Integration of multiannual climate predictions in the estimation of stock status and rebuilding time frames for highly migratory species

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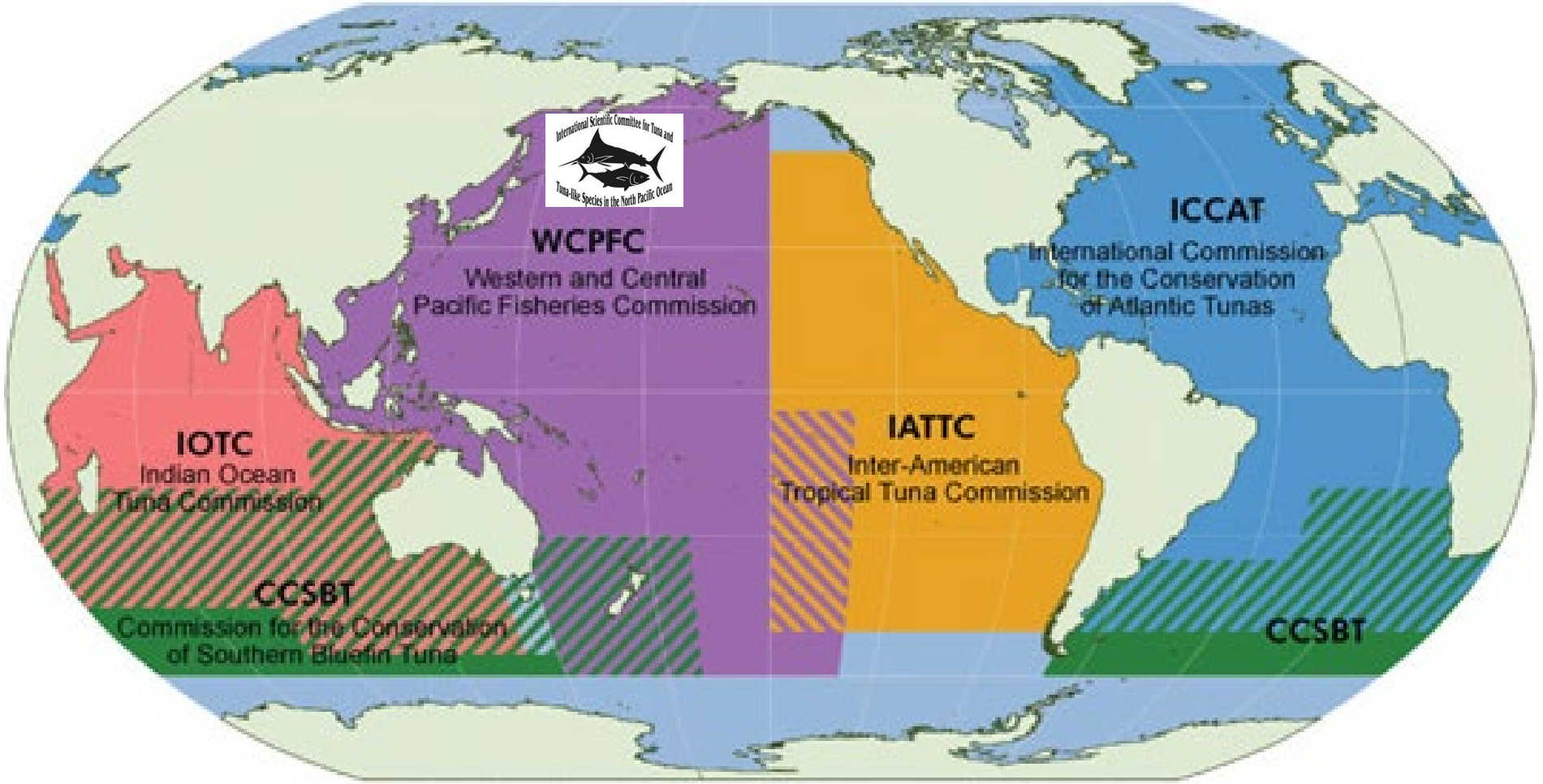
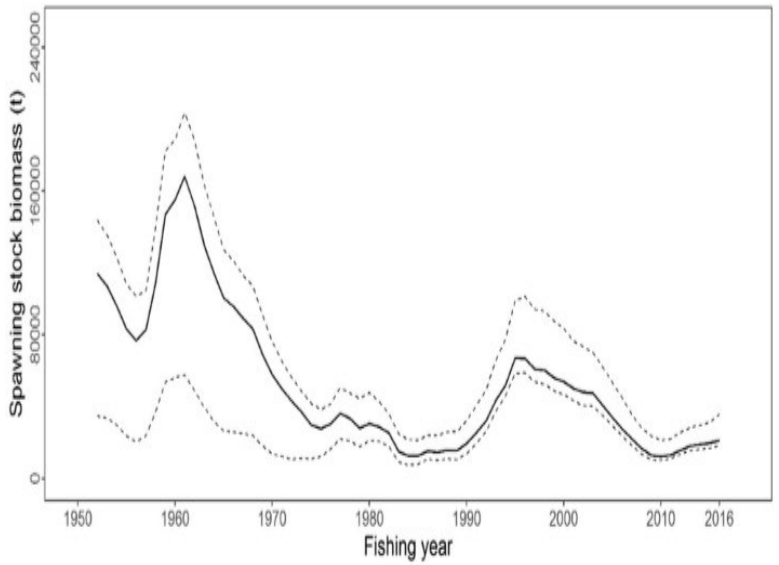
Management of Highly Migratory Species (HMS) in the North Pacific

