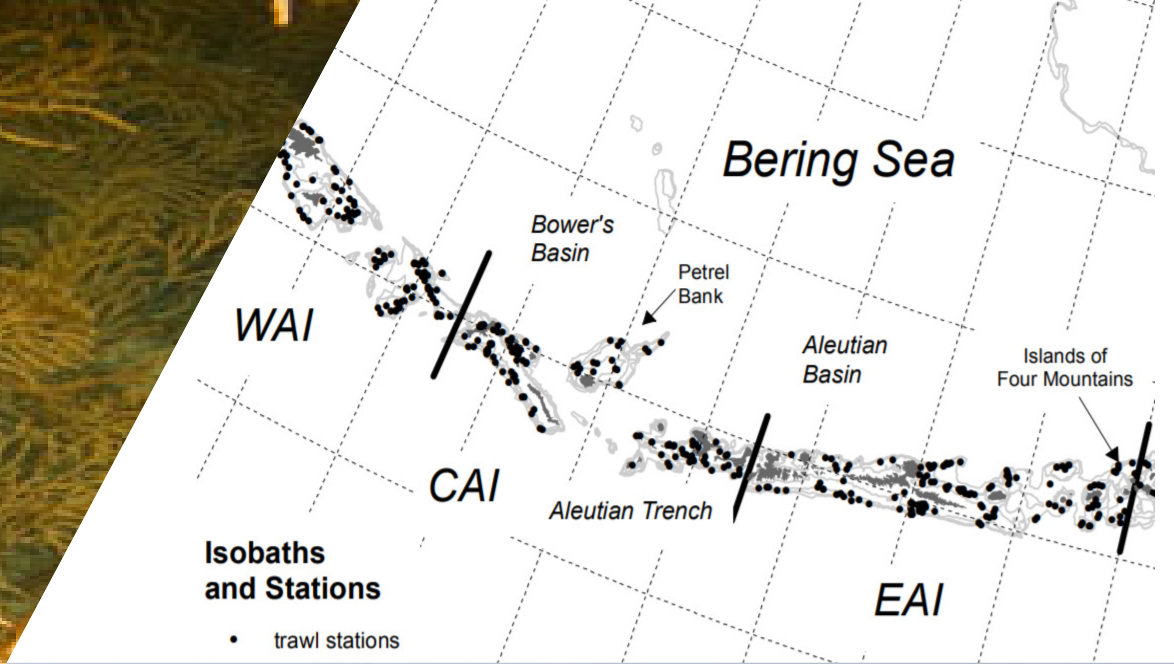
Quantifying the overlap of fisheries with deep-sea corals and sponges in the Aleutian Islands, Alaska

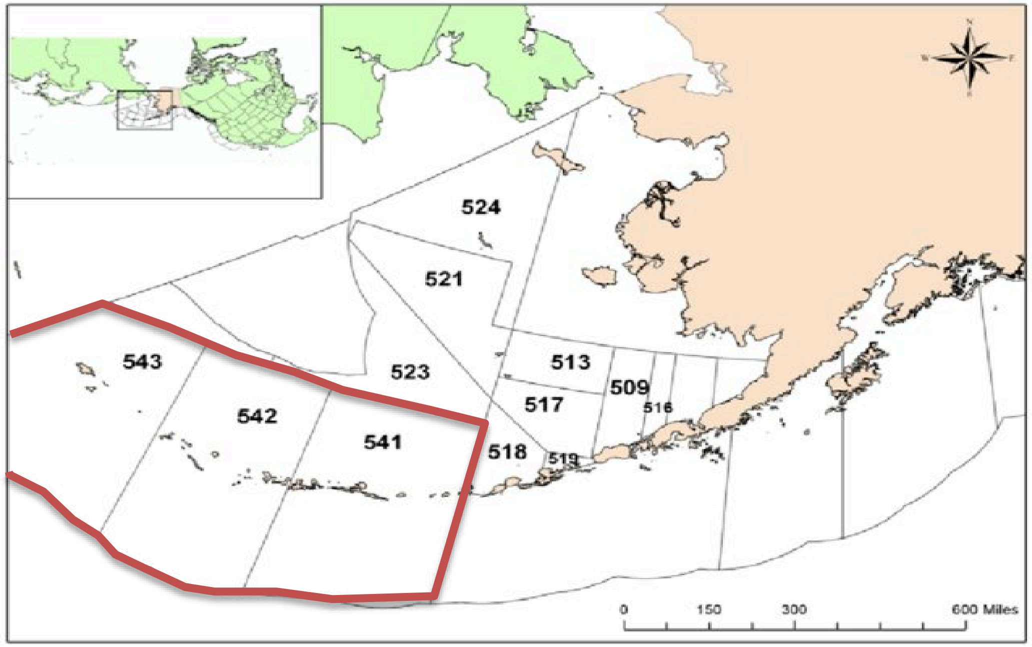


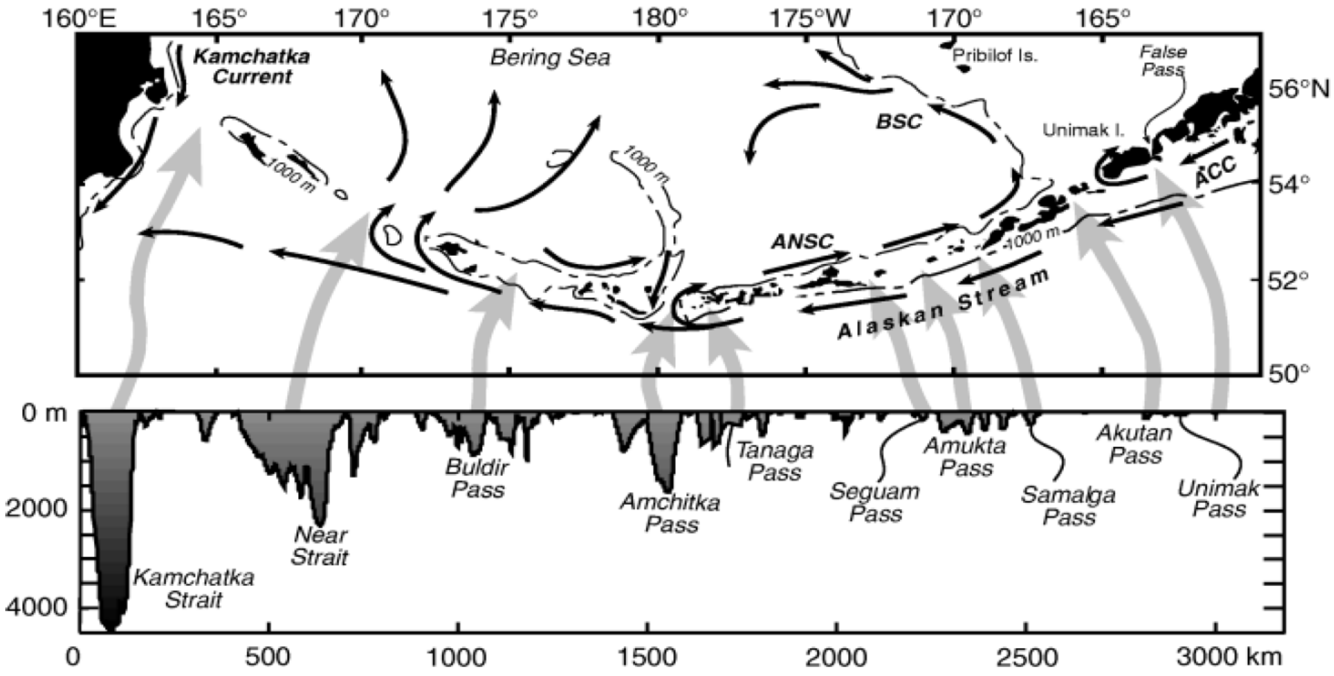
John V. Olson

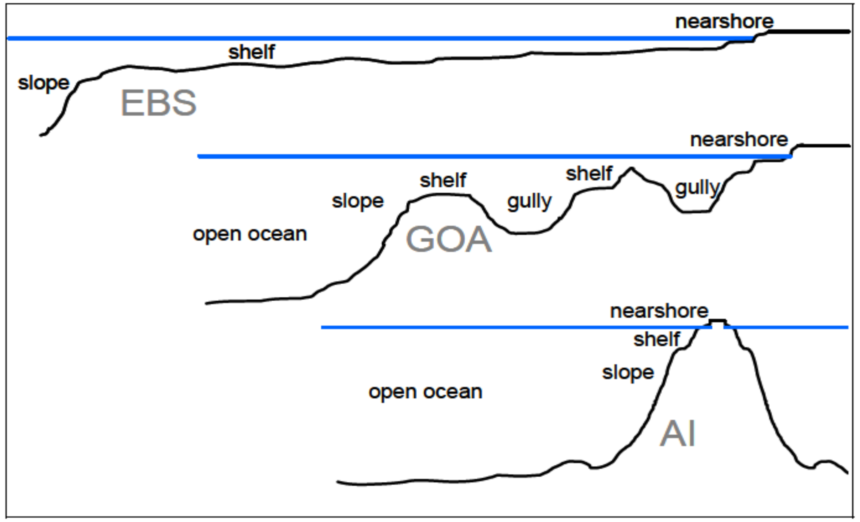
National Marine Fisheries Service
Habitat Conservation Division
Anchorage Field Office

Alaska Pacific University
Fisheries, Aquatic Science, and Technology Lab

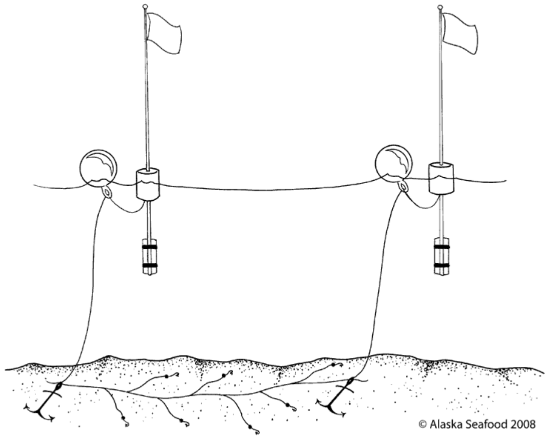
Aleutian Islands

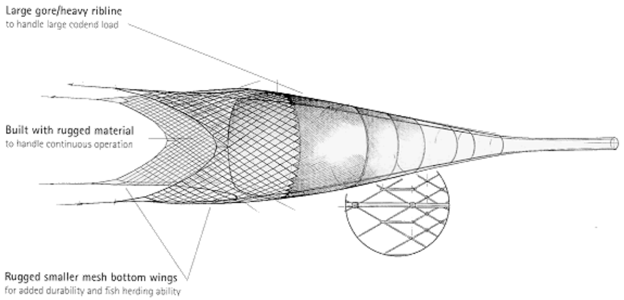


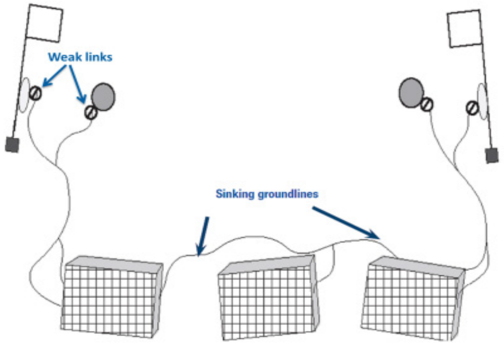


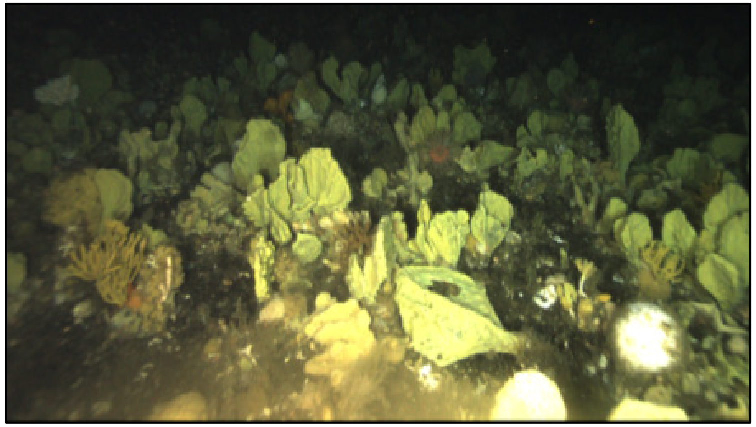


Aleutian Island resources







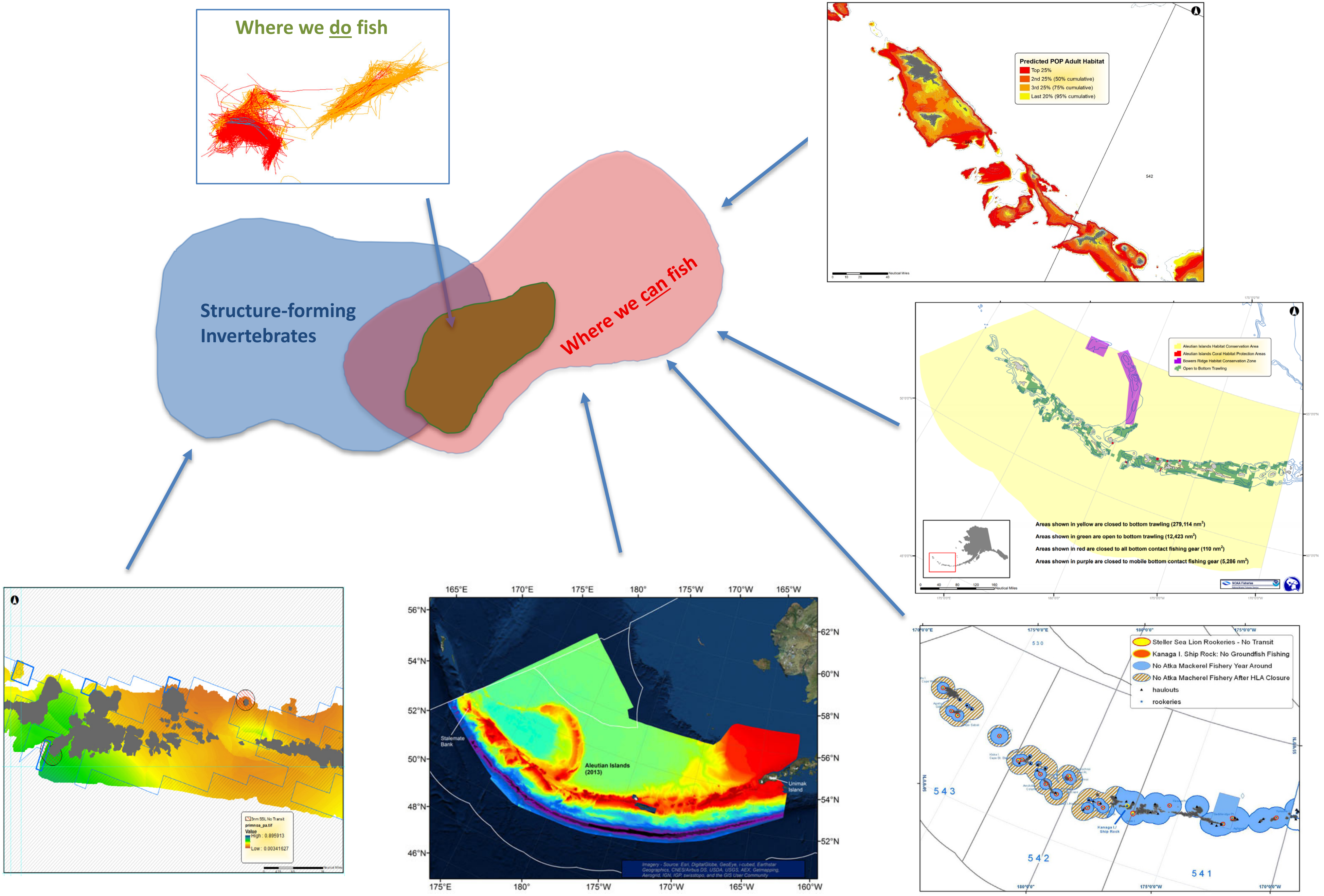


Objectives

Use Vessel Monitoring System (VMS) data to delineate the footprint of commercial fishing by gear and target, initially focusing on trawling.

