Evaluating VAST as a model-based estimator for acoustic-trawl survey data: winter Shelikof Strait survey

David McGowan

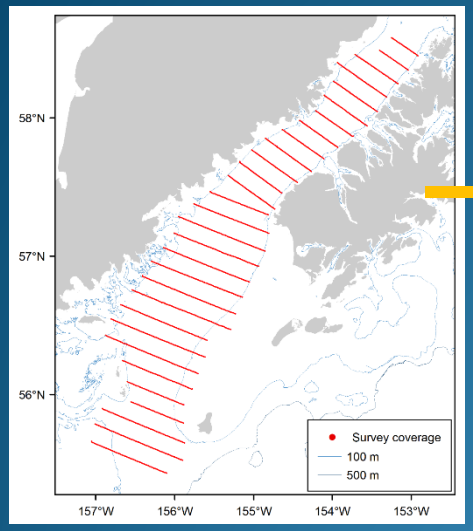
Midwater Assessment & Conservation Engineering

david.mcgowan@noaa.gov

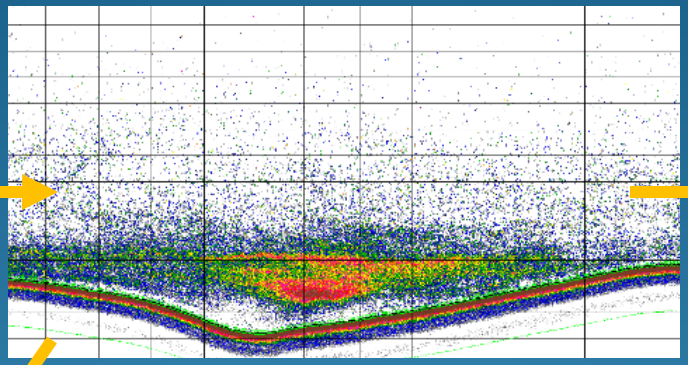
September 22, 2021

Acoustic-trawl survey estimation approach

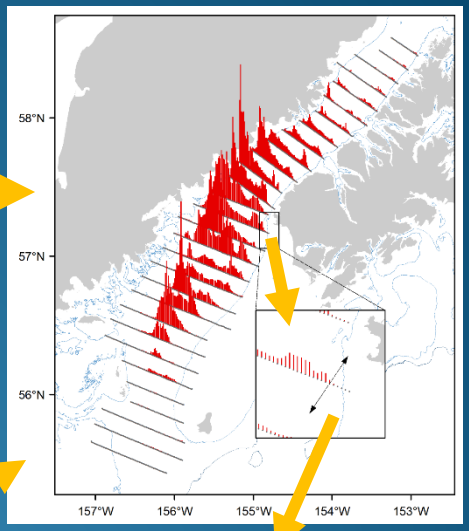
