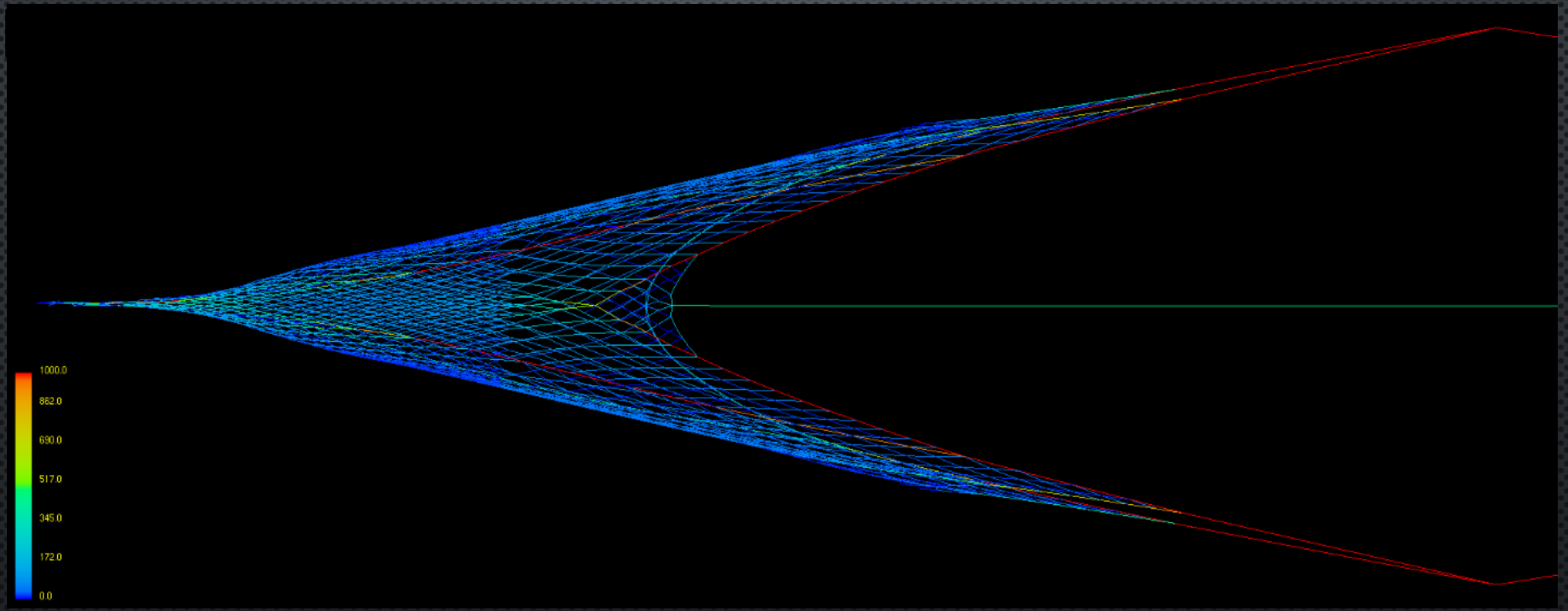
FISHING RESEARCH AND EFFECTS MODELING



Brad Harris, Ph.D. - FAST Lab, Alaska Pacific University
Craig Rose, Ph.D. - Fishnext Research

ALASKA PACIFIC UNIVERSITY

PURPOSE

Review available information and tools to assess the degree to which fishing gears are contacting the bottom, and studies on impacts, which could be used to evaluate whether additional management actions are needed to mitigate the impacts of fishing gear on benthic habitat and stocks that rely on such habitat.

The presentation will include:

1) Summary of research conducted in the Bering Sea, Aleutian Islands, and Gulf of Alaska to estimate and reduce the impacts of fishing gear on benthic habitat including examples of Council fishery management actions informed by this research;

2) Review of the FEM including current uses of the model and potential future applications to inform management actions; and

3) Update on the ongoing research to catalog pelagic trawl gear configurations and methods to measure pelagic trawl gear ground clearance and contact with the seafloor.

Research to Estimate and Reduce Benthic Effects of Alaska Groundfish Trawling

Dr. Craig S. Rose, FishNext Research
(Leader of Conservation Engineering research at the Alaska Fisheries Science Center 1987 – 2014)

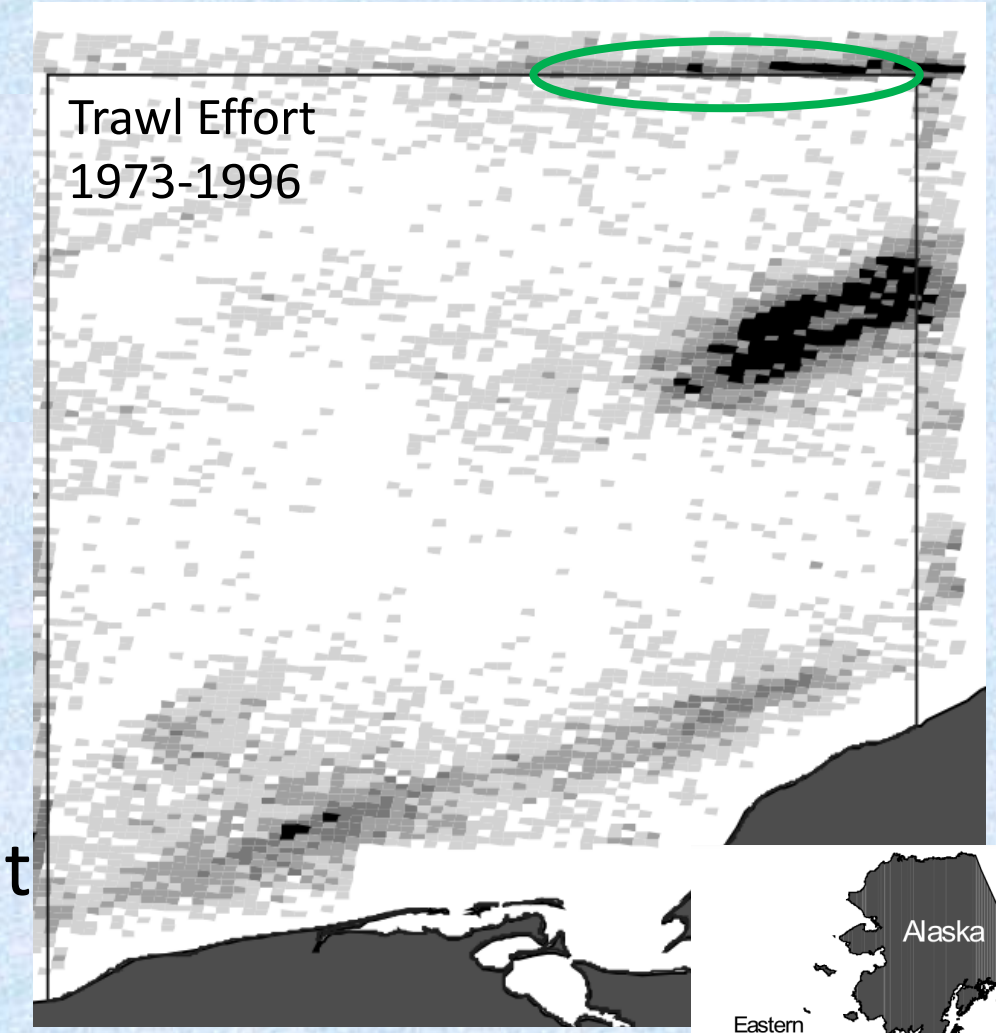
Most of the research herein was conducted by the AFSC Conservation Engineering Program with funding from the Cooperative Research Program and the North Pacific Research Board

Comparing invertebrates in nearby blocks: historically heavily trawled (HT) vs. unfished (UF)

Methods:

Mapped historical fishing effort

Sampled 42 paired sites (HT and UF) with a survey trawl



Results:

- Stalked, attached animals were more abundant in the UF area (most not sig.)
- Mixed responses for motile animals
- Most species were smaller in HT areas, but only 2 significantly

McConnaughey, Mier & Dew 200. ICES J Marine Science, 57: 1377–1388.

McConnaughey, Syrjala & Dew 2005. AFS Symposium 41:425–437.

Trawling Experiment with Controls

2001-2002

Methods:

Six paired Control and Impact corridors in an untrawled area

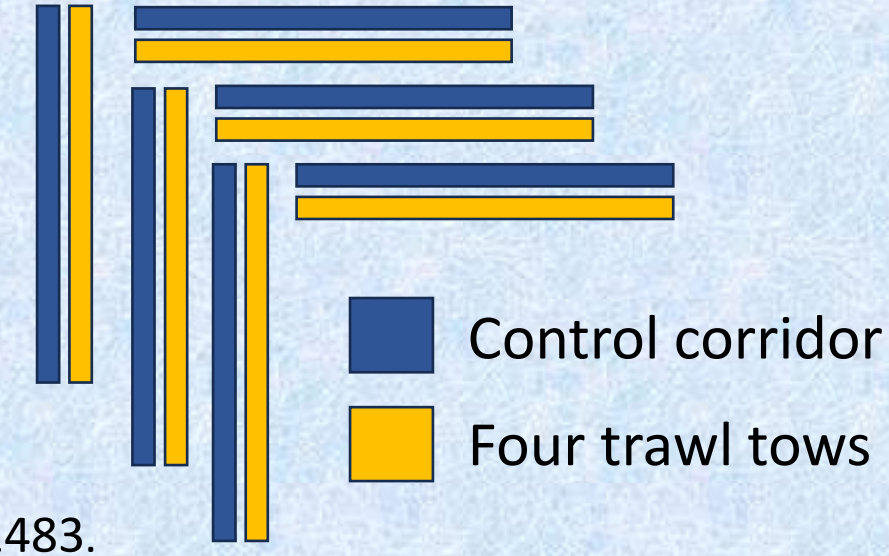
Impact - four overlapped benthic trawl tows

Sampled with survey trawl and benthic grabs

Prior, Immediate, and one-year sampling (BACI)

Results:

- Little change in benthic biomass or species composition
- Effects of a storm were more detectable than trawling (control areas changed)



McConnaughey & Syrjala 2014. ICES J Marine Science 71(9), 2469–2483.

Experimental trawling of hard-bottom area with tire gear

1996-1997

Methods:

- Eight trawl tows with tire gear footrope on pebble seafloor with boulders
- Observed trawl tracks with a submersible immediately after trawling and one year after

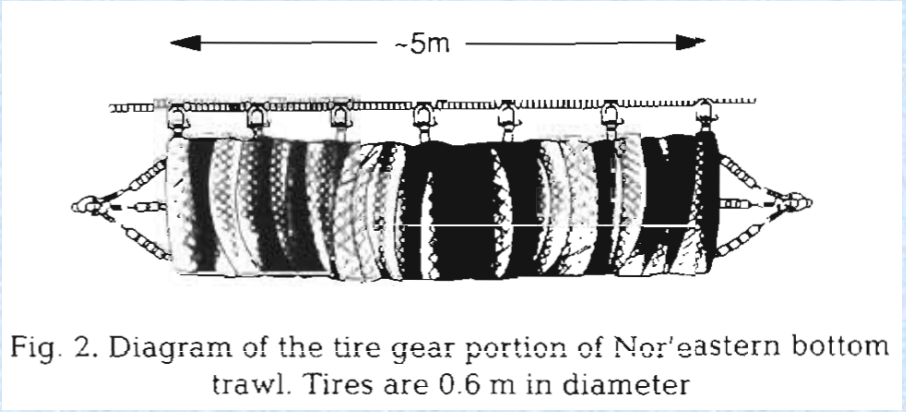
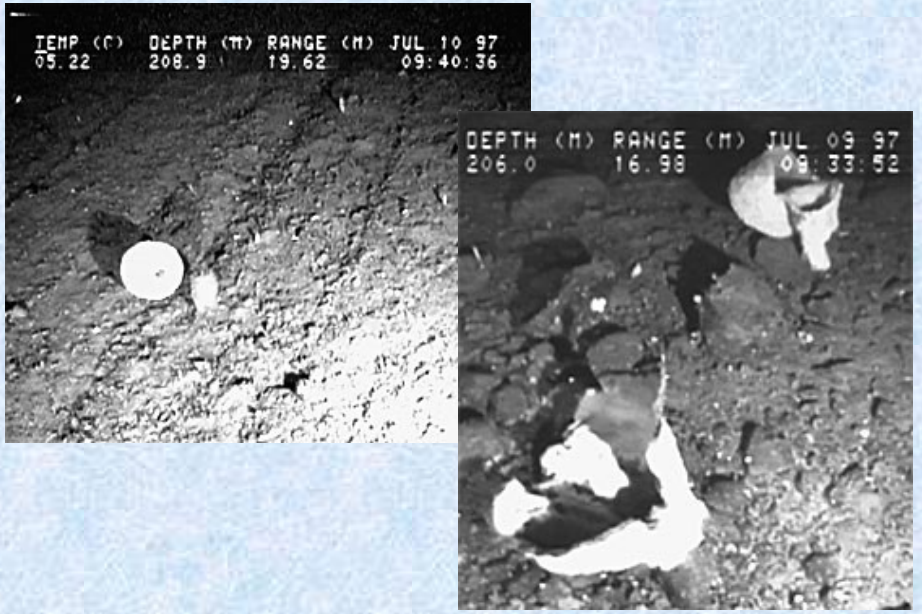


Fig. 2. Diagram of the tire gear portion of Nor'eastern bottom trawl. Tires are 0.6 m in diameter

Results:

- Boulders displaced (19%) and many sponges and anemones damaged or removed (67% of large sponges damaged, 16% lower sponge density)
- Detectable effects were limited to the 5m wide path of the tire gear (about 1/3 of net width)
- Effects persisted after one year

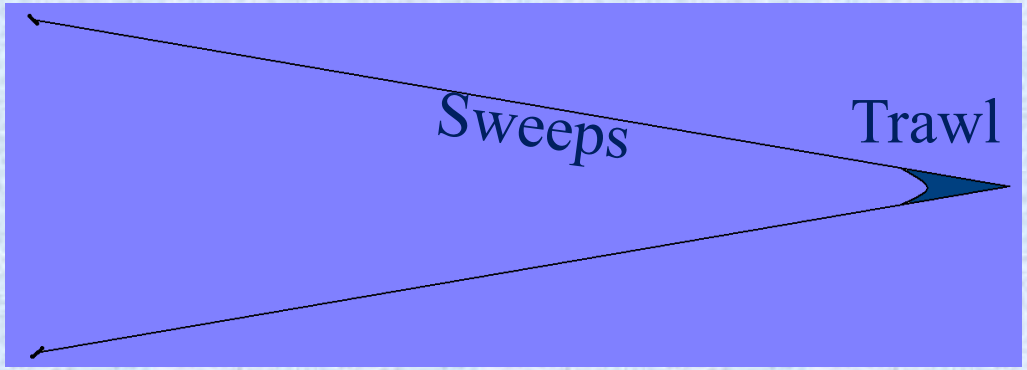


Freese, Auster, Heifetz & Wing 1999. Marine Ecological Progress Series 182: 119-126.

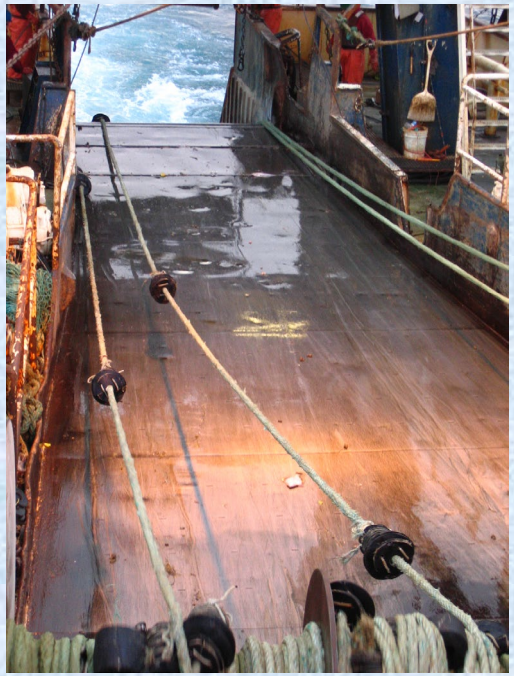
Freese 2001. Marine Fisheries Review 63(3) 7-13.

