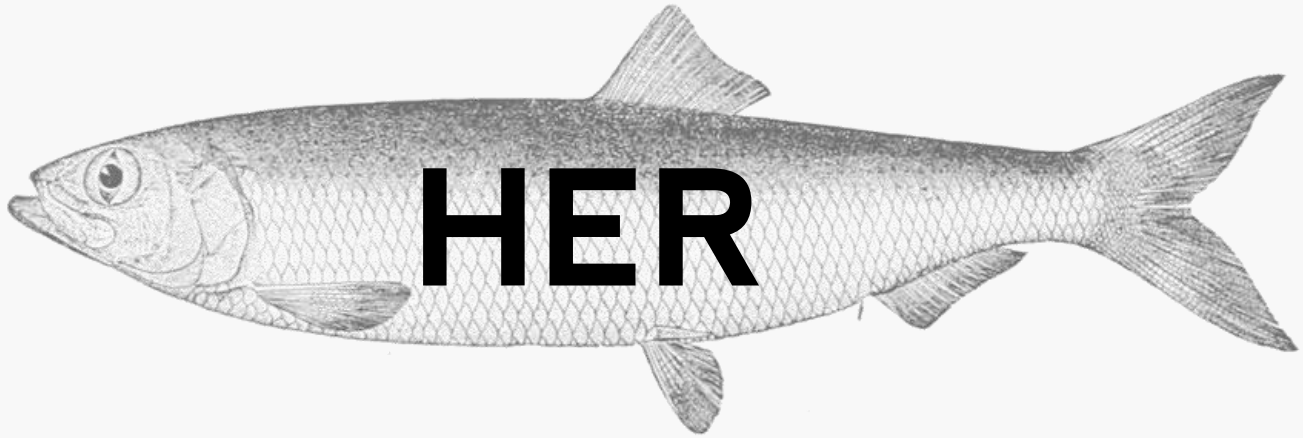


A new framework for assessing Southeast Alaska herring stocks

Jane Sullivan

Sherri Dressel

Sara Miller

Take homes

1. HER provides a modern and robust modeling framework
2. Biological reference points tell us about stock status, set the stage for future management
3. Uncertainty is a useful tool for managers

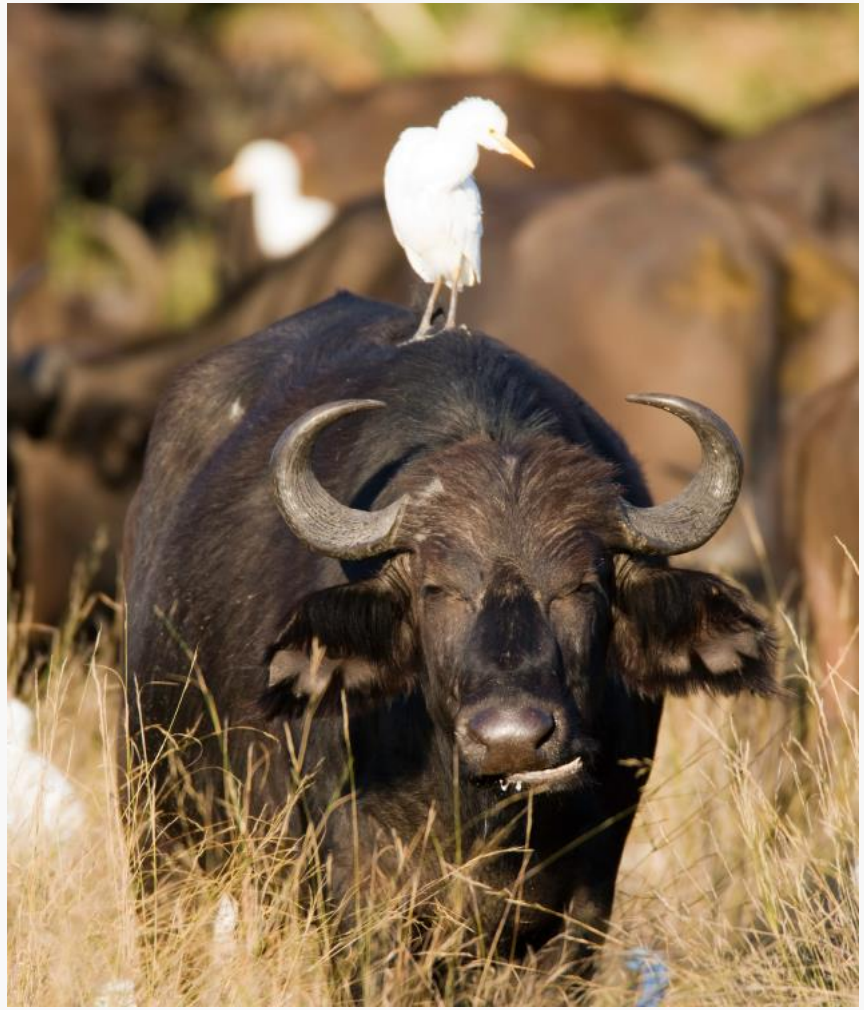
Symbiosis: we need your input and feedback

What's useful, what's not?

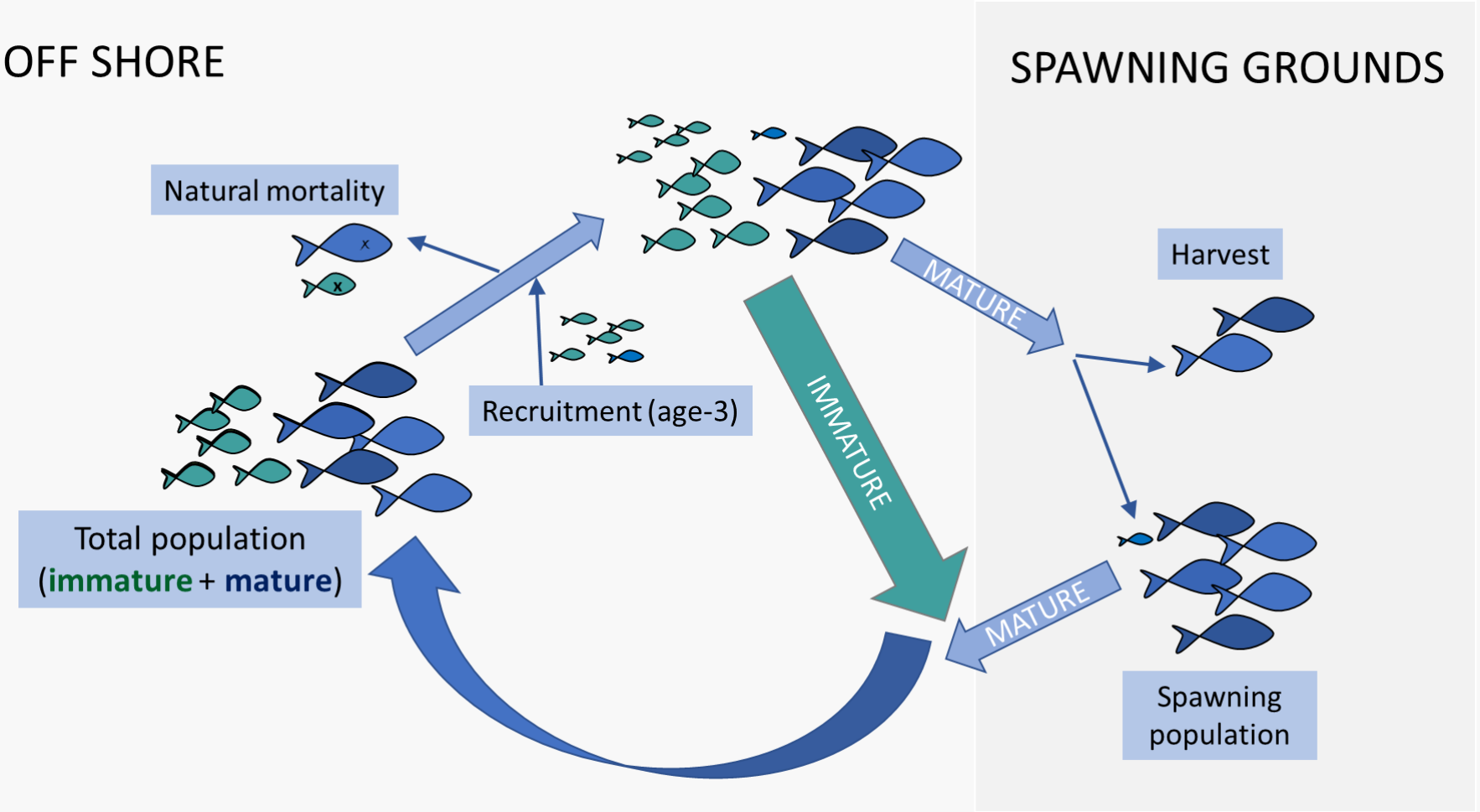
What did I get wrong?

Do you have concerns?

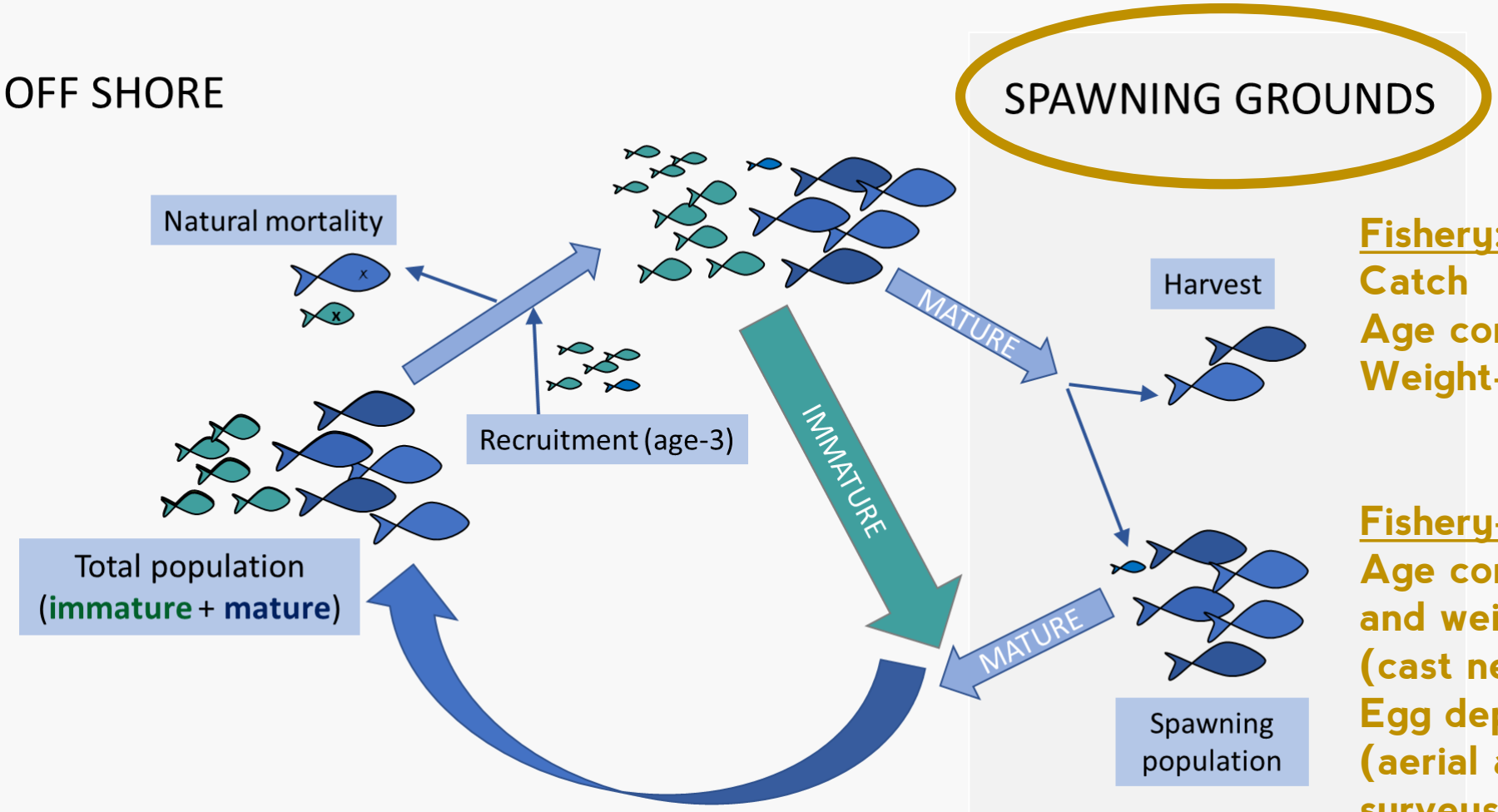
Do you have priorities that I haven't addressed?



