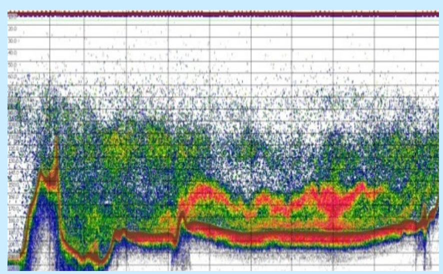
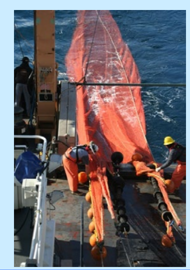
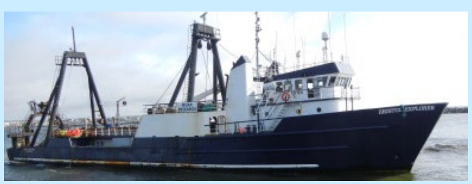
NOAA FISHERIES SERVICE

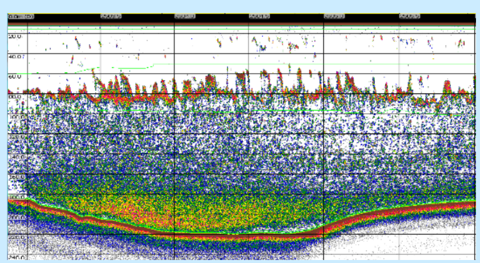
Gulf of Alaska Acoustic-Trawl Surveys

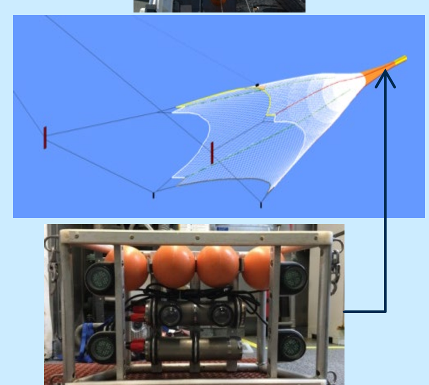
MACE Program, RACE Division, Alaska Fisheries Science Center











CIE Review May 2024

Outline

Survey Equipment and Methods

Areas Surveyed

Example Survey Results

Active areas of survey-related research

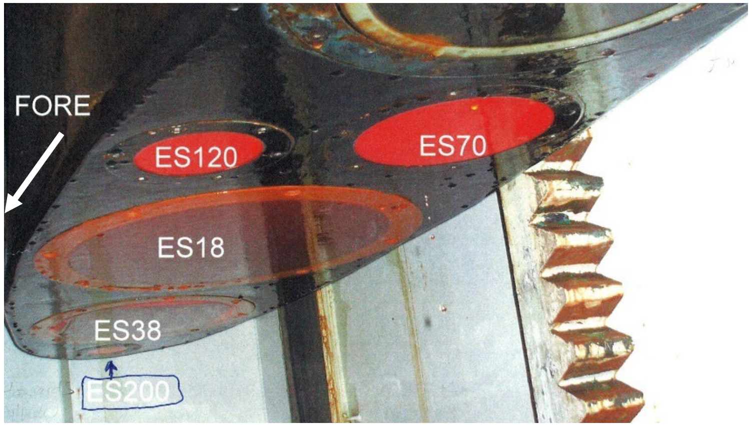
Acoustic-Trawl Survey Equipment

- **Vessel**: principally, NOAA Ship *Oscar Dyson* (Commissioned 2005, 64 m, 2500 t, 3100 hp)

- **Acoustic System**: **Simrad EK80** echosounder (18, **38**, 70, 120, 200 kHz)
  Echoview software to analyze acoustic data

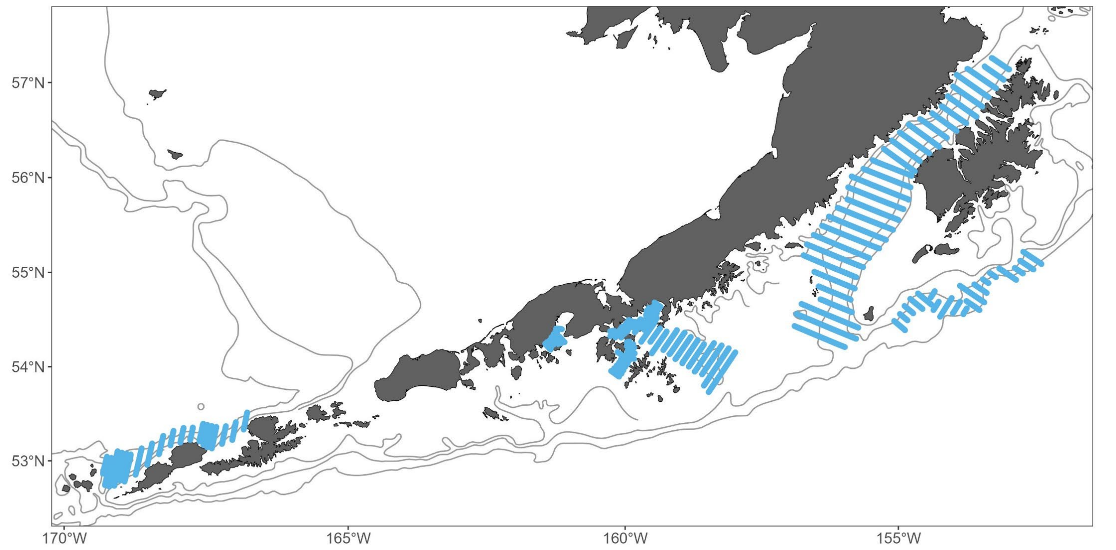
- **Nets**: Midwater - **LFS1421** (76.8 m head/ft rope, vert. open. 14-17 m, net mesh 6.5 m to 3 mm codend liner)

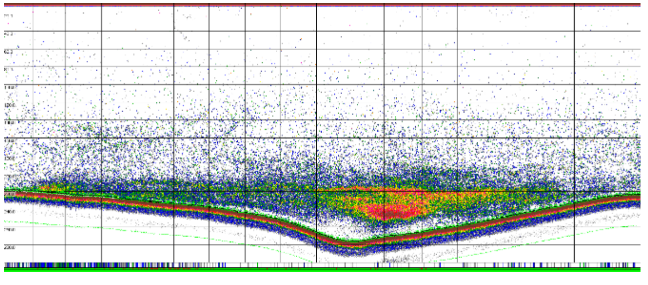
- Bottom - **poly Nor'eastern trawl** (27.4/25 m head/ft rope, vert. open. 6-10 m, net mesh 12.7 cm to 13 mm codend liner)



Acoustic-Trawl Survey Methods

- Survey 24 hrs/day (winter) or daylight hours only (summer)
- Abundance estimates use 38 kHz acoustic backscatter, 16 m from surface to 0.5 m above seafloor
- High backscatter "targeted" hauls
- Physical oceanographic data collected





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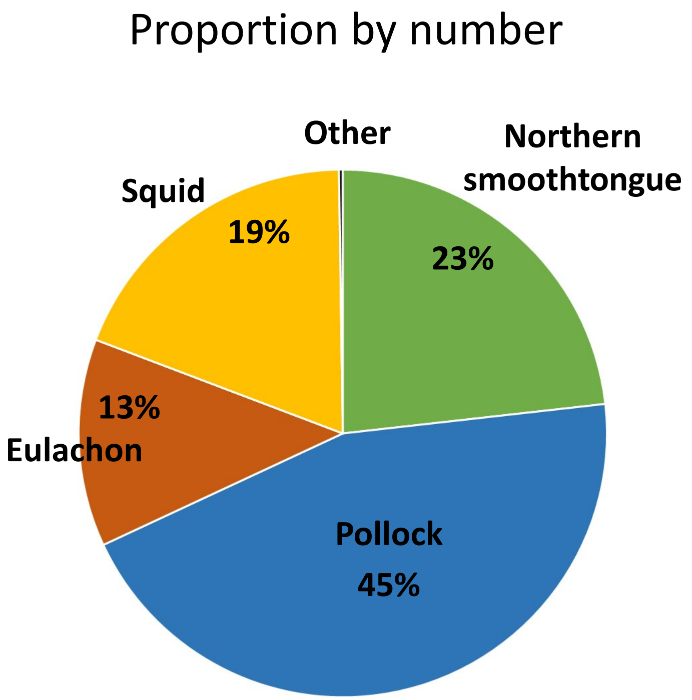
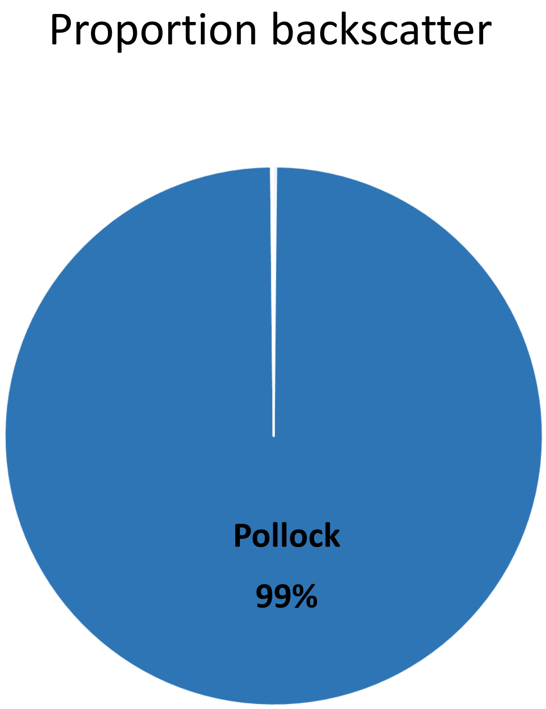
Survey Biomass estimate

