Incorporating recruitment-environment linkages into stock assessment models for Alaskan groundfish

population projections in a changing climate

Ashley Weston, Gavin Fay, Carey McGilliard

aweston@umassd.edu

@AshleyEWeston @gavin_fay

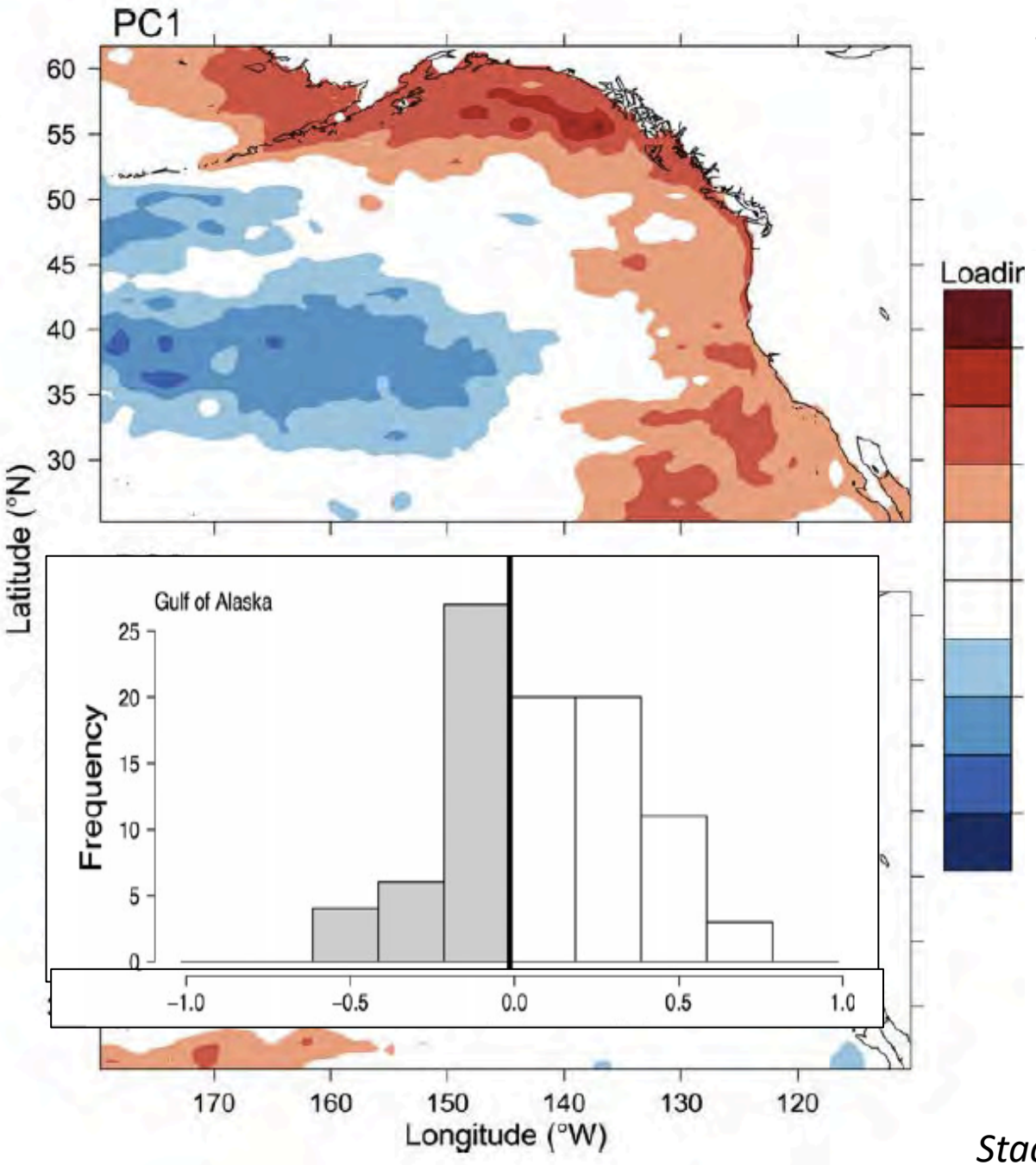
UMass Dartmouth

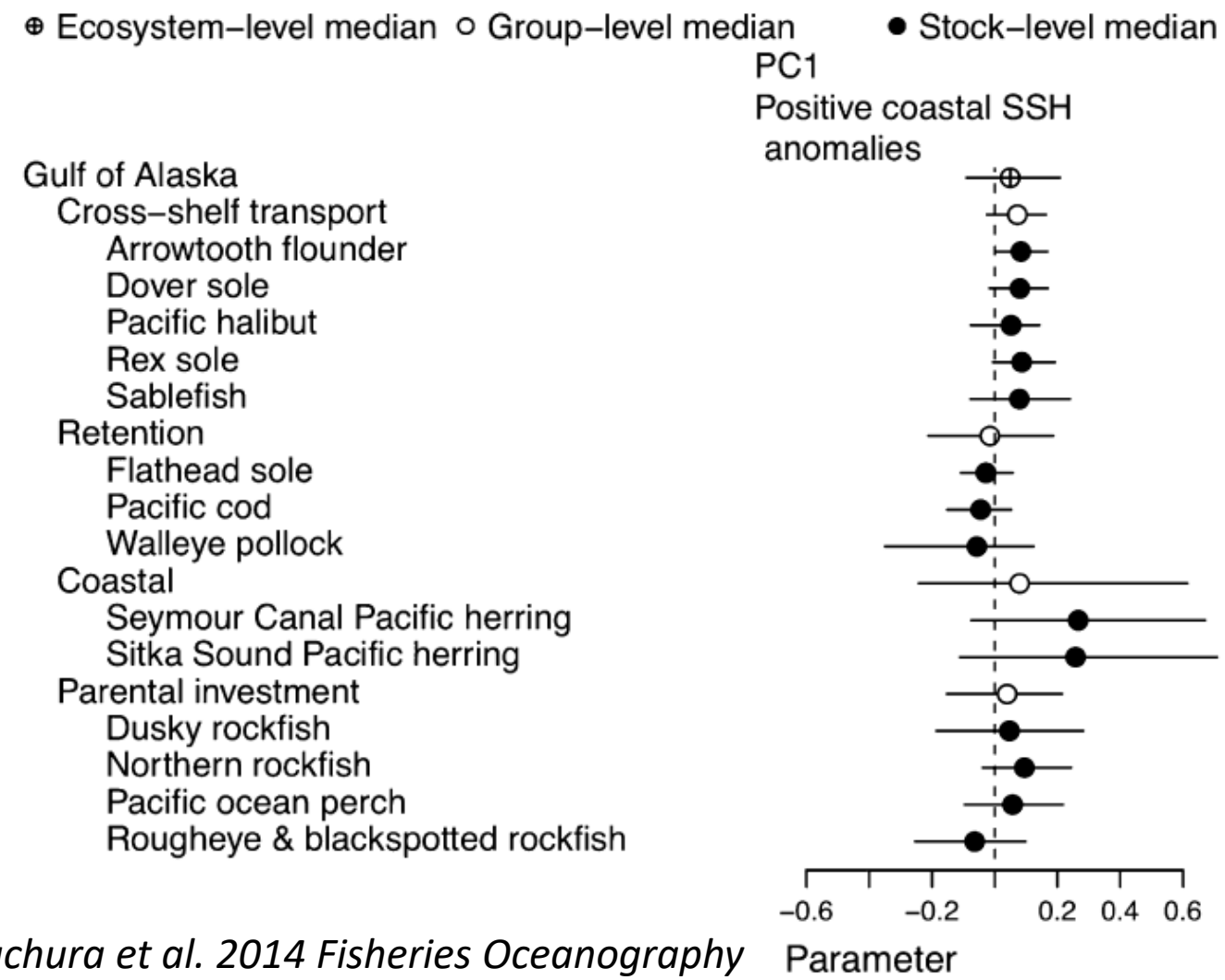
FATE Fisheries and the Environment

NOAA FISHERIES

@ed_hawkins https://www.climate-lab-book.ac.uk/2018/warming-stripes/

Synchronous recruitment of groundfish in Gulf of Alaska correlated with an index of Sea Surface Height





