Methods and criteria to evaluate the effects of fishing on Essential Fish Habitat

Proposal from the SSC subcommittee

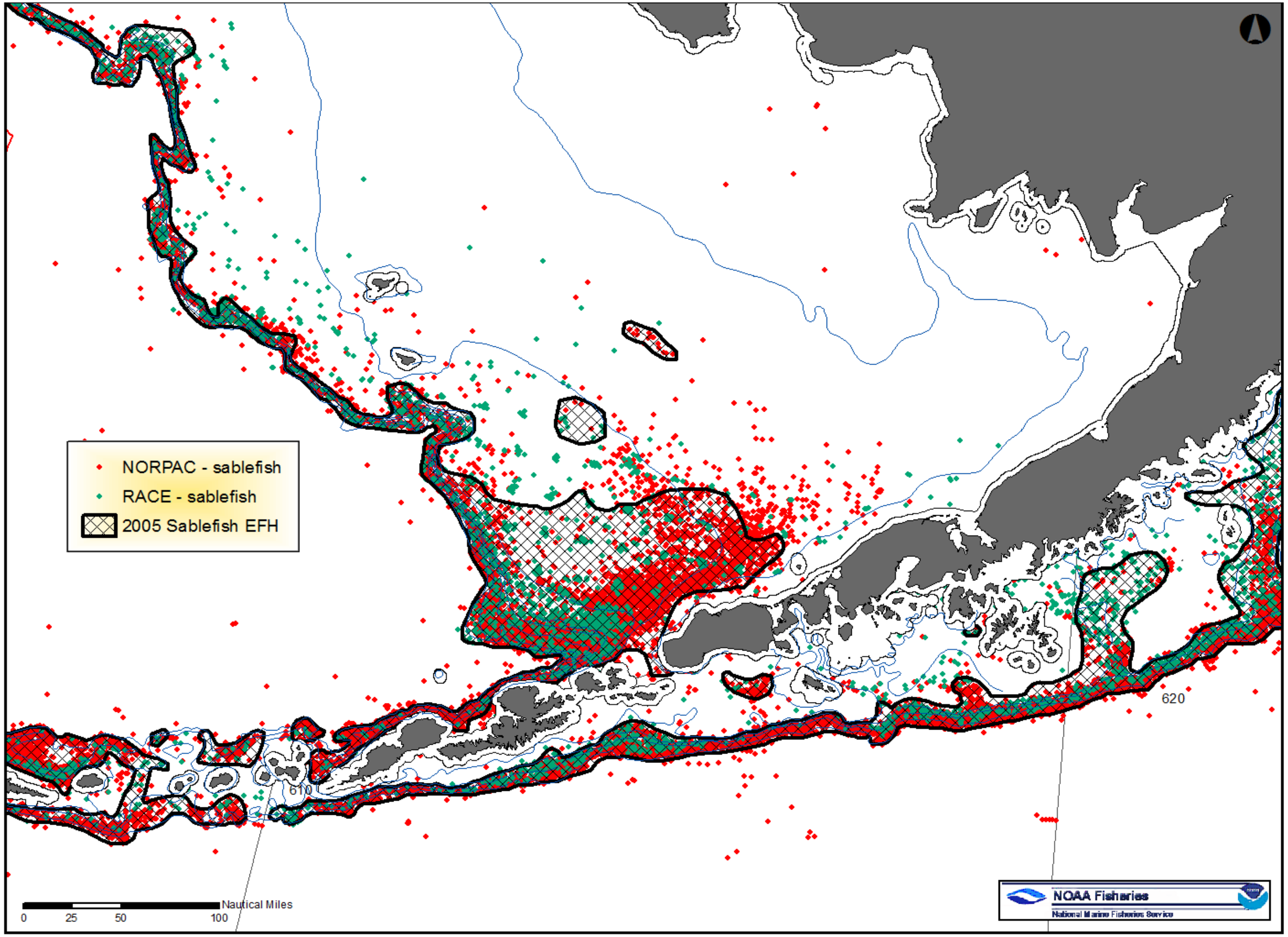
Liz Chilton, Bob Foy, Brandee Gerke, Anne Hallowed, Brad Harris, Dan Ito, Sandra Lowe, John Olson, Steve MacLean

With input and help from many others

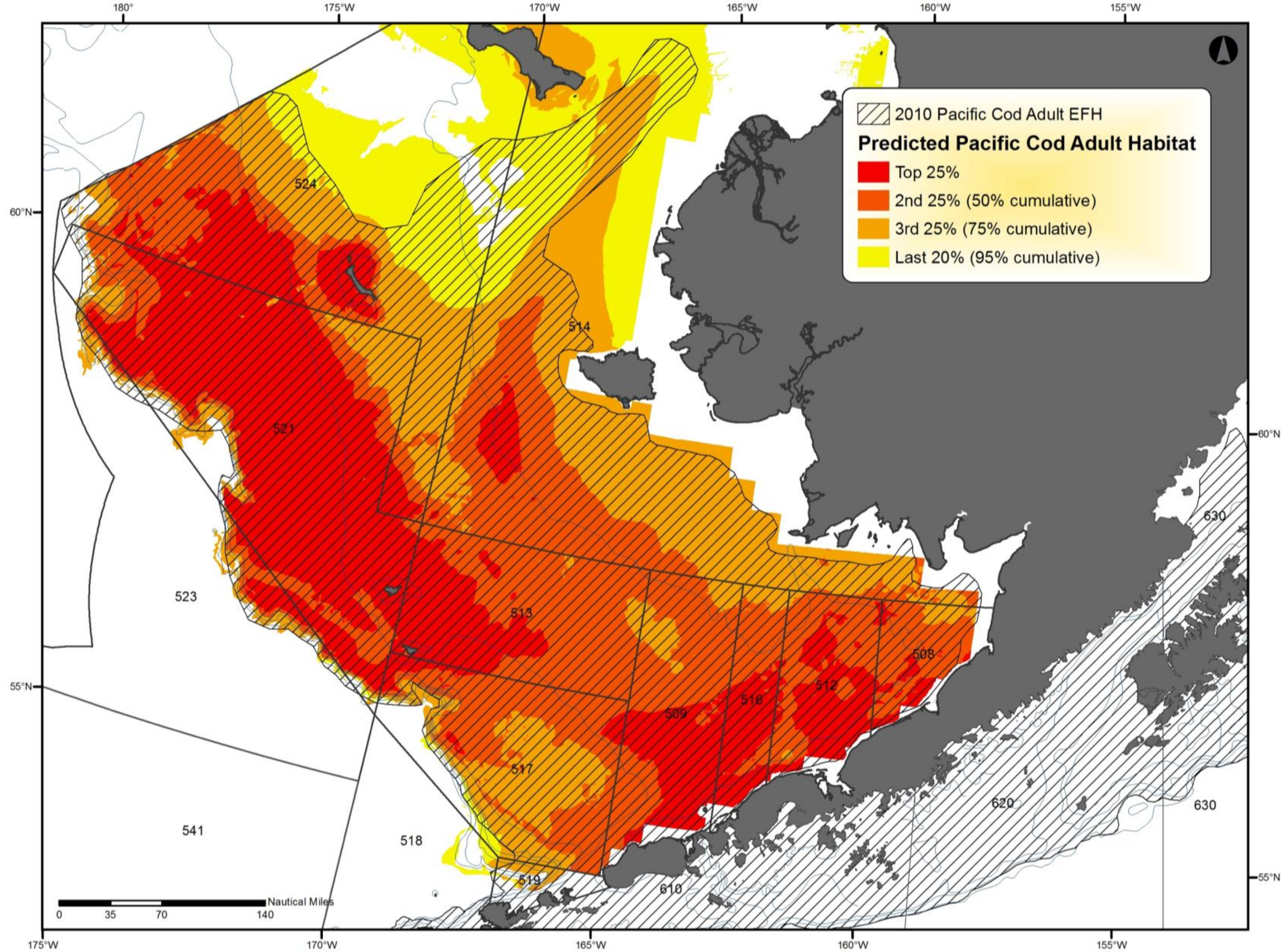
Background

- MSA requires Councils to minimize adverse effects of fishing on EFH
- Council identified new definitions of EFH in October
- Model-based definitions of EFH developed at AFSC
  - BSAI and GOA Groundfish, BSAI Crab
  - GAM
  - Hurdle GAM
  - MaxEnt
- New fishing effects (FE) model for Alaska fisheries utilizing VMS data
- SSC requested new criteria and methods to evaluate effects of fishing

Sablefish EFH, 2005/2010



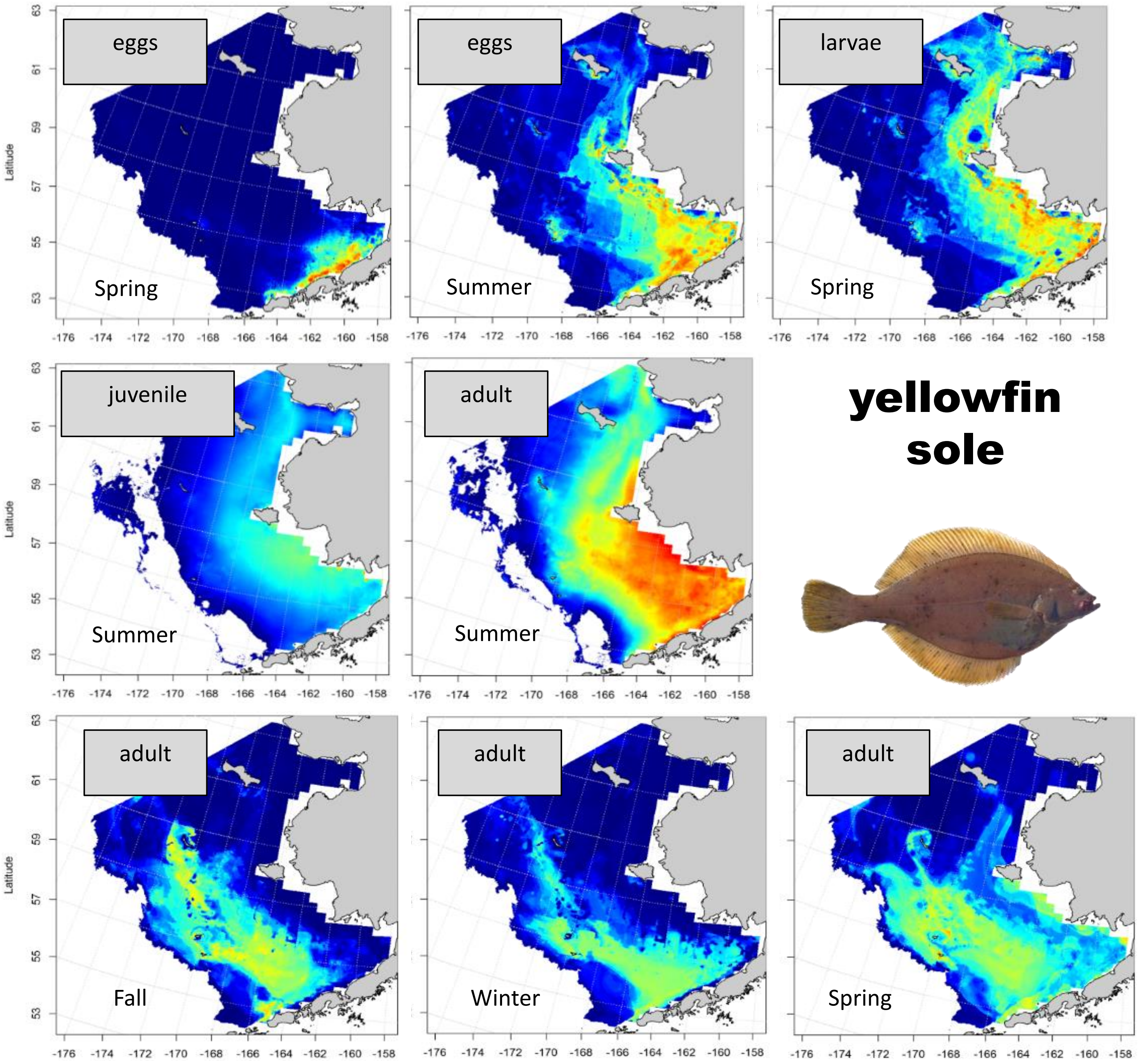
Modeled EFH Description for Pacific Cod

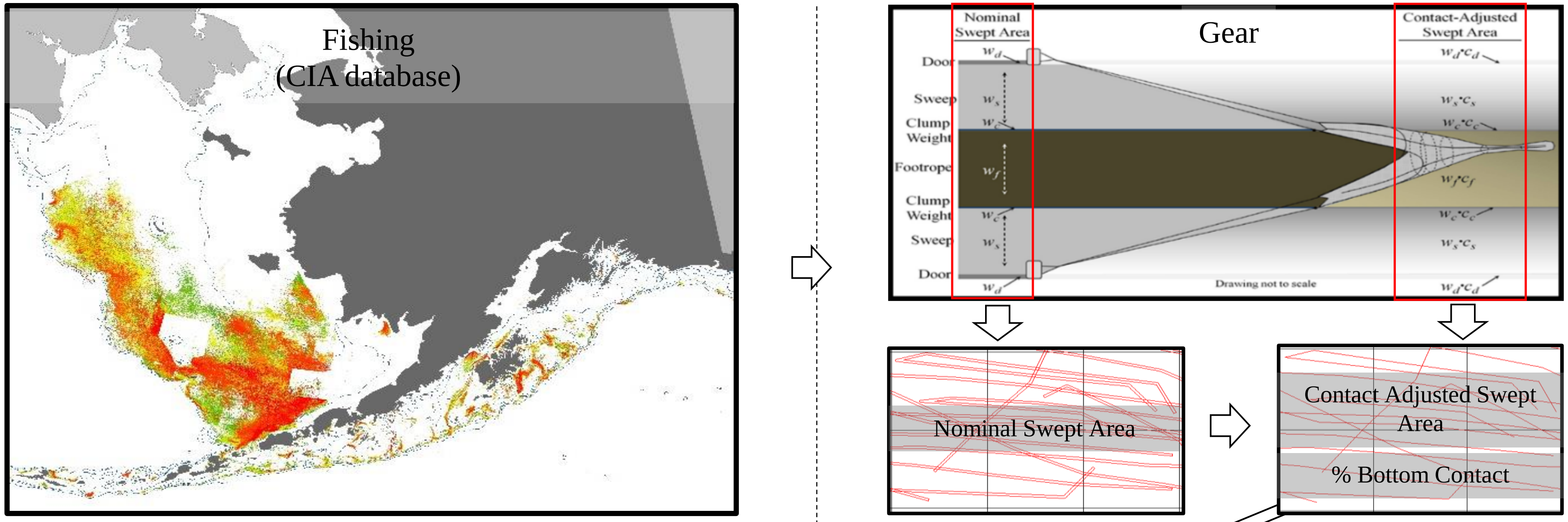


ichthyoplankton survey
MaxEnt - presence only
(probability)

bottom trawl survey
GAM-abundance

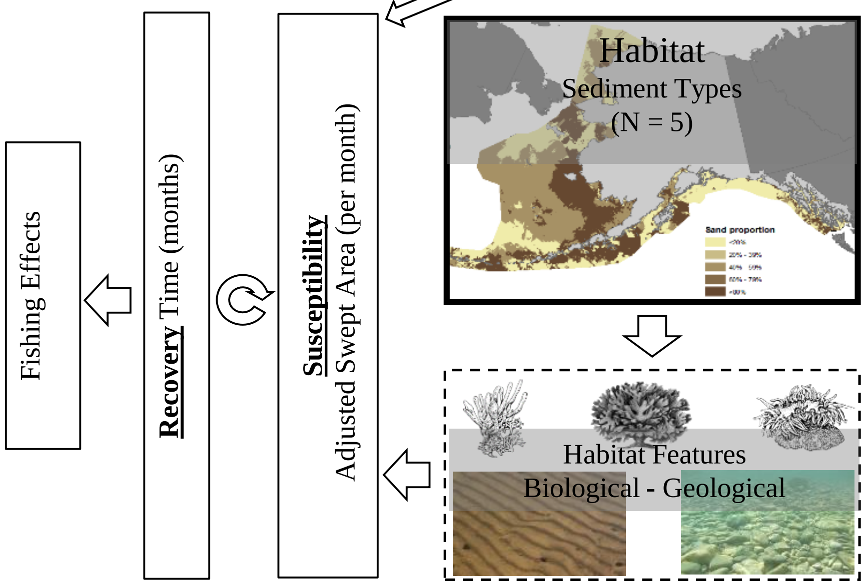
observer catch
MaxEnt-presence only
(probability)