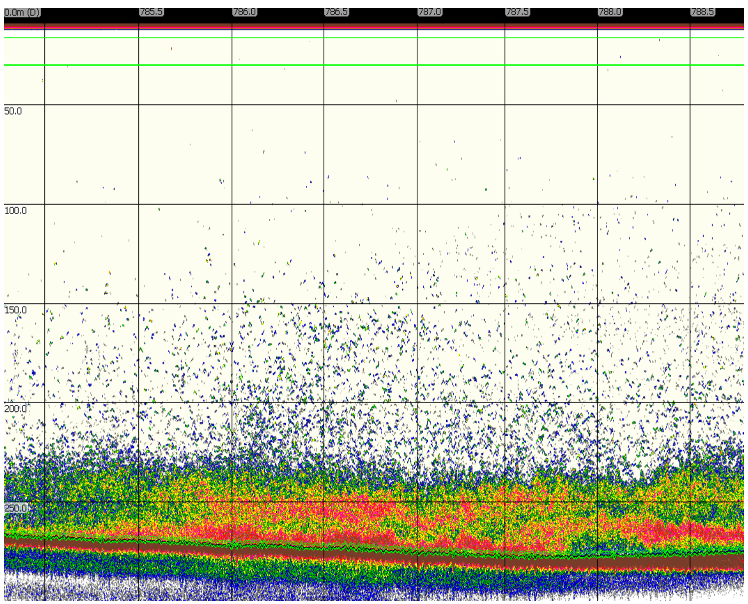
Species & length composition in trawl samples





Estimating abundance in acoustic-trawl surveys (multiple species/sizes)

Fish abundance (# fish/m^2) is estimated by combining ***backscatter*** with the ***acoustic properties*** of species in the net.



$$\text{Density}_{s,l} = \frac{\left(p_{s,l} \ast \text{backscatter density} \right)}{\sigma_{bs,s,l}}$$

Proportion of backscatter from species *s* in length class *l* (Trawl data)

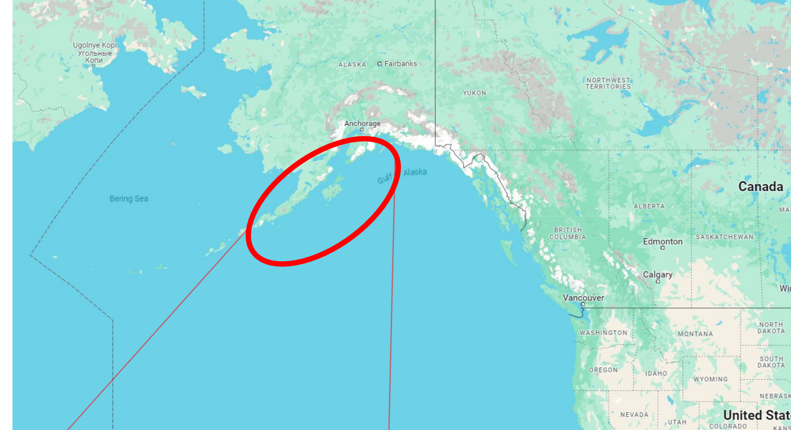
backscatter from one individual of species s in length class *l*

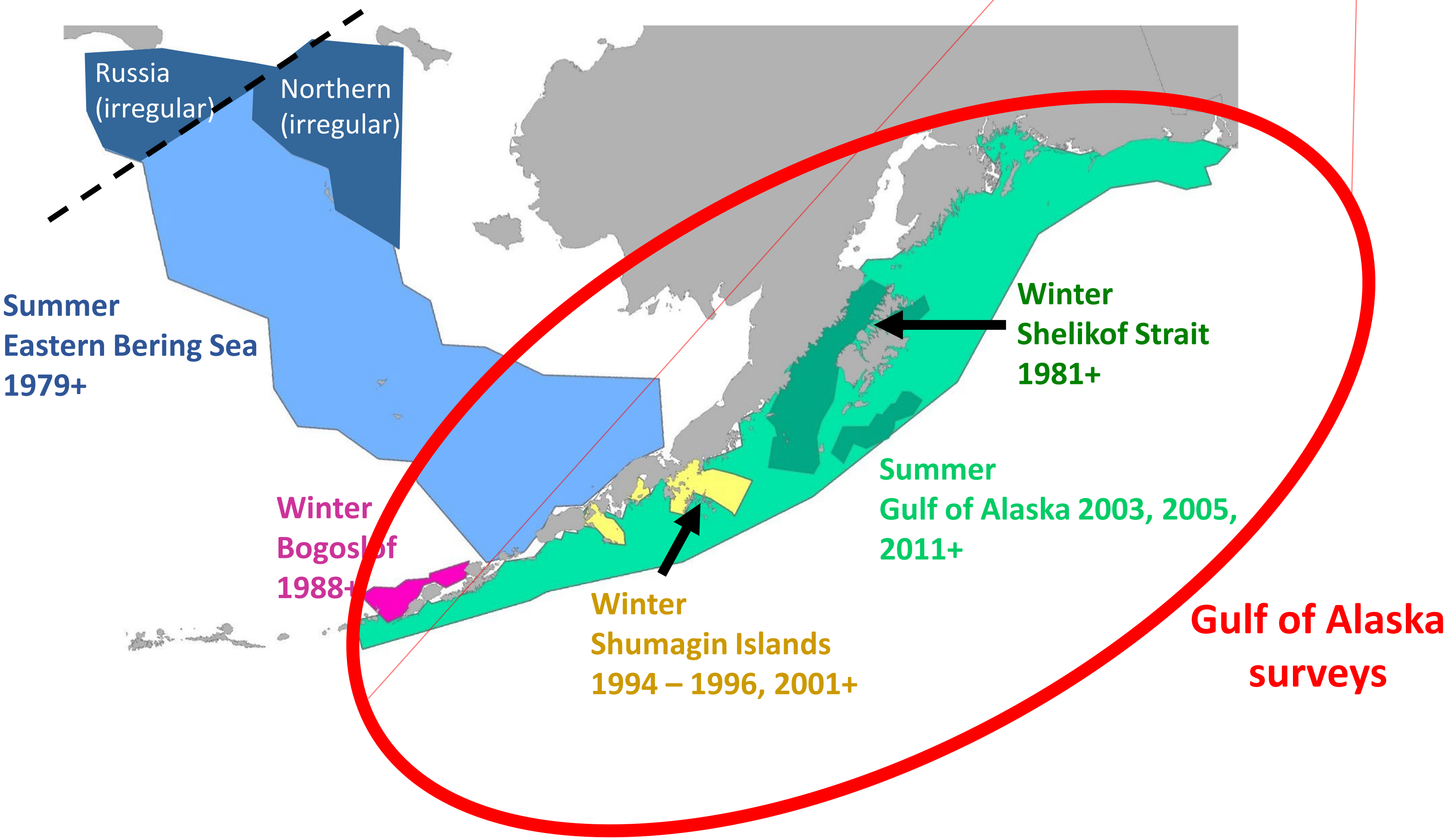
# of pollock by length* X** *Weight of 1 pollock by length =* ***Biomass of pollock by length