Examine overlap of commercial fishing activity by gear and target on Aleutian Island corals and sponges

Use these results to develop a risk assessment for corals and sponges in the Aleutian Islands



Where we do fish
Structure-forming Invertebrates
Where we can fish
Predicted POP Adult Habitat
Top 25%
2nd 25% (50% cumulative)
3rd 25% (75% cumulative)
Last 20% (95% cumulative)
Aleutian Islands Habitat Conservation Area
Aleutian Islands Coral Habitat Protection Areas
Bowers Ridge Habitat Conservation Zone
Open to Bottom Trawling
Areas shown in yellow are closed to bottom trawling (279,114 nm²)
Areas shown in green are open to bottom trawling (12,423 nm²)
Areas shown in red are closed to all bottom contact fishing gear (110 nm²)
Areas shown in purple are closed to mobile bottom contact fishing gear (5,286 nm²)
Steller Sea Lion Rookeries - No Transit
Kanaga I. Ship Rock: No Groundfish Fishing
No Atka Mackerel Fishery Year Around
No Atka Macherel Fishery After HLA Closure
haulouts
rookeries
530
543
542
541
Stalemate Bank
Aleutian Islands (2013)
Unimak Island
165°E 170°E 175°E 180° 175°W 170°W 165°W
175°E 180° 175°W 170°W 165°W 160°W
56°N 54°N 52°N 50°N 48°N 46°N
62°N 60°N 58°N 56°N 54°N 52°N
High : 0.895913
Low : 0.00341627

Models for Corals and Sponges in the Aleutian Islands

Predictive models of coral and sponge distribution, abundance and diversity in bottom trawl surveys of the Aleutian Islands, Alaska

Christopher N. Rooper[1,*], Mark Zimmermann[1], Megan M. Prescott[2], Albert J. Hermann[3]

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[2]Ocean Associates Inc., 4007 N. Abington St., Arlington, Virginia 22207, USA
[3]Pacific Marine Environmental Laboratory, 7600 Sand Point Way NE, Bldg. 3, Seattle, Washington 98115, USA

Response variable (presence or absence)	With/ without location	Model	Modeled data (1991–2011) Deviance explained (%)	edf	AUC (95% CI)	Test data (2012) AUC (95% CI)
Upright sponge	With	s(long,lat)+s(max_tide)+s(depth) +s(temp)+s(aspect)	8	27.9; 2.6; 1.4; 2.4; 2.7	0.73 (0.71–0.74)	0.67 (0.61–0.73)
	Without	s(max_tide)+s(depth)+s(temp) +s(aspect)	4	2.2; 2.8; 1.7; 2.8	0.62 (0.60–0.64)	
Coral	With	s(long,lat)+s(max_tide)+s(color) +s(slope)	16	27.2; 2.9; 2.3; 1.6	0.75 (0.74–0.77)	0.74 (0.69–0.79)
	Without	s(max_tide)+s(color)+s(slope)	6	2.8; 3.0; 1.0	0.66 (0.64–0.68)	
Primnoidae	With	s(long,lat)+s(max_tide)+s(color)	18	27.2; 2.8; 2.6	0.77 (0.76–0.79)	0.76 (0.72–0.81)
	Without	s(max_tide)+s(color)	6	2.6; 2.9	0.66 (0.64–0.68)	
Stylasteridae	With	s(long,lat)+s(max_tide) +s(mean_current)+s(aspect)	19	25.1; 2.5; 2.9; 2.6	0.80 (0.78–0.82)	0.78 (0.73–0.83)
	Without	s(max_tide)+s(mean_current) +s(aspect)	8	2.8; 2.9; 2.7	0.68 (0.66–0.71)	

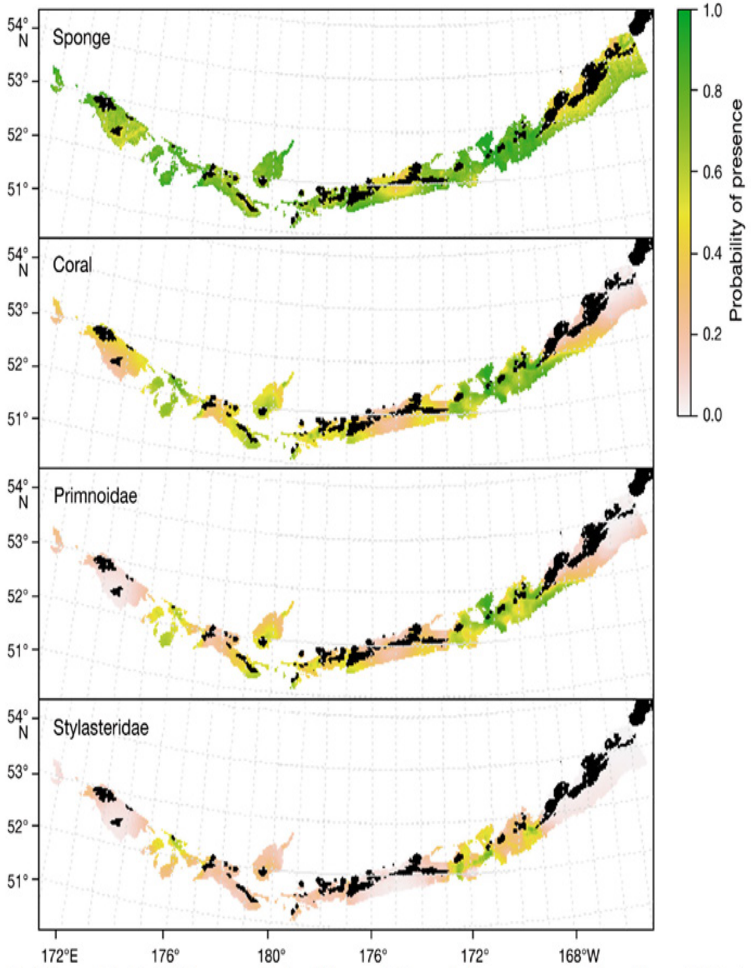
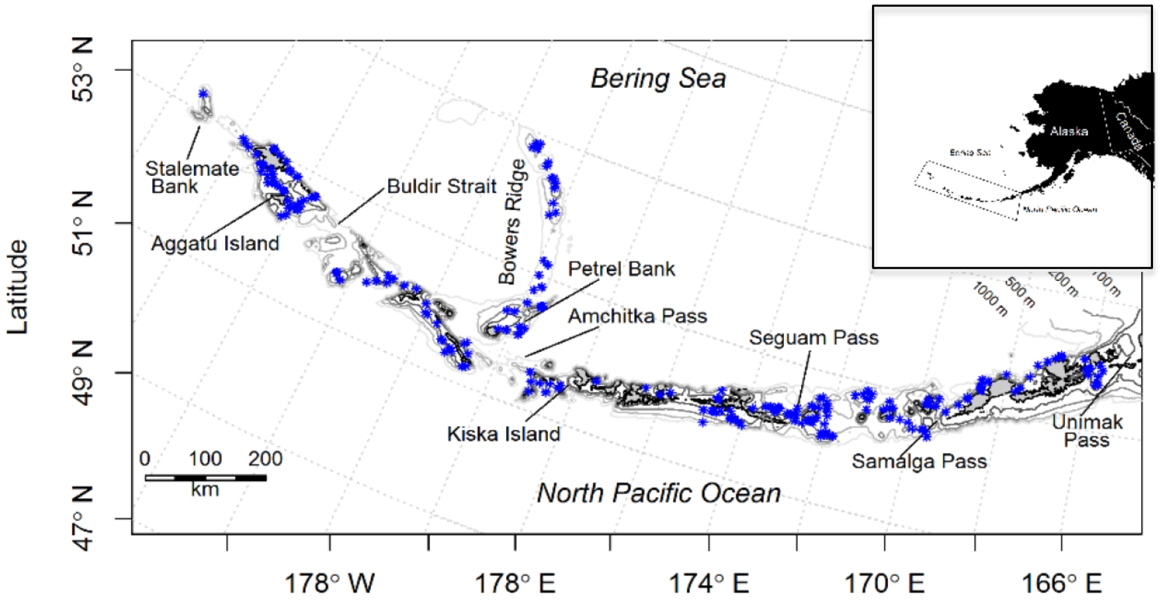
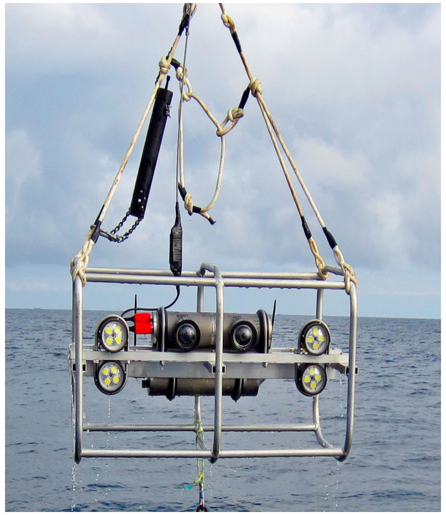


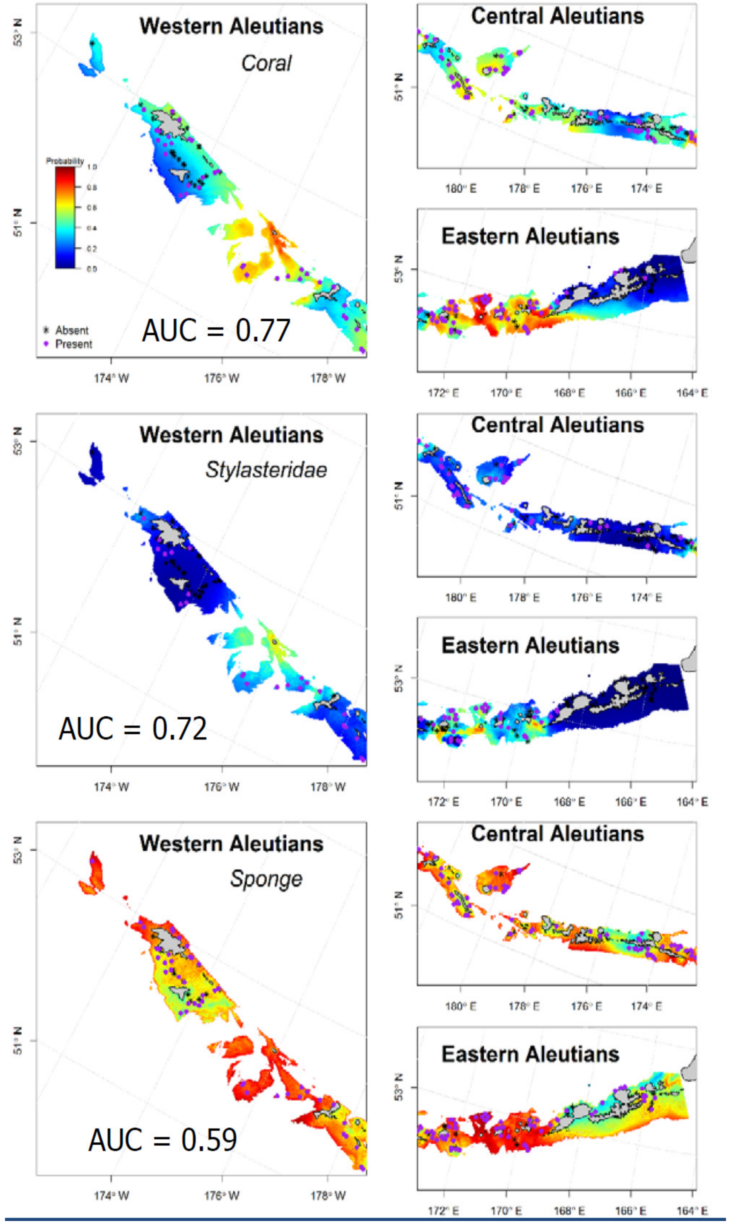
Fig. 4. Predictions of the best-fitting generalized additive model for upright sponge, coral, Primnoidae and Stylasteridae predicting the probability of presence in the Aleutian Islands bottom trawl surveys

Model Validation



Camera survey (n = 216)





Fisheries Observer Data

Full Coverage

- Catcher Processors
- Motherships

Partial Coverage (% covered)

- Electronically Monitored (30%)
- Tender trawl (27%)
- Trawl (24%)
- Hook and line (18%)
- Pot (15%)
- Tender pot (16%)
- Exempted Catcher Processors