Stachura et al. 2014 Fisheries Oceanography

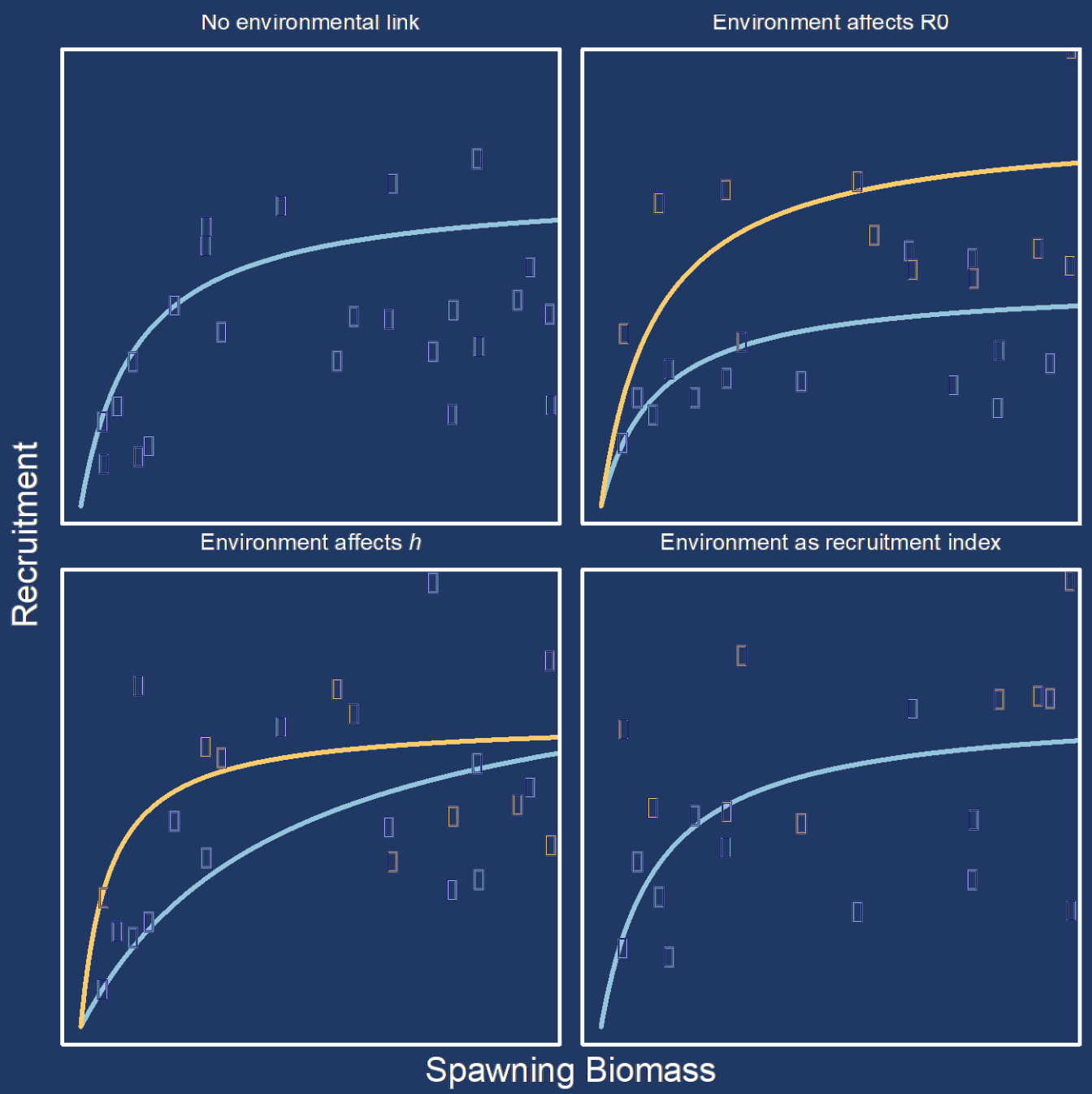
Stock assessment models can include effects of environment on recruitment to assess management consequences, but…

Environmental drivers in fisheries management are not often used:

- Relationships may break down over time
- May not improve assessment model fit
- Best way to account for the relationship is unclear

How best to choose among assessment models that differ in how environment affects recruitment?

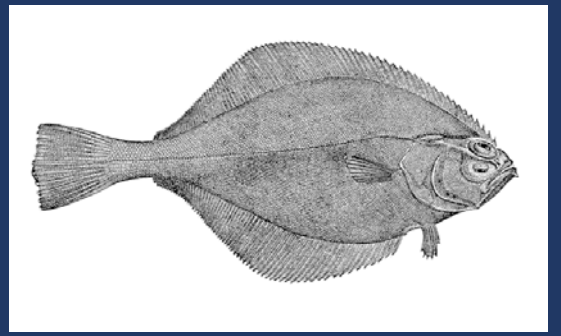
How do current harvest control rules perform under future climate change scenarios when linkages exist and mechanism is unclear?



Operating models that assume different effects of environment on recruitment

Models & simulations implemented in Stock Synthesis

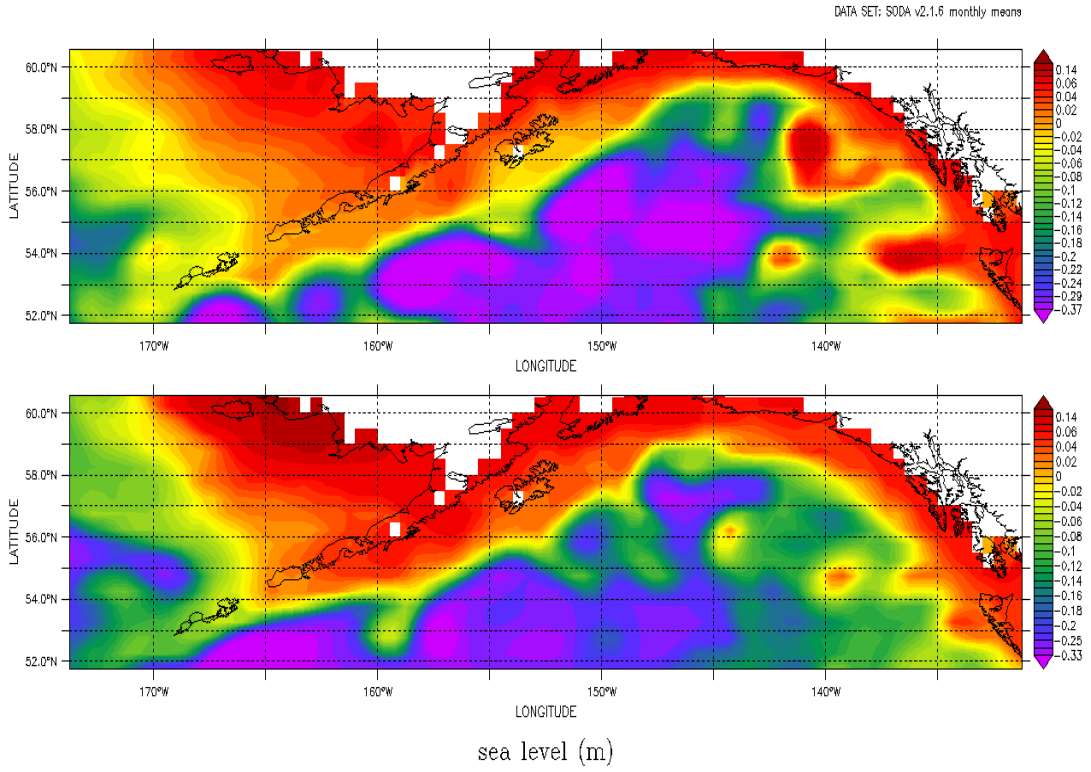
Conditioned to be characteristic of a flatfish-like, loosely based on Gulf of Alaska flathead sole