Biomass of pollock by length* X** *proportion of age at length =* ***Biomass of pollock by age

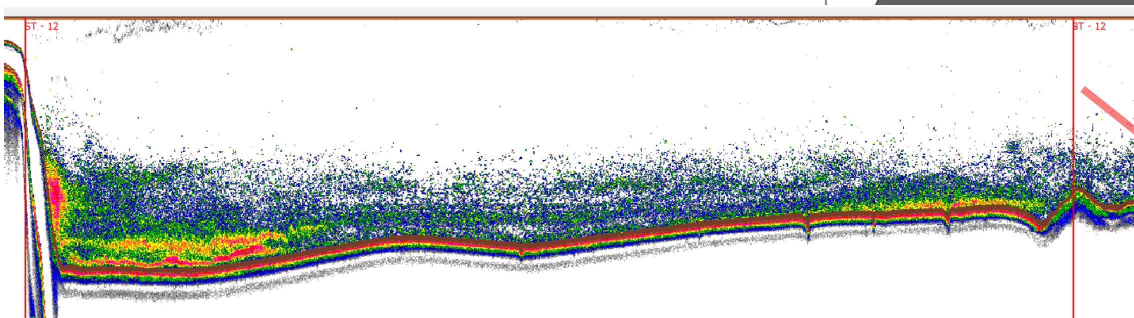
De Robertis et al. 2017

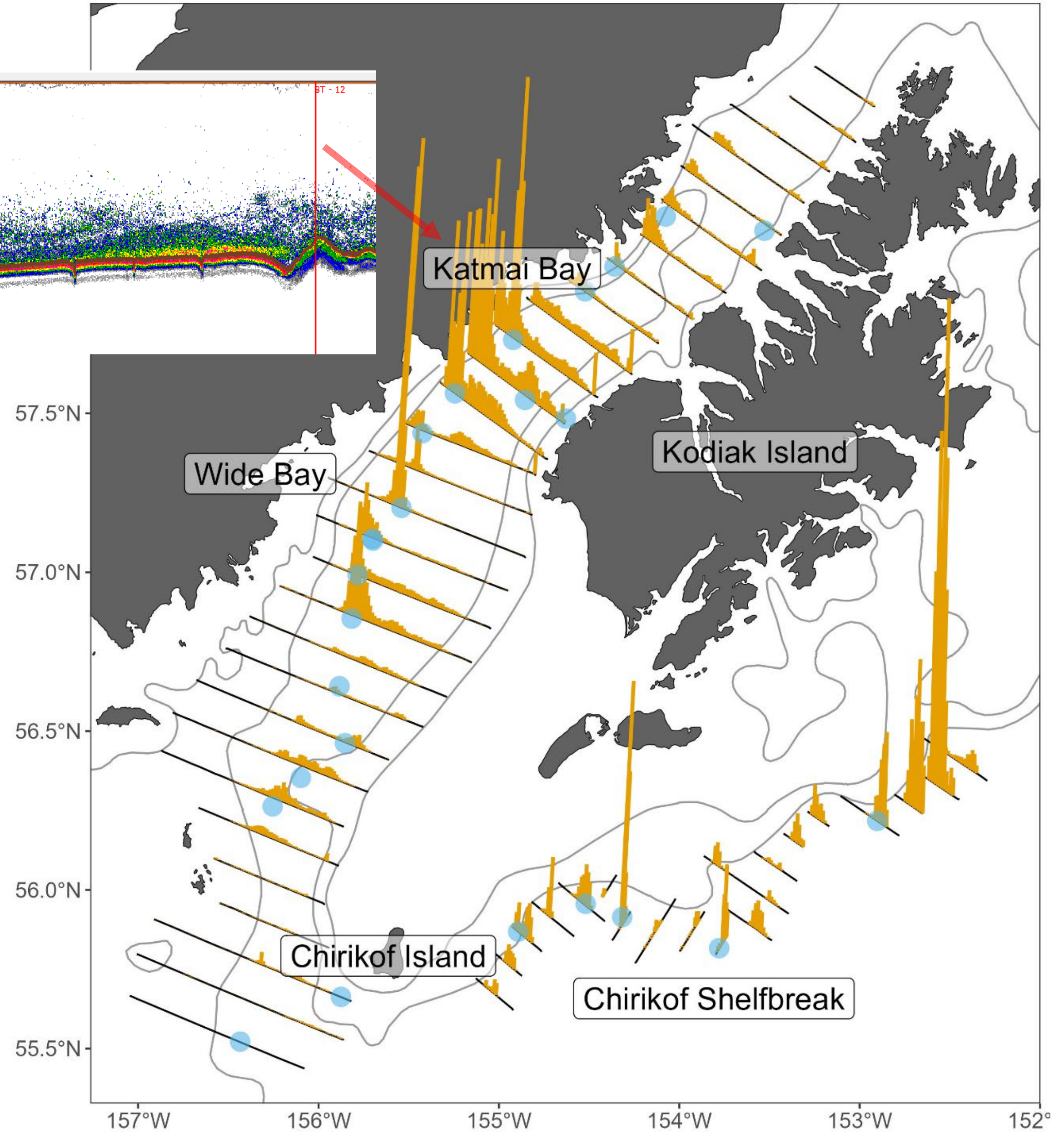
Acoustic-trawl surveys by season