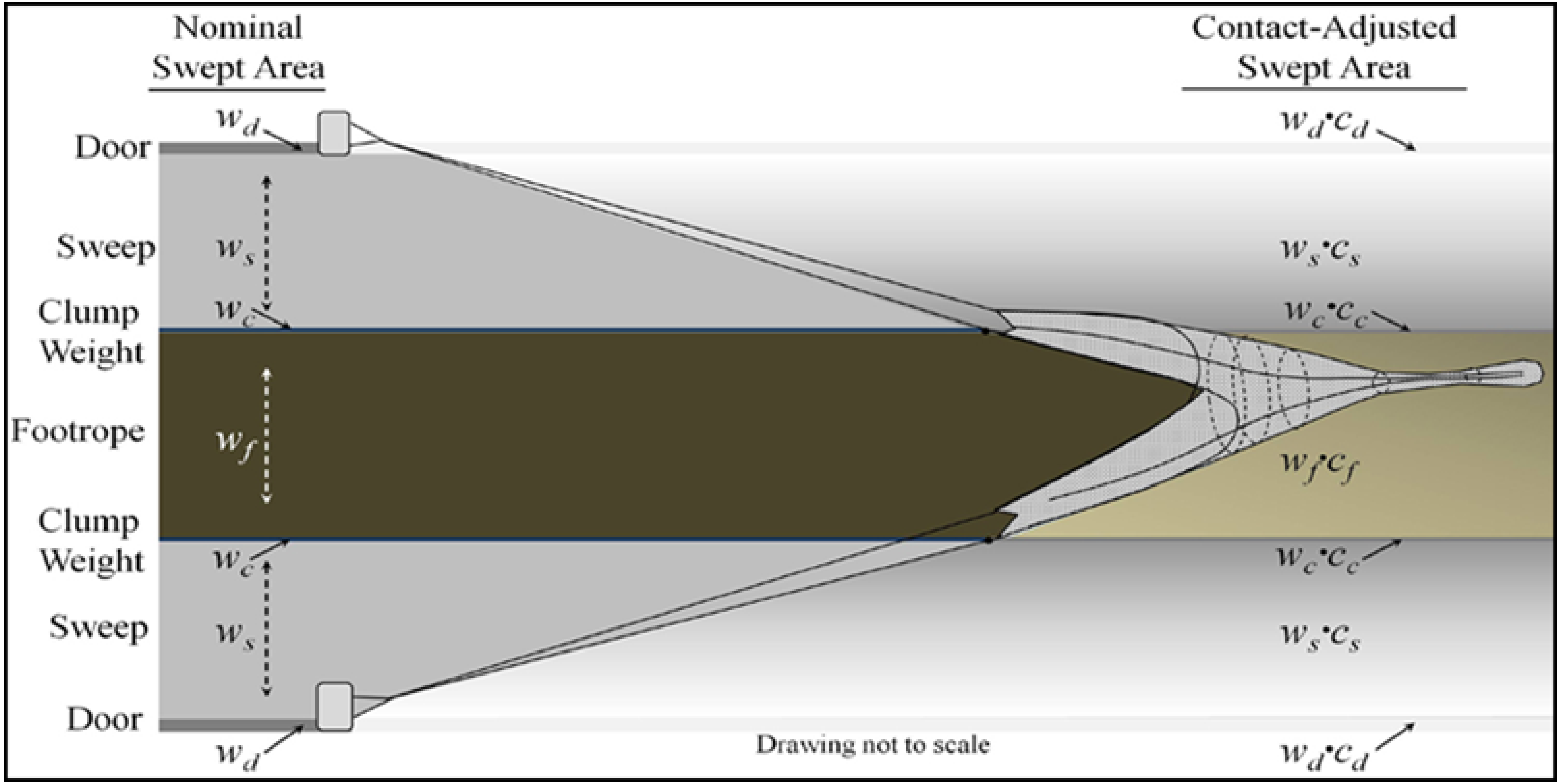


$$H_{t+1} = H_t(1 - I'_t) + h_t\rho'_t$$

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

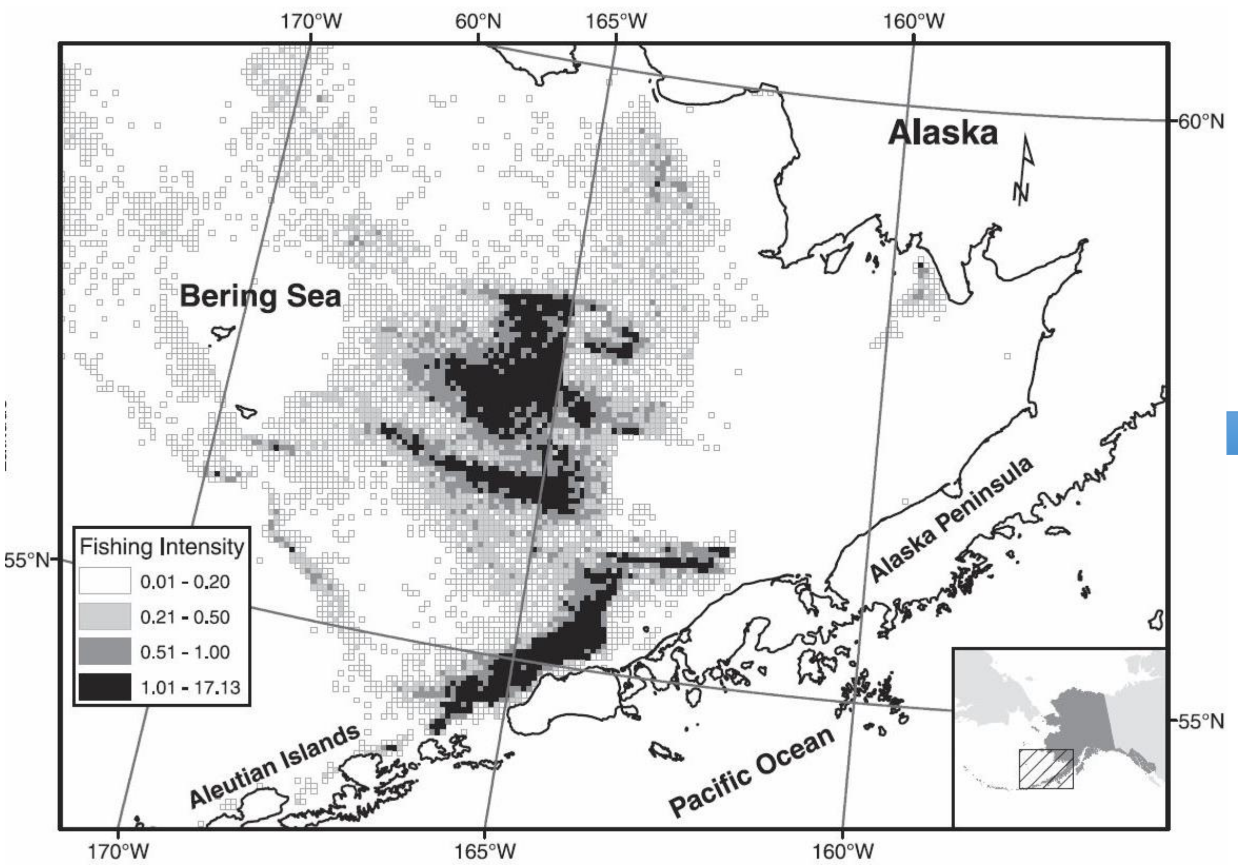


Nominal Area Swept

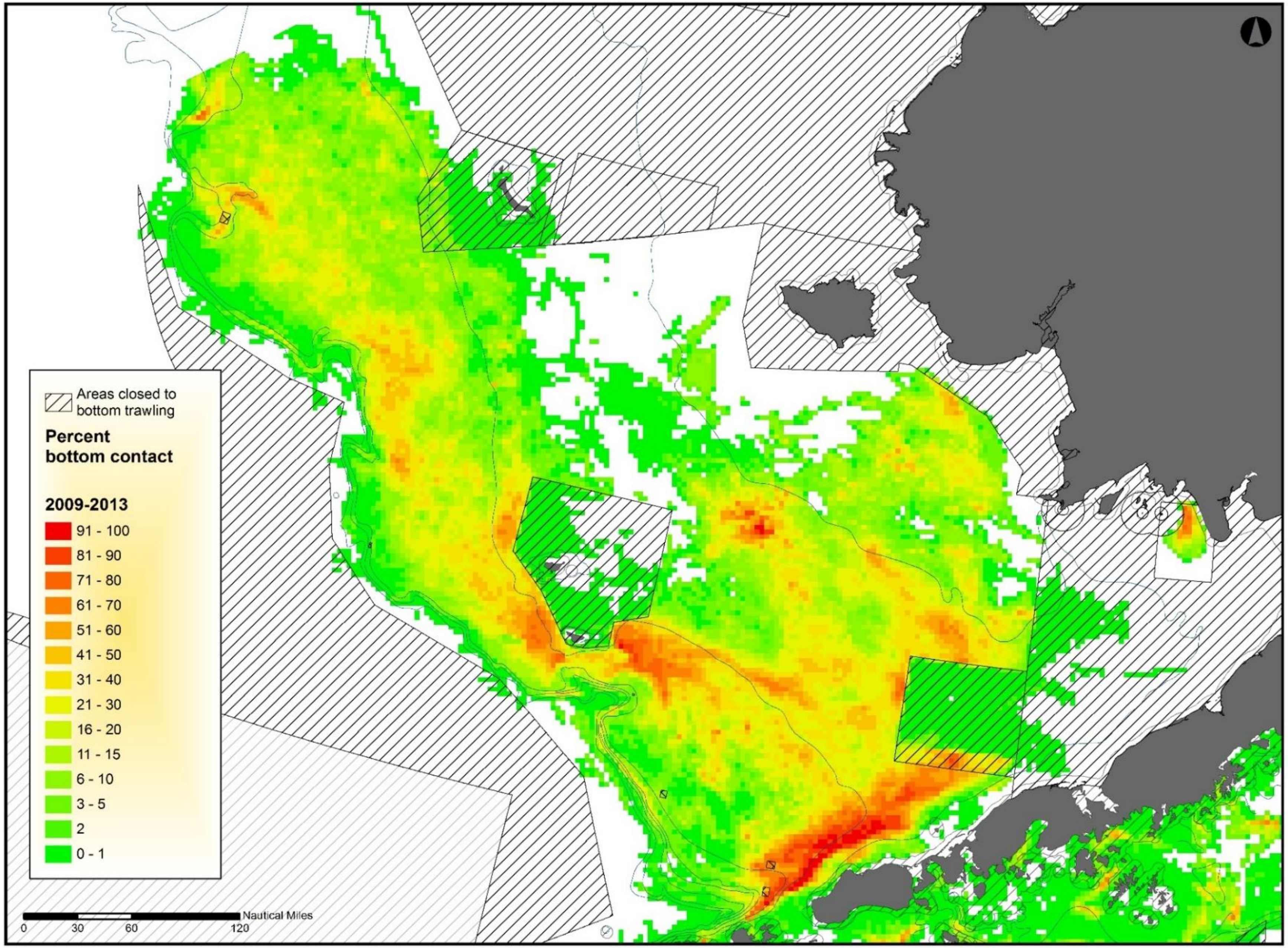


Impact = (Nominal area swept) x **(**Contact adjustment) x (Susceptibility)

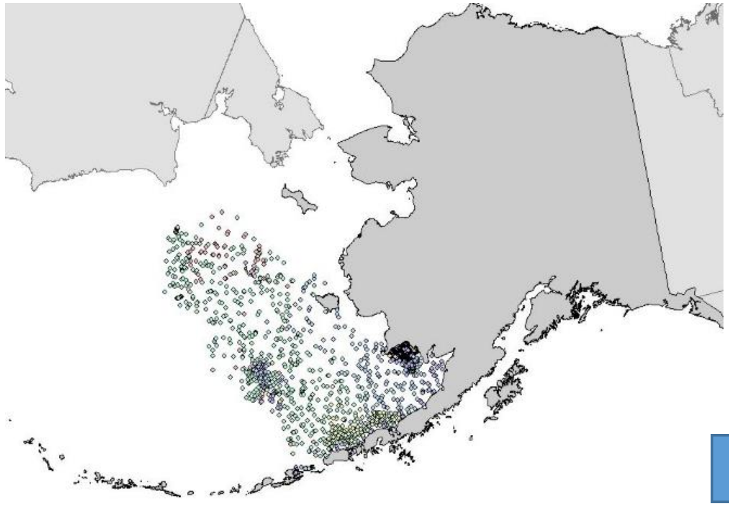
Increasing spatial resolution

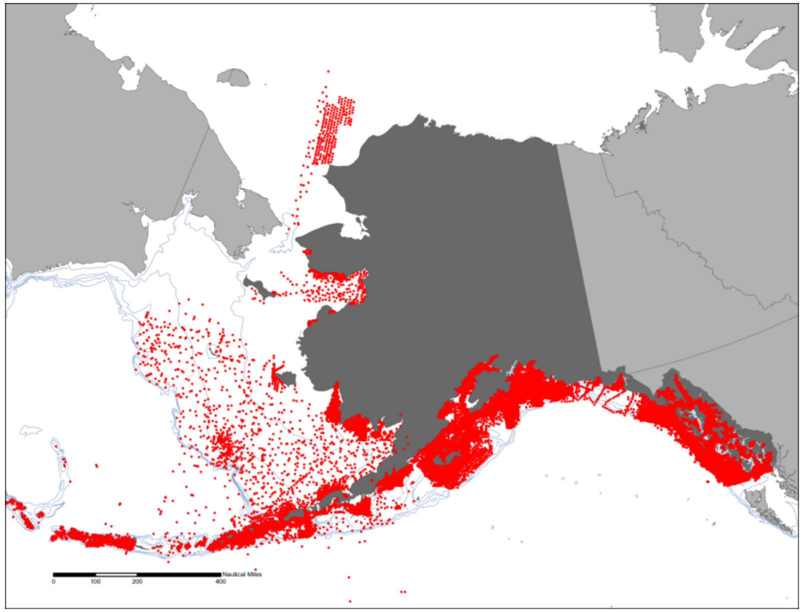


Bottom Contact



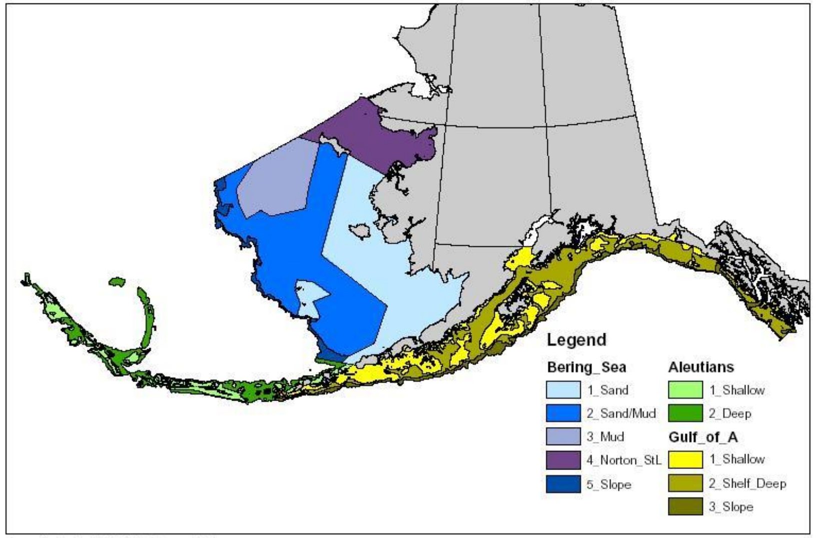
Habitat (sediment type)



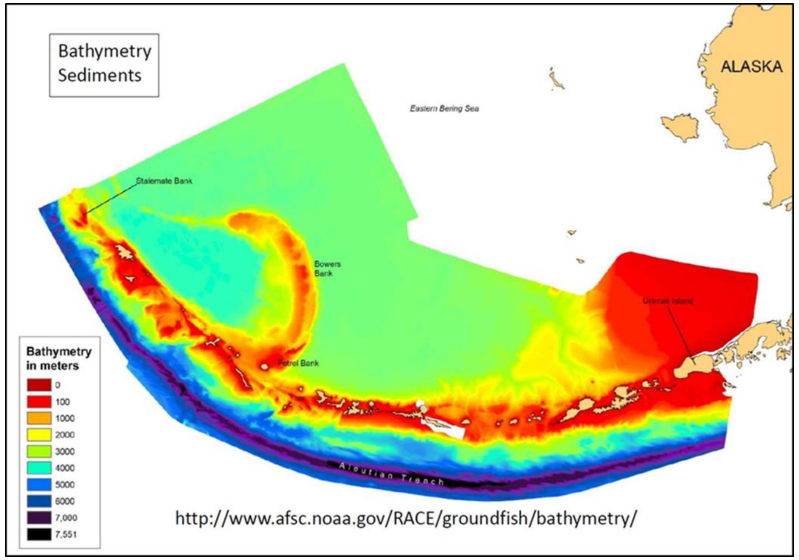


250,000+ points with 6,000+ sediment Descriptions coded into 5 sediment classes: Mud, Sand, Granule/Pebble, Cobble, Boulder

Figure B.2-1 Habitats Used for Evaluation of Fishing Activities



Appendix B - Draft EFH EIS - January 2004



Classification of Habitat Features

Infauna Prey - clams, polychaetes

Epifauna Prey - brittle stars, amphipods

Non-living Structure - sand waves, rocks

Living Structure - Anemones, sponges, coral

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

LITERATURE REVIEW DATABASE V 3.0

☑ Final review?