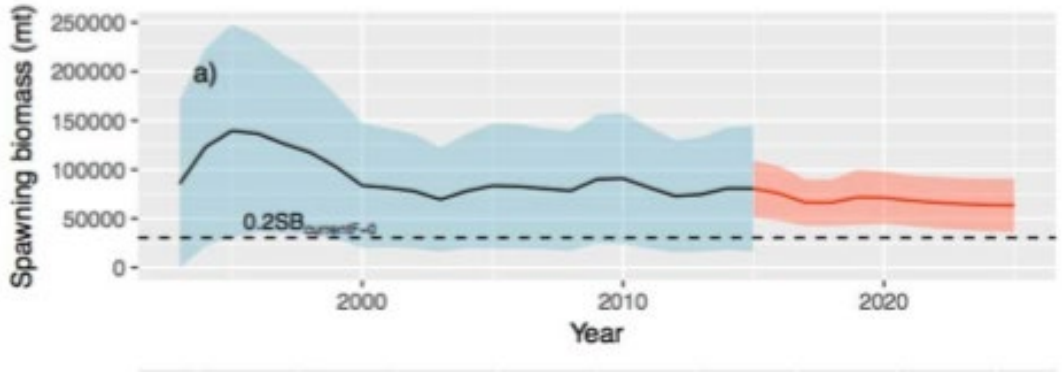


The Pew Charitable Trust
https://www.pewtrusts.org/en/research-and-analysis/fact-sheets/2012/02/23/faq-what-is-a-regional-fishery-management-organization

Stock Status Determination of Highly Migratory Species in the North Pacific



Stock Assessment
Reconstruction of Historical Conditions
Estimation of Current Biomass and Reference Points



Future Projections
Project population forward with constant catch rate
Probability of biomass > reference points or rebuilding target

Management Decision

Stock Projections

- Sensitive to assumptions of future recruitment

- Often future recruitment is simulated as random noise around average stock-recruitment based on historical patterns

- Environment can drive substantial variability in recruitment (e.g. Szuwalski et al. 2015)

- Can lead to biased estimates of stock status or rebuilding probabilities

Stock Projections

- Informative to know if recruitment over the next 10 years will be likely to be

- Less bias?

- Narrower window of probable outcomes?

Pacific Bluefin Tuna Case Study

ICES Journal of Marine Science

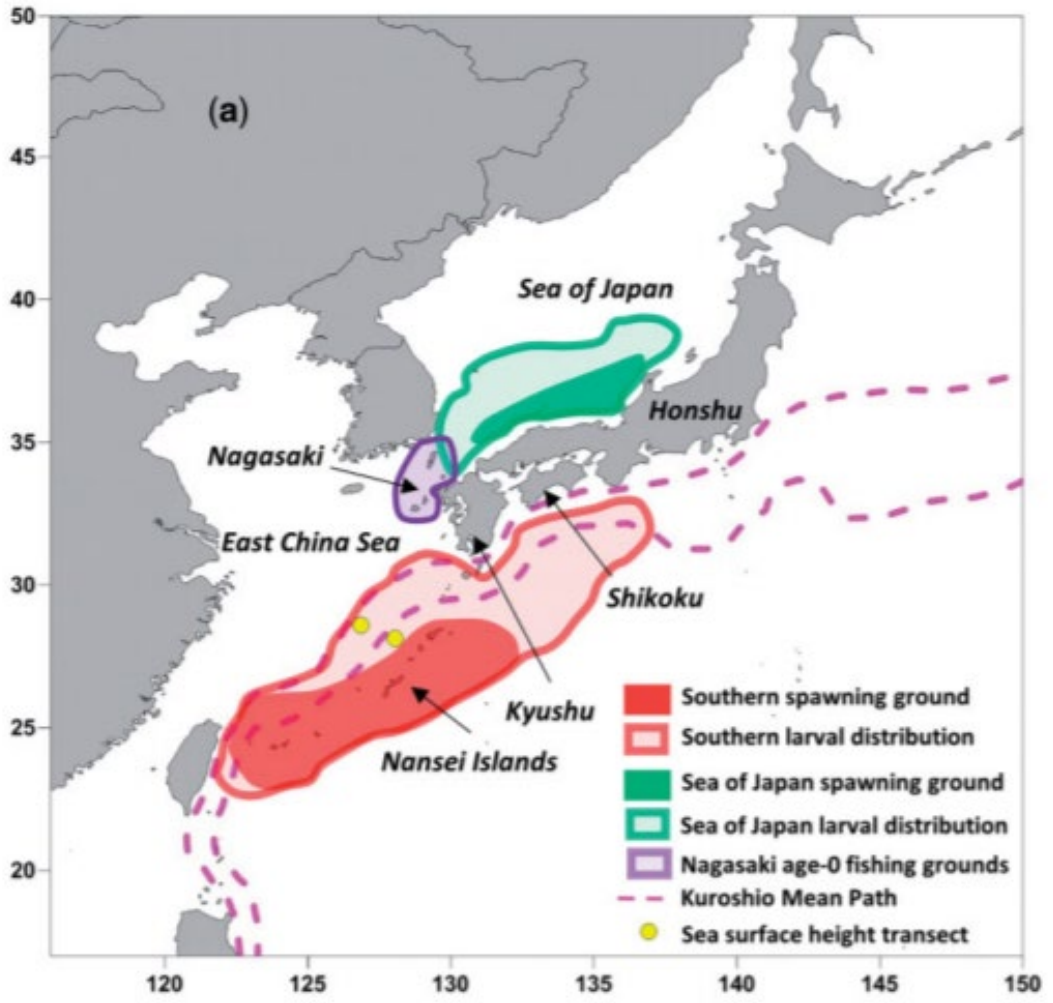
ICES International Council for the Exploration of the Sea
CIEM Conseil International pour l'Exploration de la Mer

ICES Journal of Marine Science (2018), doi:10.1093/icesjms/fsy017

Regional-scale surface temperature variability allows prediction of Pacific bluefin tuna recruitment

Barbara A. Muhling[1,2]*, Desiree Tommasi[1,2], Seiji Ohshimo[3], Michael A. Alexander[4], and Gerard DiNardo[2]

- SST-informed recruitment model skillful
- R^2 = 0.72 for training (1982-2005)
- R^2 = 0.51 for out of sample prediction (2006-2012)