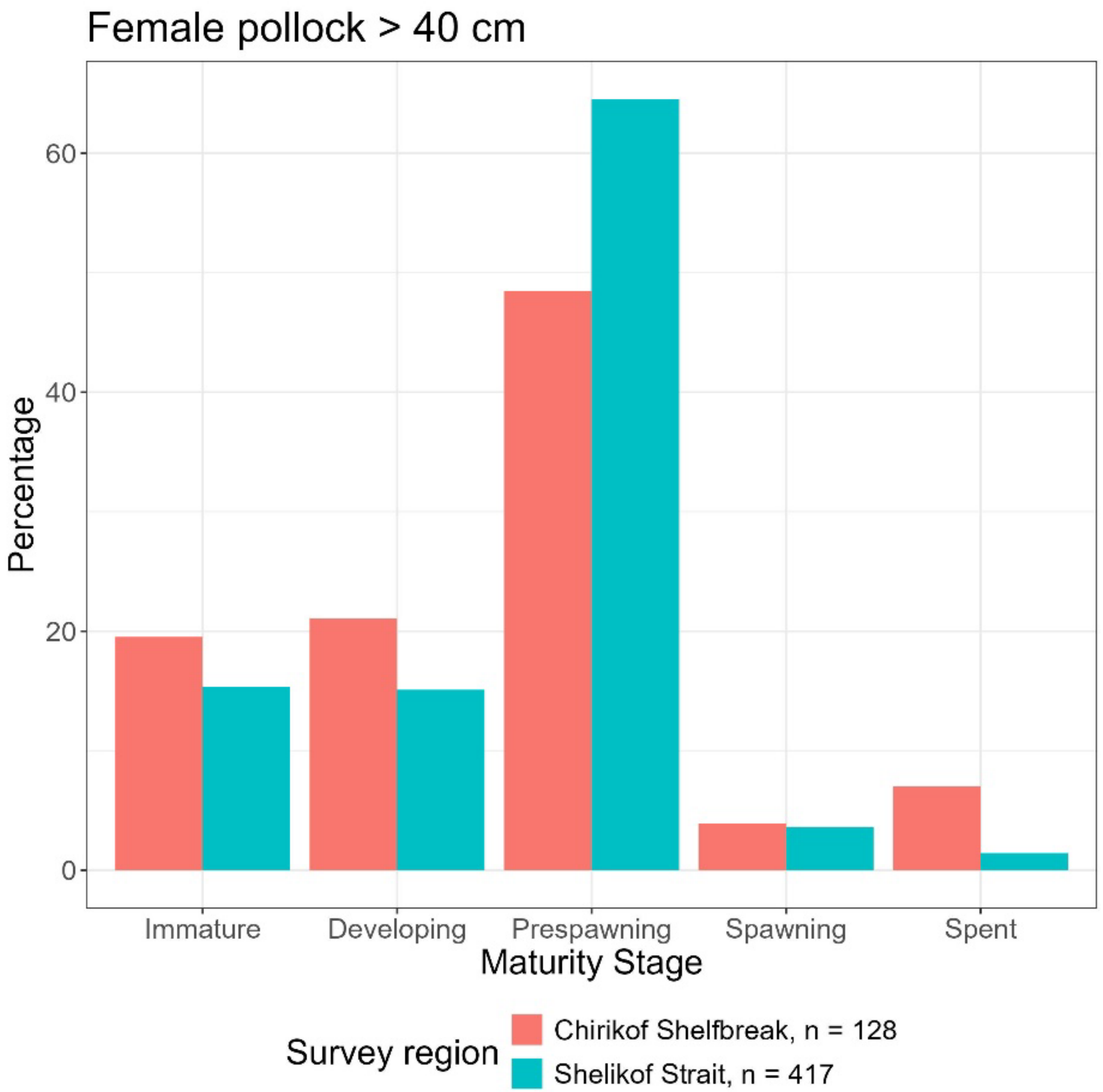
Example result: spatial distribution



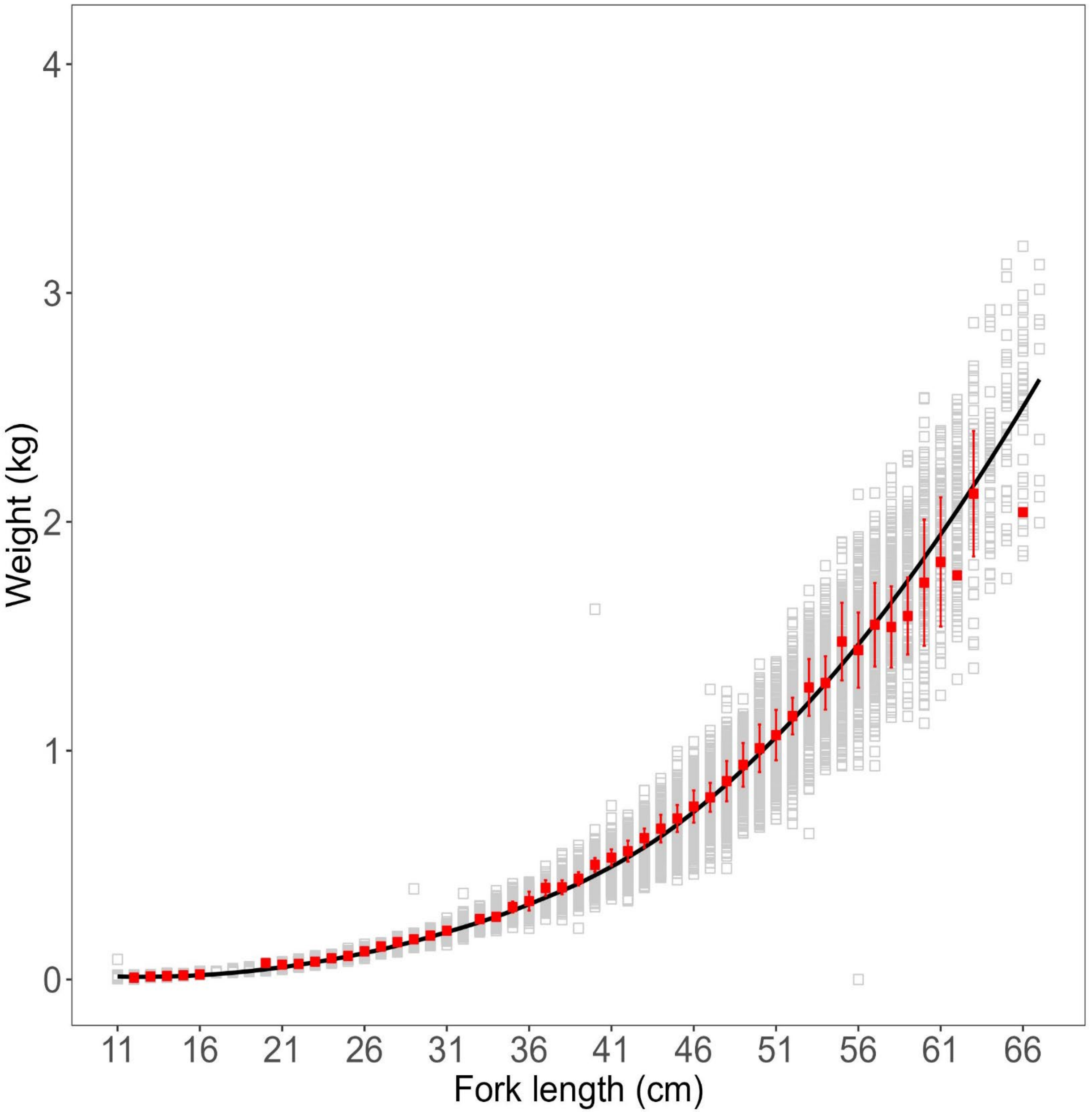


At right: black lines are transects, vertical orange bars are proportional to pollock biomass, blue dots are haul locations

