# Use of posterior predictive intervals in complex statistical agestructured assessment models 

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## Diagnostics

- Some data preview
- Visual diagnostics

Survey work






NOAA's 2021 bottom trawl survey relative to the average



2021 survey catch rate difference from mean
NOAA's 2021 bottom trawl survey relative to the average

## Age composition

- From NOAA's
bottom-trawl survey


Vertical scale is relative to survey population estimate

## Age composition

- From NOAA's bottom-trawl survey





## Survey transit

- Opportunistic acoustic data

Can show young fish abundance off bottom


Acoustic data


Opportunistically collected from chartered bottomtrawl survey boats The AVO index


Mean backscatte

- 100
- 2000
- 3000
- 4000

2020


## Acoustic data



## Model details

- Tuning indices
- Acoustic Trawl survey (even years)
- Annual fixed-station bottom trawl survey
- Acoustic vessel of opportunity (AVO index)
- Foreign trawler CPUE (in 1970s)
- Fishery data
- Total catch
- Catch-at-age
- Mean fishery weights-at-age


## Model details

- Age specific schedules
- Natural mortality
- Maturity
- Other
- Conditioned on catch biomass (F's estimated)
- Selectivity varies in fishery
- Slightly in surveys
- Ricker
- Projection options built in to evaluate policy trade offs
- Complicated?
- Multiple random-effects models used to process available data


## New data impact on model

## Data considerations

| Name | Updated catch <br> to 2021 | 2020 fishery <br> age data | Bottom trawl survey | Acoustic from Bottom <br> trawl transits (AVO) |
| :---: | :---: | :---: | :---: | :---: |
| Fishery | X | X |  |  |
| + BTS | X | X | X |  |
| AVO | X | X | X | X |




## Model

- last year
- Catch-age added, 2020
- Add BTS data
- Add AVO

Fishery catch-age



Fit to survey indices



Fit to survey age compositions


Biomass
trend



Diagnostics
Posterior predictive distributions

Base model



## Subsample of posterior (from MCMC)

Yellow is the model "predictions" from the posterior
Grey are "simulated" data from posterior (using obs variance)
Black dots are actual obervations

Diagnostics
Posterior predictive distributions

Base model


Diagnostics
Posterior predictive distributions

Alternative model


EBS pollock survey age composition data



## Acoustic

 trawl survey


Fishery


model
Alt
Base

## Steps as part of ACLIM project

Climate-informed fisheries management: Proposed "on-ramps" and existing coordination


