pens	2	2			
B	Hydroids	1	1	1	1	1
B	Macroalgae			1	1	1
B	Mollusks, epifaunal bivalve, *Modiolus modiolus*	1	1	2	2	2
B	Mollusks, epifaunal bivalve, *Placopecten magellanicus*		2	1	1	
B	Polychaetes, *Filograna implexa*		2	2	2	2
B	Polychaetes, other tube-dwelling			2	2	2
B	Sponges		2	2	2	2

Adapted from the SASI model (NEFMC, 2011)

Recovery

Feature Class	Features	Mud	Sand	Gran-Peb	Cobble	Boulder
G	Bedforms		0			
G	Biogenic burrows	0	0			
G	Biogenic depressions	0	0			
G	Boulder, piled					3
G	Boulder, scattered, in sand					0
G	Cobble, pavement				0	
G	Cobble, piled				3	
G	Cobble, scattered in sand				0	
G	Granule-pebble, pavement			0		
G	Granule-pebble, scattered, in sand			2		
G	Sediments, suface/subsurface	0	0			
G	Shell deposits		2	2		
B	Amphipods, tube-dwelling	0	0			
B	Anemones, actinarian			2	2	2
B	Anemones, cerianthid burrowing	2	2	2		
B	Ascidians		1	1	1	1
B	Brachiopods			2	2	2
B	Bryozoans			1	1	1
B	Corals, sea pens	2	2			
B	Hydroids	1	1	1	1	1
B	Macroalgae			1	1	1
B	Mollusks, epifaunal bivalve, *Modiolus modiolus*	3	3	3	3	3
B	Mollusks, epifaunal bivalve, *Placopecten magellanicus*		2	2	2	
B	Polychaetes, *Filograna implexa*		2	2	2	2
B	Polychaetes, other tube-dwelling			1	1	1
B	Sponges		2	2	2	2

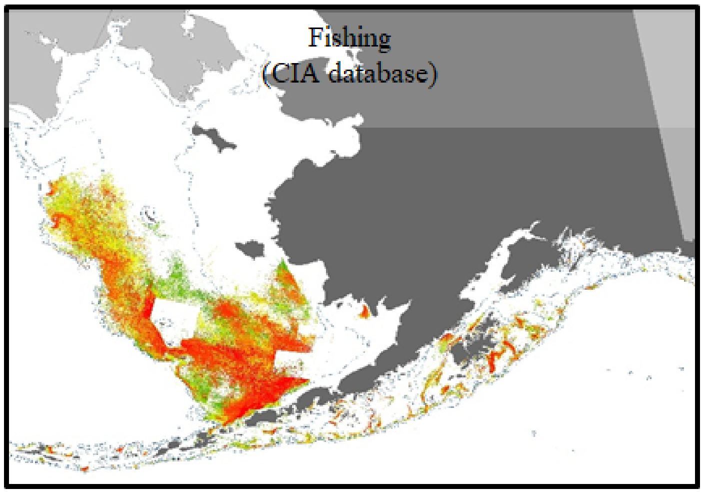
Adapted from the SASI model (NEFMC, 2011)
Recovery codes: 0: < 1 year; 1: 1–2 years; 2: 2–5 years; 3: >5 years
Blank spaces are habitat features not associated with the given sediment class
G is Geological features and B is Biological features