STUDY DESCRIPTION

Number: 239
Cite: McConnaughey et al 2005
Related studies: 238

Study Characteristics

Study design 1
Study relevance 2
Study appropriateness 1

Methods/general comments:
Analyzed mean size (wt) of 16 invert taxa in 42 paired trawl samples from inside and outside closed area

Depth (m): 0-50m

Minimum: 44
Maximum: 52

Energy 3

Energy notes:
Site in similar location as compared to studies 34, 35; author describes site as 'high tidal currents', Flow >1m/s

Location

Multisite? ☐

Bristol Bay, Eastern Bering Sea, AK, USA

Substrate

Clay-silt ☐
Muddy sand ☐
Sand ☑
Granule-pebble ☐
Cobble ☐
Boulder ☐
Rock outcrop ☐

Substrate notes:
Same study area as #238

Gear Types

Multigear? ☐

Generic otter trawl ☑
Shrimp trawl ☐
Squid trawl ☐
Raised footrope trawl ☐
New Bedford scallop dredge ☐
S. clam/O. quahog dredge ☐
Lobster trap ☐
Deep-sea red crab trap ☐
Longline ☐
Gillnet ☐

Gear notes:

Look up by study #
Reviewer: Harris/Stevenson

FEATURES EVALUATED AND IMPACTS

☐ **Geological** ☑ Biological ☐ Prey ☐ Recovery? ☐ Deep-sea corals?

Geological features

☐ Featureless
☐ Bedforms
☐ Biogenic depression:
☐ Biogenic burrows
☐ **Special case biogenic burrows**
☐ **Gravel**
☐ Gravel pavement
☐ Gravel piles
☐ Shell deposits
☐ Geochemical

Impacts:
bedforms mentioned but not evaluated

Biological features

☐ Emergent sponge
☐ Hydroids
☑ Emergent anemones
☐ Burrowing anemones
☐ Soft corals
☐ Sea pens
☐ Hard corals
☐ Colonial tube worms
☑ Epifaunal bivalves
☐ Emergent bryozoans
☑ Tunicates
☐ Leafy macroalgae
☐ *Sea grass*
☐ *Brachiopods*

Species:
Asterias, Crangon, Evasterias, Hyas, Neptunea, Oregonia, Paguridae, Pagurus, paralithodes, Actiniaria, Aplidium,

Impacts:
On average, 15 of 16 taxa smaller inside closed area but individually, only a whelk and anemones were signif smaller

Prey features

☐ **Amphipods**
☐ **Isopods**
☑ **Decapod shrimp**
☐ **Mysids**
☑ **Decapod crabs**
☑ **Polychaetes**
☑ **Infaunal bivalves**
☐ **Brittle stars**
☐ **Sea urchins**
☐ **Sand dollars**
☑ **Sea stars**

Species:

Impacts:
All organisms collcted in bottom trawl, so none of them are strictly infauna

Record: 53 of 105 No Filter Search

Alaska-specific references (14) currently included in Literature Review database

Stone, R. P. (2006). "Coral habitat in the Aleutian Islands of Alaska: depth distribution, finescale species association, and fisheries interactions." Coral Reefs **25**(2): 229-238. **(Ref#353)** *internal-pdf://353_Stone_2006-0230588673/353_Stone_2006.pdf*

Stone, R. P., M. M. Masuda and P. W. Malecha (2005). Effects of Bottom Trawling on Soft-Sediment Epibenthic Communities in the Gulf of Alaska. Benthic Habitats and the Effects of Fishing: American Fisheries Society Symposium 41. P. W. Barnes and J. P. Thomas. Bethesda, MD, American Fisheries Society**:** 461-475. **(Ref#355)** *internal-pdf://355_Stone_etal_2005-2919427585/355_Stone_etal_2005.pdf*

McConnaughey, R. A., K. L. Mier and C. B. Dew (2000). "An examination of chronic trawling effects on soft-bottom benthos of the eastern Bering Sea." ICES J. Mar. Sci. **57**(5): 1377-1388. **(Ref#238)** *internal-pdf://238_McConnaughey_etal_2000-1124486146/238_McConnaughey_etal_2000.pdf*

McConnaughey, R. A. and K. R. Smith (2000). "Associations between flatfish abundance and surficial sediments in the eastern Bering Sea." Canadian Journal of Fisheries and Aquatic Sciences **57**(12): 2410-2419. **(Ref#237)** *internal-pdf://237_McConnaughey_Smith_2000-1752844801/237_McConnaughey_Smith_2000.pdf*

McConnaughey, R. A., S. E. Syrjala and C. B. Dew (2005). Effects of Chronic Bottom Trawling on the Size Structure of Soft-Bottom Benthic Invertebrates. Benthic Habitats and the Effects of Fishing: American Fisheries Society Symposium 41. P. W. Barnes and J. P. Thomas. Bethesda, MD, American Fisheries Society**:** 425-437. **(Ref#239)** *internal-pdf://239_McConnaughey_etal_2005-0637692673/239_McConnaughey_etal_2005.pdf*

Stoner, A. W., C. L. Ryer and R. A. McConnaughey (2005). Ecological Consequences of Lost Habitat Structure for Commercially Significant Flatfishes: Habitat Choice and Vulnerability to Predators. **(Ref#357)**

Freese, J. L. (2001). "Trawl-induced Damage to Sponges Observed From a Research Submersible." Mar. Fish. Rev. **63**(3): 7-13. **(Ref#110)** *internal-pdf://110_Freese_2001-4192454913/110_Freese_2001.pdf*

Freese, L., P. J. Auster, J. Heifetz, et al. (1999). "Effects of trawling on seafloor habitat and associated invertebrate taxa in the Gulf of Alaska." Mar. Ecol. Prog. Ser.: Vol. 182, p. **(Ref#111)** *internal-pdf://111_Freese_etal_1999-3201981697/111_Freese_etal_1999.pdf*

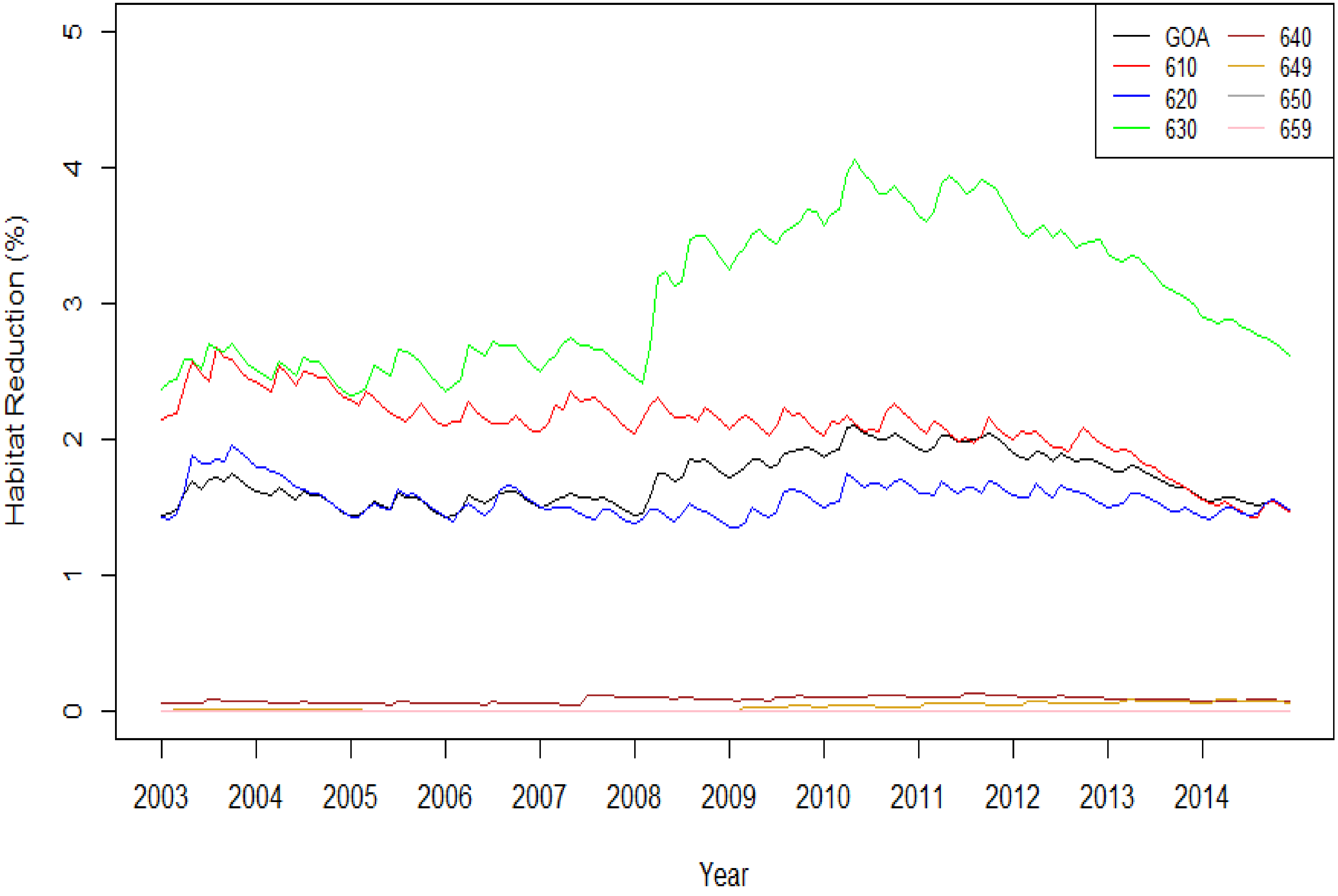
Fujioka, J. T. (2006). "A model for evaluating fishing impacts on habitat and comparing fishing closure strategies." Canadian journal of fisheries and aquatic sciences/Journal canadien des sciences halieutiques et aquatiques **63**(10): 2330-2342. **(Ref#114)** *internal-pdf://114_Fujioka_2005-0805663745/114_Fujioka_2005.pdf*

Brooke, S. and R. Stone (2007). "Reproduction of deep-water Hydrocorals (family Stylasteridae) from the Aleutian Islands, Alaska." Bulletin of Marine Science **81**(3): 519-532. **(Ref#539)** *internal-pdf://539_Brooke_Stone_2007-0685702912/539_Brooke_Stone_2007.pdf*

Habitat Reduction, all gears

Example output

	GOA	REP610	REP620	REP630	REP640	REP649	REP650	REP659
Jan-03	1.43%	2.14%	1.43%	2.36%	0.06%	0.01%	0.00%	0.00%
Feb-03	1.45%	2.17%	1.41%	2.43%	0.06%	0.01%	0.00%	0.00%
Mar-03	1.48%	2.19%	1.46%	2.45%	0.06%	0.01%	0.00%	0.00%
Apr-03	1.60%	2.40%	1.64%	2.59%	0.06%	0.01%	0.00%	0.00%
May-03	1.68%	2.57%	1.88%	2.59%	0.06%	0.01%	0.00%	0.00%
Jun-03	1.64%	2.49%	1.83%	2.52%	0.05%	0.01%	0.00%	0.00%
Jul-03	1.70%	2.43%	1.83%	2.70%	0.08%	0.01%	0.00%	0.00%
Aug-03	1.71%	2.68%	1.85%	2.66%	0.08%	0.01%	0.00%	0.00%
Sep-03	1.70%	2.61%	1.83%	2.64%	0.08%	0.01%	0.00%	0.00%
Oct-03	1.75%	2.58%	1.96%	2.70%	0.08%	0.01%	0.00%	0.00%
Nov-03	1.70%	2.51%	1.91%	2.62%	0.07%	0.01%	0.00%	0.00%
Dec-03	1.65%	2.43%	1.85%	2.55%	0.07%	0.01%	0.00%	0.00%
Jan-04	1.62%	2.43%	1.80%	2.51%	0.07%	0.01%	0.00%	0.00%
Feb-04	1.60%	2.39%	1.79%	2.47%	0.07%	0.01%	0.00%	0.00%
Mar-04	1.58%	2.35%	1.77%	2.44%	0.07%	0.01%	0.00%	0.00%
Apr-04	1.64%	2.54%	1.75%	2.57%	0.06%	0.01%	0.00%	0.00%
May-04	1.61%	2.48%	1.71%	2.53%	0.06%	0.01%	0.00%	0.00%
Jun-04	1.56%	2.40%	1.65%	2.47%	0.06%	0.01%	0.00%	0.00%
Jul-04	1.61%	2.50%	1.63%	2.61%	0.07%	0.01%	0.00%	0.00%
Aug-04	1.59%	2.49%	1.60%	2.57%	0.07%	0.01%	0.00%	0.00%
Sep-04	1.59%	2.45%	1.60%	2.57%	0.06%	0.01%	0.00%	0.00%



Habitat Reduction (%)
0
1
2
3
4
5
GOA
610
620
630
640
649
650
659
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
Year

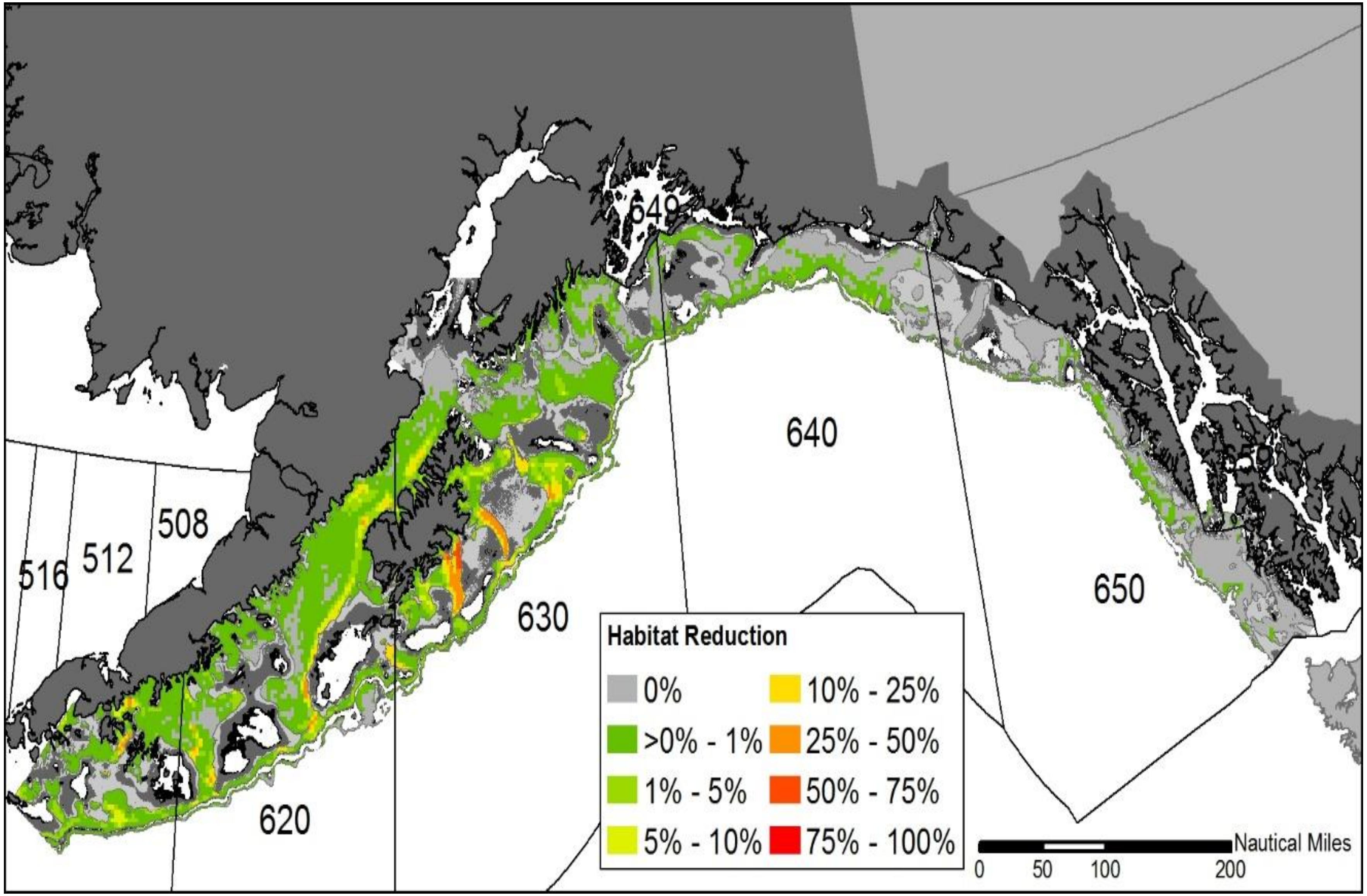
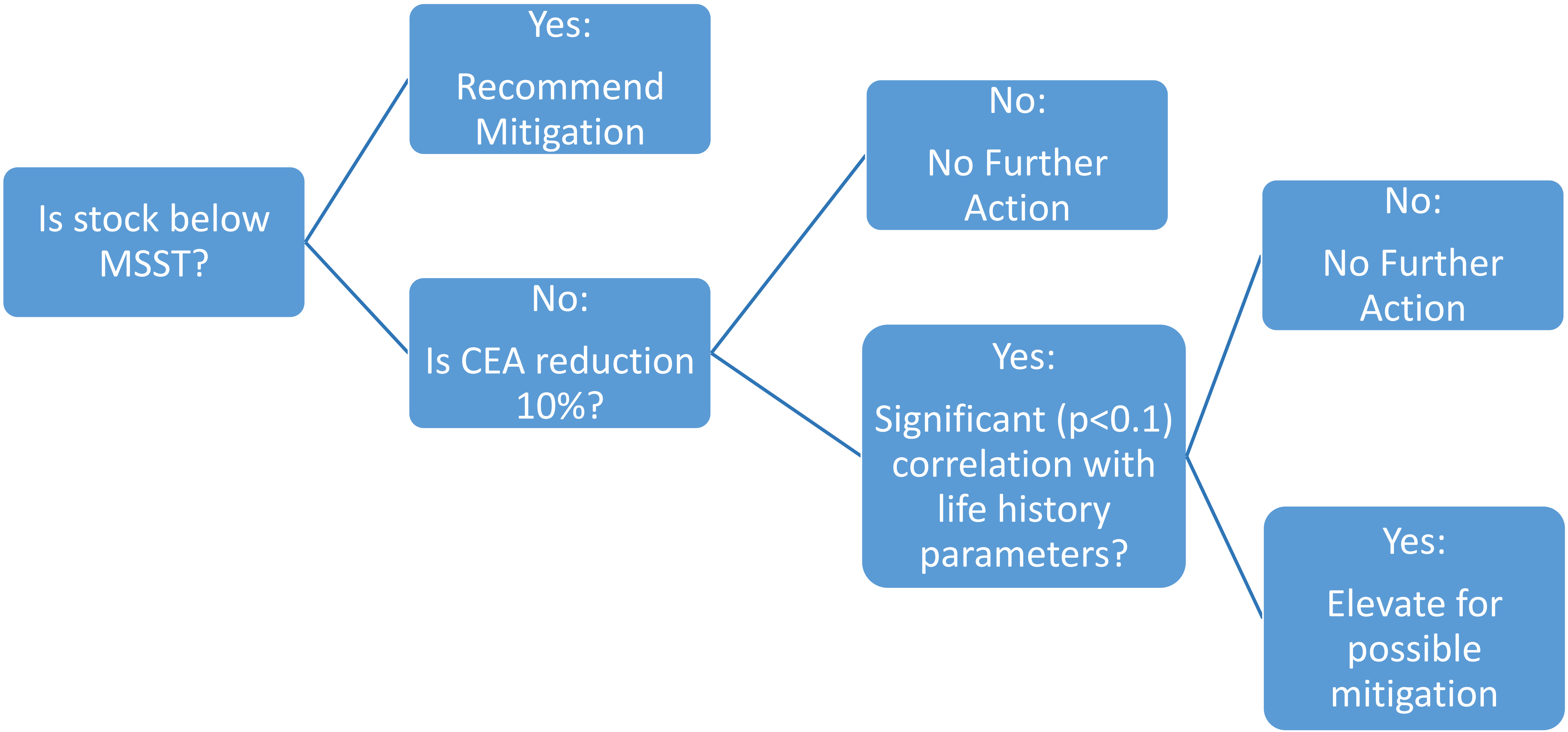