Transects



Acoustic data

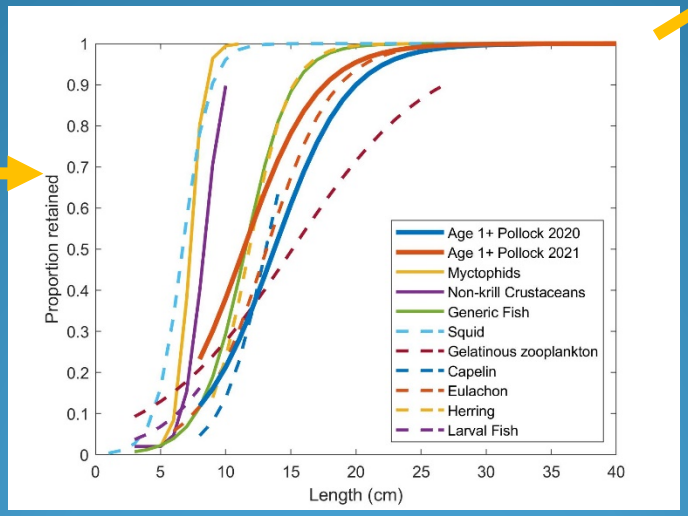


Biomass density

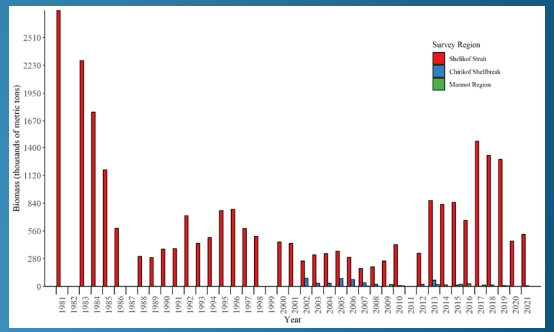


Trawl data

Net selectivity corrections



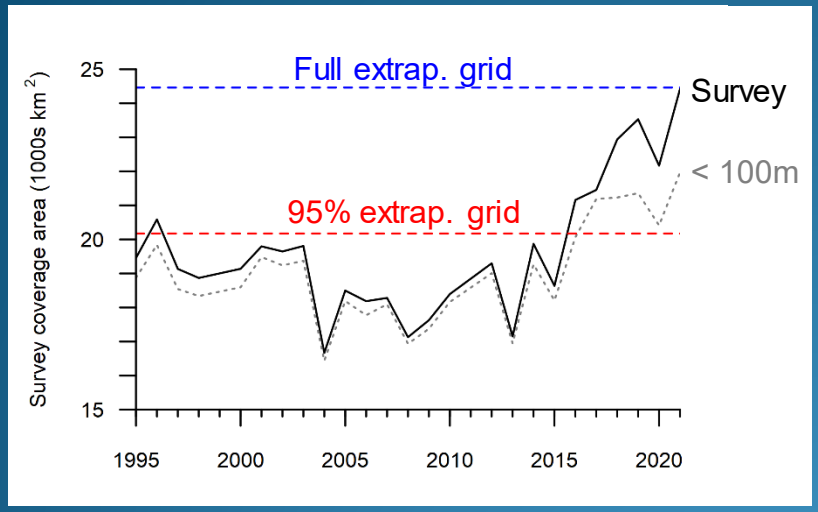
Biomass estimate

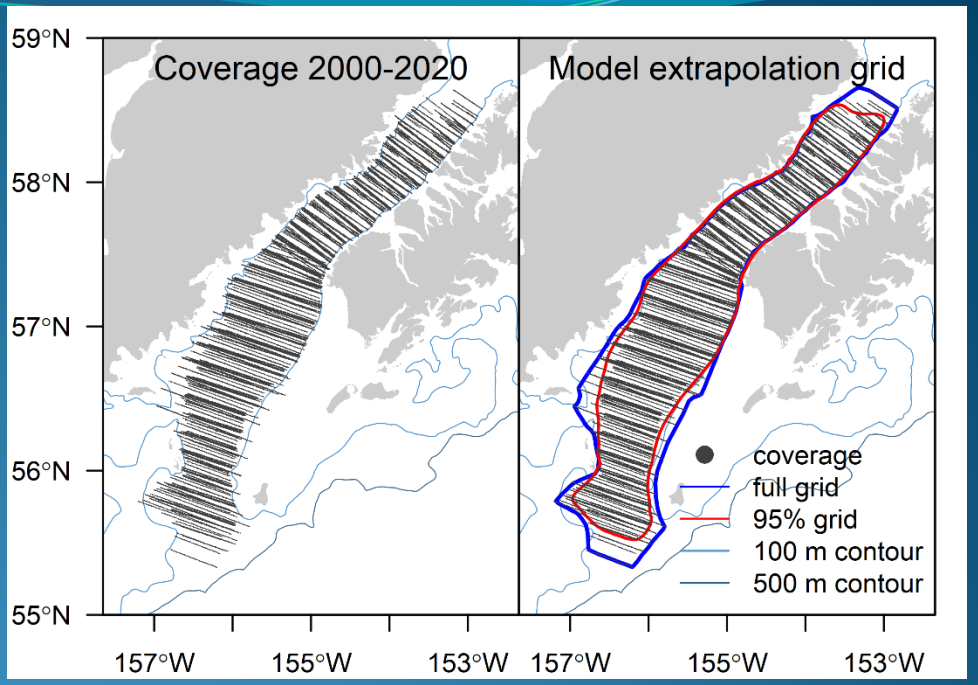


Model uncertainty estimated using 1-D geostat model

Why use a model-based estimator for AT surveys?