Raised Sweeps to reduce seafloor effects (crabs too)

NPRB project 2007-11



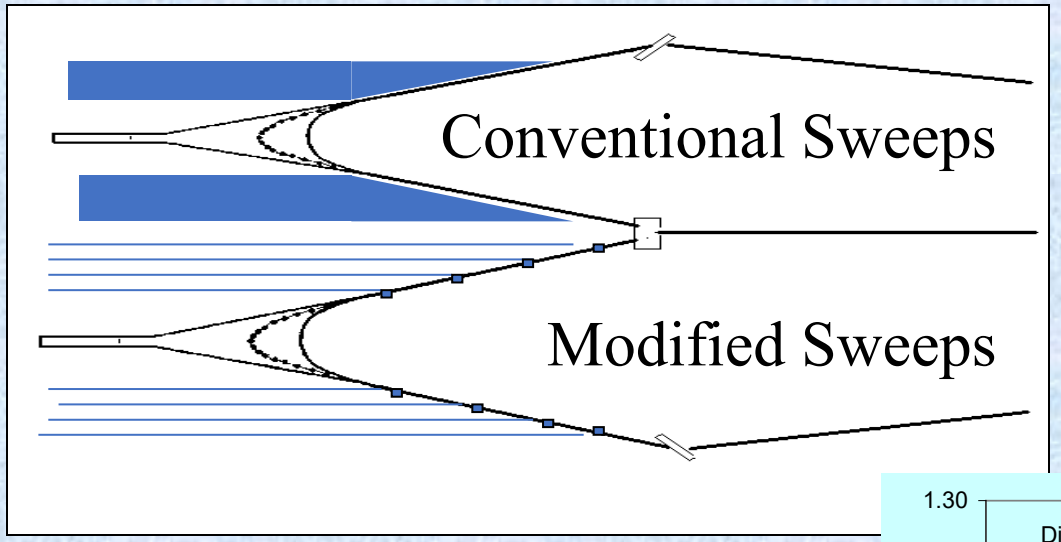
- Most Bering Sea sessile seafloor animals are only inches high and flexible (worst case - sea whips)
- Sweeps cover 90% of potential contact area



<u>Change:</u>

- Bobbins widely spaced on sweeps
- Keeps cable above seafloor

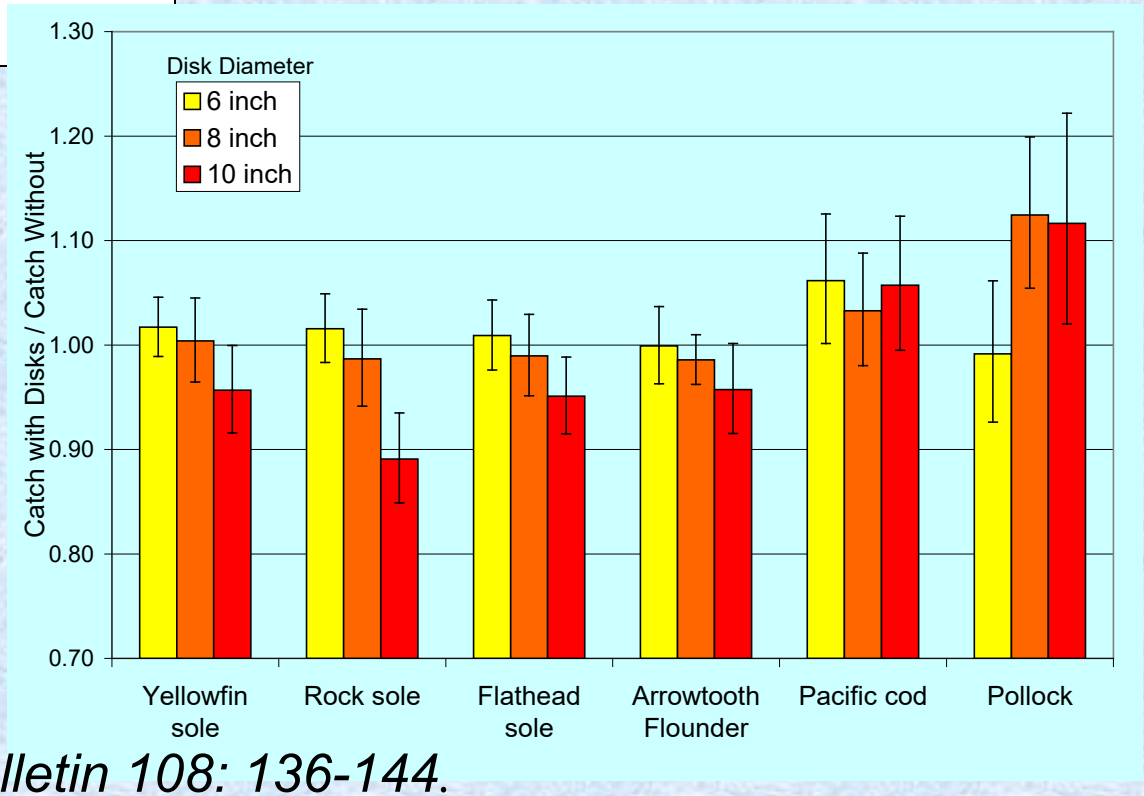
Testing for changes in catch rates (F/V *Cape Horn*)



Significant catch loss means longer tows:

Hence more impact

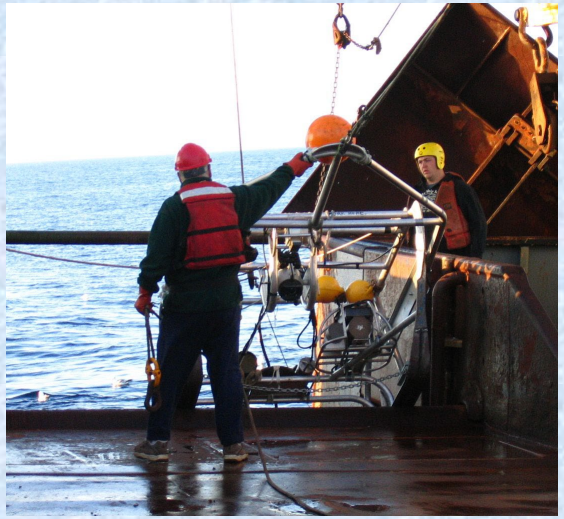
- Twin Trawl - Fishes two trawl systems in parallel at the same time
- **Flatfish catches not reduced with 6 and 8 inch disks**
- **Pollock catch increased with 8 and 10 inch disks**



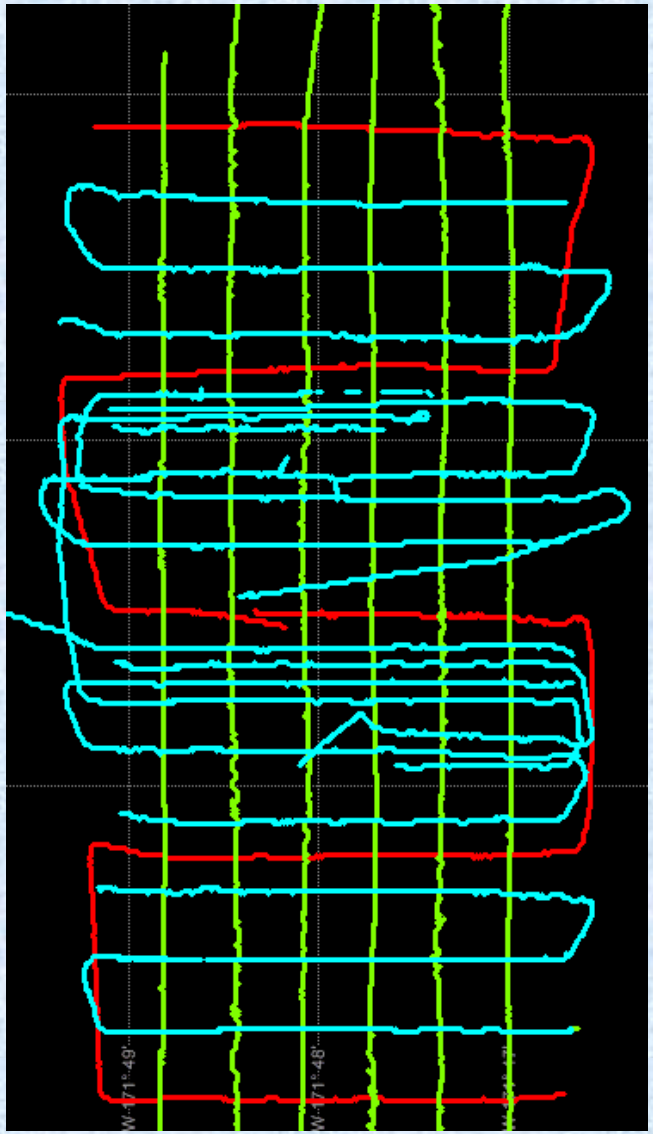
Rose, C.S., Gauvin, & Hammond. 2010. Fishery Bulletin 108: 136-144.

Testing for reduced damage to sessile epifauna

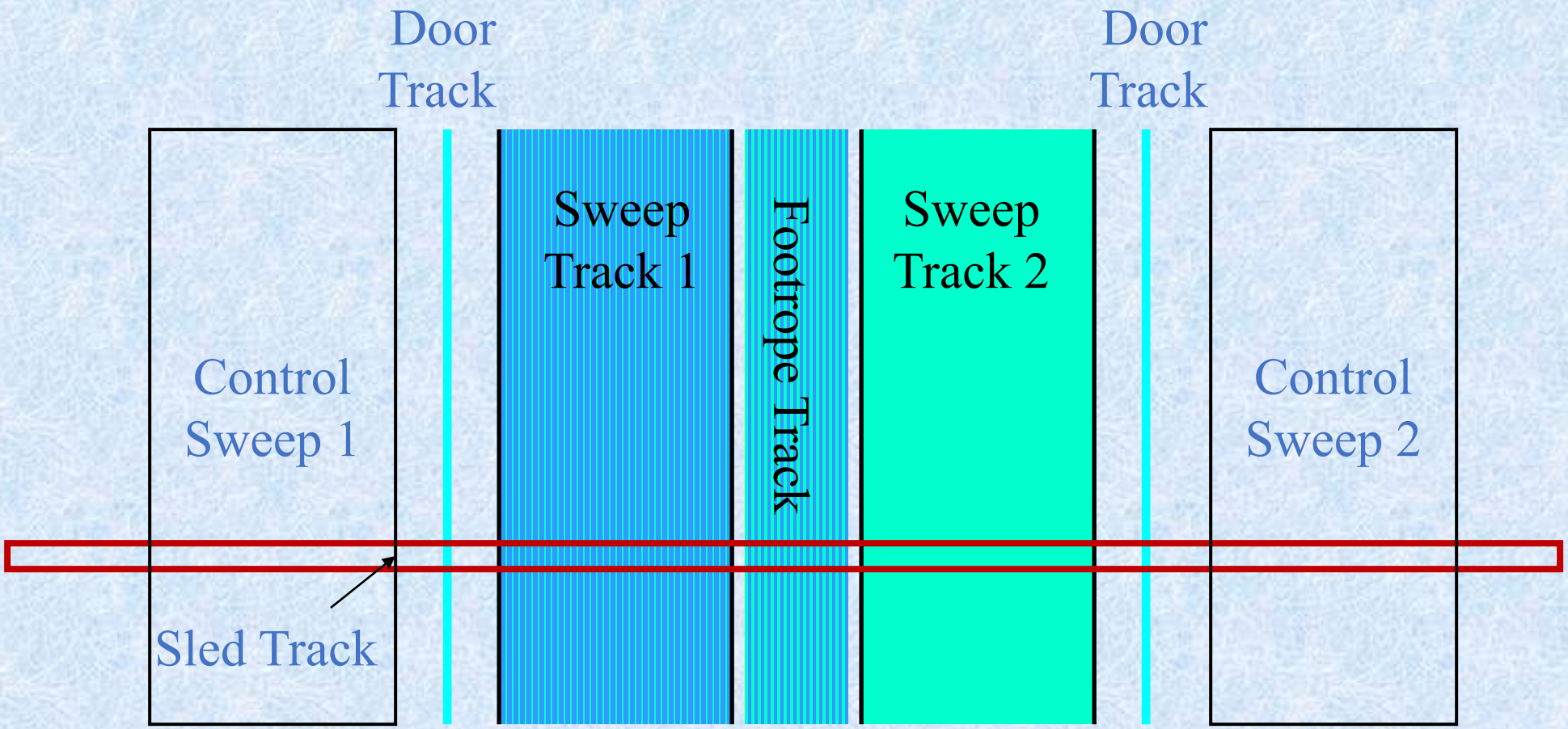
- Area with sea whips but little historical trawling
- Six trawl tracks (N-S)
- Sled transects across trawl paths (E-W)
  - Before
  - Day,
  - Week,
  - Month,
  - Year, after trawling