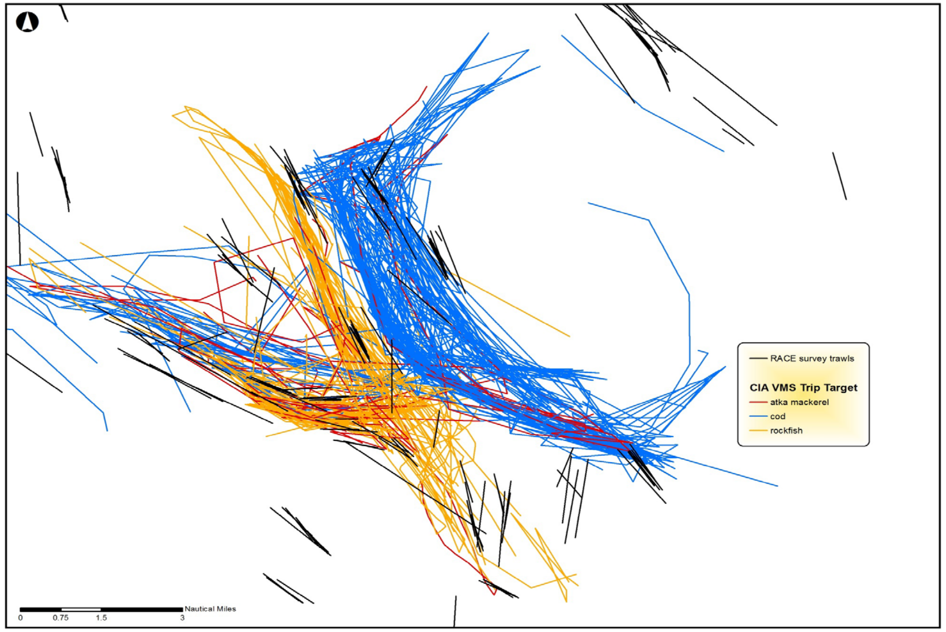
No Coverage

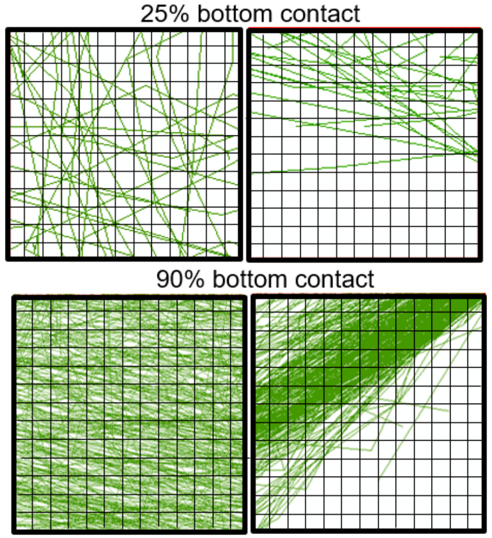
- Fixed Gear < 40 ft
- Jig Gear < 40 ft
- Fixed Gear Electronic Monitored Vessels

Aleutian Islands Catch represented in the VMS-enabled Catch-in-Areas Database

Year	Matching Method	SubArea	Tons	PerMatched
2010	VMS_OBS_Intersect_Distinct	AI	139,603	94.00%
2010	CV_StatArea	AI	3,438	2.32%
2010	CP-Stat-Area	AI	2,165	1.46%
2010	CP-Reporting Area	AI	69	0.05%
2010	CV-Reporting Area	AI	247	0.17%
2010	1.Avg_HS-RA-Tgt-WED-VesID-StFlg	AI	1,563	1.05%
2010	2. Avg_HS-RA-Gr-Tgt-WED-St-Flg	AI	826	0.56%
2010	3. Avg_HS-RA-Tgt-WED-StFlg	AI	127	0.09%
2010	4. Avg_HS-RA-Gr-WED-St-Flg	AI	170	0.11%
2010	5. Avg_HS-RA-Gr-Tgt-Yr-Mth-StFlg	AI	176	0.12%
2010	6. Avg_HS-RA-Gr-Tgt-Yr-StFlg	AI	136	0.09%
			148,521	100.00%

VMS data to delineate the footprint of the fishery by gear and target





Ping Rates

Trawl – 5 minutes

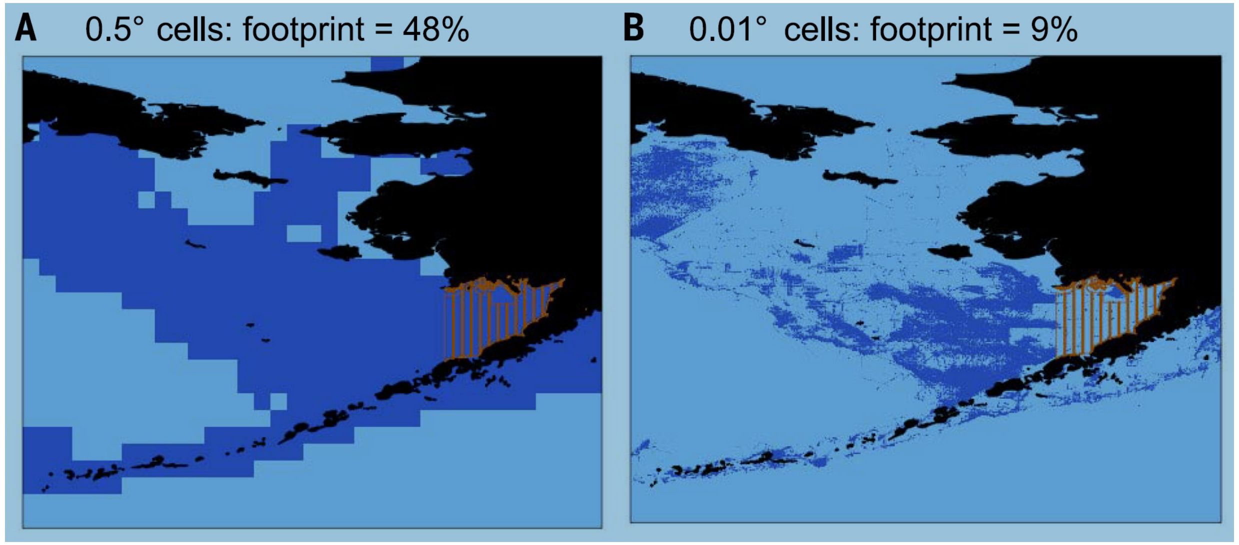
Longline/pot – 30 minutes

Fishery	Vessel type	Area	Gear	Target	Nom Width (m)
AI Pcod Bottom Trawl	CV	AI	NPT	C	90
AI Atka and Rockfish Bottom Trawl	CP	AI	NPT	A	100
BSAI Pcod Pot		BSAI	POT	C	5.6
BSAI Sablefish Pot		BSAI	POT	S	5.6
BSAI Pcod Longline		BSAI	HAL	C	2
BSAI Sablefish Longline		BSAI	HAL	S	2
BSAI Halibut longline		BSAI	HAL	I	2

Gear/Target pairs

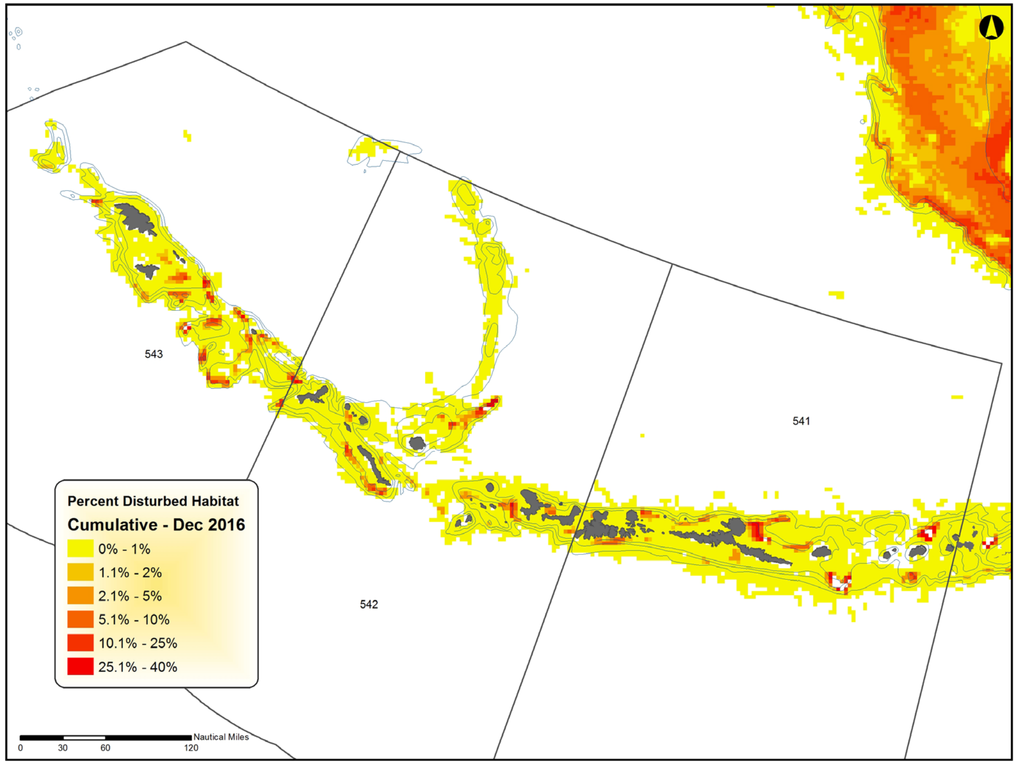
Non-pelagic Trawl
Atka mackerel
Pacific cod
Rockfish
Longline
Sablefish
Pacific cod
Pots
Pacific cod
Sablefish

Use VMS data to delineate the footprint of the fishery by gear and target

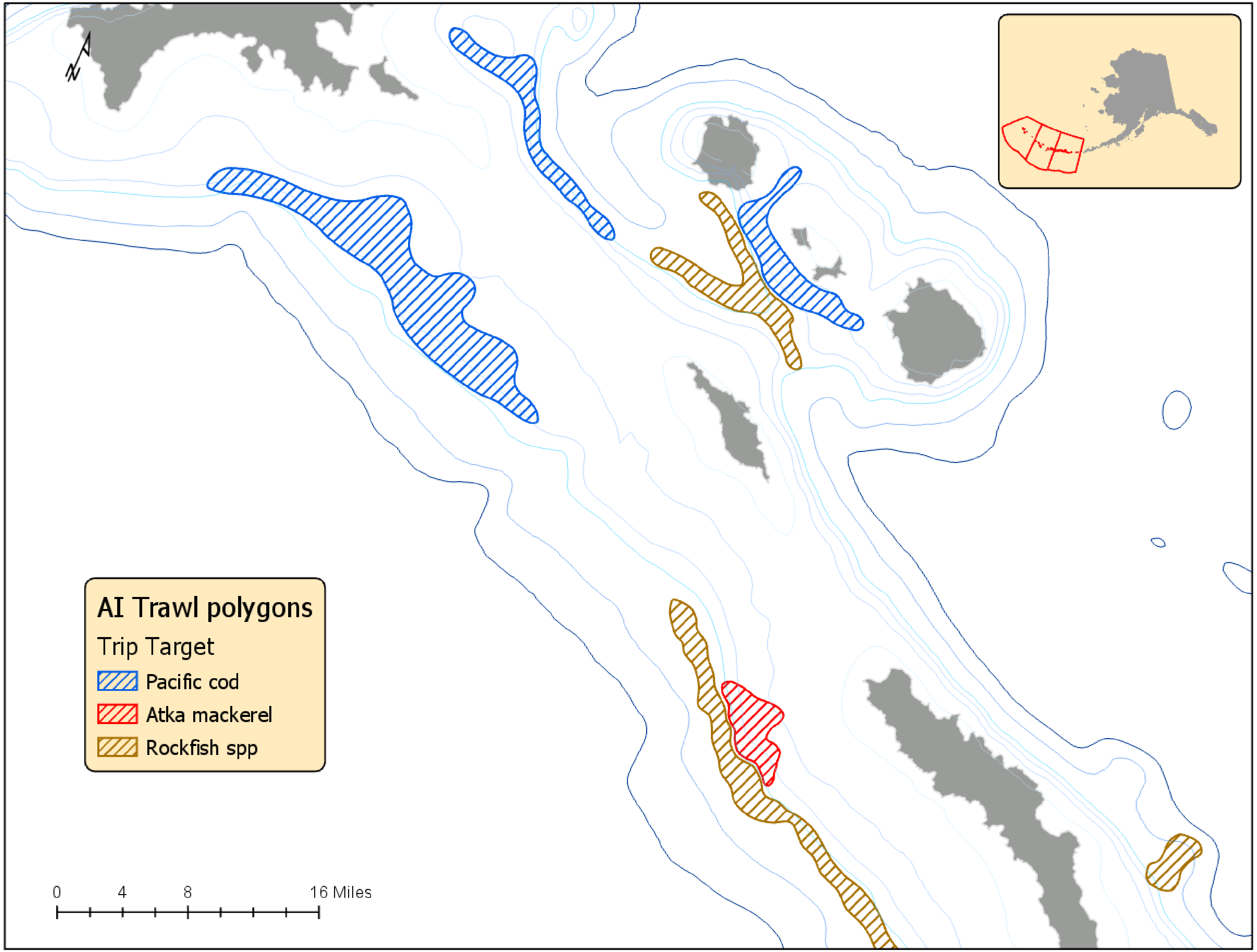


Kroosdma et al 2018, Amaroso et al 2018

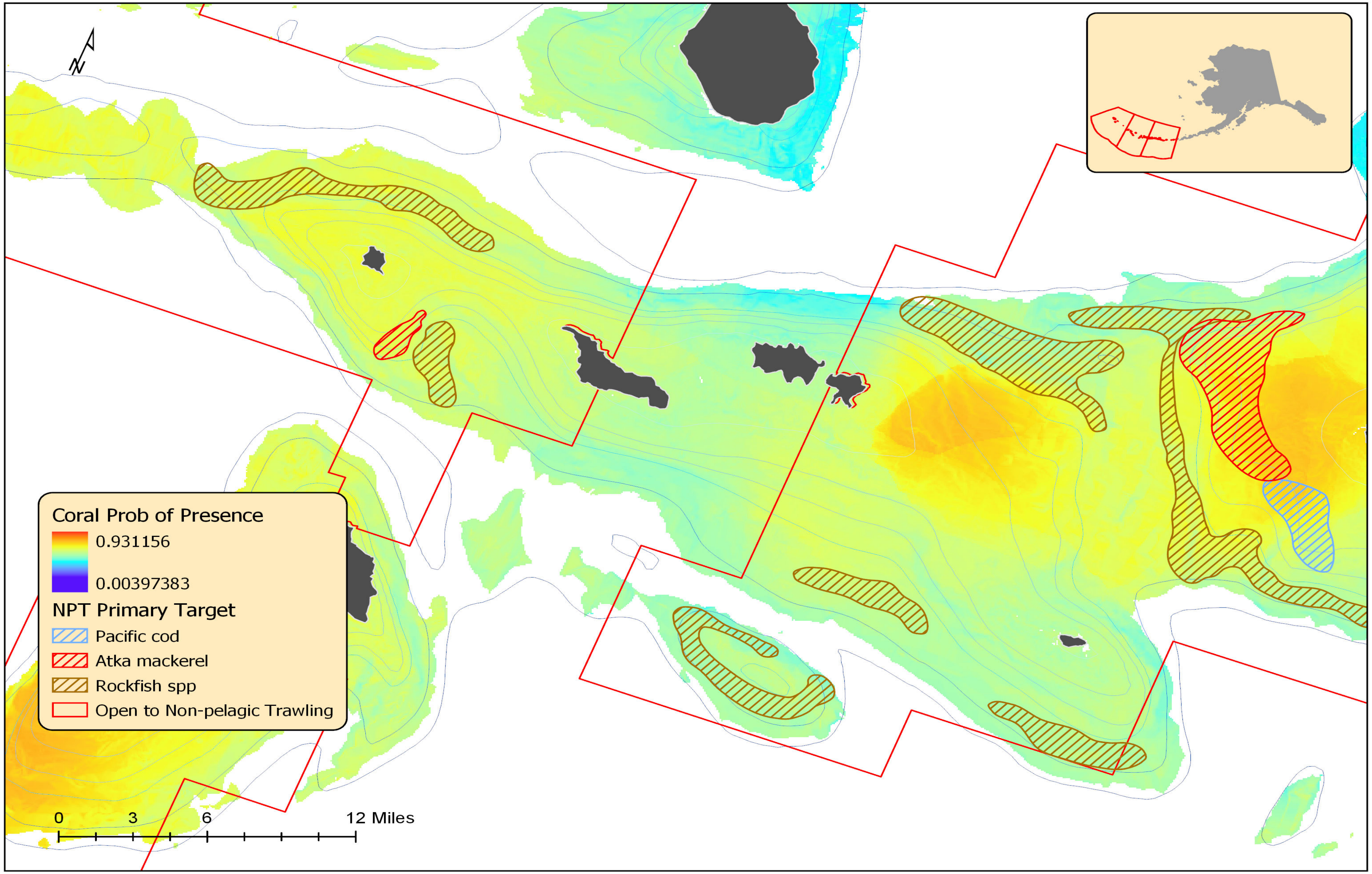
0.5° cells = 3,100 km^2
0.01° cells = 1.23 km^2



I have converted fishing events into 100m grids for this analysis.