Modeling herring populations in Southeast Alaska



What information do we have?



Fishery:
Catch
Age compositions
Weight-at-age

Fishery-independent:
Age compositions and weight-at-age (cast net)
Egg deposition (aerial and dive surveys)

Where we are – LS (ASA Model)

Integrated catch-at-age model

- **Least-squares (LS) estimator**
- **Implemented by Carlile in 1994 when computing power was relatively poor (1994)**
- **Translated from Excel to ADMB by Hulson (2007/08 contract)**
- **Applied to Sitka, Craig, Seymour Canal, Kah Shakes/Cat Island, and Tenakee (Dressel, Miller, Van Kirk)**

Where we're going – HER

Integrated statistical catch-at-age model

- **Bayesian or Maximum Likelihood Estimation**
- **Developed by Martell (2016 contract)**
- **Start with Sitka, goal to apply to other Alaska stocks**
- **Estimation of biological reference points (e.g. MSY, B0)**
- **Management strategy evaluation**

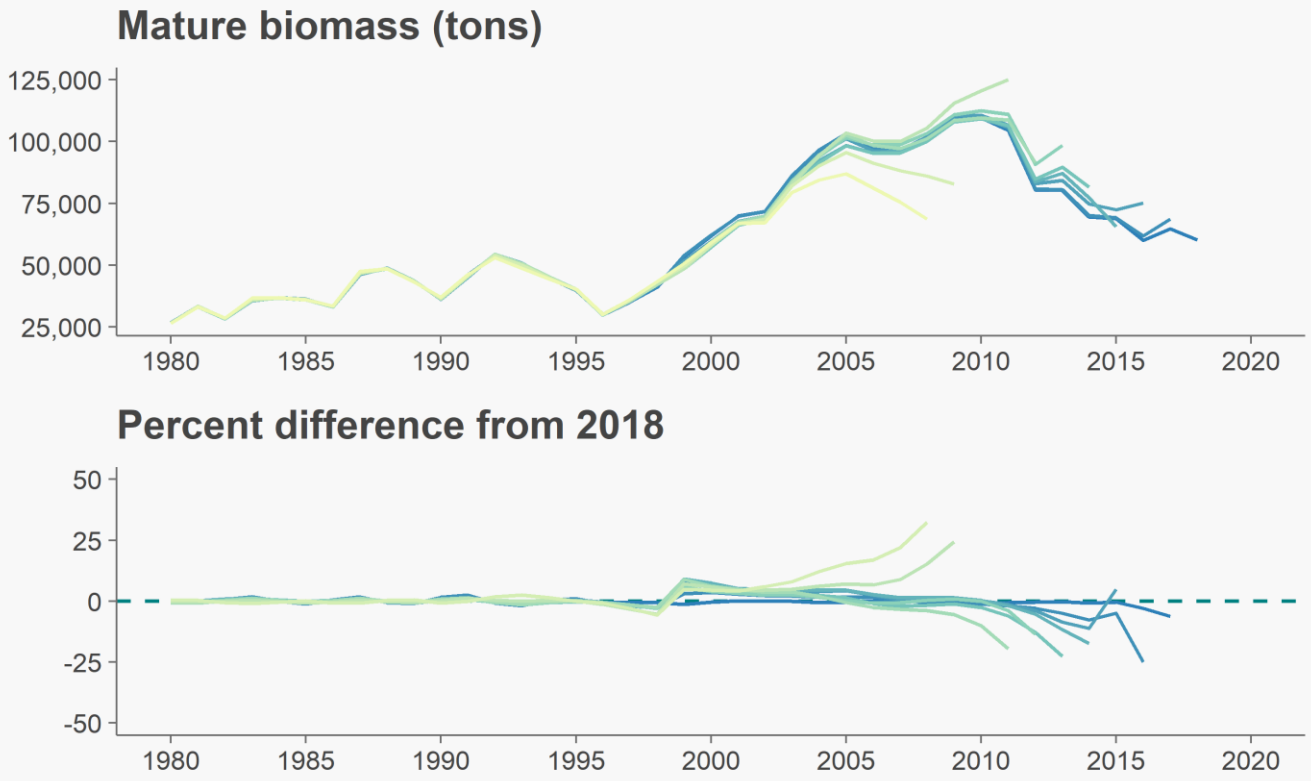
Motivation for a new model

- Improve model structure, scale, and stability
- Estimate uncertainty
- Automatic weighting on data sources

If you need more motivation

- Retrospective analysis
- Alternatives for time-varying natural mortality
- Biological reference points
- Management strategy evaluation

Example retrospective:
How does the model perform when we remove data?



HER vs. LS

Similarities

- Data
- Time-varying parameters linked to environment and regime shifts
- Model selection

Differences

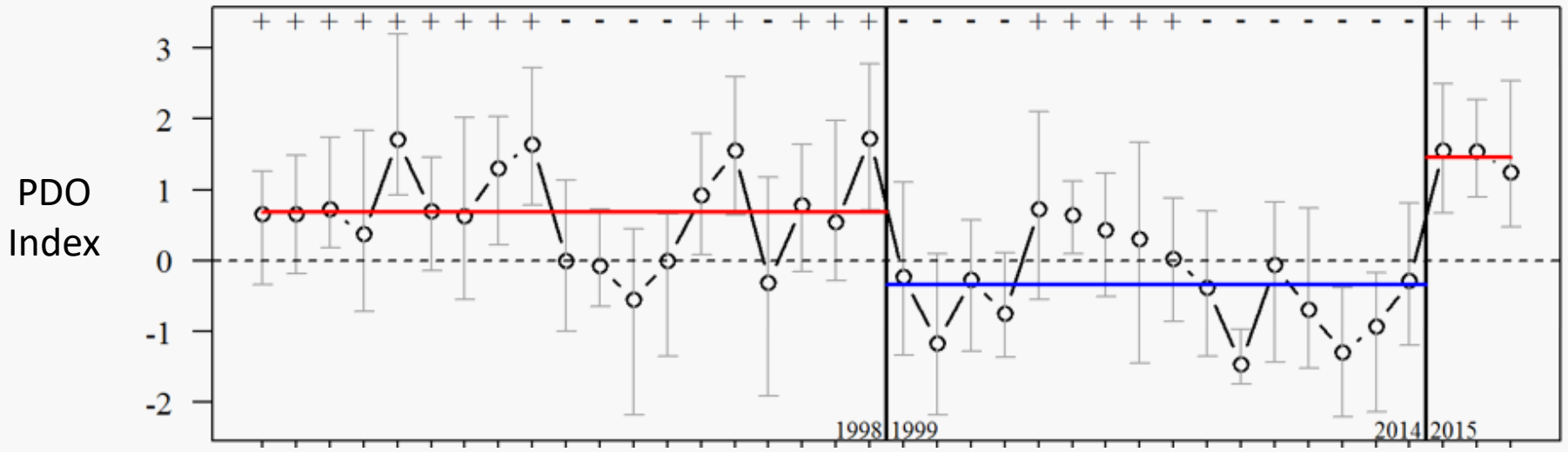
- Bayesian vs. frequentist
- Model structure and assumptions
- Estimate parameters in log-space instead of imposing bounds
- Assumption that catch is 100% mature
- Conditioning on catch vs. effort

Conditioning on catch vs. effort

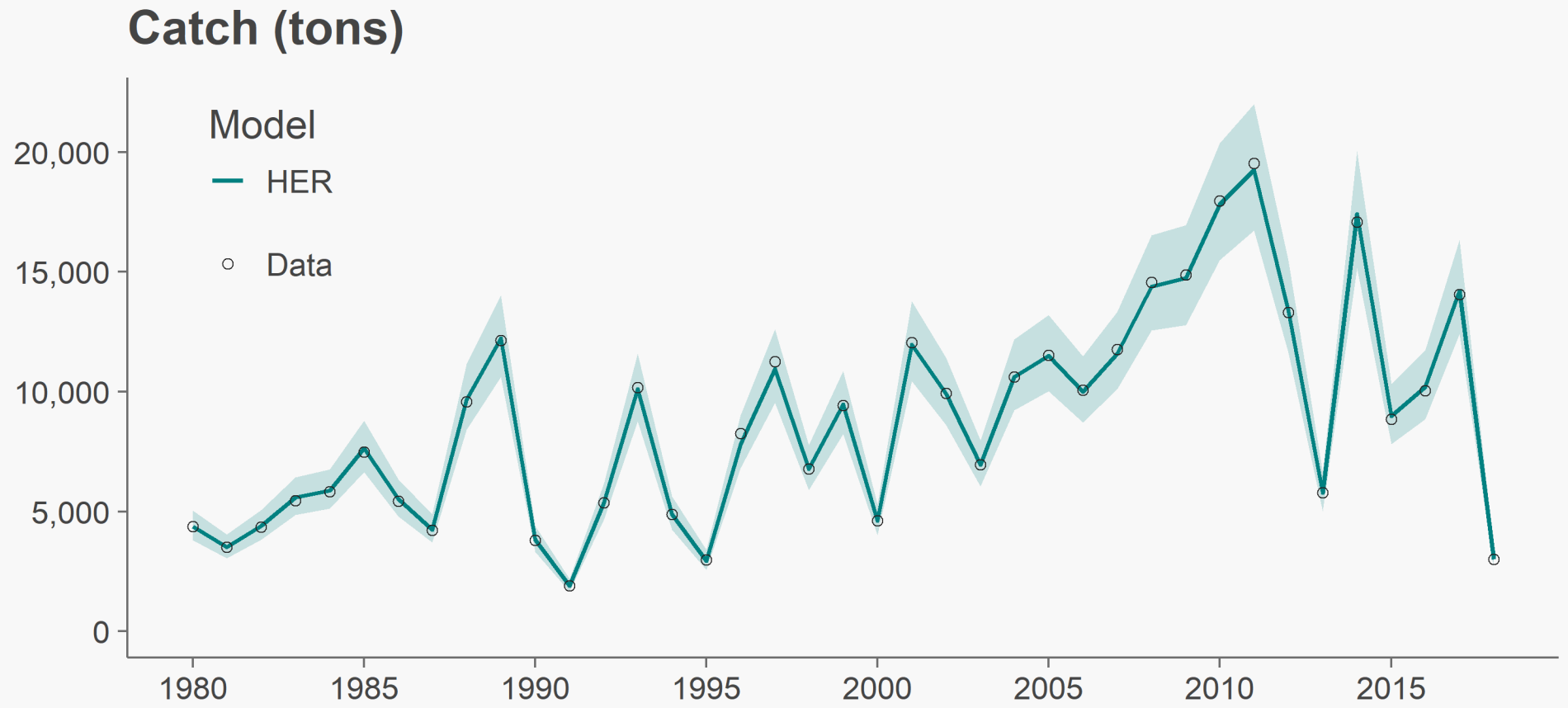
- LS conditioned on catch: catch assumed 100% known, error-free
- HER conditioned on effort – assume 7% error on catch
- HER can be conditioned on catch or conditioned on effort
- Estimates of fishing mortality & biological reference points