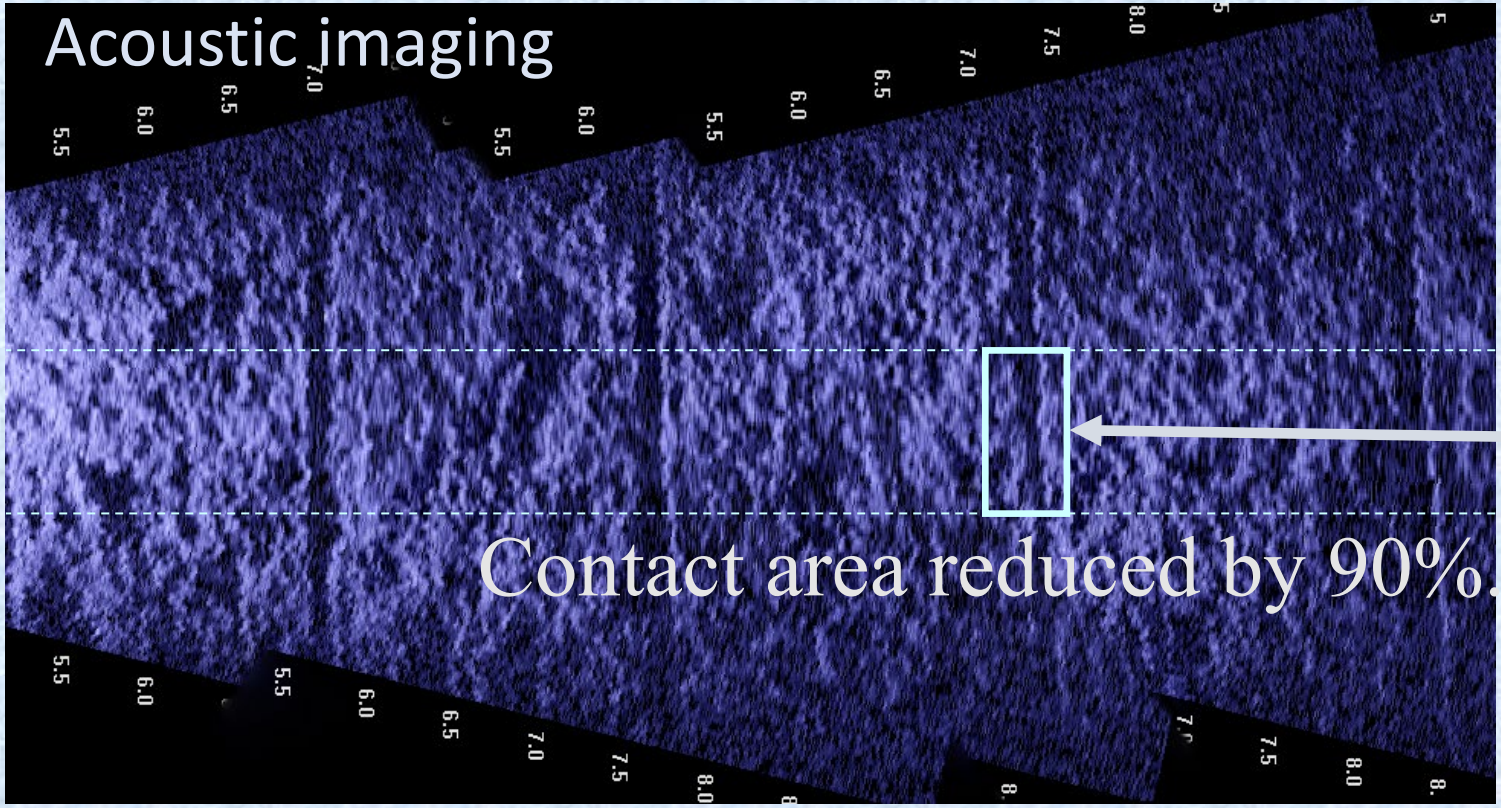
Video and sonar on a sled

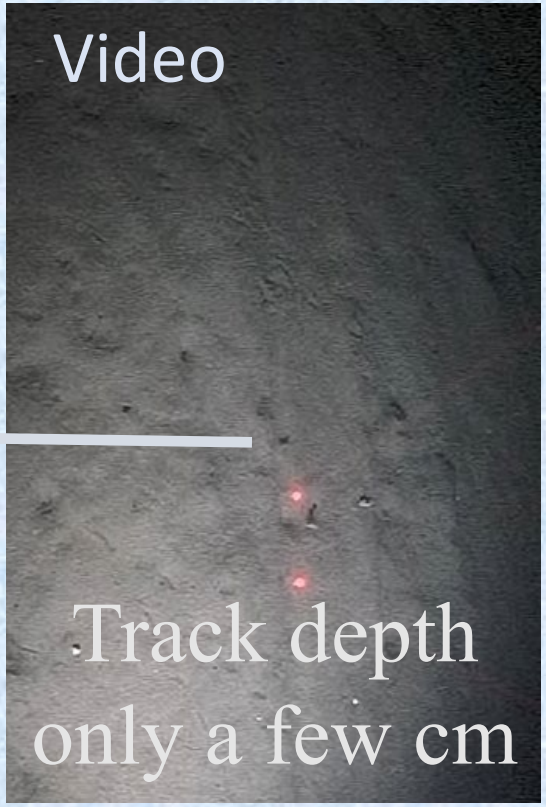


Sled sampling of trawl tracks



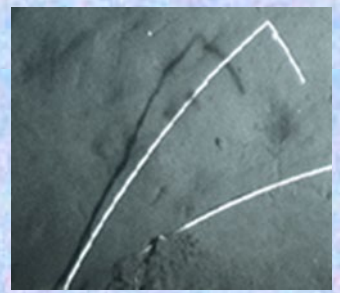
Measuring reductions in seafloor contact

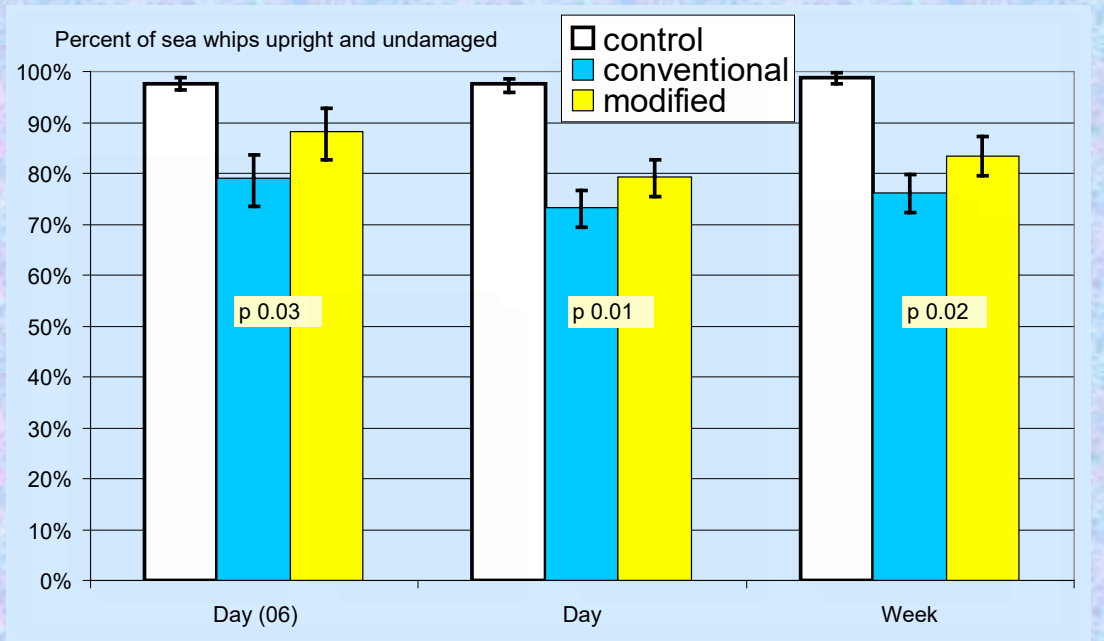




Effects on living-structure animals

Sea whips: most vulnerable and easiest to observe





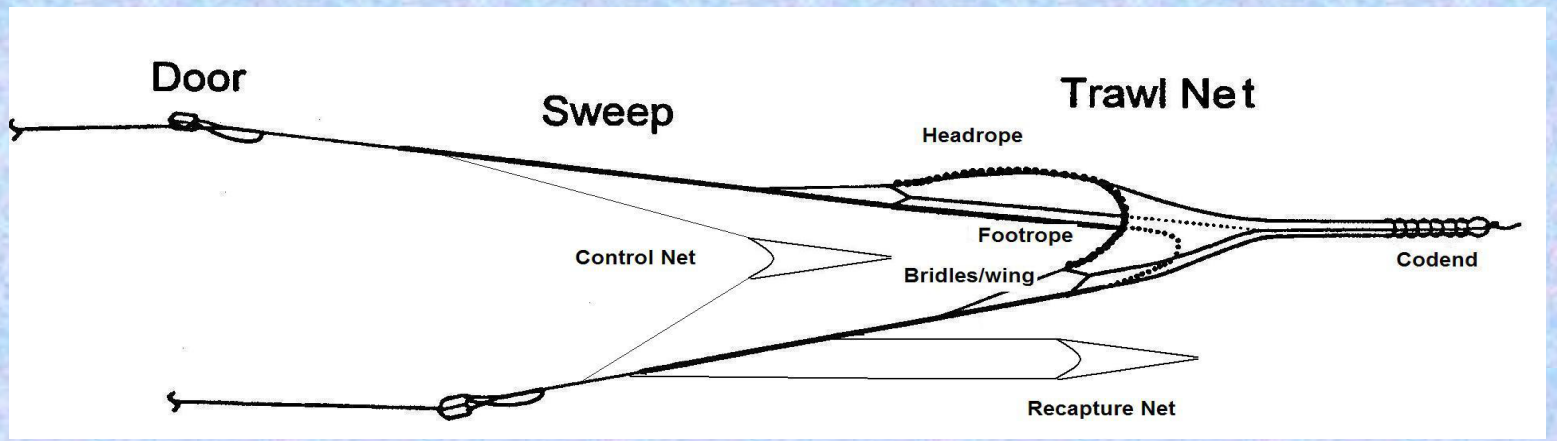
Raised sweeps affected sea whips much less than continuous contact sweeps

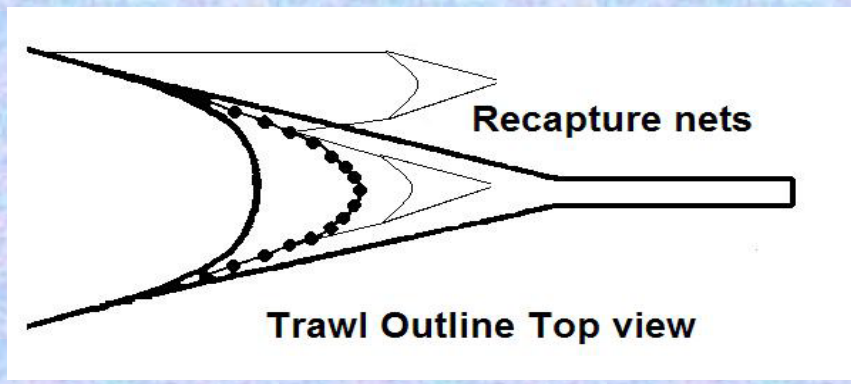
Consistent across Day, Week, Month, Year

Rose, Munk, Hammond & Stoner. 2010. AFSC Quarterly Report (First quarter 2010). 1-6.

Unobserved Mortality Rates of Crabs

NPRB project 2007-11



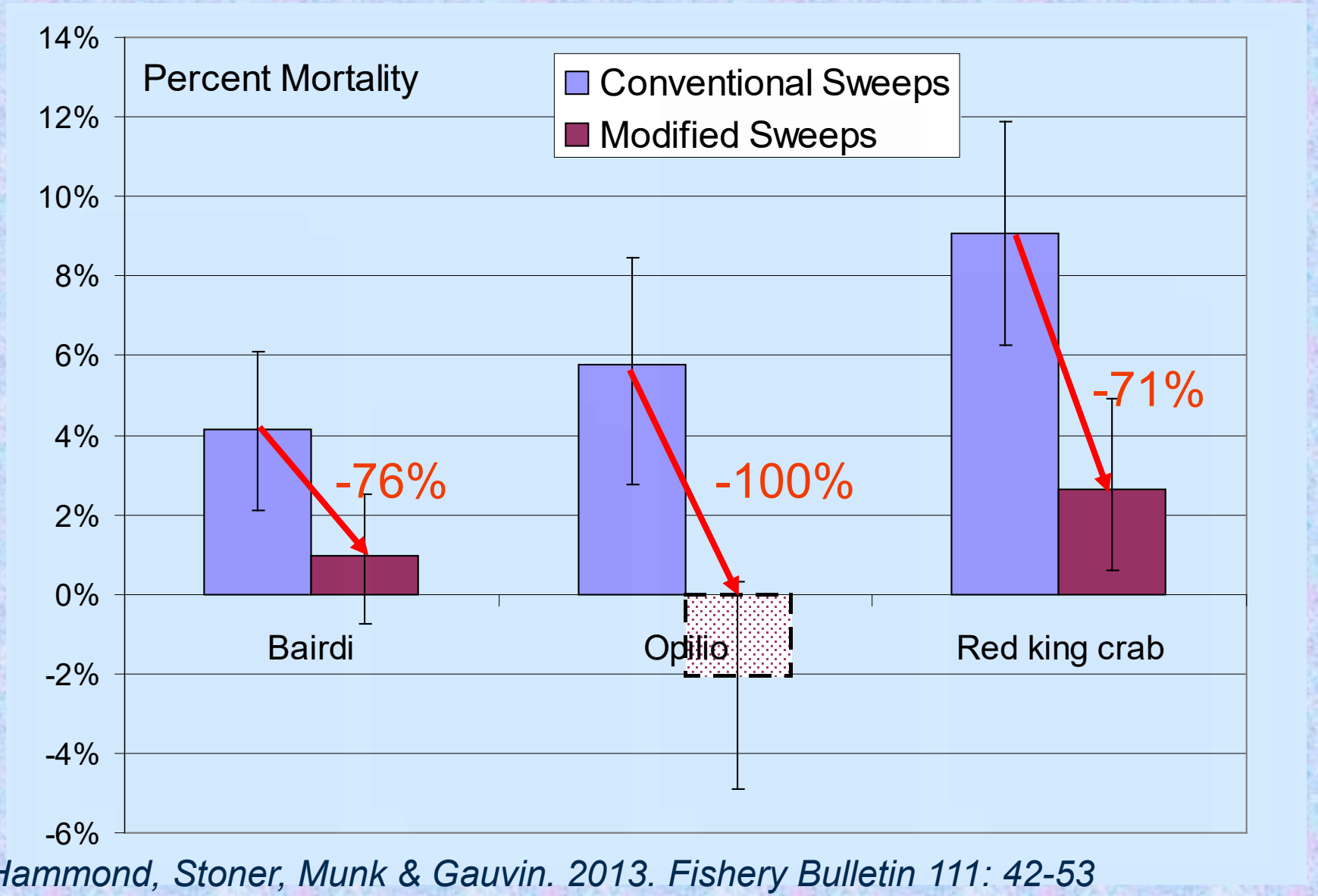


- Captured crabs in nets immediately after contact (short tows)
- Control net (no gear contact) to adjust for capture and handling damage
- Reflex loss scored to predict mortality
- Crabs held in on-board tanks to calibrate reflex/mortality relationship

Stoner, Rose, Munk, Hammond & Davis 2008. Fishery Bulletin 106: 337-347

Reduced Mortality Rate with Raised Sweeps

corrected for handling effects



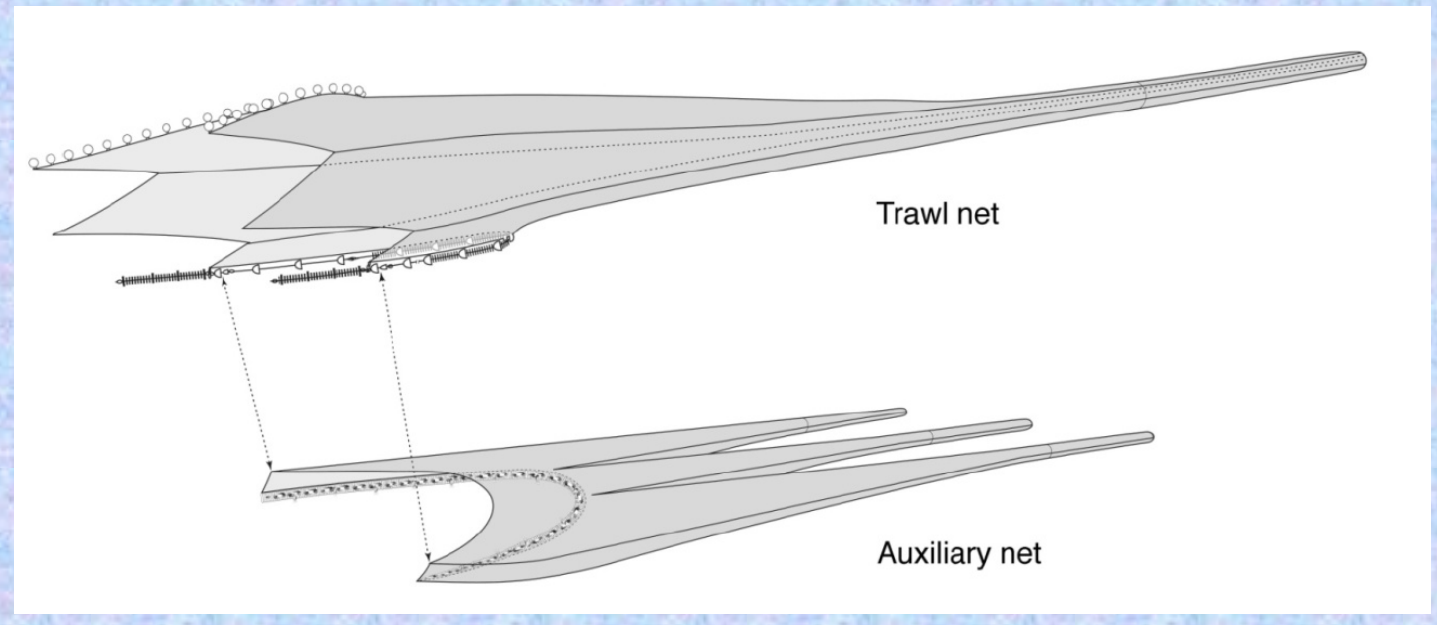
Rose, Hammond, Stoner, Munk & Gauvin. 2013. Fishery Bulletin 111: 42-53