AI Trawl polygons
Trip Target
Pacific cod
Atka mackerel
Rockfish spp
0
4
8
16 Miles

Fishing Footprint by Gear/Target & SFI Models

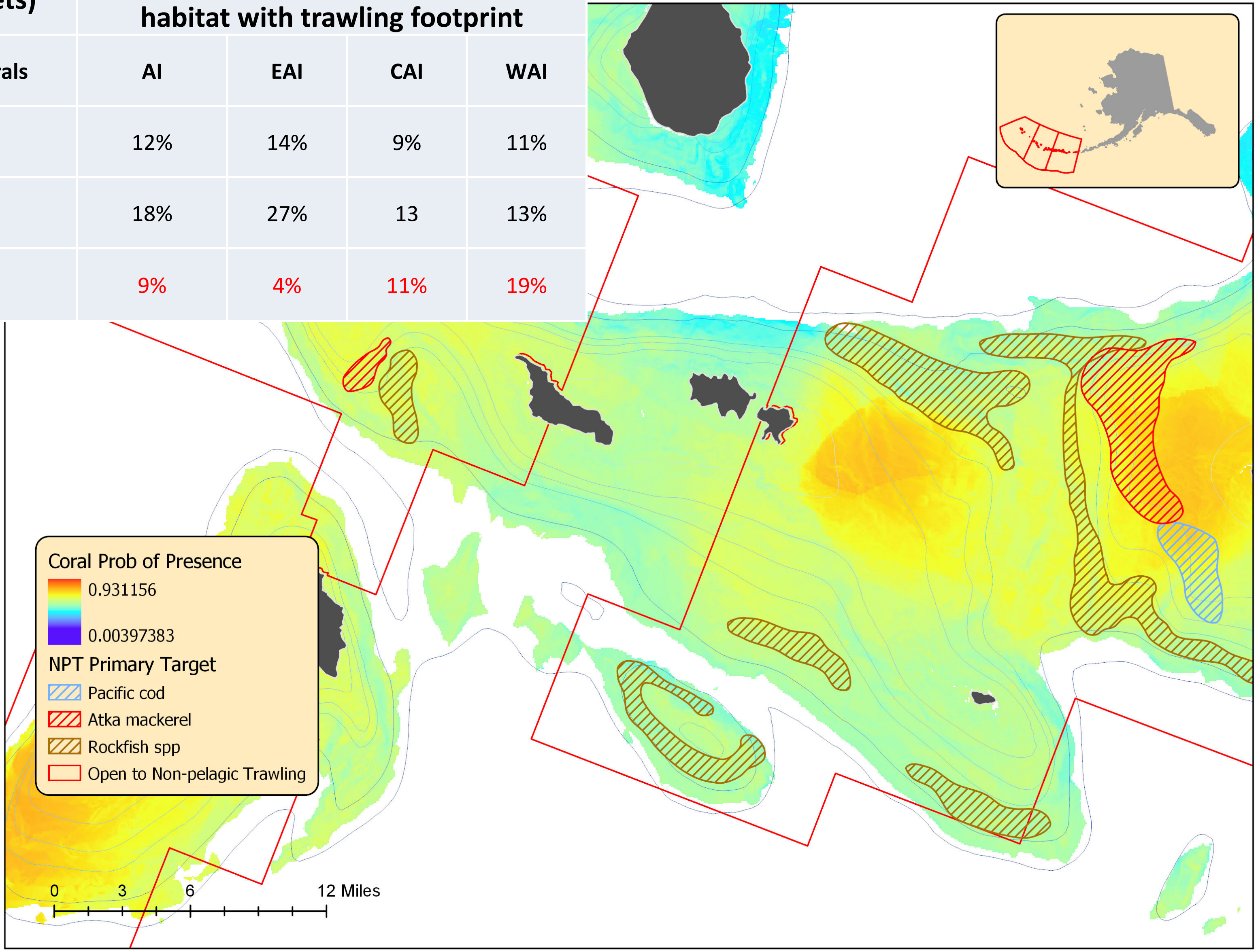


Results (and caveats)

- These are still initial analyses
- SFI models are developed using AFSC survey data and are probability of presence (low/medium/high).
- These figures represent **overlap only**
- The overlap accounts for 40,000+ trawl events between 2003 - 2019
- Doesn’t account for fishing that occurred before 2003

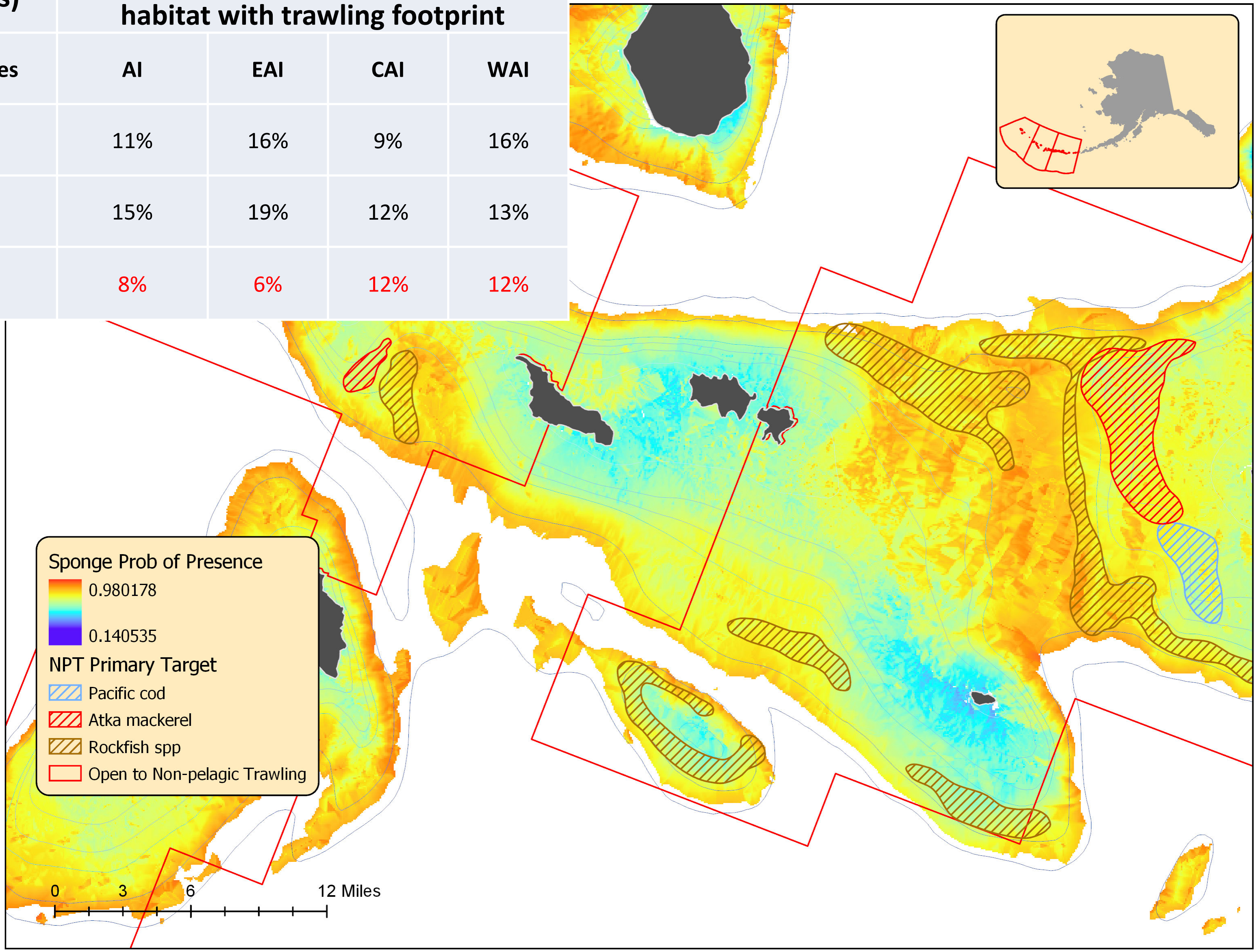
Preliminary Results – Corals

Trawl (all targets)	Percent overlap of modeled coral habitat with trawling footprint			
Probability of Corals	**AI**	**EAI**	**CAI**	**WAI**
Low	12%	14%	9%	11%
Medium	18%	27%	13	13%
High	9%	4%	11%	19%



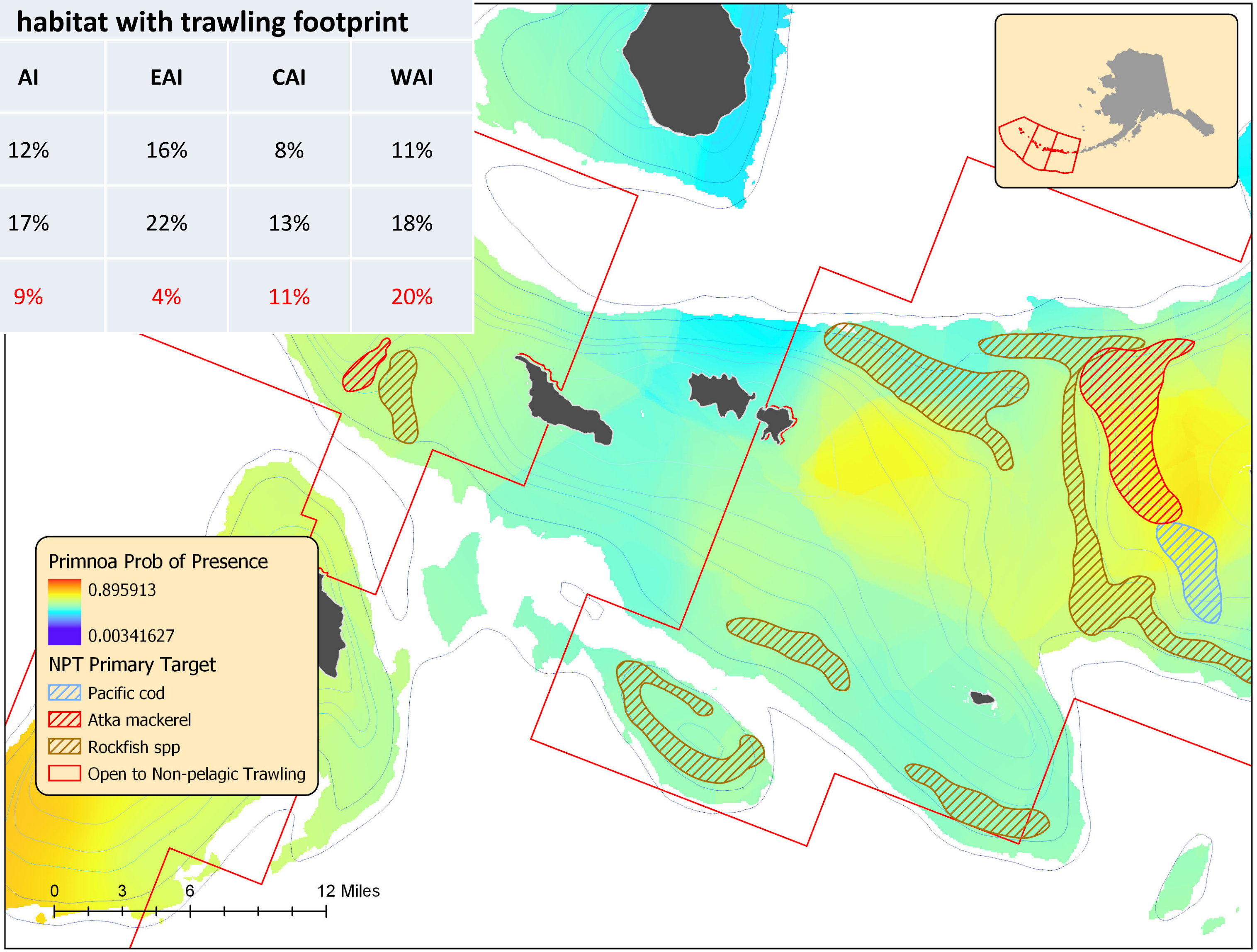
Preliminary Results – Sponges

Trawl (all targets)	Percent overlap of modeled sponge habitat with trawling footprint			
Probability of Sponges	**AI**	**EAI**	**CAI**	**WAI**
Low	11%	16%	9%	16%
Medium	15%	19%	12%	13%
High	8%	6%	12%	12%