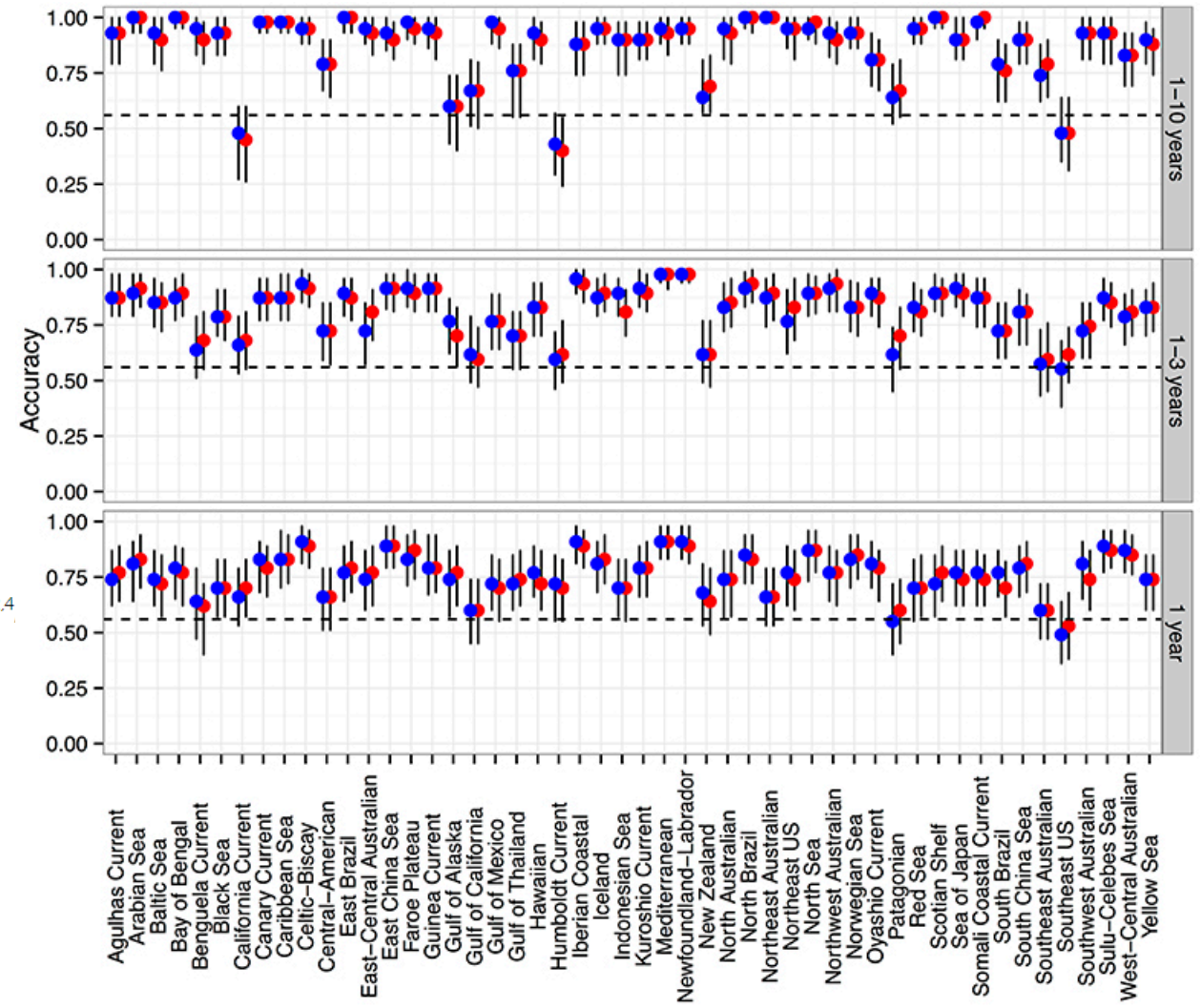


Pacific Bluefin Tuna Case Study

frontiers in Marine Science
ORIGINAL RESEARCH ARTICLE
Front. Mar. Sci., 30 June 2017 | https://doi.org/10.3389/fmars.2017.00201

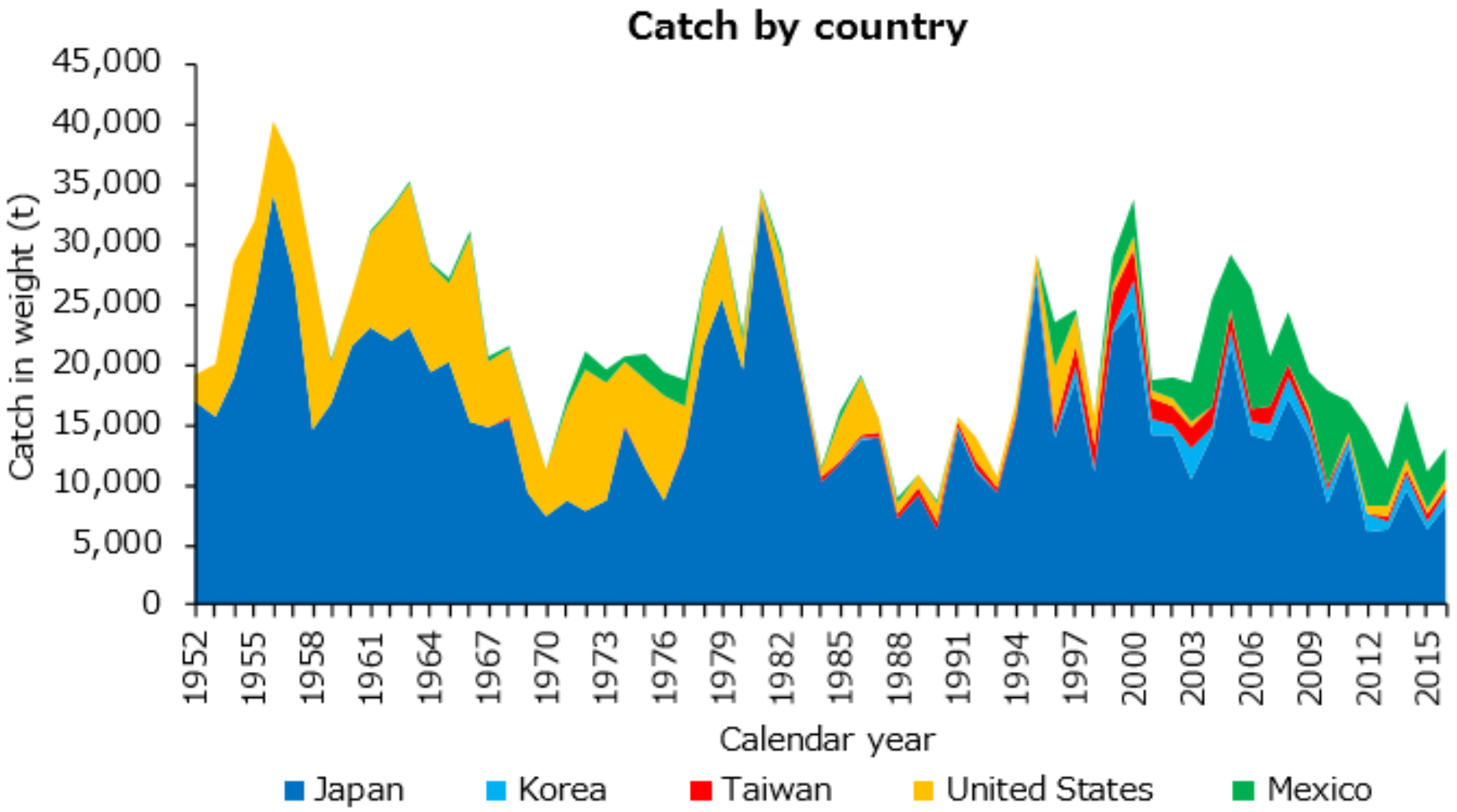
Multi-Annual Climate Predictions for Fisheries: An Assessment of Skill of Sea Surface Temperature Forecasts for Large Marine Ecosystems