Unobserved mortality rates with recent (2013) **footrope** designs

NPRB project 2011-17

Older style footrope

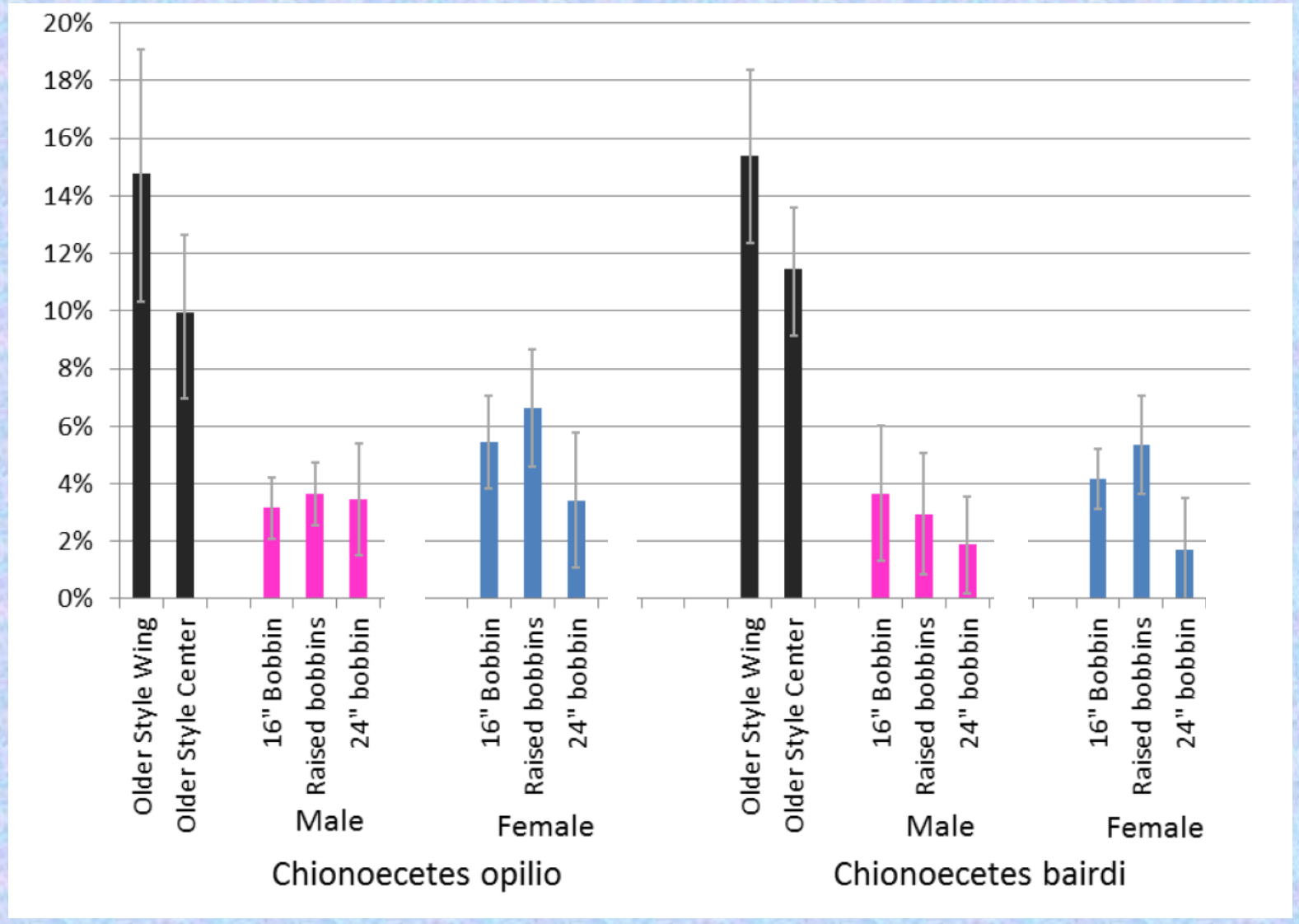
Less weight and more clearance space



- Footrope used in initial trials – Heavy
- Industry feedback – Recent footropes use less steel and more seafloor clearance
- Tested three other footrope designs
- Recapture net covered the full footrope of full-scale trawls
  - Unobserved mortality rates and catch rates of crabs

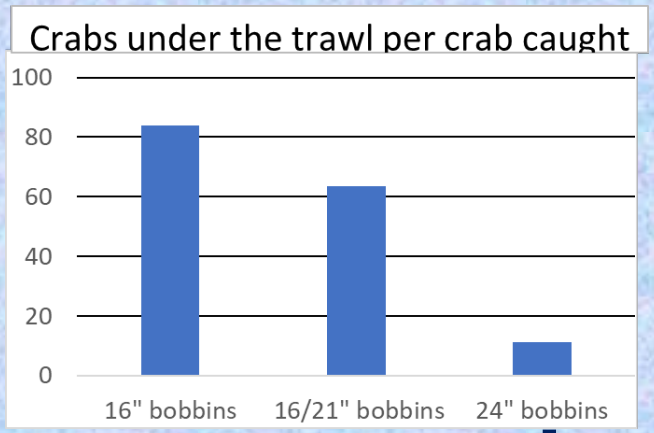
Hammond, Conquest & Rose 2014. ICES Journal of Marine Science 70: 1308-1318.

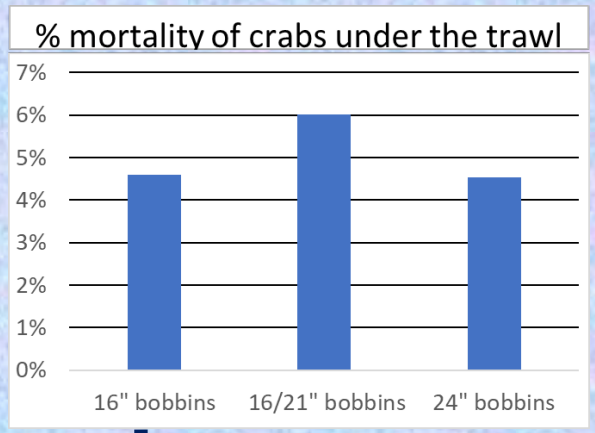
Unobserved mortality rates with recent **footrope** designs

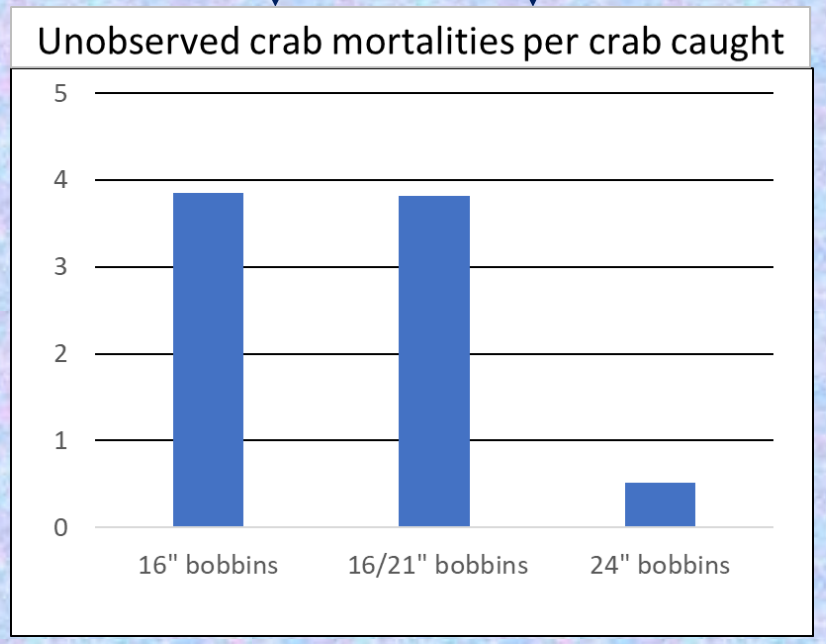


Rose, Hammond & Swanson. 2014. NPRB Project 1117 Final Report. 26 pp.

Estimating unobserved crab mortalities from capture and mortality rates





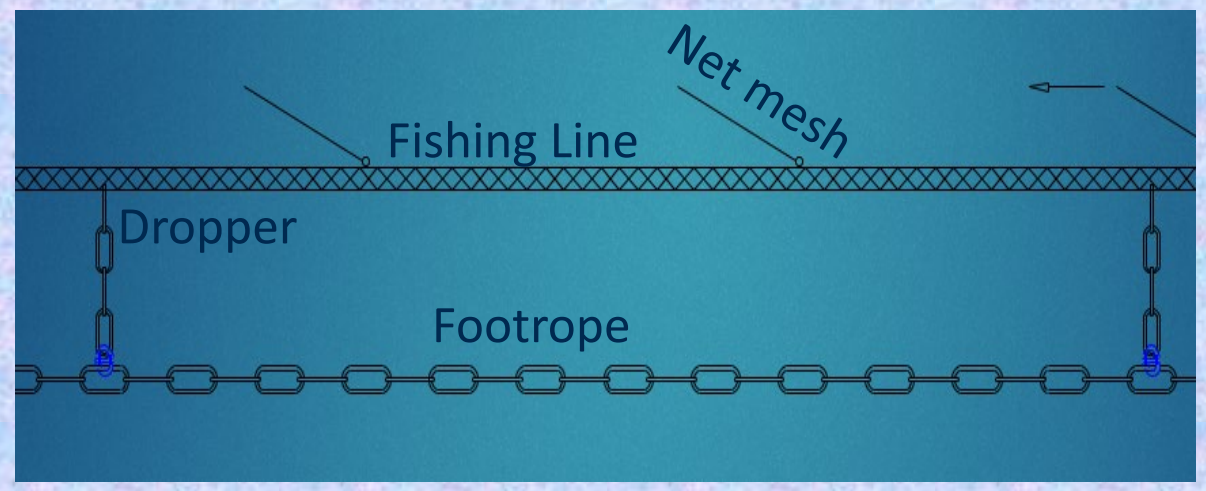


- With crab counts from underbag and codend, their ratio, crabs escaping per crab caught, can be calculated
- With % mortality, unobserved mortalities per crab caught can be estimated
- Not calculated in the original report
- Capture proportions changed substantially with footrope rigging – net trailed from the top of bobbins (16 & 16/21) vs. center (24”)

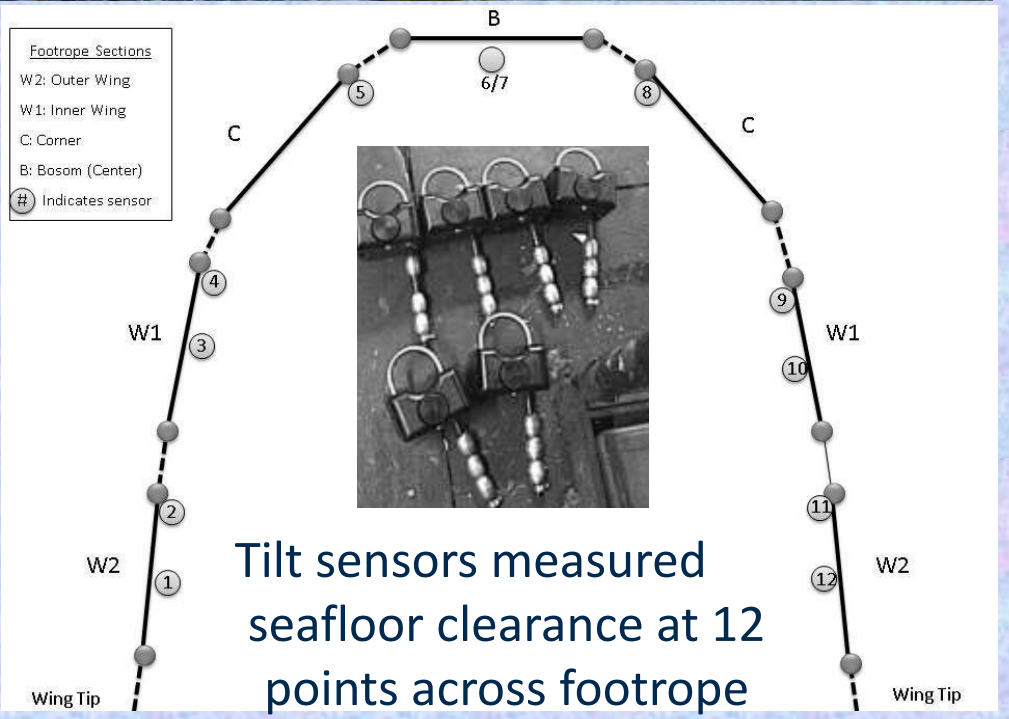
Rose 2022 (Oct). Written comment to NPFMC on Snow Crab topic

Pelagic trawl footrope to reduce seafloor impacts

NPRB project 2013-19



- Current footropes all chain
- Instead, weight was concentrated in 6’ sections of very heavy chain with 90’ rope sections between
- With or without bobbins

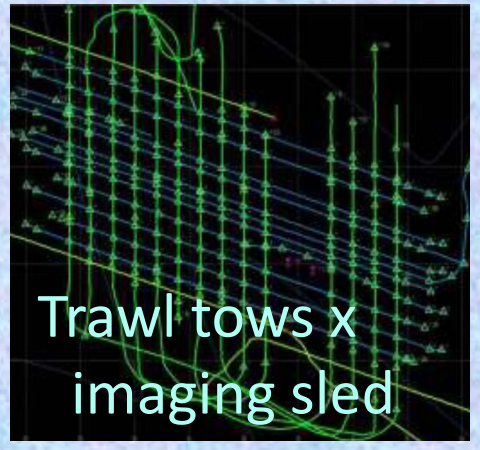


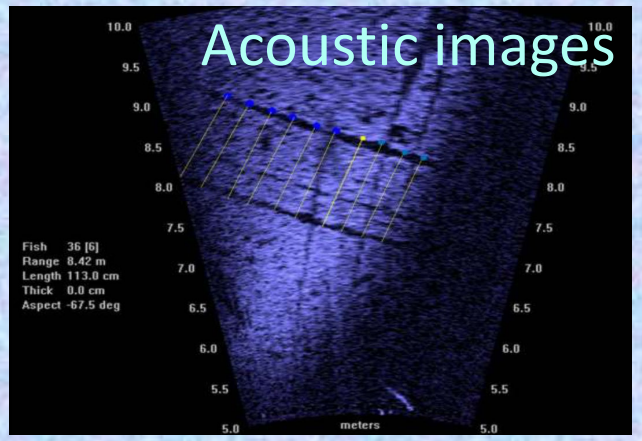
Tilt sensors measured seafloor clearance at 12 points across footrope

Rope sections were off-bottom

Rose, C.S., B.P. Harris, S.L. Zagorski, C.F. Hammond, S.A. Sethi, S. McEntire. 2016. NPRB Project 1319 Final Report. 53 pp.