Modeling approach

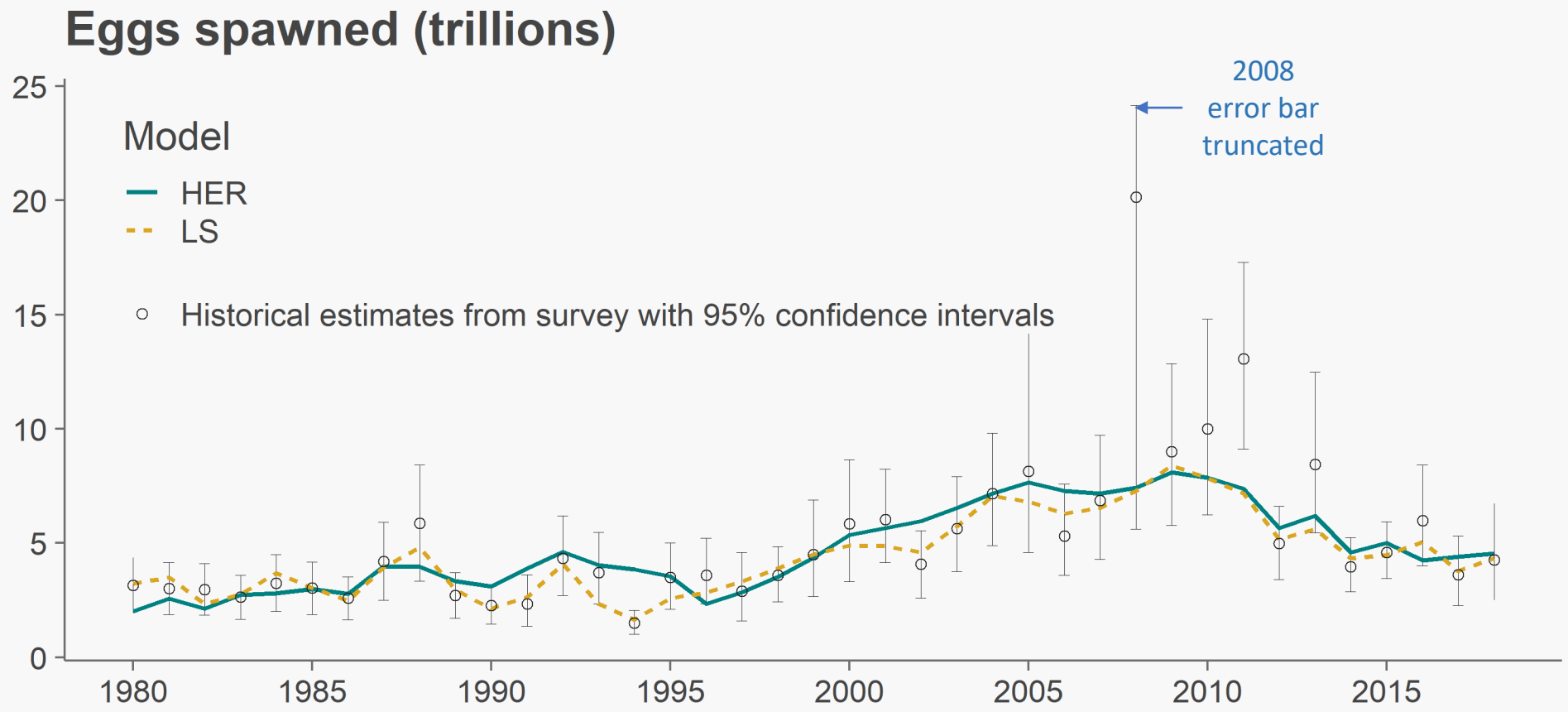
- Conditioning on catch vs. effort
- Current method: time-varying natural mortality, maturity, and gear selectivity
- Time blocks correspond to shifts in the Pacific Decadal Oscillation (PDO) (Hulson et al. 2018)



What does conditioning on effort look like?

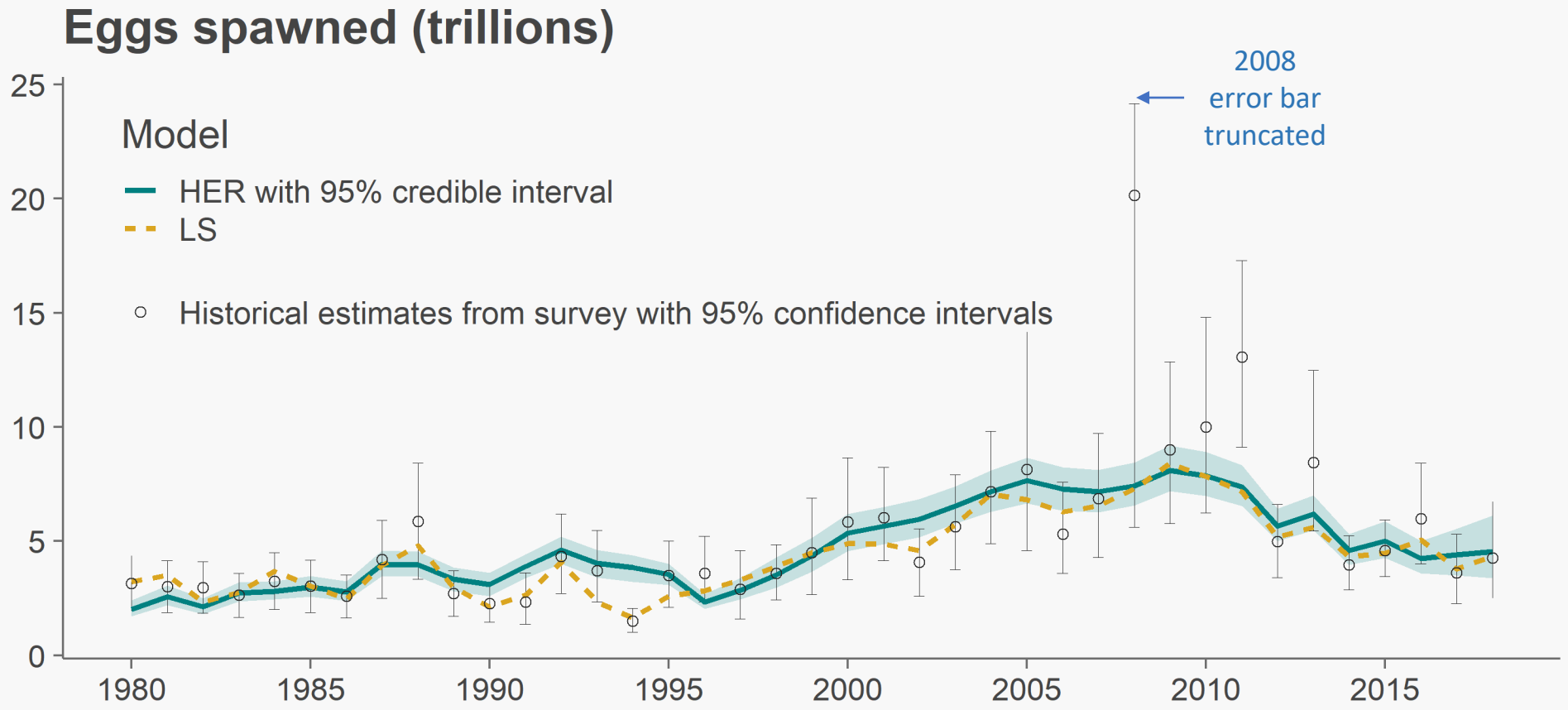


Fit to egg deposition data



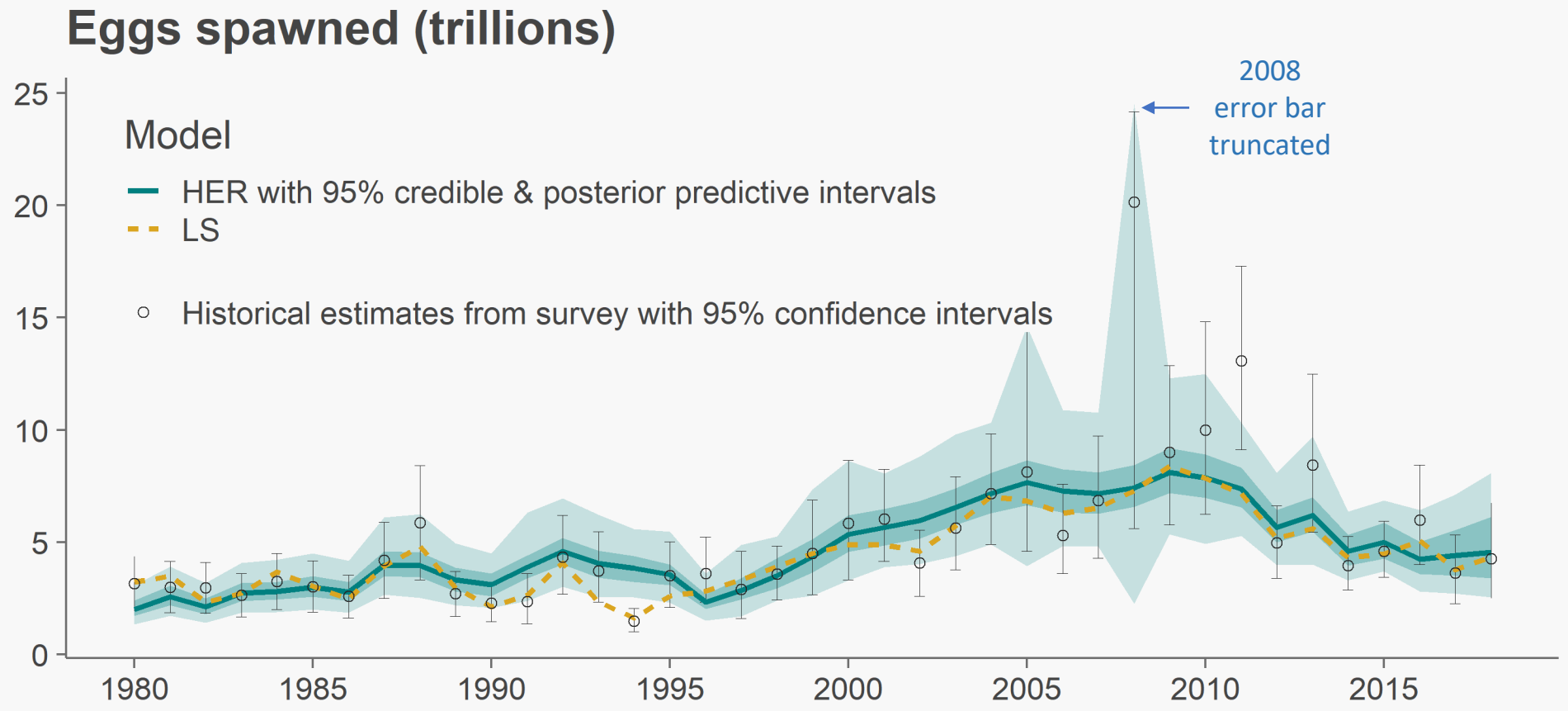
Interpreting the 95% credible interval:

Given our data, there is a 95% probability that the true value (e.g. mean egg deposition) falls within this interval



Interpreting the 95% posterior predictive interval:

Given the uncertainty in the data and the model, there is a 95% probability that if we were to collect more data, mean egg deposition would fall within this interval.