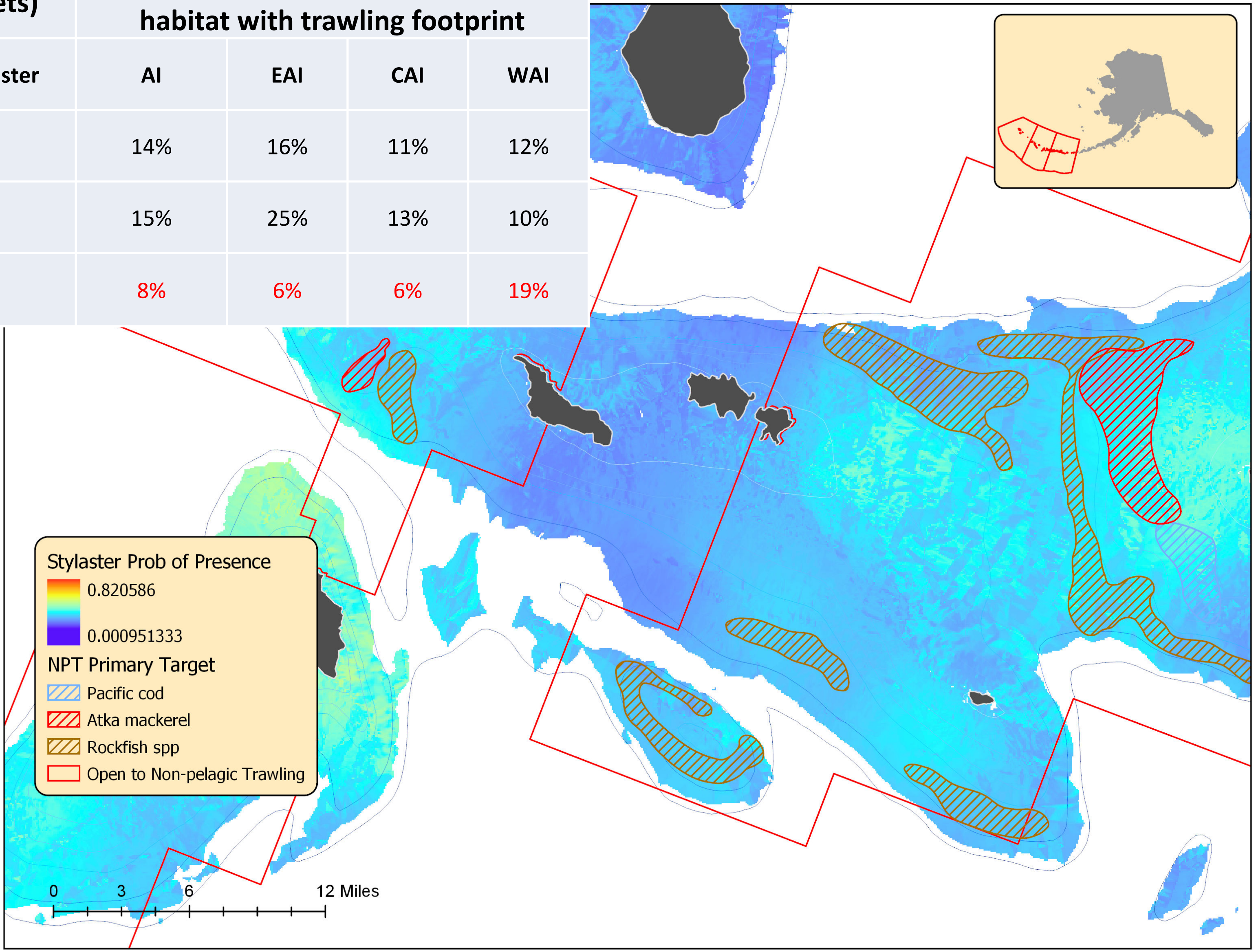
Preliminary Results – Primnoa

Trawl (all targets)	Percent overlap of modeled primnoa habitat with trawling footprint			
Probability of Primnoa	AI	EAI	CAI	WAI
Low	12%	16%	8%	11%
Medium	17%	22%	13%	18%
High	9%	4%	11%	20%



Preliminary Results – Stylaster

Trawl (all targets)	Percent overlap of modeled stylaster habitat with trawling footprint			
Probability of Stylaster	**AI**	**EAI**	**CAI**	**WAI**
Low	14%	16%	11%	12%
Medium	15%	25%	13%	10%
High	8%	6%	6%	19%



Preliminary Results – by Target

Target	NMFS Area	Coral Presence Probability			Sponge Presence Probability			Primnoa Presence Probability			Stylaster Presence Probability		
		low	*medium*	*high*	*low*	*medium*	*high*	*low*	*medium*	*high*	*low*	*medium*	*high*
All Trawl	**AI**	12%	18%	9%	11%	15%	8%	12%	17%	9%	14%	15%	8%
	EAI	14%	27%	4%	16%	19%	6%	16%	22%	4%	16%	25%	5%
	CAI	8%	13%	11%	9%	12%	15%	8%	13%	11%	11%	13%	6%
	WAI	11%	13%	19%	16%	13%	12%	11%	18%	19%	12%	10%	18%
Atka mackerel	**AI**	3%	7%	5%	5%	6%	4%	2%	7%	5%	2%	6%	9%
	EAI	3%	10%	1%	7%	5%	1%	4%	7%	1%	4%	7%	2%
	CAI	3%	6%	8%	2%	6%	11%	3%	6%	7%	4%	7%	4%
	WAI	1%	5%	11%	3%	7%	6%	2%	11%	12%	1%	5%	11%
Pacific cod	**AI**	9%	10%	1%	10%	8%	2%	9%	10%	1%	13%	7%	1%
	EAI	11%	17%	2%	11%	12%	2%	11%	15%	1%	13%	16%	1%
	CAI	6%	6%	2%	5%	5%	4%	6%	7%	1%	6%	6%	1%
	WAI	9%	8%	1%	12%	5%	1%	9%	1%	1%	10%	2%	1%
Rockfish	**AI**	3%	7%	6%	5%	6%	6%	3%	6%	5%	3%	7%	7%
	EAI	4%	7%	1%	5%	5%	1%	5%	6%	1%	3%	6%	3%
	CAI	4%	7%	8%	2%	6%	9%	2%	5%	7%	5%	7%	4%
	WAI	3%	7%	17%	4%	17%	17%	3%	15%	14%	2%	8%	17%
HAL Sablefish	**AI**	2%	2%	1%	1%	1%	2%	1%	2%	1%	1%	2%	1%
	EAI	3%	1%	1%	1%	1%	1%	3%	1%	1%	2%	2%	1%
	CAI	2%	3%	1%	1%	2%	4%	1%	2%	2%	2%	2%	2%
	WAI	1%	1%	1%	1%	1%	2%	1%	3%	2%	1%	1%	2%

Terrestrial habitat fragmentation examples?

What are the factors mitigating fishing effects on corals and sponges?

Management

Table 5 *(continued)*. Groundfish catches (metric tons) in the Aleutian Islands, 1954-2018.

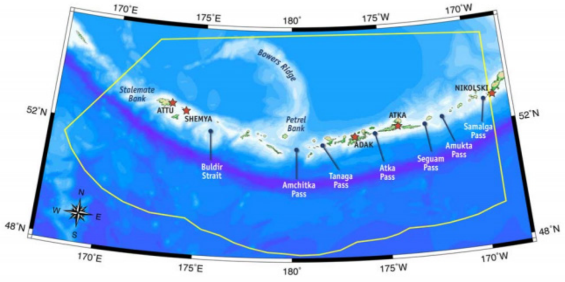
Year	POP Complex/d	POP	N. Rockfish	RE Rockfish	BS/SR Rockfish	Other Rockfish	Atka Mack.	Other Species/e	Skate	Sculpin	Shark	Squid	Octopus	Total (All Species)
1954														0
1955														0
1956														0
1957														0
1958														0
1959														0
1960														0
1961														0
1962	200													200
1963	20,800													21,471
1964	90,300							66						92,652
1965	109,100							768						111,868
1966	85,900							131						87,589
1967	55,900							8,542						66,781
1968	44,900							8,948						56,023
1969	38,800							3,088						44,009
1970	66,900						949	10,671						80,610
1971	21,800							2,973						32,118
1972	33,200						5,907	22,447						79,717
1973	11,800						1,712	4,244						34,006
1974	22,400						1,377	9,724						49,340
1975	16,600						13,326	8,288						46,553
1976	14,000						13,126	7,053						43,465
1977	8,080					3,043	20,975	16,170				1,808		67,348
1978	5,286					921	23,418	12,436				2,085		61,092
1979	5,487					4,517	21,279	12,934				2,252		75,195
1980	4,700					420	15,533	13,028				2,332		108,531
1981	3,622					328	16,661	7,274				1,763		104,199
1982	1,014					2,114	19,546	5,167				1,201		98,233
1983	280					1,045	11,585	3,675				510		94,617
1984	631					56	35,998	1,670				343		147,022
1985	308					99	37,856	2,050				9		113,310
1986	286					169	31,978	1,509				20		96,259
1987	1,004					147	30,049	1,155				23		81,364
1988	1,979					278	21,656	437				3		77,383
1989	2,706					481	14,868	108				6		186,494
1990	14,650					864	21,725	627				11		124,886
1991	2,545					549	22,258	91				30		117,942
1992	10,277					3,689	46,831	3,081				61		164,513
1993	13,375					495	65,805	2,540				85		179,659
1994	16,959					301	69,401	1,102				86		175,614
1995	14,734					220	81,214	1,273				95		183,862
1996	20,443					278	103,087	1,720				87		190,750
1997	15,687					307	65,668	1,555				323		139,049
1998	13,729					385	56,195	2,448				25		134,182
1999	18,501					657	53,966	1,670				9		106,453
2000	14,893					601	46,990	3,010				8		110,348
2001	15,587					610	61,296	4,029				5		120,550
2002	14,996					551	44,722	1,980				10		98,216
2003	18,765					401	52,988	1,326				36		111,560
2004		11,165	4,567	185	123	337	53,405	1,866				14		104,798
2005		9,548	3,852	78	62	286	58,474	1,417				17		101,446
2006		11,826	3,582	196	165	426	58,719	1,943				15		106,650
2007		17,581	3,946	157	210	435	55,742	2,053				13		120,357
2008		16,923	3,265	171	91	390	57,690	2,322				49		118,010
2009		14,725	3,064	184	116	403	72,563	2,514				91		138,594
2010		14,304	4,033	202	139	503	68,496	2,713				105		148,446
2011		18,403	2,566	129	227	616	50,600		732	502	4	99	11	96,616
2012		18,554	2,388	174	227	736	46,863		1,083	808	2	128	11	103,804
2013		26,311	1,900	296	267	623	23,034		1,058	606	17	141	39	84,619
2014		24,944	2,195	173	101	621	30,815		1,185	373	3	110	18	82,089
2015		23,507	6,998	150	78	501	53,003		1,252	925	4	83	23	99,916
2016		23,097	4,333	117	54	506	54,125		1,174	511	11	50	10	101,375
2017		23,240	4,461	165	62	568	63,401		1,387	882	4	42	21	110,824
2018		25,114	5,579	223	80	775	69,248		1,733	712	8	35	158	123,896
2019		28,476	8,591	335	82	569	55,429		1,225	791	3	0	93	113,556

Note: Numbers don't include fish taken for research.
a/ Arrowtooth flounder included in Greenland turbot catch statistics, 1960-69.
b/ Kamchatka flounder included in Arrowtooth flounder prior to 2011.
c/ Rock sole prior to 1991 and flathead sole prior to 1995 are included in other flatfish catch statistics.
d/ Includes POP, northern, rougheye, shortraker, and sharpchin rockfish until 2004.
e/ Octopus, sculpin, sharks, skates included in Other species prior to 2011.
f/ Data through November 2, 2019.

Amendment 80 (BSAI FMP), implemented in 2008, allocates BSAI yellowfin sole, flathead sole, rock sole, Atka mackerel, and Aleutian Islands Pacific ocean perch to the head and gut trawl catcher processor sector, and allows qualified vessels to form cooperatives.

Aleutian Islands Fishery Ecosystem Plan

December 2007



"Our creation story tells us that we dropped from the heavens above onto these islands that stretch across the stormy seas like a lifeline."

