Use of posterior predictive intervals in complex statistical age-structured assessment models

Alaska Fisheries
Science Center

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CAPAM Diagnostics workshop
Feb 1st, 2022

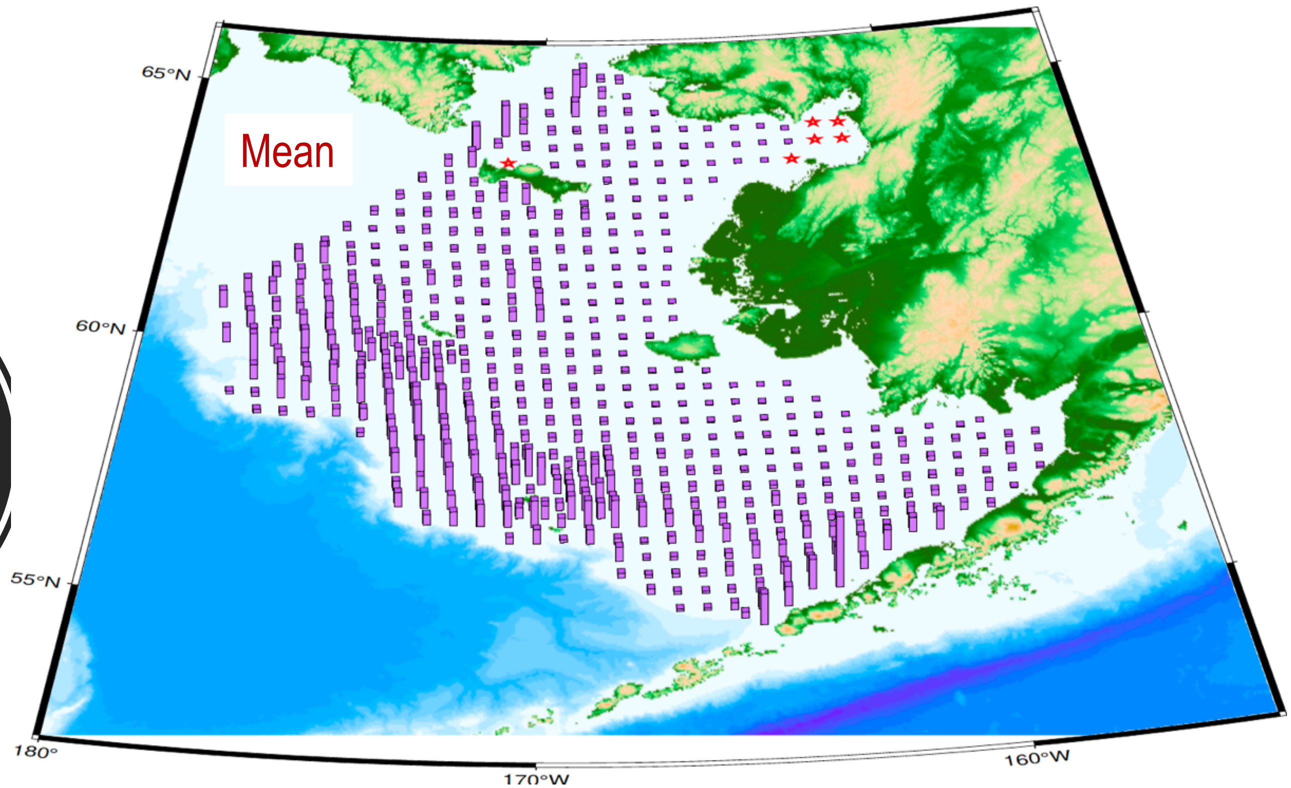
https://apps-afsc.fisheries.noaa.gov/Plan_Team/2021/EBSPollock.pdf

Diagnostics

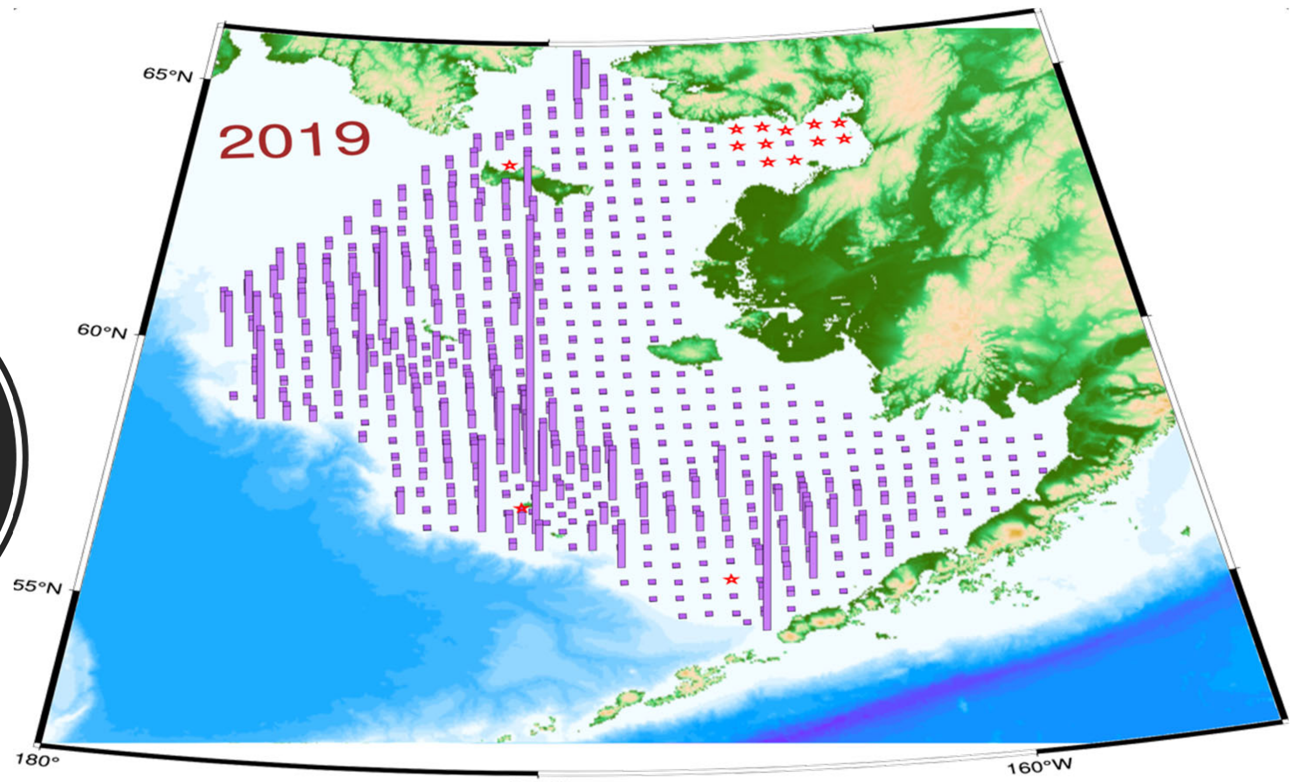
- Some data preview
- Visual diagnostics

