2022 Symposium: Small Pelagic Fish
S5: Progress in Pelagic Surveys
Lisbon, Portugal
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Improved monitoring of forage species in the Gulf of Alaska in the absence of directed surveys

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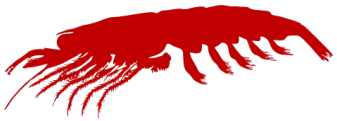
Forage Species Management in Alaska

No directed fisheries for forage spp. in U.S. federal waters, limited fisheries in Alaska state waters (< 5.5 km, 3 nmi)

Forage fish group

sand lance, capelin, eulachon, other smelts, deep-sea smelts, myctophids, & krill



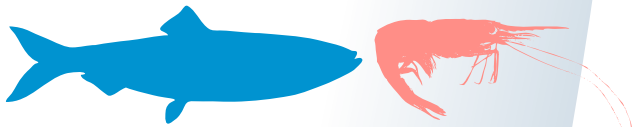
Juvenile groundfish

e.g. walleye pollock, Arctic cod

Juvenile salmon

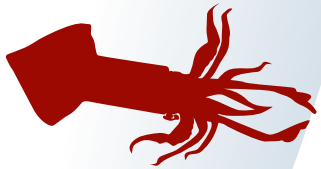
Juvenile invertebrates

e.g. snow crab



Herring, shrimp

Squid



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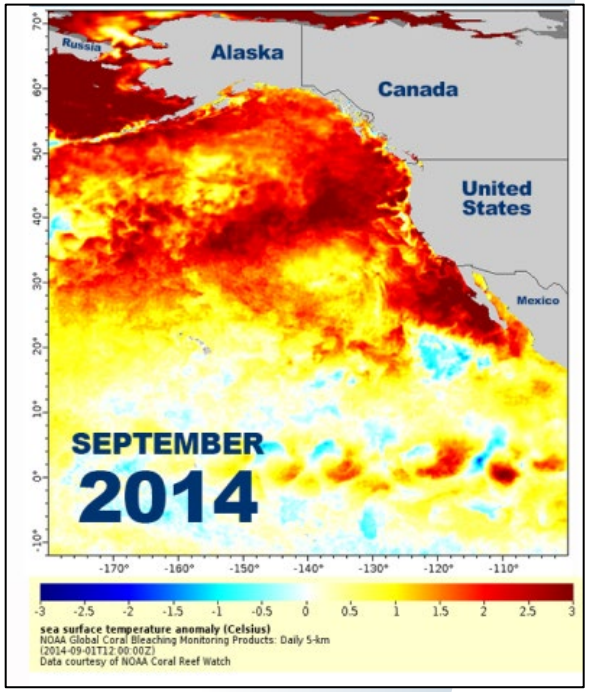
Ecosystem-based Impacts of Changes in Forage Community in Gulf of Alaska (GOA)

Collapse of key forage species during NE Pacific marine heatwave (2014–2016) coincided with severe impacts to predators (Arimitsu et al. ’21)



Courtesy of NOAA Coral Reef Watch

Impacts to top pelagic predators:

- Pacific cod declined >70% (Barbeaux et al. ‘20)
- Seabird mass mortality (Jones et al., ‘18; Piatt et al. ‘20)
- Humpback and fin whale mass mortality (Savage ‘17)
- Decline in humpback whale abundance & reproduction (Arimitsu et al. ’21; Neilson & Gabriele ’19)

EBFM need to monitor availability of forage species to predators

- Major data gaps persist, primarily due to a lack of directed surveys

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Monitoring in the Absence of Directed Surveys

Forage species data from existing stock assessment surveys designed for other species often limited or biased