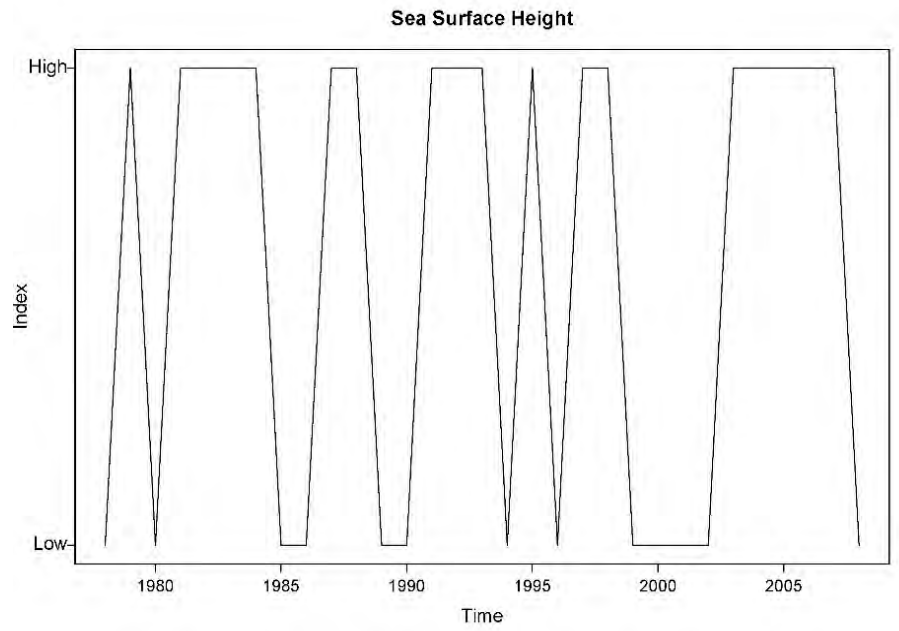


Including environmental drivers of recruitment

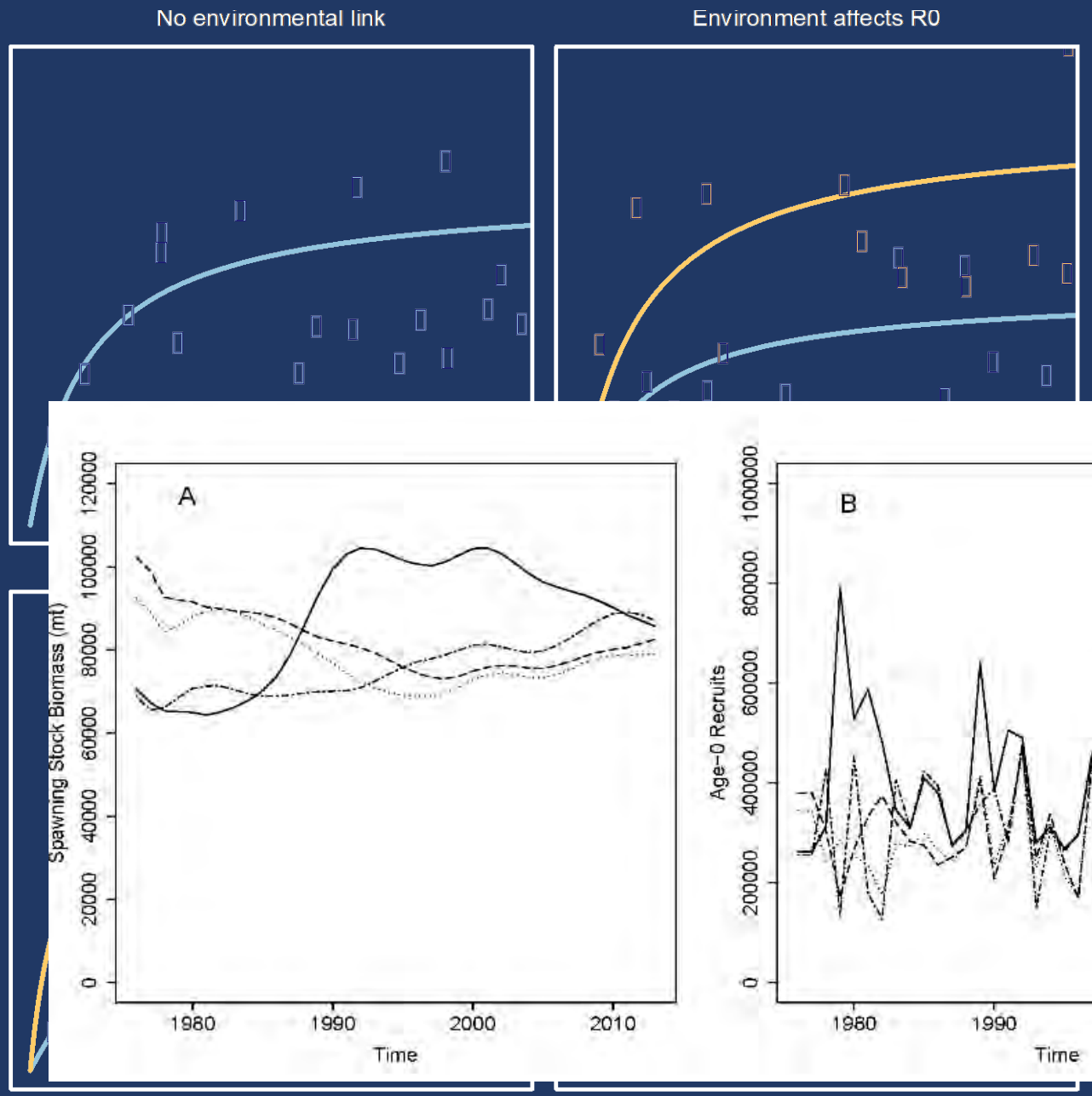
Derive time series index of Sea Surface Height based on Stachura et al. (2014).