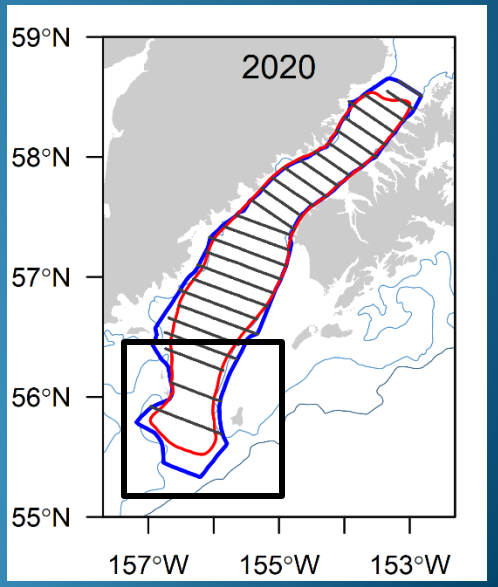
- **Estimate biomass within a standardized area for all years**





- **Improve interpolation within areas not sampled or at lower resolution (e.g. increased transect spacing)**

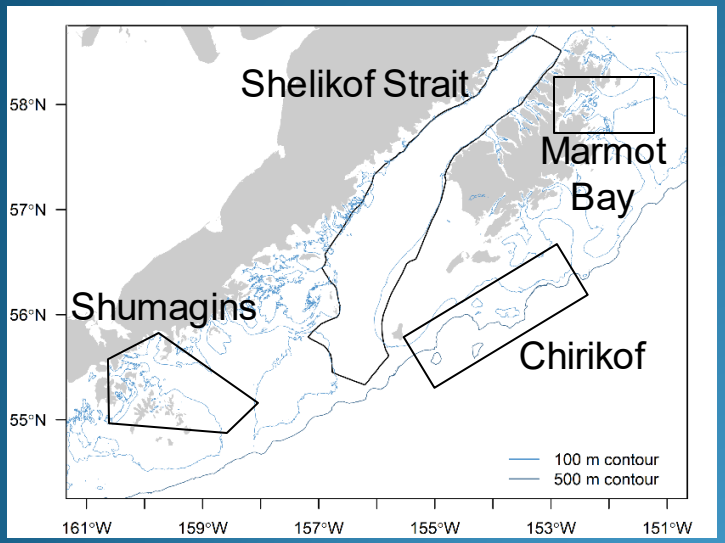
- **Quantify model uncertainty using a maximum likelihood estimator**
  - Allows for increased flexibility in survey design
  - Facilitates exploring adaptive sampling and evaluation of alternative survey designs



Why use a model-based estimator for AT surveys?

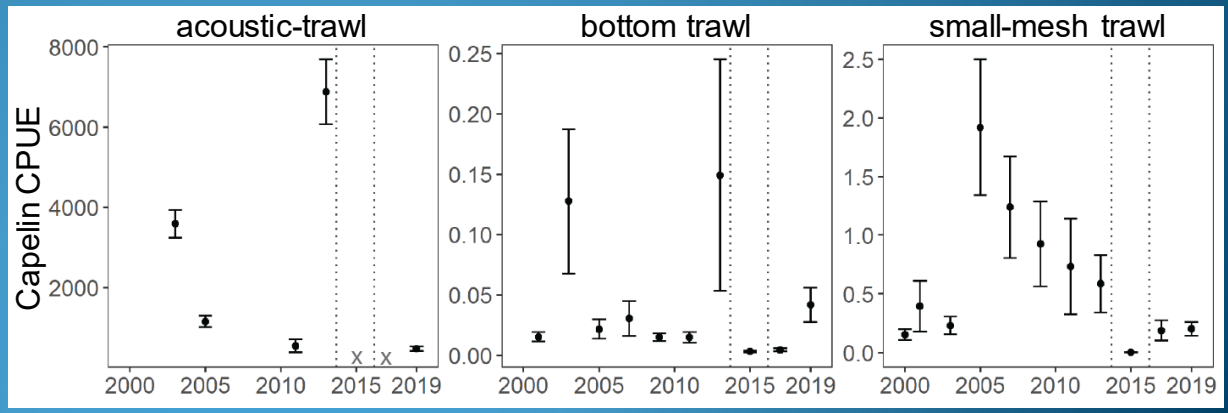
- **Improve accuracy & precision of non-target spp. estimates: capelin, POP**
- **Standardized index of relative abundance from multiple data sources**