Desiree Tommasi[1,2*], Charles A. Stock[2], Michael A. Alexander[3], Xiaosong Yang[2,4] Anthony Rosati[2] and Gabriel A. Vecchi[5,6]



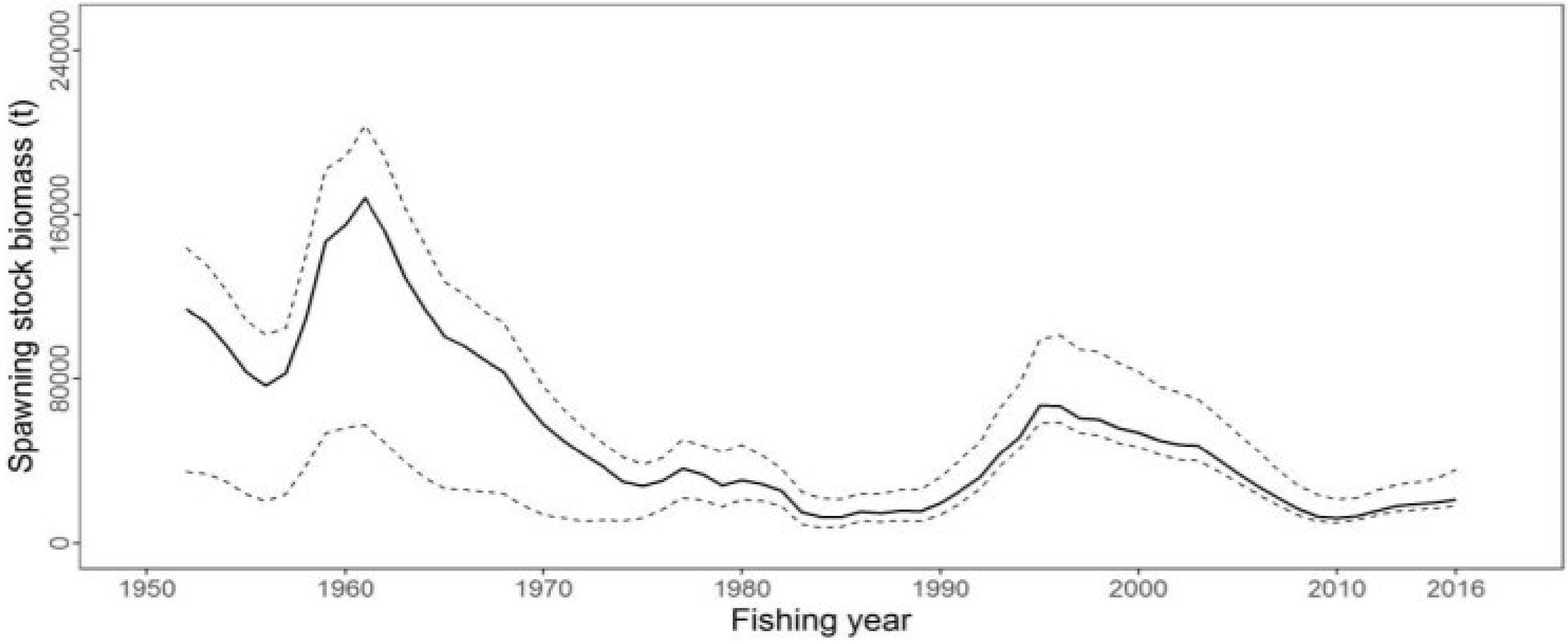
- skillful multiannual predictions in spawning region LMEs

Pacific Bluefin Tuna Catch by Country



PBT 2018 Stock Assessment
http://isc.fra.go.jp/pdf/ISC18/ISC_18_ANNEX_14_Pacific_Bluefin_Tuna_Stock_Assessment_2018_FINAL.pdf

Pacific Bluefin Biomass



PBT 2018 Stock Assessment
http://isc.fra.go.jp/pdf/ISC18/ISC_18_ANNEX_14_Pacific_Bluefin_Tuna_Stock_Assessment_2018_FINAL.pdf

Pacific Bluefin Tuna Harvest Control

- If the SSB projection indicates that the probability of achieving the initial rebuilding target by 2024 is less than 60%, management measures will be modified…

- If the SSB projection indicates that the probability of achieving the initial rebuilding target by 2024 is at 75% or larger, the WCPFC may increase their catch limits

Pacific Bluefin Tuna Harvest Control

- Probabilities of achieving rebuilding target depend on stock projections

- Stock projections are sensitive to recruitment assumption

- Projections are run with average and low recruitment scenarios (resampling from 1980-1989 low recruitment period)

Pacific Bluefin Tuna Case Study

- Are multi-annual, probabilistic recruitment forecasts skillful?