Survey work

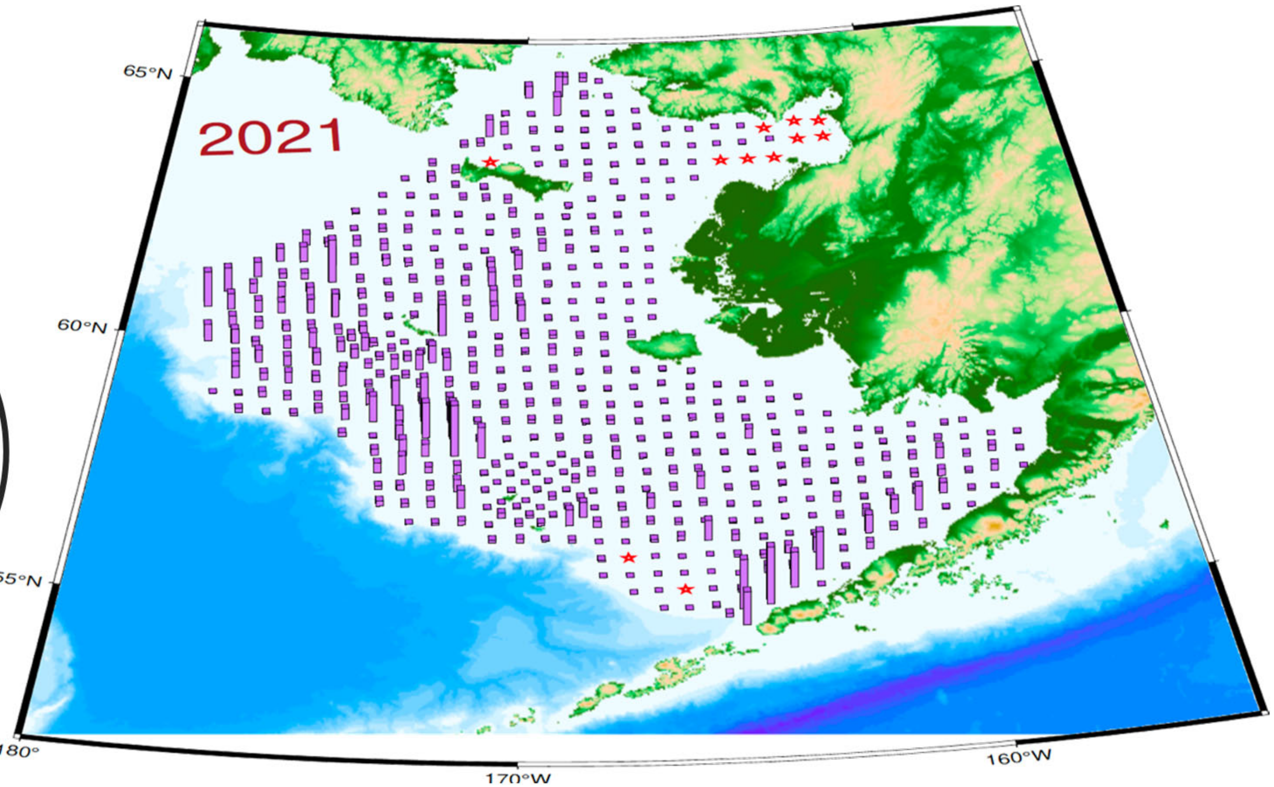
Pollock survey mean density by station



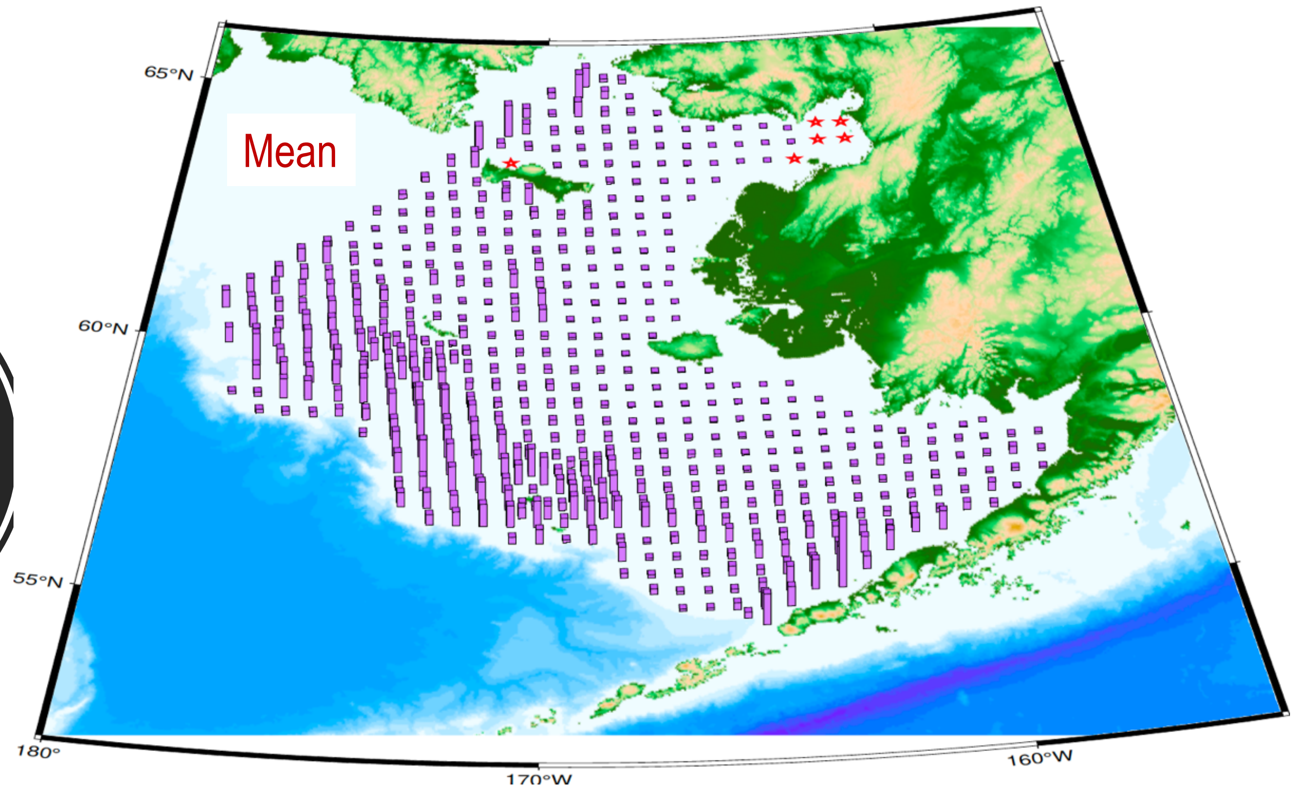
Pollock
Survey
2019



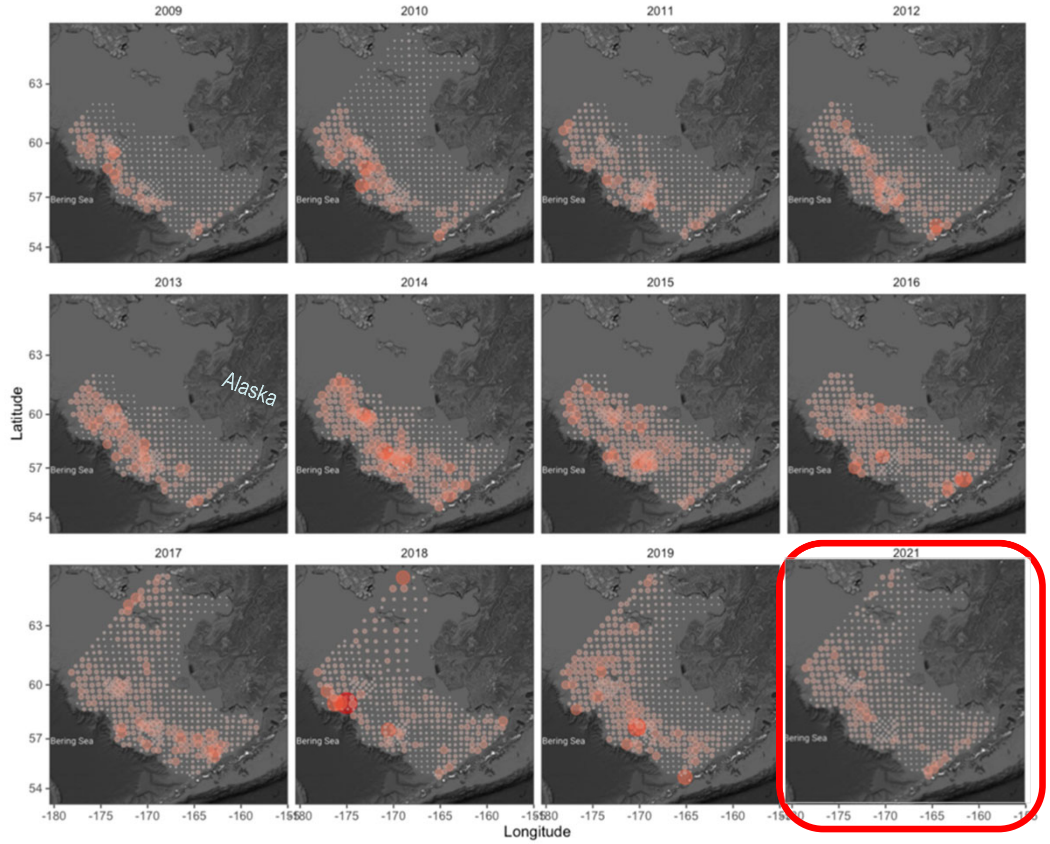
Pollock
Survey
2021



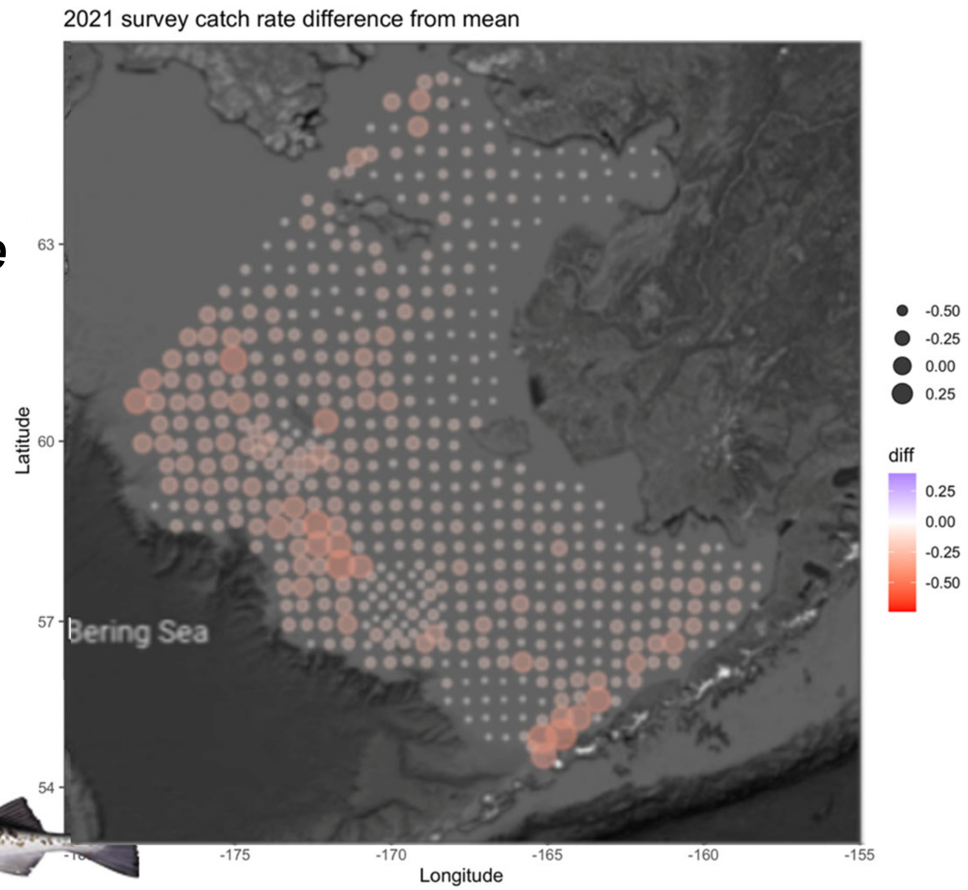
Pollock survey mean density by station



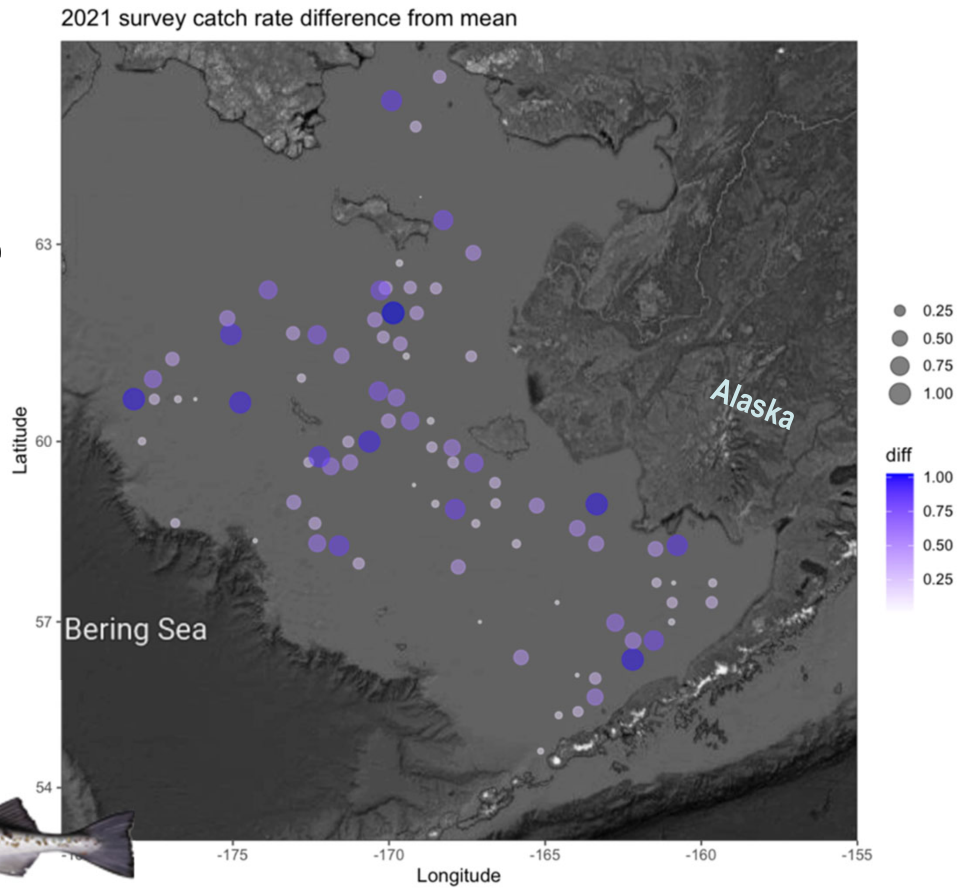
Recent bottom trawl surveys



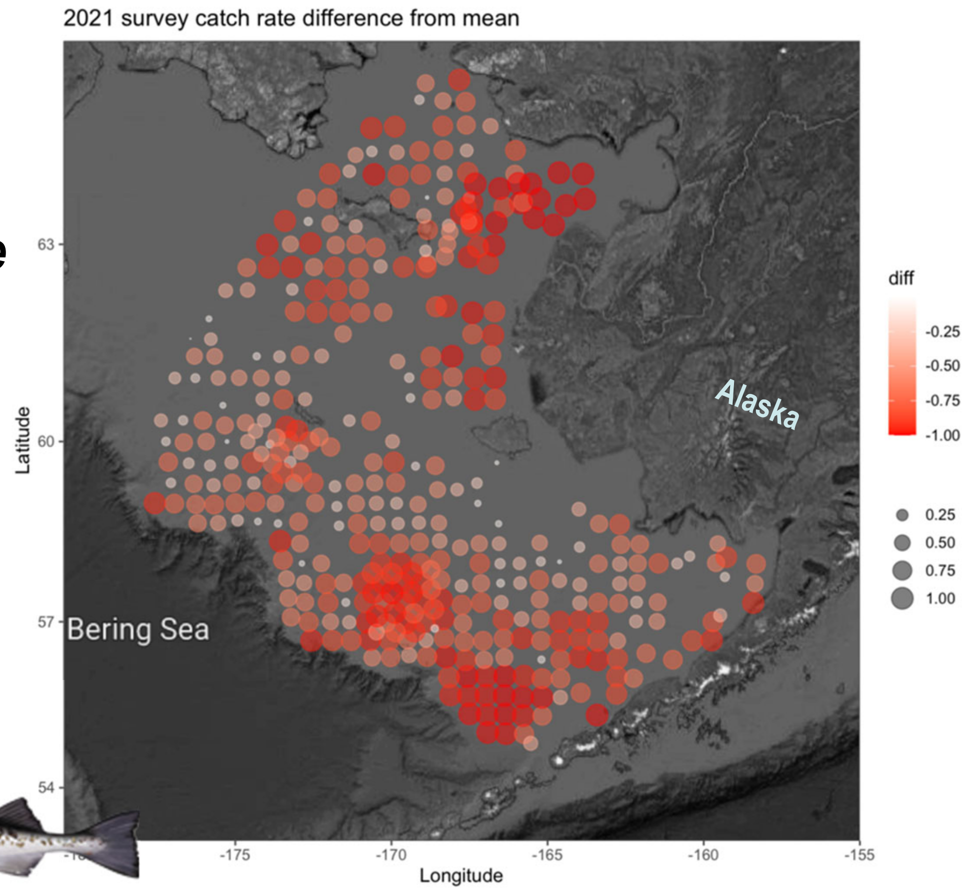
NOAA's 2021 bottom trawl survey relative to the average



NOAA's 2021 bottom trawl survey relative to the average

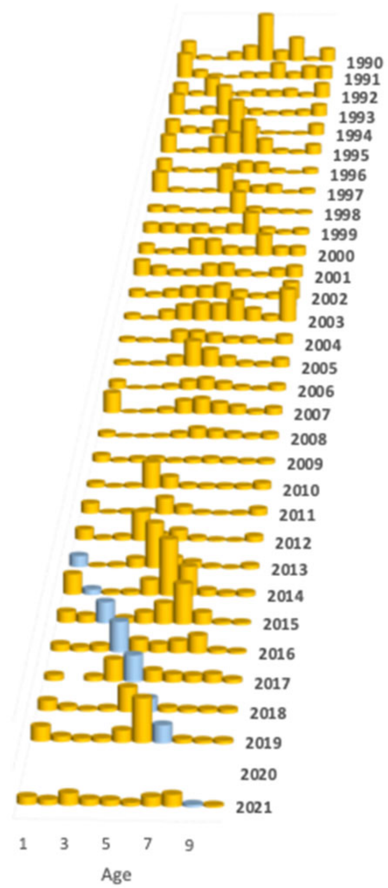


NOAA's 2021 bottom trawl survey relative to the average



Age composition

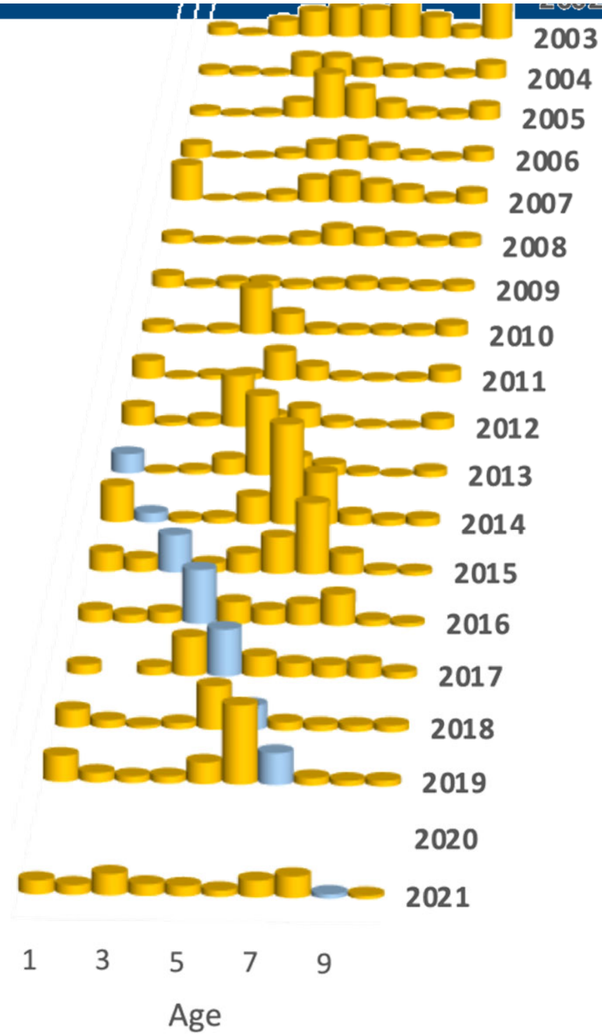
- From NOAA's bottom-trawl survey



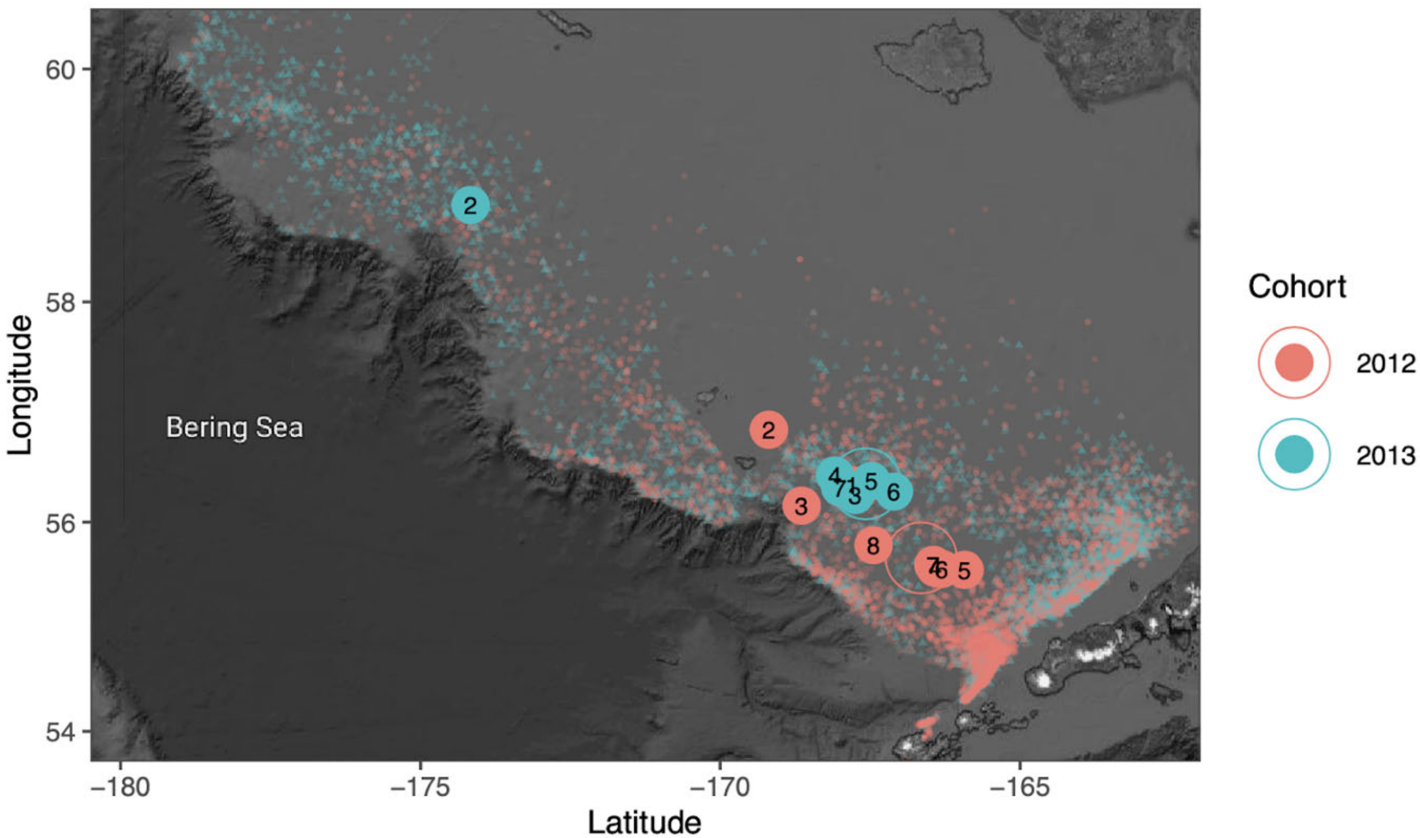
Vertical scale is relative to survey population estimate