Binary time series created for input into stock assessment models

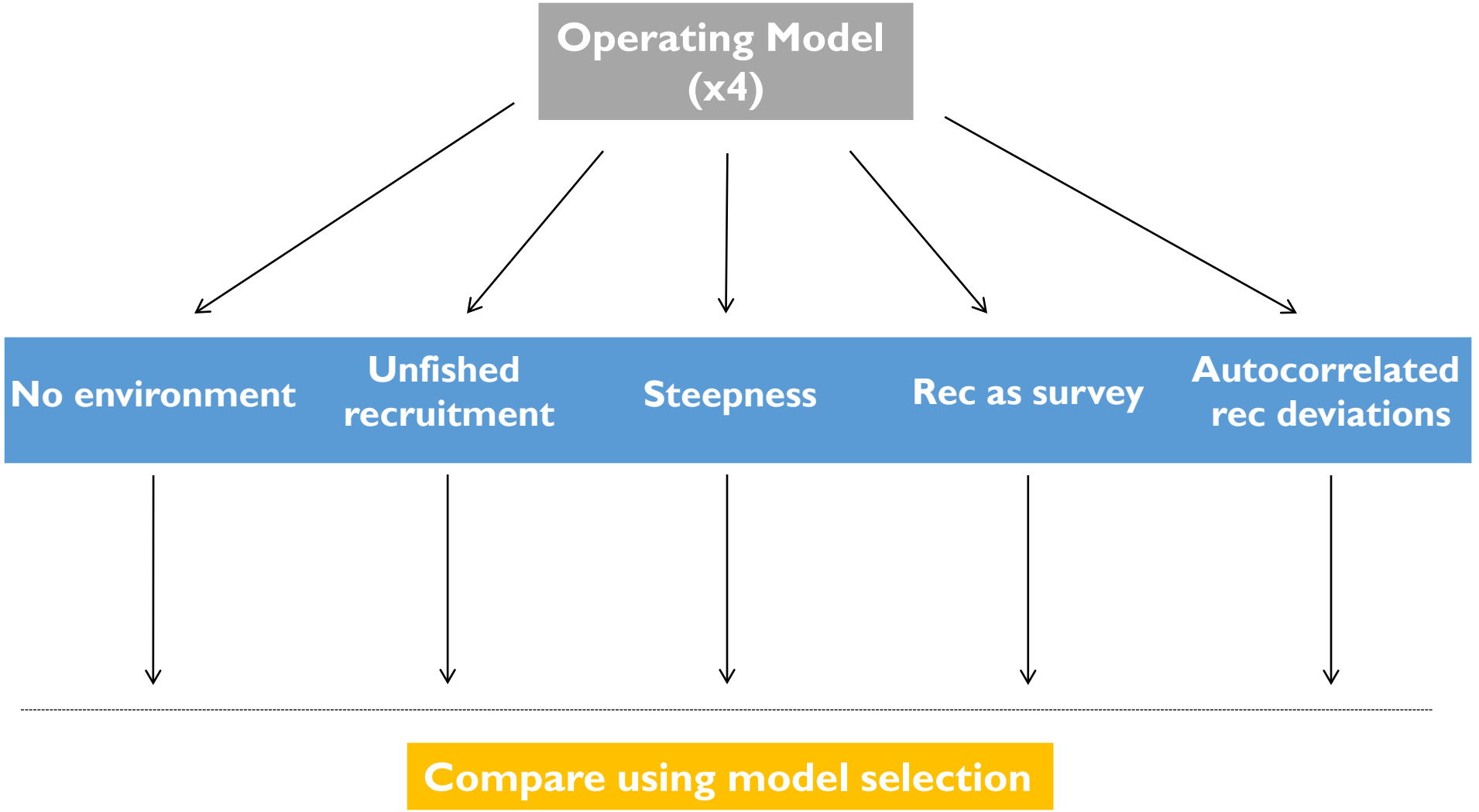




Models with different effects of environment on recruitment lead to different conclusions



Fitting Stock Assessment Estimation Models

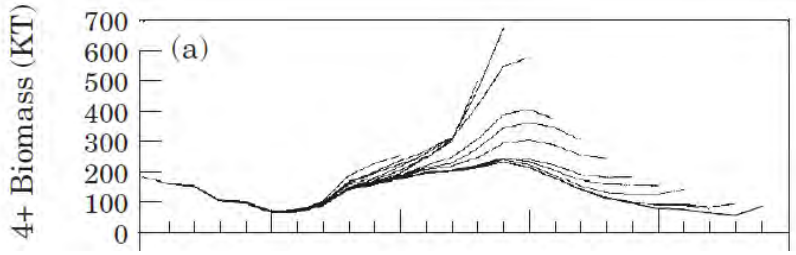


How to choose the best model?

Goal is to recover the model that originally generated the data

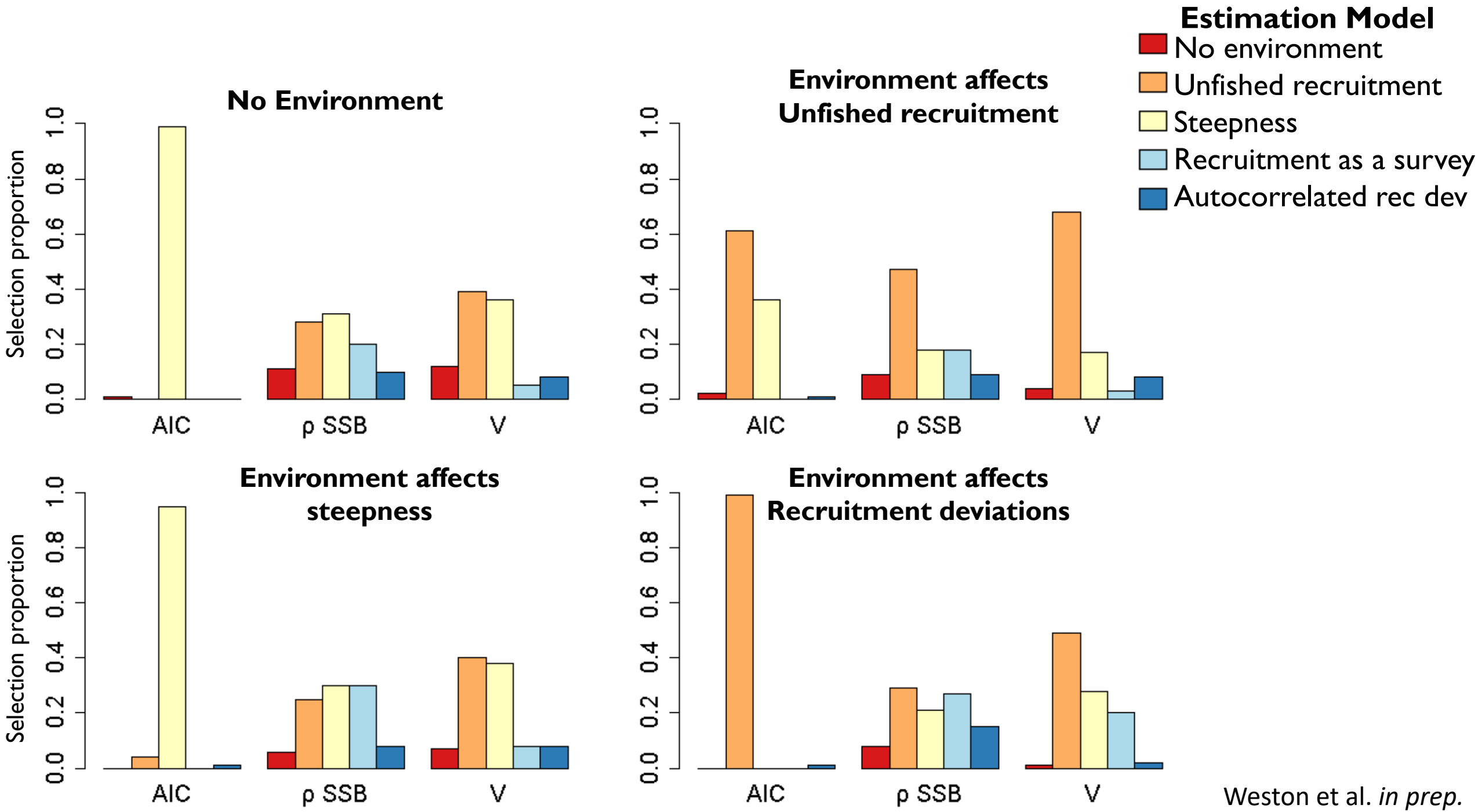
Akaike's Information Criterion (AIC)
balances model fit and complexity (Akaike 1974)

Mohn's retrospective statistic (ρ) quantifies retrospective patterns (Mohn 1999, Linton and Bence 2011)