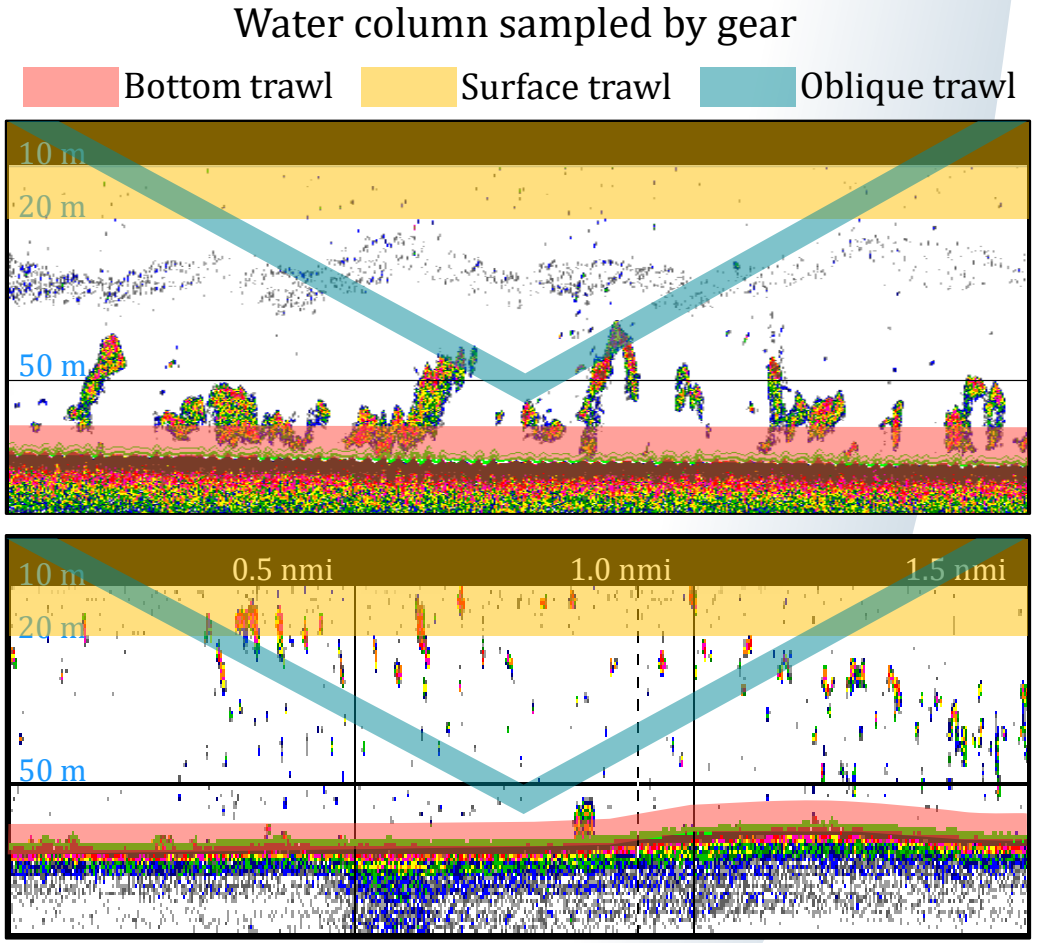
Fish behavior & distribution affect availability to gear:

(O'Driscoll et al. '02; McQuinn, '09; Parker-Stetter et al. '13; McGowan et al. '20)

Gear selectivity may bias species & size composition of samples, CPUEs, and abundance estimates

(Williams et al. '11; De Robertis et al. '17a)

Limited/mismatched spatial and temporal coverage



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NOAA Alaska Fisheries Science Center (AFSC) 2022 Forage Species Congress

Goal: *Improve the AFSC's state of knowledge regarding forage species in Alaska's large marine ecosystems and integrate research efforts across programs*

2-day workshop (spring 2022)

Objectives:

1. Identify functional forage species & groups in Alaska;
2. Assess forage-related research efforts;
3. Identify major scientific goals for forage research and knowledge gaps;
4. Provide recommendations regarding (1) important ecological and management questions addressed in next 5-7 years & (2) improved coordination of forage research.

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2022 AFSC Forage Species Congress

Key elements in AFSC processed report (2023)

Identify major goals & knowledge gaps by region (GOA, Bering Sea, Arctic)

Recommendations for future research priorities:

Improved surveys & data collection

- *Modifications to existing surveys: **GOA capelin example***
- *New data collection*
- *Analytic approaches for improved monitoring*

Identify scientific information needed for EBFM

- *Fishery impacts on forage species*
- *Impacts of changes in forage on managed predators*
- *Measure status of ecosystem to support sustainable fisheries; climate change monitoring & projections*

Prioritizing process studies for key forage species

Photo: NOAA

Photo: NOAA

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Improvements in Monitoring of Forage Species

Case study: *Gulf of Alaska Pacific capelin (Mallotus catervarius)*


Photo: NOAA

Synthesis of existing, limited data

Improving existing data sources

- Improving retention of small pelagic fish
- Accounting for sampling bias and/or gear selectivity
- Expanding single-species focus to multi-species

Model-based approaches for improved abundance time series

- Spatio-temporal models
- Combining survey- and predator diet-based indices

Incorporating new technologies in monitoring

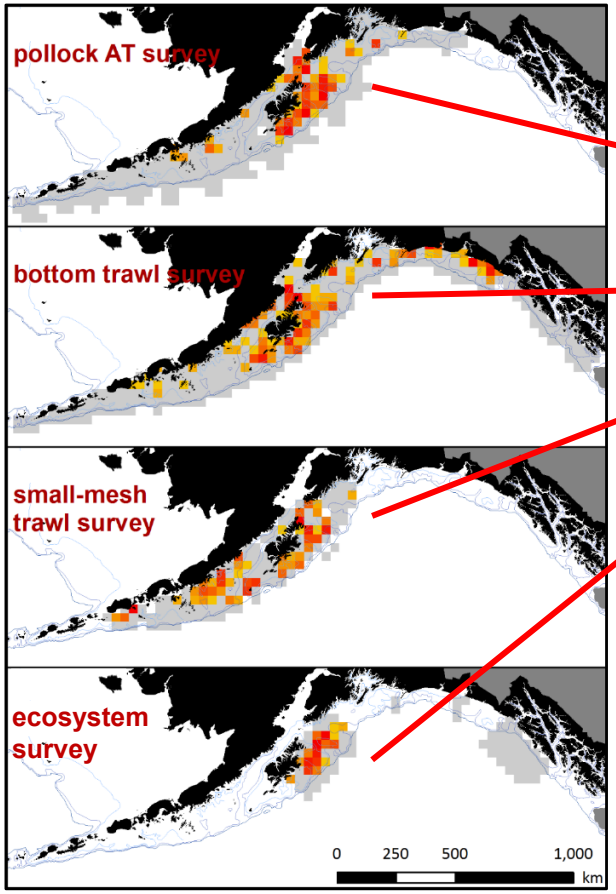
Augmenting existing surveys with an uncrewed surface vehicles (USV)