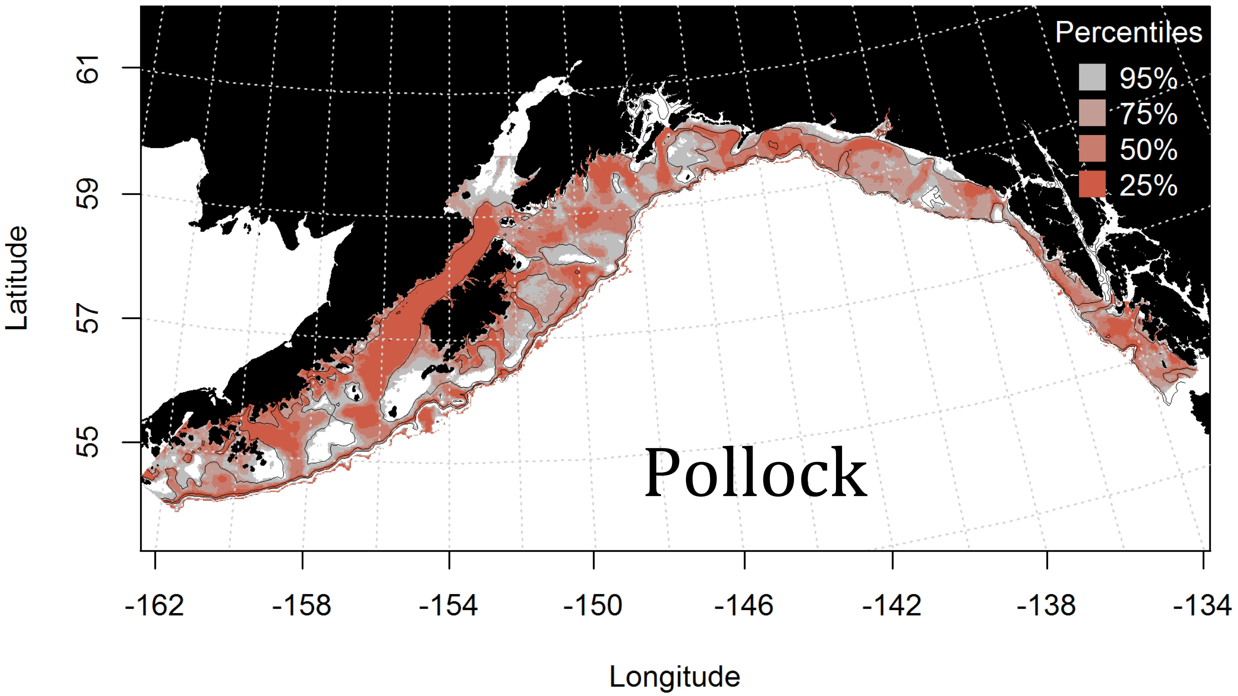
Figure 4. Habitat reduction for December 2014 in GOA pollock summer core EFH area.


Is stock below MSST?
Yes:
Recommend Mitigation
No:
Is CEA reduction 10%?
No:
No Further Action
Yes:
Significant (p<0.1) correlation with life history parameters?
No:
No Further Action
Yes:
Elevate for possible mitigation

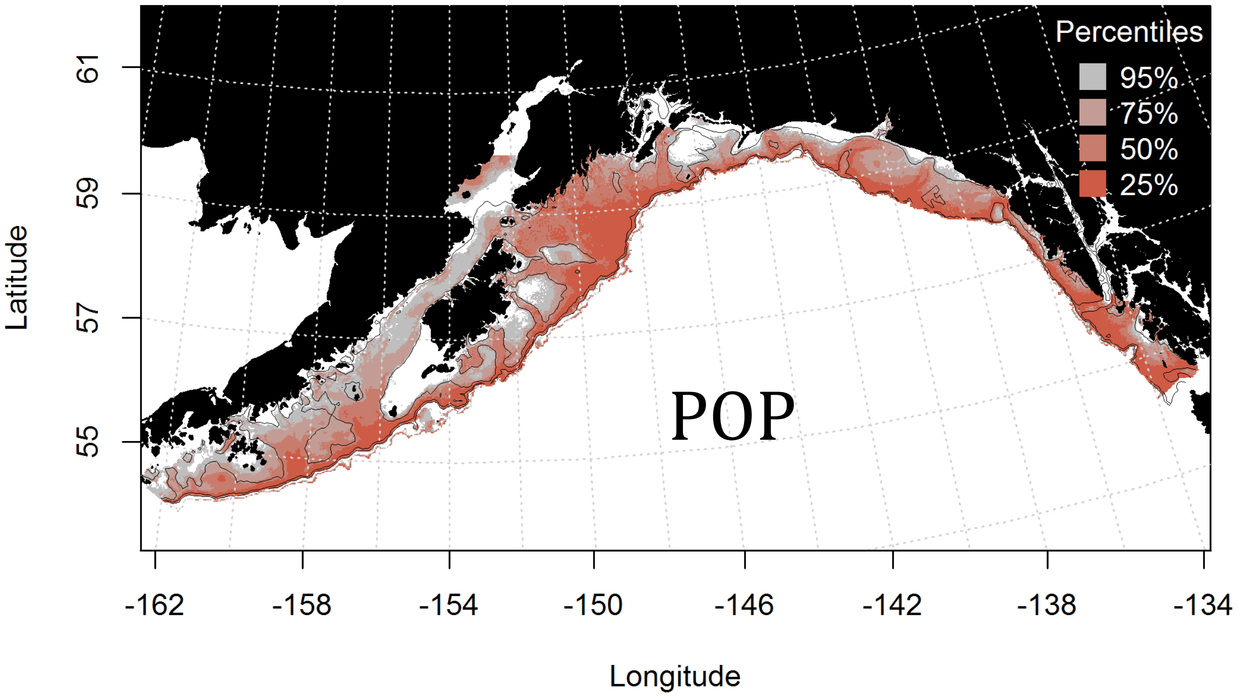
How does this work?

Trial by two lucky stock assessment authors

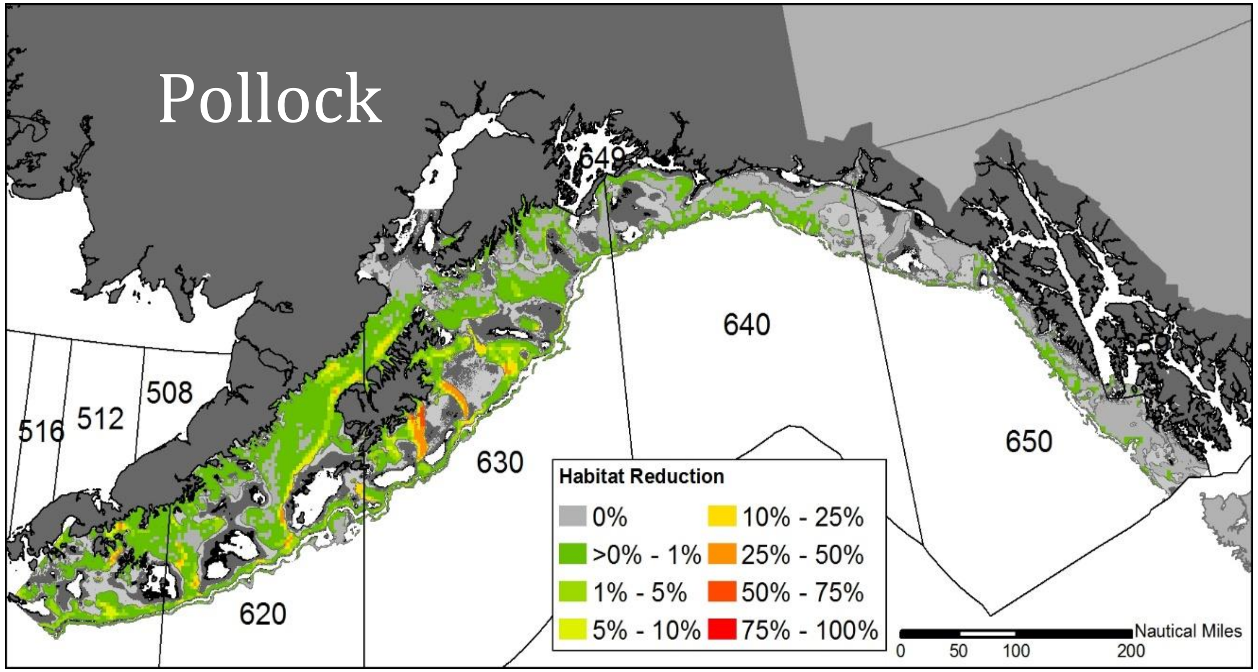
Percentiles of abundance



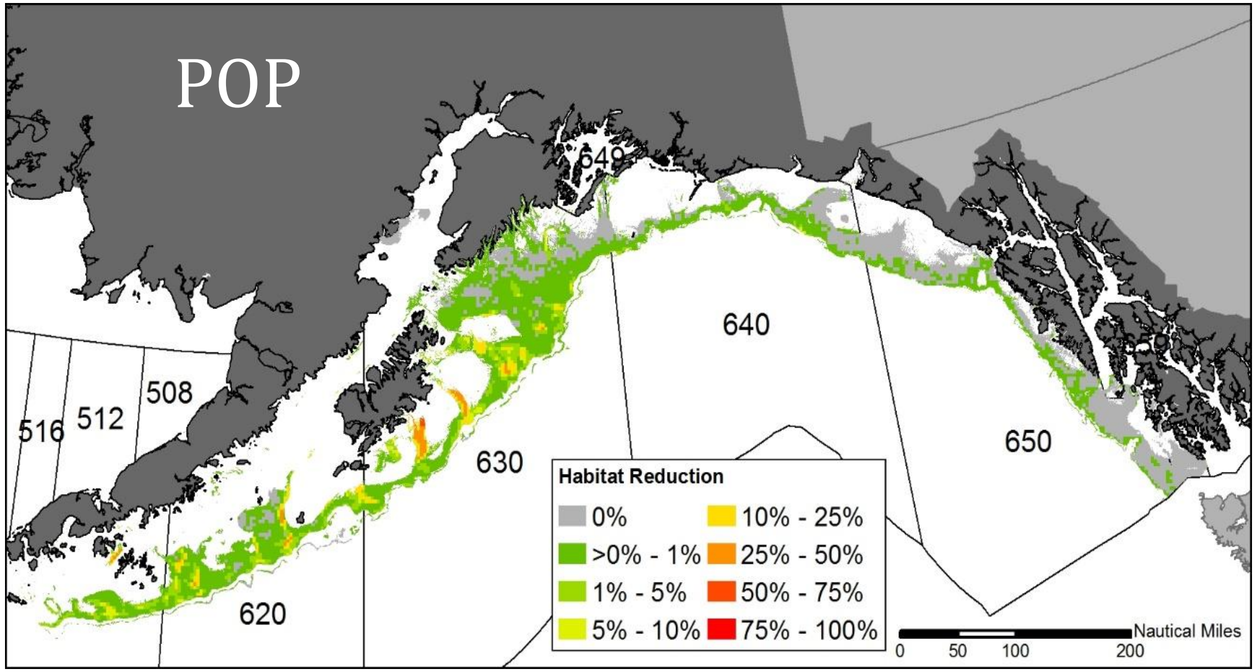
Core EFH area defined as 50% cumulative distribution