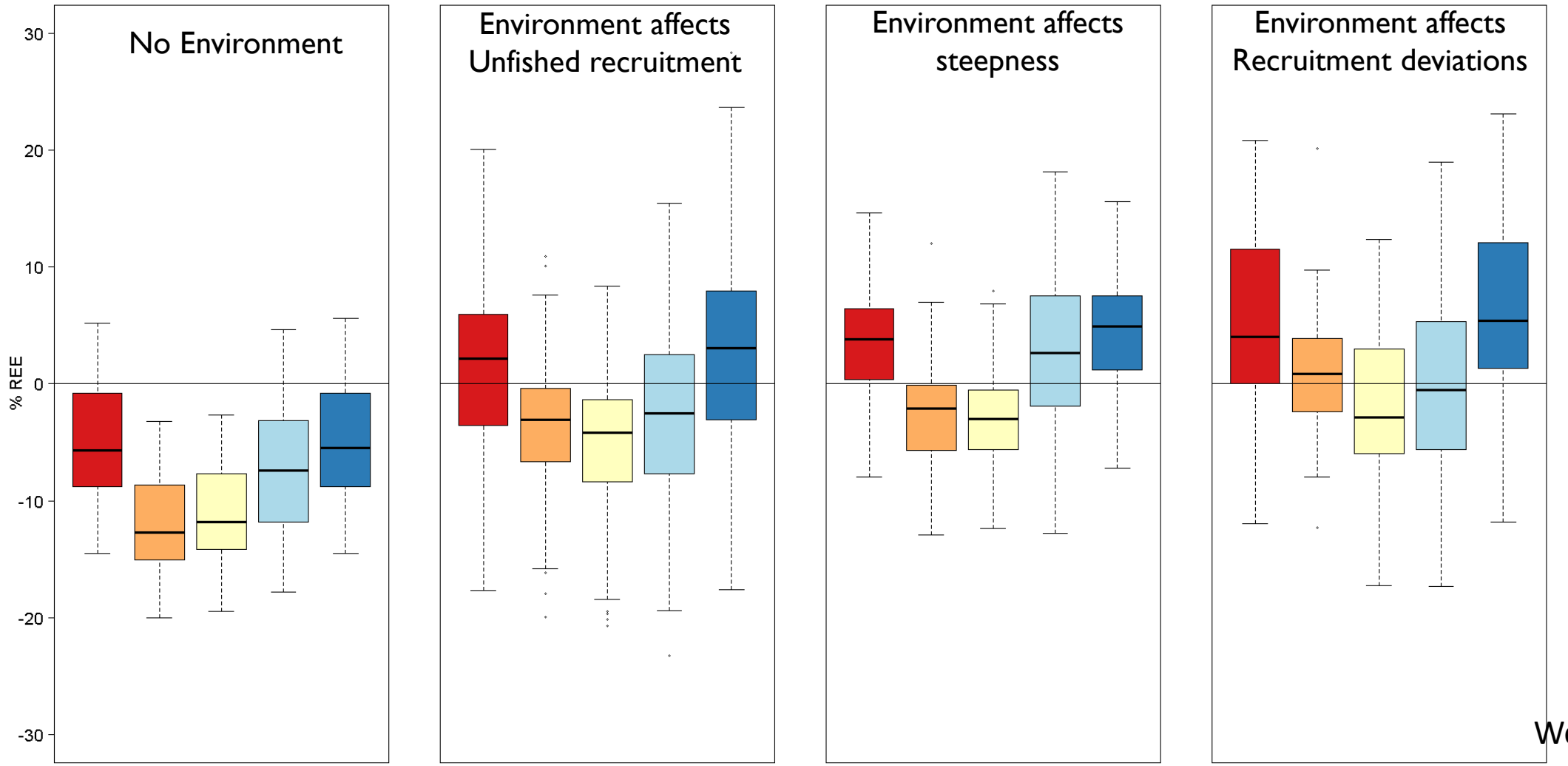
Hold-out validation (V) measures a model's predictive ability (Maunder and Harley 2011)

C	34		23	53	72		26		01	16
Yr	1		3	4	5		7		9	10



Weston et al. *in prep.*

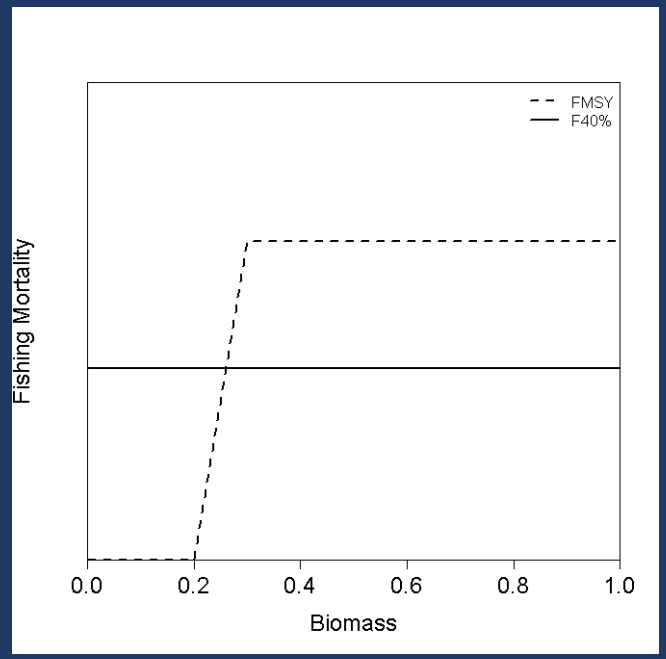
Model selection leads to bias in estimates of expected yield

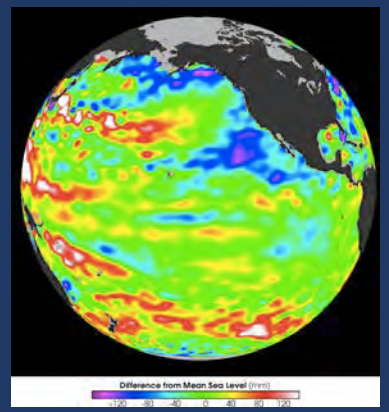


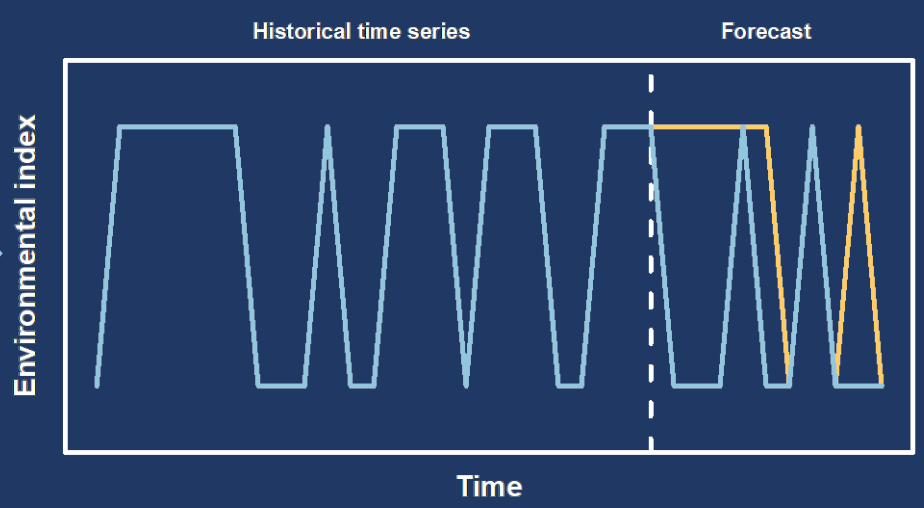
Weston et al. *in prep.*

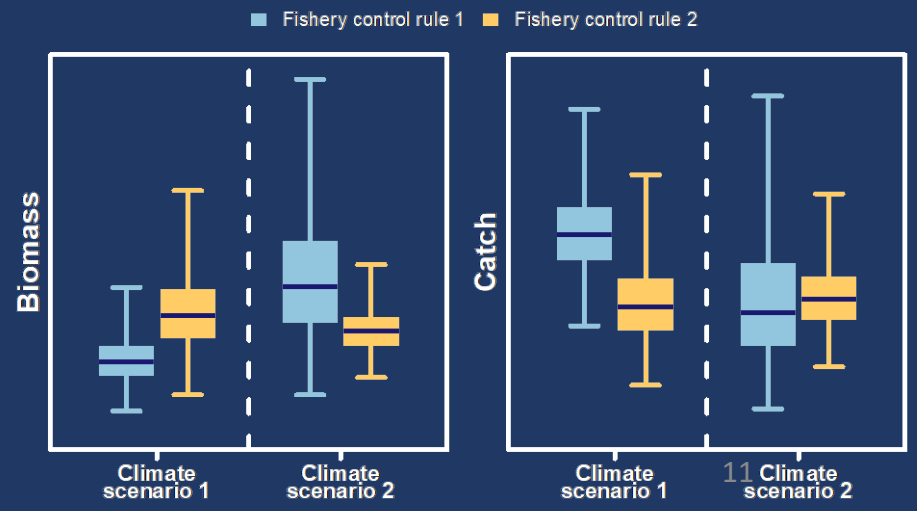
What are the consequences of model uncertainty for assessment forecasts under climate change?