## Model selection and prediction of new data?



## What things affect FMSY?

$\begin{array}{lllllllll}0.29 & 0.48 & 0.6 & 0.73 & 0.84 & 0.87 & 1.01 & 1.13\end{array}$ $\begin{array}{lllllllll}0.39 & 0.46 & 0.65 & 0.7 & 0.81 & 0.98 & 1.03 & 1.21\end{array}$ | 0.5 | 0.61 | 0.65 | 0.75 | 0.9 | 1.04 | 1.21 | 1.23 |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| 0.41 | 0.65 | 0.73 | 0.75 | 0.71 | 1.06 | 1.39 | 1.35 | $\begin{array}{llllllllll}0.41 & 0.65 & 0.73 & 0.75 & 0.71 & 1.06 & 1.39 & 1.35\end{array}$ $\begin{array}{llllllll}0.38 & 0.5 & 0.74 & 0.84 & 0.86 & 0.99 & 1.22 & 1.31\end{array}$ $\begin{array}{llllllllll}0.32 & 0.43 & 0.68 & 0.79 & 0.95 & 0.95 & 1.02 & 1.1 \\ 0.32 & 0.47 & 0.56 & 0.75 & 0.89 & 1.07 & 1.09 & 1.24\end{array}$ $\begin{array}{llllllllll}0.37 & 0.59 & 0.63 & 0.62 & 0.78 & 1.03 & 1.17 & 1.25\end{array}$ $\begin{array}{lllllllll}0.4 & 0.51 & 0.64 & 0.7 & 0.73 & 0.89 & 1.04 & 1.25\end{array}$ $\begin{array}{lllllllllll}0.35 & 0.53 & 0.63 & 0.73 & 0.78 & 0.89 & 1.04 & 1.25\end{array}$ $\begin{array}{llllllllll}0.33 & 0.5 & 0.67 & 0.79 & 0.96 & 0.99 & 1.06 & 1.12\end{array}$ $\begin{array}{lllllllll}0.39 & 0.51 & 0.67 & 0.79 & 0.91 & 1.03 & 1.1 & 1.09\end{array}$ $\begin{array}{llllllll}0.49 & 0.55 & 0.65 & 0.77 & 0.86 & 0.95 & 1.08 & 1.2\end{array}$ $\begin{array}{llllllll}0.41 & 0.58 & 0.64 & 0.76 & 0.89 & 0.92 & 1.04 & 1.16\end{array}$ $\begin{array}{lllllllll}0.35 & 0.51 & 0.64 & 0.74 & 0.88 & 0.95 & 1.06 & 1.1\end{array}$ $\begin{array}{lllllllll}0.31 & 0.45 & 0.61 & 0.75 & 0.85 & 0.95 & 1.06 & 1.11\end{array}$ $\begin{array}{lllllllll}0.35 & 0.51 & 0.64 & 0.78 & 0.96 & 1.1 & 1.18 & 1.27\end{array}$ $\begin{array}{llllllll}0.33 & 0.52 & 0.65 & 0.77 & 0.9 & 1.05 & 1.12 & 1.28\end{array}$ $\begin{array}{llllllll}0.34 & 0.53 & 0.7 & 0.88 & 1 & 1.13 & 1.4 & 1.49\end{array}$ $\begin{array}{llllllll}0.38 & 0.49 & 0.66 & 0.92 & 1.12 & 1.26 & 1.37 & 1.59\end{array}$ $\begin{array}{lllllllll}0.29 & 0.51 & 0.67 & 0.81 & 0.98 & 1.22 & 1.35 & 1.52 \\ 0.27 & 0.41 & 0.54 & 0.82 & 0.07 & 1.17 & 1.31 & 1.52\end{array}$ $\begin{array}{lllllllll}0.27 & 0.41 & 0.64 & 0.82 & 0.97 & 1.17 & 1.31 & 1.52 \\ 0.29 & 0.44 & 0.56 & 0.78 & 1.13 & 1.28 & 1.43 & 1.69\end{array}$ $\begin{array}{llllllllll}0.29 & 0.44 & 0.56 & 0.78 & 1.13 & 1.28 & 1.43 & 1.59\end{array}$ $\begin{array}{lllllllll}0.4 & 0.46 & 0.57 & 0.69 & 0.79 & 0.89 & 1.15 & 1.2\end{array}$ $\begin{array}{llllllllll}0.4 & 0.46 & 0.57 & 0.69 & 0.79 & 0.89 & 1.15 & 1.2 \\ 0.41 & 0.53 & 0.56 & 0.65 & 0.73 & 0.8 & 0.94 & 1.04\end{array}$ $\begin{array}{lllllllll}0.4 & .53 & 0.56 \\ 0.4 & 0.5 & 0.65 & 0.69 & 0.75 & 0.83 & 0.89 & 0.91\end{array}$ $\begin{array}{llllllllll}0.38 & 0.47 & 0.57 & 0.73 & 0.81 & 0.85 & 0.9 & 1.05\end{array}$ $\begin{array}{lllllllll}0.42 & 0.57 & 0.64 & 0.76 & 0.88 & 0.96 & 1.01 & 1.06\end{array}$ $\begin{array}{llllllll}0.39 & 0.52 & 0.64 & 0.72 & 0.8 & 0.95 & 1 & 1.06\end{array}$