1. One index for winter GOA surveys



2. Integrate data streams from a ship & uncrewed surface vehicle (USV) working in tandem (FY23)

3. Capelin relative abundance index from RACE summer Gulf of Alaska surveys:
   - MACE pollock acoustic-trawl
   - GAP bottom trawl
   - EcoFOCI small-mesh trawl



Objectives

1. Identify optimal model specification for spatio-temporal GLMMs using VAST to analyze acoustic-based measurements of age-1+ pollock biomass density from winter Shelikof Strait survey (1995 to 2021)

2. Assess model performance by comparing model- & design-based estimates of pollock biomass for an acoustic-trawl survey with coverage

3. Conduct a sensitivity analysis of model performance to examine effects of model structure, extrapolation area, & spatial resolution on estimates

Objectives

1. Identify optimal model specification for spatio-temporal GLMMs using VAST to analyze acoustic-based measurements of age-1+ pollock biomass density from winter Shelikof Strait survey (1995 to 2021)

2. Assess model performance by comparing model- & design-based estimates of pollock biomass for an acoustic-trawl survey with coverage

3. Conduct a sensitivity analysis of model performance to examine effects of model structure, extrapolation area, & spatial resolution on estimates

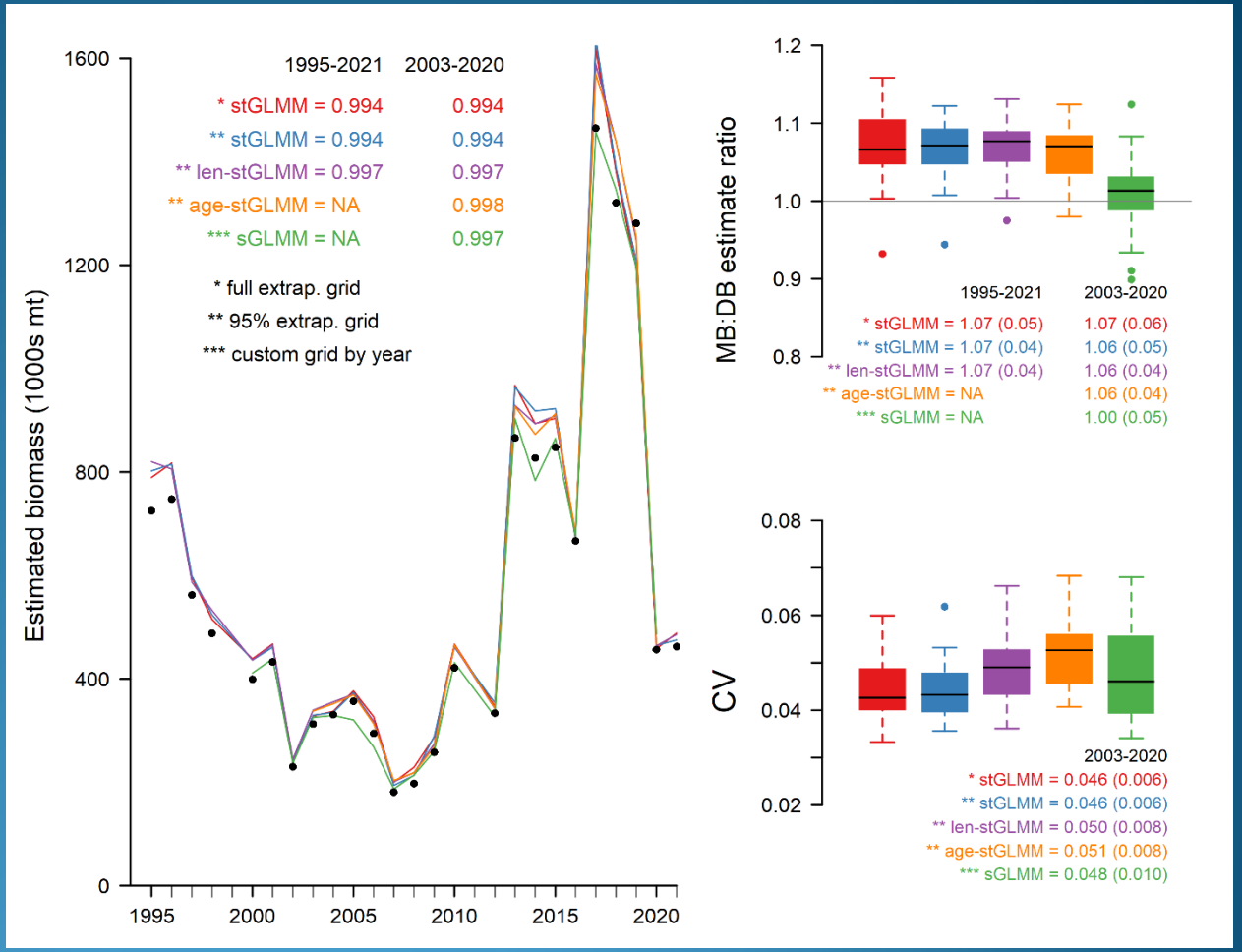
Model type	Data input	Extrapolation grid	Model spatial resolution
Delta-gamma	**Univariate**	**Full grid**	100, 200, **300**, 400, 500 knots
Poisson-link	**Multivariate (length- or age-structured**	**95% grid**	
Tweedie		**Custom grid by year**	