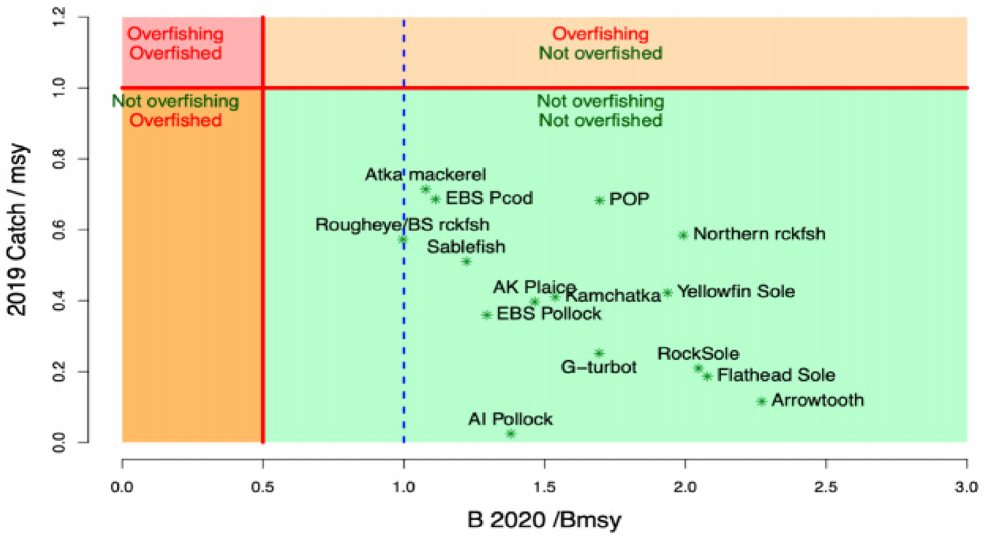
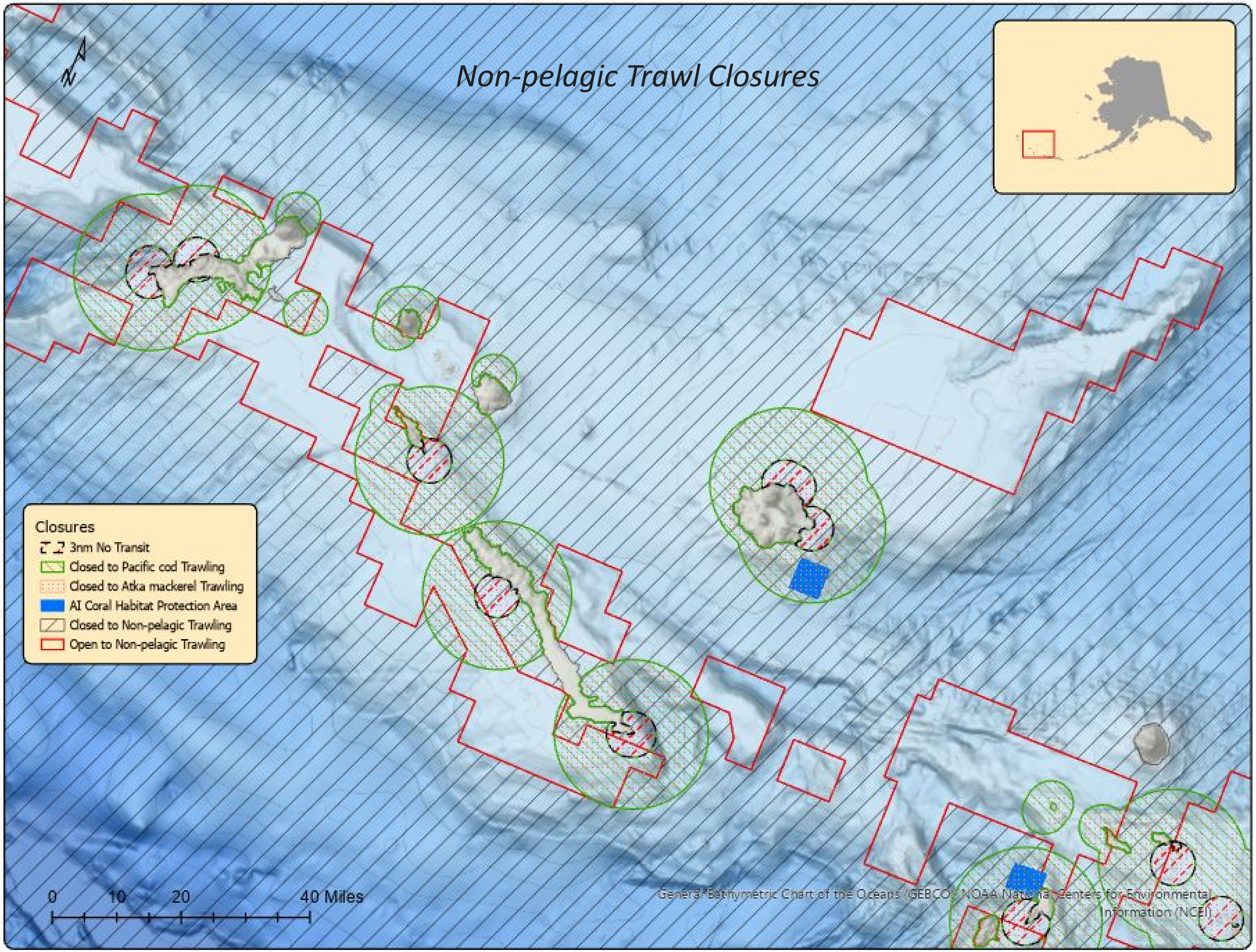
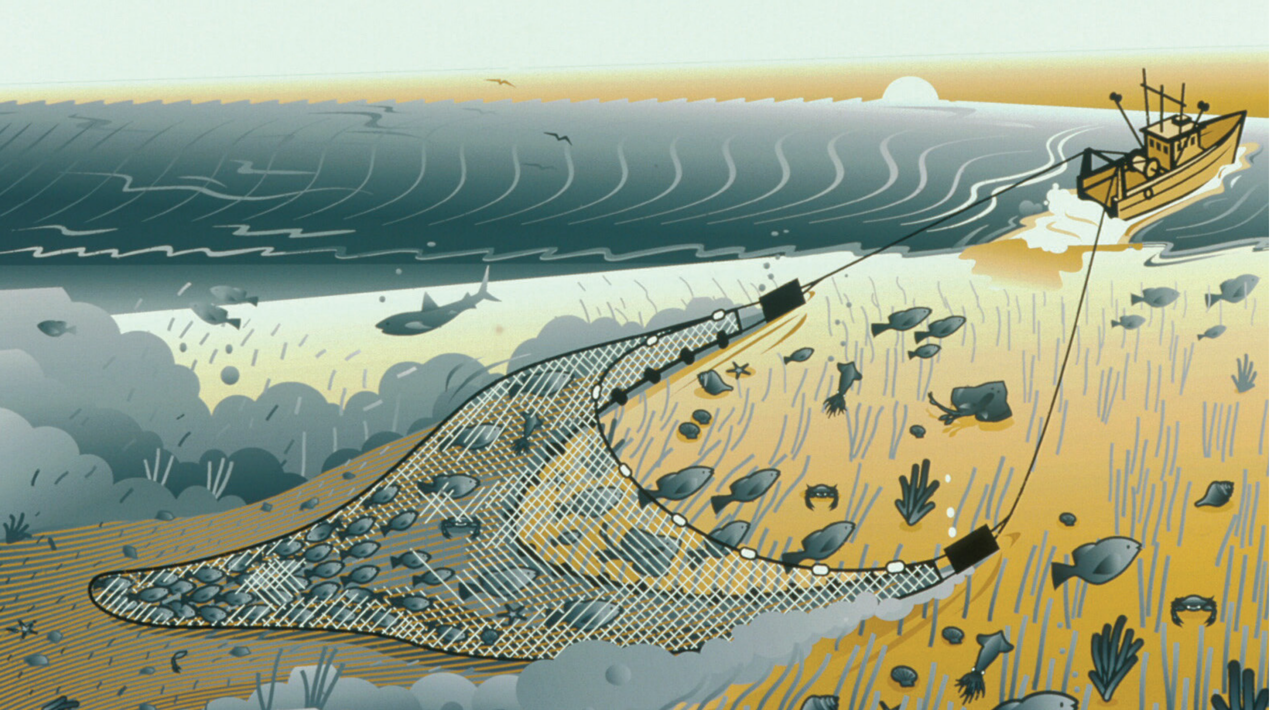


Figure 2. Summary of Bering Sea stock status next year (spawning biomass relative to B_{msy}; horizontal axis) and current year catch relative to fishing at F_{msy} (vertical axis) where F_{OFL} is taken to equal F_{msy}.



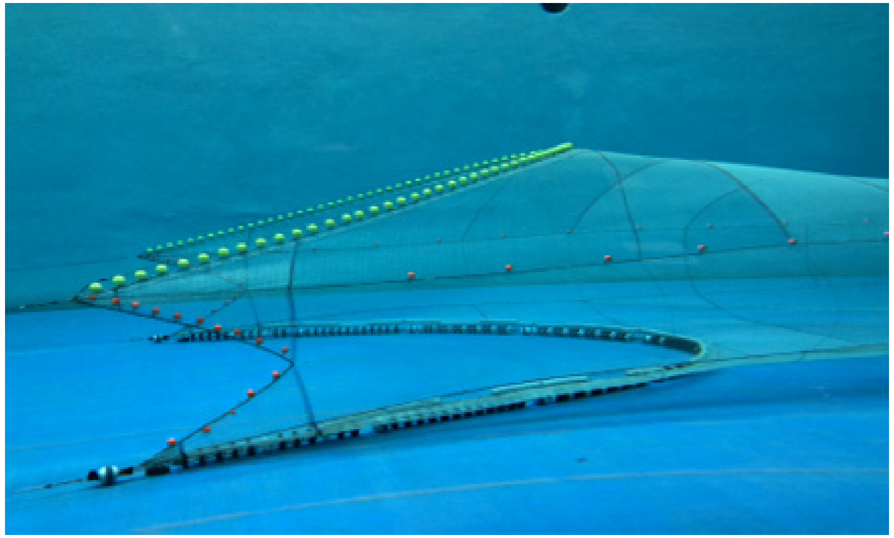
N
Non-pelagic Trawl Closures
Closures
3nm No Transit
Closed to Pacific cod Trawling
Closed to Atka mackerel Trawling
AI Coral Habitat Protection Area
Closed to Non-pelagic Trawling
Open to Non-pelagic Trawling
0
10
20
40 Miles
General Bathymetric Chart of the Oceans (GEBCO); NOAA National Centers for Environmental Information (NCEI)

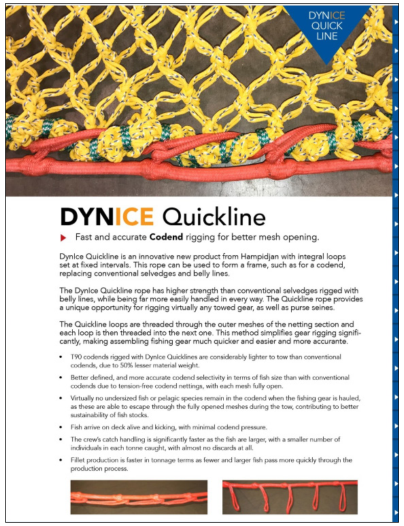


What does modern trawling look like?

"Bottom trawling is a widespread industrial fishing practice that involves dragging heavy nets, large metal doors and chains over the seafloor to catch fish."





DYNICE Quickline

- Fast and accurate **Codend** rigging for better mesh opening.

DynIce Quickline is an innovative new product from Hampidjan with integral loops set at fixed intervals. This rope can be used to form a frame, such as for a codend, replacing conventional selvedges and belly lines.

The DynIce Quickline rope has higher strength than conventional selvedges rigged with belly lines, while being far more easily handled in every way. The Quickline rope provides a unique opportunity for rigging virtually any towed gear, as well as purse seines.

The Quickline loops are threaded through the outer meshes of the netting section and each loop is then threaded into the next one. This method simplifies gear rigging significantly, making assembling fishing gear much quicker and easier and more accurante.

- T90 codends rigged with DynIce Quicklines are considerably lighter to tow than conventional codends, due to 50% lesser material weight.
- Better defined, and more accurate codend selectivity in terms of fish size than with conventional codends due to tension-free codend nettings, with each mesh fully open.
- Virtually no undersized fish or pelagic species remain in the codend when the fishing gear is hauled, as these are able to escape through the fully opened meshes during the tow, contributing to better sustainability of fish stocks.
- Fish arrive on deck alive and kicking, with minimal codend pressure.
- The crew's catch handling is significantly faster as the fish are larger, with a smaller number of individuals in each tonne caught, with almost no discards at all.
- Fillet production is faster in tonnage terms as fewer and larger fish pass more quickly through the production process.

New vessels, lighter materials, fuel efficiency and gear design

GULL WING SEMI-PELAGIC TRAWL DOORS

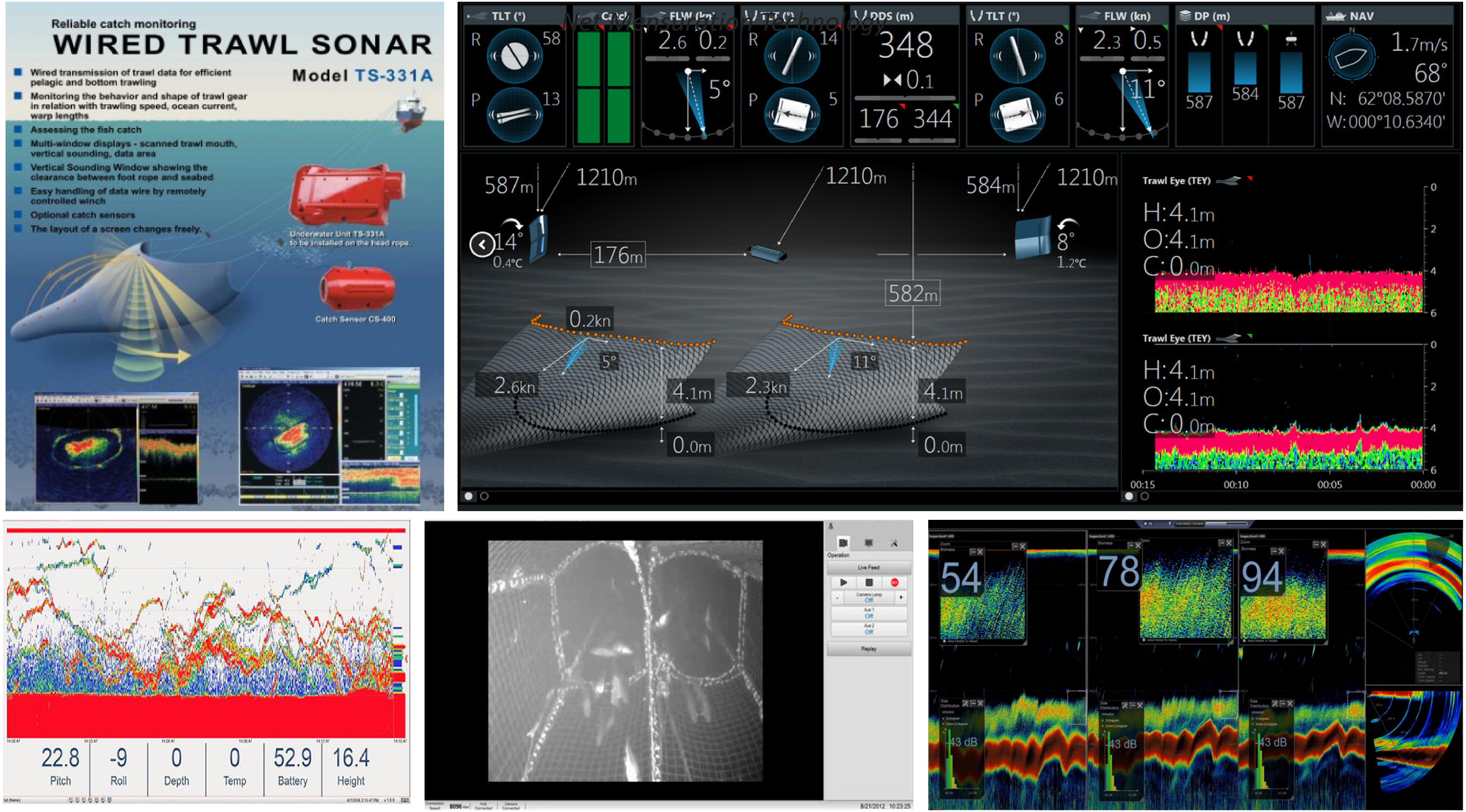
Gull Wing trawl doors are high aspect, double foil, cambered doors introduced by NET Systems in September 2010. They may be rigged to fish on bottom, semi-pelagic, or midwater. With a shoe weight and balanced center of gravity, the Gull Wing door is very stable in all phases of fishing while providing excellent spread.