Using additional data sources (eDNA, video) to classify acoustic data

Data Synthesis: Characterizing Spatial Patterns

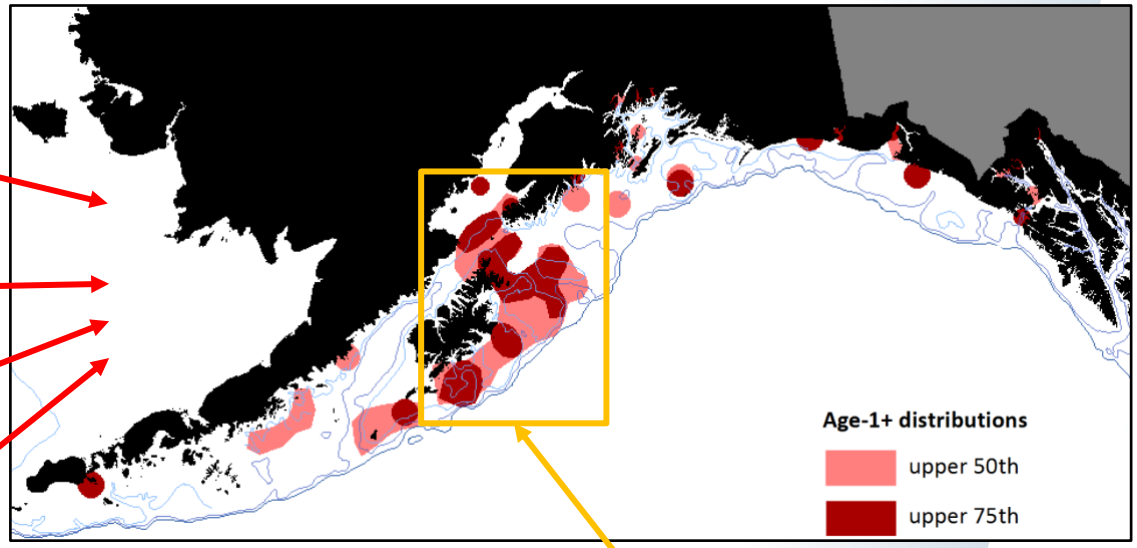
Integrate multiple data sources to identify core areas where capelin concentrate → informs where to prioritize monitoring

Normalized density by survey



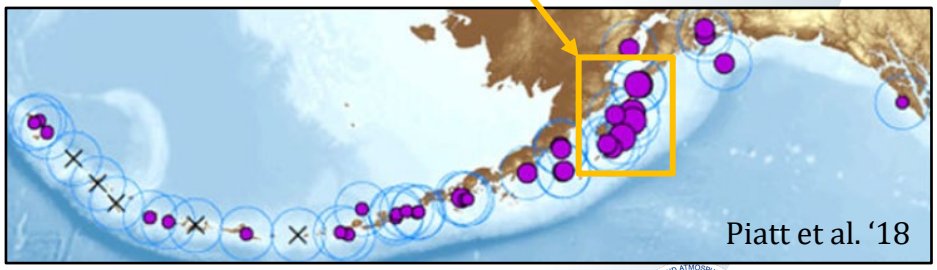
Normalized Density Percentile (%)
- < 10
- 10 - 20
- 20 - 30
- 30 - 40
- 40 - 50
- 50 - 60
- 60 - 70
- 70 - 80
- 80 - 90
- > 90

Composite spatial pattern based on all surveys



McGowan et al. '20

Capelin in groundfish diets



Piatt et al. '18

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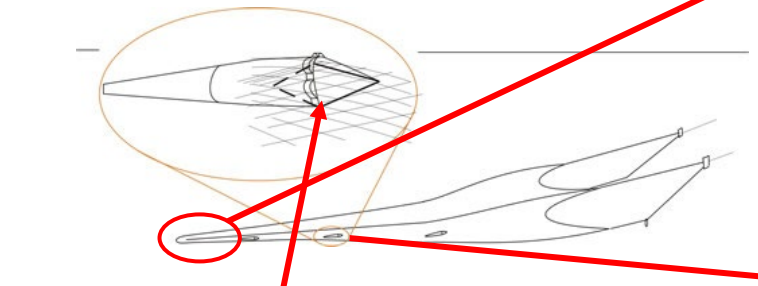
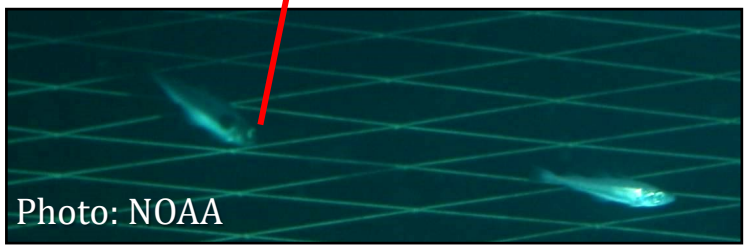
Gulf of Alaska Pollock Acoustic-Trawl (AT) Survey