Model results

Model-based indices closely track survey index trends ($r > 0.99$)

Minimal differences in index scale among stGLMMs and length- & age-structured models

- Mean MB:DB ratios range 1.06-1.07 for models using full or 95% extrapolation grid
- Mean MB:DB ratios ~1.0 for single-year spatial GLMMs using custom grid by year



Model uncertainty estimates marginally higher for multivariate models

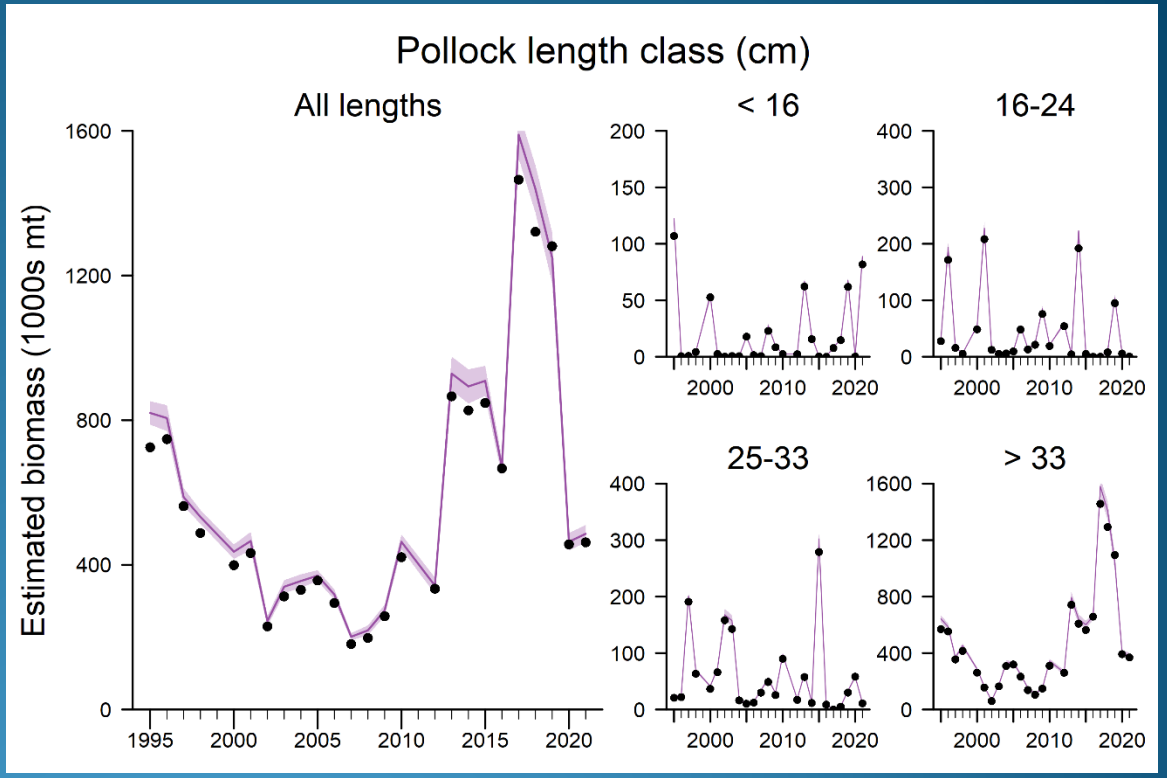
- Mean CV ~0.05

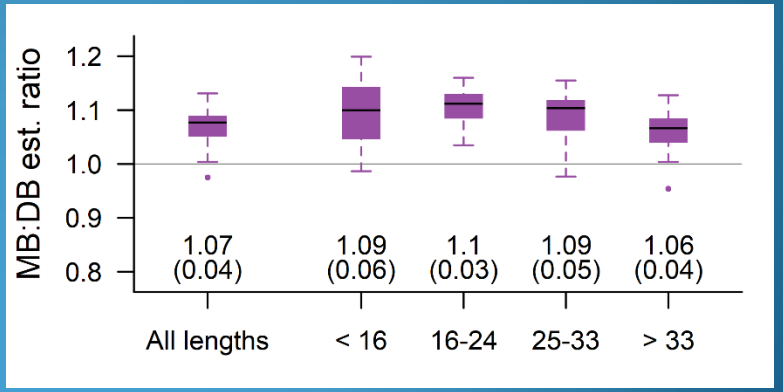
Length-structured models

4 length categories

MB biomass estimates closely track survey indices for each length class

Differences between MB & DB estimates higher for juvenile length classes (≤ 33 cm)