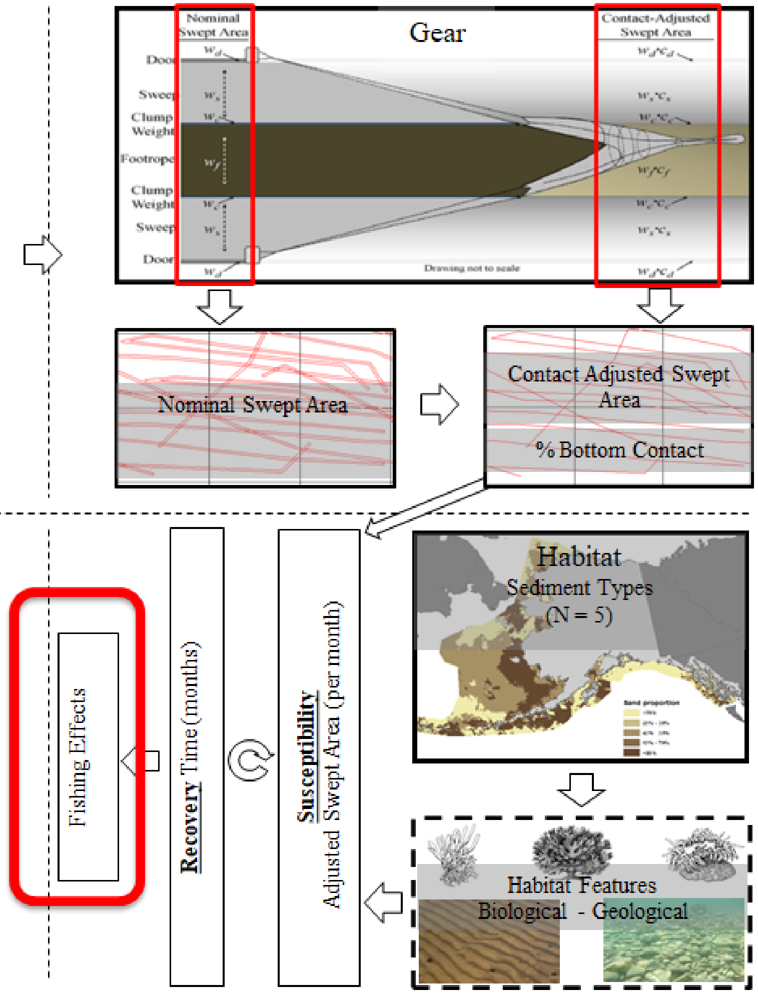
Recovery code	τ
0	<1 year
1	1 – 2 years
2	2 – 5 years
3	>5 years

Susceptibility code	Susceptibility
0	0 – 10%
1	10 – 25%
2	25 – 50%
3	>50%

Global analysis of depletion and recovery of seabed biota after bottom trawling disturbance. 2017. Hiddink, J.G., Jennings, S., Sciberras, M., Szostek, C.L., Hughes, K.M., Ellis, N., Rijnsdorp, A.D., McConnaughey, R.A., Mazor, T., Hilborn, R., Collie, J.S., Pitcher, C.R., Amoroso, R.O., Parma, A.M., Suuronen, P., and Kaiser, M.J. https://doi.org/10.1073/pnas.1618858114