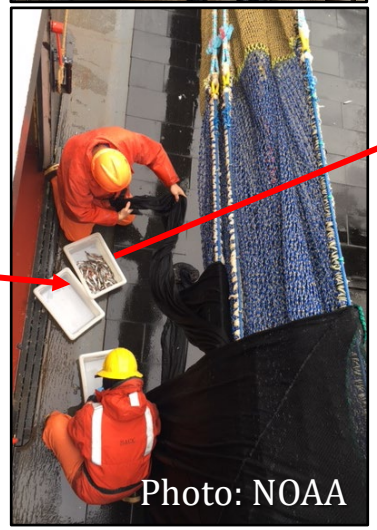
Improving retention of small pelagic fish and correcting for species- & length-related trawl selectivity

Switch to fine-mesh codend liner (3.2 → 1.3 → 0.3 cm) to retain smaller fish/organisms

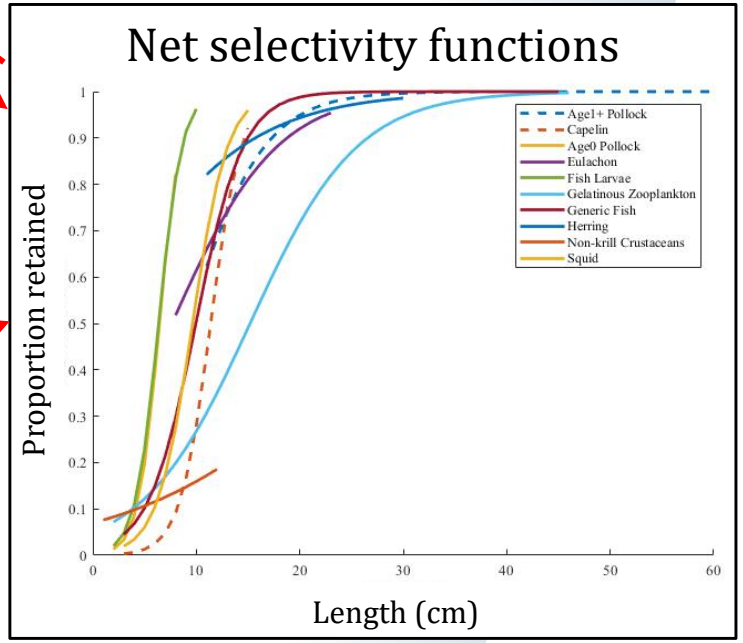
Use recapture nets to estimate species-specific selectivity correction functions
(Williams et al. '11; De Robertis et al. '17a)







Trawl-derived estimates of species & size composition adjusted by probability of escapement of all organisms



Levine et al. *In prep*

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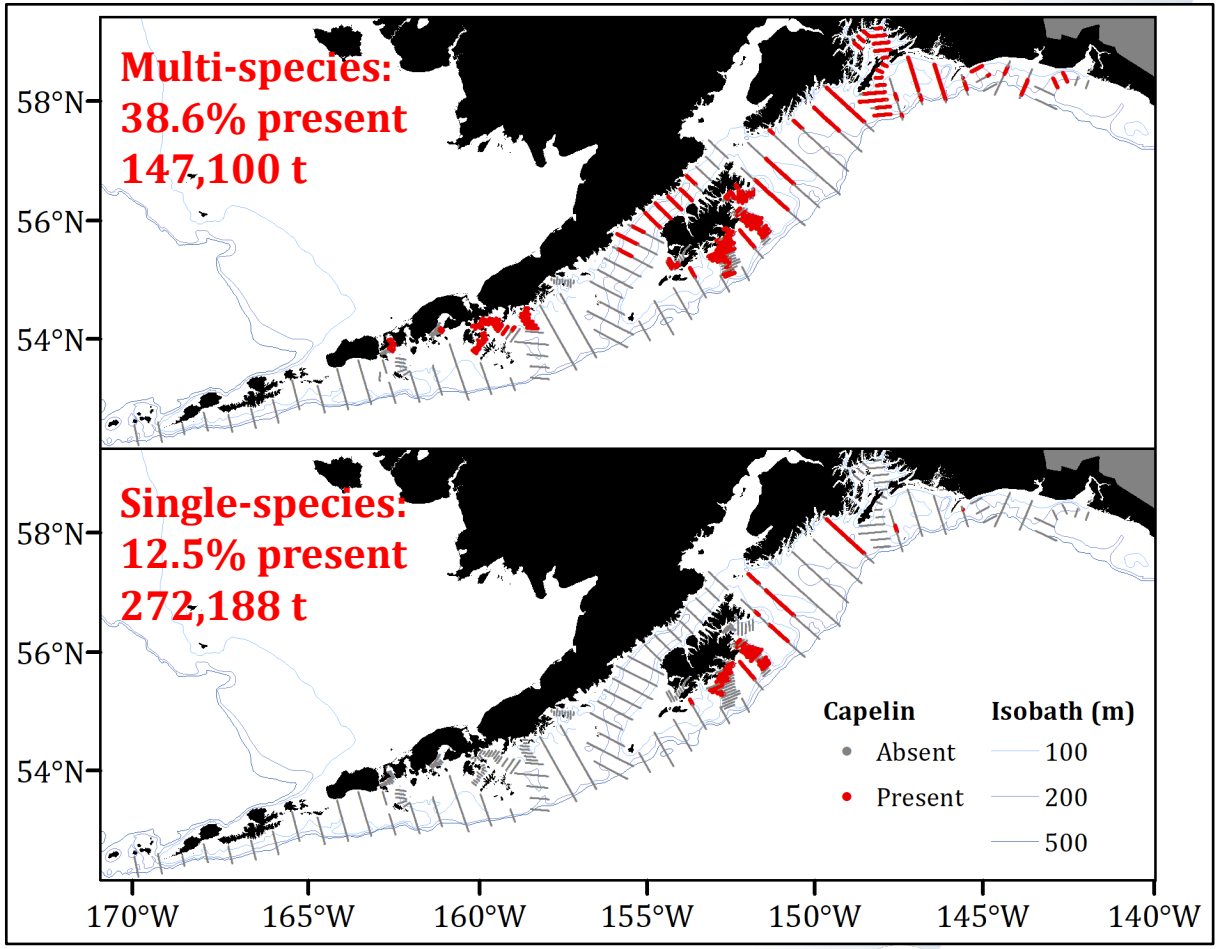
GOA Pollock AT Survey: Multi-species Allocation