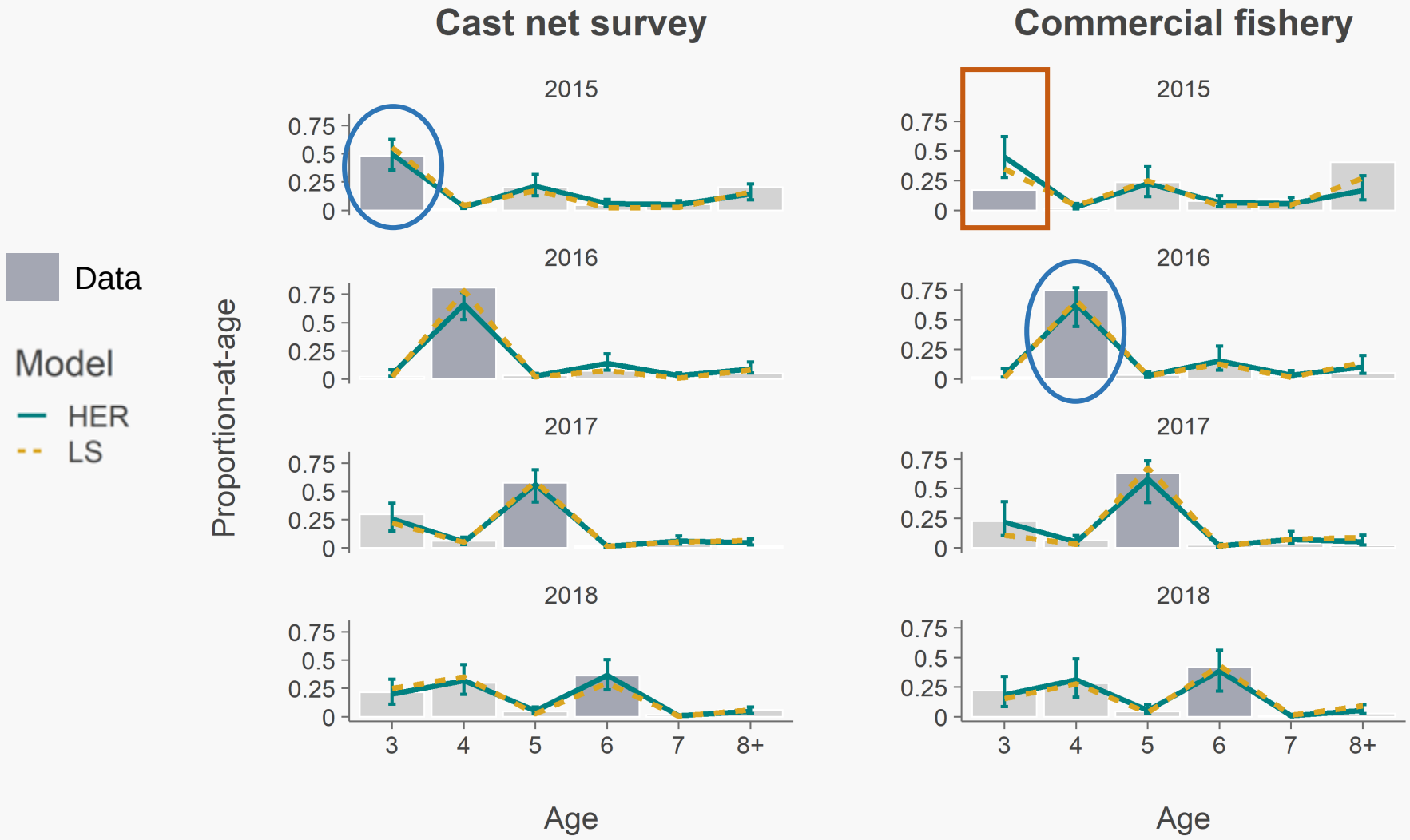


Examples of fits to age compositions with 95% credible intervals

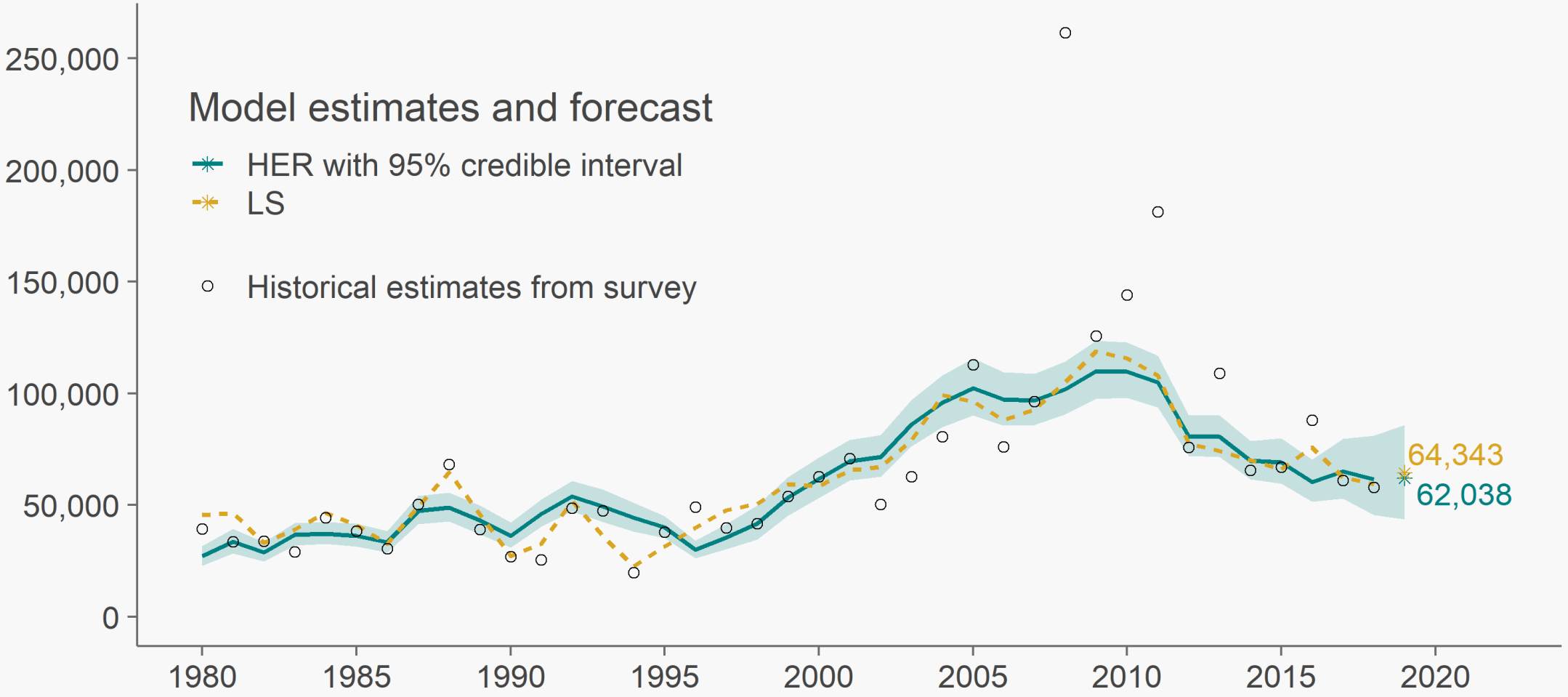
Fits to age compositions with 95% credible intervals

Tracking cohorts through time

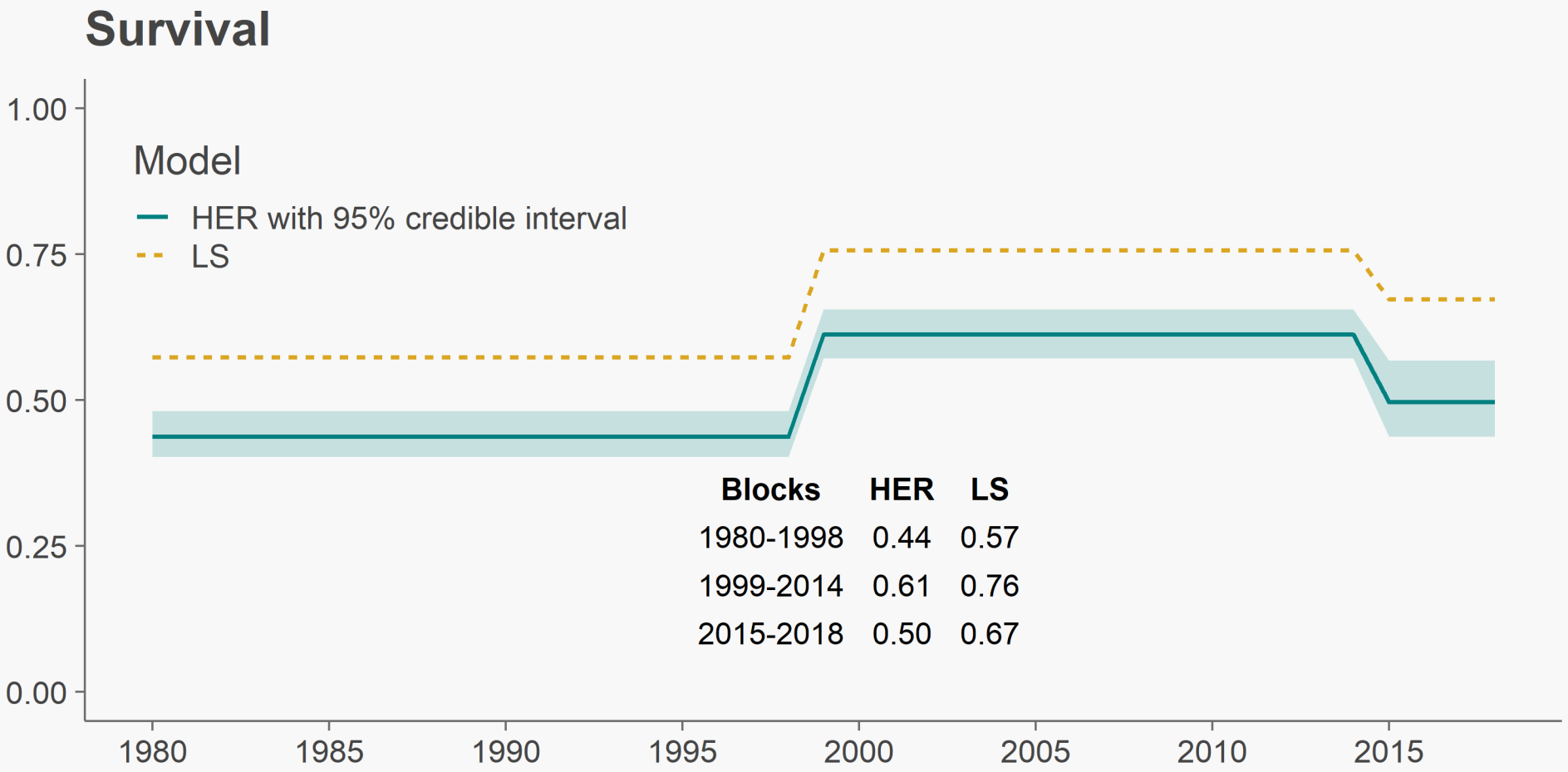
Leveraging other data sources



Mature biomass (tons)