FE Output - Habitat Reduction





$$H_{t+1} = H_t(1 - I'_t) + h_t \rho'_t$$

H : habitat undisturbed from fishing
h : habitat disturbed from fishing
I': monthly impact rate
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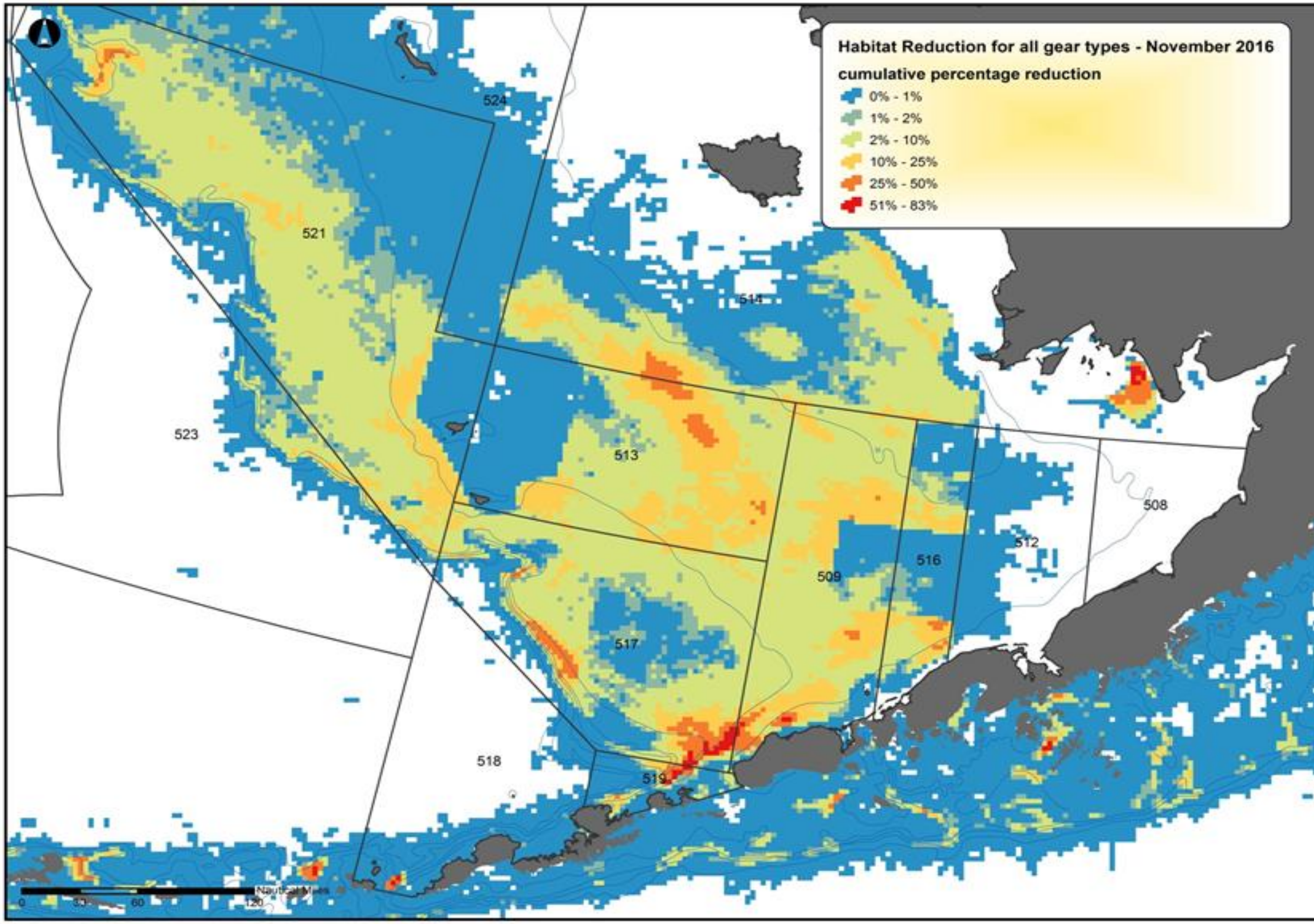
Cumulative Habitat Reduction