Age composition

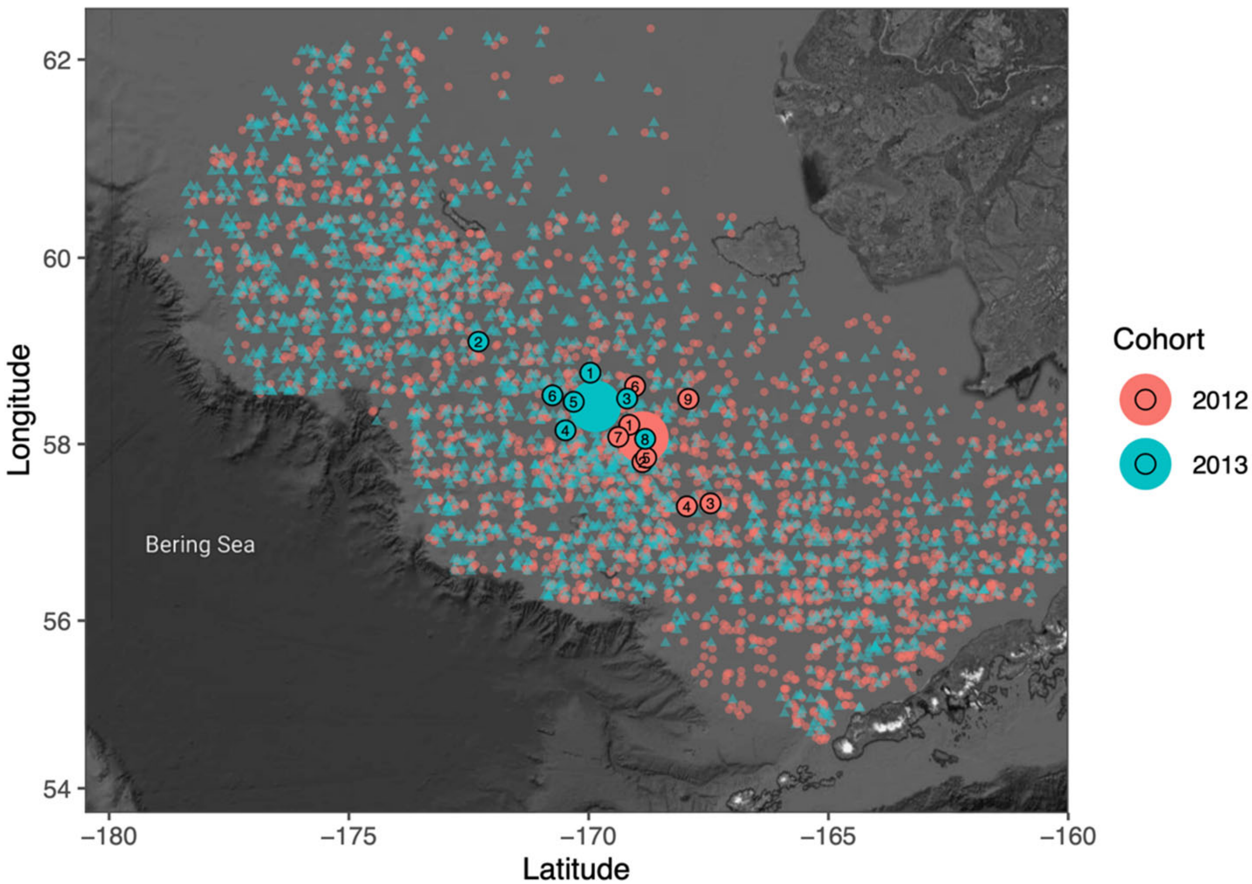
- From NOAA's bottom-trawl survey



Vertical scale is relative to survey population estimate



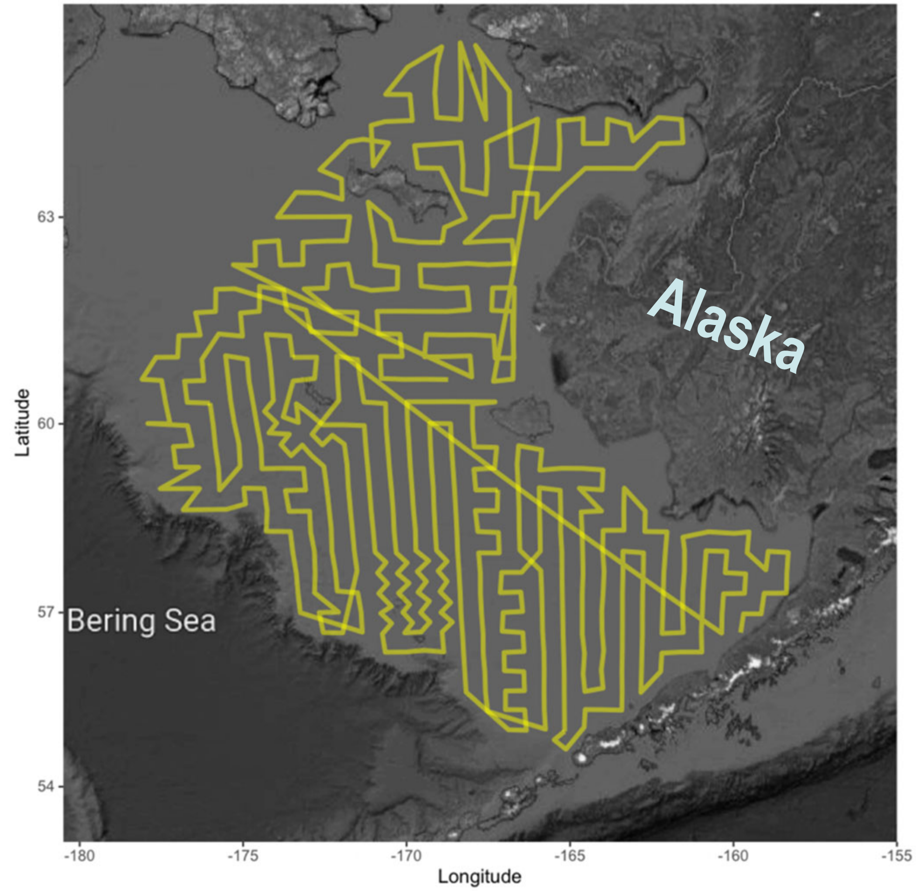
Bering Sea
2
2
3
8
4
7
1
3
5
6
7
6
5
60
58
56
54
Longitude
−180
−175
−170
−165
Latitude
Cohort
2012
2013

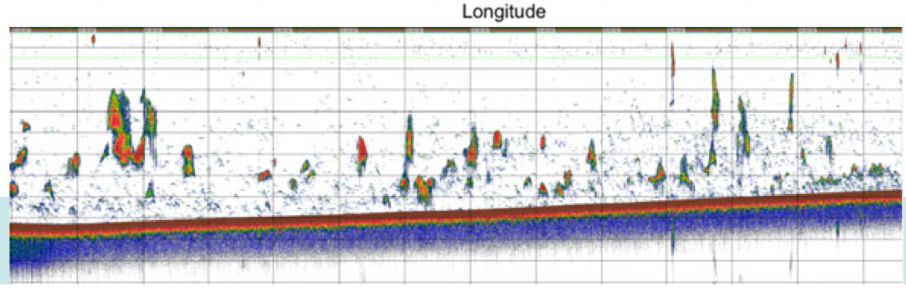


Bering Sea
62
60
58
56
54
Longitude
−180
−175
−170
−165
−160
Latitude
Cohort
2012
2013

Survey transit

- Opportunistic acoustic data
- Can show young fish abundance off bottom

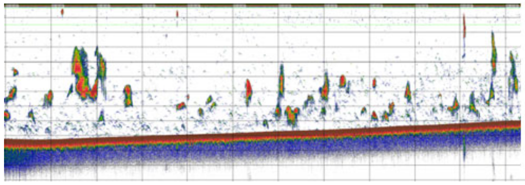


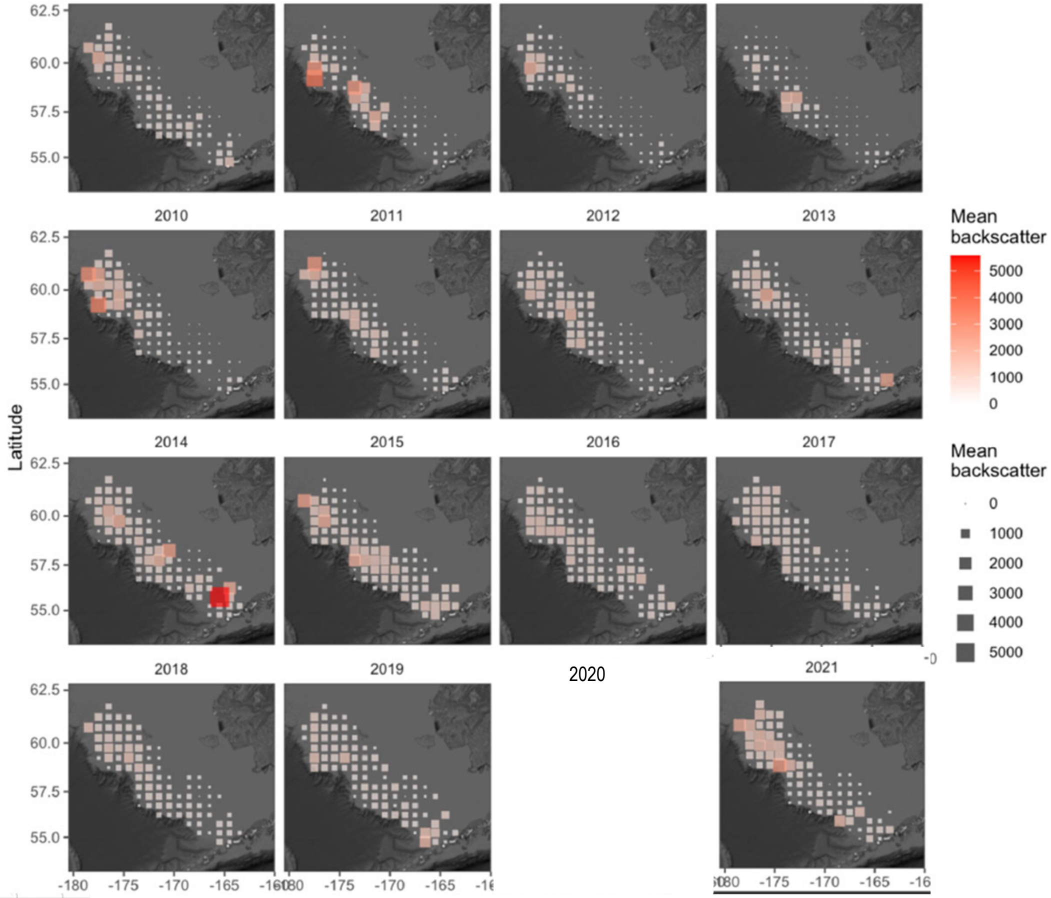


Acoustic data

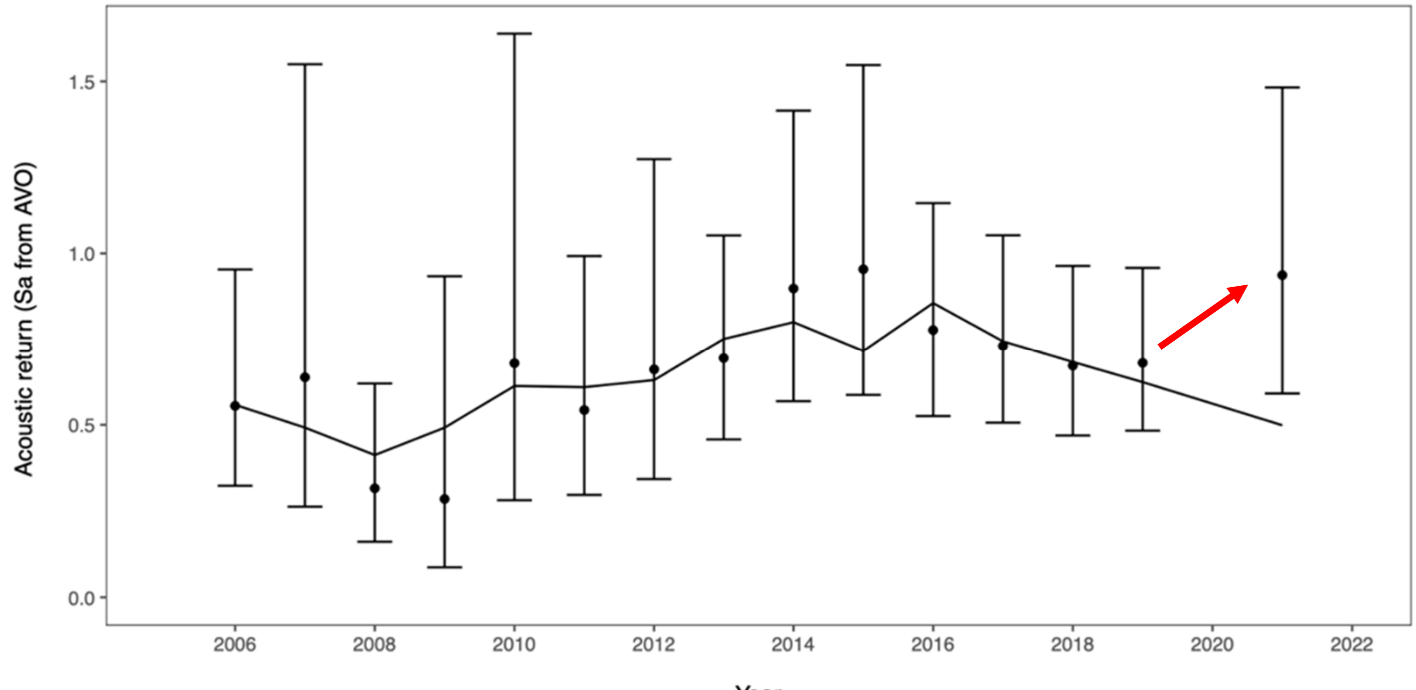
Opportunistically collected from chartered bottom-trawl survey boats