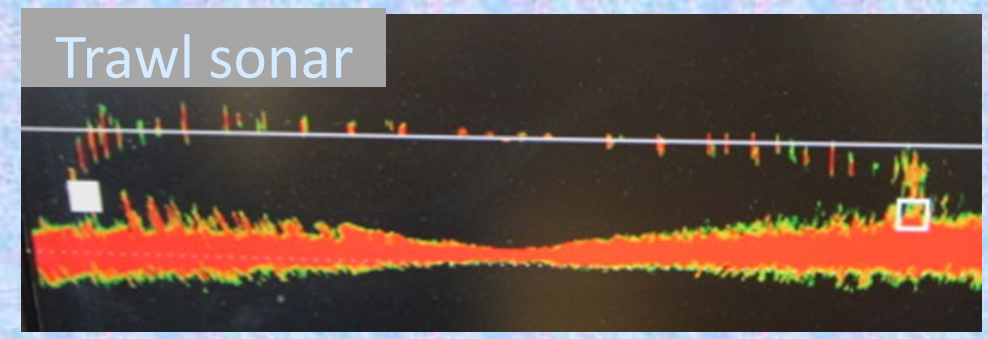
Pelagic trawl footrope to reduce seafloor impacts





Sea whip condition (video)

Trawl sonar



- Small seafloor contact (2-16%)
- Small sea whip effects (<10%)
- Sonar missed footrope clearance
- Variable contact across net
  - Many chain marks were missing

Zagorski S.L. 2016. APU Masters Thesis. 91 pp.

What Council Actions Are Informed by Benthic Impact Research?

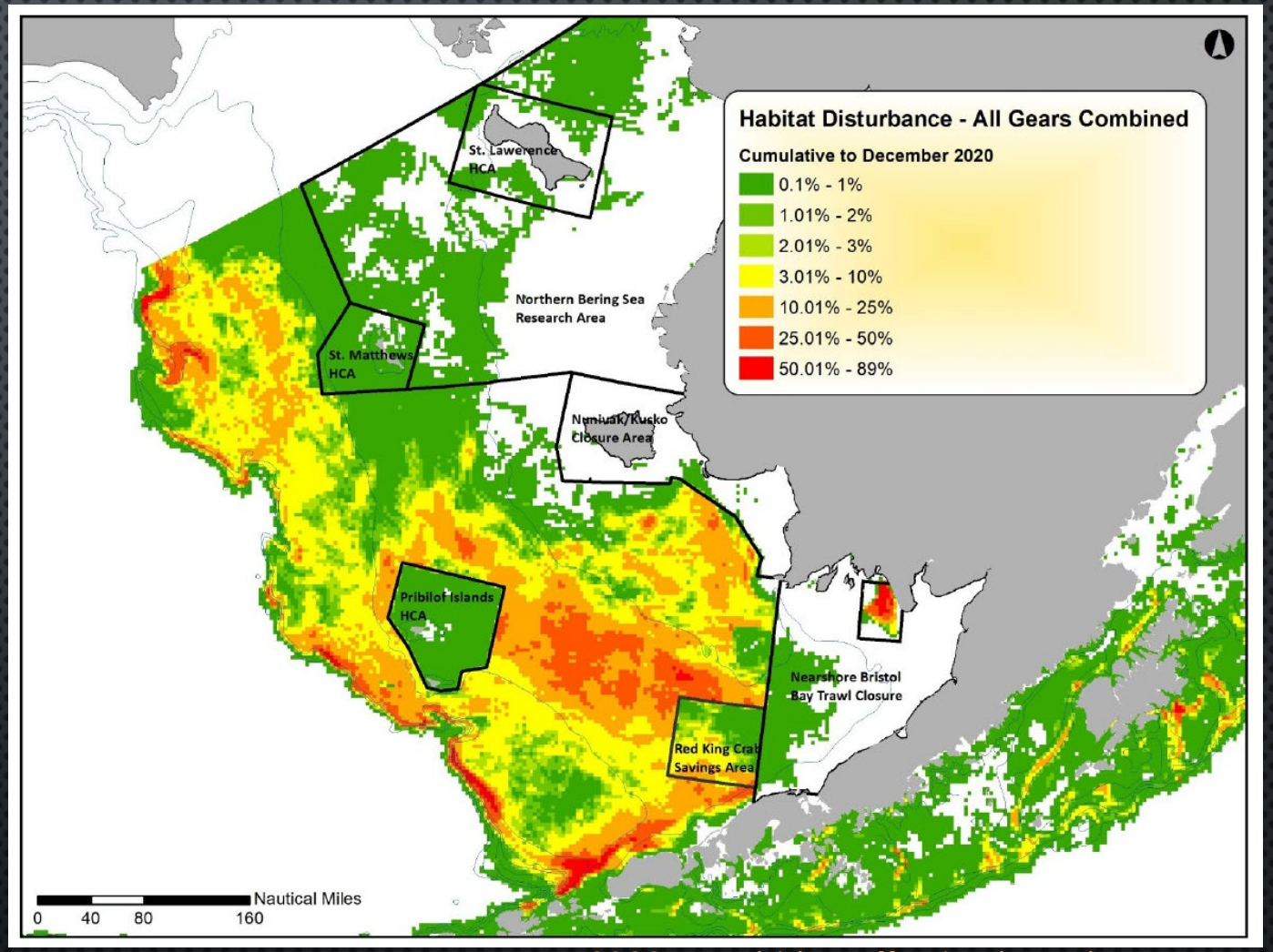
- Essential Fish Habitat actions
  - Inform Fishing Effects Model

- Gear configurations with less impact
  - Raised sweep requirement
  - Voluntary use or motivated by bycatch quotas

- Bycatch management
  - Unobserved crab mortality

FISHING EFFECTS MODEL

- Fishing Effects Model employs spatially-explicit Vessel Monitoring System (VMS), Observer data, gear dimensional and contact information and literature-based habitat impact information to:
- Estimate fishing footprint and bottom contact based.
- Estimate cumulative impacts of fishing on on Essential Fish Habitat while accounting for the nature of its ability to recover.

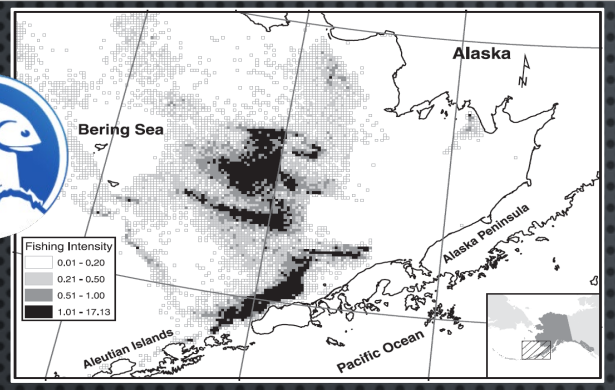


2022 EFH Fishing Effects Discussion Paper

Brad Harris, Ph.D.

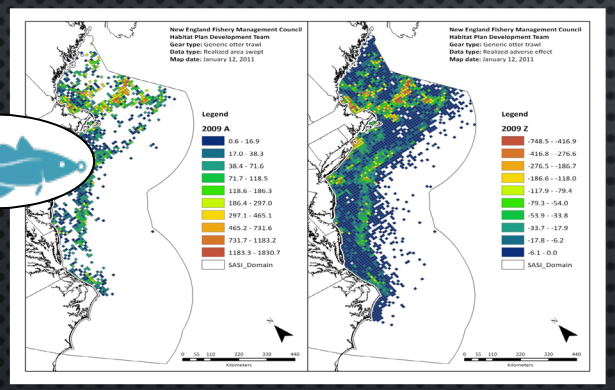
- Fisheries Aquatic Science & Technology Laboratory, Alaska Pacific University -

FISHING EFFECTS MODEL - FOUNDATIONS



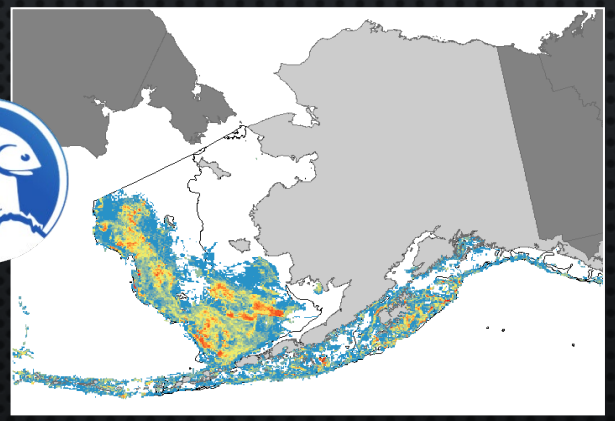
Long-term effects index (LEI)

- NPFMC 2005 & 2010 EFH reviews, Fujioka (2006)
- Continuous time, 5x5 km resolution, End-point only
- 4 substrate types × 4 habitat features × 11 gear types



Swept Area Seabed Impacts (SASI)

- NEFMC EFH Reviews since 2010, Grabowski et al. (2014)
- Discrete time (annual), 10x10 km resolution, Trip Reports
- 2 energy regimes × 5 substrate types × 27 substrate-specific habitat features × 9 gear types



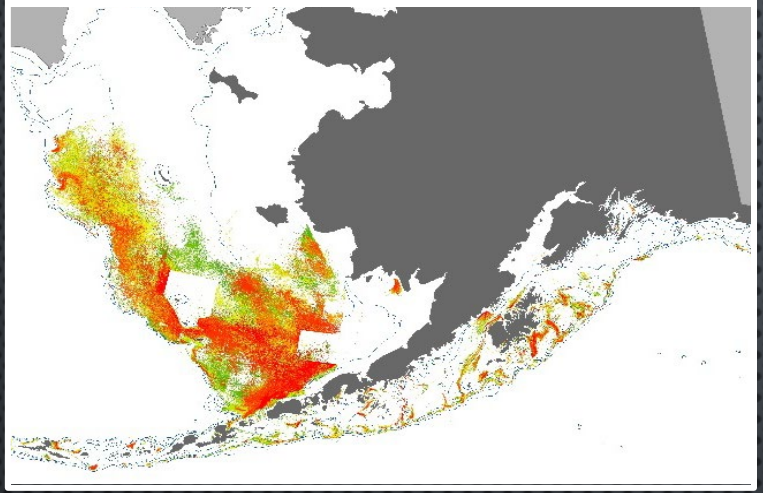
The Fishing Effects (FE) Model

- NPFMC EFH Review since 2015, Smeltz et al. (2019)
- Discrete time (monthly) 2003 - 2022, CIA
- 5 substrate types x 27 substrate-specific habitat features × 73 gear types

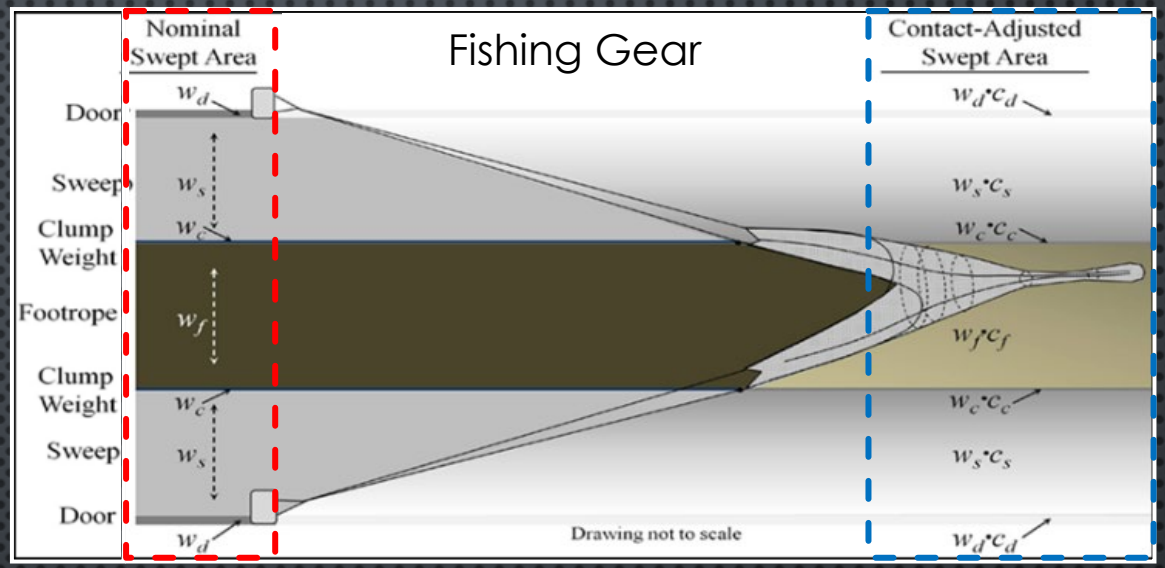
FISHING EFFECTS MODEL – WORKFLOW

Fishing Module

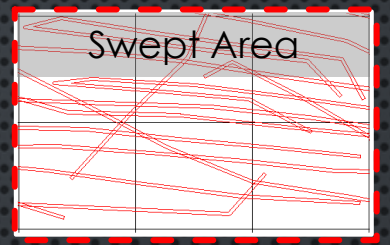
Fishing Events



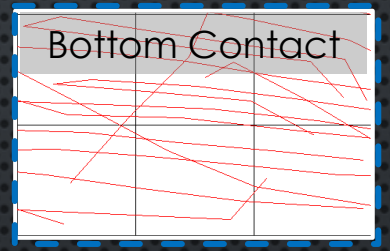
Fishing Gear



Swept Area

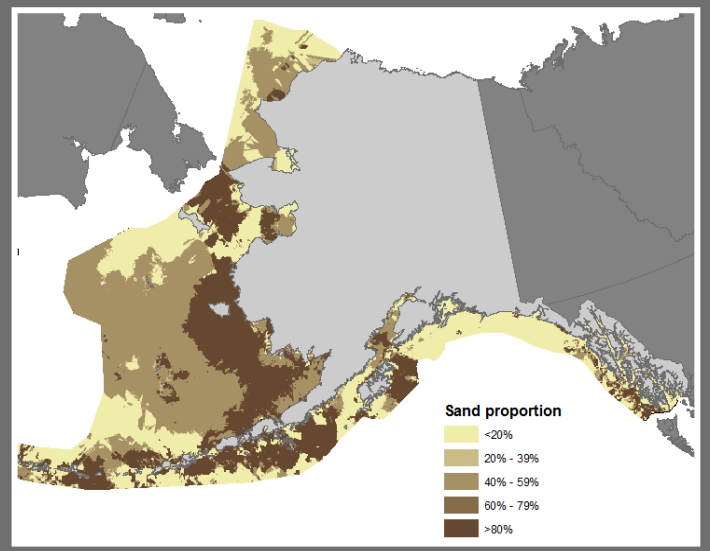


Bottom Contact

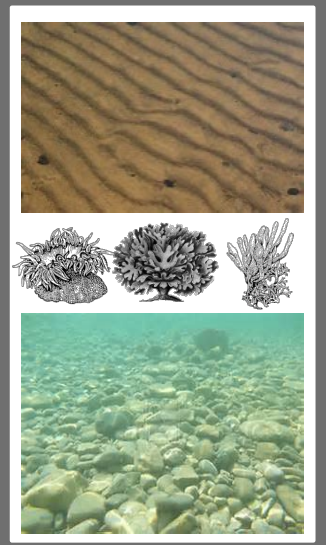


Habitat Module

Habitat
Sediments (N = 5)

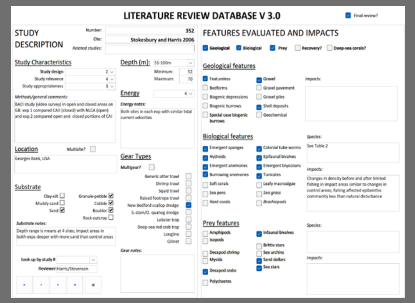


Features
Geo / Bio (N = 27)