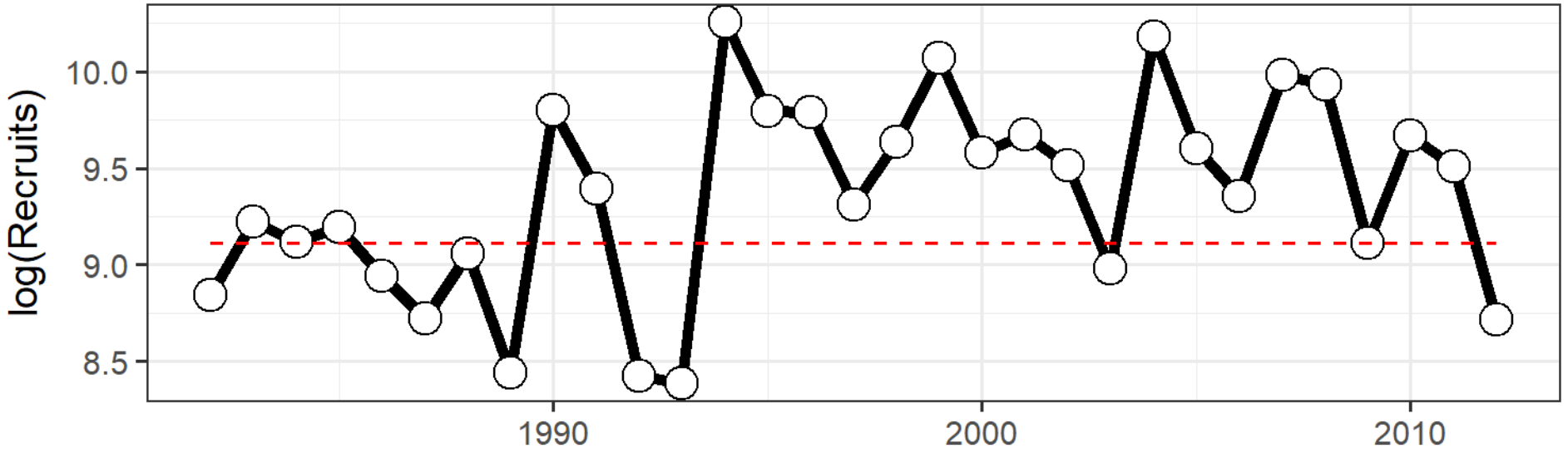
- Focused on probability of recruitment being below average (lower tercile)

Pacific Bluefin Tuna Case Study

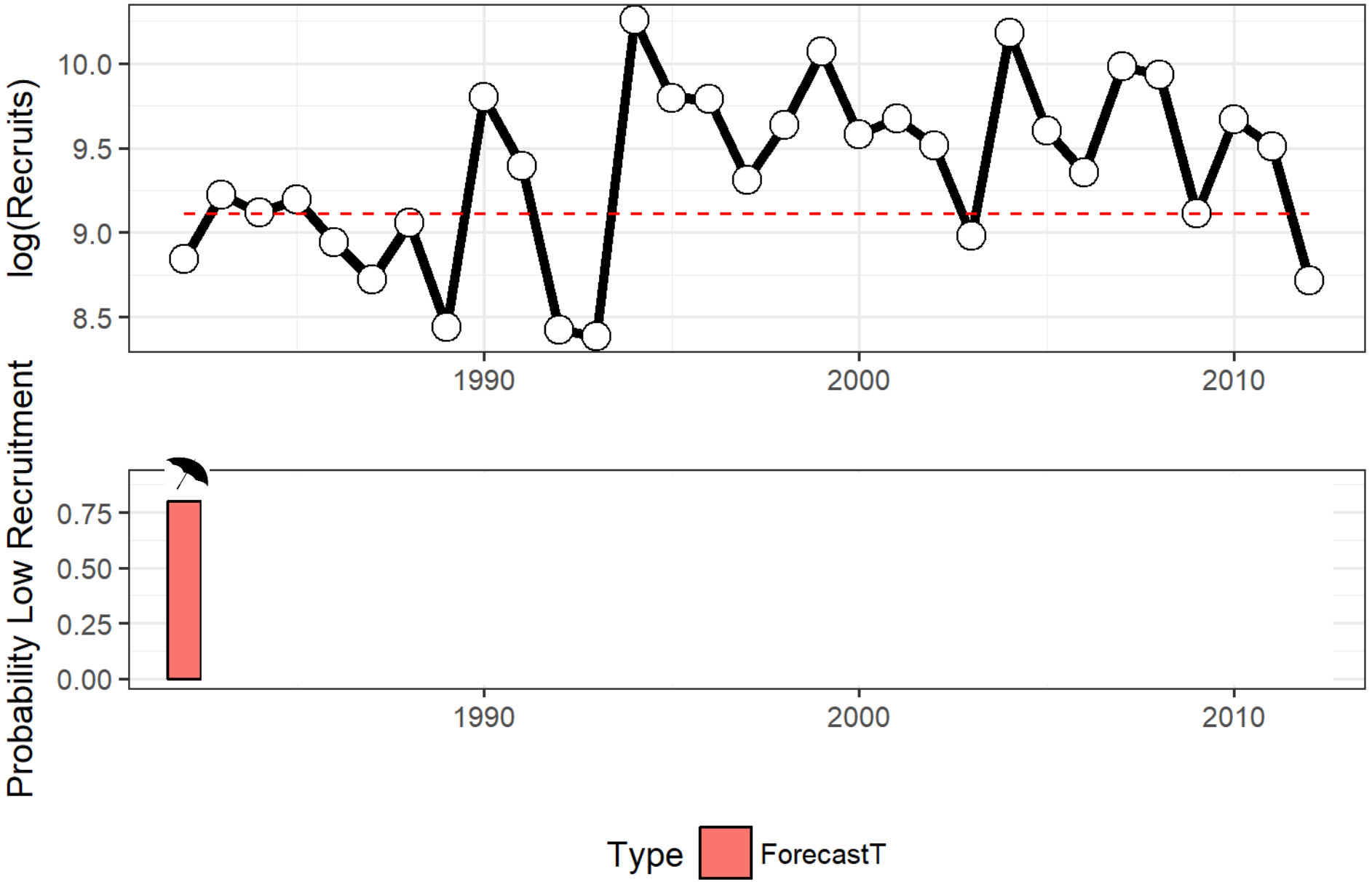
SST predictions 1 to 10 years into the future for 1991 to 2012 from GFDL CMIP5 decadal experiment
Initialized between Jan 1st 1982 to Jan 1st 2012
10 ensemble members