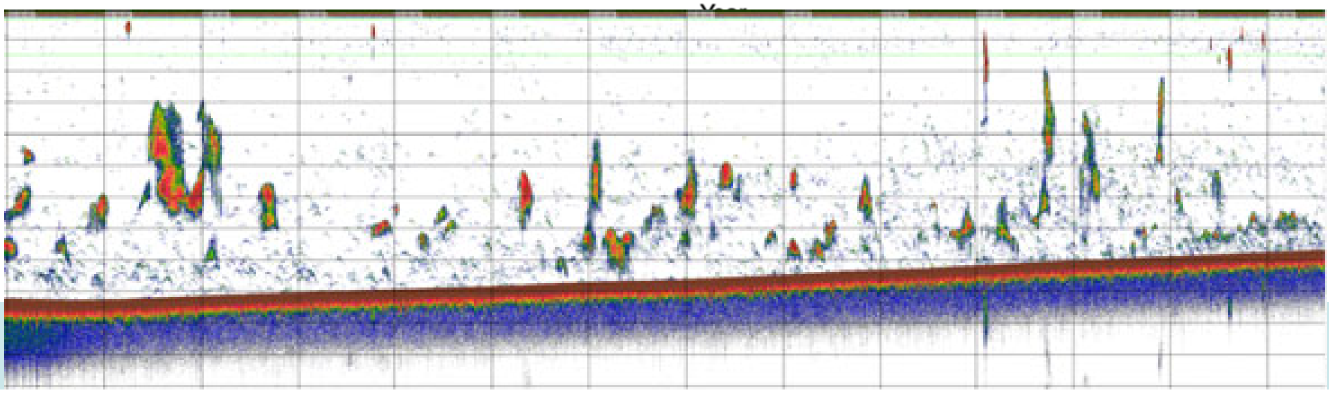
The AVO index





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

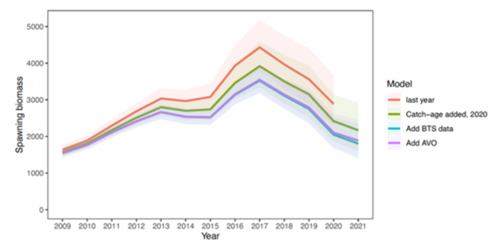
Model details

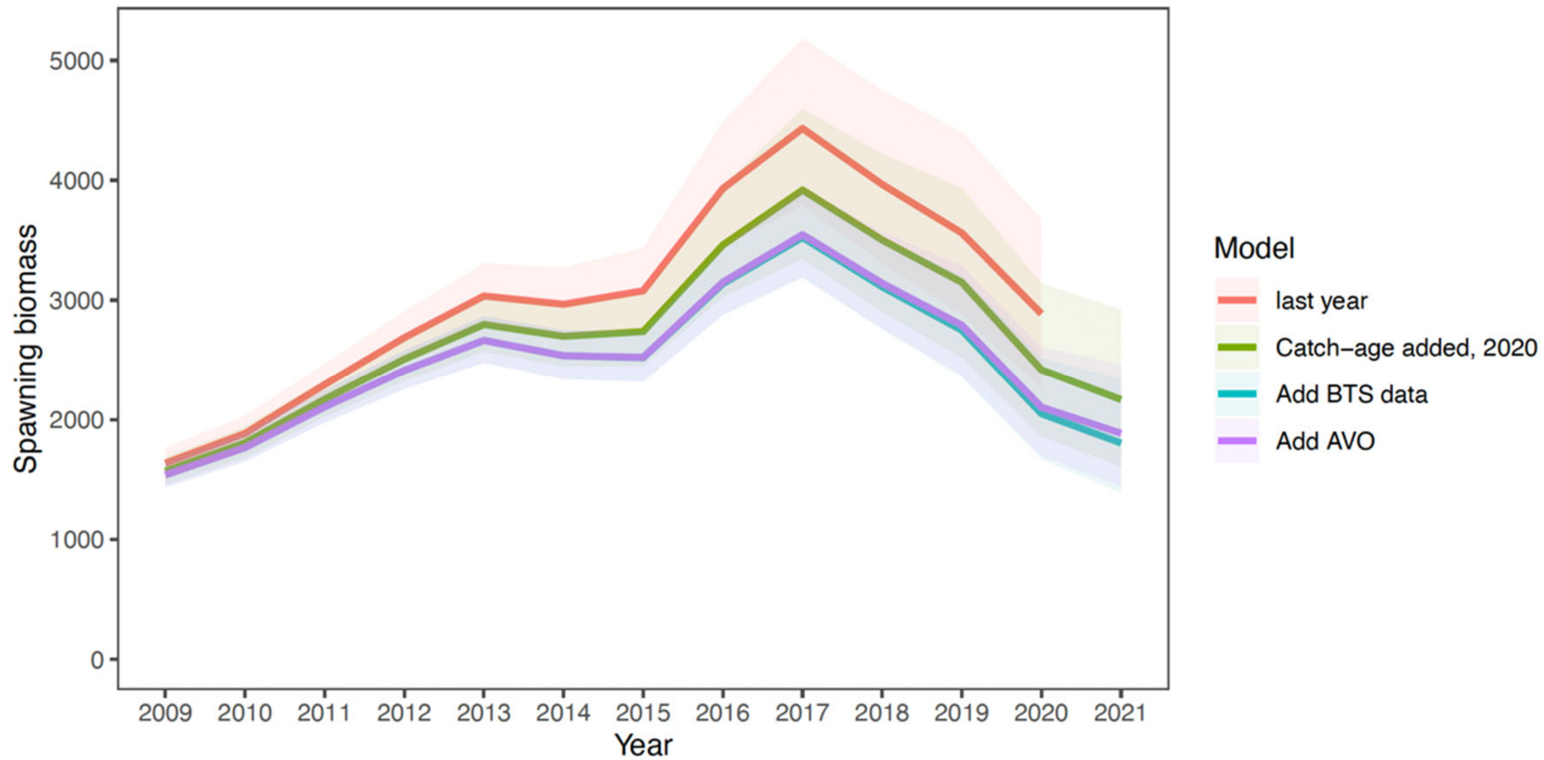
- Age specific schedules
  - Natural mortality
  - Maturity
- Other
  - Conditioned on catch biomass (F’s estimated)
  - Selectivity varies in fishery
    - Slightly in surveys
  - Ricker
  - Projection options built in to evaluate policy trade offs

- Complicated?
  - Multiple random-effects models used to process available data

New data impact on model

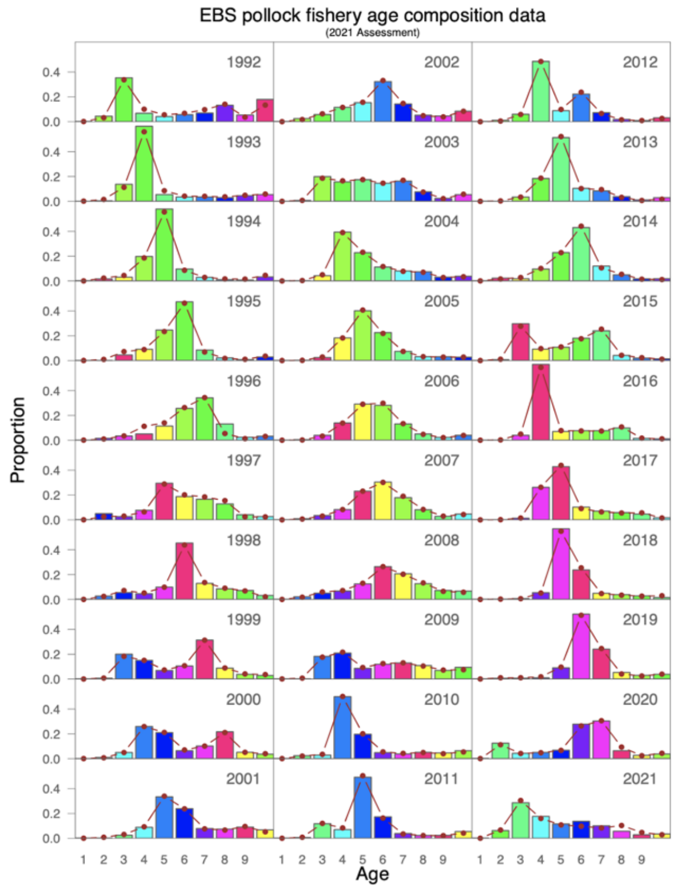
Data considerations				
Name	**Updated catch to 2021**	**2020 fishery age data**	**Bottom trawl survey**	**Acoustic from Bottom trawl transits (AVO)**
Fishery	X	X		
+ BTS	X	X	X	
+ AVO	X	X	X	X

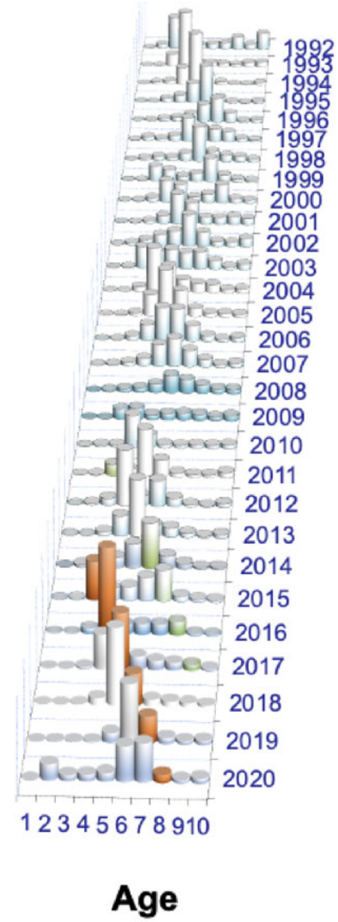




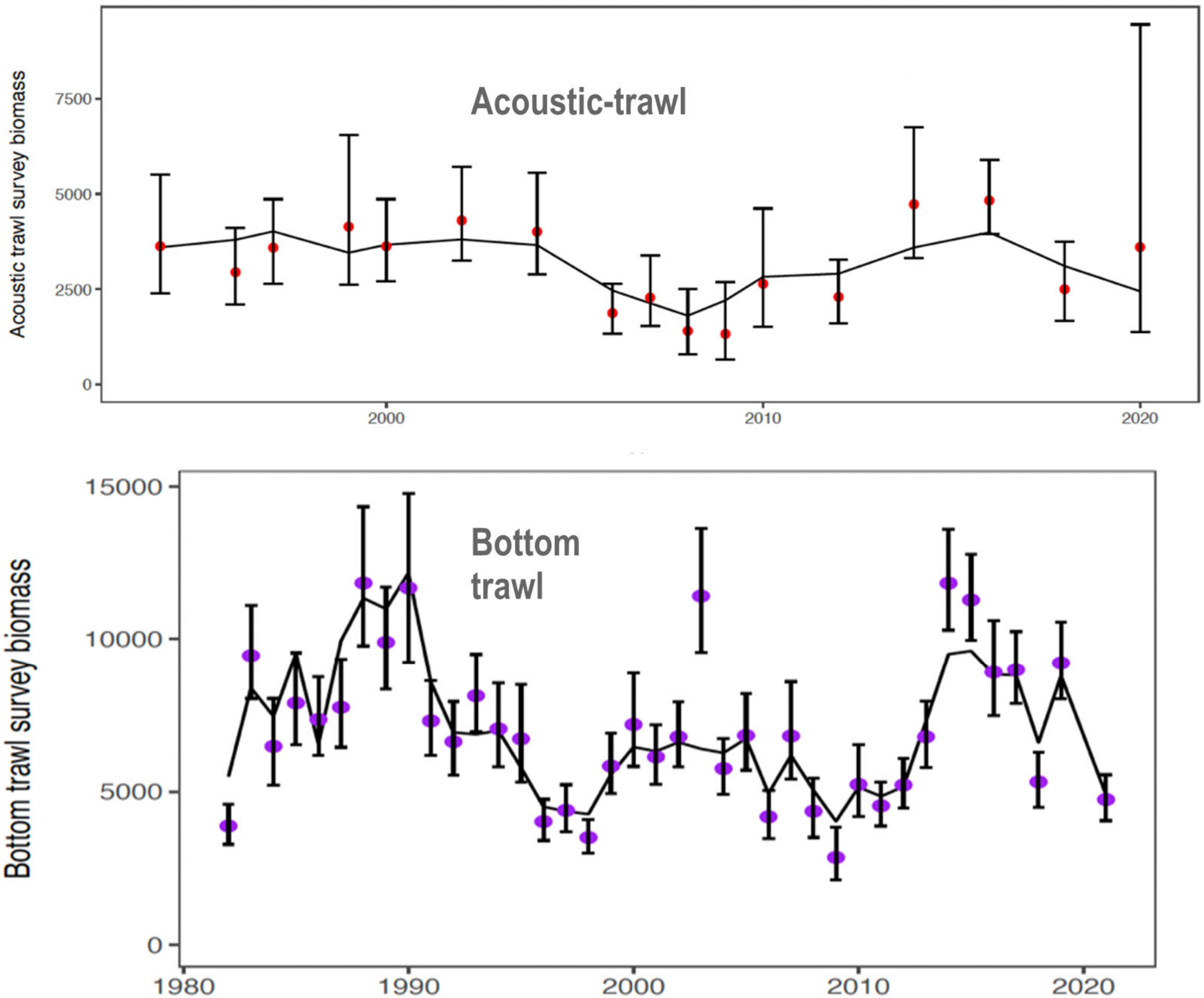
Spawning biomass
5000
4000
3000
2000
1000
0
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
Year
Model
last year
Catch–age added, 2020
Add BTS data
Add AVO