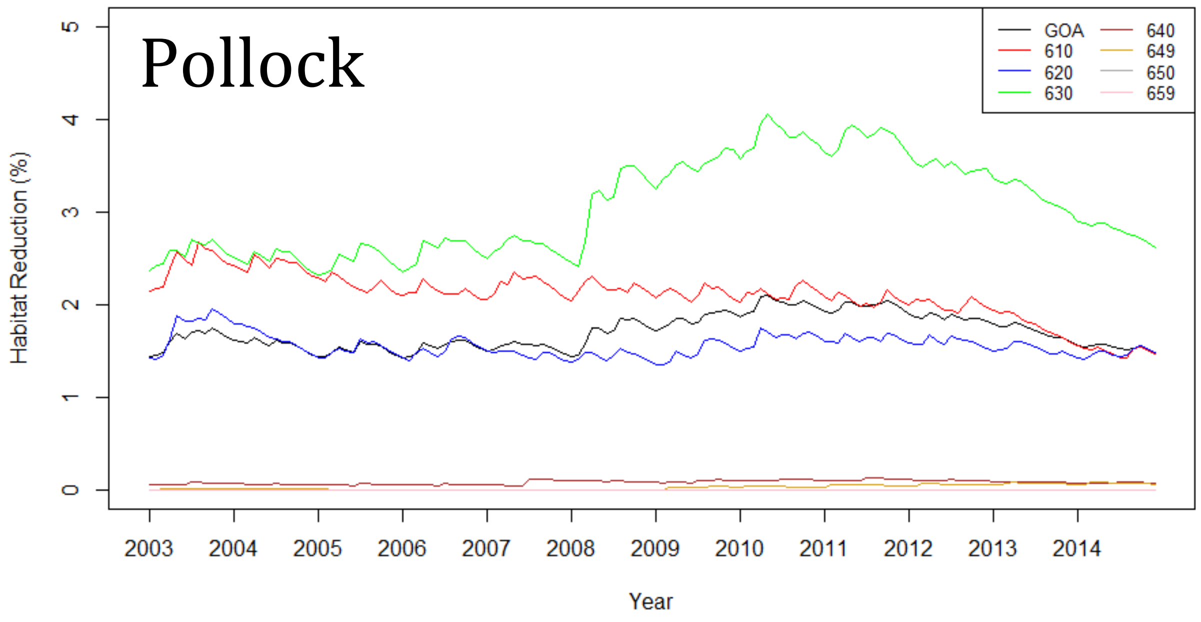
Proportion of habitat reduction



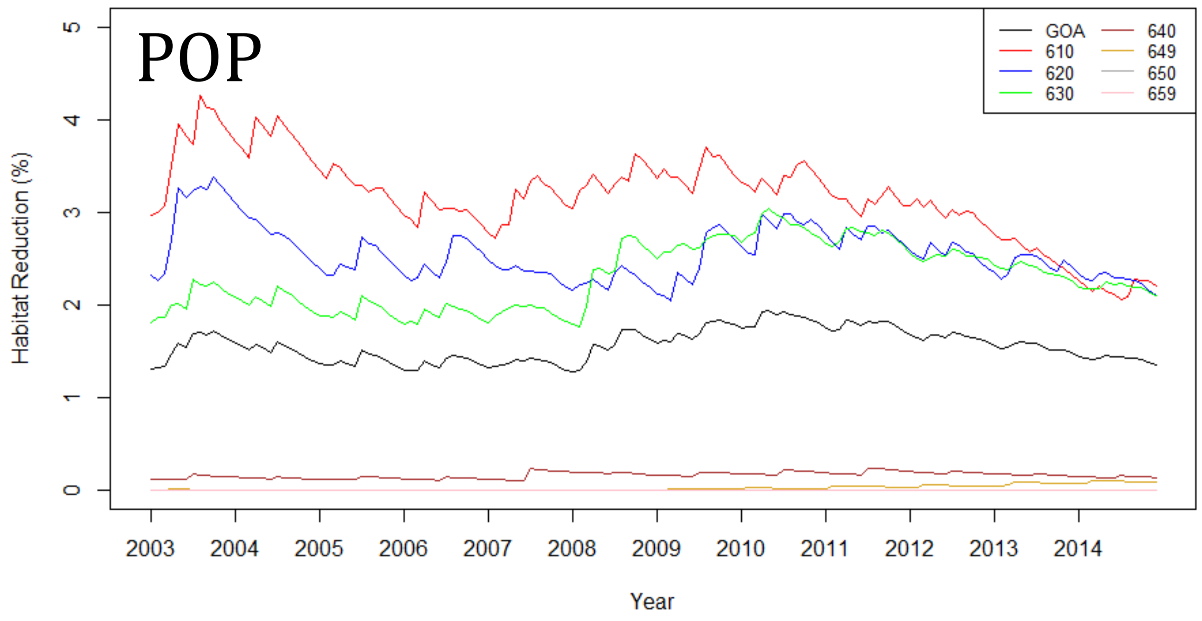
Example map for December 2014



Monthly proportion of habitat reduction (2003-2014)



No area exceeds 5% habitat reduction



Correlations:

- Proportion of habitat disturbed: Annual values calc'd as average across months (Jan-Dec)
  - pollock: 610-630 (W/CGOA)
  - POP: GOA wide

- Stock indices:
  - Growth-to-maturity: time trends in growth/maturity
  - Spawning success: recruitment
  - Breeding success: spawning distributions
  - Feeding success: feeding distributions

Correlations: pollock

- Growth-to-maturity
  - Growth: weight-at-age anomalies from Shelikof straight acoustic survey, lagged 1 year (habitat impact year prior influences weight the beginning of following year observed in survey)
    - p= 0.12,
  - Maturity: length at age at 50% maturity from Shelikof acoustic survey, lagged 1 year
    - p = 0.61

- Spawning success: log-recruitment, lagged 1 year
  - p = 0.99

Correlations: POP

- Growth-to-maturity
  - Growth: mean size-at-age from AFSC bottom trawl survey for most frequent ages (3-15), annual estimates of LVB parameters from bottom trawl survey
  - Maturity: only 2 years of data…

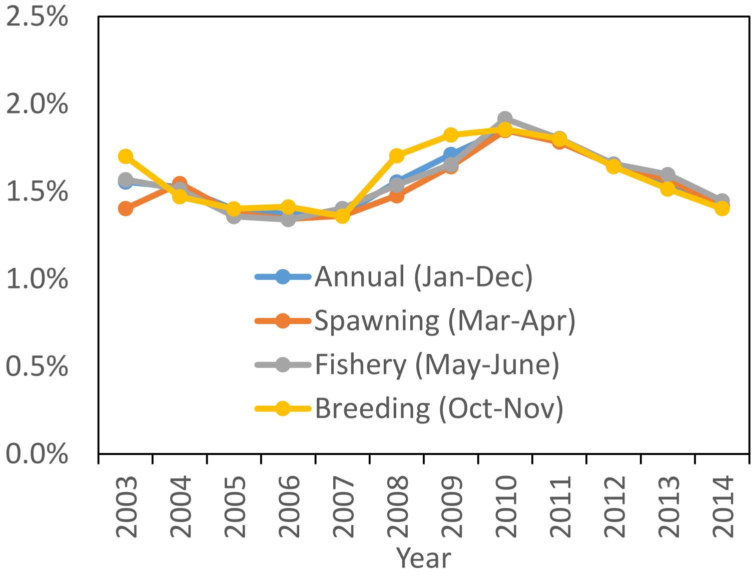
- Spawning success: recruitment, not lagged

- Breeding success/spawning distribution: assume spawning biomass proportional to distribution

- Feeding success/feeding distribution: assume total biomass proportional to distribution

Correlations: POP

- No p-values < 0.1



		ρ	p-value
Average size-at-age	age-3	-0.49	0.33
	age-4	-0.25	0.63
	age-5	-0.56	0.24
	age-6	-0.58	0.23
	age-7	-0.20	0.71
	age-8	-0.71	0.11
	age-9	-0.25	0.63
	age-10	-0.60	0.21
	age-11	0.02	0.97
	age-12	-0.40	0.43
	age-13	-0.38	0.46
	age-14	0.42	0.41
	age-15	-0.14	0.79
LVB params	L_∞	0.56	0.33
	κ	-0.64	0.24
	t_0	-0.64	0.24
SAFE output	Spawning biomass	0.43	0.17
	Total biomass	0.37	0.24
	Recruitment	0.33	0.30

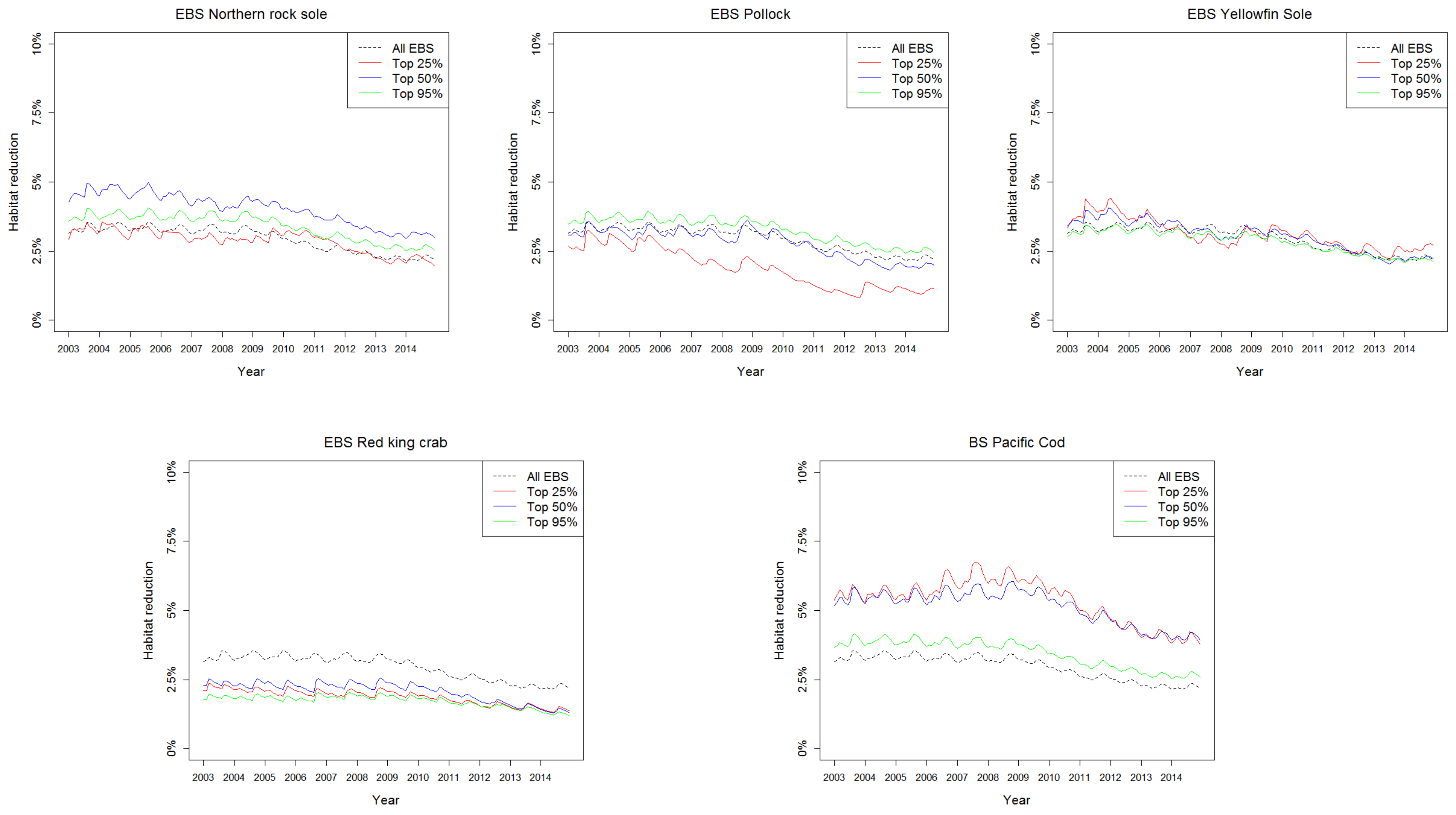
Correlations: overall

"The purpose of this criterion is not to determine whether any correlation is statistically significant, but rather to provide an objective threshold to ensure that a "hard look" has been taken for each species, as appropriate. Because multiple parameters will be examined for correlation to habitat reduction, it is possible that spurious significant ($p > 0.1$) correlations will be found. Whenever significant correlations are found, the expert judgement and opinion of the stock assessment authors will be important to determine whether there is a plausible connection to reductions in EFH as the cause, or if the result is spurious. If stock assessment authors determine that the correlation between the impacts to the CEA and life history parameter(s) suggest a stock effect, then they will raise that potential impact to the attention of the Plan Teams, SSC, and Council."

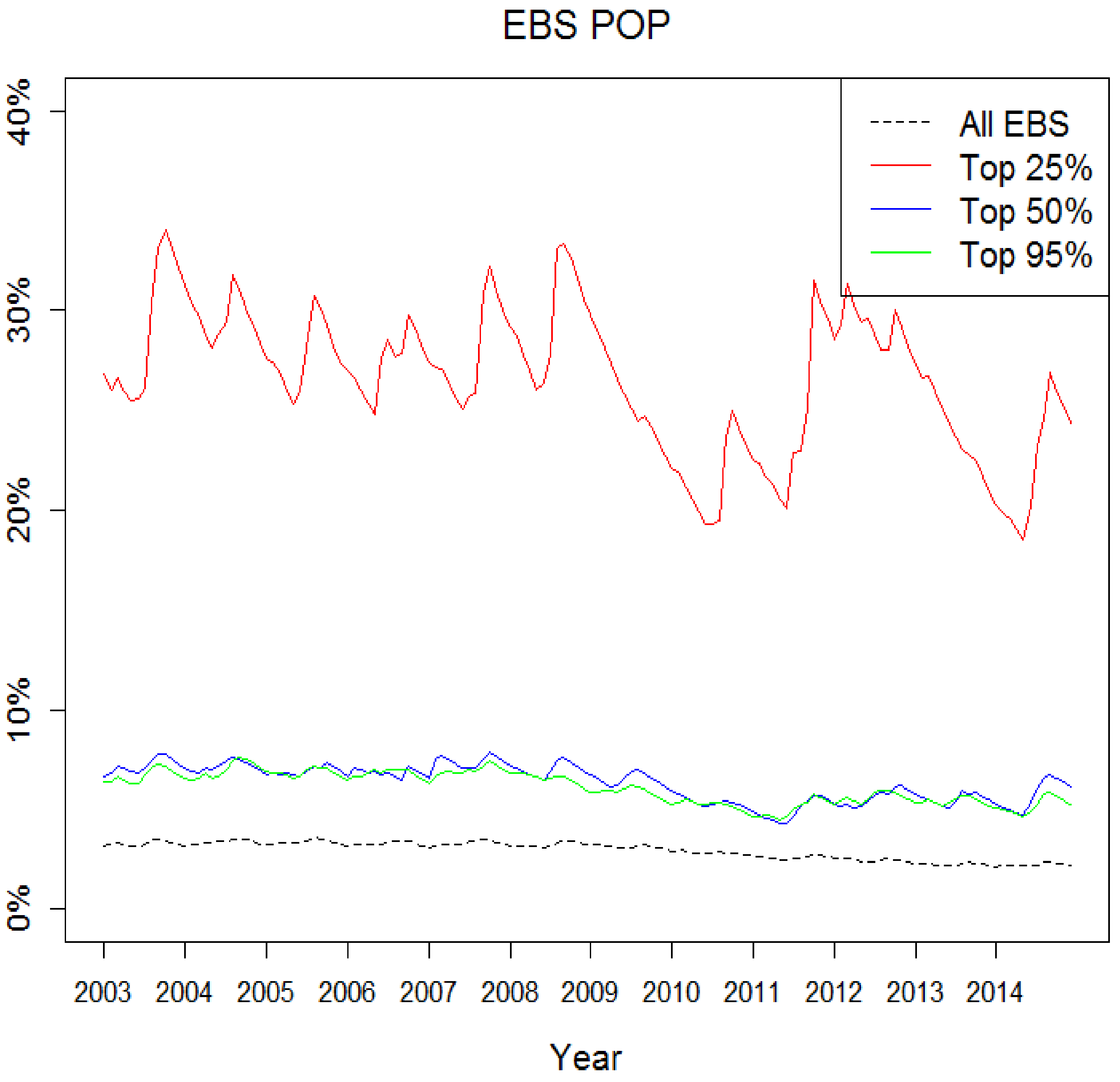
- Martin and I took a "hard look", no significant correlations found, no concerns at this time

Background, continued

- Draft methods presented to Plan Teams, Ecosystem Committee, SSC in October
- Suggested revising
  1. Core EFH Area: 25%, 50%, 95%
  2. CEA impact threshold: 5%, 10%, 20%
  3. Correlation significance criteria: p-value
  4. Recovery assumptions for long-lived species
- SSC Subcommittee reviewed suggestions in November
- FE model authors reviewed and revised model

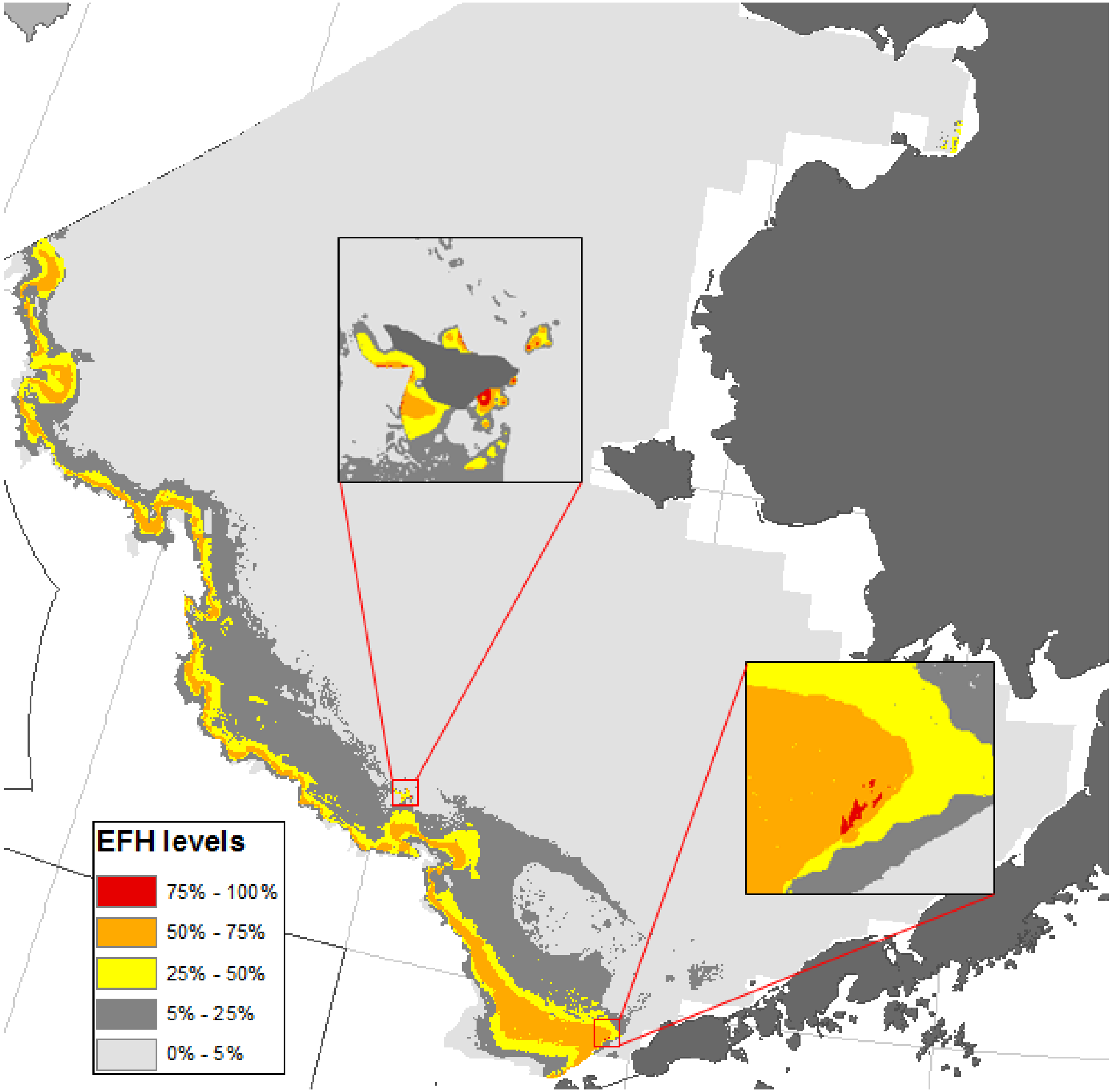

EBS Northern rock sole
EBS Pollock
EBS Yellowfin Sole
EBS Red king crab
BS Pacific Cod
All EBS
Top 25%
Top 50%
Top 95%
Habitat reduction
0%
2.5%
5%
7.5%
10%
Year
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014

EBS Pacific ocean perch showed apparent high levels of habitat impact at over 25% for the 25th percentile CEA.