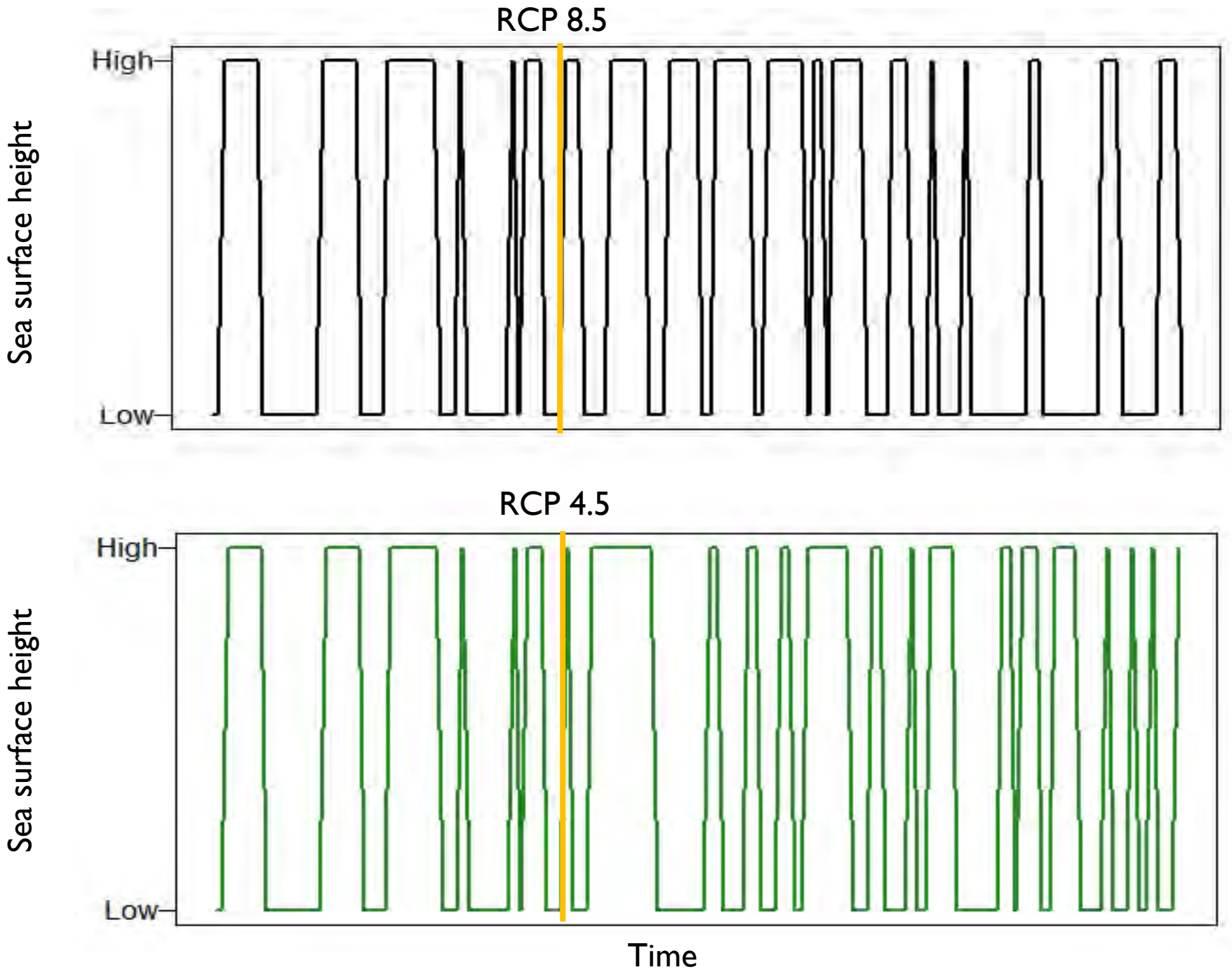
Project assessment models forward under RCP 4.5 & 8.5 (GFDL ESM2G) using Sea Surface Height predictions under current harvest control rules.