Fishery catch-age

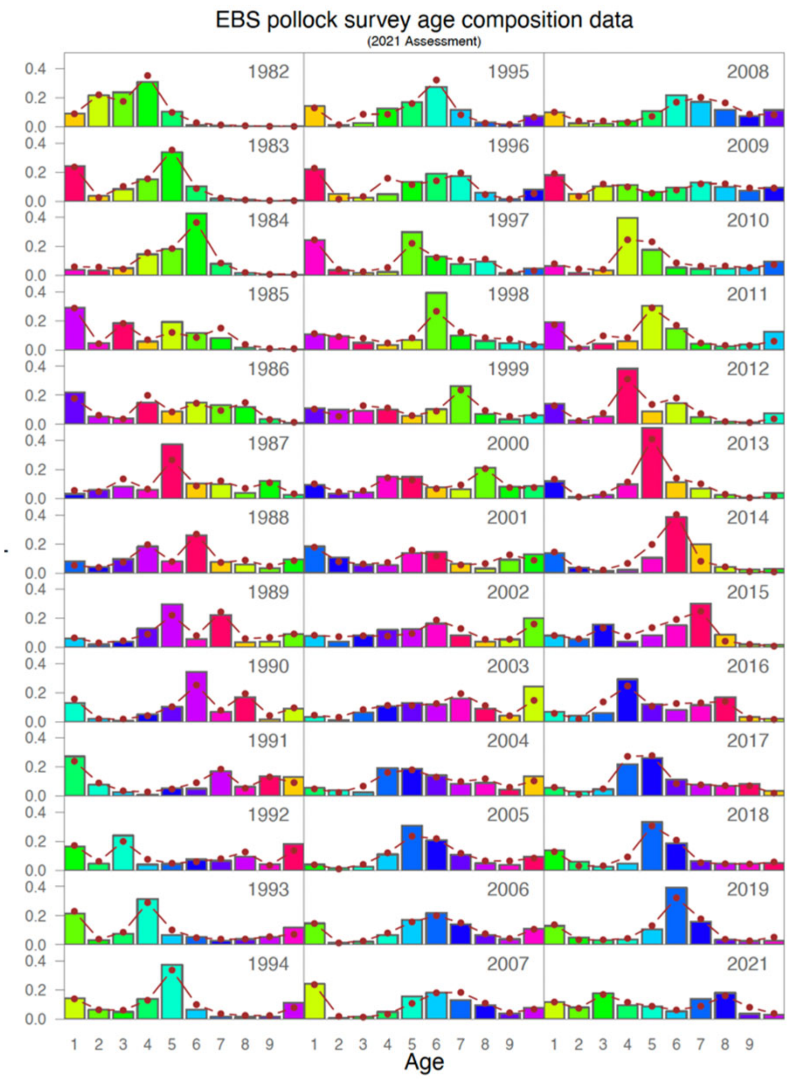




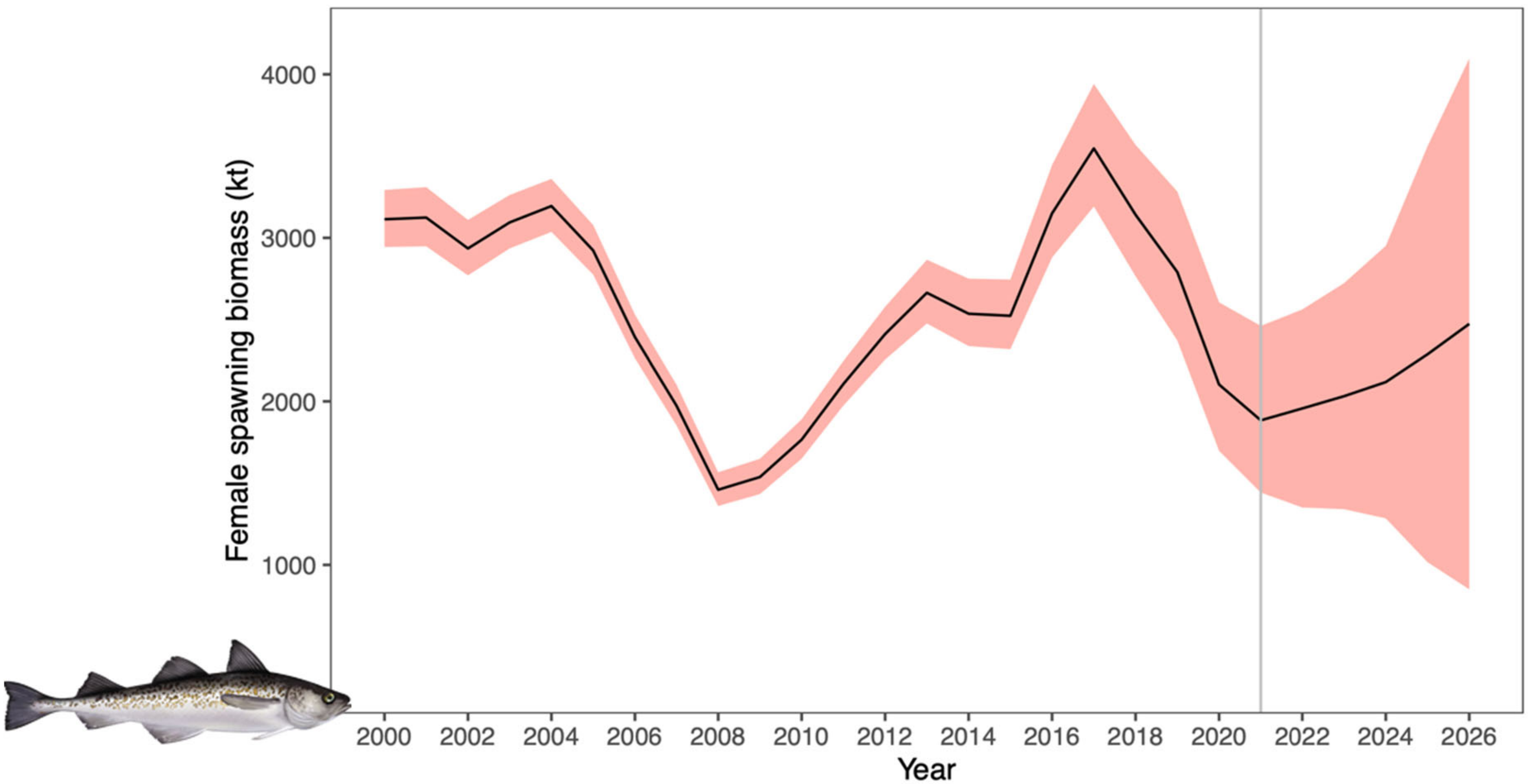
Fit to survey indices

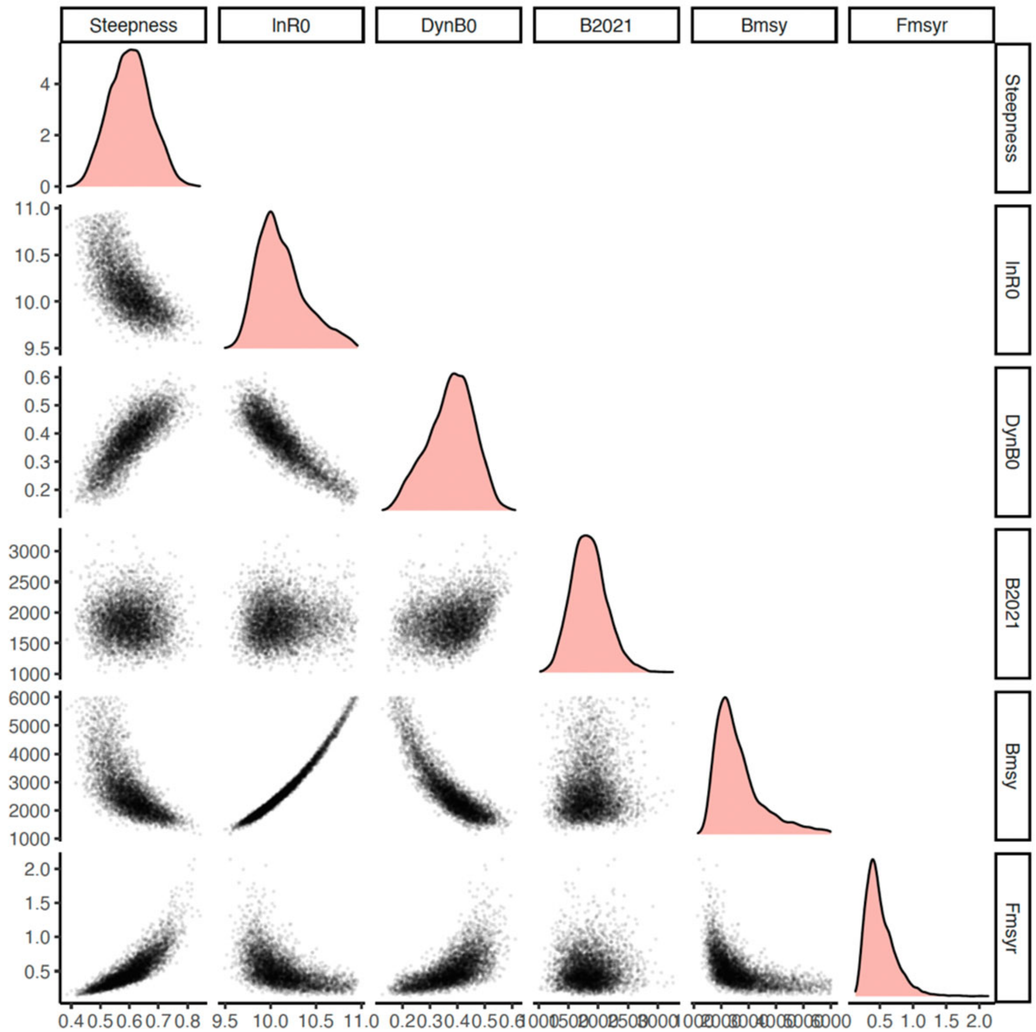


Fit to survey age compositions



Biomass trend



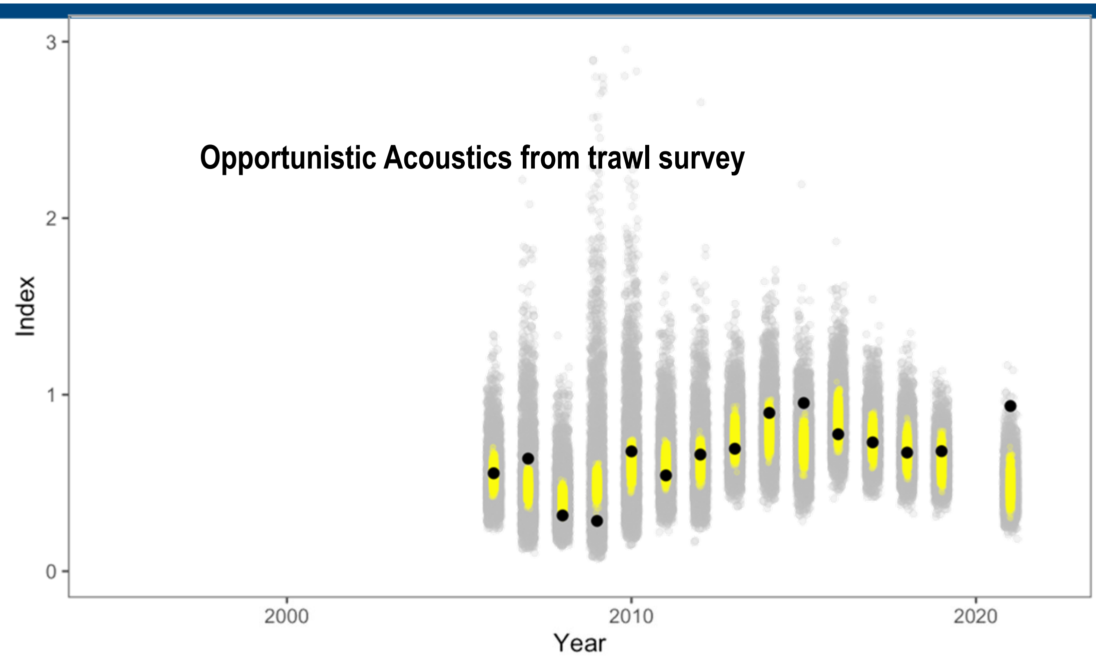


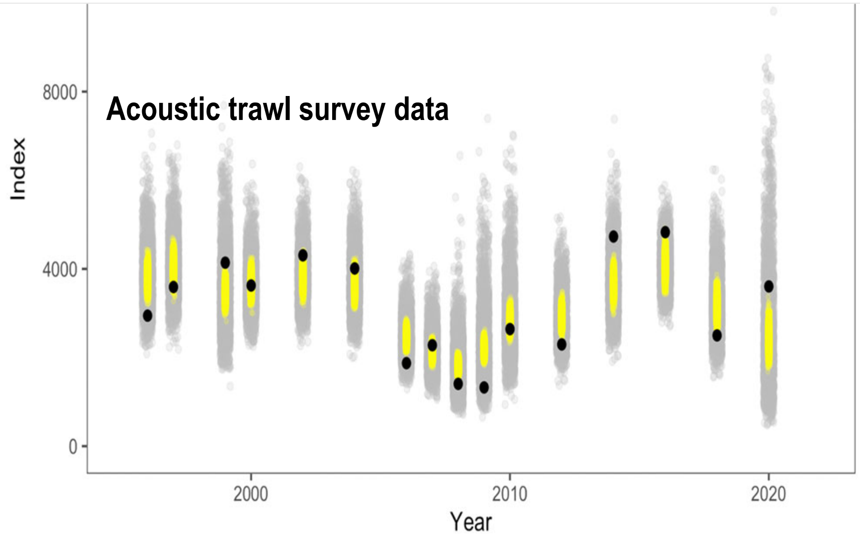
Steepness
lnR0
DynB0
B2021
Bmsy
Fmsyr

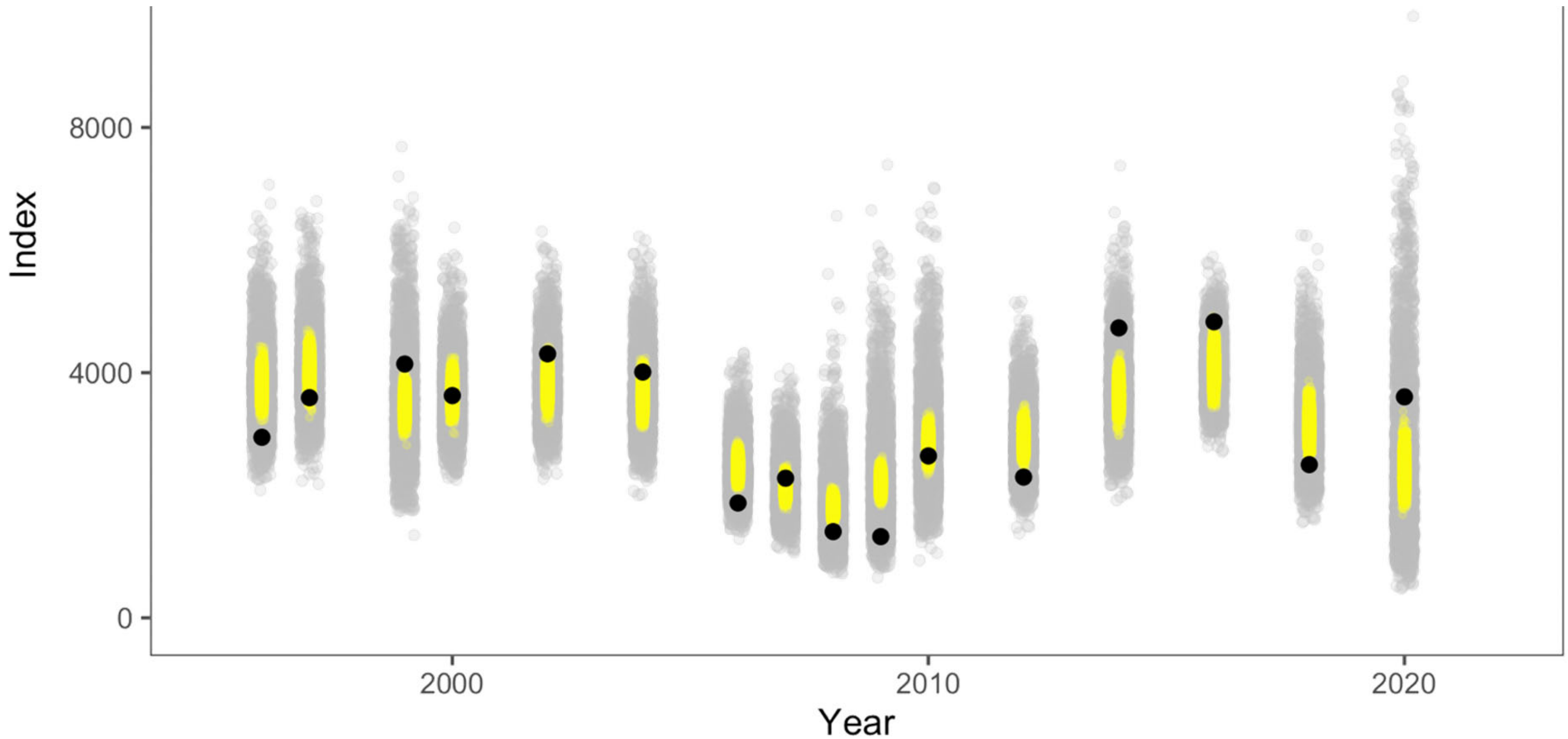
Diagnostics

Posterior predictive distributions

Base model







Subsample of posterior (from MCMC)

Yellow is the model “predictions” from the posterior

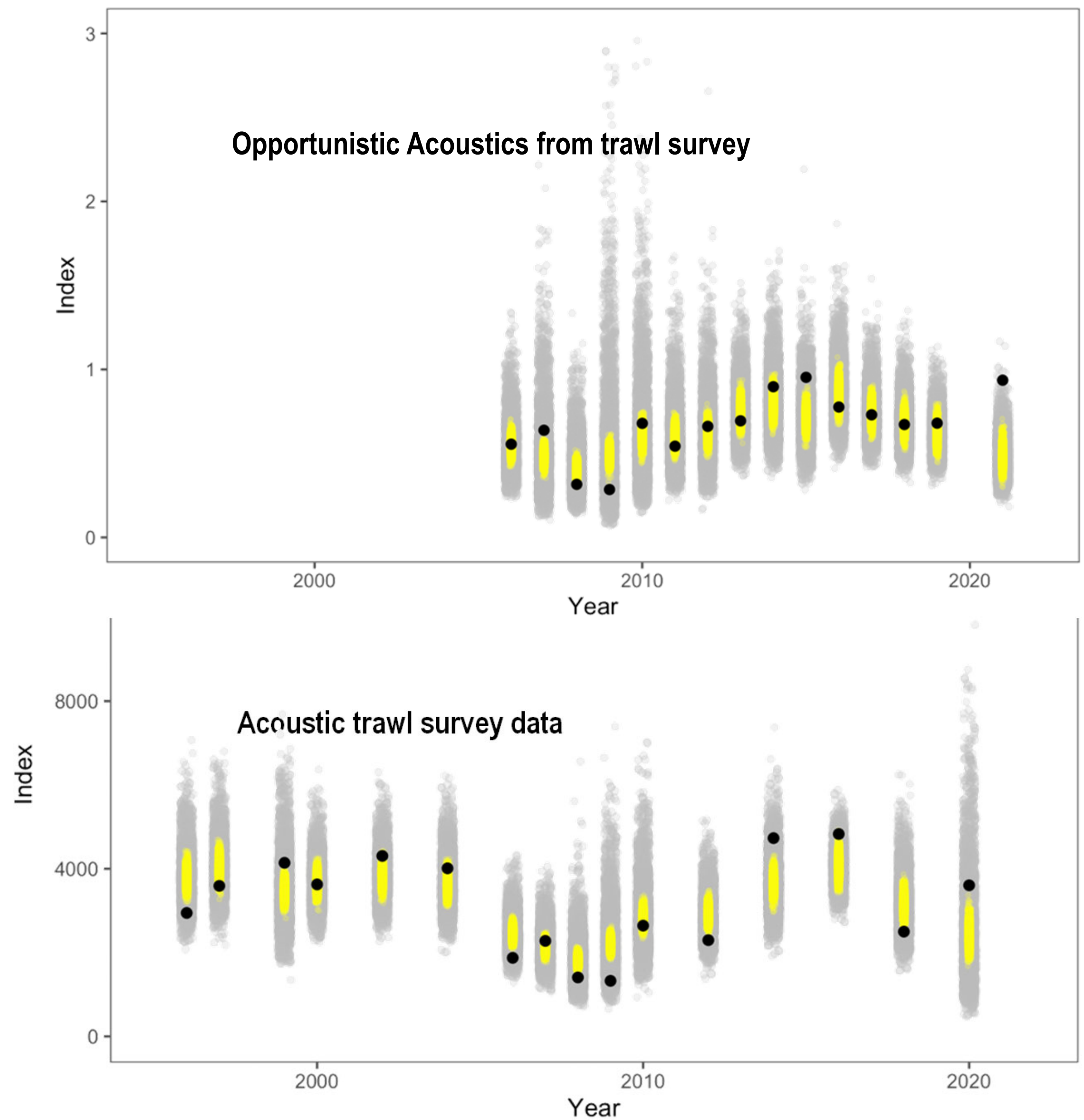
Grey are “simulated” data from posterior (using obs variance)