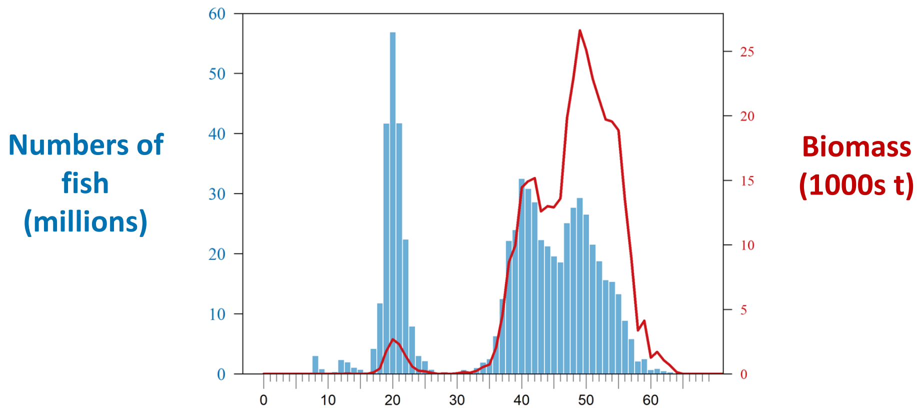
Example result: maturity composition

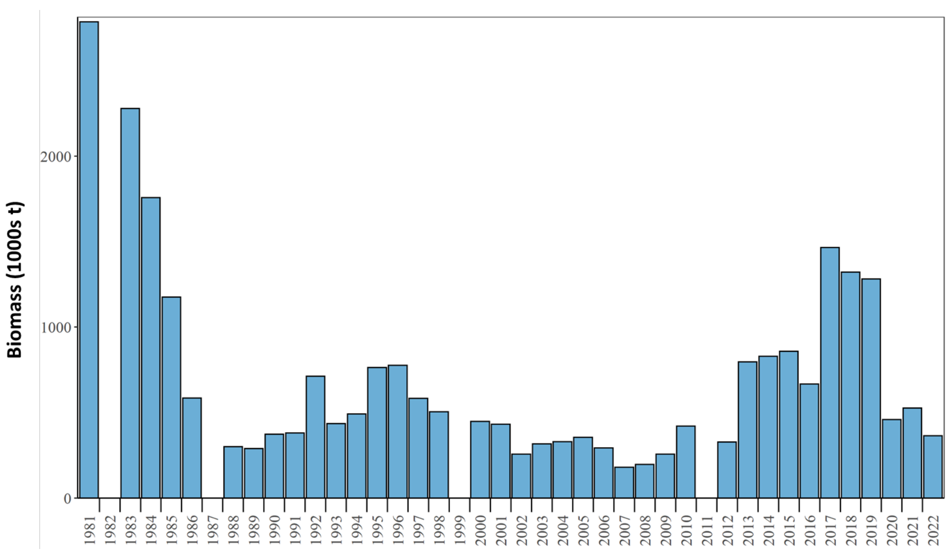


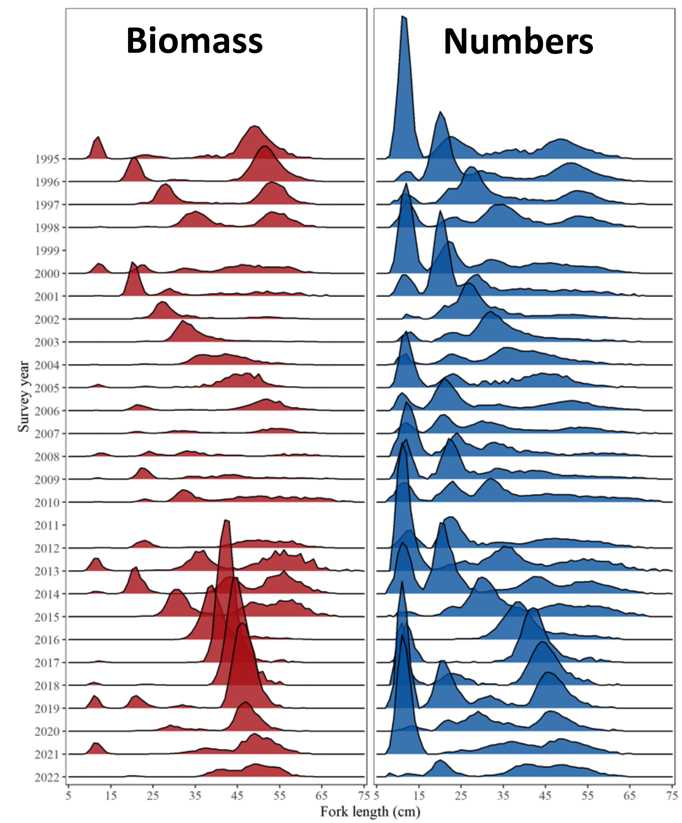
Example result: weight at length, age



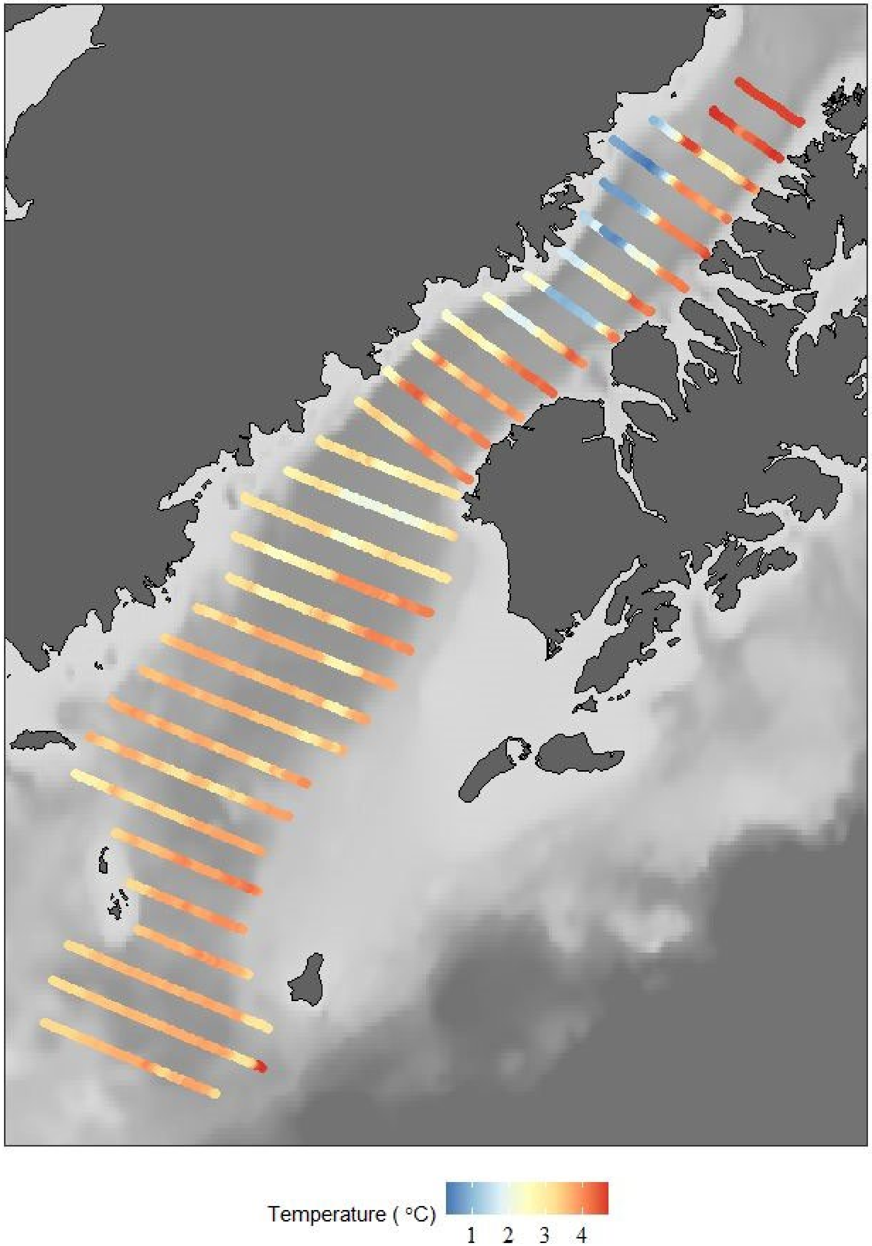
Example result: time series of pollock abundance and biomass at length, age

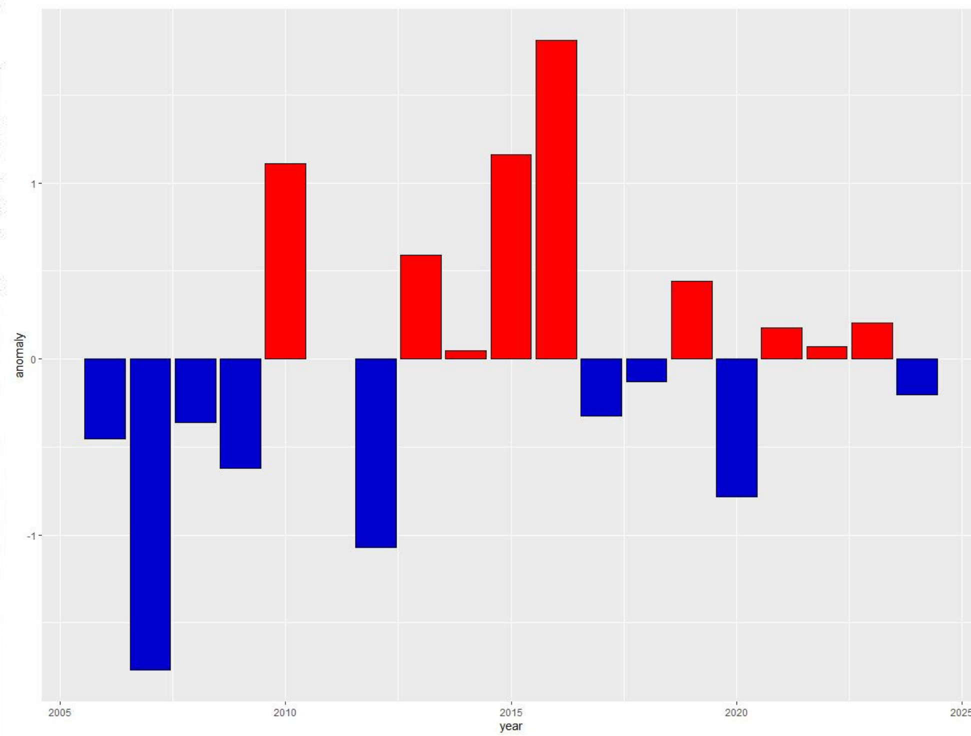






Example result: sea surface temperatures





2006-2024 average sst: 3.93°C
2024 is 0.4°C **deg below** average

Acoustic-trawl surveys

Different from bottom trawl surveys

- Combines acoustic and trawl measurements to estimate abundance
- Continuously measure backscatter along tracklines
- Targeted trawl samples scale the backscatter (not preplanned locations)

Acoustic-trawl surveys

Limitations of acoustics

- Near-boundary blind zones
- Species ID relies on trawl samples,
  -takes time, and it's a coarser sampling tool than the higher resolution of acoustics, we need lots of samples, especially in a complex ecosystem

Advantages of acoustics

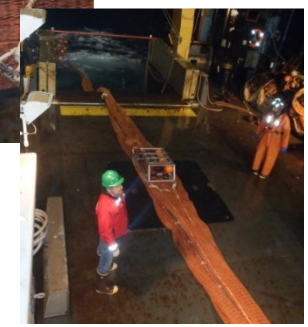
- Large sampling volume (high precision)
- Efficient
- Good spatial and temporal coverage
- Vertical distribution
- Works best in ecosystems with low species diversity or dominated by a single species