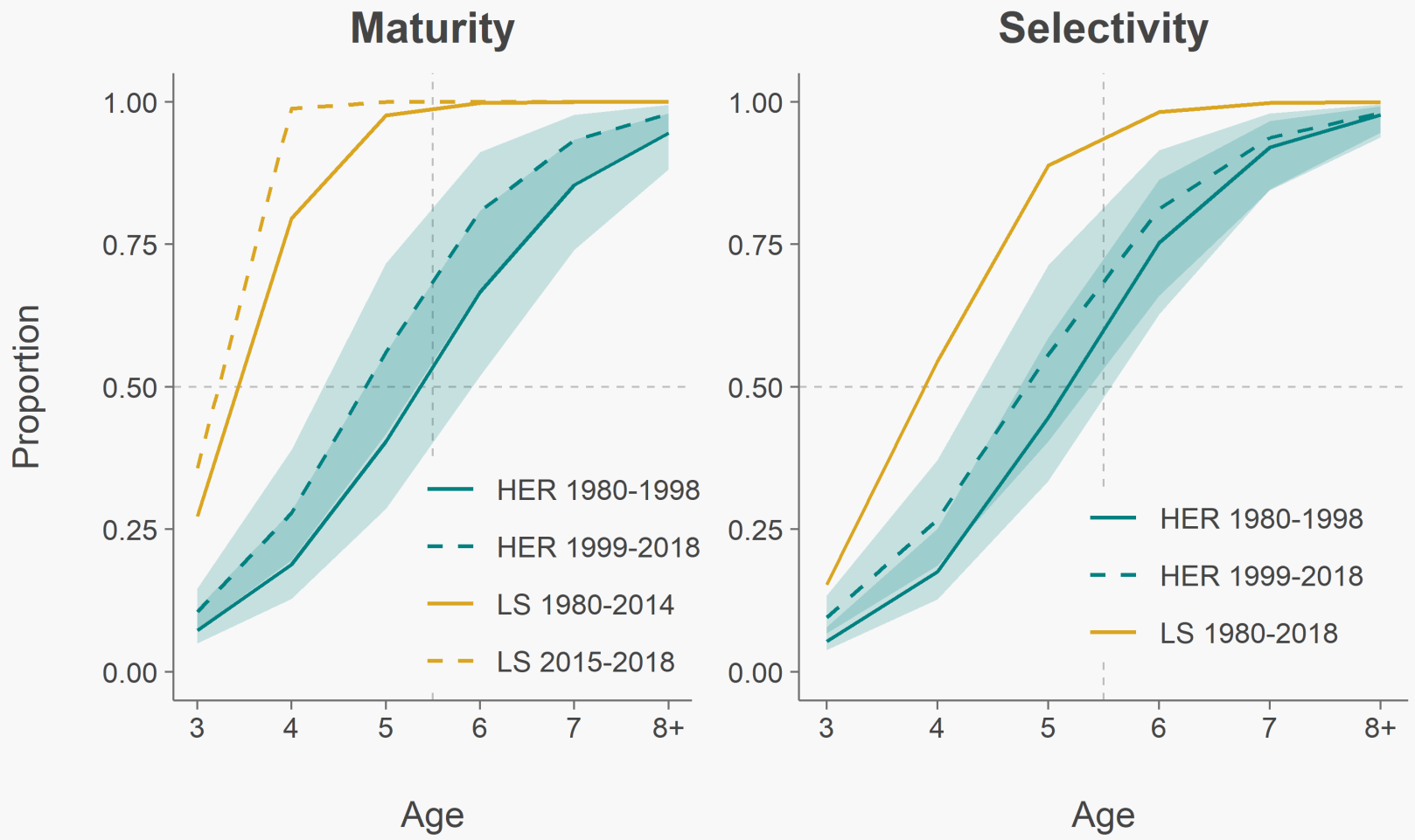


Time-varying survival



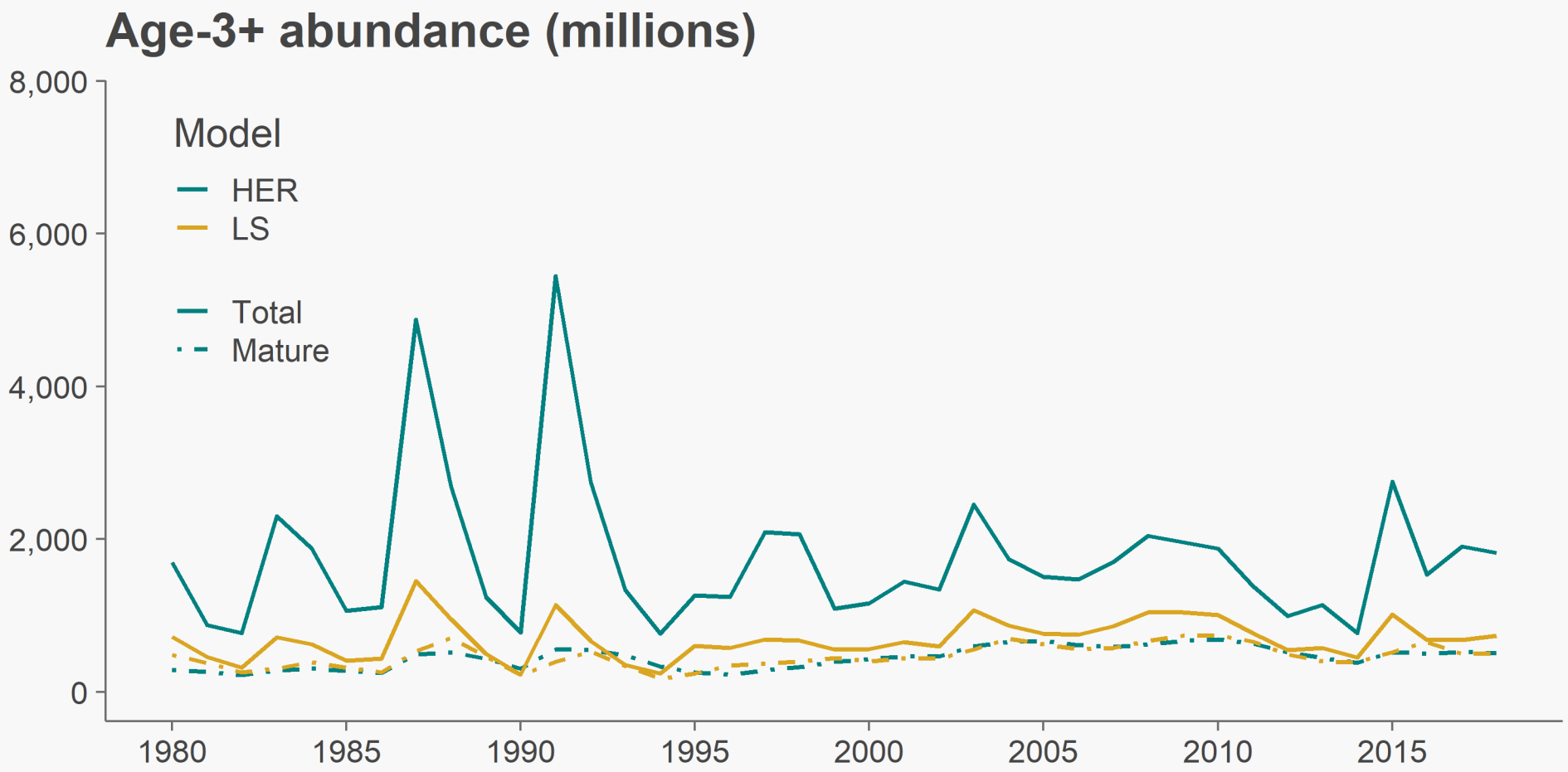
Blocks	HER	LS
1980-1998	0.44	0.57
1999-2014	0.61	0.76
2015-2018	0.50	0.67