Black dots are actual obervations

Diagnostics

Posterior predictive distributions

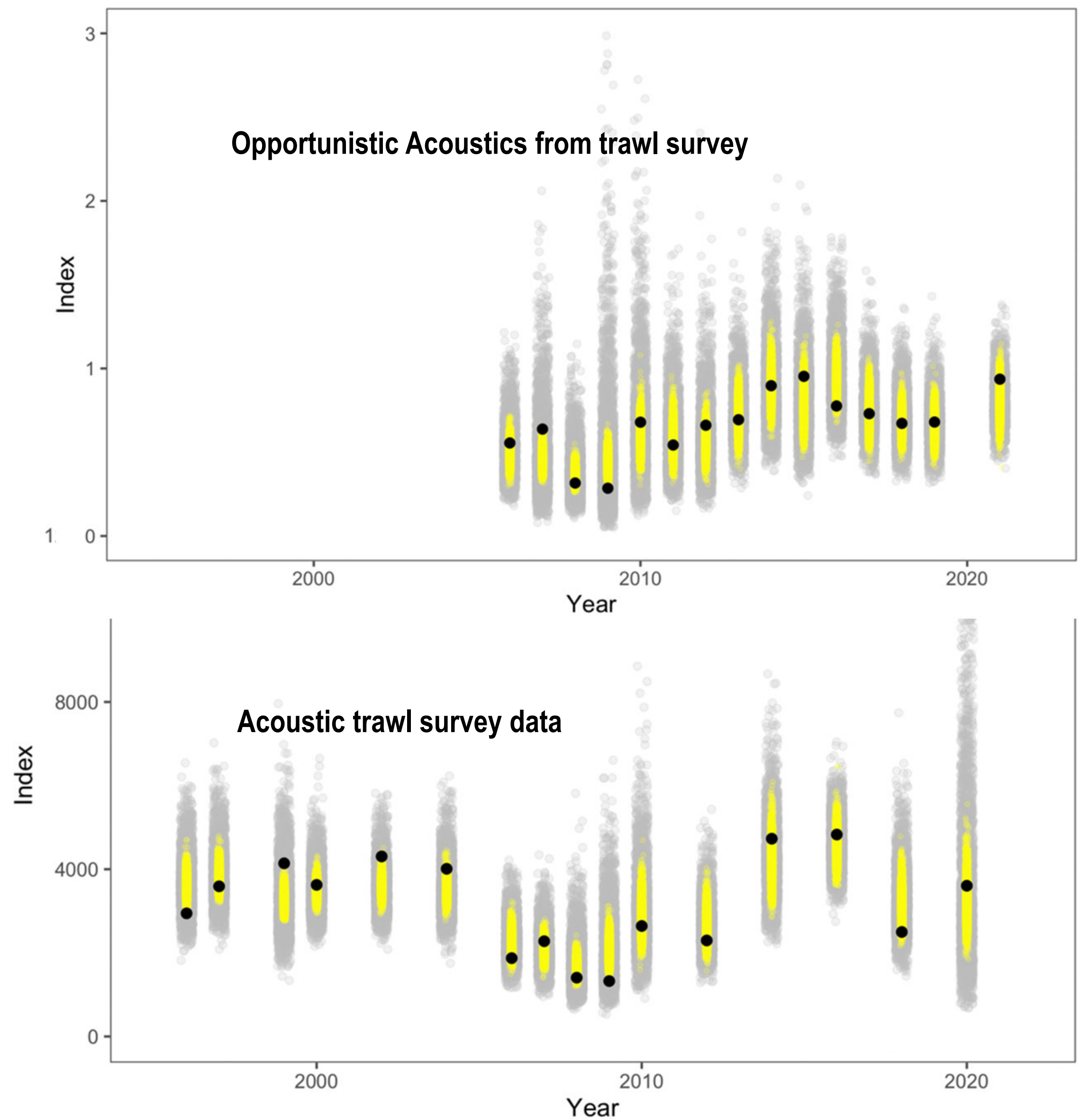
Base model

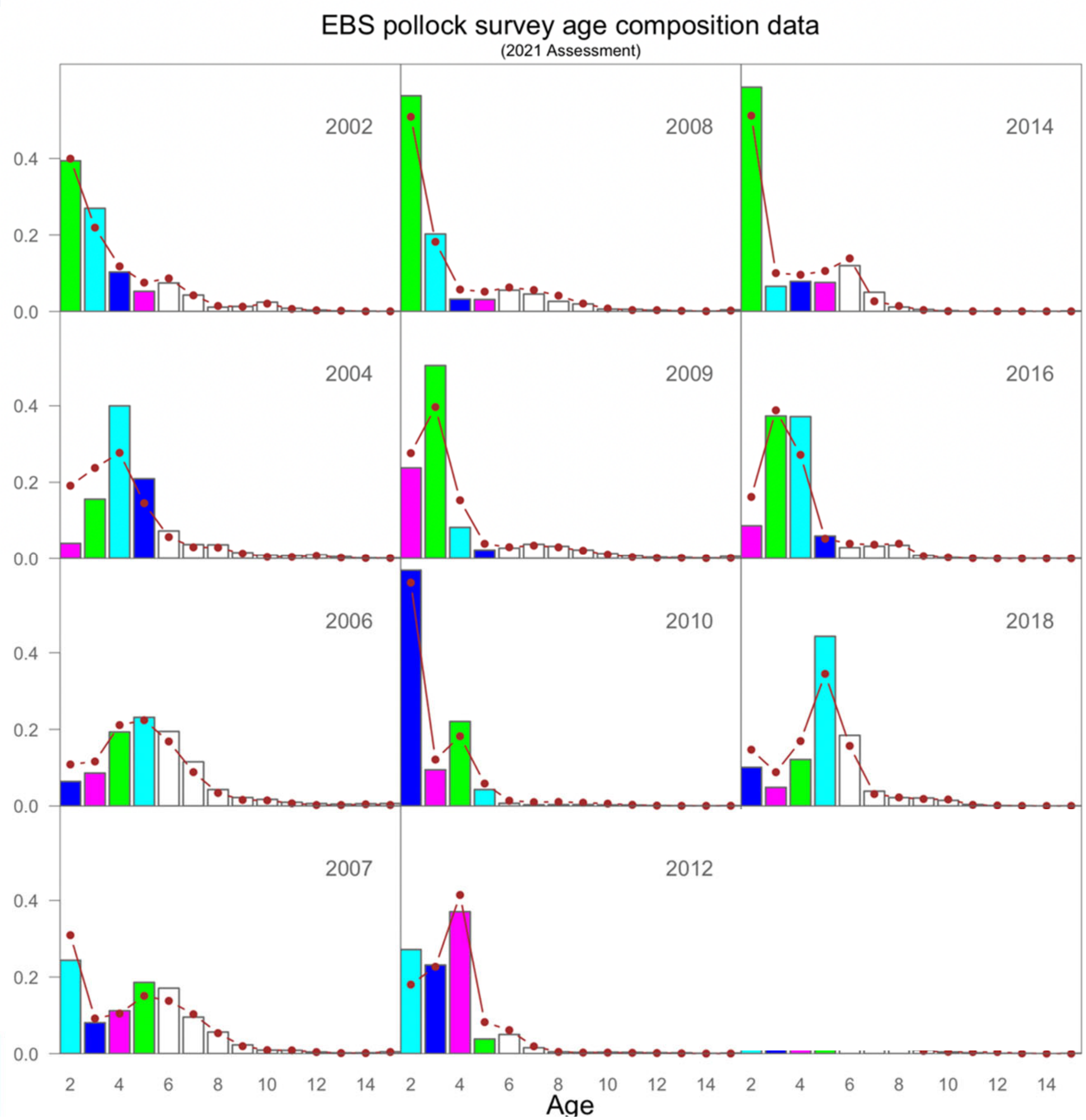


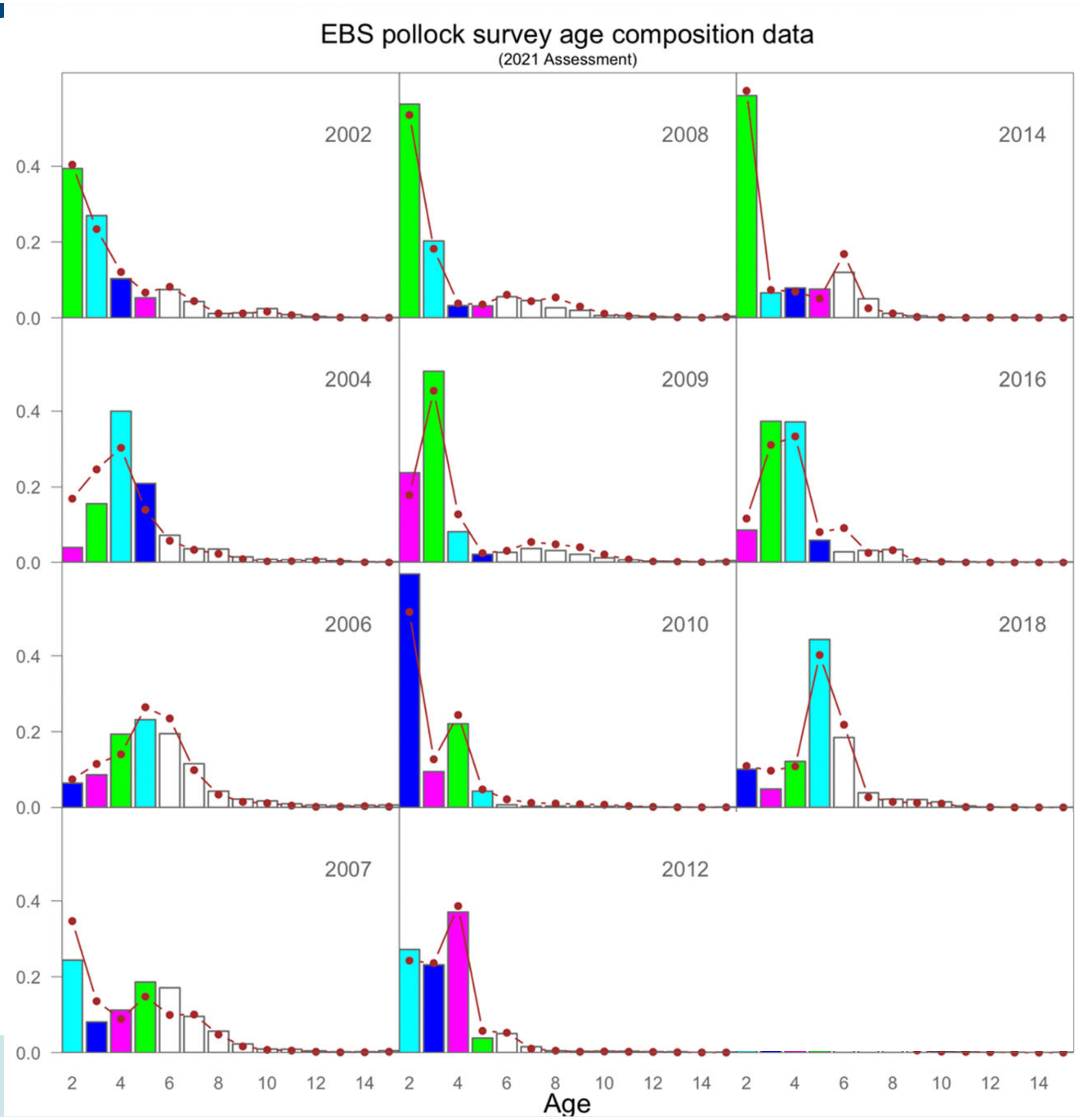
Diagnostics

Posterior predictive distributions

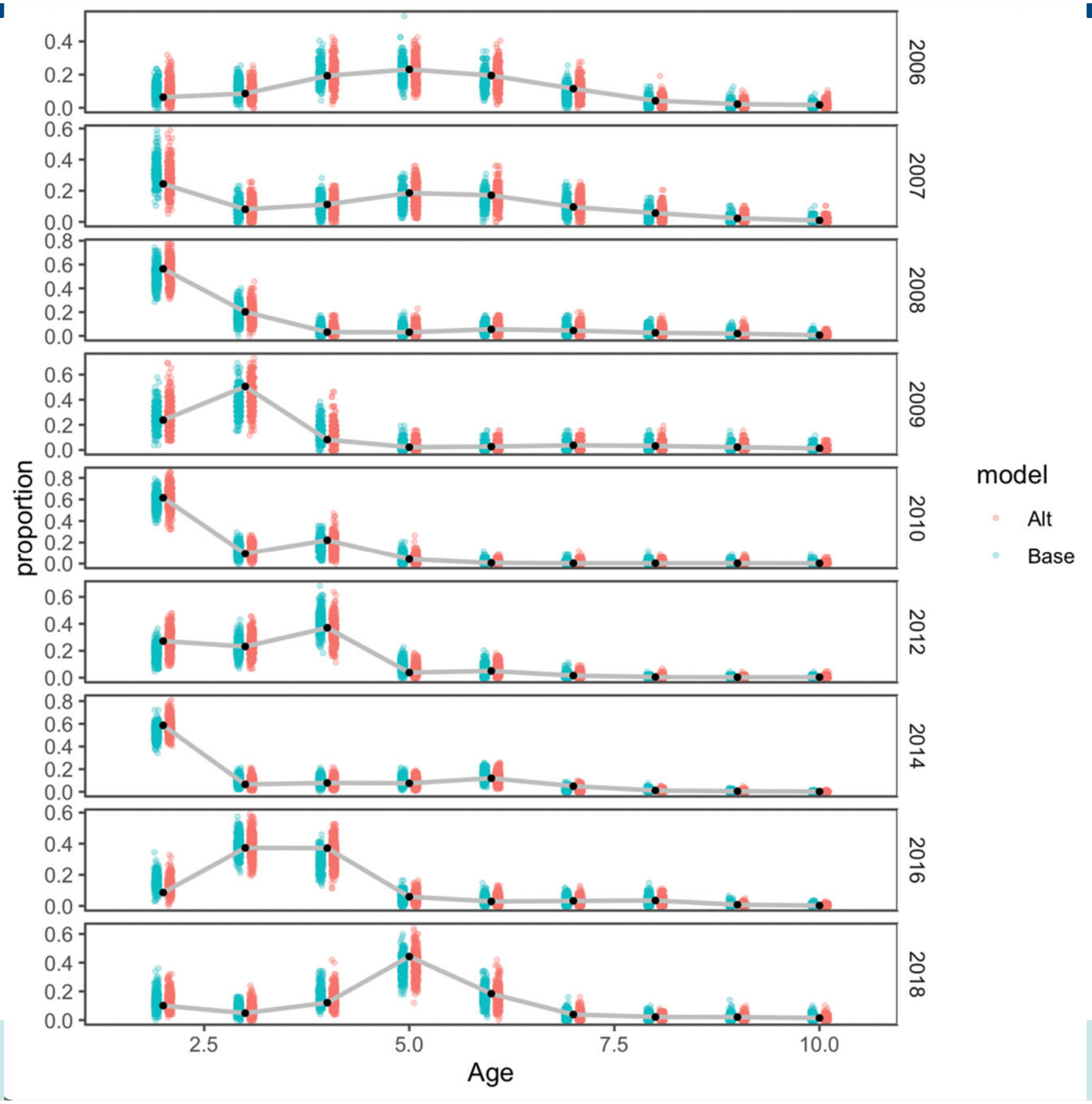
Alternative model



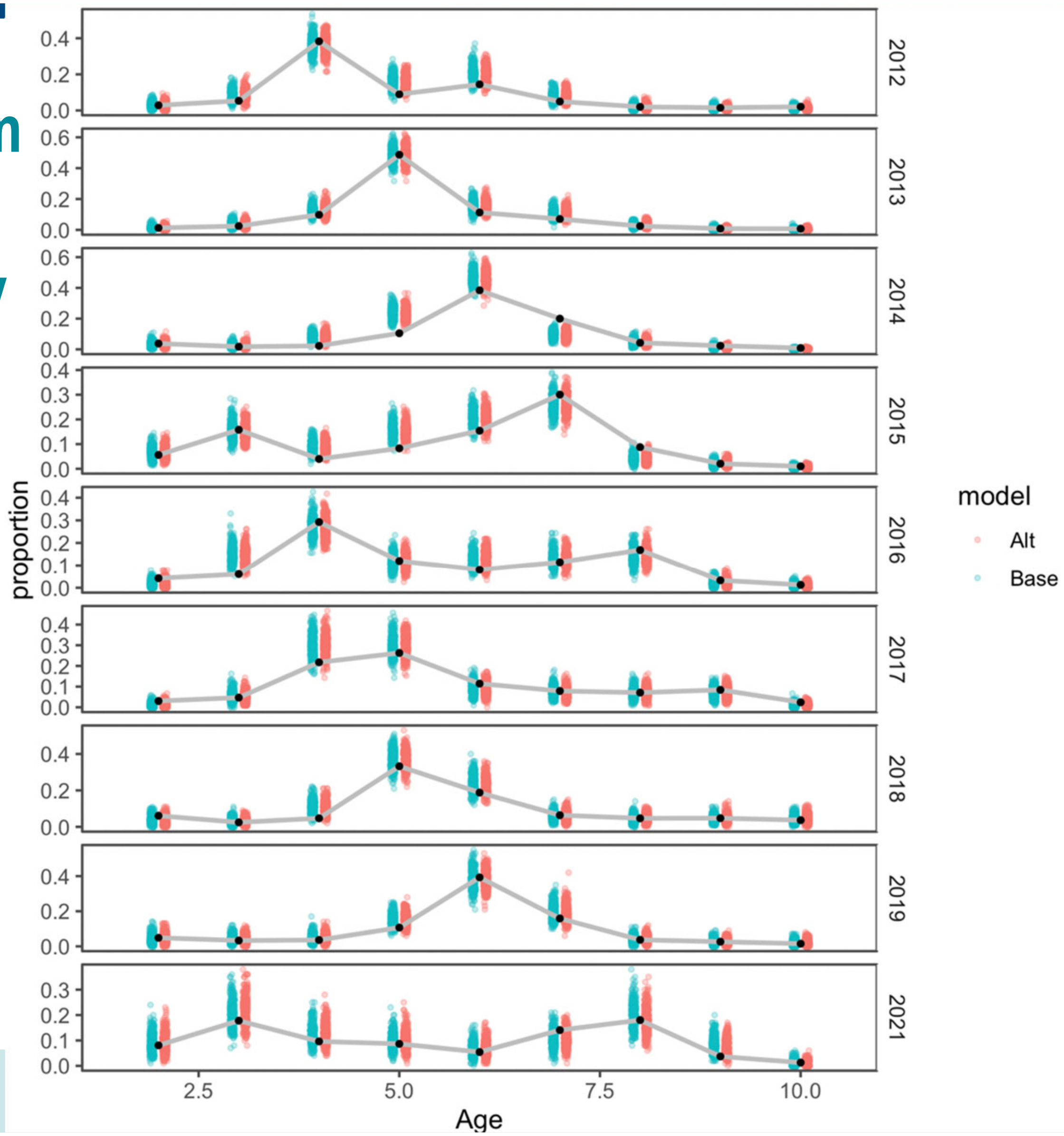

EBS pollock survey age composition data
(2021 Assessment)
2002
2008
2014
2004
2009
2016
2006
2010
2018
2007
2012
0.0
0.2
0.4
2
4
6
8
10
12
14
Age