Allocate acoustic data among all species in trawl catch instead of only to dominant single species

Acoustic backscatter allocated to all observed species using selectivity-corrected trawl catch
(De Robertis et al. '17b)

- Increases capelin occurrence frequency from low density observations & mixed catches
- 46% decline capelin biomass



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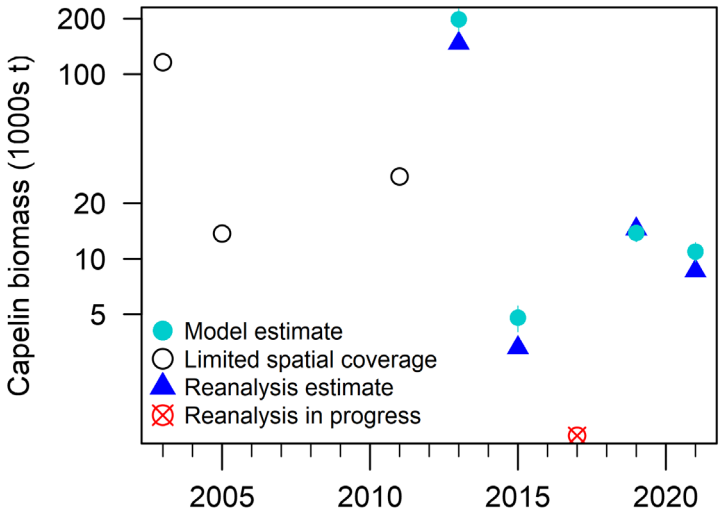
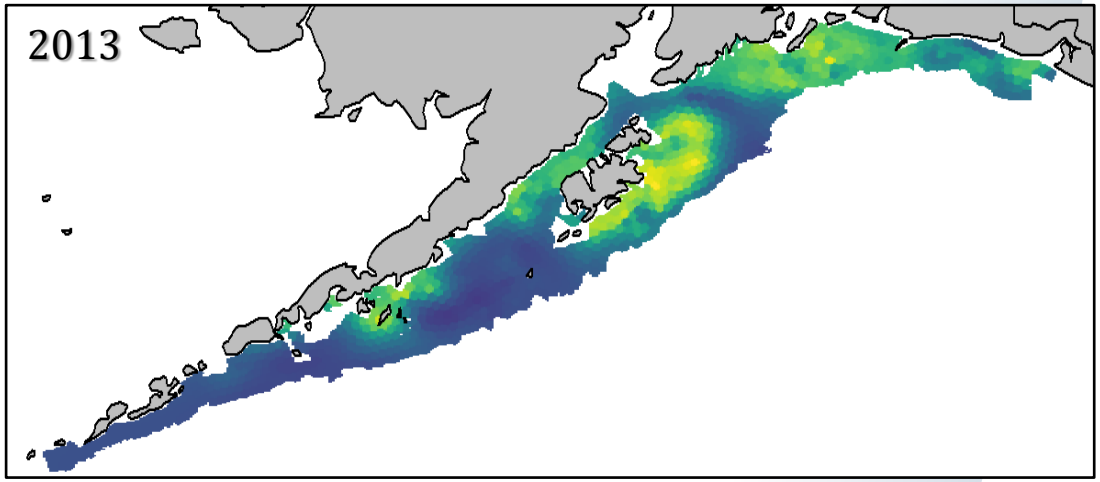
GOA Pollock AT Survey: Capelin Abundance Index