Impacts
Literature

Susceptibility
(Prop. Disturbed)



Recovery
(Time to 95%)

Fishing Effects

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

Impacts (I')

Disturbed (h) ⇄ Undisturbed (H)

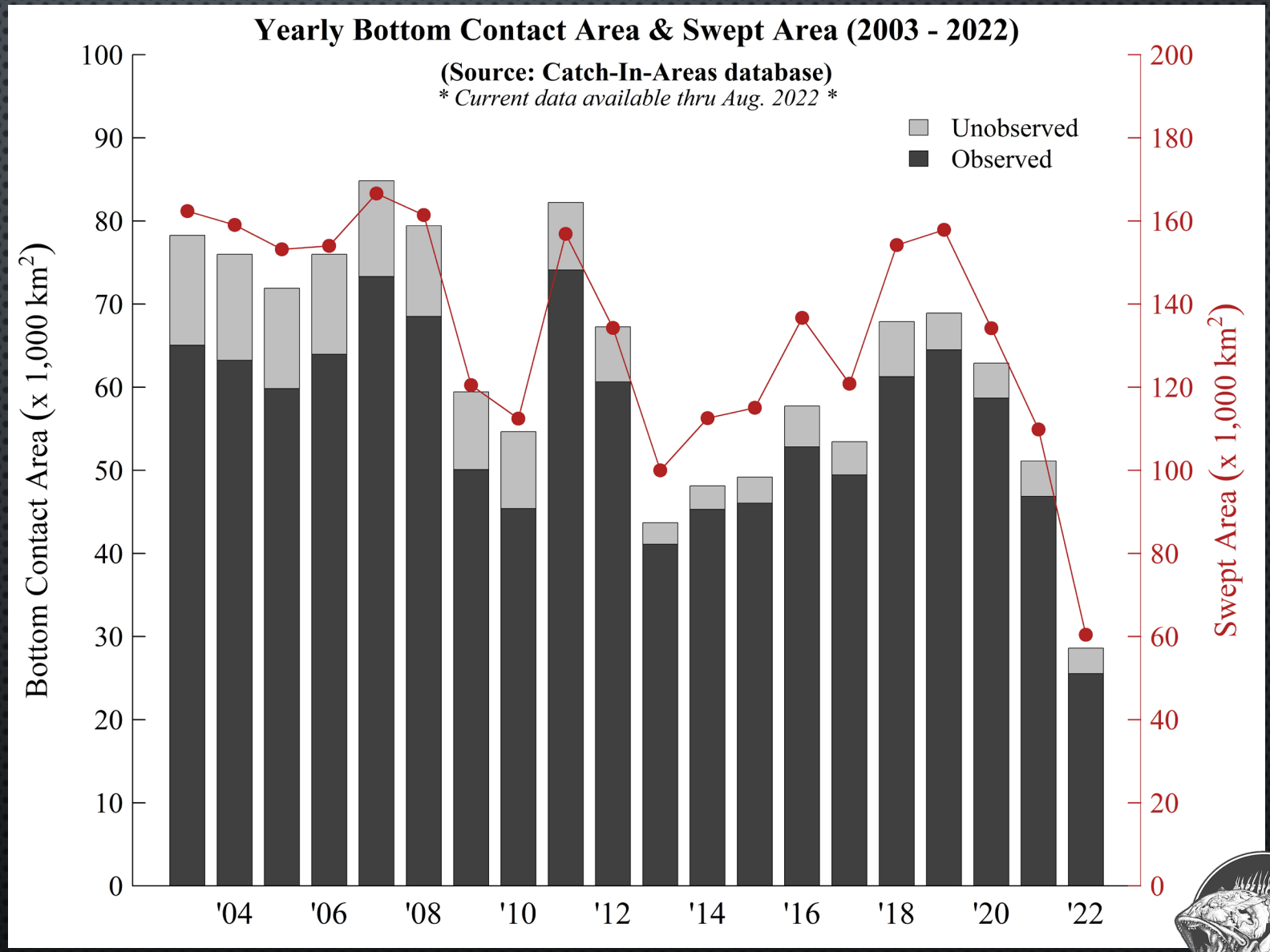
Recovery (ρ')

FISHING EFFECTS MODEL – FISHING

GOA & BSAI 2003 - 2022:
- All Gears (N = 73)
- 8 Million Fishing Events
- % Unobserved = 12 – 18%
- Footprint = 58 – 67k km^2
- Contact = 30 - 85k km^2

2013 – 2022
- ↓ % Unobserved Fishing

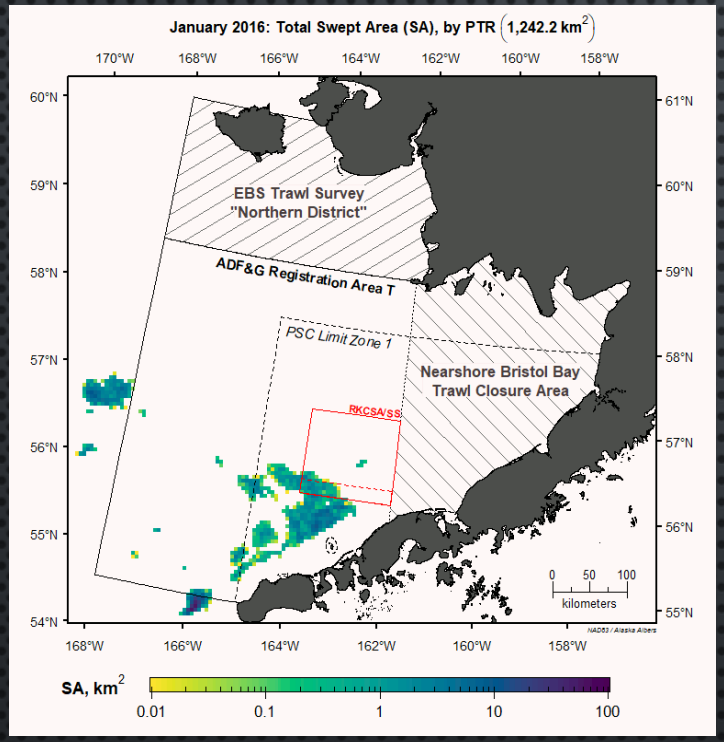
2019 - 2022:
- ↓ Swept Area
- ↓ Contact



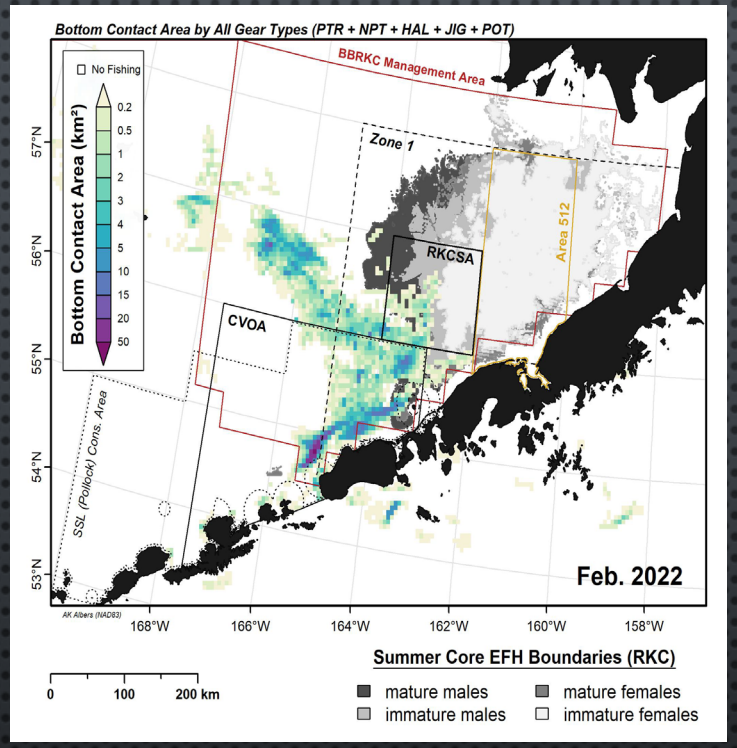
JIG = 3, POT = 4, HAL = 7, NPT = 24, PTR = 35

FISHING EFFECTS MODEL – FISHING INFORMATION PRODUCTS

Swept Area



Bottom Contact



Trends by (Management) Area

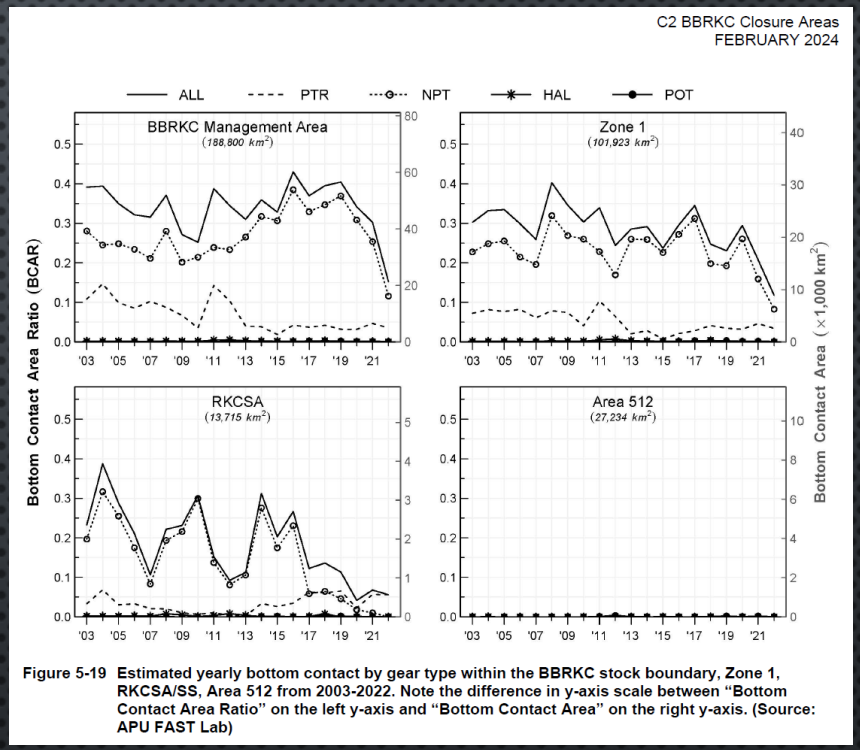


Figure 5-19 Estimated yearly bottom contact by gear type within the BBRKC stock boundary, Zone 1, RKCSA/SS, Area 512 from 2003-2022. Note the difference in y-axis scale between "Bottom Contact Area Ratio" on the left y-axis and "Bottom Contact Area" on the right y-axis. (Source: APU FAST Lab)

Swept Area (Fishing Footprint)

- Area of *potential* gear – seabed interaction
- Gear(s)
- Monthly
- 5x5 km
- No Habitat Information
- ⚠ Overlap

Bottom Contact (adjusted Swept Area)

- Area of *expected* gear – seabed interaction
- Gears(s)
- Monthly
- 5x5 km
- No Habitat Information
- ⚠ Overlap

Summary Information

- Footprint vs. Contact
- Ratio vs. Area
- Gear(s)
- Monthly
- 5x5 km
- No Habitat Information
- ⚠ Trends

FISHING EFFECTS MODEL - HABITAT

2003-2020:

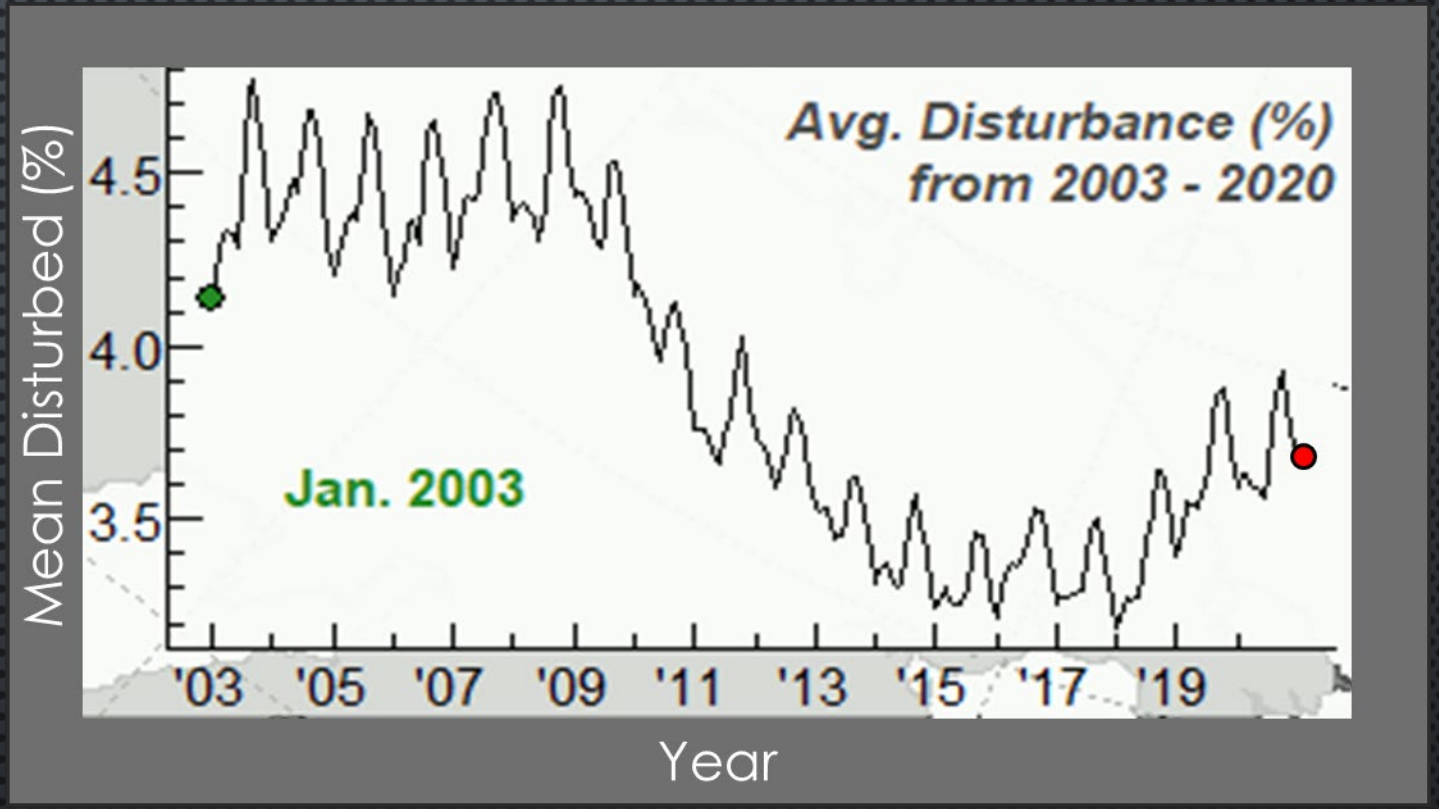
- 3.2 – 4.8% of benthic habitat (<1000m) in a disturbed state.
- A/B Season pulse of fishing disturbance.
- 2008
  - ↓ Disturbance
    - A80, Elevated-sweeps, …

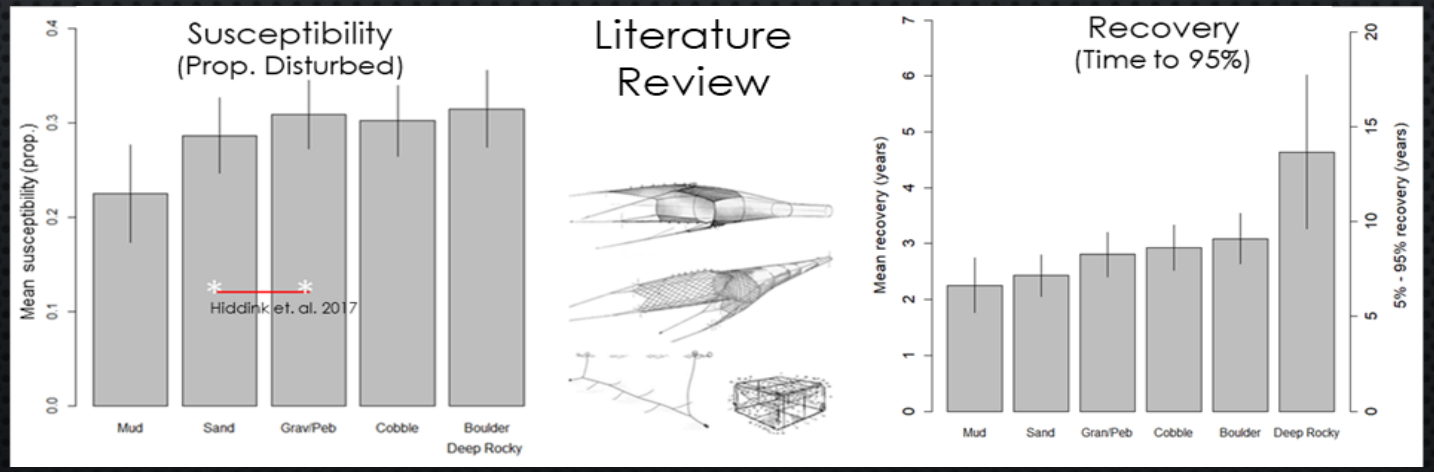
2019 - 2020

- ↑ Disturbance

December 2020:

- 3.8% of habitat in a disturbed state, 96.2% undisturbed.