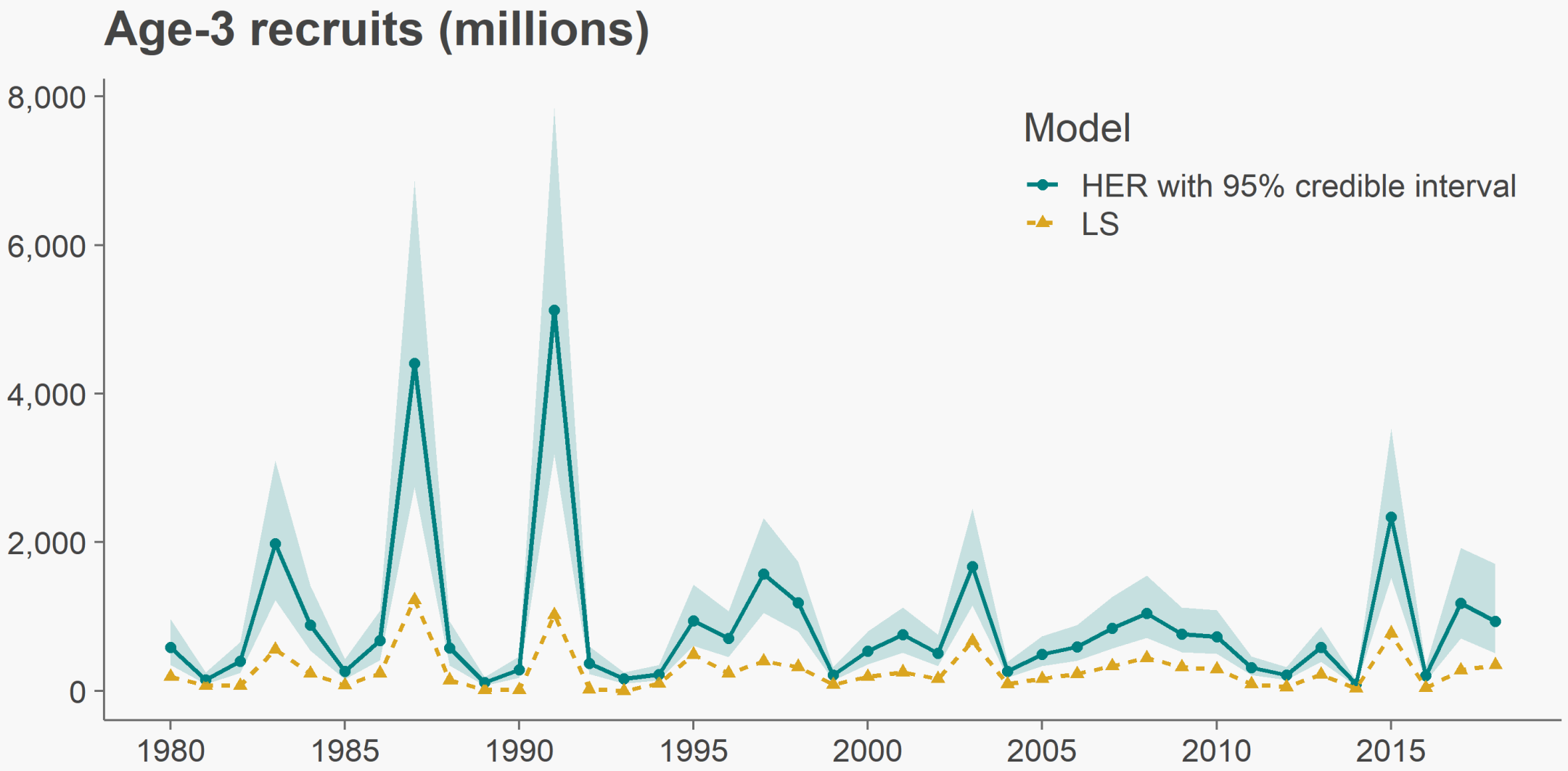
Very different results for maturity and selectivity between HER and LS



How can HER and LS give similar forecasts but have dramatically different maturity and selectivity curves?

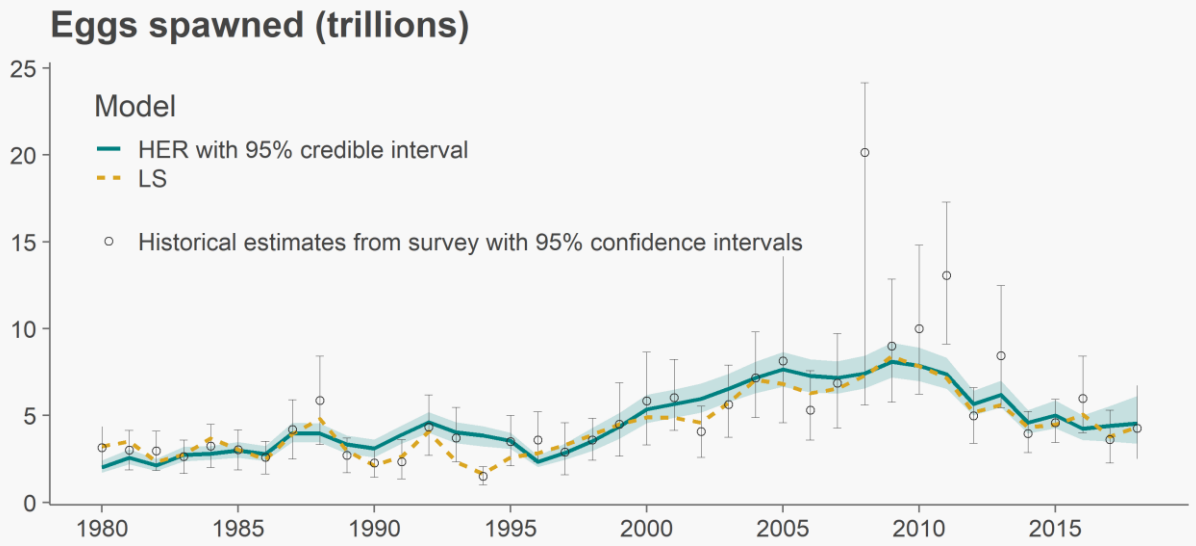
The scale of the HER population is larger than LS

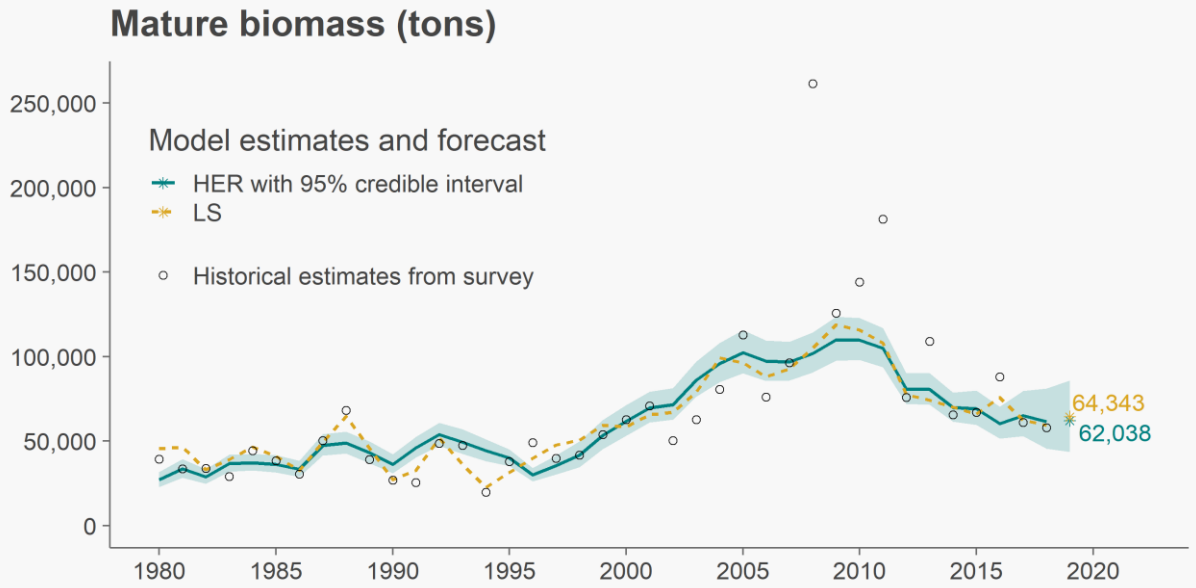



Age-3 recruits (millions)
8,000
6,000
4,000
2,000
0
1980
1985
1990
1995
2000
2005
2010
2015
Model
HER with 95% credible interval
LS

Summary

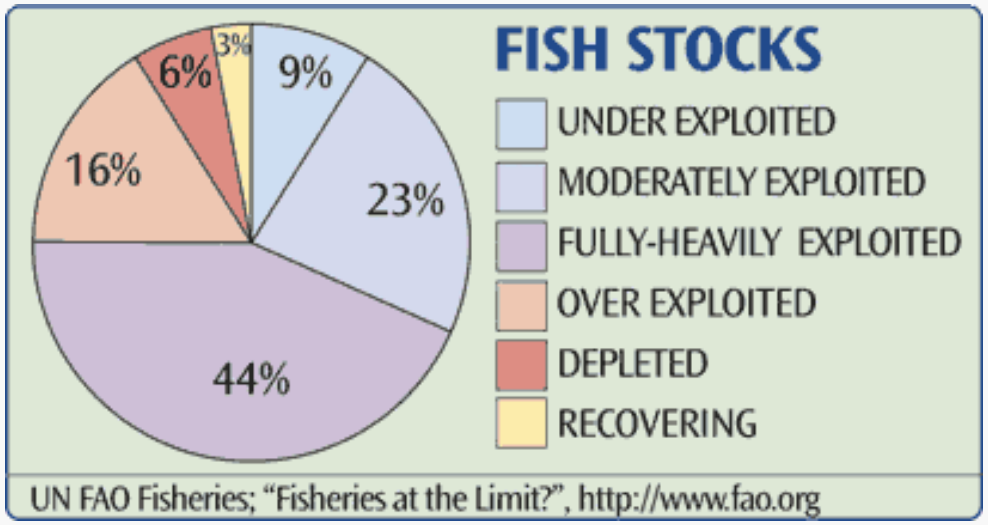
- Good fits to the data
- Result in similar forecasts
- New estimates of uncertainty
- Work in progress: time-varying maturity, selectivity, and survival





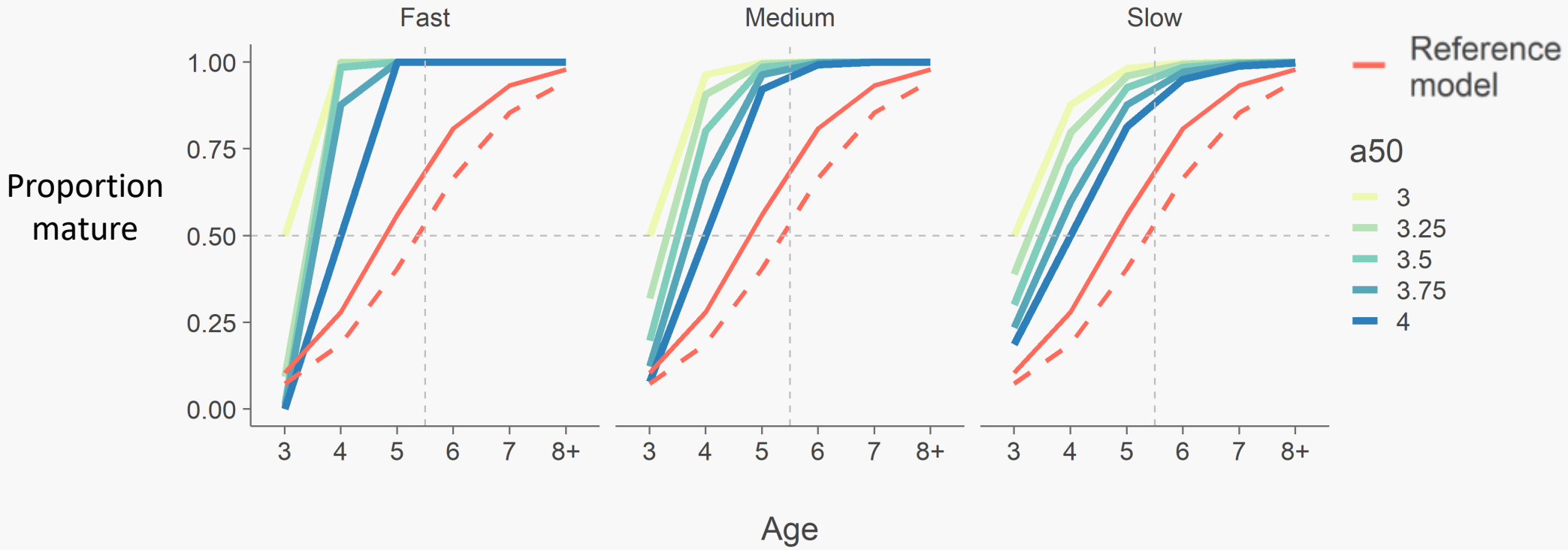
Preliminary biological reference points

- Status or health of a stock
- Describe life under equilibrium conditions
- Maximum sustainable yield (MSY), Fishing mortality at MSY (F_{MSY}), Unfished mature biomass (B_0)