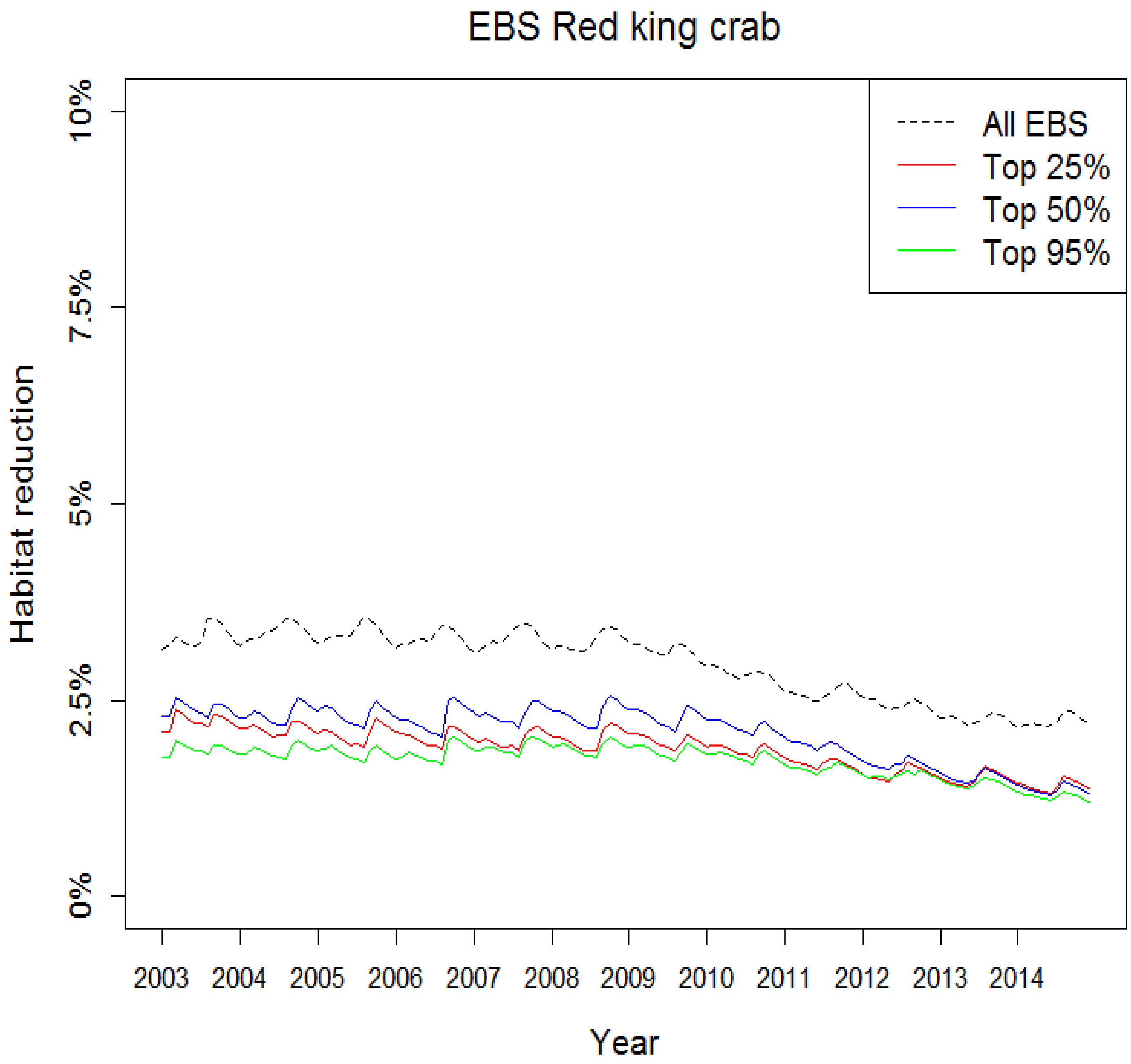
EBS Pacific ocean perch showed apparent high levels of habitat disturbance with the highest (top 25%) quantile

Model predicted 25% CEA area around St. George Island, but also in cod alley.



Similarly, all EBS selection overstates habitat impact for RKC

- Most fishing occurs outside top 95%



Core EFH Area (CEA)

CEA – 50% quantile of summer EFH

- GAM or Summer MaxEnt

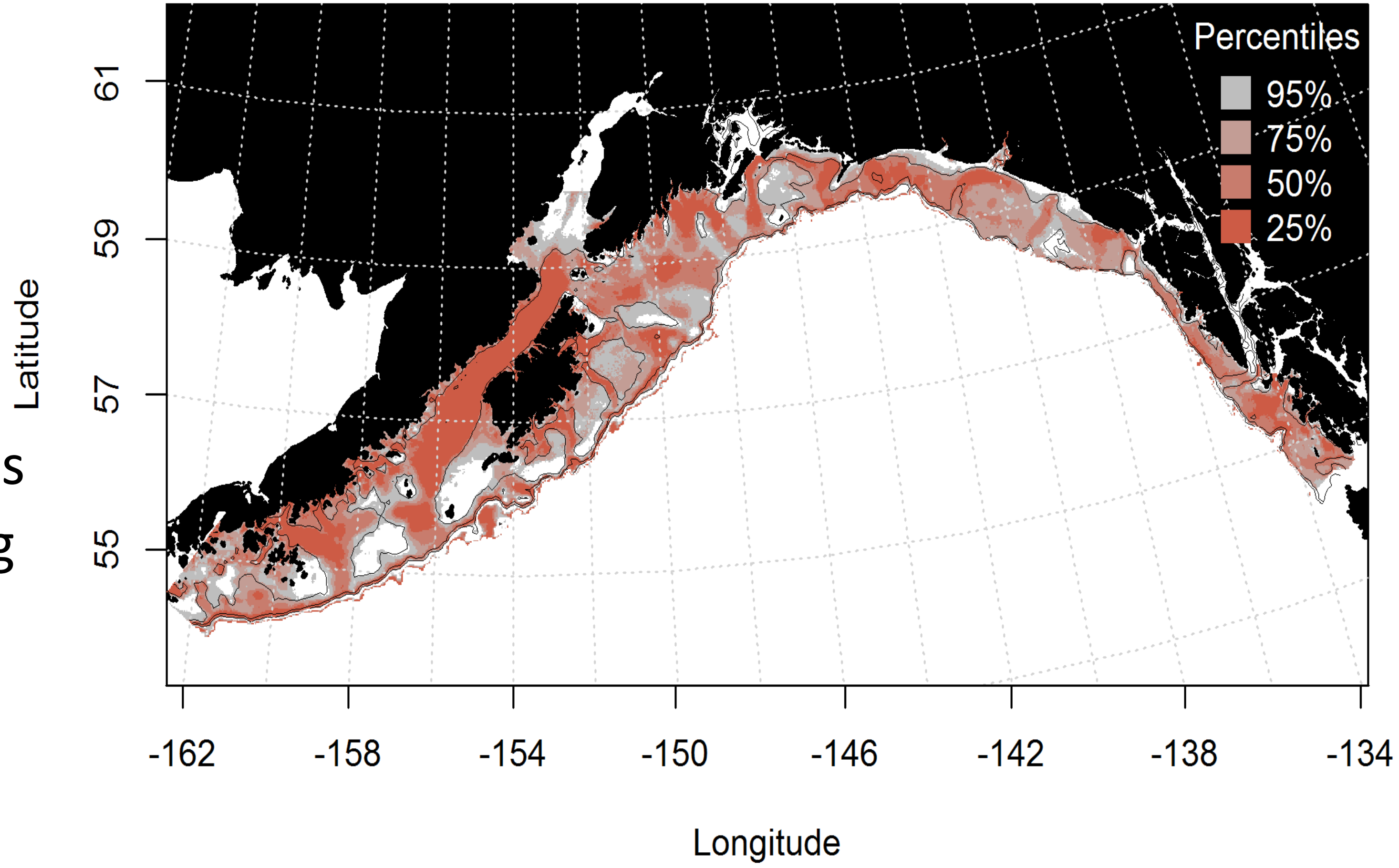
Suggestions to consider other quantiles

- 25% - risk missing important areas
- 95% - risk diluting effect of fishing

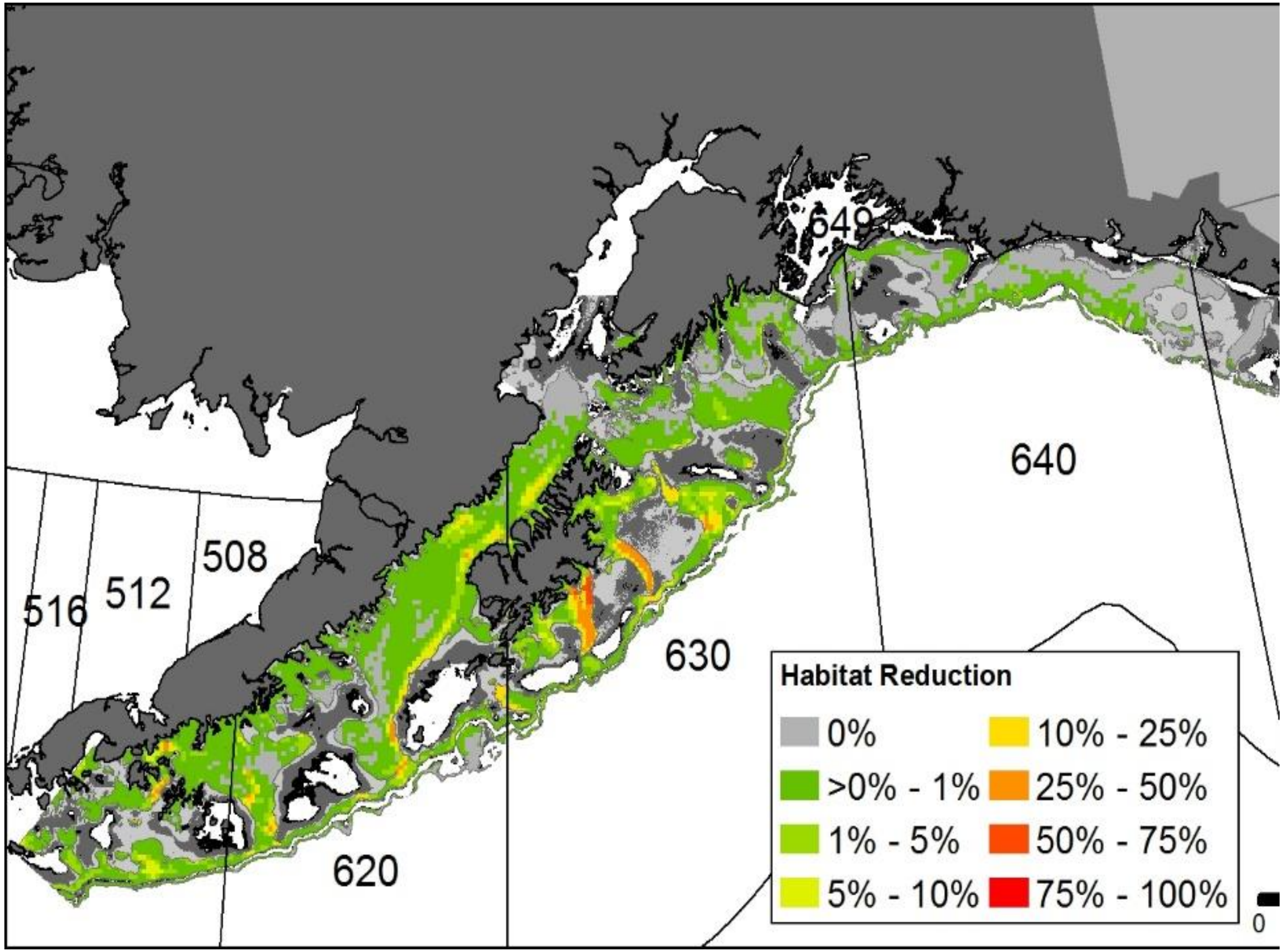
Subcommittee recommends 50% quantile, and if possible provide 95%