FISHING EFFECTS MODEL - HABITAT

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- A/B Season pulse of fishing disturbance.

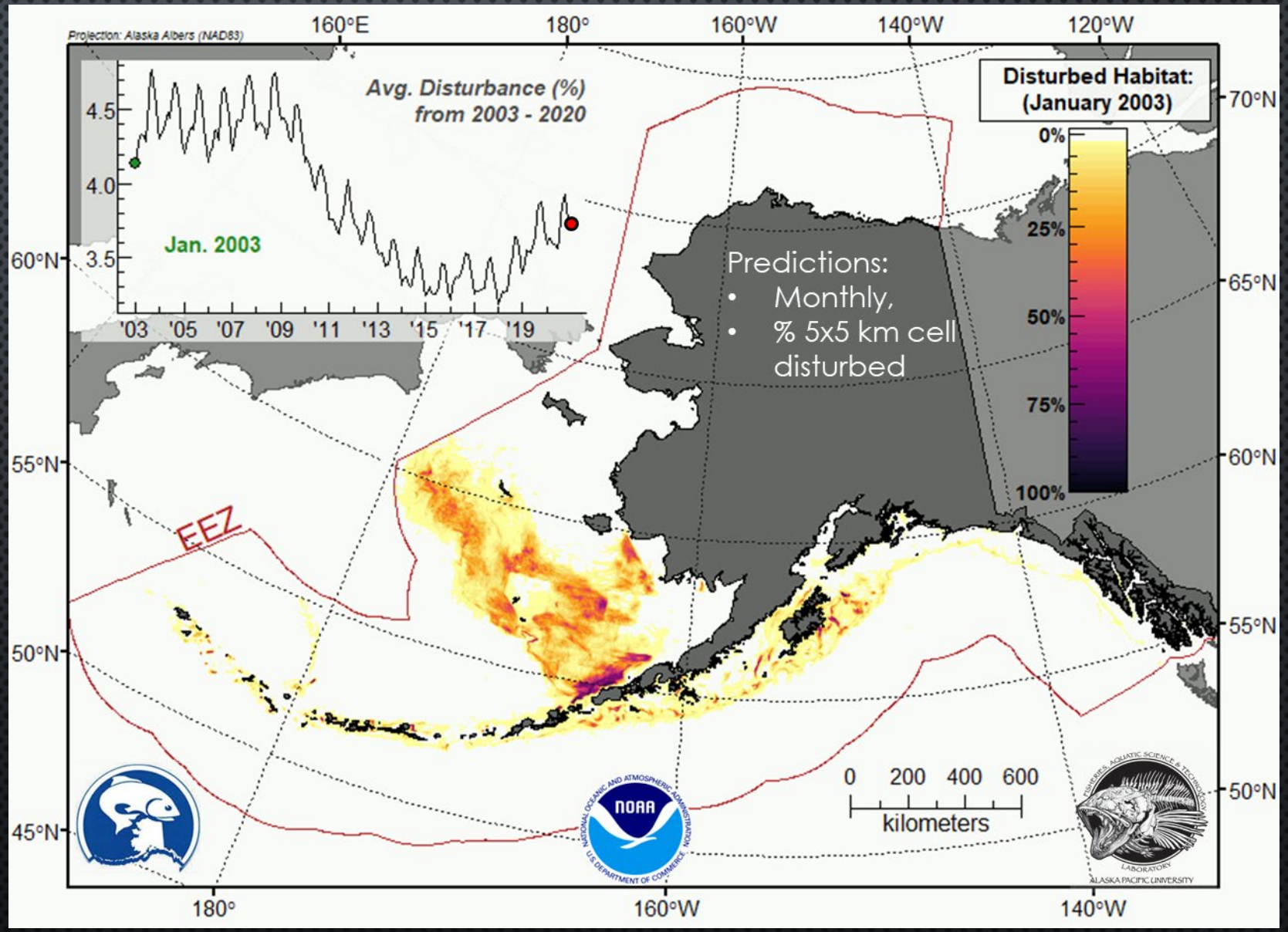
- 2008
  - ↓ Disturbance
    - A80, elevated-sweeps, …

2019 - 2020

- ↑ Disturbance
  - Shift N. in fishing, …

December 2020:

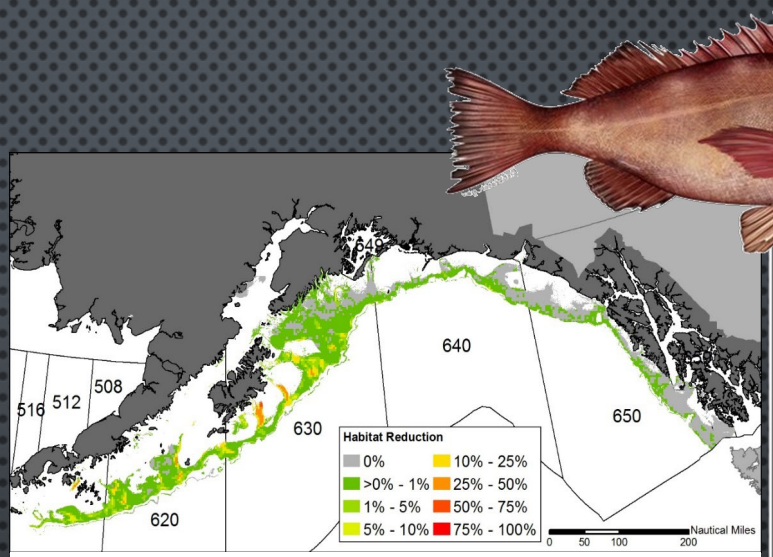
- 3.8% of habitat in a disturbed state, 96.2% undisturbed.

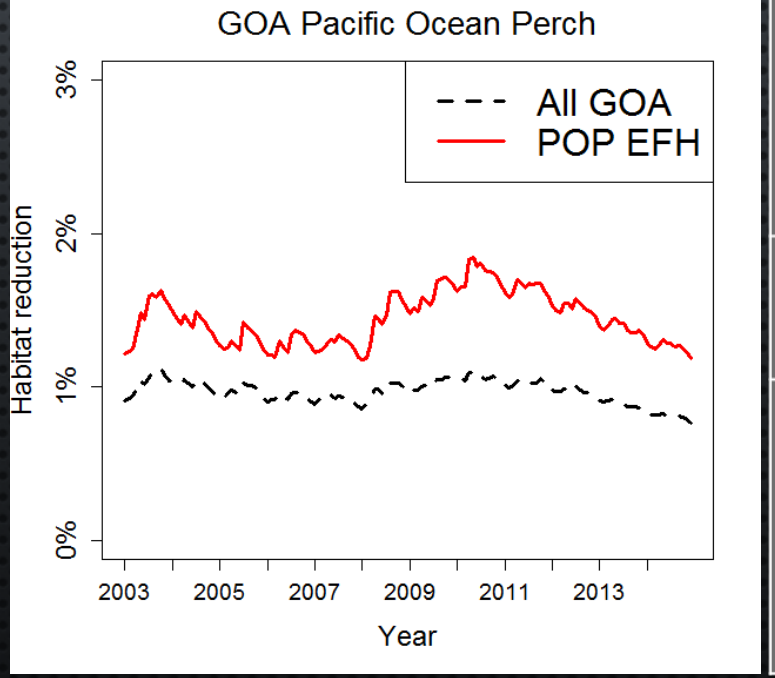


FISHING EFFECTS MODEL – EFH: *ADVERSE FISHING EFFECTS*

Essential Fish Habitat Adverse Fishing Effects Framework

- *More than minimal & not temporary*
- *FMP Species - Feeding, breeding and growth to maturity*





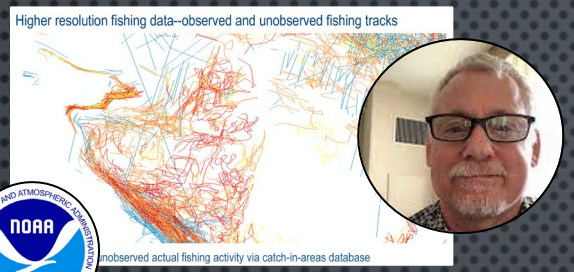
	Element	ρ	p-value
Average size-at-age	age-3	-0.49	0.33
	age-4	-0.25	0.63
	age-5	-0.56	0.24
	age-6	-0.58	0.23
	age-7	-0.20	0.71
	age-8	-0.71	0.11
	age-9	-0.25	0.63
	age-10	-0.60	0.21
	age-11	0.02	0.97
	age-12	-0.40	0.43
	age-13	-0.38	0.46
	age-14	0.42	0.41
	age-15	-0.14	0.79
LVB params	L_∞	0.56	0.33
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

FISHING EFFECTS MODEL – NEXT

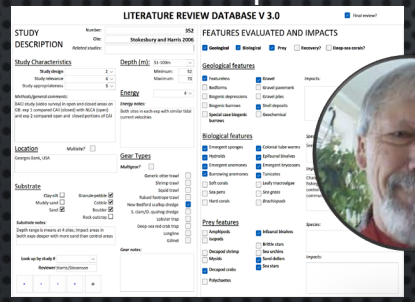
Gear tables

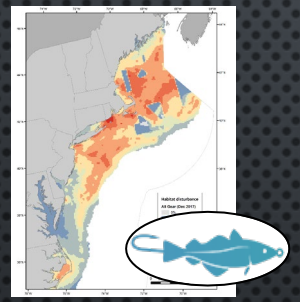
GearID	Gear	Fishery
2	trawl	GOA Pollock Pelagic Trawl
3	trawl	GOA Slope Rockfish Pelagic Trawl
5	trawl	GOA PCod Bottom Trawl Inshore
11	trawl	GOA Slope Rockfish Bottom Tra
23	trawl	BS Pollock Pelagic Trawl (incl M
24	trawl	BS Pollock Pelagic Trawl
42	trawl	BS Pcod Bottom Trawl
47	trawl	BS Yellowfin Sole Bottom Trawl
57	trawl	AI Pcod Bottom Trawl
61	trap	BSAI Pcod Pot
68	longline	BSAI Pcod Longline
72	trap	BS Pcod Jig

Catch-in-Areas DB

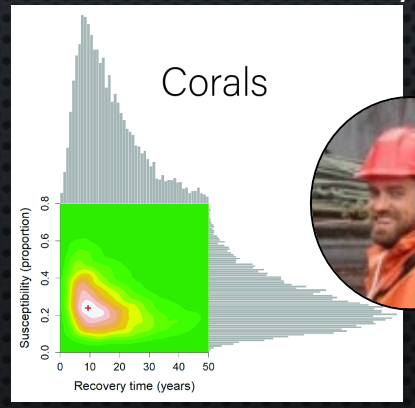


Habitat Impacts





Habitat Recovery



Updates - Underway

- *Fishing*
  - Catch-in-Areas
  - Footprint & Bottom Contact
- *Habitat Effects*
  - Species
  - Life stage
  - Stock area
  - Fishery

Upgrades - Future

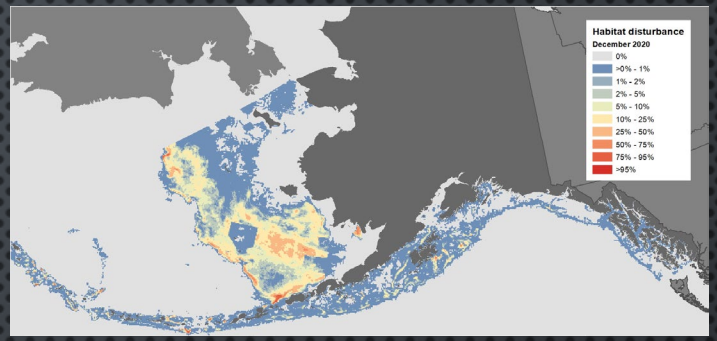
- *Scenario -Exploration*
  - Response to changes - regs, environment, fish, markets
- *Gear – Fishery Species Interactions*
  - Catch/ Discard performance
  - Unobserved Fishing Mortality

POLLOCK GEAR PROJECT

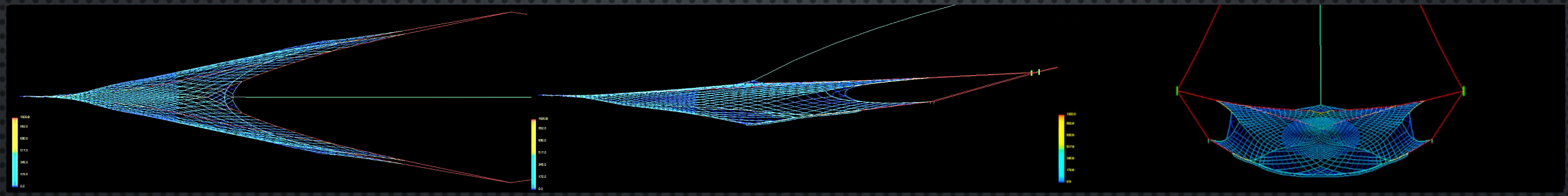
- Cataloging the gear (K. Yahnke)

	A	B	C	D	E
1	ID_trawl	Year	Company	Vessel	Trawl
2	1	2023	Confidential	Confidential	Egersund 1128
3	2	2023			Egersund 1512
4	3	2023			Egersund 1824
5	4	2023			Egersund 1128
6	5	2023			Egersund 1512
7	6	2023			Egersund 1632
8	7	2023			Egersund 1920
9	8	2023			Egersund 1512
10	9	2023			Swan 1280
11	10	2023			Egersund 1920
12	11	2023			Swan 1056

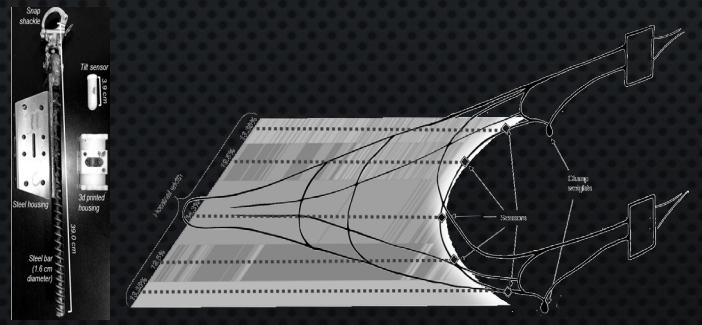
Comp_Vess_Gear | Doors | Bridles | Weight Chains | Footrope | Nom and adj width | FEM_Table