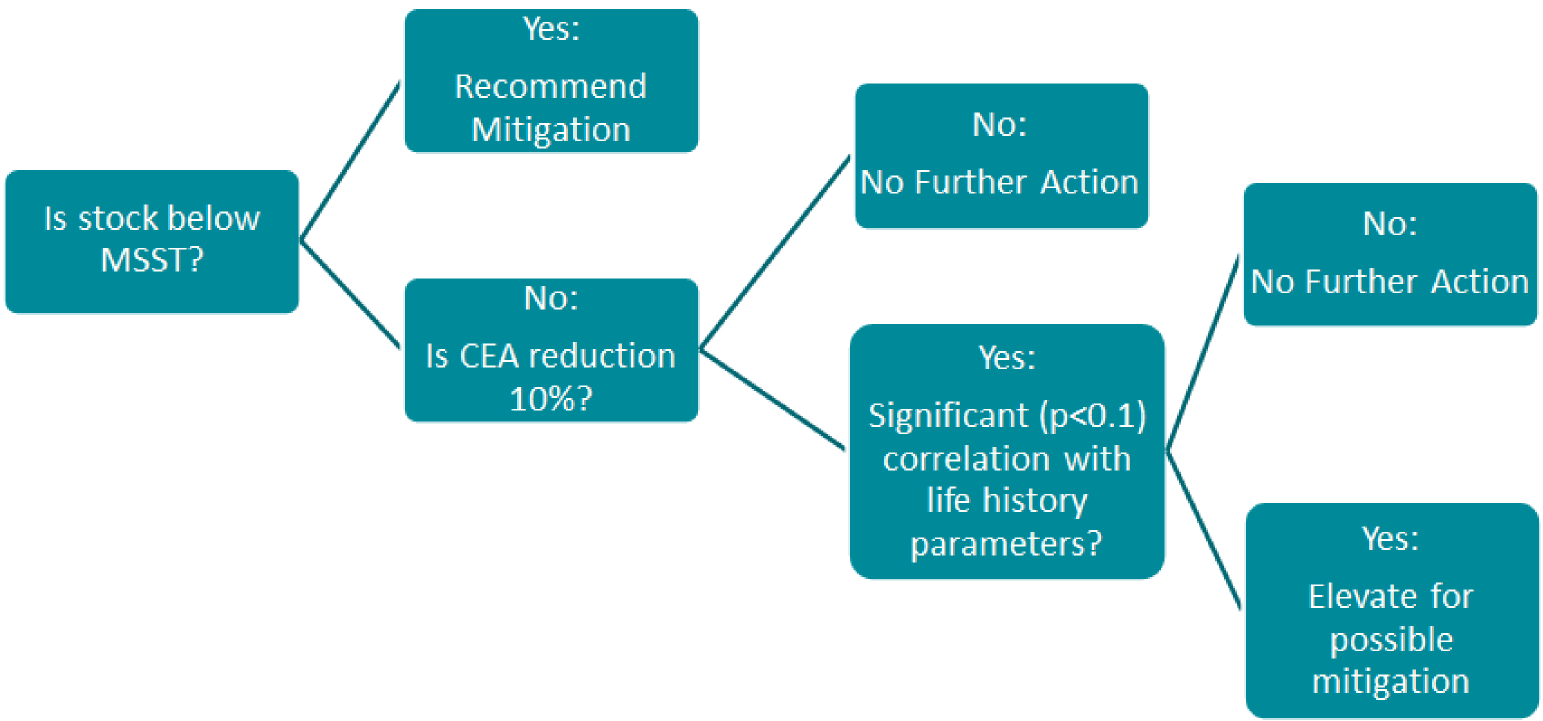
Stock Author Review Process

Methods to evaluate the effects of fishing on Essential Fish Habitat

Proposal from the SSC subcommittee

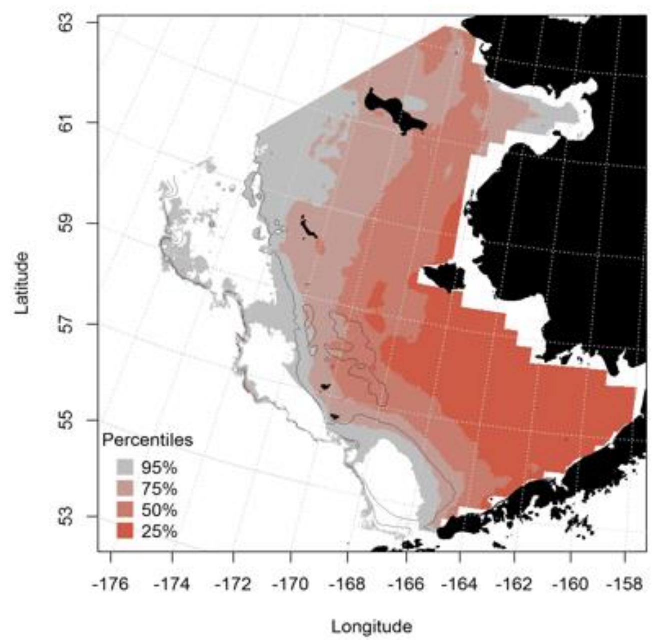
DRAFT 9/16/16

Assessment Methodology for Stock Author Review

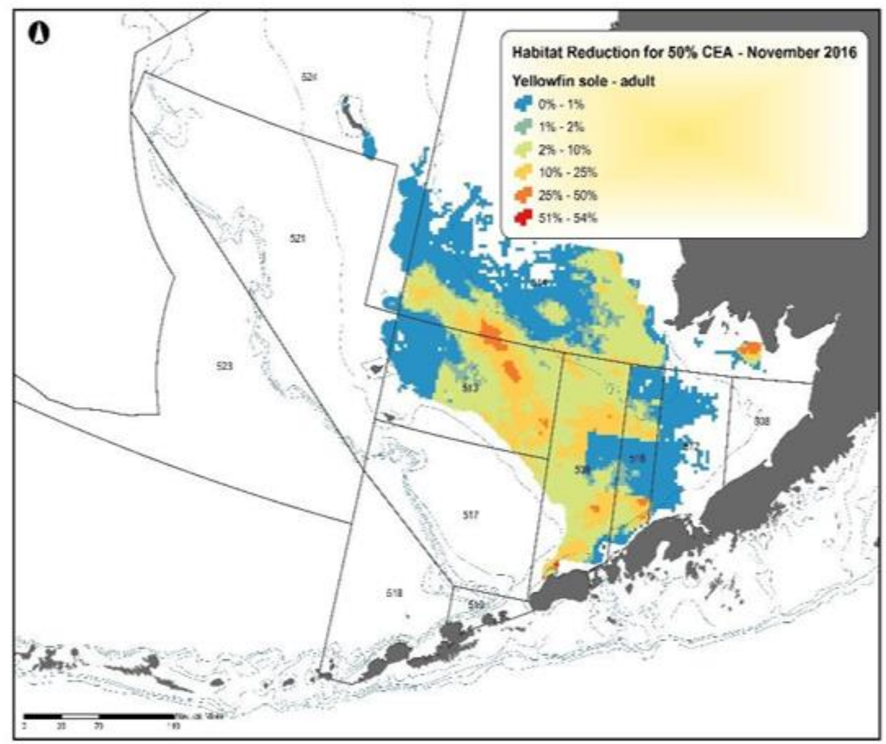


Bering Sea YFS Core EFH & FE Output (2017)

Core EFH area defined as 50% cumulative distribution



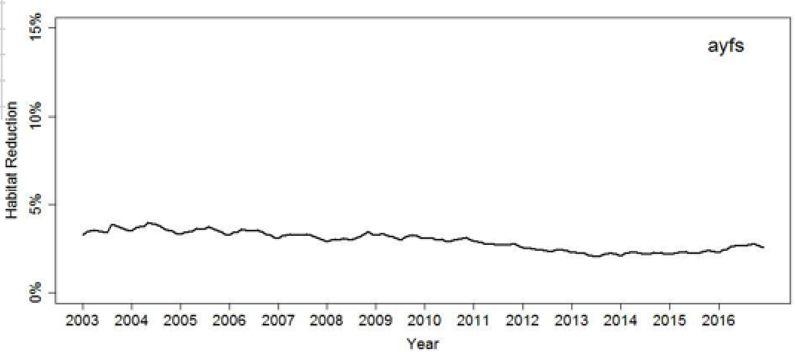
Proportion of habitat reduction (November 2016)



Habitat Reduction Time Series - YFS CEA

Monthly proportion of habitat reduction (2003-2016)

species	Jan-03	Feb-03	Mar-03	Apr-03	May-03	Jun-03
alaska skate	0.015072	0.015238	0.015307	0.015497	0.015896	0.015454
aleutian skate	0.030762	0.031581	0.034609	0.03401	0.033244	0.032472
arrowtooth flounder	0.024122	0.024701	0.027073	0.027118	0.027671	0.027084
atka mackerel	0.019402	0.019593	0.02083	0.020922	0.021332	0.020864
bigmouth sculpin	0.027292	0.028309	0.029771	0.029318	0.029178	0.028668
blackspotted rockfish	0.012141	0.012206	0.012462	0.012744	0.012565	0.012245
dover sole	0.027229	0.026911	0.028724	0.030118	0.032297	0.031532
dusky rockfish	0.008501	0.008506	0.008943	0.008796	0.008592	0.008352
flathead sole	0.031171	0.031774	0.034327	0.034812	0.036687	0.035777
golden king crab	0.01376	0.013862	0.013781	0.013571	0.013193	0.012873
great sculpin	0.029272	0.03033	0.03721	0.036513	0.03625	0.035605
greenland turbot	0.021942	0.022081	0.022184	0.023647	0.02504	0.024442
harlequin rockfish	0.041663	0.04316	0.046849	0.04602		
kamchatka flounder	0.012634	0.012702	0.012817	0.013232		
mud skate	0.028584	0.029611	0.031817	0.031306		
northern rock sole	0.014667	0.015245	0.018632	0.018363		
northern rockfish	0.017787	0.018239	0.021624	0.021322		
octopus	0.02561	0.026456	0.028616	0.028076		