Probabilistic prediction 1 to 10 years into the future of recruitment being below average

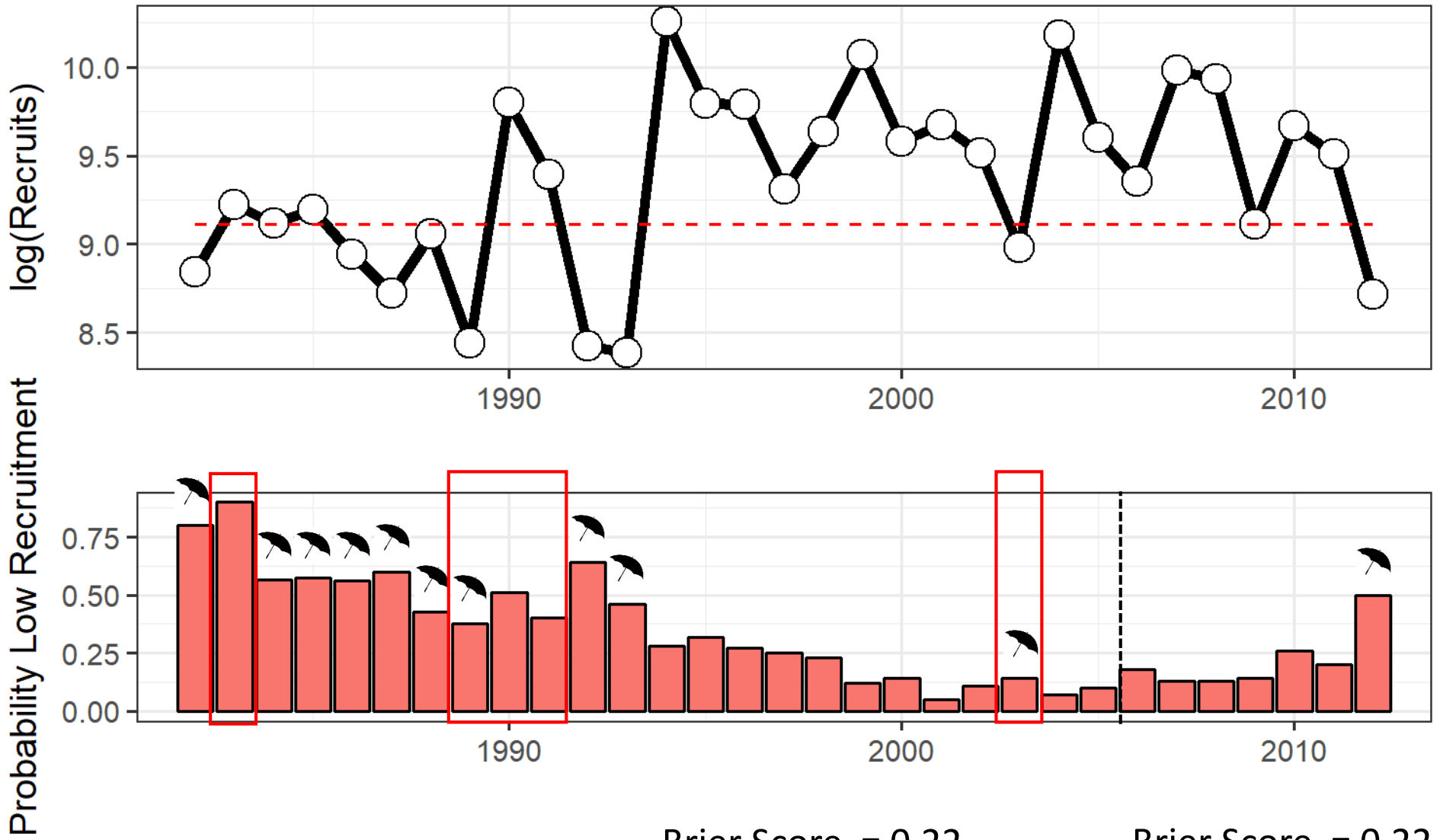
Pacific Bluefin Case Study



Recruitment Forecasts



Retrospective skill assessment



Brier Score = 0.22
(0 to 1, lower better)