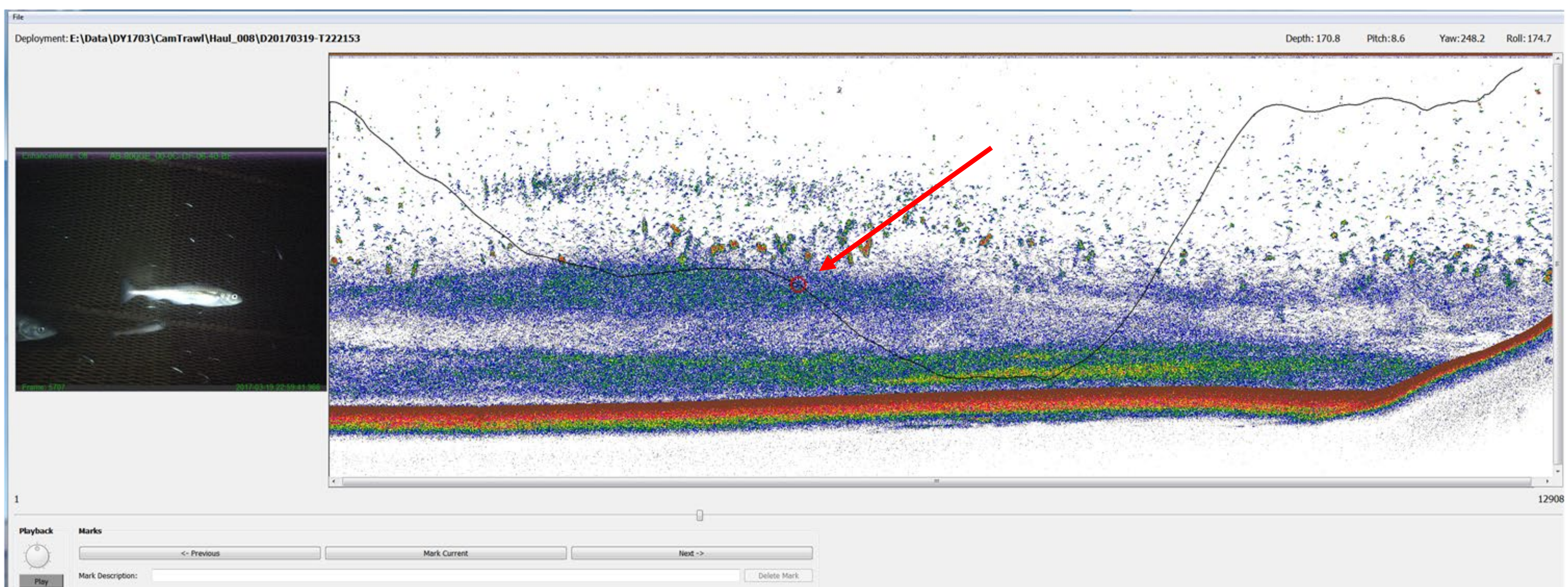
Active areas of research

- Underwater camera observations of fish and other species
- Correcting trawl catches for selective capture, improving trawl performance
- Echosounder moorings to observe time series of aggregation and movement
- Uncrewed systems for more efficient surveys
- Acoustic-trawl survey uncertainty budget
- Probabilitistic, multifrquency acoustic classification
- Model-based (vs. design-based) survey estimates
- Acoustic-trawl survey estimates of pollock prey

Underwater camera observations of fish and other species

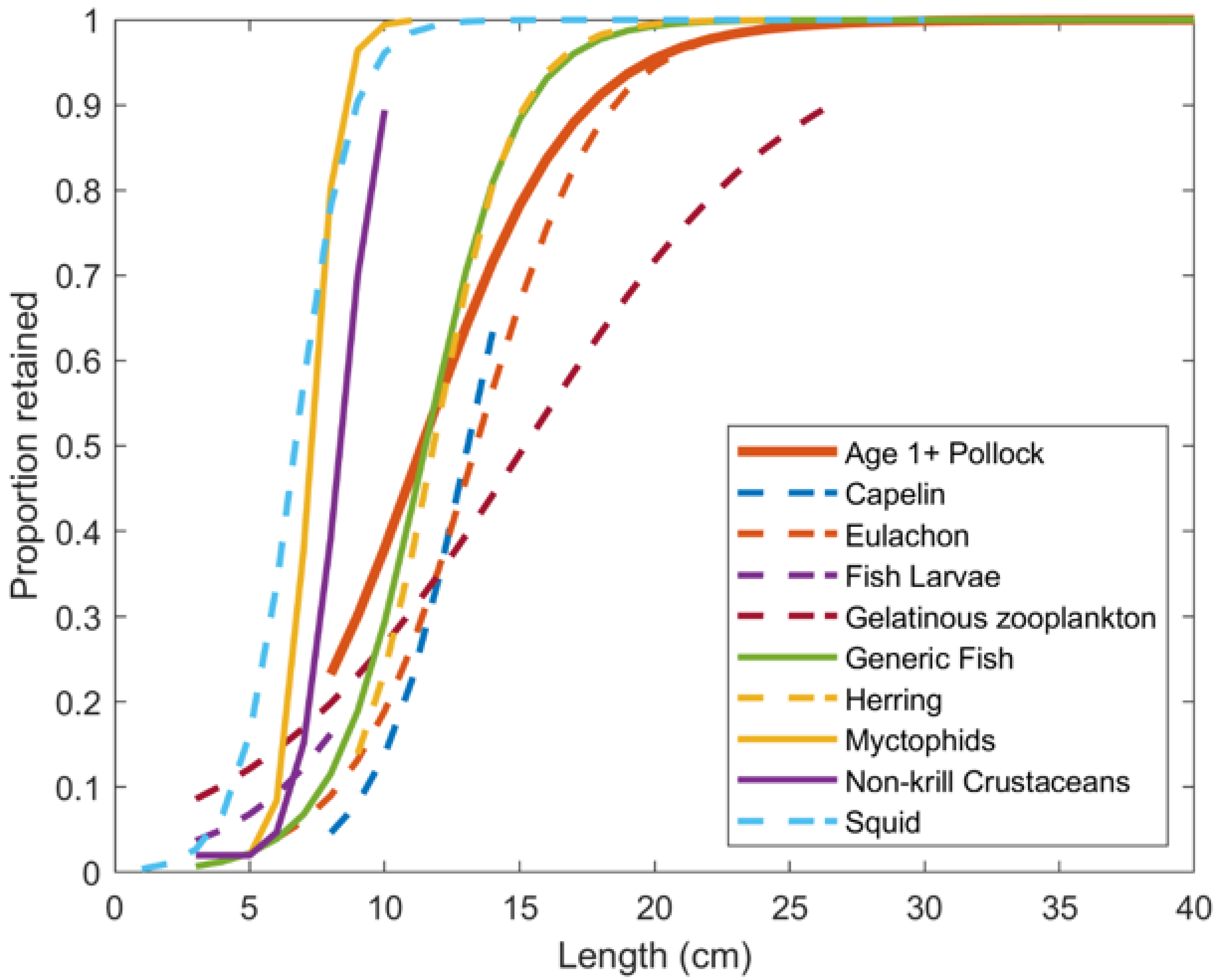
- Improves species classification of backscatter
- Can be a non-extractive sampling device
- Understand vertical distribution with single codend trawl