Read More >>

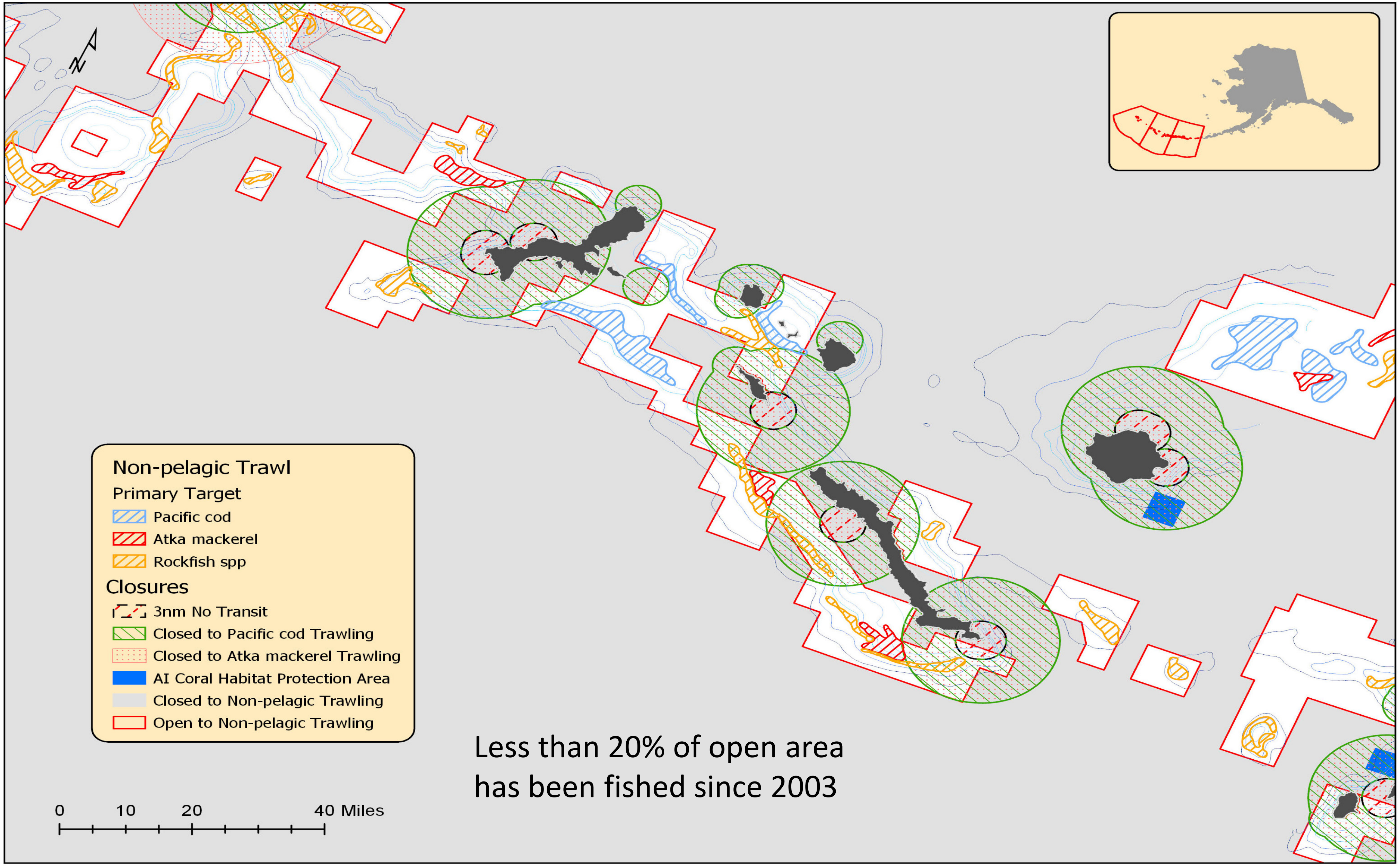
LITE PELAGIC/BOTTOM

Lite Pelagic/Bottom Doors incorporate ingeniously engineered foam cores, encased within a rigid steel shell, which dramatically reduces their weight in water. The optional shoe lowers the center of gravity, increasing stability and durability for bottom operation.

Read More >>


Reliable catch monitoring
WIRED TRAWL SONAR
Model TS-331A
Wired transmission of trawl data for efficient pelagic and bottom trawling
Monitoring the behavior and shape of trawl gear in relation with trawling speed, ocean current, warp lengths
Assessing the fish catch
Multi-window displays - scanned trawl mouth, vertical sounding, data area
Vertical Sounding Window showing the clearance between foot rope and seabed
Easy handling of data wire by remotely controlled winch
Optional catch sensors
The layout of a screen changes freely.
Underwater Unit TS-331A to be installed on the head rope.
Catch Sensor CS-400
TLT (°)
Catch
FLW (kn)
DDS (m)
DP (m)
NAV
348
176
344
587
584
1.7m/s
68°
N: 62°08.5870'
W:000°10.6340'
587m
1210m
584m
176m
582m
0.2kn
2.6kn
2.3kn
4.1m
0.0m
Trawl Eye (TEY)
H:4.1m
O:4.1m
C:0.0m
00:15
00:10
00:05
00:00
22.8
Pitch
-9
Roll
0
Depth
0
Temp
52.9
Battery
16.4
Height
Live Feed
Replay
54
78
94
43 dB

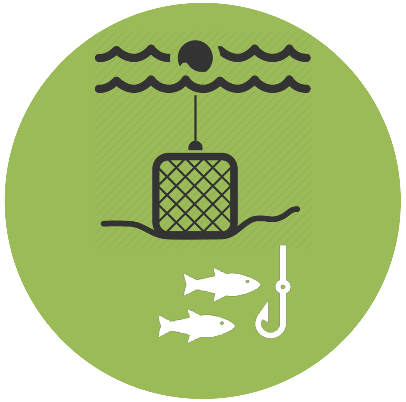
Highly-aggregated trawl fishing (high-CPUE)



Less than 20% of open area has been fished since 2003

Where do we go from here?

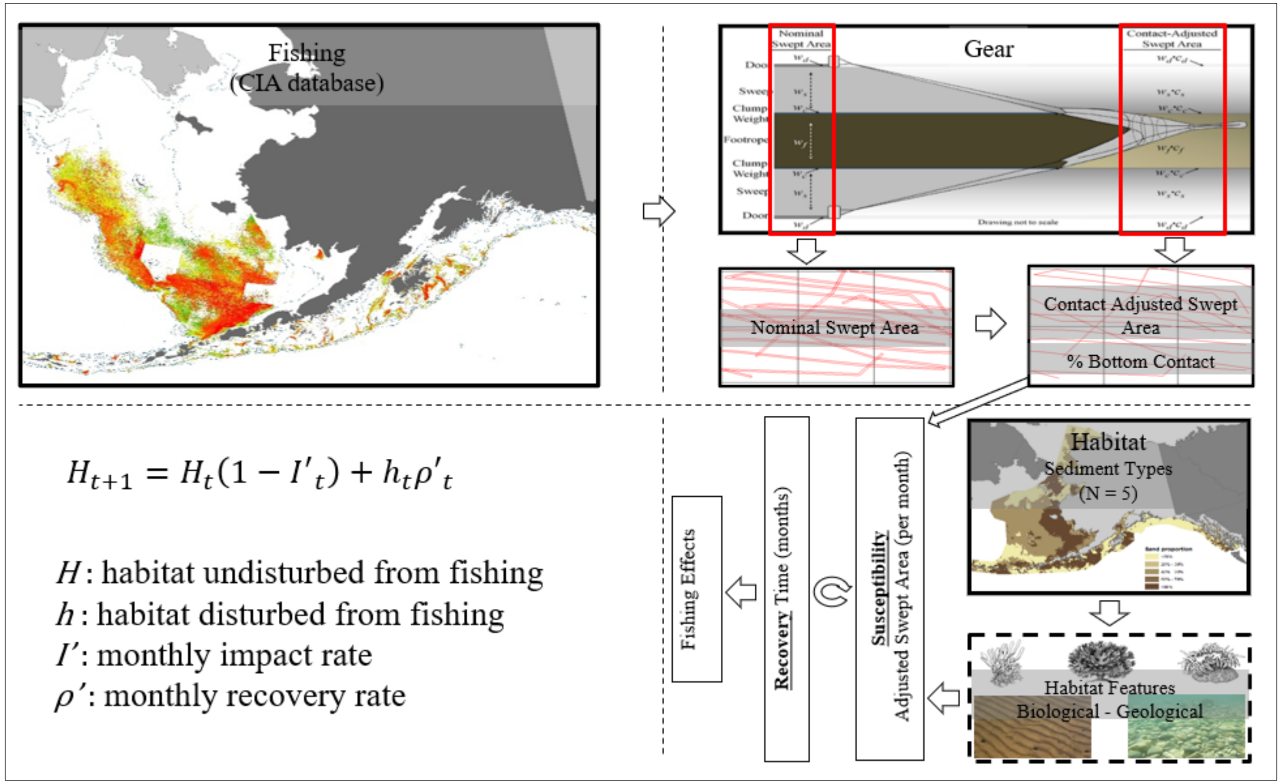
VALIDATION OF MODELS



BETTER ESTIMATES OF LONGLINE AND POT INTERACTIONS

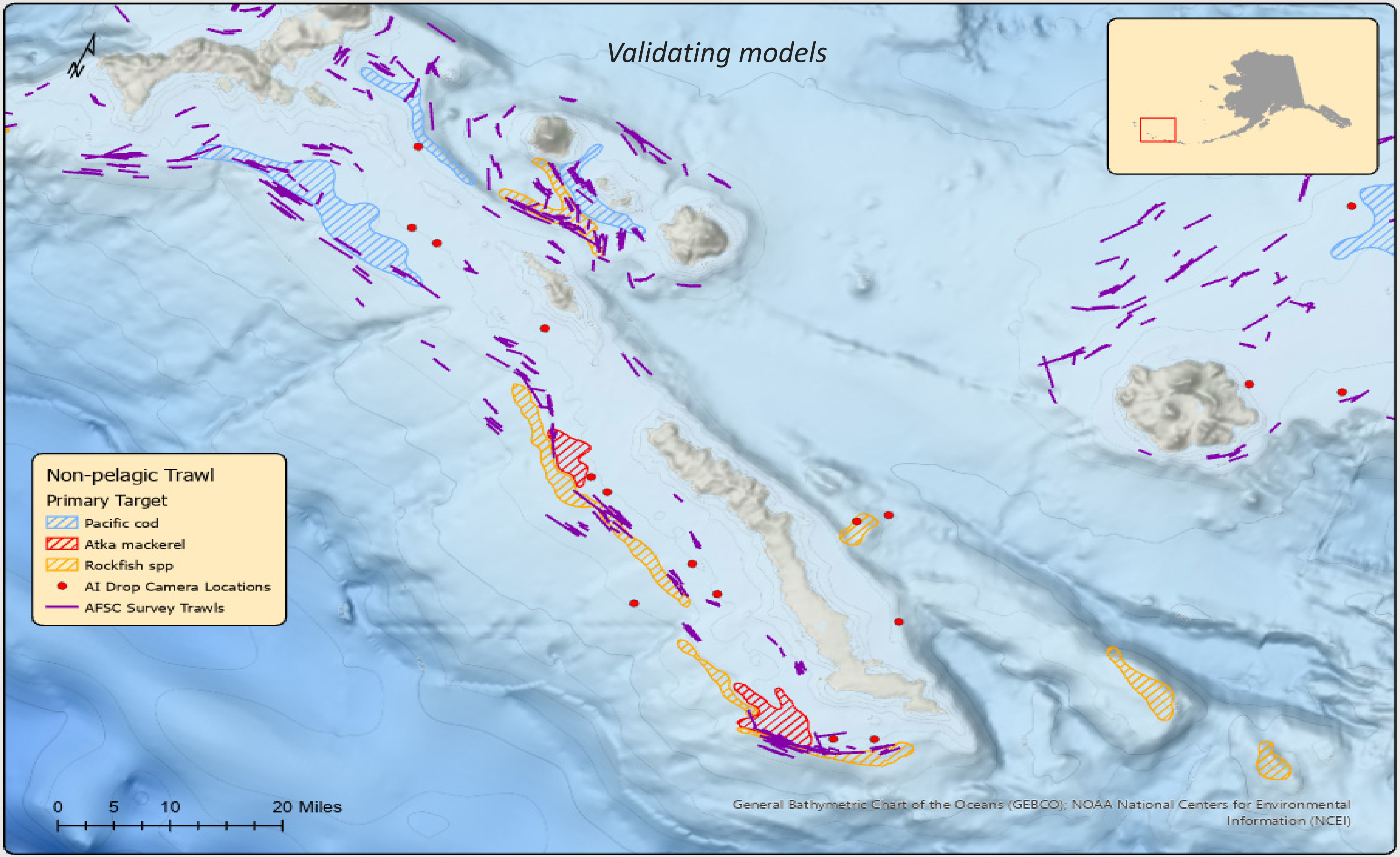
RISK ASSESSMENT

Validating models



Fishing Effects model output

Validating models



Appendix 4. An autonomous video camera system for monitoring impacts to benthic habitats from demersal fishing gear, including longlines.

Robert Kilpatrick, Graeme Ewing, Tim Lamb, Dirk Welsford and Andrew Constable

Demersal longline gear is considered to exert two types of interactions with the benthos, with overlapping swept areas: 1) line shearing interactions and 2) hooking interactions. The swept area of both of these interactions is strongly dependent on the manner in which lines move on the seafloor during a fishing event and analyses suggested that longlines are very likely to move across the seafloor in both longitudinal and lateral directions during their retrieval (an average of 6.2 m lateral movement).

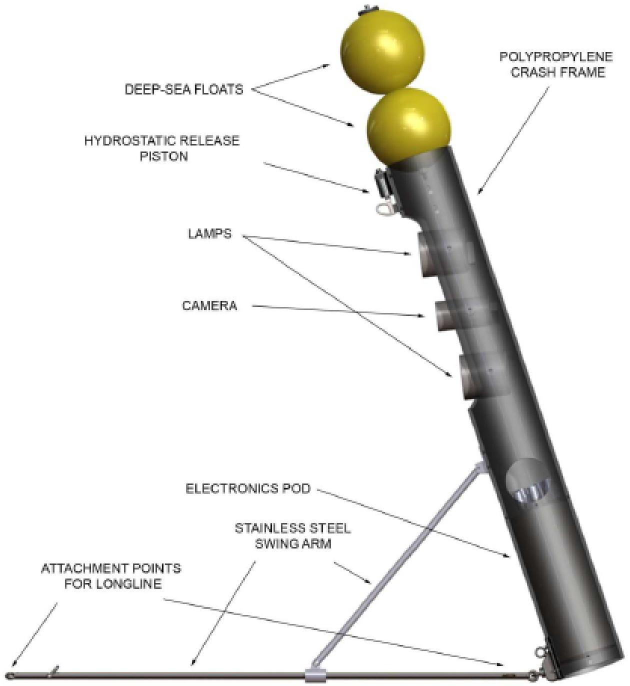


Figure A4.2. Benthic Impacts Camera System (BICS) mounted in the longline crash frame. The narrow cylindrical shape of the longline housing allows it to be deployed through a narrow shooting window, the stainless steel swing arm on the left side is attached to the longline and folds open after deployment (as shown). The floats keep the unit upright and filming down the longline during fishing and retrieval.