EBS pollock survey age composition data
(2021 Assessment)
2002
2008
2014
2004
2009
2016
2006
2010
2018
2007
2012
0.0
0.2
0.4
2
4
6
8
10
12
14
Age

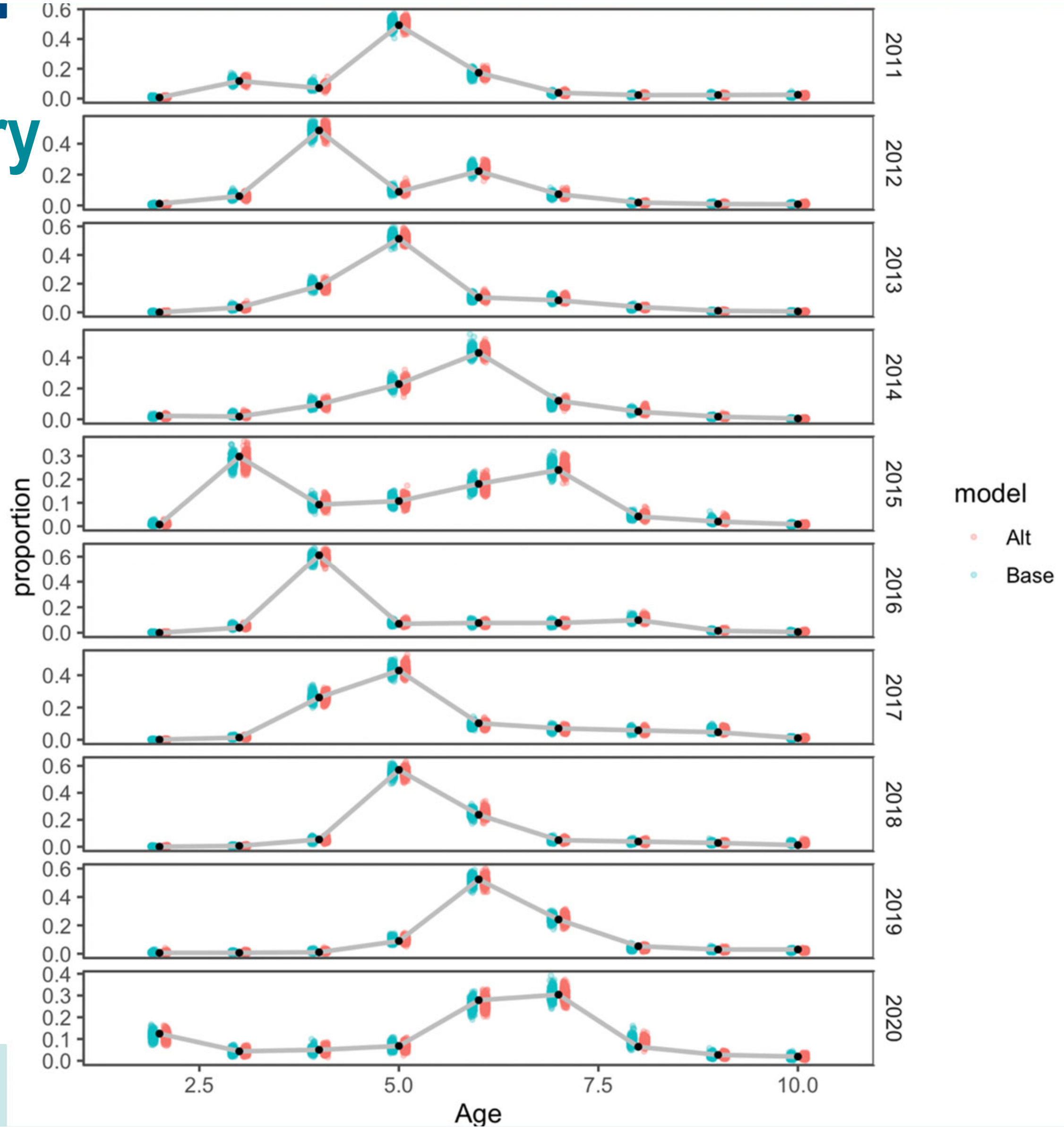
Acoustic trawl survey



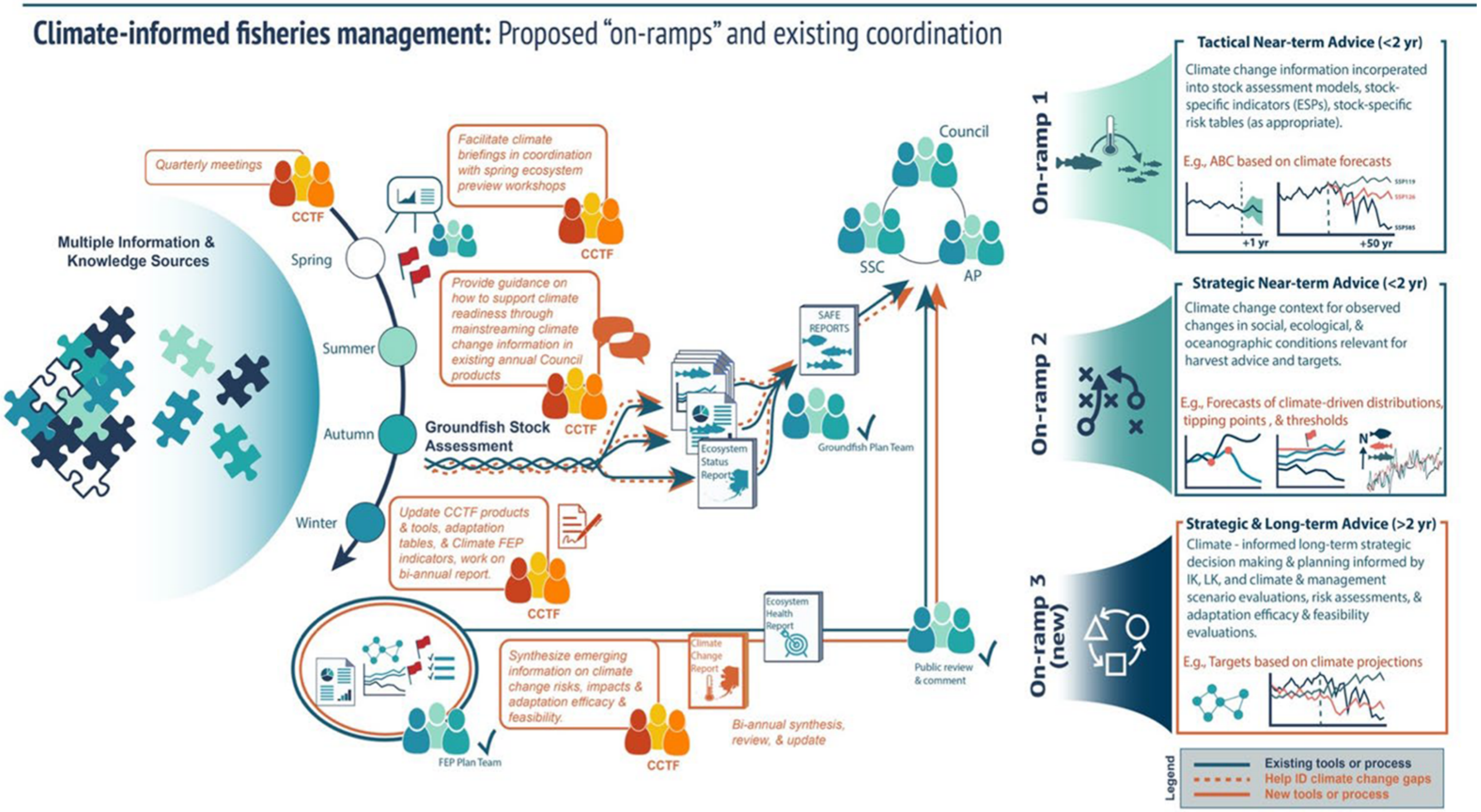
Bottom trawl survey



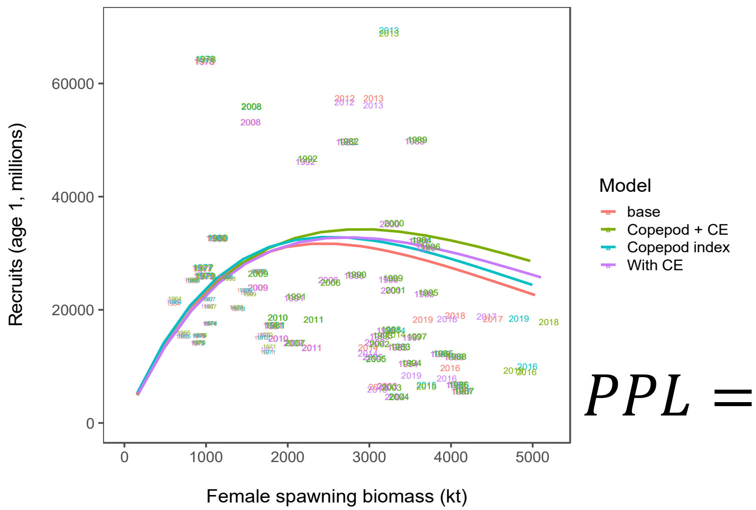
Fishery


proportion
Age
model
Alt
Base
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020

Steps as part of ACLIM project



Model selection and prediction of new data?



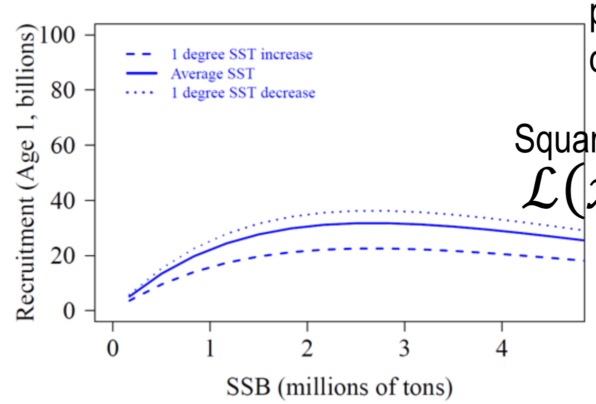
Posterior Predictive Loss
(PPL; Gelfand and Gnosh 1998)

Based on decision theory

$$PPL = \mathcal{L}(\tilde{y}_i, \hat{y}_i) + w\mathcal{L}(y_i, \hat{y}_i)$$

$\tilde{y}_i$ = Replicate data drawn from posterior predictive distribution of the data