| 0.17 | 0.35 | 0.43 | 0.67 | 1.02 | 1.13 | 1.2 | 1.38 |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| 0.24 | 0.36 | 0.49 | 0.58 | 0.72 | 1.07 | 1.12 | 1.01 | $\begin{array}{llllllll}0.24 & 0.36 & 0.49 & 0.58 & 0.72 & 1.07 & 1.12 & 1.01 \\ 0.26 & 0.36 & 0.48 & 0.62 & 0.76 & 1.02 & 1.21 & 1.4\end{array}$ $\begin{array}{lllllllll}0.23 & 0.4 & 0.49 & 0.62 & 0.77 & 0.9 & 1.41 & 1.11\end{array}$ $\begin{array}{llllllll}0.18 & 0.36 & 0.46 & 0.64 & 0.72 & 0.84 & 1 & 1.28\end{array}$ $\begin{array}{llllllll}0.26 & 0.35 & 0.43 & 0.52 & 0.7 & 0.79 & 0.88 & 0.98\end{array}$ $\begin{array}{lllllllll}0.29 & 0.35 & 0.46 & 0.52 & 0.6 & 0.75 & 0.85 & 0.99\end{array}$ $\begin{array}{llllllll}0.17 & 0.37 & 0.44 & 0.52 & 0.62 & 0.66 & 0.92 & 0.92\end{array}$ $\begin{array}{llllllll}0.15 & 0.38 & 0.5 & 0.57 & 0.61 & 0.72 & 0.78 & 1.04\end{array}$ $\begin{array}{lllllllll}0.16 & 0.35 & 0.49 & 0.58 & 0.69 & 0.74 & 0.87 & 0.91\end{array}$ $\begin{array}{lllllllll}0.29 & 0.38 & 0.51 & 0.62 & 0.77 & 0.83 & 0.89 & 0.98\end{array}$ $\begin{array}{llllllll}0.31 & 0.45 & 0.5 & 0.55 & 0.66 & 0.79 & 0.98 & 1.03 \\ 0.27\end{array}$ $\begin{array}{llllllll}0.22 & 0.47 & 0.57 & 0.63 & 0.71 & 0.97 & 1.16 & 1.12\end{array}$ $\begin{array}{llllllll}0.14 & 0.38 & 0.49 & 0.63 & 0.65 & 0.8 & 0.93 & 1.16\end{array}$ $\begin{array}{lllllllll}0.23 & 0.34 & 0.4 & 0.54 & 0.69 & 0.89 & 0.97 & 1.06\end{array}$ $\begin{array}{llllllllll}0.18 & 0.34 & 0.48 & 0.52 & 0.67 & 0.81 & 0.9 & 0.07\end{array}$ $\begin{array}{llllllllll}0.21 & 0.36 & 0.42 & 0.56 & 0.63 & 0.77 & 0.97 & 1\end{array}$ $\begin{array}{llllllllll}0.23 & 0.38 & 0.45 & 0.53 & 0.65 & 0.71 & 0.78 & 0.95\end{array}$ $\begin{array}{llllllllll}0.17 & 0.37 & 0.5 & 0.6 & 0.67 & 0.77 & 0.85 & 0.91\end{array}$ $\begin{array}{lllllllll}0.25 & 0.39 & 0.53 & 0.65 & 0.67 & 0.8 & 0.89 & 0.92\end{array}$ $\begin{array}{llllllll}0.44 & 0.57 & 0.67 & 0.73 & 0.84 & 0.89 & 0.96\end{array}$ $\begin{array}{llllllllll}.29 & 0.48 & 0.55 & 0.68 & 0.76 & 0.79 & 0.94 & 0.95\end{array}$ $\begin{array}{llllllll}0.22 & 0.4 & 0.53 & 0.6 & 0.7 & 0.8 & 0.87 & 0.91\end{array}$ $\begin{array}{lllllllll}0.18 & 0.36 & 0.51 & 0.61 & 0.72 & 0.81 & 0.91 & 1.04\end{array}$ $\begin{array}{llllllllll}0.28 & 0.43 & 0.55 & 0.67 & 0.77 & 0.84 & 0.92 & 1.08\end{array}$ $\begin{array}{llllllll}0.23 & 0.41 & 0.52 & 0.64 & 0.76 & 0.86 & 0.92 & 1.07\end{array}$ $\begin{array}{llllllll}0.22 & 0.41 & 0.55 & 0.68 & 0.84 & 0.91 & 0.96 & 1.17\end{array}$ $\begin{array}{llllllll}0.24 & 0.4 & 0.54 & 0.68 & 0.9 & 0.98 & 1.02 & 1.11\end{array}$ $\begin{array}{llllllll}0.23 & 0.42 & 0.55 & 0.65 & 0.8 & 1 & 1.1 & 1.15\end{array}$ $\begin{array}{llllllllllll}0.2 & 0.36 & 0.53 & 0.67 & 0.81 & 0.95 & 1.21 & 1.23\end{array}$ $\begin{array}{lllllllll}0.22 & 0.36 & 0.48 & 0.6 & 0.66 & 0.89 & 0.98 & 1.12\end{array}$ $\begin{array}{lllllllll}0.28 & 0.39 & 0.52 & 0.6 & 0.72 & 0.81 & 1.05 & 1.08\end{array}$ $\begin{array}{llllllllll}0.23 & 0.44 & 0.51 & 0.61 & 0.7 & 0.78 & 0.84 & 0.93\end{array}$ $\begin{array}{lllllllll}0.19 & 0.4 & 0.53 & 0.6 & 0.69 & 0.74 & 0.82 & 0.83\end{array}$ $\begin{array}{lllllllll}0.2 & 0.37 & 0.5 & 0.61 & 0.7 & 0.75 & 0.84 & 0.88\end{array}$ $\begin{array}{lllllllll}0.23 & 0.43 & 0.54 & 0.63 & 0.71 & 0.79 & 0.84 & 0.93\end{array}$