Subcommittee continues to recommend 10% threshold

Walleye Pollock EFH in the Gulf of Alaska



CEA Impact Threshold

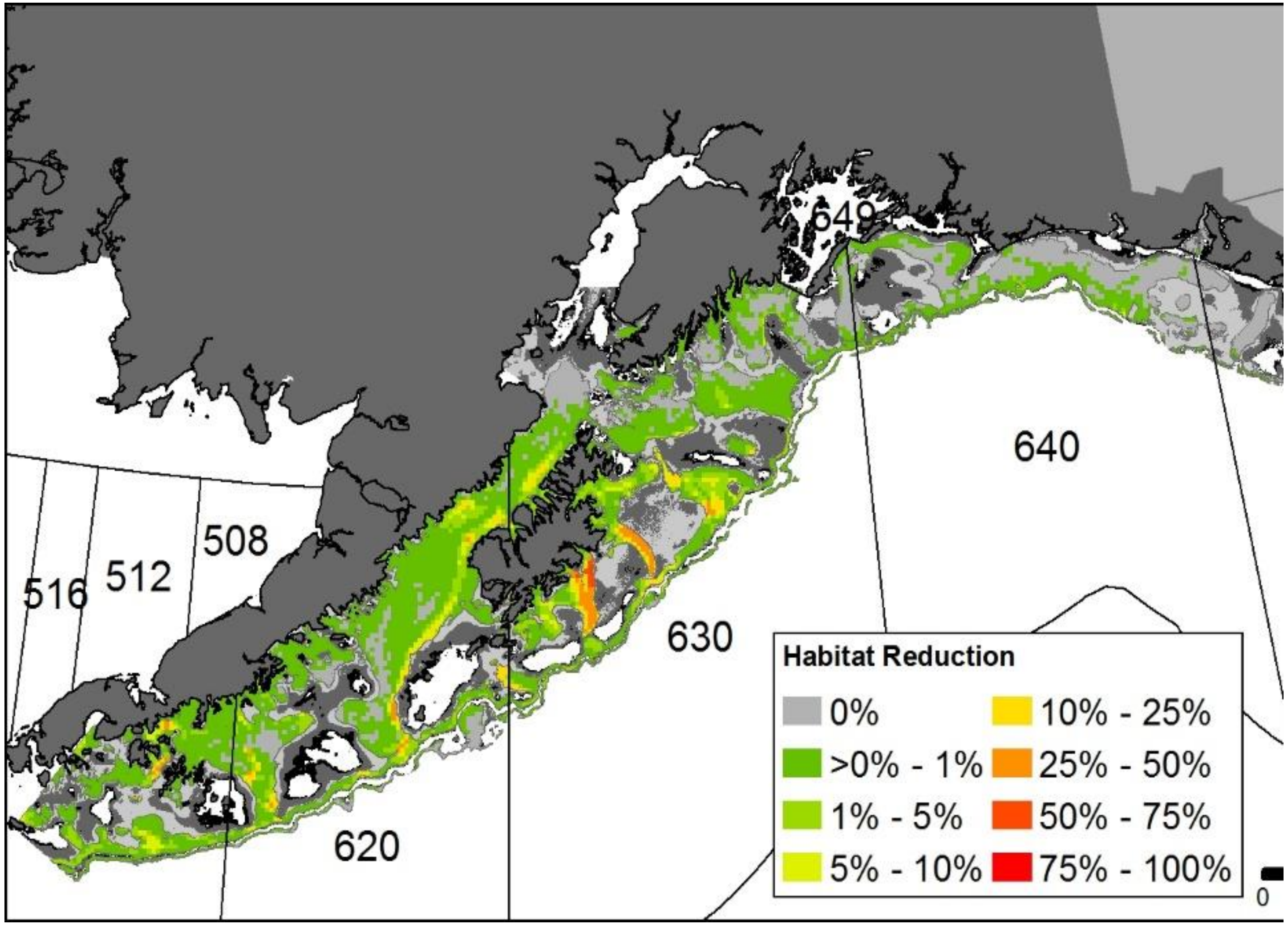


Minimal impact if <10% reduced

Suggestions to evaluate other thresholds

- 5%, 20%

Correlation significance criteria



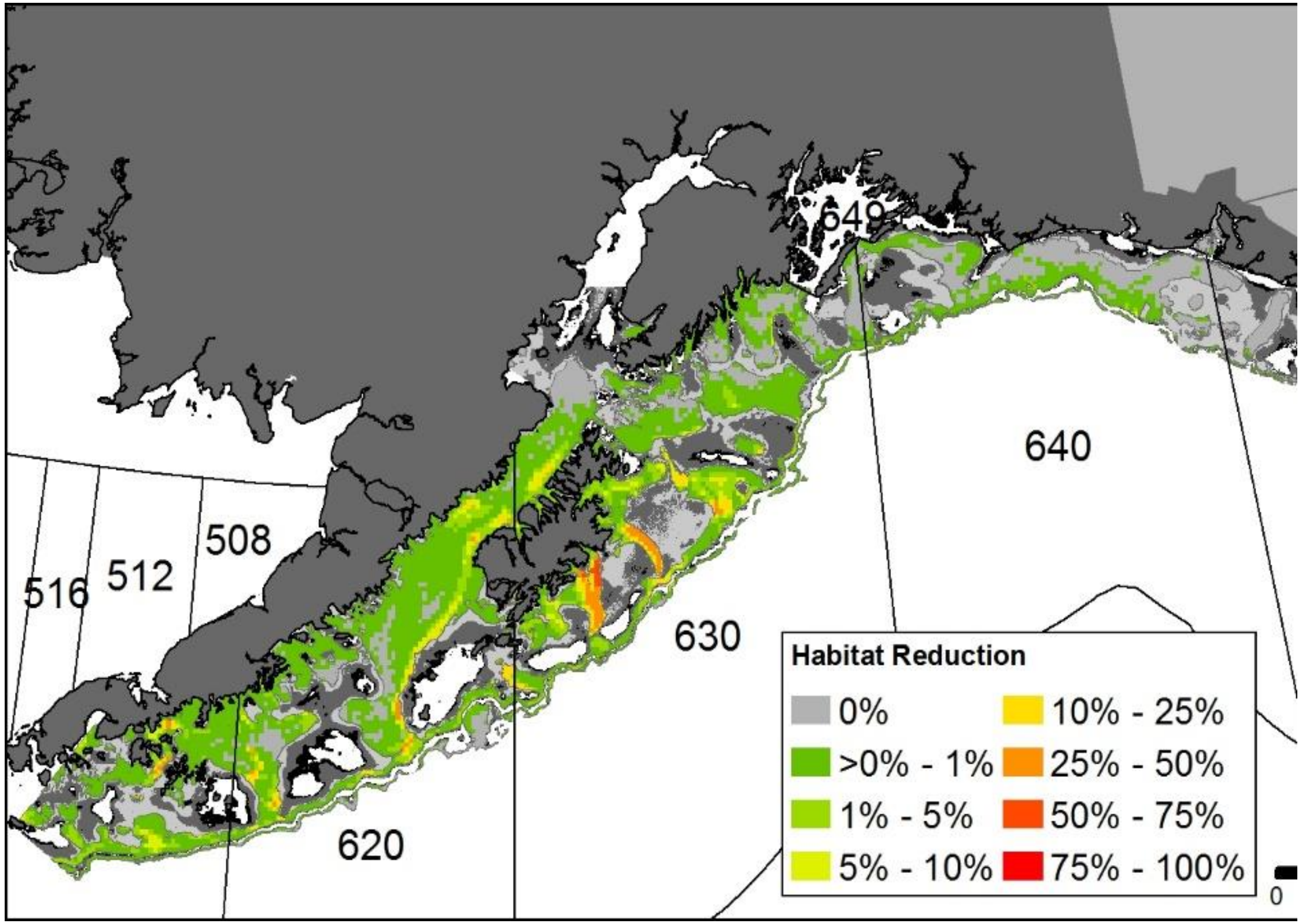
Evaluate life history parameters if impact > 10%

Correlation at p>0.1

Suggestions to consider other p values or multiple test issues

P-value used to create unambiguous threshold, not test hypotheses

Correlation significance criteria, continued



- If correlation is significant, stock authors will report result to Plan Teams and SSC for review
- Authors can elevate issue if other data suggest it is necessary

OR

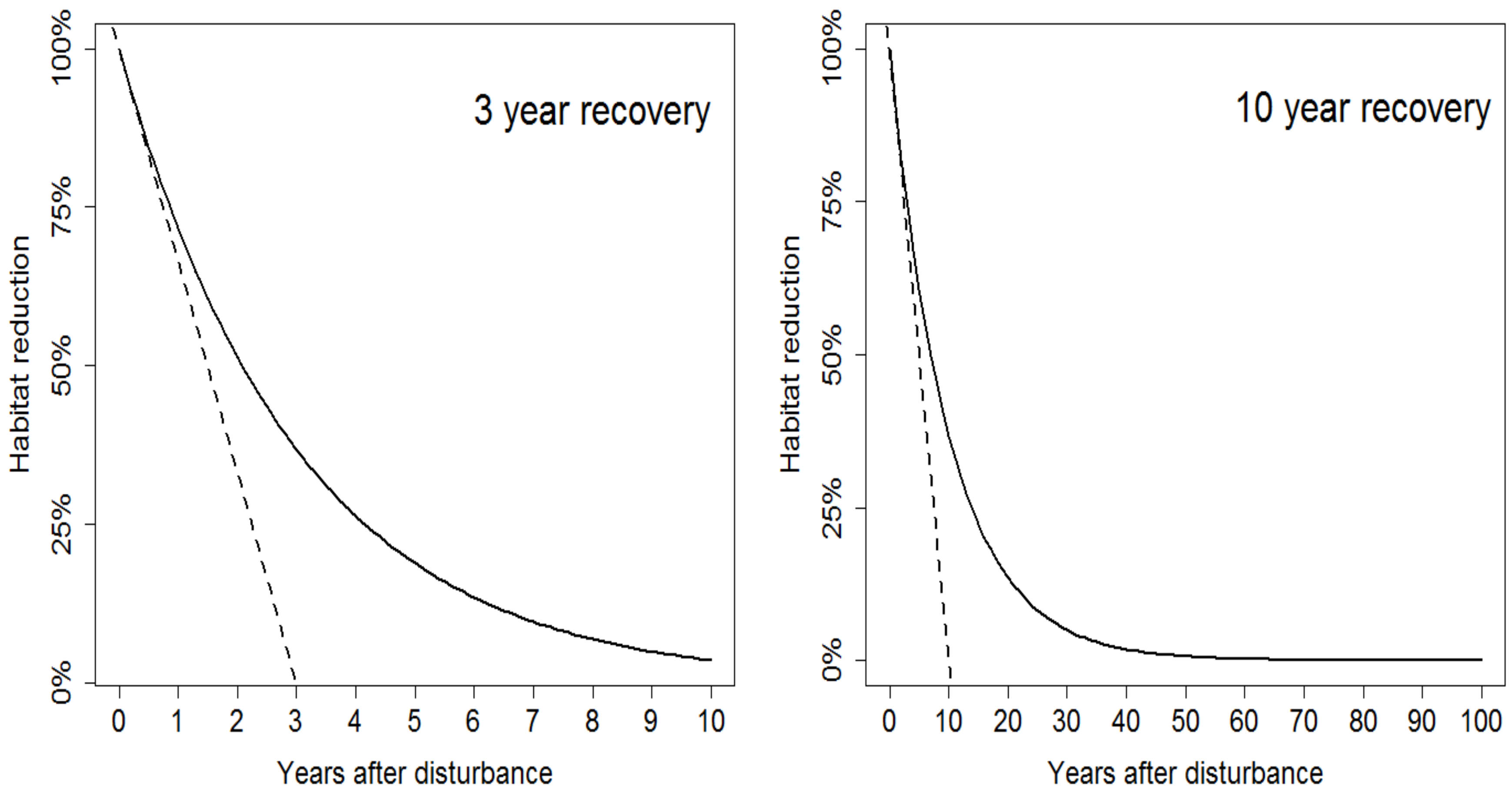
- Explain why result is spurious

Recovery assumptions for long-lived species

October 2016 – SSC comments

The SSC recommends that the subcommittee include an additional biological feature category for long-lived corals/sponges and develop a white a paper describing the expected fishing effects to this group.

Adaptation of the FE model to include long-lived species on deep and rocky habitats



Rooper et al (2011) states: Mortality of 67% of the coral biomass at a site would recover to 80% of the original biomass after 34 years in the absence of further damage or removals.

Adaptation of the FE model to include long-lived species on deep and rocky habitats

Parameter values for model performance analysis

	Literature derived parameters		Maximum habitat reduction		Minimum habitat reduction		Long recovery scenario 1		Long recovery scenario 2	
Score	R	S	R	S	R	S	R	S	R	S
0	0 – 1	0 – 10%	1	10%	0	0%	0 – 1	0 – 10%	0 – 1	0 – 10%
1	1 – 2	10 – 25%	2	25%	1	10%	1 – 2	10 – 25%	1 – 2	10 – 25%
2	2 – 5	25 – 50%	5	50%	2	25%	2 – 5	25 – 50%	2 – 5	25 – 50%
3	5 – 10	50 – 100%	10	100%	5	50%	5 – 10	50 – 100%	5 – 10	50 – 100%
4	-	-	-	-	-	-	10 – 100	-	10 – 50	-

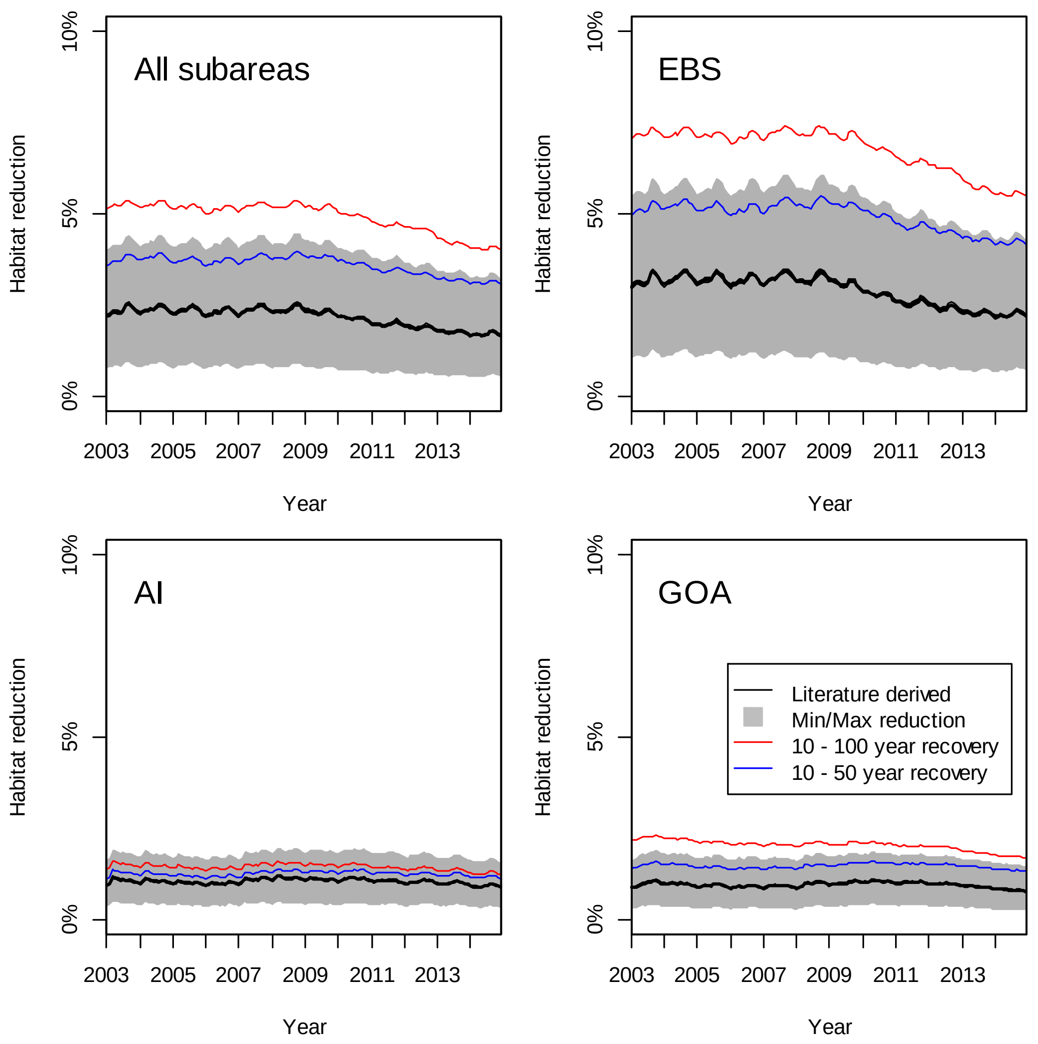


Figure 1: Habitat reduction for five scenarios. The literature derived parameters (black lines) represent five model runs. The grey band is the range between the *minimum habitat reduction* and *maximum habitat reduction* model runs. The red and black lines represent model runs with 10 – 100 year and 10 – 50 year recovery parameters, respectively, for the “coral, sea pen” habitat feature.

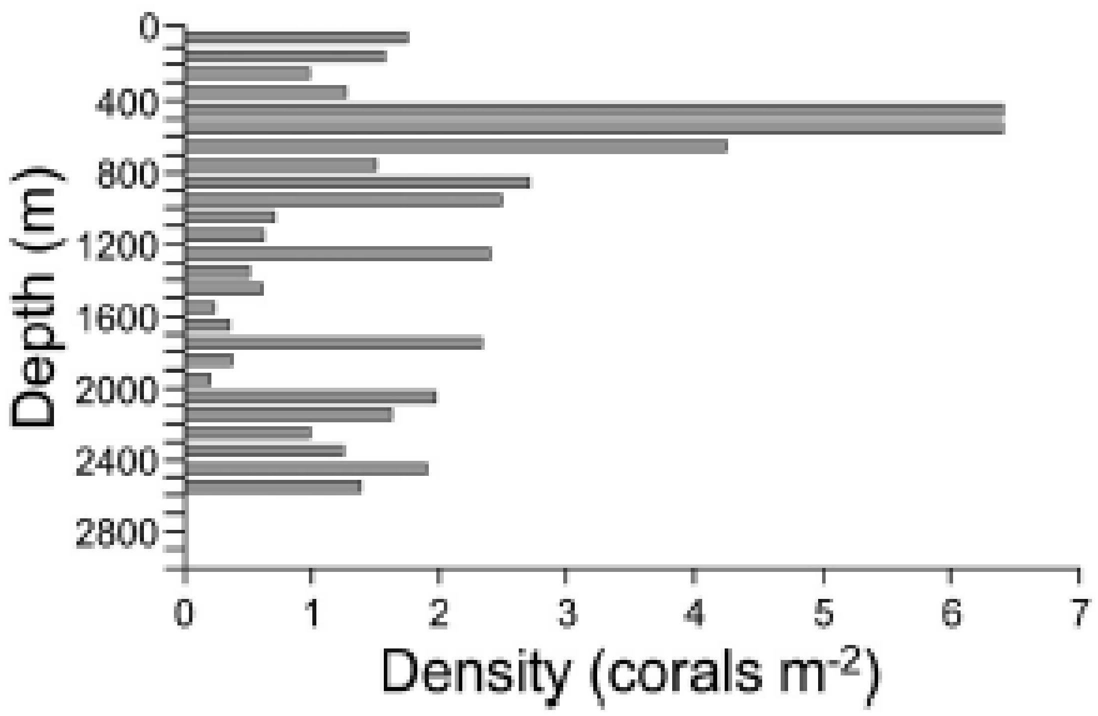


Figure 8

Absolute density of corals (corals m^{-2}) per depth strata (100-m) observed in analysis of video collected along transects with the submersible *Delta* and remotely operated vehicle *Jason II* in 2003 and 2004 in the central Aleutian Islands. Corals were observed at depths below 2600 m, but at densities (<0.03 m^2) that cannot be shown in the scale of this figure.