Goodness of fit to observed data

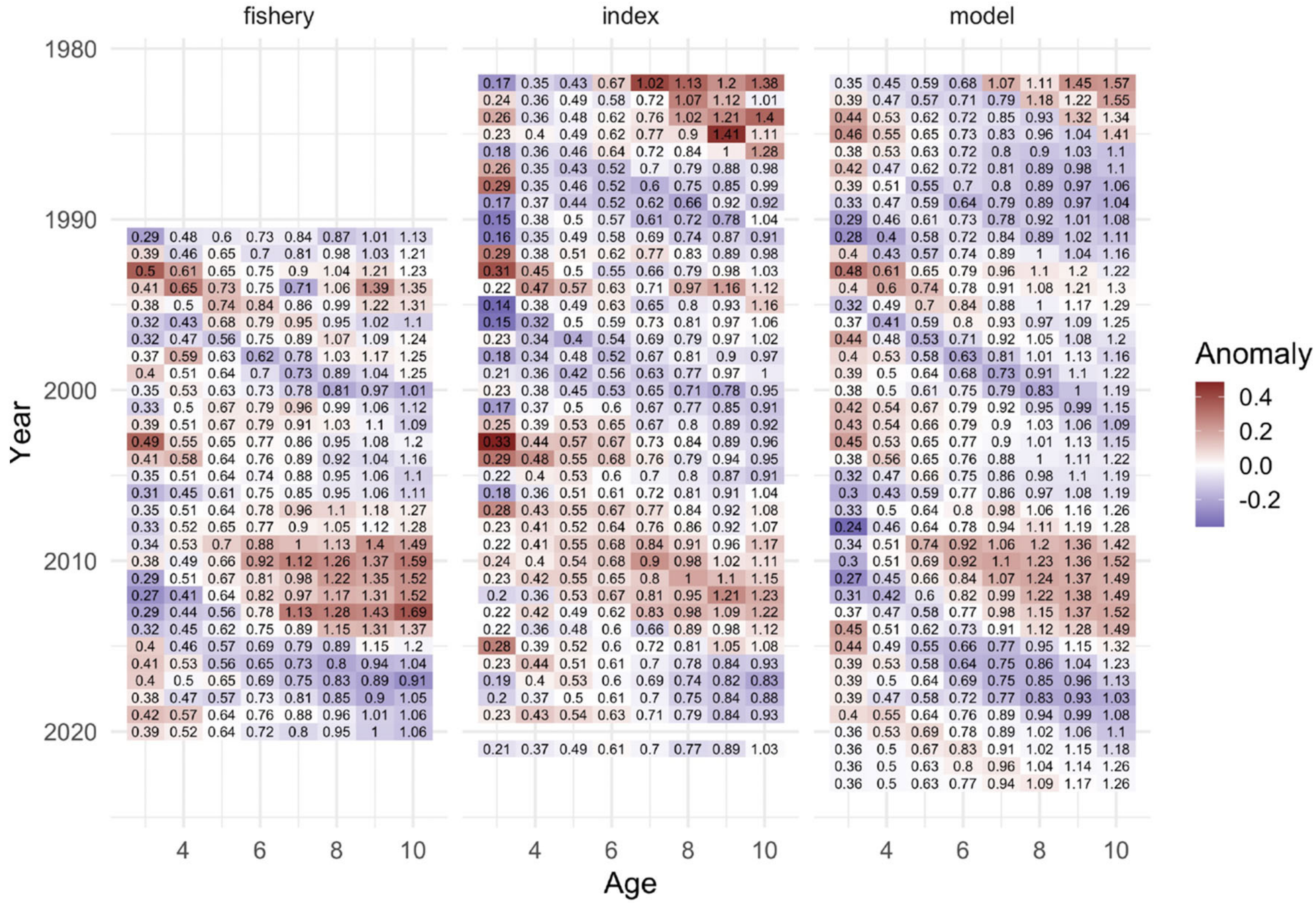


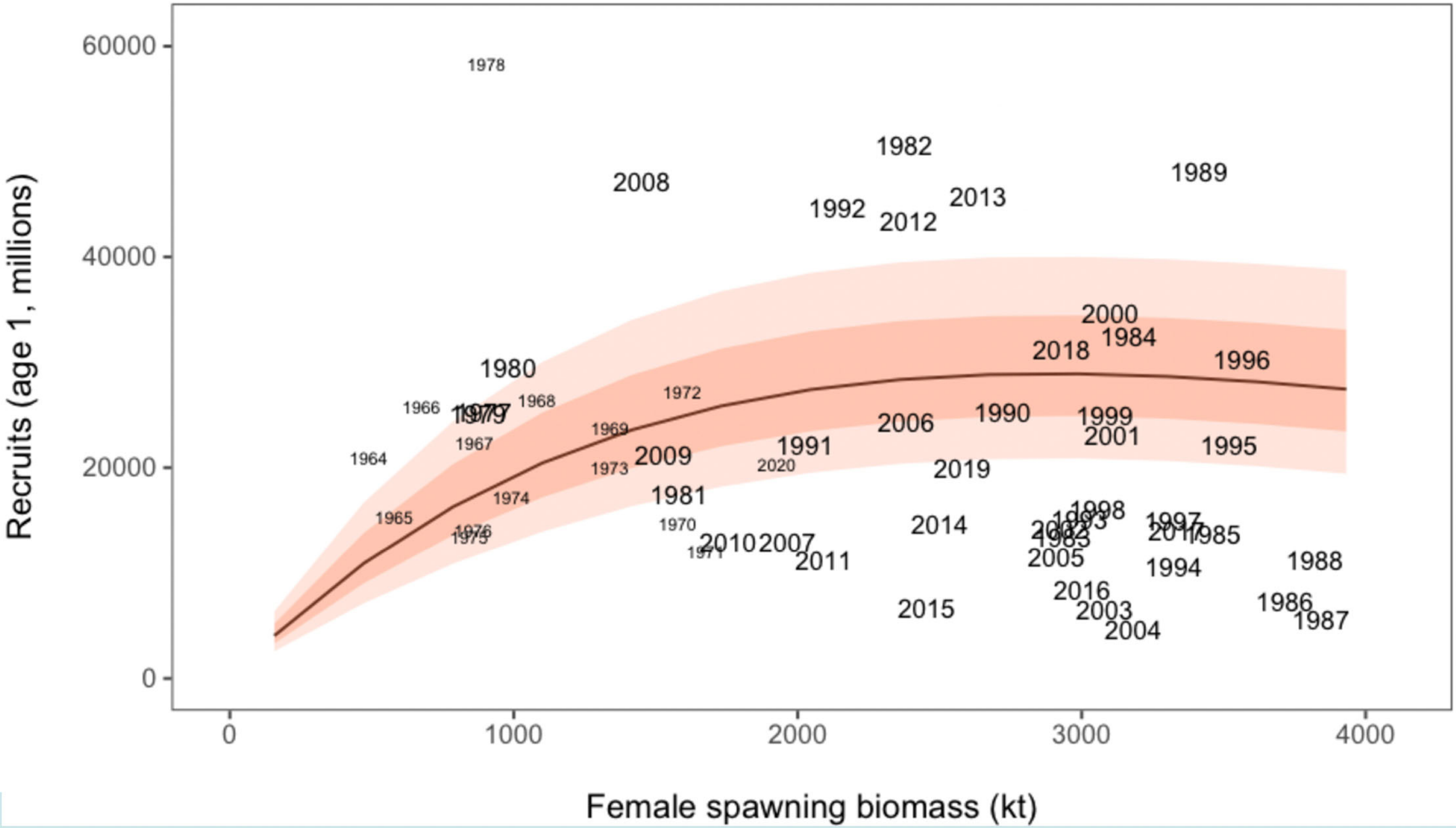
Squared error loss function

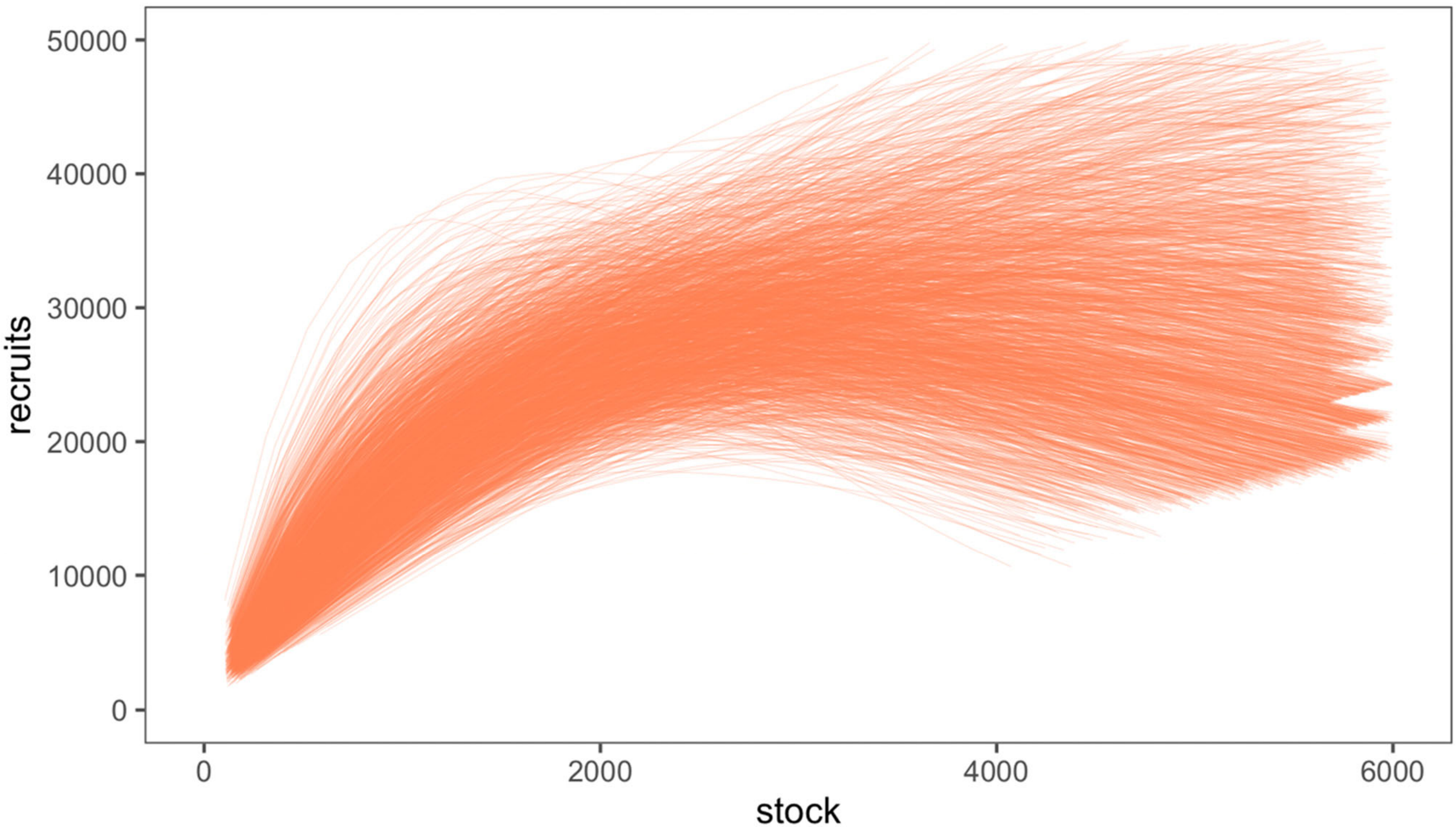
$$\mathcal{L}(x, y) = (x - y)^2$$

Precision of estimation (i.e., how well the model fits new data not used in model fitting)

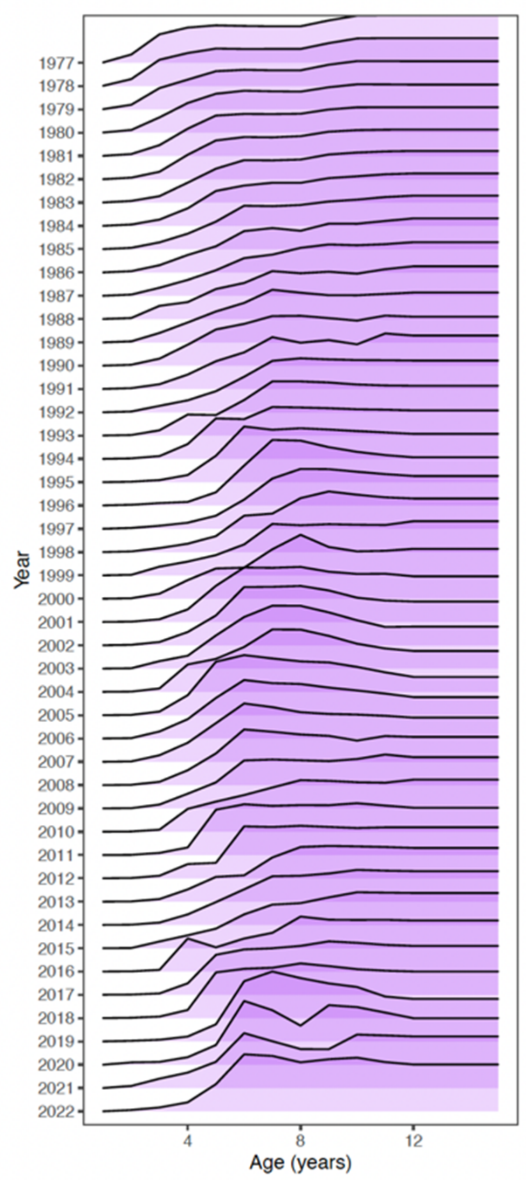
What things affect FMSY?


fishery
index
model
Year
1980
1990
2000
2010
2020
Age
4
6
8
10
Anomaly
0.4
0.2
0.0
-0.2

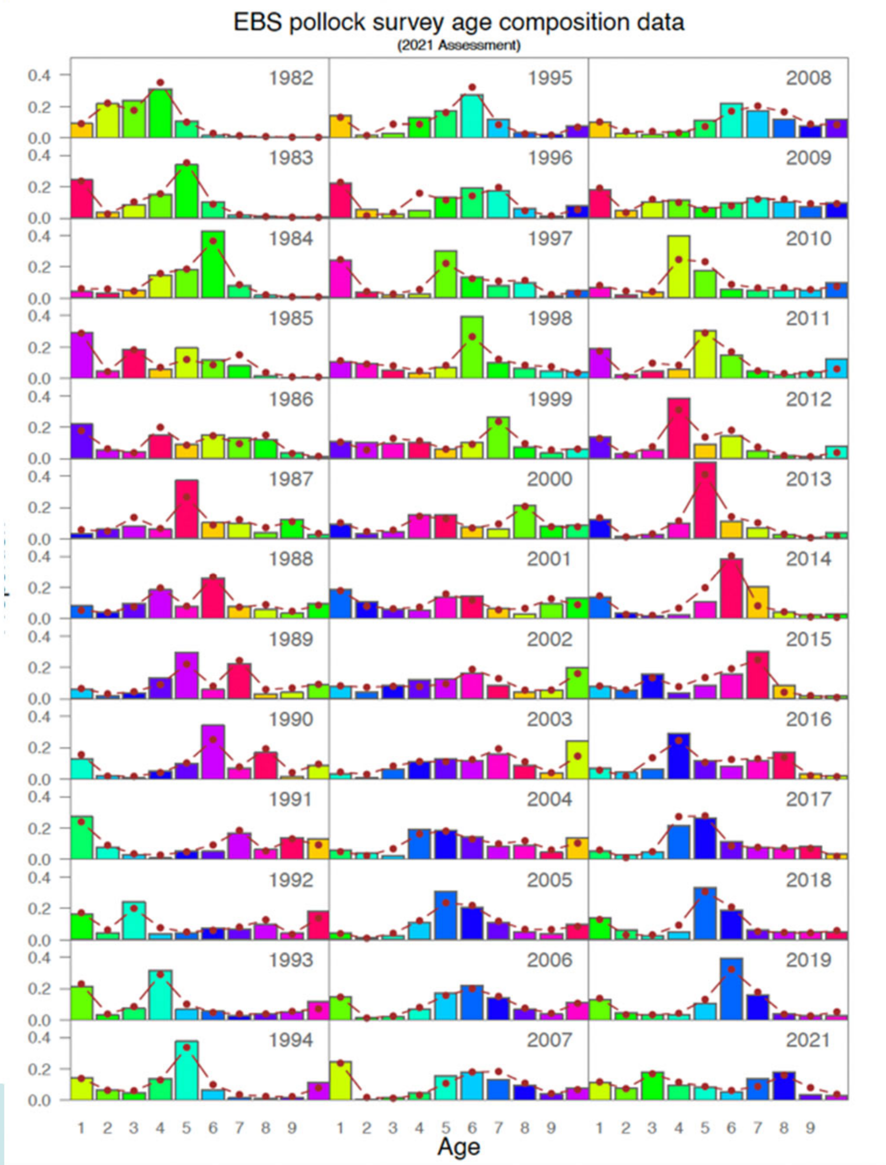

Recruits (age 1, millions)
60000
40000
20000
0
0
1000
2000
3000
4000
Female spawning biomass (kt)



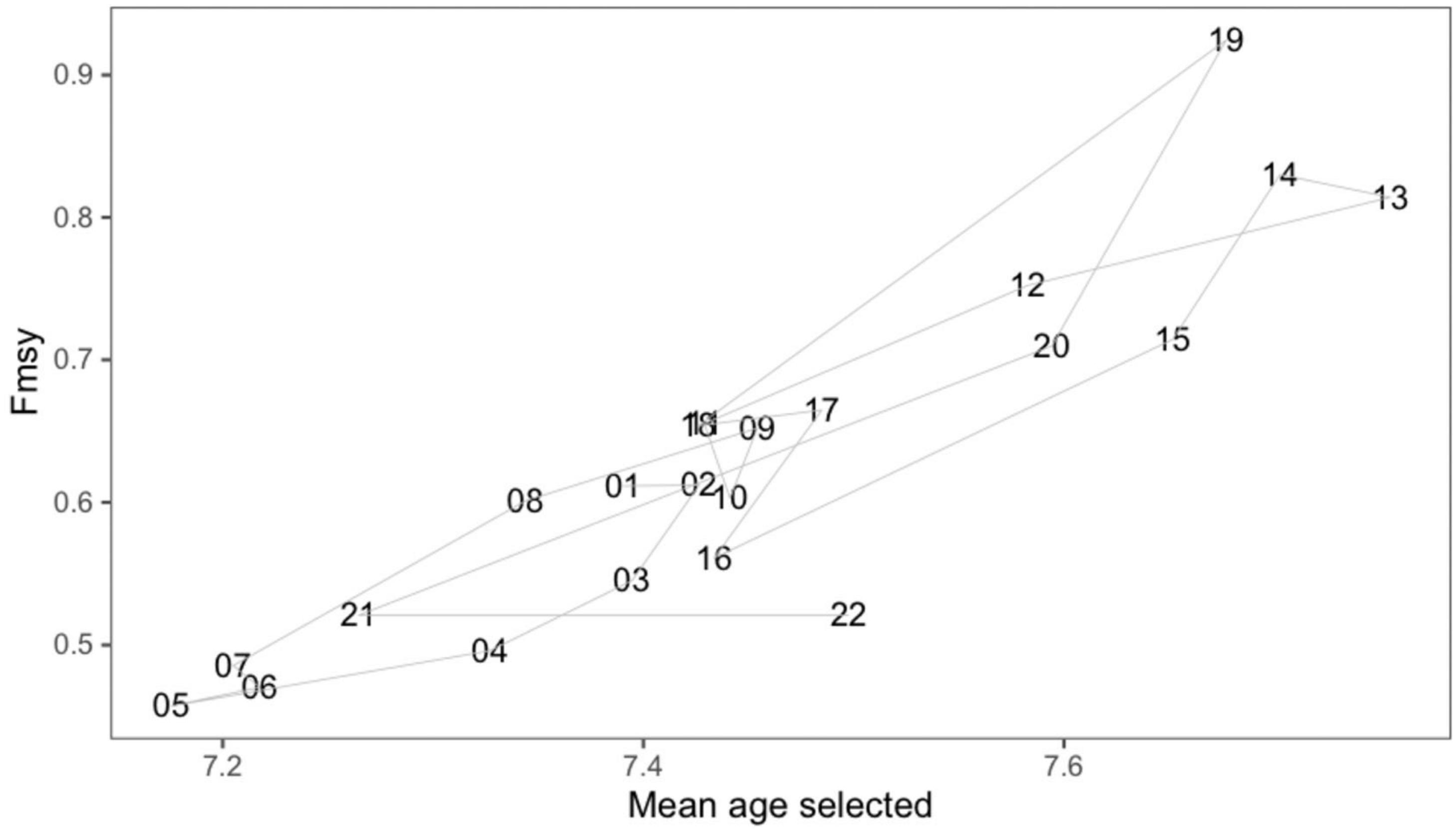
50000
40000
30000
20000
10000
0
recruits
0
2000
4000
6000
stock



Year
Age (years)



EBS pollock survey age composition data
(2021 Assessment)
Age


Fmsy
Mean age selected
0.9
0.8
0.7
0.6
0.5
7.2
7.4
7.6
19
14
13
12
20
15
17
09
08
01
02
10
16
03
21
22
04
07
06
05

Contributions

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