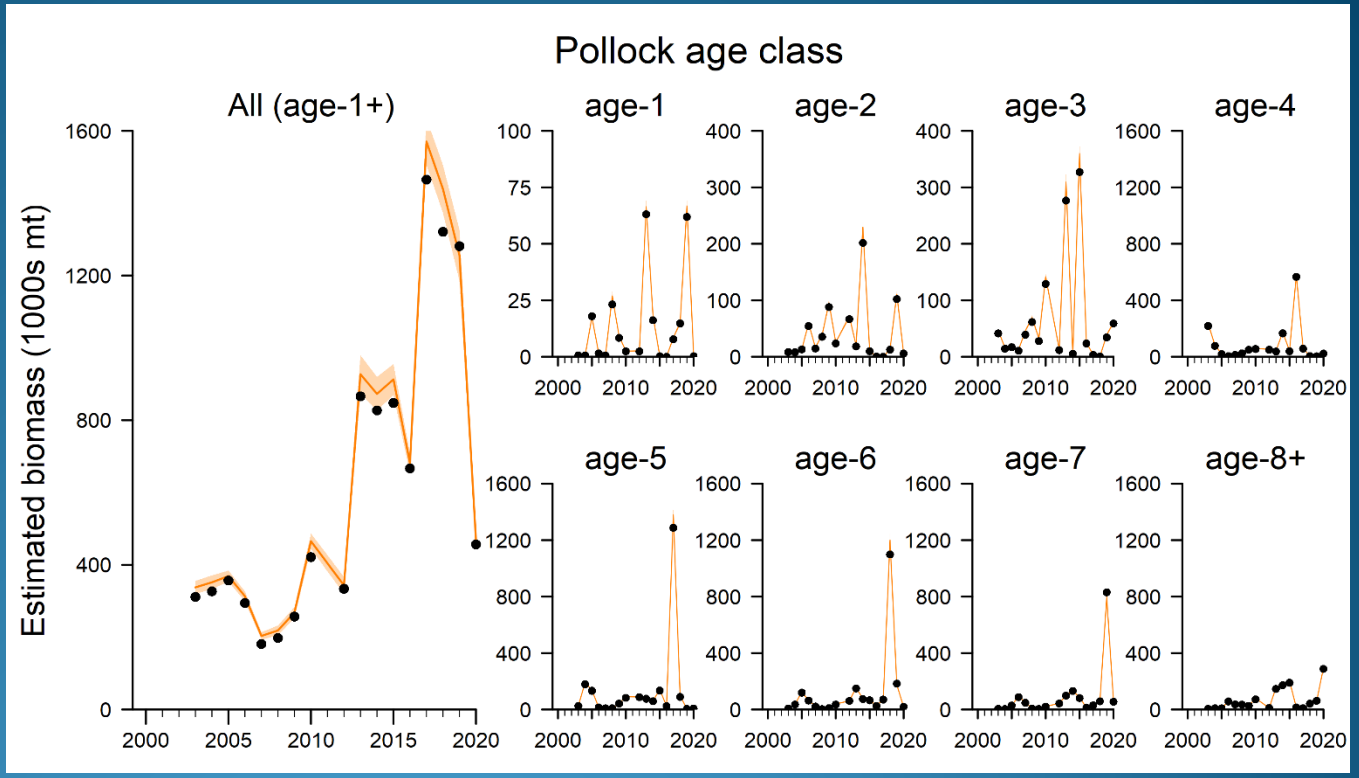


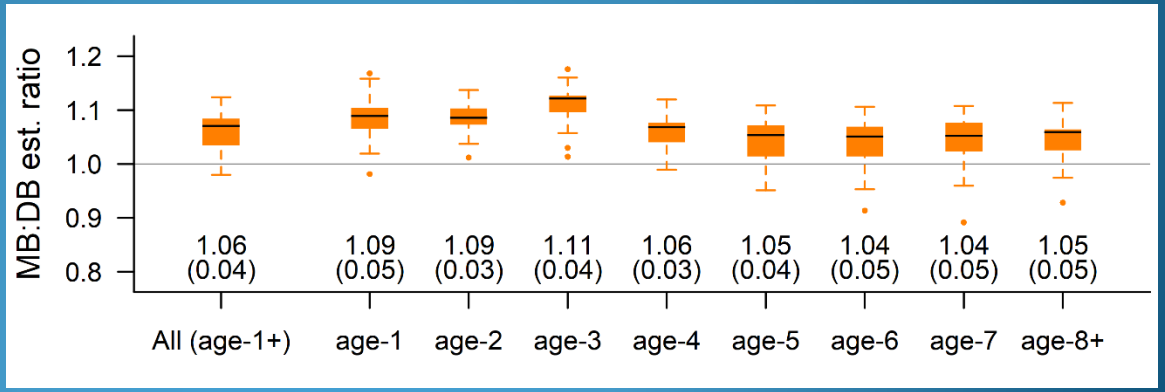
Age-structured models

8 age categories (will ↑ to 10)

MB biomass estimates closely track survey indices for each age class

Differences between MB & DB estimates higher for juvenile age classes (ages 1-3)