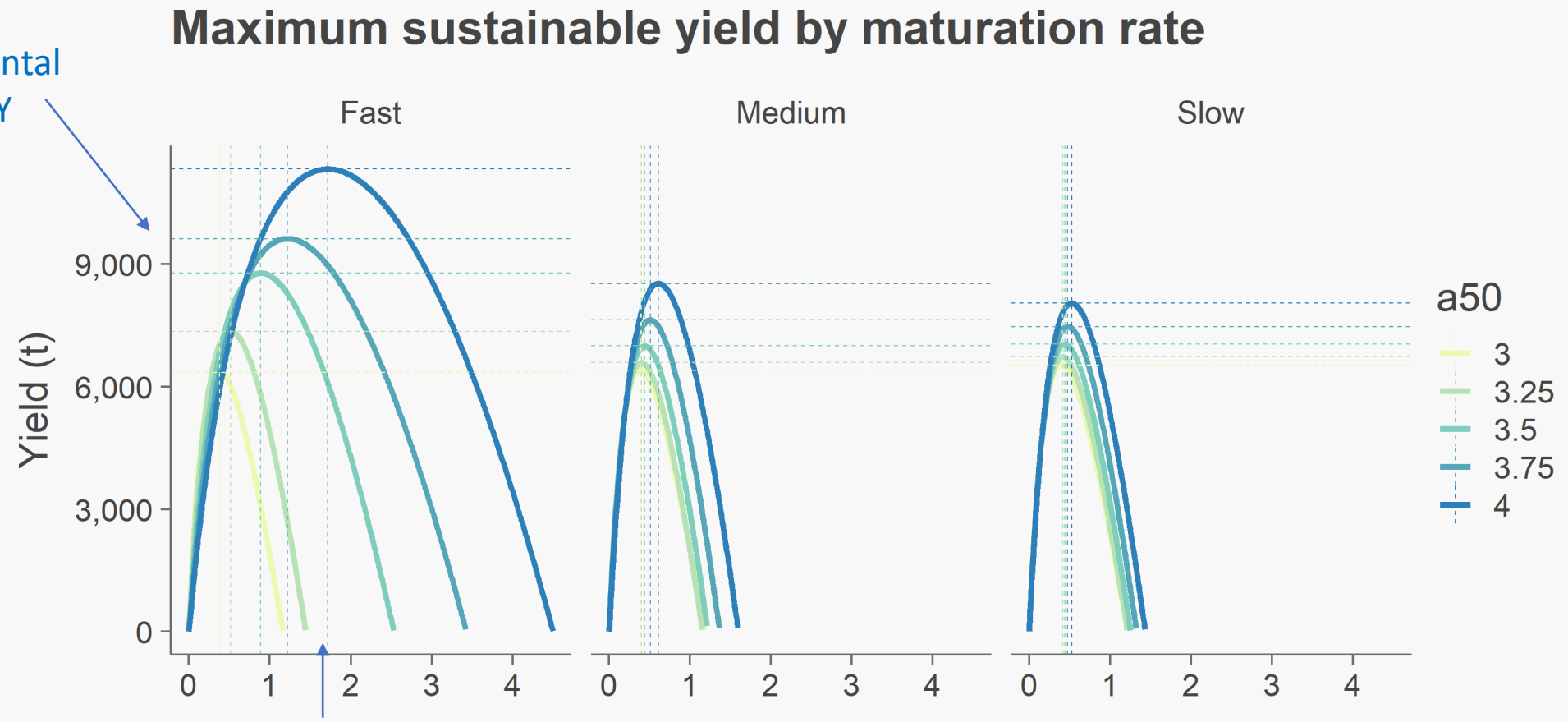
Biological reference points depend on biologically plausible parameter estimates

- Examine age at 50% maturity (a_{50}) between age-3 and age-4 (a50 ≈ 3.7 yrs in FishBase/FishLife Thorson et al. 2017)
- How quickly do herring reach 100% maturity? Explore slow, medium, and fast maturation rates



Peak of each curve corresponds to MSY

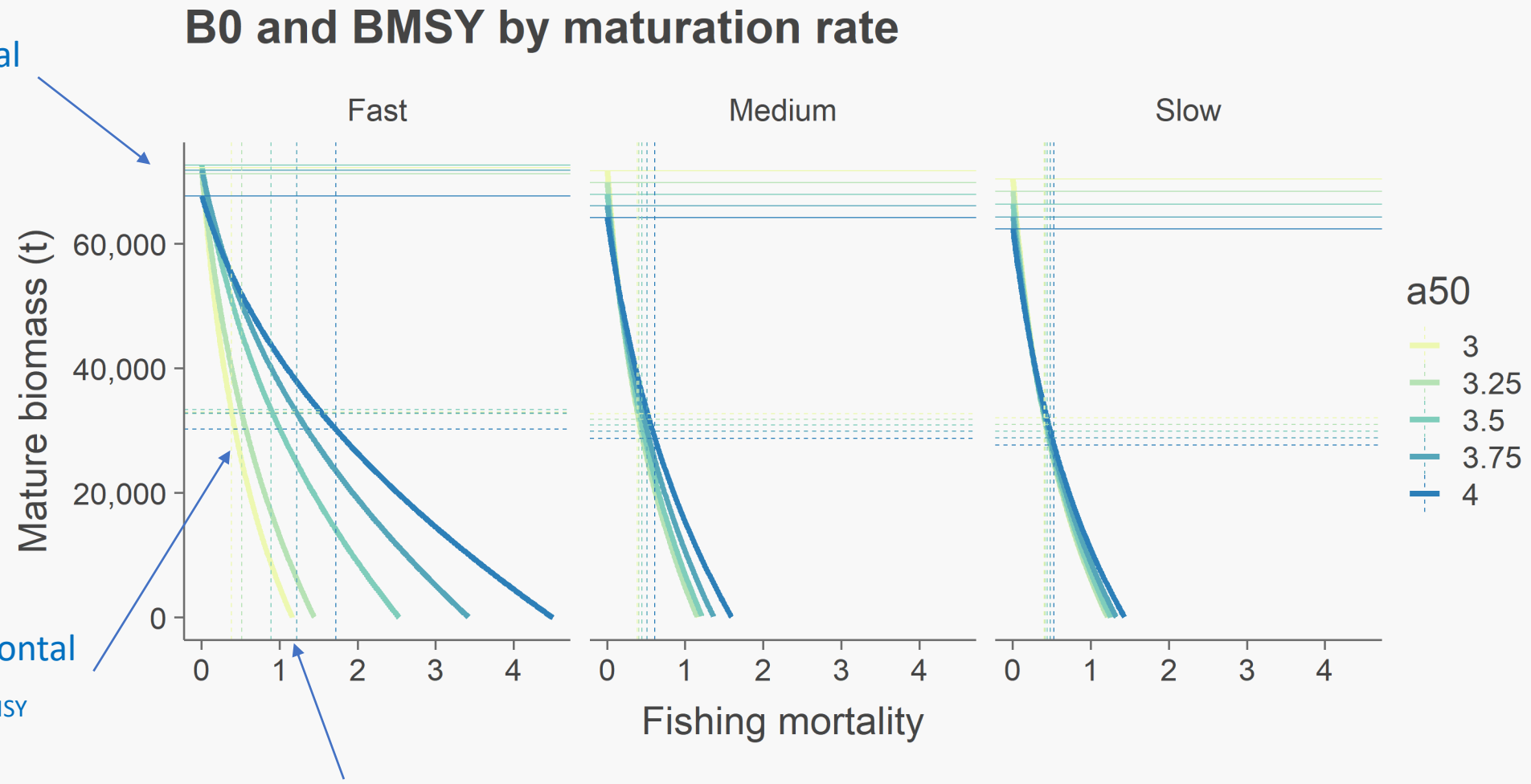
Dashed horizontal lines = MSY



Dashed vertical lines = FMSY

Preliminary estimates of B_0: 62,326-72,561 tons (Mean: 68,431 tons) (Carlile 1998: 67,036 tons)