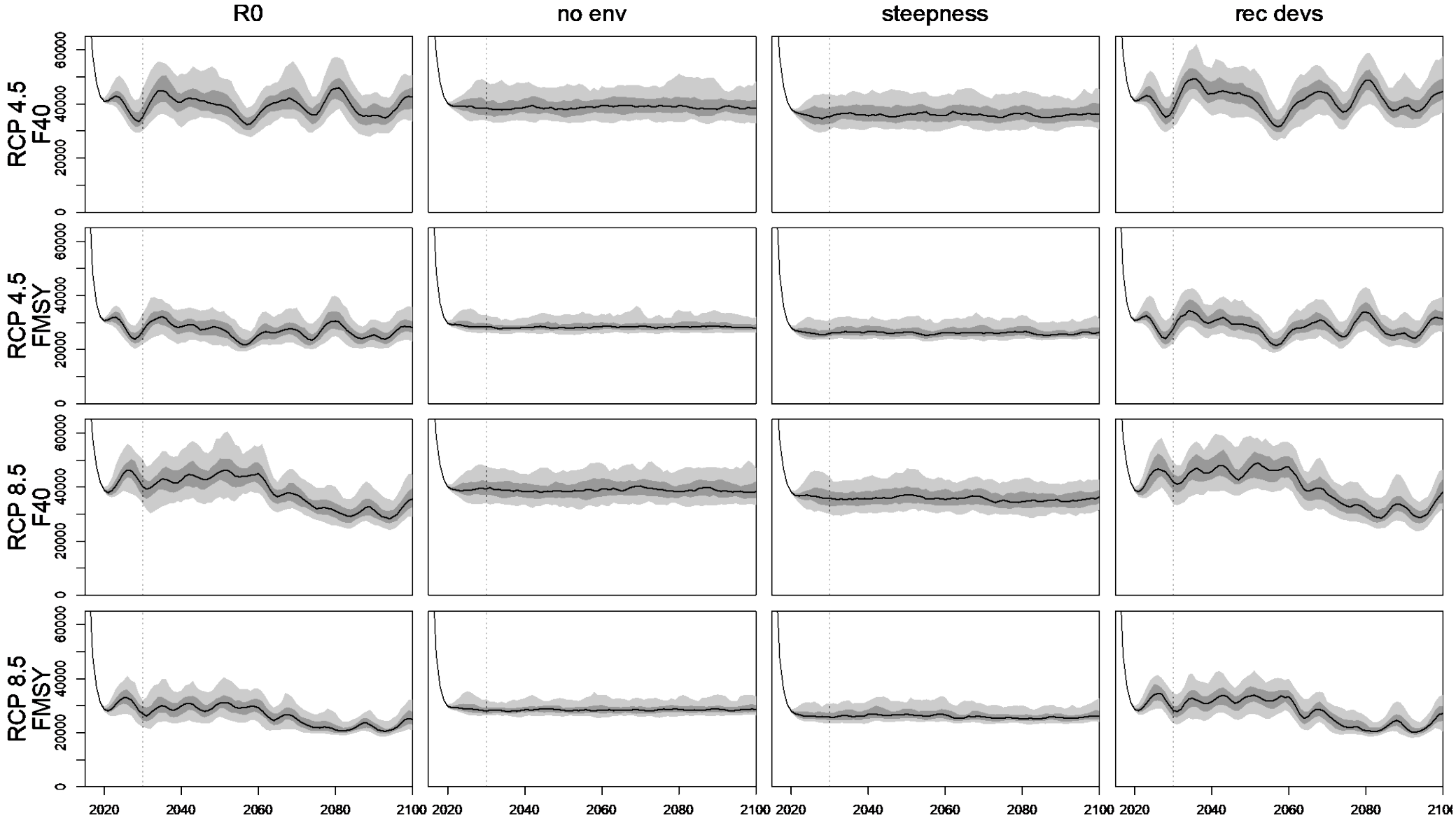






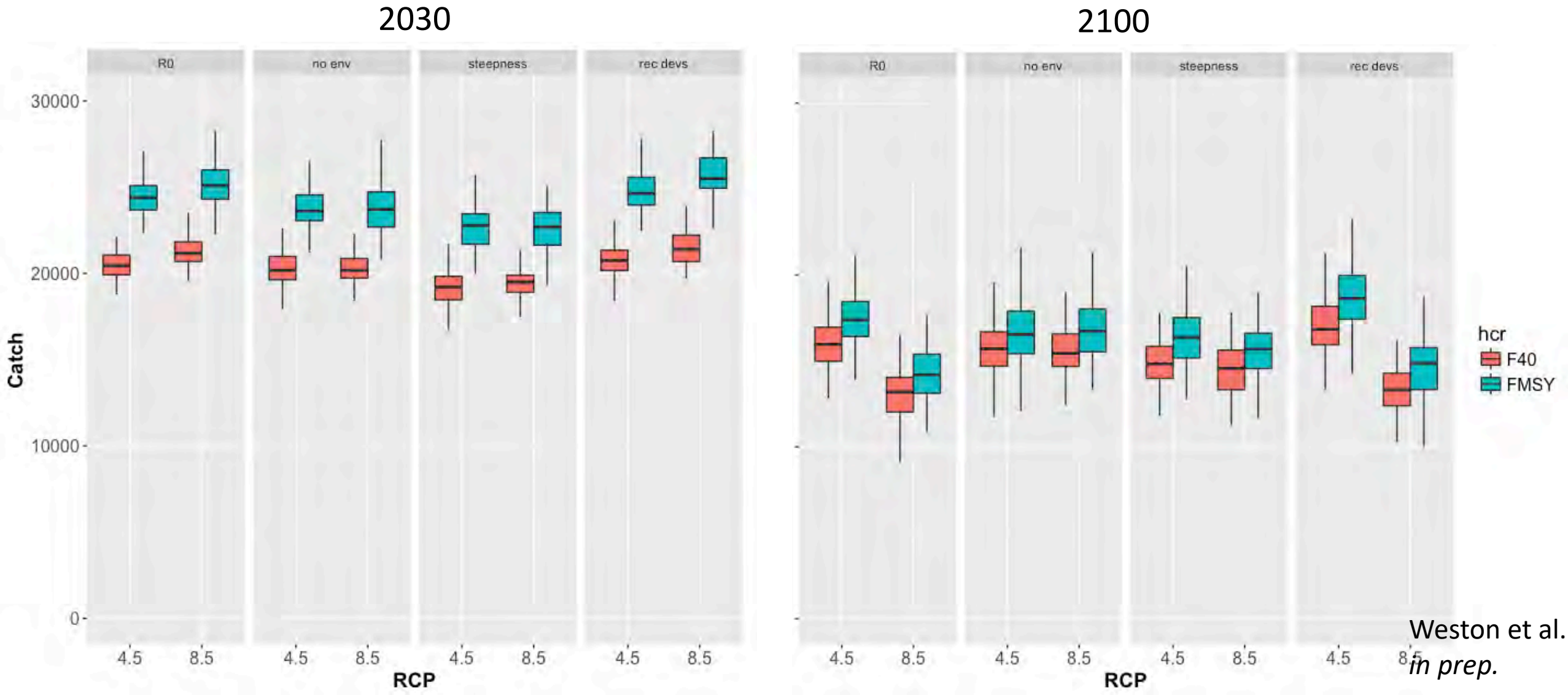
Weston et al. *in prep.*

Model uncertainty influences variability in stock forecasts, lower biomass under FMSY & RCP 8.5



Weston et al *in prep.*

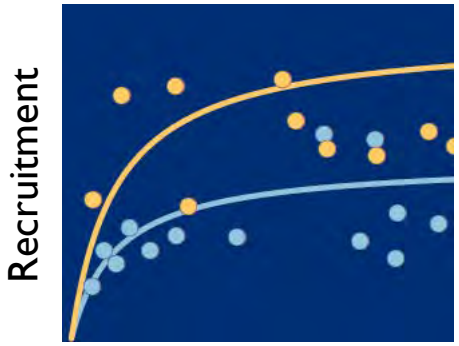
Catch in first 15 years of forecast is higher under FMSY & RCP 8.5 when effect is on carrying capacity



Weston et al. *in prep.*

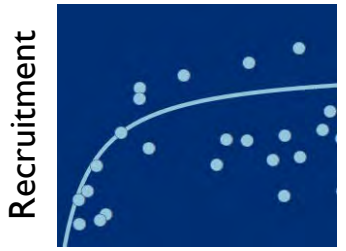
What happens if we are wrong about the environmental relationship in the assessment?