$\begin{array}{llllllll}0.21 & 0.37 & 0.49 & 0.61 & 0.7 & 0.77 & 0.89 & 1.03\end{array}$
$\begin{array}{lllllllll}0.35 & 0.45 & 0.59 & 0.68 & 1.07 & 1.11 & 1.45 & 1.57\end{array}$ $\begin{array}{lllllllll}0.35 & 0.45 & 0.59 & 0.68 & 1.07 & 1.11 & 1.45 & 1.57\end{array}$ $\begin{array}{llllllll}0.39 & 0.47 & 0.57 & 0.71 & 0.79 & 1.18 & 1.22 & 1.55 \\ 0.44 & 0.53 & 0.62 & 0.72 & 0.85 & 0.93 & 1.32 & 1.34\end{array}$ $\begin{array}{llllllll}0.44 & 0.53 & 0.62 & 0.72 & 0.85 & 0.93 & 1.32 & 1.34 \\ 0.46 & 0.55 & 0.65 & 0.73 & 0.83 & 0.96 & 1.04 & 1.41\end{array}$ $\begin{array}{llllllll}0.46 & 0.55 \\ 0.38 & 0.53 & 0.63 & 0.72 & 0.8 & 0.9 & 1.03 & 1.1 \\ 0.4 & 0.4 & 0.7 & 0.7 & 0.1 & 0.9 & 0.8 & 1.1\end{array}$ $\begin{array}{llllllll}0.42 & 0.47 & 0.62 & 0.72 & 0.81 & 0.89 & 0.98 & 1.1\end{array}$ $\begin{array}{llllllll}0.39 & 0.51 & 0.55 & 0.7 & 0.8 & 0.89 & 0.97 & 1.06\end{array}$ $\begin{array}{llllllll}0.33 & 0.47 & 0.59 & 0.64 & 0.79 & 0.89 & 0.97 & 1.04\end{array}$ $\begin{array}{llllllll}0.29 & 0.46 & 0.61 & 0.73 & 0.78 & 0.92 & 1.01 & 1.08\end{array}$ $\begin{array}{lllllllll}0.28 & 0.4 & 0.58 & 0.72 & 0.84 & 0.89 & 1.02 & 1.11\end{array}$ $\begin{array}{llllllll}0.4 & 0.43 & 0.57 & 0.74 & 0.89 & 1 & 1.04 & 1.16\end{array}$ $\begin{array}{llllllll}0.48 & 0.61 & 0.65 & 0.79 & 0.96 & 1.1 & 1.2 & 1.22\end{array}$ $\begin{array}{llllllll}0.4 & 0.6 & 0.74 & 0.78 & 0.91 & 1.08 & 1.21 & 1.3 \\ 0.32 & 0.49 & 0.7 & 0.84 & 0.8 & 1 & 1.17 & 1.29\end{array}$ $\begin{array}{llllllll}0.32 & 0.49 & 0.7 & 0.84 & 0.88 & 1 & 1.17 & 1.29 \\ 0.37 & 0.41 & 0.59 & 0.8 & 0.93 & 0.97 & 1.09 & 1.25\end{array}$ $\begin{array}{lllllllll}0.37 & 0.41 & 0.59 & 0.8 & 0.93 & 0.97 & 1.09 & 1.25\end{array}$ $\begin{array}{llllllllllll}0.44 & 0.53 & 0.58 & 0.76 & 0.58 & 1.01 & 1.13 & 1.16\end{array}$ $\begin{array}{llllllllll}0.4 & 0.53 & 0.58 & 0.63 & 0.81 & 1.01 & 1.13 & 1.16\end{array}$ $\begin{array}{lllllllll}0.39 & 0.5 & 0.64 & 0.68 & 0.73 & 0.91 & 1.1 & 1.22\end{array}$ $\begin{array}{lllllllll}0.42 & 0.54 & 0.67 & 0.79 & 0.92 & 0.95 & 0.99 & 1.15\end{array}$ $\begin{array}{llllllll}0.43 & 0.54 & 0.66 & 0.79 & 0.9 & 1.03 & 1.06 & 1.09\end{array}$ $\begin{array}{llllllll}0.45 & 0.53 & 0.65 & 0.77 & 0.9 & 1.01 & 1.13 & 1.15\end{array}$ $\begin{array}{llllllll}0.38 & 0.56 & 0.65 & 0.76 & 0.88 & 1 & 1.11 & 1.22\end{array}$ $\begin{array}{llllllll}0.32 & 0.47 & 0.66 & 0.75 & 0.86 & 0.98 & 1.1 & 1.19\end{array}$ $\begin{array}{llllllll}0.3 & 0.43 & 0.59 & 0.77 & 0.86 & 0.97 & 1.08 & 1.19\end{array}$ $\begin{array}{llllllll}0.33 & 0.5 & 0.64 & 0.8 & 0.98 & 1.06 & 1.16 & 1.26\end{array}$ $\begin{array}{lllllllll}0.24 & 0.46 & 0.64 & 0.78 & 0.94 & 1.11 & 1.19 & 1.28\end{array}$ $\begin{array}{lllllllll}0.34 & 0.51 & 0.74 & 0.92 & 1.06 & 1.2 & 1.36 & 1.42\end{array}$ $\begin{array}{llllllll}0.3 & 0.51 & 0.69 & 0.92 & 1.1 & 1.23 & 1.36 & 1.52\end{array}$ $\begin{array}{lllllllll}0.27 & 0.45 & 0.66 & 0.84 & 1.07 & 1.24 & 1.37 & 1.49 \\ 0.31 & 0.42 & 0.6 & 0.82 & 0.99 & 1.22 & 1.38 & 1.49\end{array}$ $\begin{array}{llllllll}0.31 & 0.42 & 0.6 & 0.82 & 0.99 & 1.22 & 1.38 & 1.49 \\ 0.37 & 0.47 & 0.58 & 0.77 & 0.98 & 1.15 & 1.37 & 1.52\end{array}$ $\begin{array}{lllllllllll}0.45 & 0.51 & 0.58 & 0.73 & 0.91 & 1.12 & 1.38 & 1.49\end{array}$ $\begin{array}{lllllllll}0.44 & 0.49 & 0.55 & 0.66 & 0.77 & 0.95 & 1.15 & 1.32\end{array}$ $\begin{array}{lllllllll}0.39 & 0.53 & 0.58 & 0.64 & 0.75 & 0.86 & 1.04 & 1.23\end{array}$ $\begin{array}{llllllll}0.39 & 0.58 & 0.64 & 0.75 & 0.86 & 1.04 & 1.23 \\ 0.39 & 0.5 & 0.64 & 0.69 & 0.75 & 0.85 & 0.96 & 1.13\end{array}$ $\begin{array}{lllllllll}0.39 & 0.47 & 0.58 & 0.72 & 0.77 & 0.83 & 0.93 & 1.03\end{array}$ $\begin{array}{llllllll}0.4 & 0.55 & 0.64 & 0.76 & 0.89 & 0.94 & 0.99 & 1.08\end{array}$ $\begin{array}{lllllllll}0.36 & 0.53 & 0.69 & 0.78 & 0.89 & 1.02 & 1.06 & 1.1\end{array}$ $\begin{array}{llllllll}0.36 & 0.5 & 0.67 & 0.83 & 0.91 & 1.02 & 1.15 & 1.18\end{array}$ $\begin{array}{llllllll}0.36 & 0.5 & 0.63 & 0.8 & 0.96 & 1.04 & 1.14 & 1.26\end{array}$ $\begin{array}{llllllll}0.36 & 0.5 & 0.63 & 0.77 & 0.94 & 1.09 & 1.17 & 1.26\end{array}$

## Anomaly

0.2
0.0
-0.2




EBS pollock survey age composition data


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## Contributions

- Argued some aspects of complexity
- Demonstrated some graphical diagnostics
- Offered next steps towards using these approaches for model selection