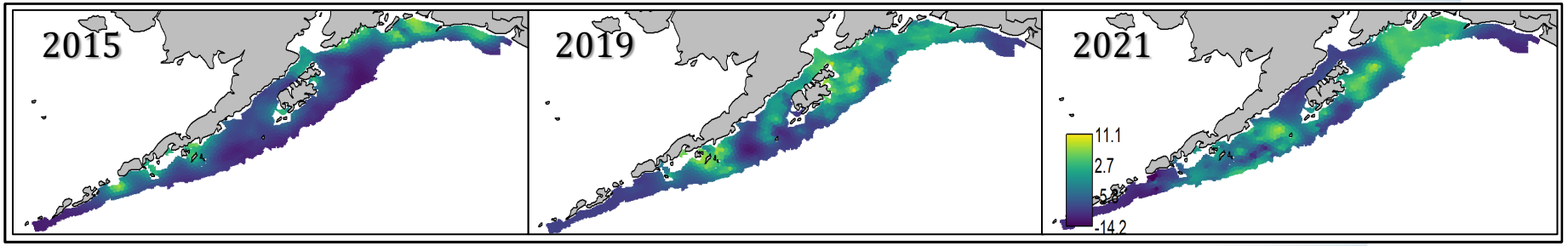
Reanalysis of historical surveys (2013–2021, ‘17 in progress)
Limited spatial coverage pre-2013 → use model-based estimator?

Capelin Index of Abundance



Vector Autoregressive Spatio-temporal (VAST) GLMM
(Thorson & Barnett ’17; Thorson ’19)





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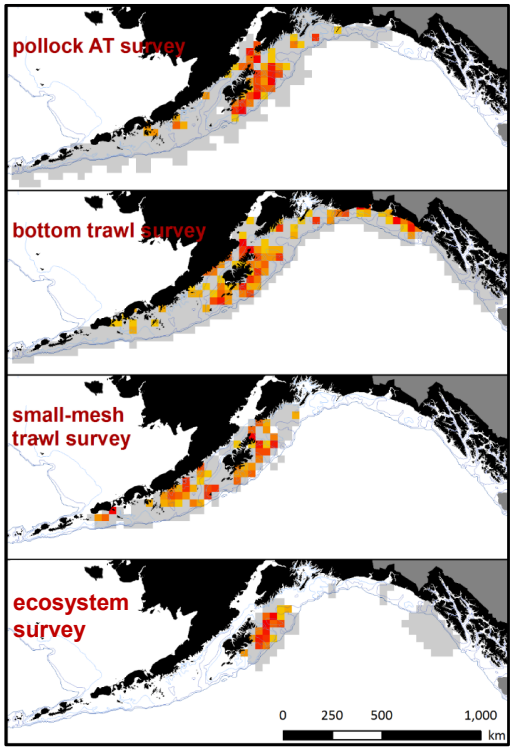
Developing Index Standardization Models

FUTURE: extend capelin time series by combining multiple survey- and predator diet-based indices in VAST

Combining multiple survey-based indices

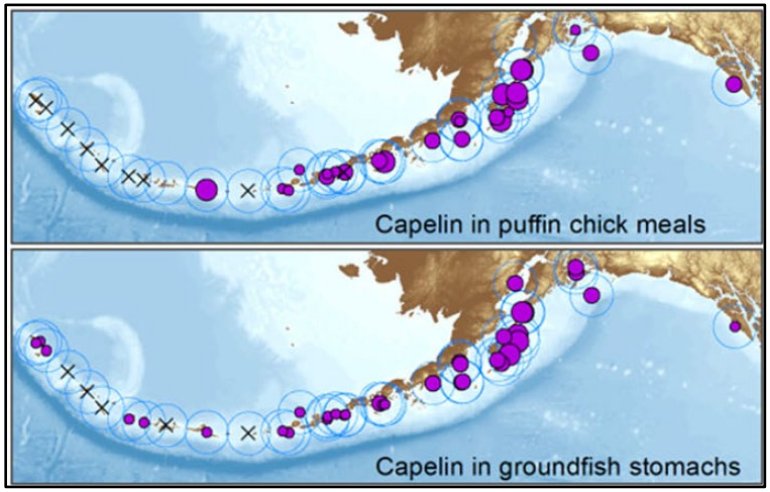
- Fit spatial model to two seasonal surveys to estimate ratio of catchability (Perretti & Thorson '19)
- Vertically integrated index for combining bottom & acoustic-trawl surveys (Monnahan et al. '21)