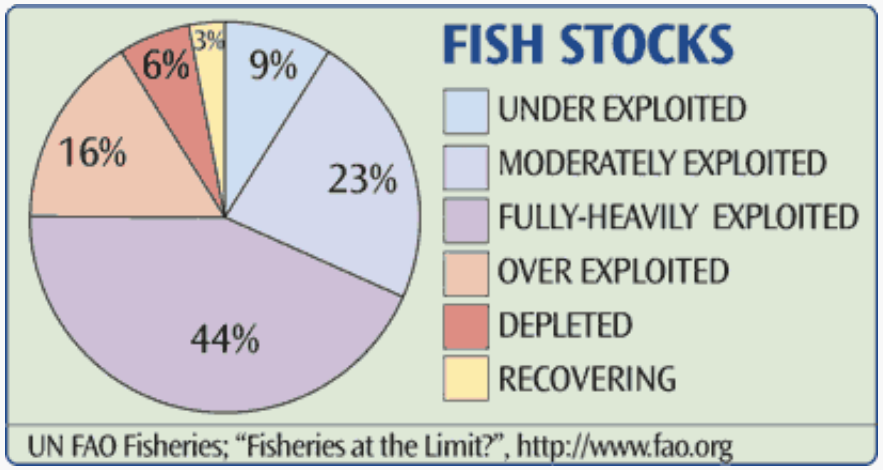
Solid horizontal lines = B_0

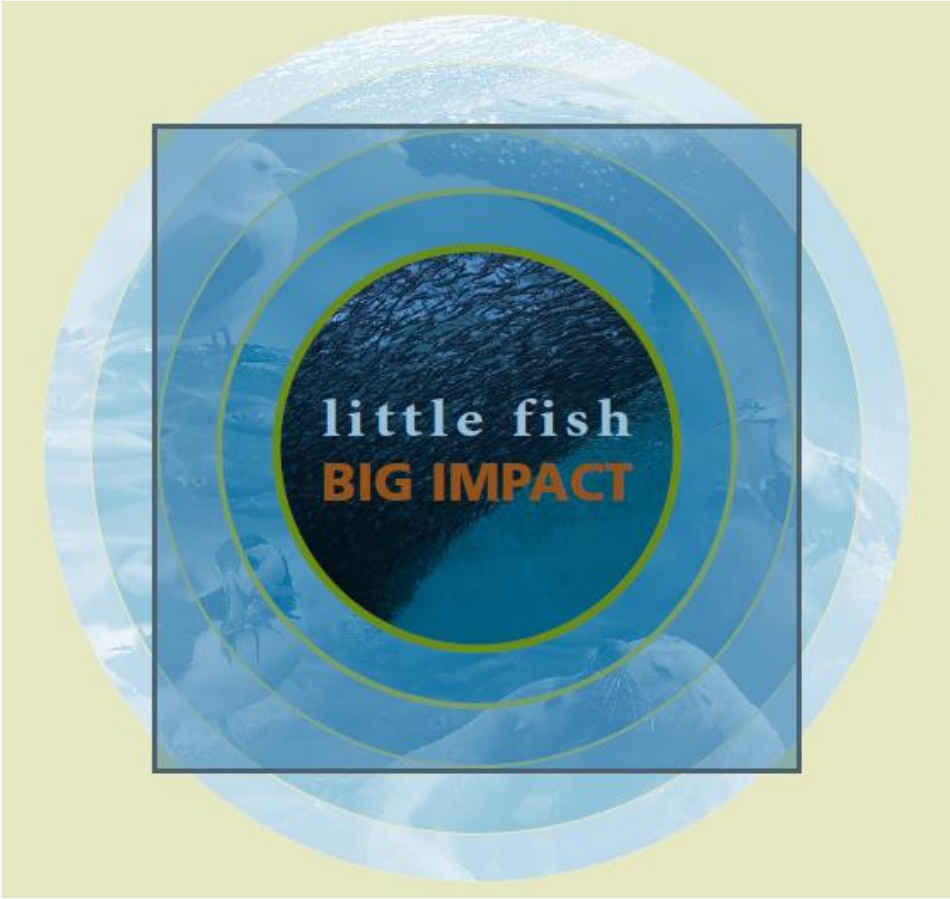


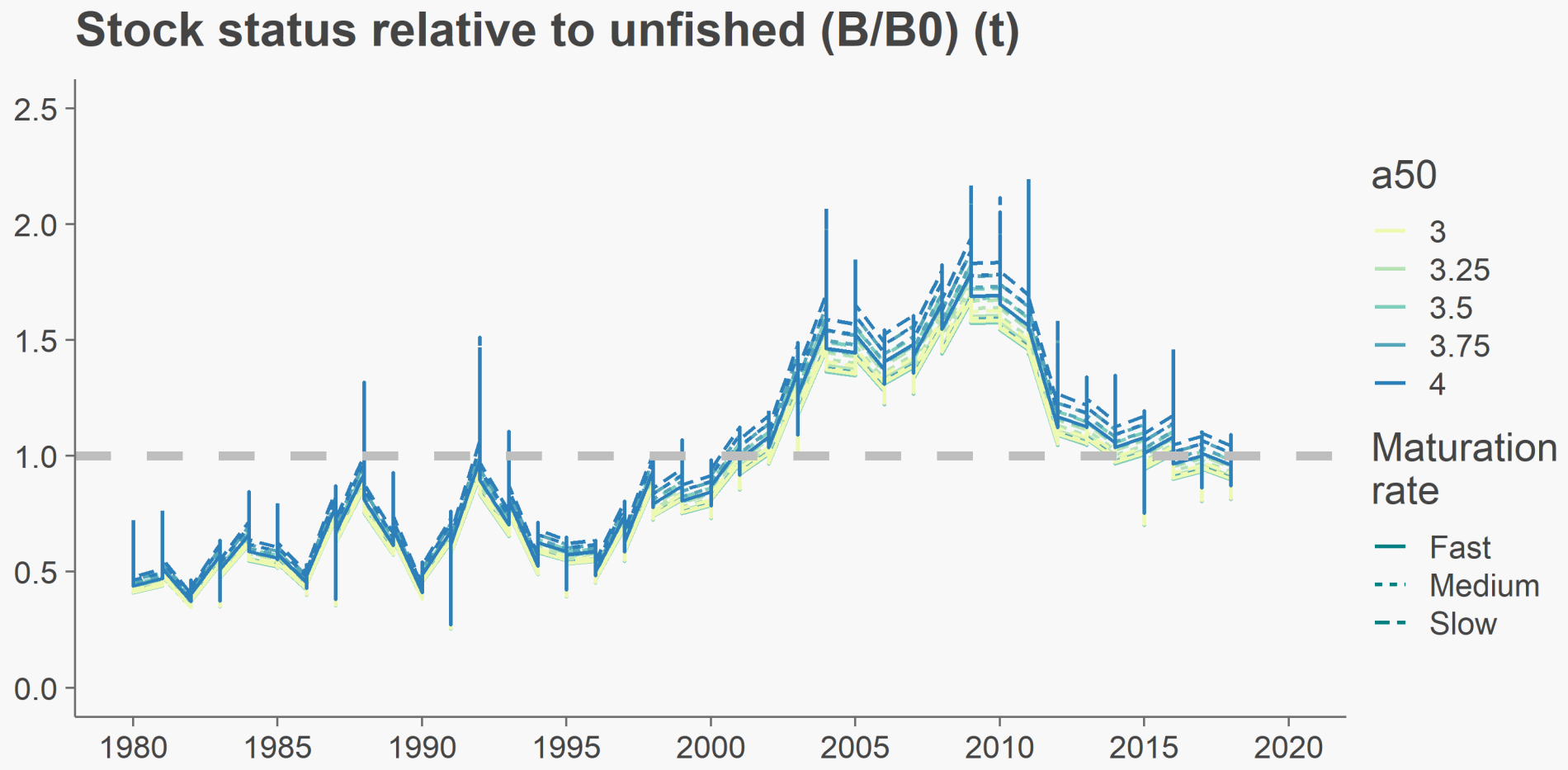
Dashed horizontal lines = B_{MSY}

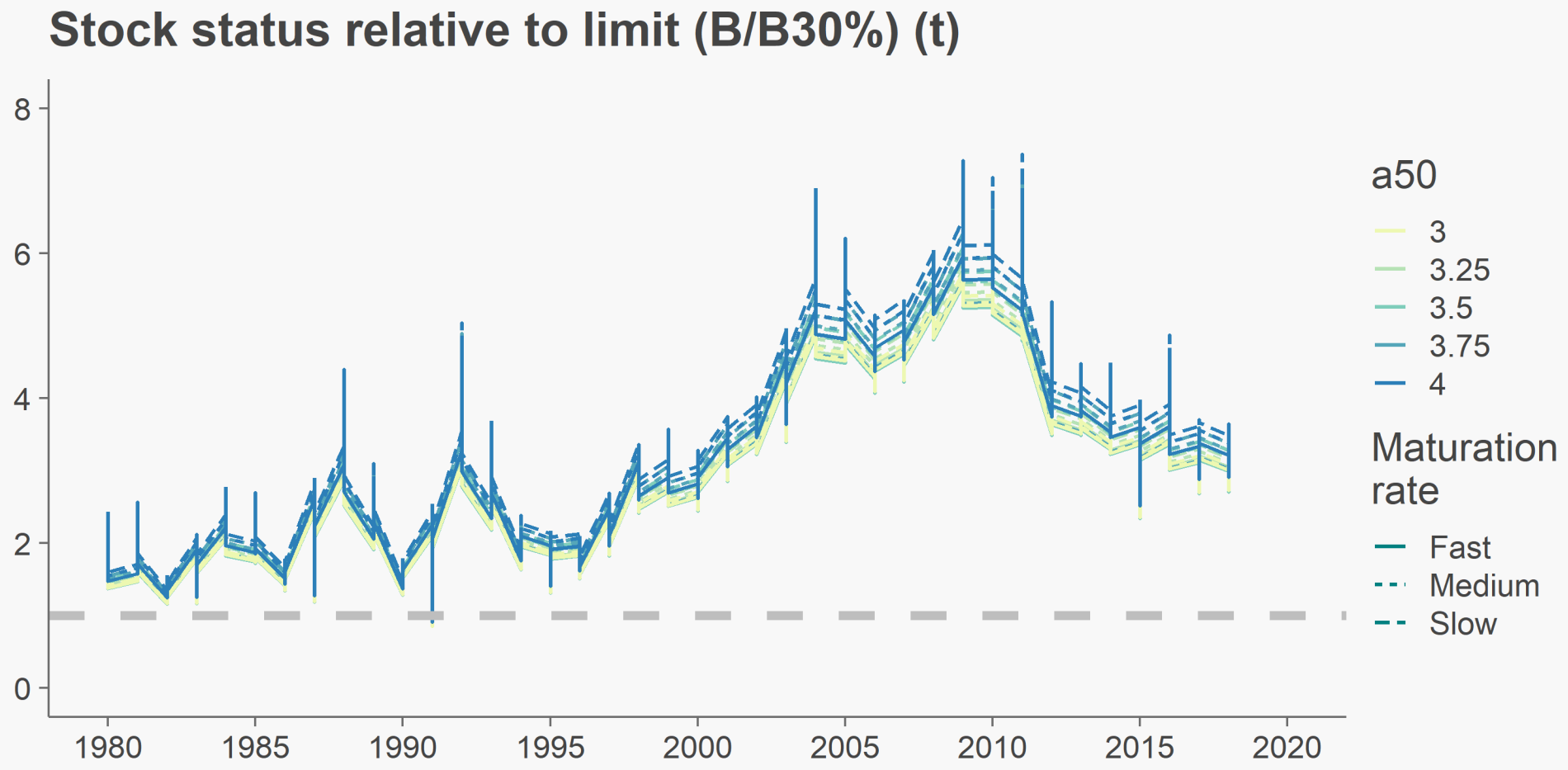
Dashed vertical lines = F_{MSY}

STATUS: What is our current estimate of mature biomass relative to unfished biomass (B/B_0)?






Stock status relative to unfished (B/B0) (t)
2.5
2.0
1.5
1.0
0.5
0.0
1980
1985
1990
1995
2000
2005
2010
2015
2020
a50
3
3.25
3.5
3.75
4
Maturation rate
Fast
Medium
Slow

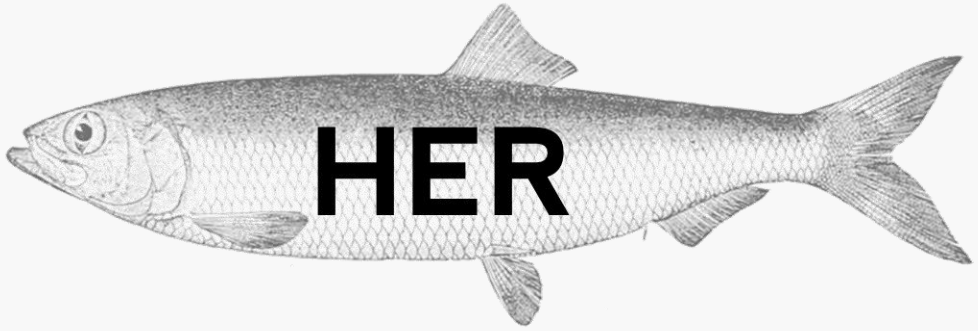

Stock status relative to limit (B/B30%) (t)
8
6
4
2
0
1980
1985
1990
1995
2000
2005
2010
2015
2020
a50
3
3.25
3.5
3.75
4
Maturation rate
Fast
Medium
Slow

Take homes

1. HER provides a modern and robust modeling framework
2. Biological reference points tell us about stock status, set the stage for future management
3. Uncertainty is a useful tool for managers
   - Transparent about uncertainty in data and model
   - Evaluate past and future management performance
     E.g., What is the probability of exceeding our limit?
   - Identity data gaps/areas for research

Next steps

- Goal for implementation: Sitka 2020 (2021 forecast)
- Revisit model selection and parameterization
- Incorporate historical data - Reid 1971, Funk 2010
- Evaluate current harvest strategy / harvest control rule
- Board of Fish



Let's work together.

What's useful, what's not?

What did I get wrong?

Do you have concerns?

Do you have priorities that I haven't addressed?

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(907) 738-3311