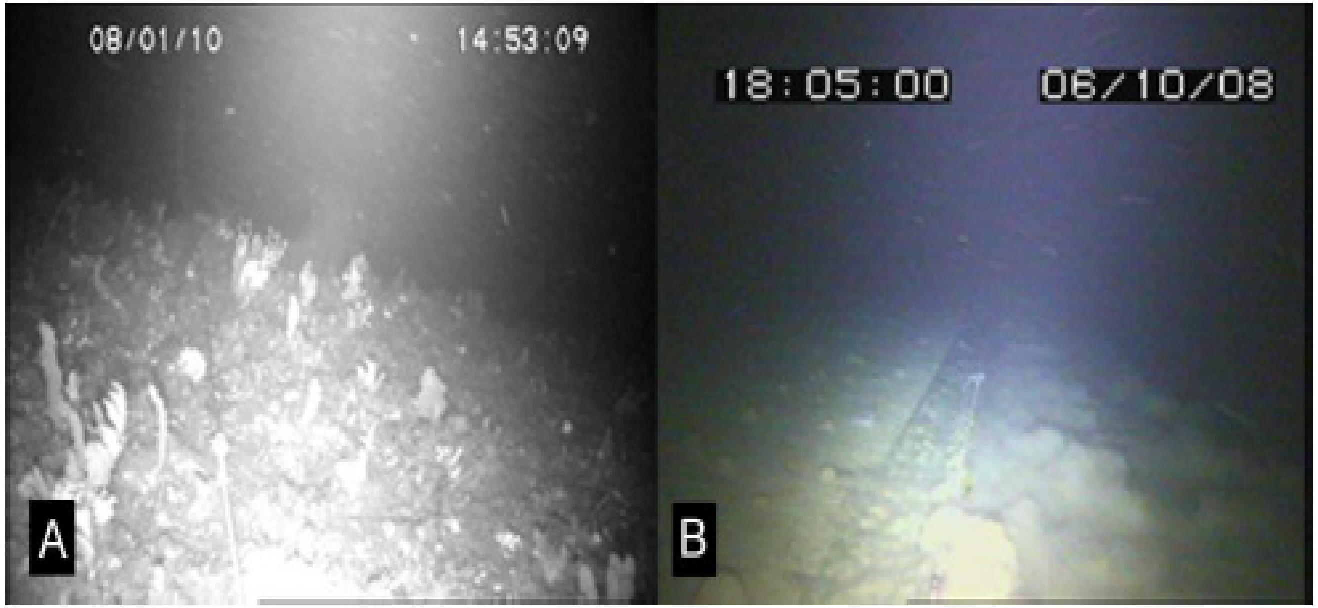
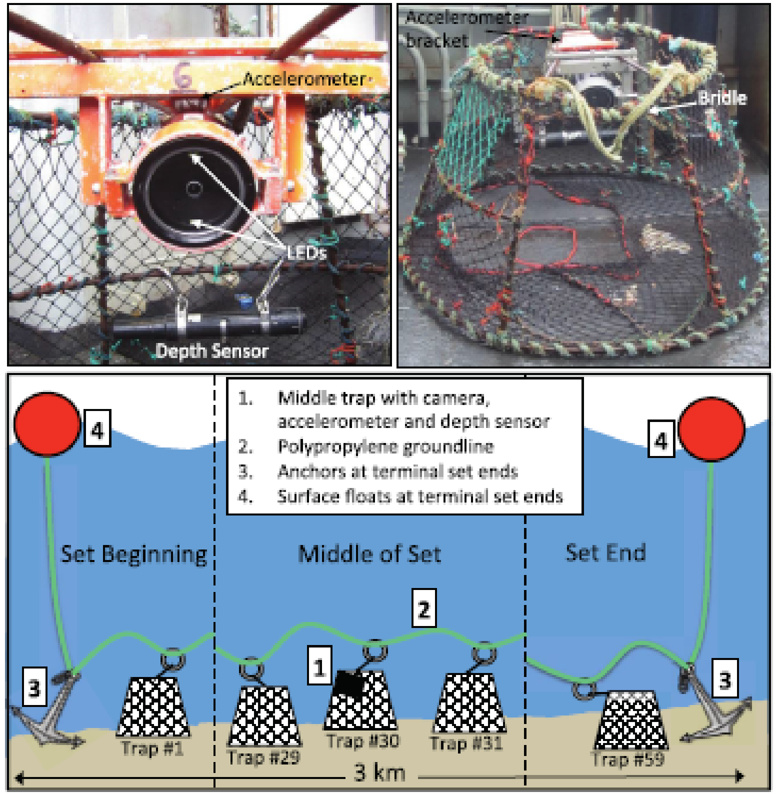
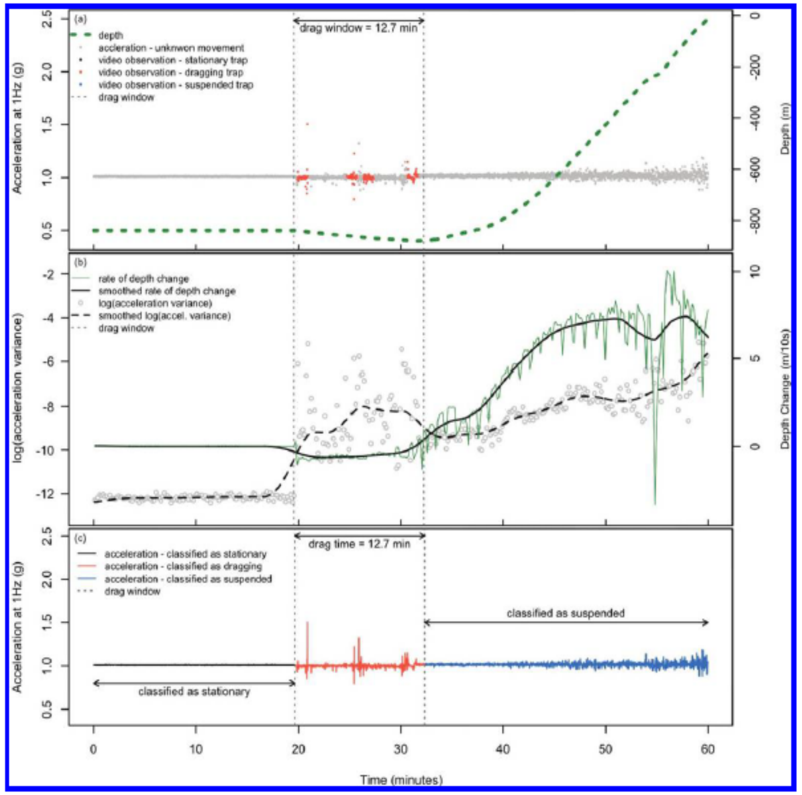


Figure A4.4. Video stills from BICS deployments during simulated demersal longline fishing showing interactions with the benthos in East Antarctica at 540 m (A) and at 720 m (B). Still A depicts the line settling in complex habitat. Still B shows a furrow created by the longline in soft sediments as hauling commences.

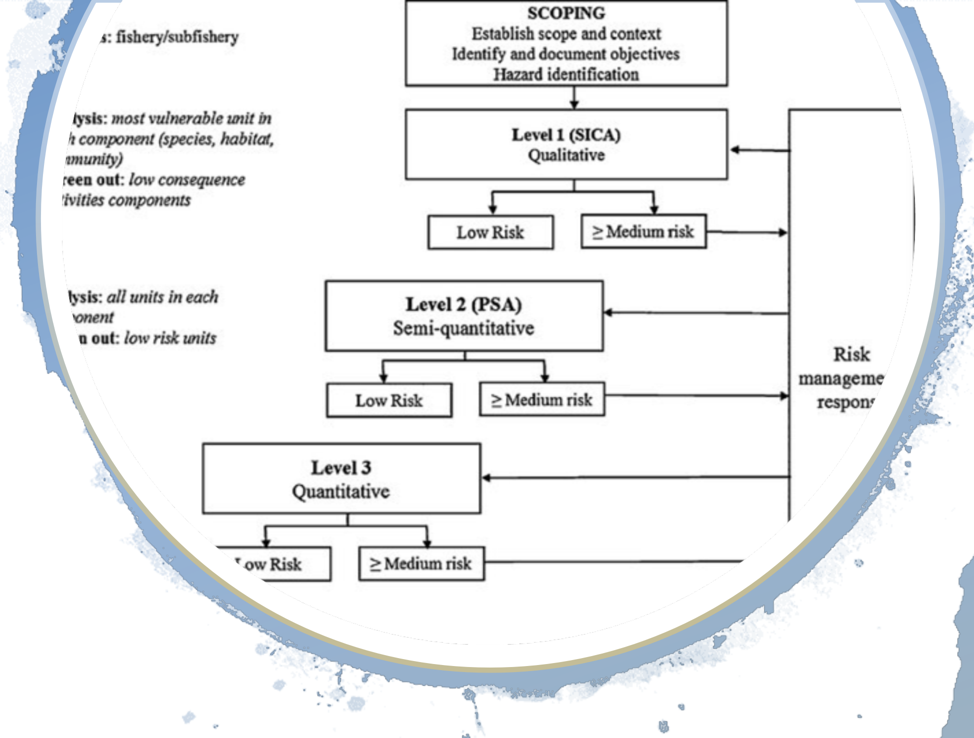
Using autonomous video to estimate the bottom-contact area of longline trap gear and presence–absence of sensitive benthic habitat[1]

Beau Doherty, Samuel D.N. Johnson, and Sean P. Cox

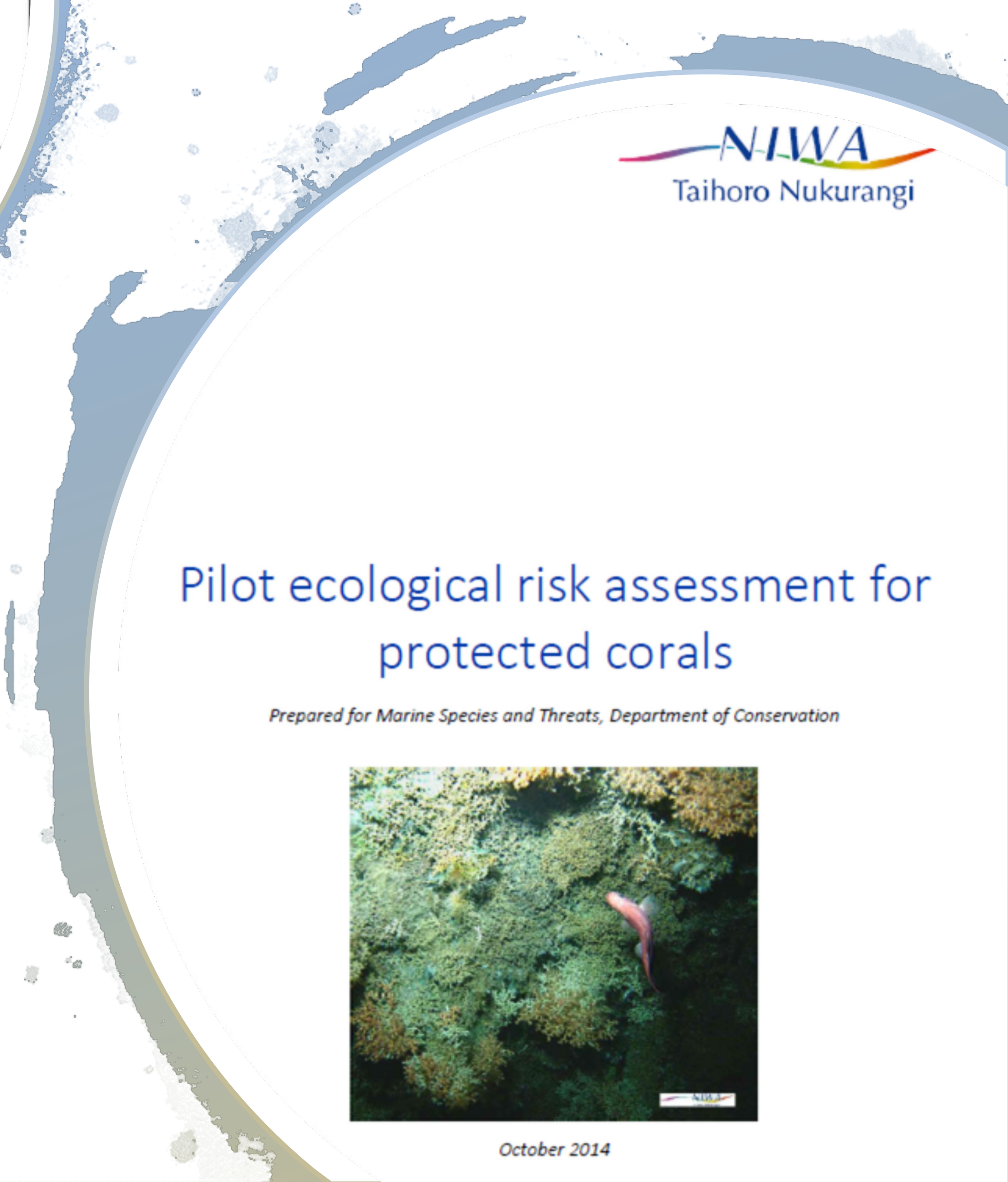




The mean estimated bottom-contact area for a 54-inch trap was 53m^2 (95% CI = 40–65m2), which is nearly 36 times the static trap footprint of 1.47m^2 (i.e., the bottom area of the trap). Variability in the estimated drag times and drag lengths dominated bottom area calculations compared with less variable haul speeds and drag widths (Fig. 10).



Risk Assessment


NIWA
Taihoro Nukurangi

Pilot ecological risk assessment for protected corals

Prepared for Marine Species and Threats, Department of Conservation

October 2014

Summary

- Objective of project has been to evaluate the overlap of fishing activity with structure-forming invertebrates
- Trawling is highly aggregated in the Aleutian Islands
- Pattern of overlap with “high” likelihood of coral/sponge presence was similar across groups for EAI, CAI, and WAI at ~5%, 10%, and 20%. Highest overlap with SFI is in WAI
- Multiple reasons for “lower than expected” overlap
- Independent validation of models, assessing other gear types, and risk assessment

Thank you … Chris Rooper, Matt Eagleton, Scott Smeltz & the APU FAST lab, and of course Tom & Heather!