Environment affects Unfished Recruitment

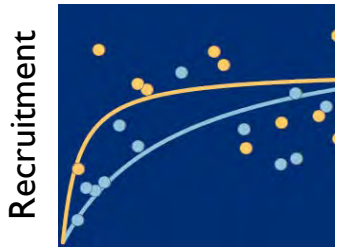


Future catches

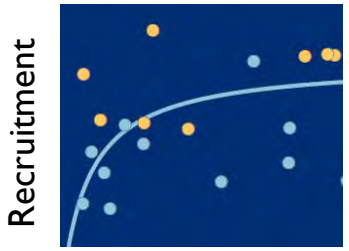
No Environment



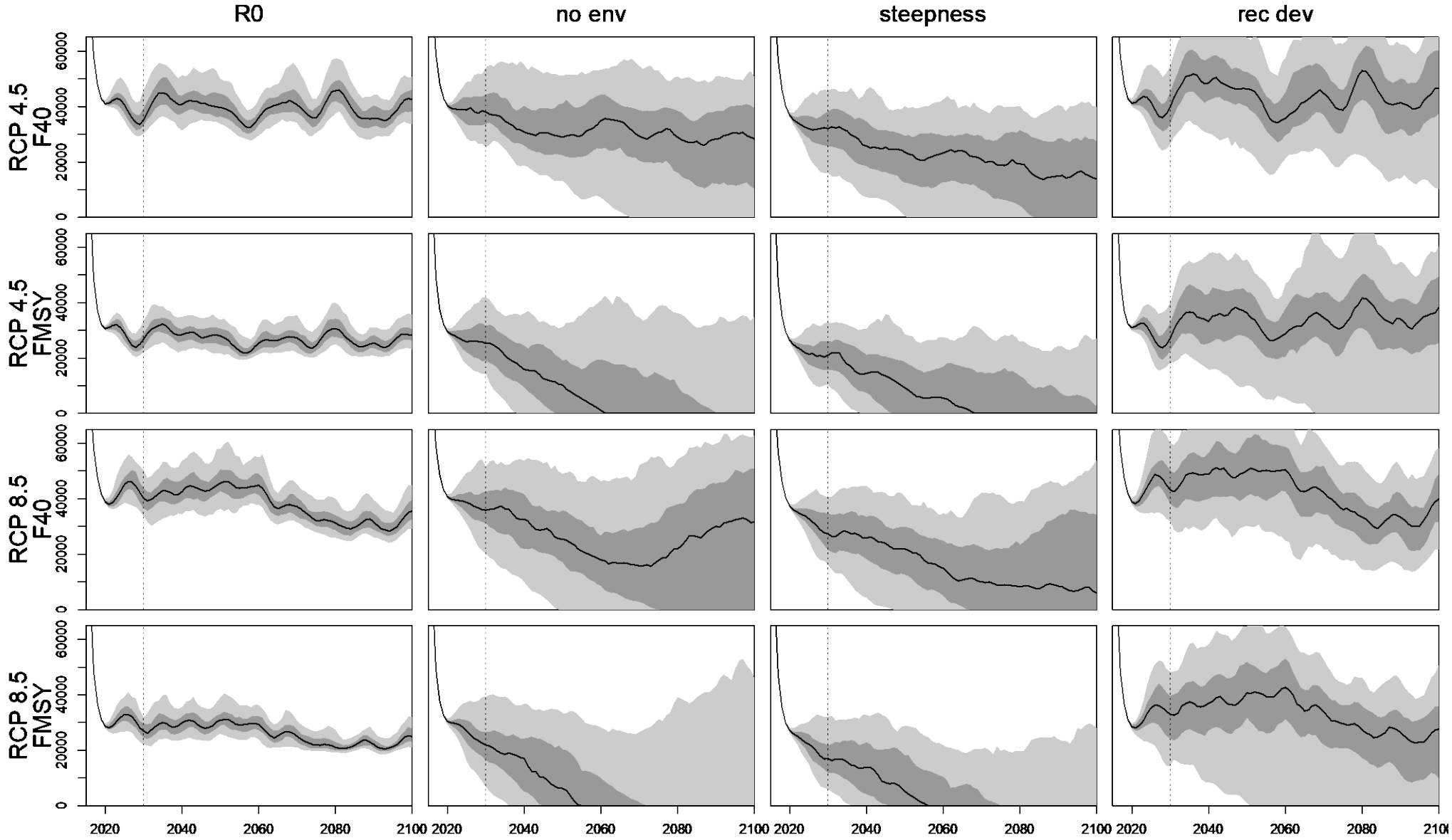
Environment affects steepness



Environment affects recruitment deviations

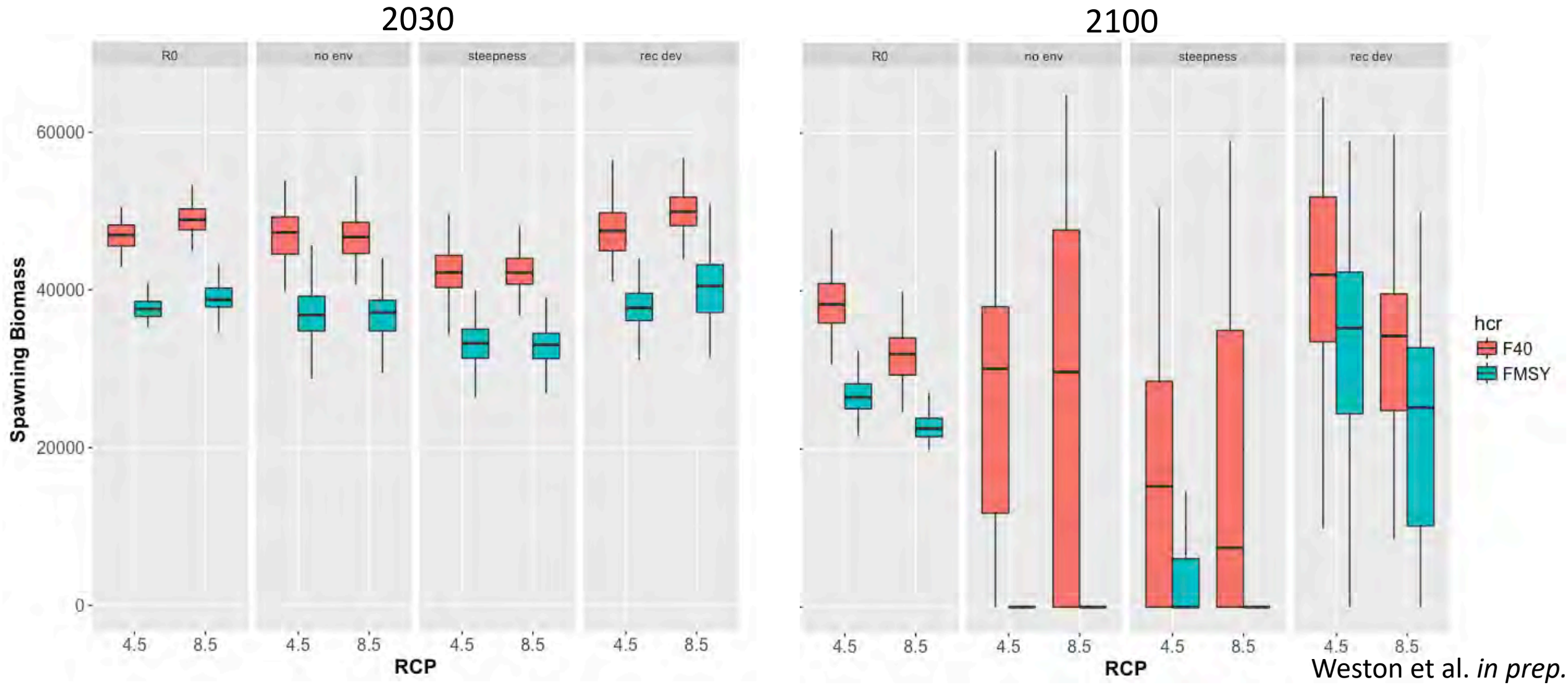


Assuming the wrong model during biomass forecasts has large consequences



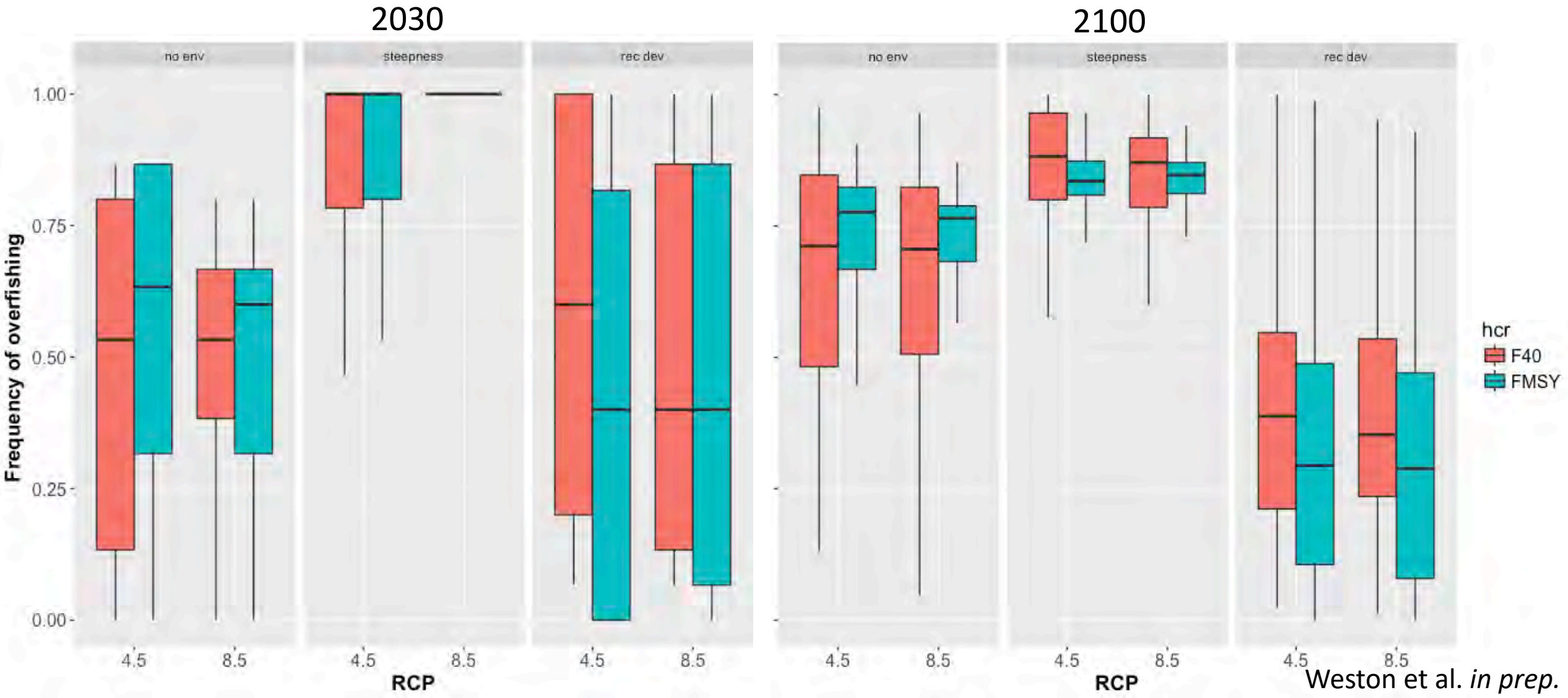
Weston et al. *in prep.*

Model uncertainty & magnitude of fishing intensity determines performance



Weston et al. *in prep.*

More overfishing when assuming no effect or productivity effect, when it really affects carrying capacity.



Weston et al. *in prep.*

Summary

- Effects of environment on recruitment can be implemented in stock assessment models & forecast under management scenario
- Using the wrong model can lead to bias in stock assessment results
- Selection tools were not robust at choosing the correct form of the recruitment-environmental linkage.
- Model mis-specification has implications for management advice.

  Consequences appear lower in short-term than long-term
- Lower rates of fishing intensity buffer the effects of climate and model uncertainty.

Future work:

- Multi-model ensembles
- Uncertainty of climate, models, & HCRs via Management strategy evaluation

Thank you!

Acknowledgements:
Ian Stewart (IPHC)
Nick Bond (UW JISAO)

aweston@umassd.edu
@AshleyEWeston
gfay@umassd.edu
@gavin_fay

UMass | Dartmouth

FATE
Fisheries and the Environment

NOAA FISHERIES

@ed_hawkins https://www.climate-lab-book.ac.uk/2018/warming-stripes/