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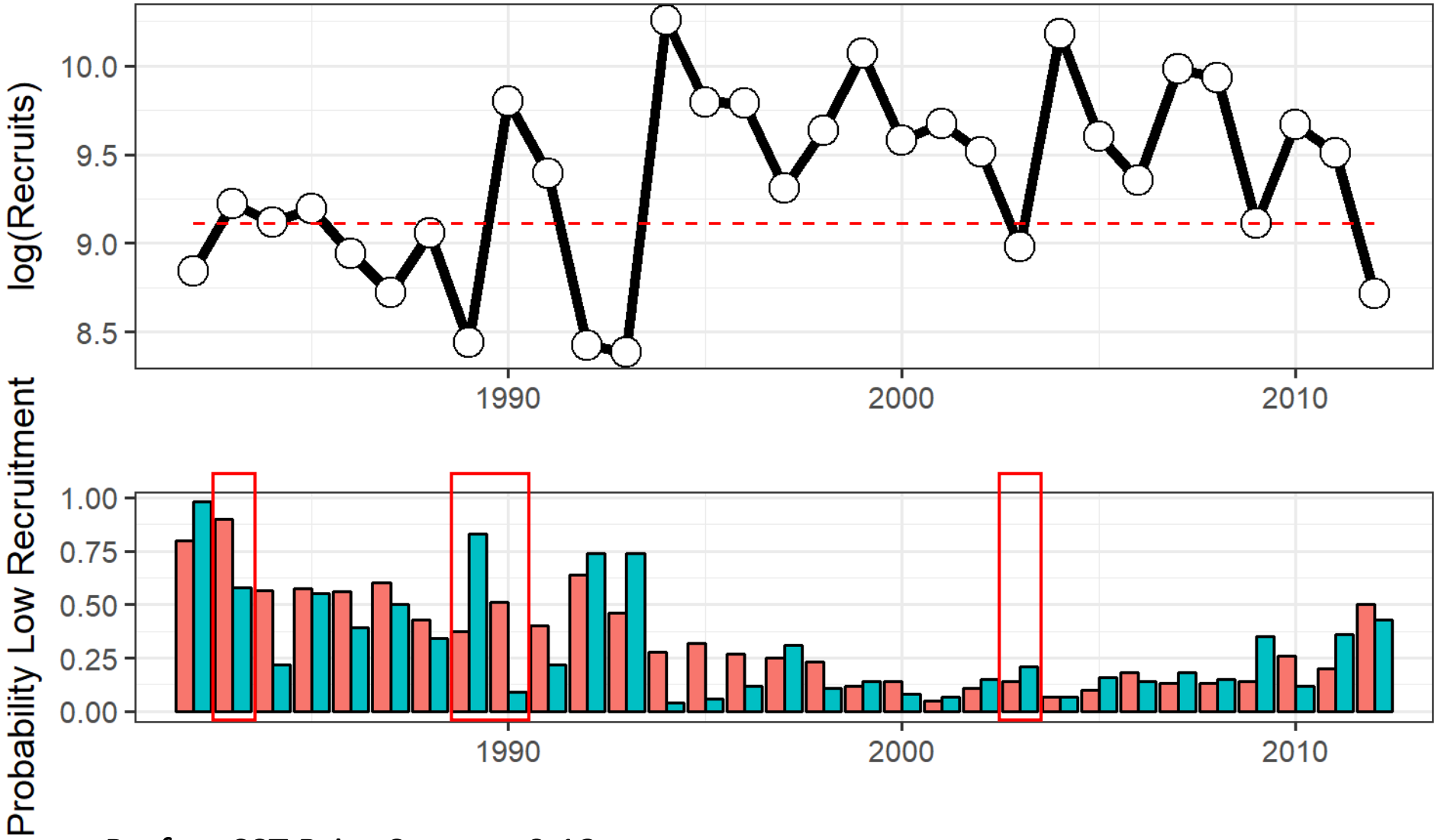
(0 to 1, lower better)