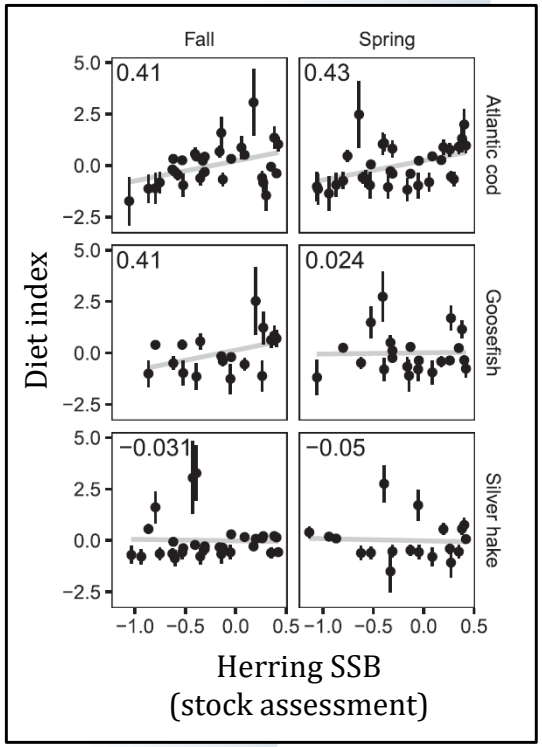
McGowan et al. '20

Predator diet-based indices

Predator stomach contents used to estimate indices of prey biomass (Grüss et al. '20; Ng et al. '21)



Piatt et al. '18



Ng et al. '21

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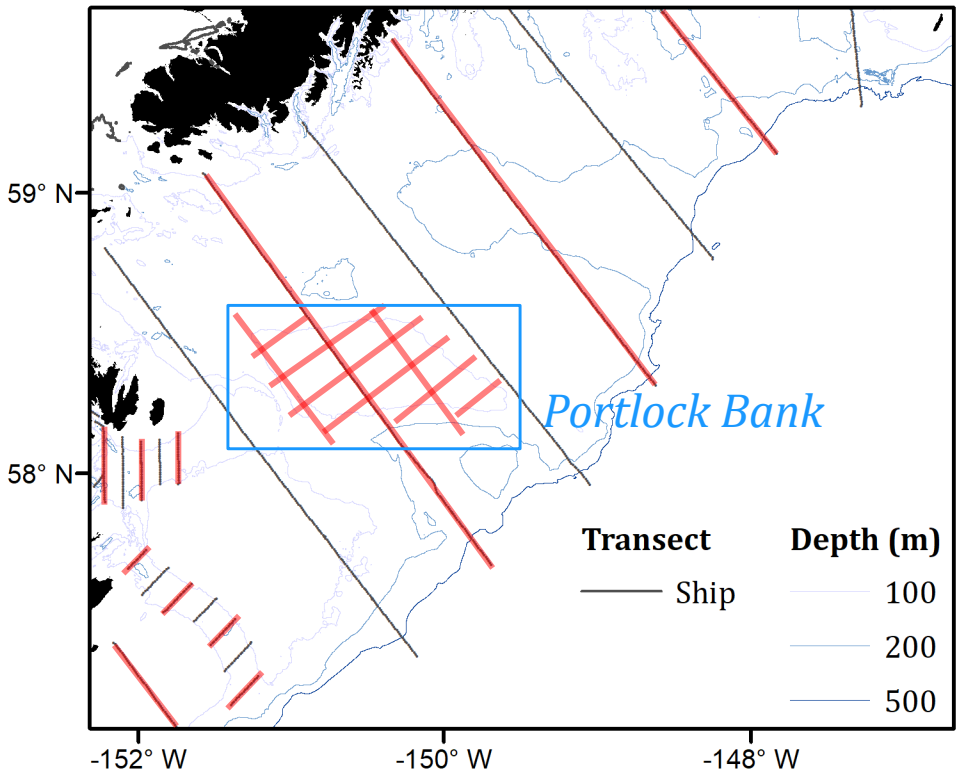
Future Improvements to Surveys & Data Collection

Using uncrewed surface vehicle (USV) to augment existing ship-based acoustic-trawl survey

Free up ship time for increased trawling

Supplemental sampling of areas of interest



iXblue DriX USV

Diesel-powered, autonomous acoustic sampling at survey speed

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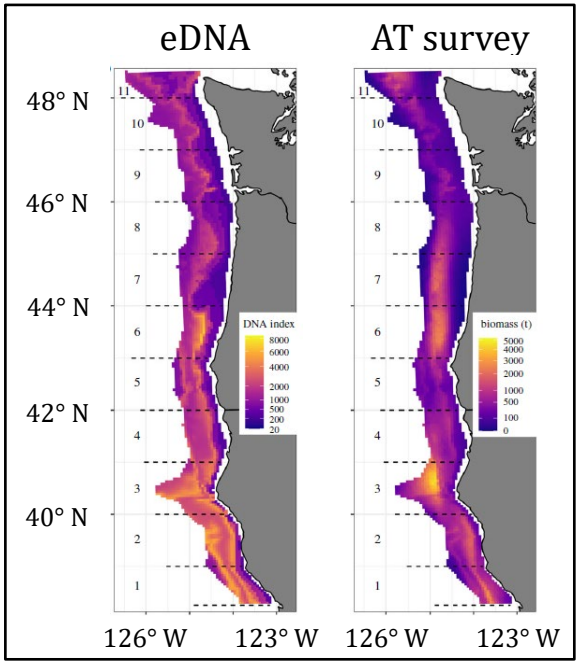
Future Improvements to Surveys & Data Collection