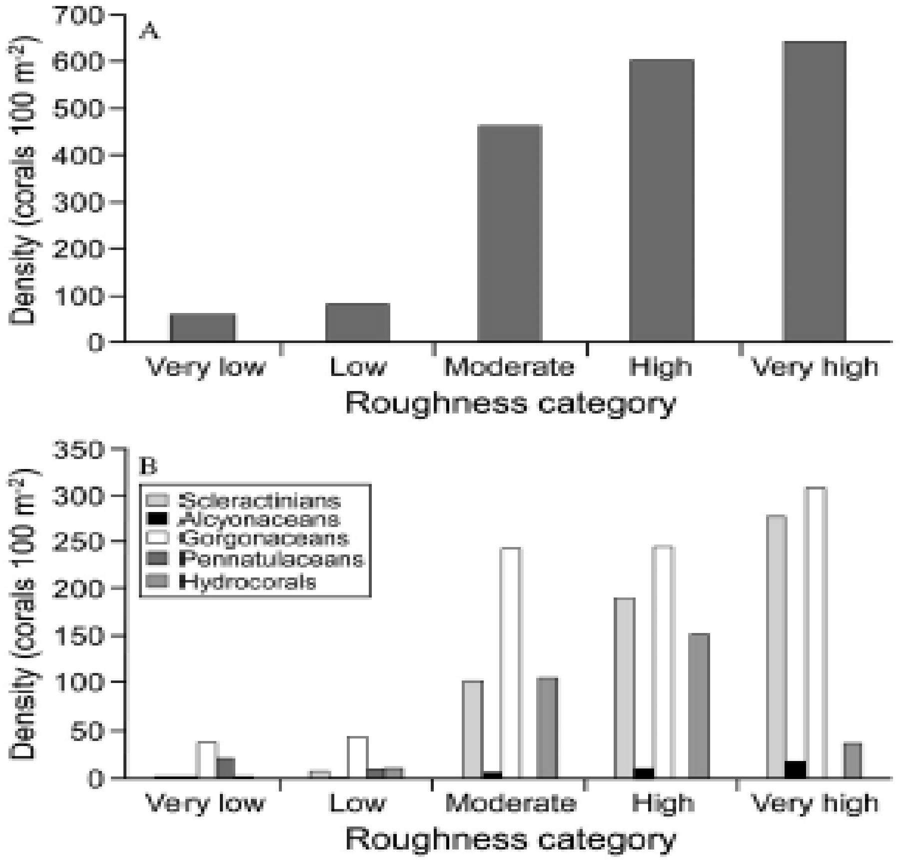


Figure 9

Absolute density (**A**) of all corals combined and (**B**) of 5 major taxa of corals per roughness category observed in frames sampled (n=33,719) from video collected along 29 transects with the submersible *Delta* and remotely operated vehicle *Jason II* in 2003 and 2004 in the central Aleutian Islands. Seafloor roughness was visually estimated and categorized into 5 hierarchal groups from very low to very high.

Adaptation of the FE model to include long-lived species on deep and rocky habitats

At the October 2016 Council Meeting, the SSC supported the use of the FE model as a tool for assessing the effects of fishing on EFH, but raised concern that the longest recovery time incorporated into the model (10 years) may not capture the recovery needed for long-lived species, in particular, hard corals that live on rocky substrate at deep depths.

To address these concerns, we added a deep and rocky substrate habitat category. (>300m, cobble & boulder habitat created new Deep/Rocky habitat type, based on Stone 2006)

Table 1. Recovery table including Deep/Rocky habitat category

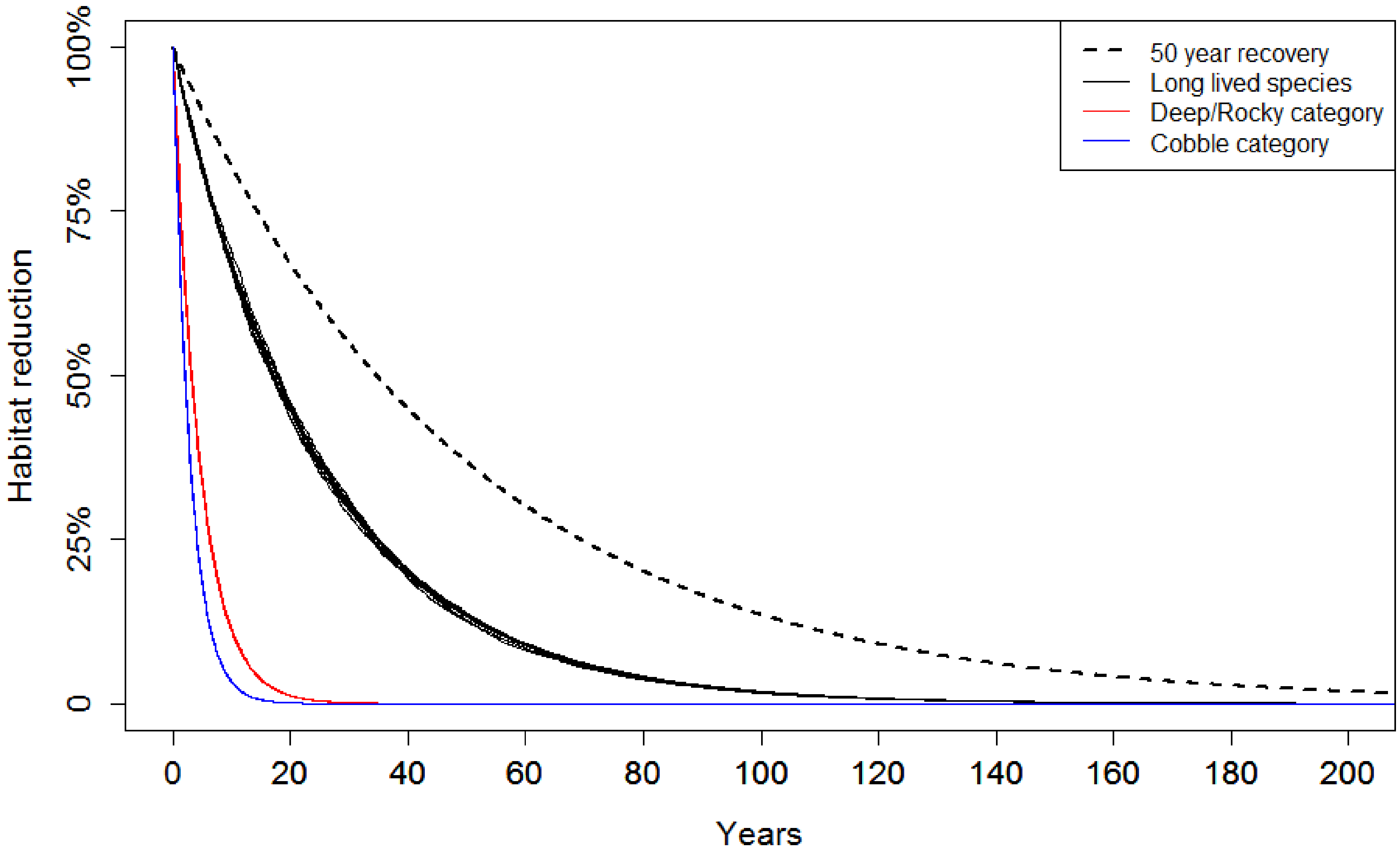
Feature Class	Features	Mud	Sand	Gran-Peb	Cobble	Boulder	Deep/Rocky
B	Bryozoans			1	1	1	1
B	Corals, sea pens	2	2				
B	Hydroids	1	1	1	1	1	1
B	Polychaetes, other tube-dwelling			1	1	1	1
B	Sponges		2	2	2	2	2
B	Long-lived species						4

Recovery codes: 0: < 1 year; 1: 1 – 2 years; 2: 2 – 5 years; 3: 5 – 10 years; 4: 10 – 50 years

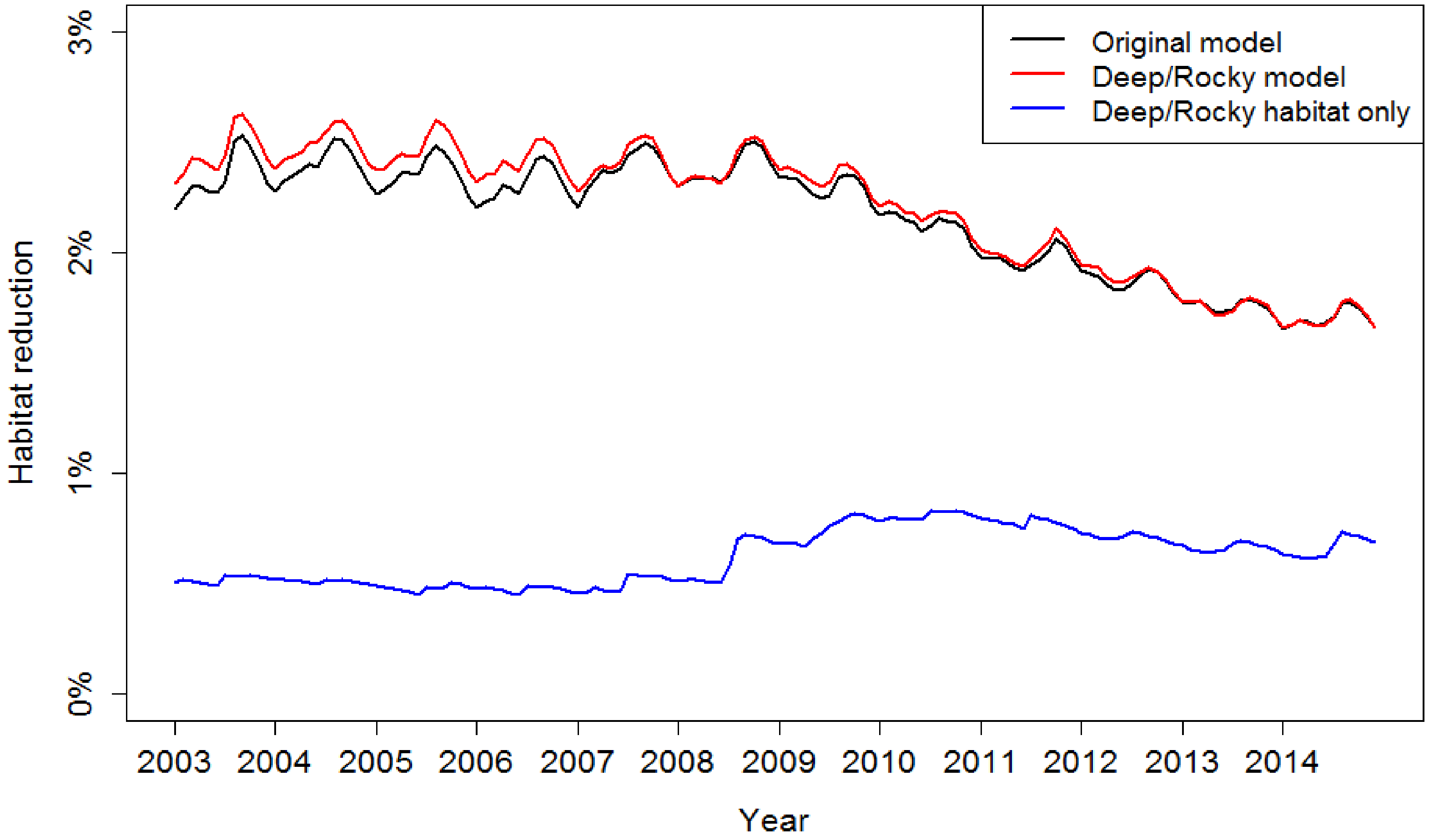
Blank spaces are habitat features not associated with the given sediment class

G = Geological features; B = Biological features

A new “Long-lived species” habitat feature was added with a new recovery score of 4 corresponding to a recovery time of 10 – 50 years. The 50-year upper limit of recovery time was calculated with the expectation that 5% of these long lived species would require over 150 years to recover

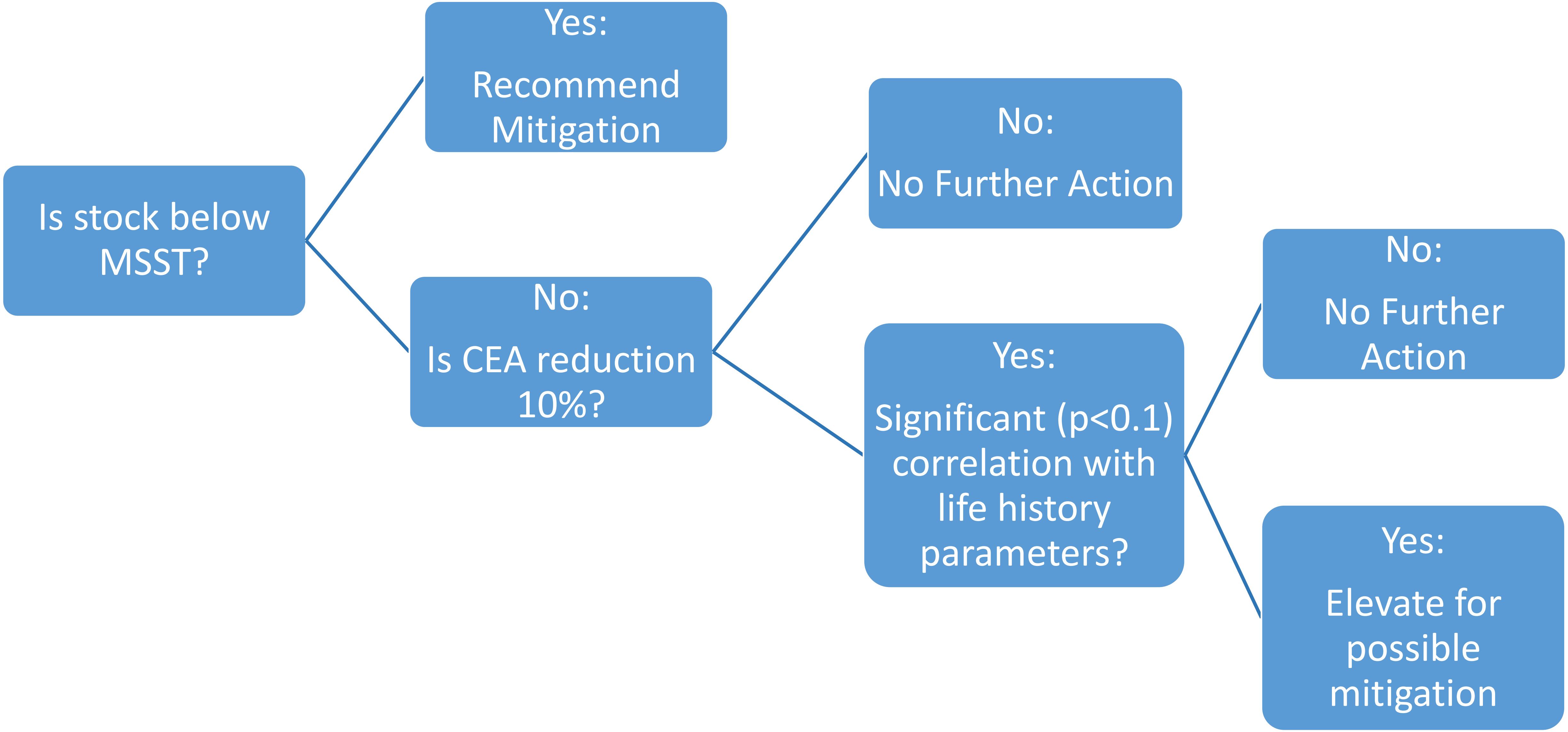


Deep/Rocky habitat category occurs in 2.4% of grid cells, average increase of 0.03% more habitat. Predicted habitat reduction was about 70% less in grid cells that contained Deep/Rocky substrate compared to the entire domain (Figure 2). The less habitat disturbance in Deep/Rocky habitats reflects less fishing effort in these areas as only 0.4% of fishing effort occurred in grid cells with Deep/Rocky substrate compared to it areal representation of 2.4%.



With council approval,

- Plan Teams will review stock author reports in March 2017
- SSC will review report and Plan Team recommendations in April 2017
- Council will review report with Plan Team and SSC recommendations in April 2017 and determine whether mitigation is necessary
  - Council will follow standard FMP amendment process to mitigate adverse impacts
  - Recommend regulatory changes to NMFS


Is stock below MSST?
Yes:
Recommend Mitigation
No:
Is CEA reduction 10%?
No:
No Further Action
Yes:
Significant (p<0.1) correlation with life history parameters?
No:
No Further Action
Yes:
Elevate for possible mitigation