Williams et al. 2010, 2023

Correcting trawl catches for selective capture, improving trawl performance

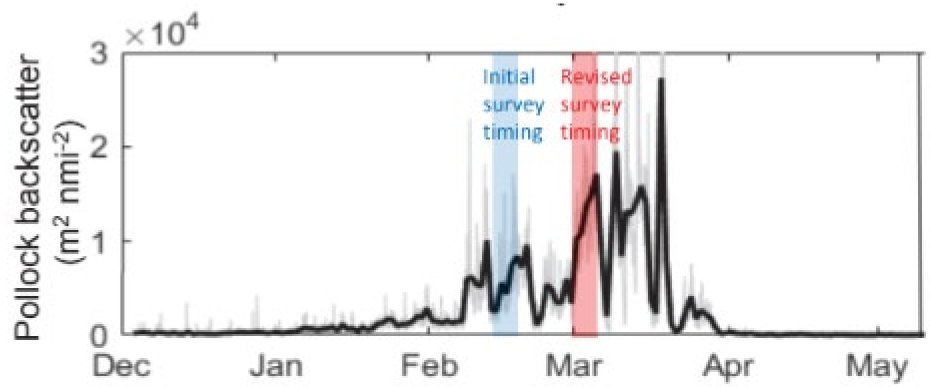


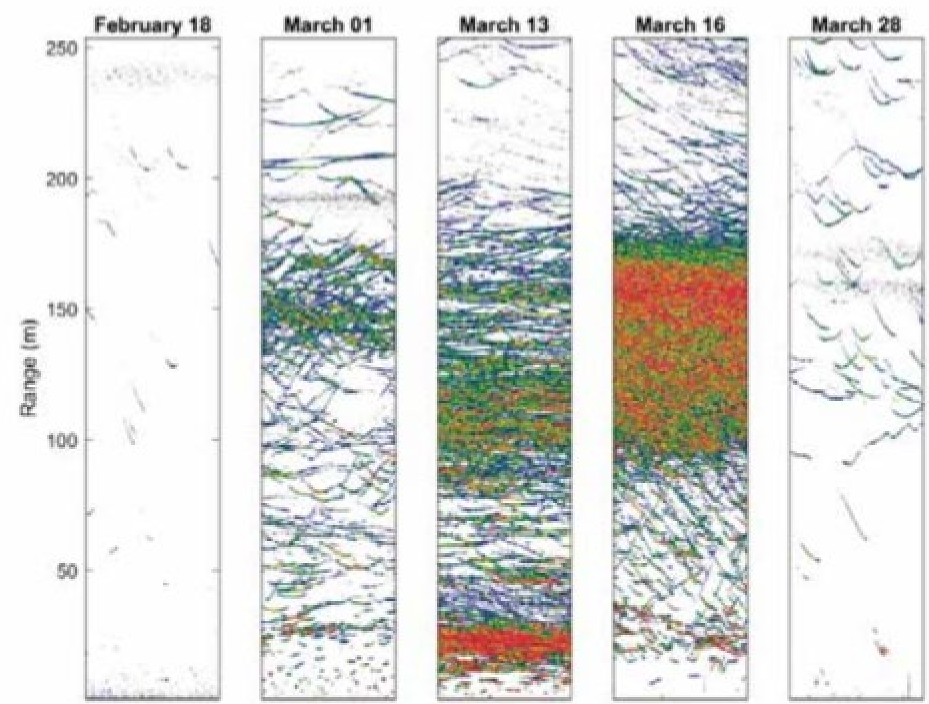
Williams et al. in prep

Figure A1. -- Selectivity functions estimated for the DY2102 survey using recapture nets. Selection function values are only plotted for length ranges encountered for each selectivity group.

Echosounder moorings on seafloor to observe time series of aggregation and movement

De Robertis et al. 2016,
Levine et al. in prep





Walleye pollock spawning aggregation, Shelikof Strait

Uncrewed systems for more efficient surveys

(Photo by Bryan Begun)

What we did

- Evaluated uncrewed surface vehicle as a ‘force multiplier’ for acoustic surveys
- Instrumented with 4-frequency EK80
- Developed shipboard procedures to safely deploy, recover, and refuel
- Controlled the USV over a satellite link
- Side-by side testing to evaluate data and fish reactions to vessel

Future goals

- Reduce propeller cavitation to improve sonar performance. Currently produces good data to 150 m
- Increase weather window for launch/recovery

Contact: Alex.DeRobertis@noaa.gov

Probabilitistic, multifrequency and wideband acoustic classification

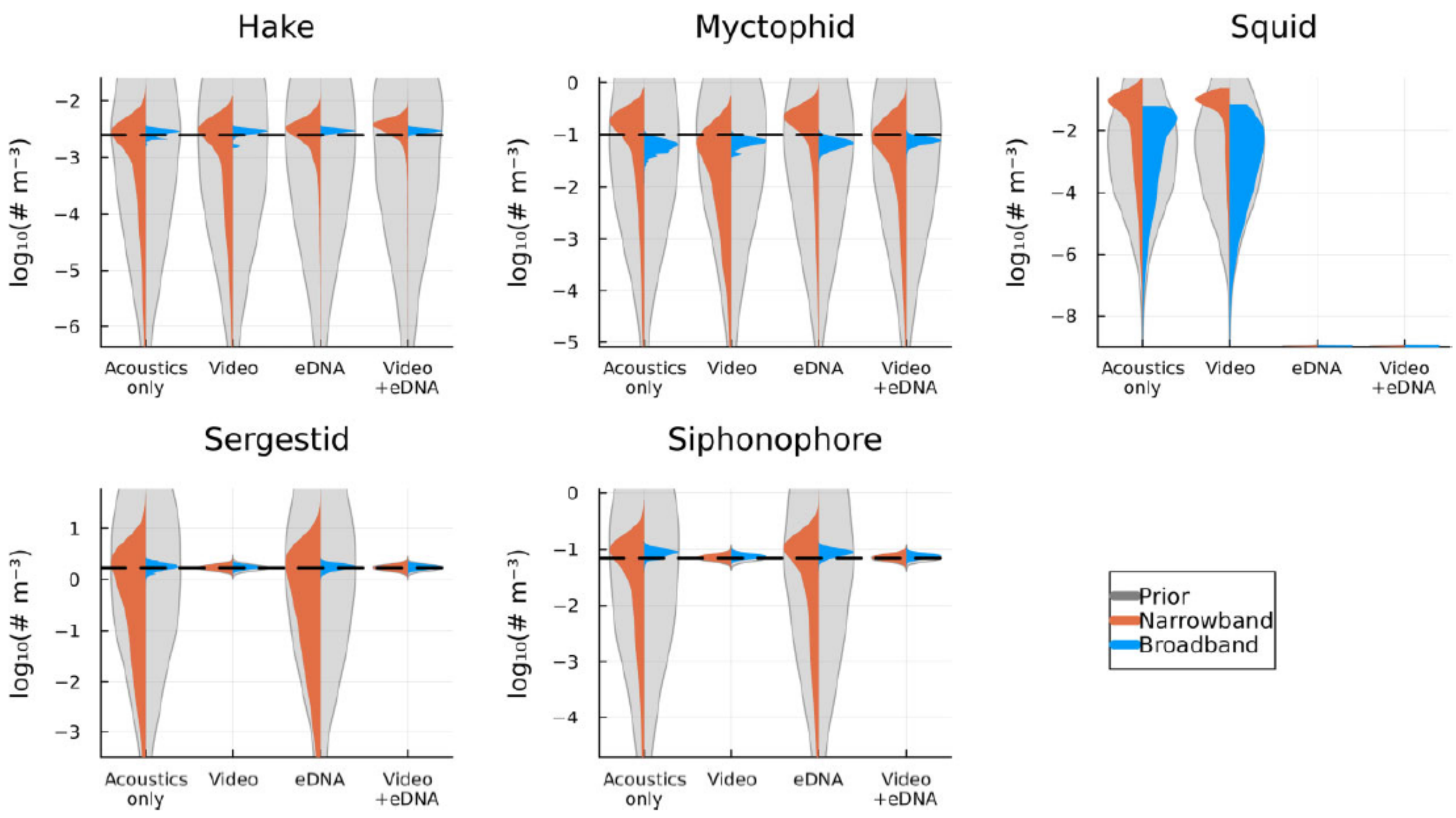
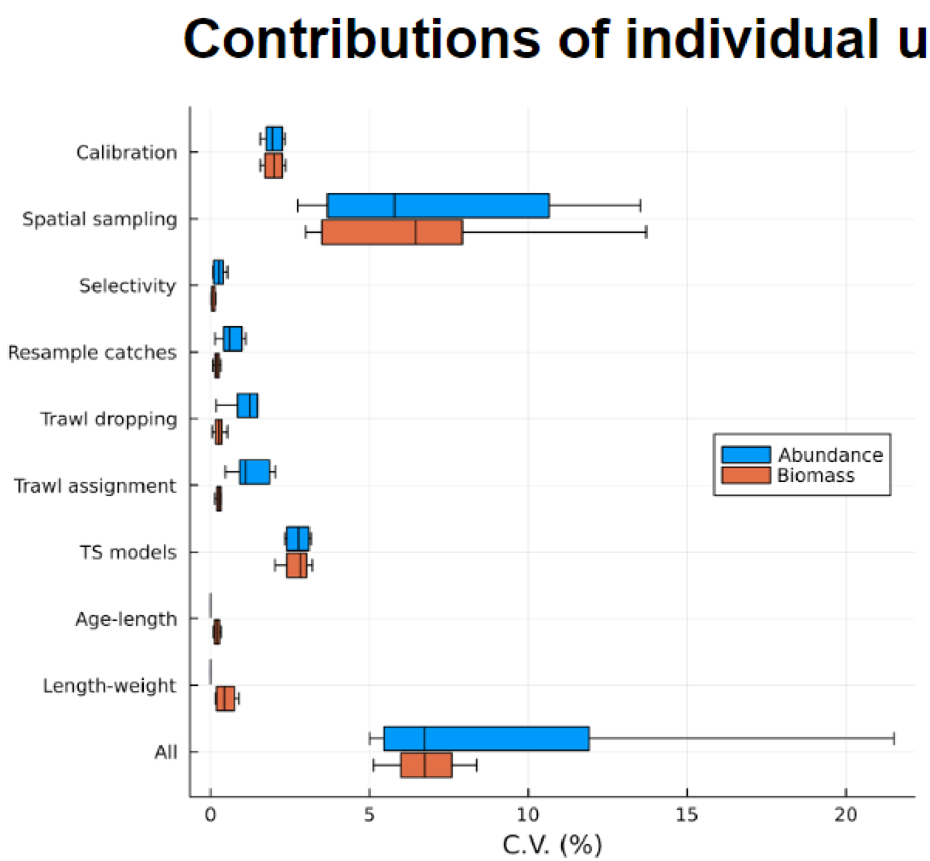