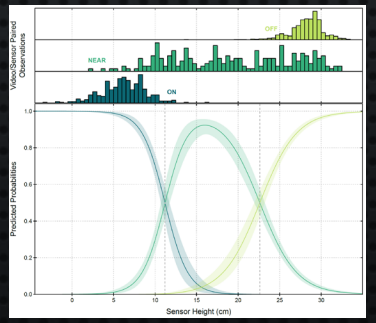


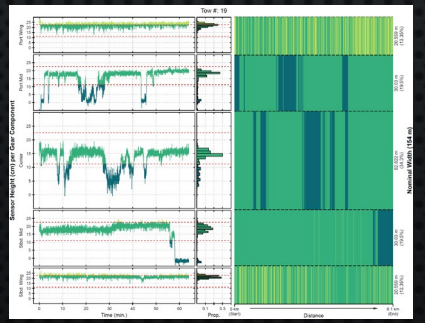
- Simulating the gear (FMI - Memorial University)

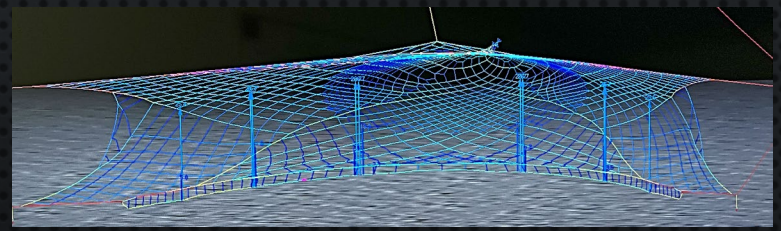


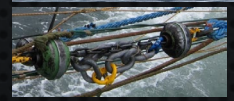
- Measuring gear – seabed interactions

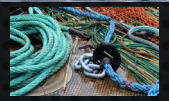


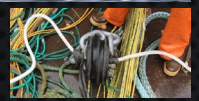








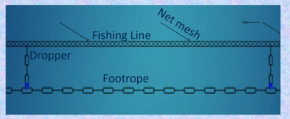


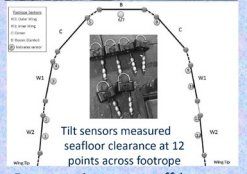


FOOTROPE MODIFICATION
NPRB PROJECT 1319

Pelagic trawl footrope to reduce seafloor impacts

NPRB project 2013-19

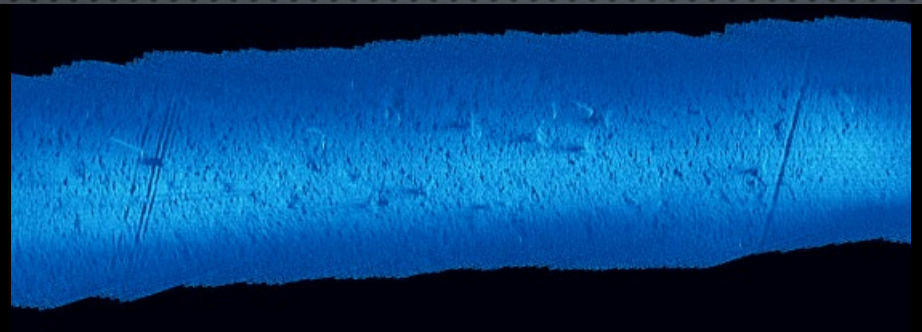




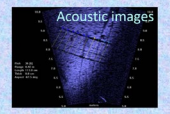
- Current footropes all chain
- Instead, weight was concentrated in 6′ sections of very heavy chain with 90′ rope sections between
- With or without bobbins

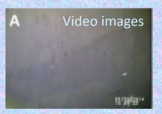
Rope sections were off-bottom

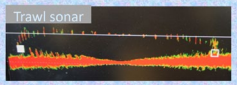
Rose, C.S., B.P. Harris, S.L. Zagorski, C.F. Hammond, S.A. Sethi, S. McEntire. 2016. NPRB Project 1319 Final Report. 53 pp. 18



Pelagic trawl footrope to reduce seafloor impacts



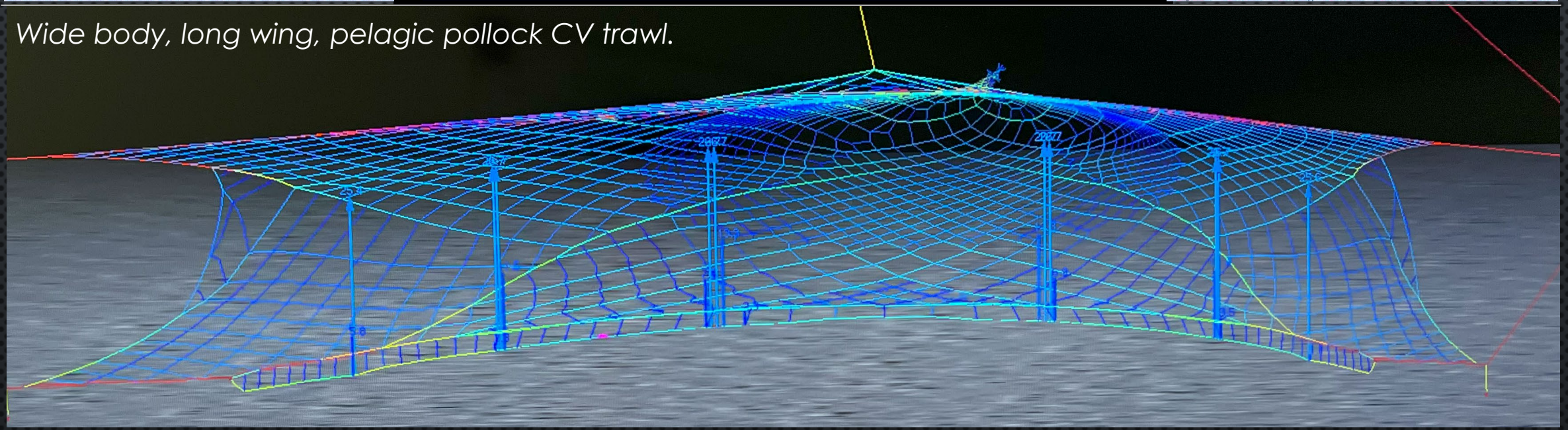




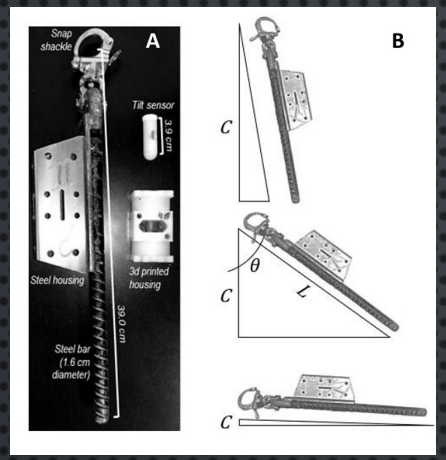
- Small seafloor contact (2-16%)
- Small sea whip effects (<10%)
- Sonar missed footrope clearance
- Variable contact across net
  - Many chain marks were missing

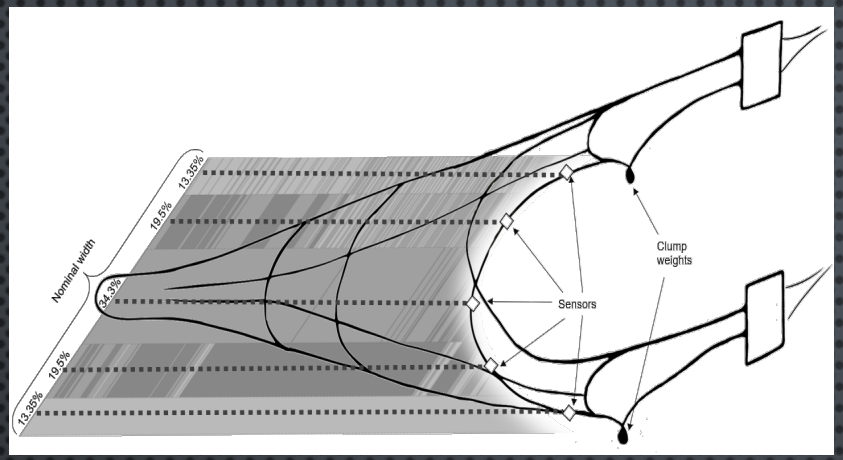
Zagorski S.L. 2016. APU Masters Thesis. 91 pp. 19

Wide body, long wing, pelagic pollock CV trawl.



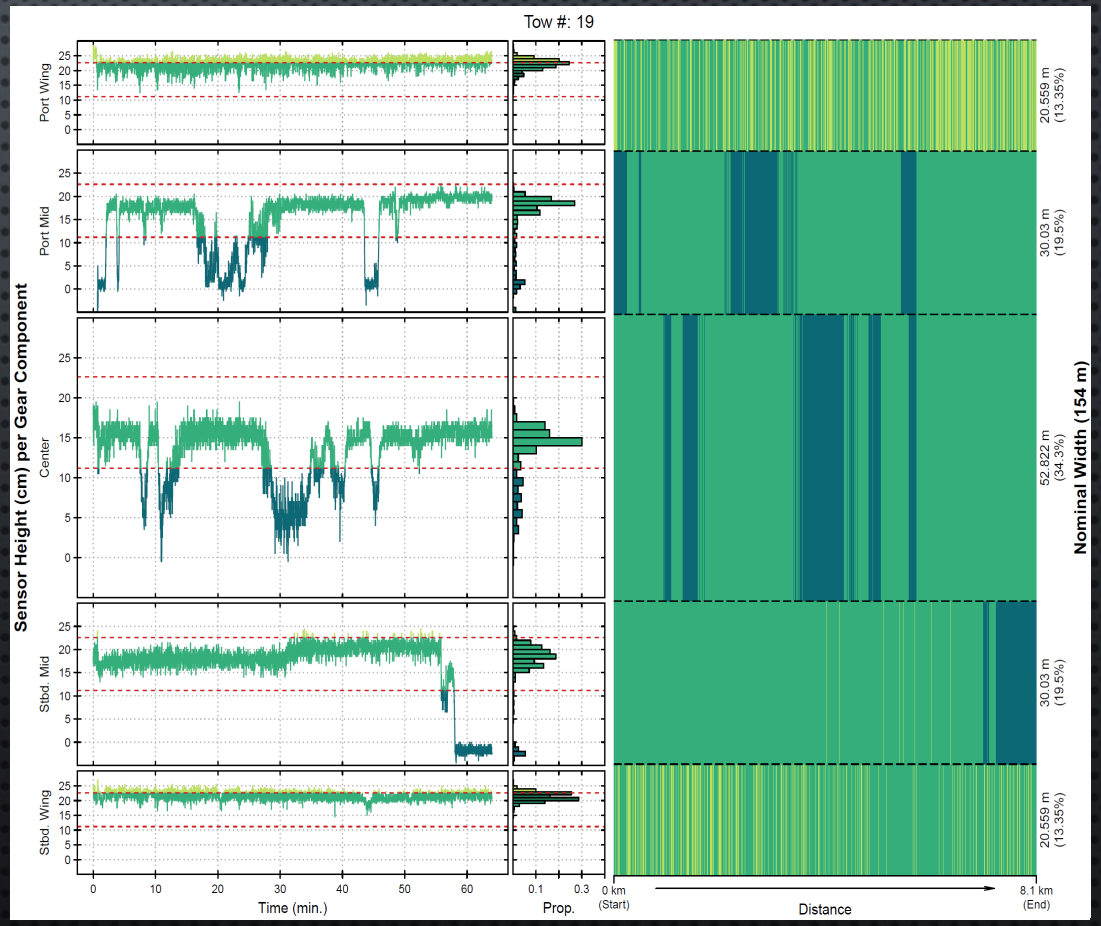
MEASURING GEAR – SEABED CONTACT AND CLEARANCE

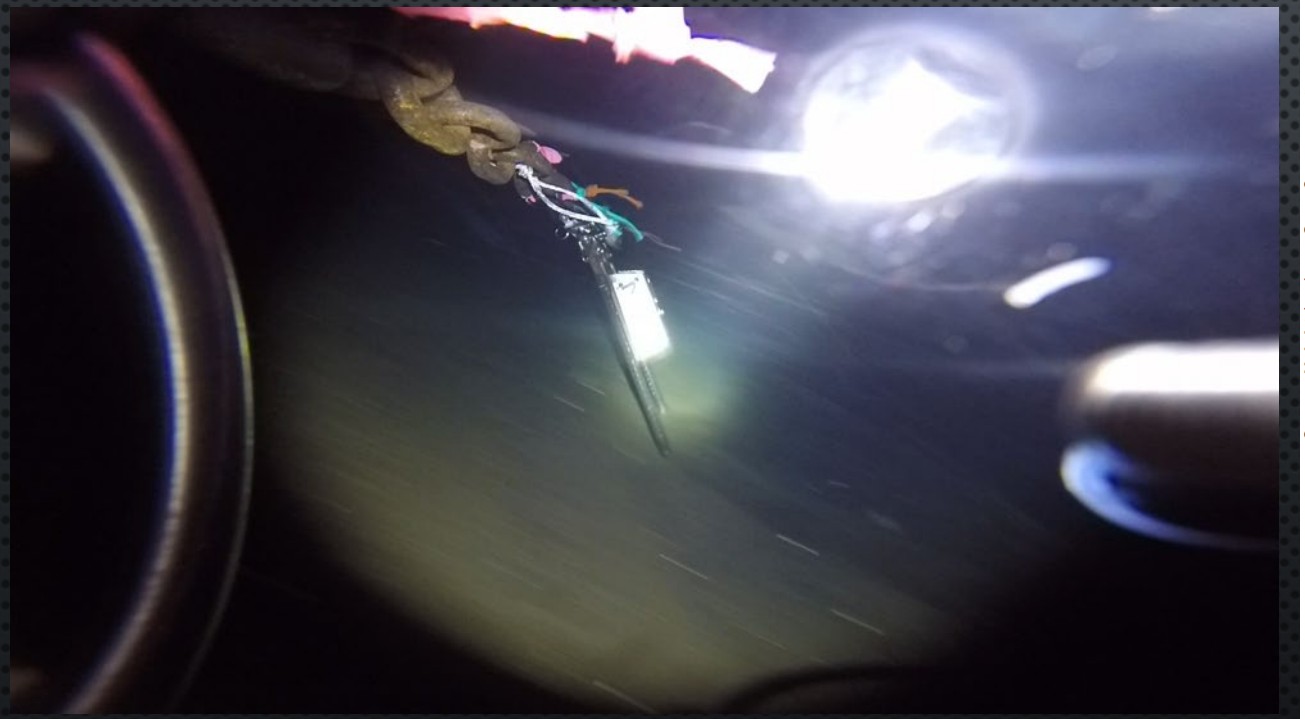




Hampidjan Gloria Wide body 672
24 mm-chain footrope
F/V Pacific Explorer

Validating and Interpreting Sensor Data





- FEM Assumes = 20 – 60%
- On Bottom = 27.4% (±5.5%)

THANK YOU

Dr. S. Smeltz
F. Restrepo
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*J. Olson
M. Eagleton
Dr. S. Lewis
Dr. C. Rose
Dr. J. Pirtle
*A. Nimick
*S. Zagorski
*B. King
*K. Yahnke
NPFMC SSC
AKRO Habitat
NEFMC SSC
NEFMC Habitat PT
…

Tilt-sensor deployment

FISHERIES INSHORE NEW ZEALAND