YFS Stock Author Review

Fishing Effects on Bering Sea/Aleutian Islands yellowfin sole

For yellowfin sole, the stock is well-above its MSST based on the results of the 2016 Bering Sea/Aleutian Islands (BSAI) yellowfin sole stock assessment, where female spawning biomass is estimated to be 1.8 times above the B_{MSY} level (Wilderbuer *et al*. 2016). Therefore, **BSAI yellowfin sole are above its MSST.**

Estimating whether the amount of disturbed habitat in the Core Essential Area (CEA) is 10% or greater is determined from the GAM model fit to survey and fishery CPUE data (Figure 1) overlaid with the results from the Fishing Effects model and summing impacts (percent reduction in habitat) within the yellowfin sole core EFH area (Figure 2). The majority of the habitat reduction occurs in the northern part of 513 and also in two locations in 514. Overall the fishing impacts on the eastern Bering Sea shelf appear to be very low with the average percent habitat reduction over the 2003-2016 time horizon estimated at 2.9%. **The Fishing Effects Model indicates a slowly declining trend in fishing impacts with the highest values (3.7%) estimated at the beginning of the time-series (2003-2005) and lowest in 2013 at 2.2% habitat reduction (Figure 3). Thus the level of benthic impact for yellowfin sole is well-below the 10% threshold identified as the level of concern**, and the trigger for additional analyses. Given these results, no further analysis (Step 3) was required to examine correlations between habitat reduction and aspects of yellowfin sole biology.

Summary of Stock Author Evaluations - BSAI YFS

To analyze growth-to-maturity, correlation analysis was performed between the estimated annual proportion of habitat disturbed and indices of growth (weight-at-age) annually available from the AFSC bottom trawl survey in the Bering Sea. For recruitment analysis, the log of average annual recruitment estimates were used for years 2003-2011 (since very little information is available on estimates of the 2012-2016 year-classes) and stock assessment model estimates of female spawning biomass were used as a proxy index for breeding success.

The results of the correlation analysis, along with the *p*-values, are shown in Table 1 below. None of the correlations resulted in a *p*-value ≤0.1, and thus are not significant. Thus the impact of the estimated fishing effects on yellowfin sole life-history traits is not a concern.

		Pearson r	p-value
Average weight-at-age	age-3	0.82	4.74
	age-4	0.80	4.44
	age-5	0.68	3.04
	age-6	0.67	3.03
	age-7	0.48	1.81
	age-8	0.13	0.44
	age-9	0.15	0.52
	age-10	-0.04	1.36
Assessment output	Spawning biomass	0.89	6.39
	Total biomass	0.67	3.03
	Recruitment	0.55	1.73

Table 1. Correlation analysis for BSAI yellowfin sole.

2017 FE Review

In April 2017 the SSC and Council concurred with species-specific EFH fishing effects reviews conducted by stock assessment authors that no stocks needed mitigation review, and that the effects of fishing on the EFH of fisheries species managed by the NPFMC are minimal and temporary (NPFMC 2017).

At the conclusion of the 2017 EFH 5-year Review, the SSC provided several recommendations related to the Fishing Effects (FE) model. In response:

- Output from the FE model is included as an indicator (habitat disturbed) in yearly Ecosystem Status Reports
- A sensitivity analysis is now available as a standard FE output
- Core EFH (CEA) maps will be available to the public
- Updated VMS, gear descriptions, and susceptibility/recovery parameters

2022 Work Plan

For the 2022 EFH Review:

- Run the FE model using updated fishing effort data and metrics, and new Core areas from revised SDMs.
- Stock assessment authors will examine trends in life history parameters and the amount of disturbed habitat in the CEA for each species using the 2017 FE assessment methodology to investigate the potential relationships between fishing effects on habitat and stock production.
- Stock Author review in Spring 2022, previous to the June NPFMC meeting.

Questions:

- How did the stock assessment author Fishing Effects assessment process work for you in 2016/2017?
- Is there more information we could provide to you in this upcoming Fishing Effects review?

THANK YOU

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