Figure 6. The accuracy and precision of Bayesian inverse solutions improved with the addition of auxiliary data and with the expansion of acoustic data from NB to BB. Each subplot shows the prior (grey) and posterior distributions (orange for NB, blue for BB) of scatterer density in each of four simulated scenarios. In the first scenario, only acoustic data were available. In the second, a video survey revealed the density of sergestid shrimp and siphonophores (reflected in their narrower priors), but none of the faster-swimming animals. In the third, environmental DNA (eDNA) confirmed the presence (but not abundance) of all scatterers except for squid. In the final scenario, both video counts and eDNA were available. Even though neither *in-situ* sampling method could quantify hake or myctophids, the constraints they imposed allowed the model to improve its estimates of their density relative to the true values (horizontal dashed lines).

Urmy et al. 2023

Acoustic-trawl survey uncertainty budget



- Re-analyzed all surveys, turning on one component at a time
- Largest individual sources, on average:
  - Spatial sampling error
  - TS models
  - Echosounder calibration
  - Trawling-related sources (mostly for abundance)

- Some differences year-to-year
- EBS is homogenous–trawling likely more important in GOA

Urmy et al. in prep

Model-based (vs. design-based) survey estimates

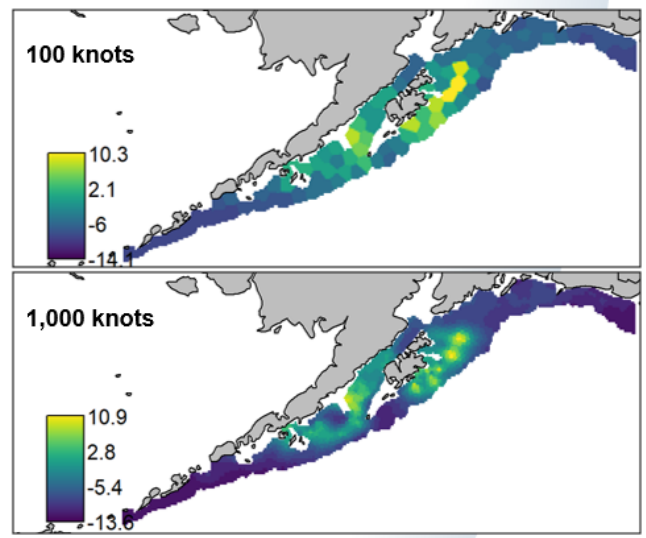
Model-based estimator: VAST

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

Delta (*i.e.*, hurdle) model, joint likelihood estimate for encounter and positive catches

GMRF for spatial & spatio-temporal effects

Different rules for fitting to acoustic data compared to trawl data



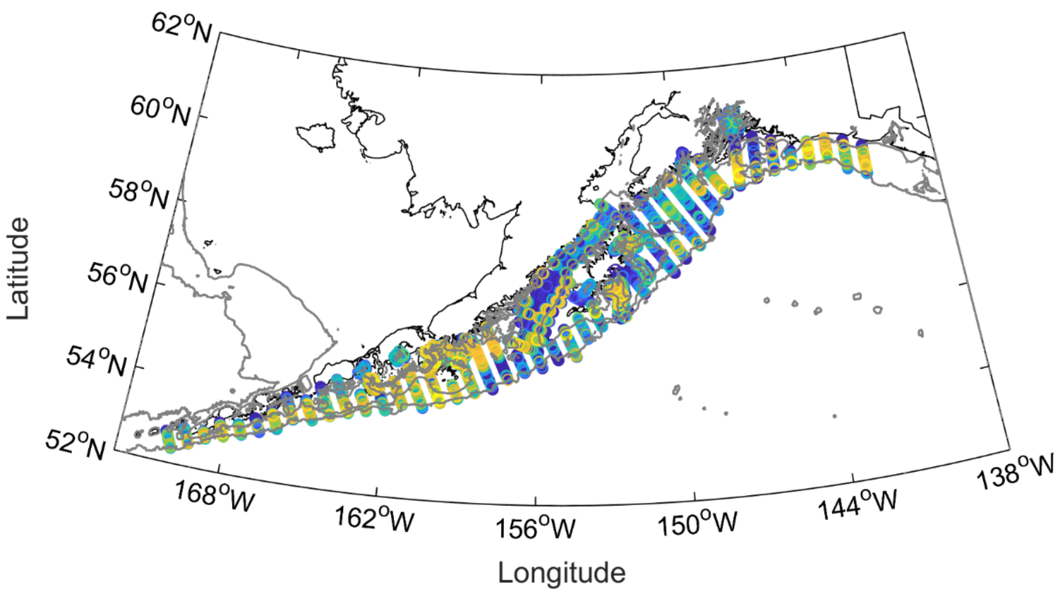
Considerations for this study:

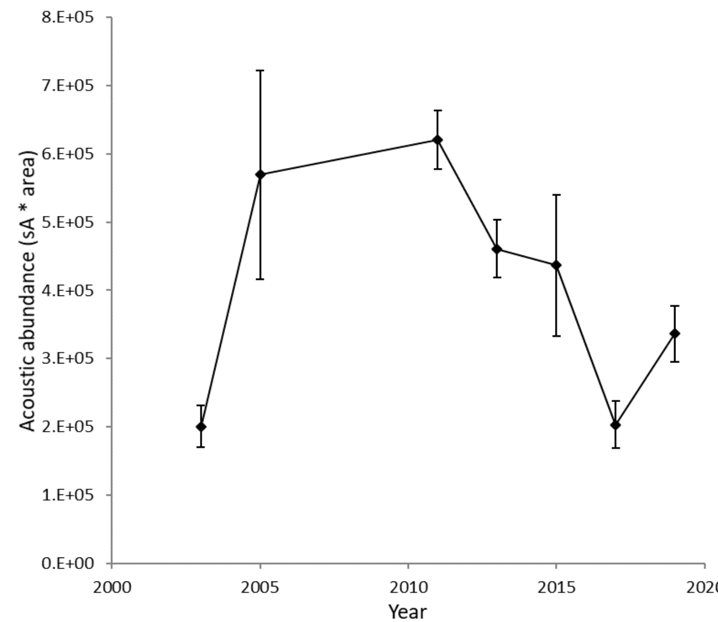
Model spatial resolution (# knots) → scale & convergence

Poisson-link distribution: estimate numbers density and average mass using log-linked linear predictors (Thorson '18)

McGowan et al. in prep

Acoustic-trawl survey estimates of pollock prey (example: euphausiids or krill





Simonsen, Ressler, et al. 2016

Questions?

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