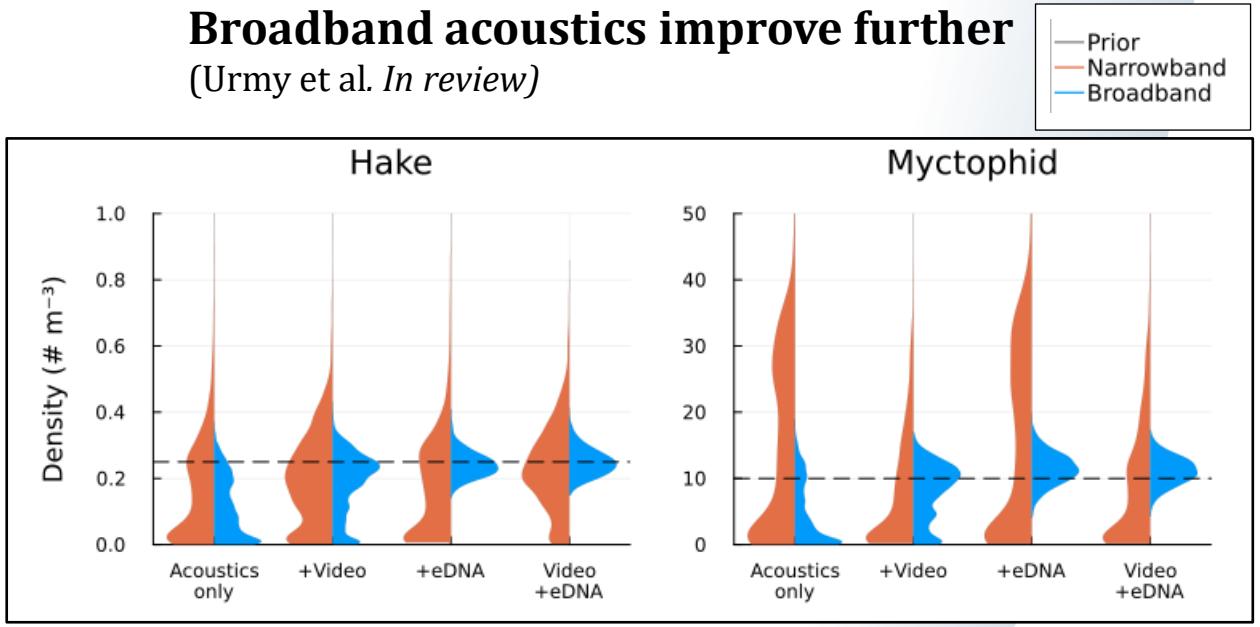
Estimating species ID and density using new ground-truth sources (eDNA, video) with broadband acoustics & Bayesian models from surveys lacking targeted trawls

Spatial patterns of hake from acoustics and eDNA similar at broad (1° N) scales
(Shelton et al. '22)



Simulation: Video + eDNA don't measure hake density, but improve acoustic estimates by constraining other species in Bayesian model

Broadband acoustics improve further
(Urmy et al. *In review)*



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Acknowledgements

MACE Program colleagues

Officers and crew of the NOAA Ship *Oscar Dyson*

2022 AFSC Forage Species Congress Steering Committee

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References:

Arimitsu et al. 2021. *Global Change Biology*, 27: 1859–1878

Barbeaux et al. 2020. *Frontiers in Marine Science*, 7

De Robertis et al. 2017a. *Deep Sea Research Part II*, 135: 40–50

De Robertis et al. 2017b. *Deep Sea Research Part II*, 135: 51–65

Grüss et al. 2020. *Fish and Fisheries*, 21: 718–739

Jones et al. 2018. *Geophysical Research Letters*, 45: 3193–3202

Levine et al. *In prep*. Results of the acoustic-trawl survey of walleye pollock (*Gadus chalcogrammus*) in the Gulf of Alaska, June-July 2021 (DY2021-04). AFSC Proc. Rep., NOAA, NMFS, Seattle WA

McGowan et al. 2020. *Marine Ecology Progress Series*, 637: 117–140

McQuinn, 2009. *Can. J. of Fish. and Aq. Sci.*, 66: 2256–2262

Monnahan et al. 2021. *ICES J. Marine Science*, 78: 1826–1839

Neilson & Gabriele, 2019. Glacier Bay & Icy Strait humpback whale population monitoring: 2018 update. National Park Service Resource Brief

Ng et al. 2021. *ICES J. Marine Science*, 78: 1146–1159

O'Driscoll et al. 2002. *ICES J. Marine Science*, 59: 1062–1071

Parker-Stetter et al. 2013. *Deep Sea Research Part II*, 94: 211–230

Perretti & Thorson, 2019. *Fisheries Research*, 215: 62–68

Piatt et al. 2018. *Fisheries Oceanography*, 27: 366–380

Piatt et al. 2020. *PLOS ONE*, 15: e0226087

Savage, 2017. Alaska and British Columbia Large Whale Unusual Mortality Event summary report. 2017. NOAA-NMFS

Shelton et al. 2022. *Proc. R. Soc. B-Biol. Sci.*, 289: 20212613

Thorson & Barnett, 2017. *ICES J. Marine Science*, 74: 1311–1321

Thorson, 2019. *Fisheries Research*, 210: 143–161

Williams et al. 2011. *ICES J. Marine Science*, 68: 119–129

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