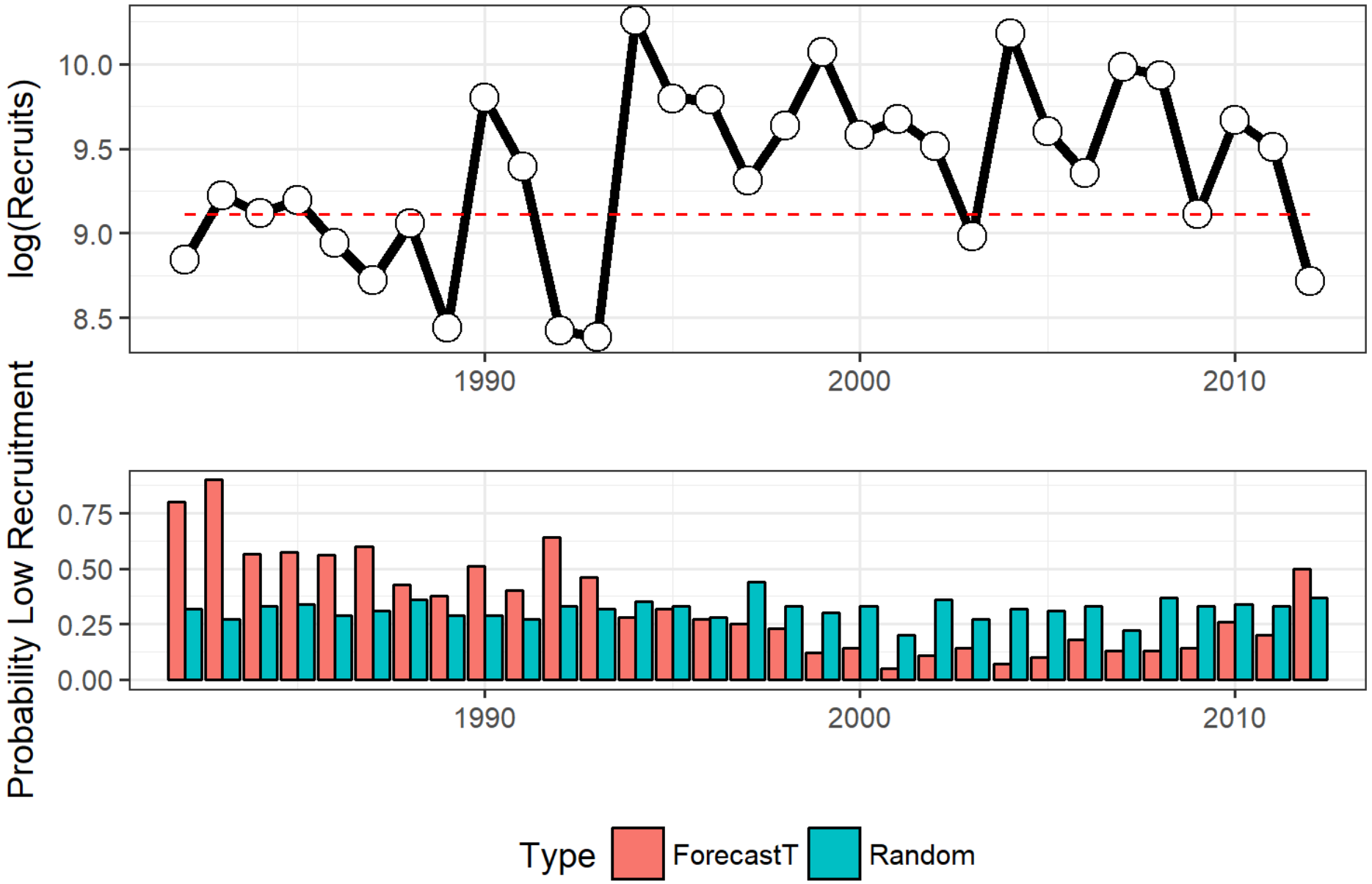
Forecast SST vs. Perfect SST



Perfect SST Brier Score = 0.13
(0 to 1, lower better)

ForecastT PerfectT

Forecast SST vs. Average Recruitment



Impact on estimate of stock status

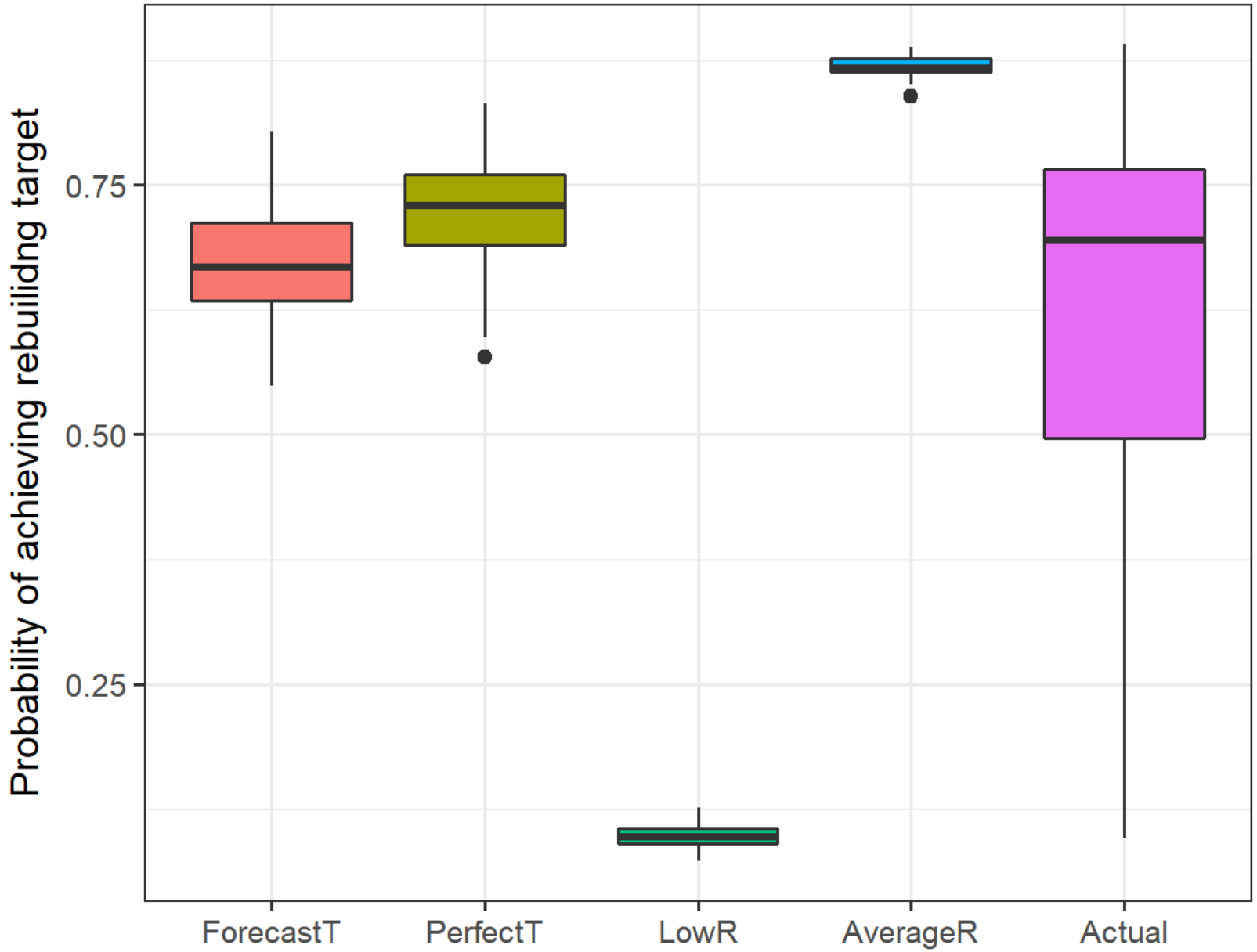
- Forced age structured population dynamics model with 5 recruitment scenarios:
  1. Actual recruits
  2. Resampling from entire recruitment time series
  3. Resampling from low recruitment period
  4. Perfect SST
  5. Forecast SST

- Compared probability of achieving rebuilding target over 8 random years across 100 simulations, each with 500 iterations per recruitment replicate

Impact on estimate of stock status

- In SST scenarios probability of low recruitment event every year influences # of iterations forced by low recruitment period
  - 500 recruitment iterations per year
  - If probability is 0.8
  - 80% of 500 recruits sampled from low recruitment period

Impact on estimate of stock status



Conclusions

- Skillful recruitment forecasts informed by SST
- Larger forecast error from physical rather than biological forecast
- Mechanisms of SST predictability in the region need to be investgated
- Use of SST informed forecast may reduce bias in stock status estimate
- However, SST-informed projections of stock status appear over-confident

Thank you!

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