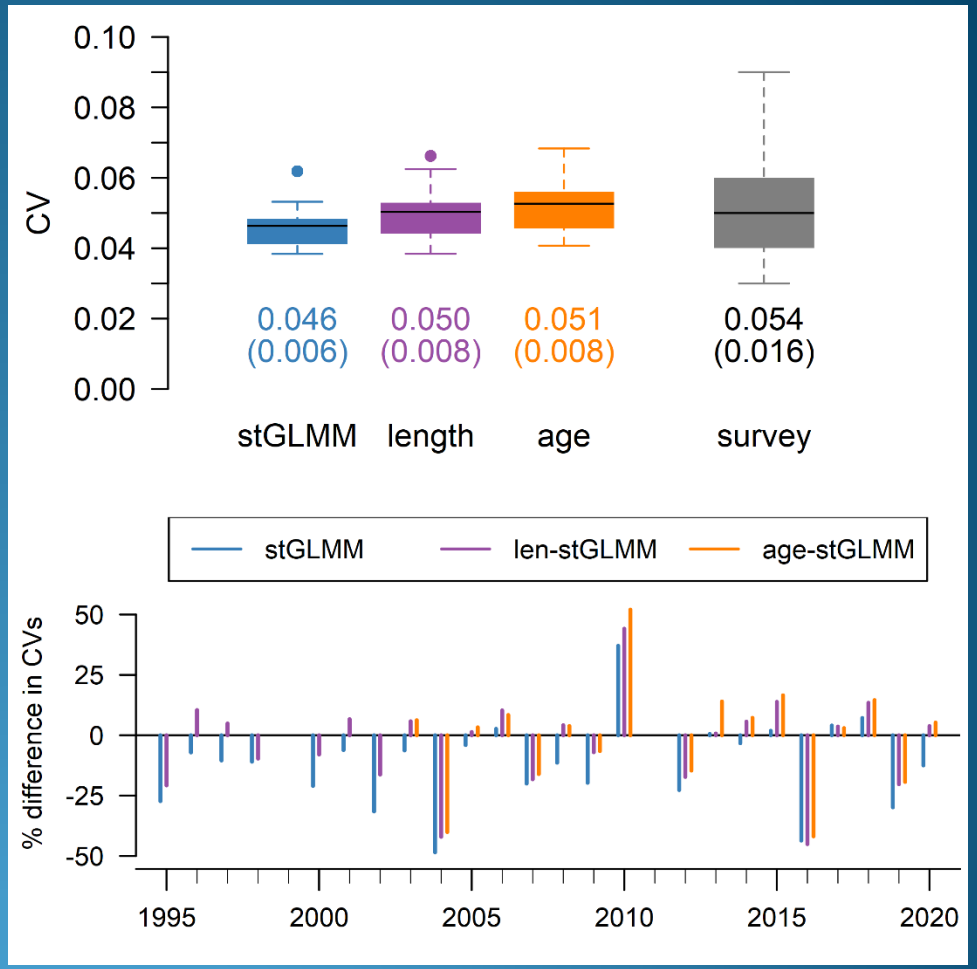


Relative Error Estimation: 1-D geostat vs. VAST

VAST model uncertainty estimates marginally lower & less variable compared to CVs from 1-D geostatistical model

CVs most similar between age-stGLMM & 1-D geostat models (mean < 1%), but high interannual variability (± 22.1%)

Model uncertainty estimates potentially improved by including error associated with converting backscatter to biomass densities within VAST framework



Summary of key findings

- **Model-based estimates of pollock biomass closely track design-based index trends ($r > 0.99$) & scale (~6-7% higher)**
- **Differences between model- and design-based estimates most sensitive to inclusion of spatial random effects & boundaries of extrapolation grid, and to a lesser extent model spatial resolution**
- **Length- and age-structured models provide similar biomass indices to simpler univariate model when estimates are combined for all classes, but are computationally demanding**
  - Length-stGLMMs useful for characterizing distribution patterns by size class and providing preliminary (off-the-boat) assessment of year class strength
  - Age-stGLMMs useful as inputs in stock assessment model
  - Univariate stGLMMs useful for monitoring abundance trends, quantifying changes in distributions, evaluating influence of catchability or habitat covariates, &/or examining effects of changes in sampling on biomass estimates

Ongoing & future work

- **Continue assessment of VAST estimator performance for summer GOA pollock survey (2013–2021)**
  - Poses different challenges for VAST due to more complicated AT sampling design with multiple sampling resolutions across a larger domain w/ complex bathymetry
- **Conduct simulation analysis to further assess sensitivity of the VAST estimator to a range of model specifications (late-Fall 2021).**
- **Compare sensitivity of MB & DB biomass estimates for simulated and empirical data to changes in survey design and unplanned reductions in sampling extent and resolution (winter 2021-22)**
- **Develop MB estimates for other non-target species (i.e. capelin, POP) from summer GOA survey (spring 2021-22)**
- **Development work on VAST framework to incorporate additional sources of uncertainty in AT surveys (FY23)**

Questions? david.mcgowan@noaa.gov