# Evaluating climate-robust management strategies for environmentally-driven recruitment in transboundary fisheries: avoiding tipping points for Pacific Hake

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Challenge: match spatiotemporal scale of predictions and models to management needs
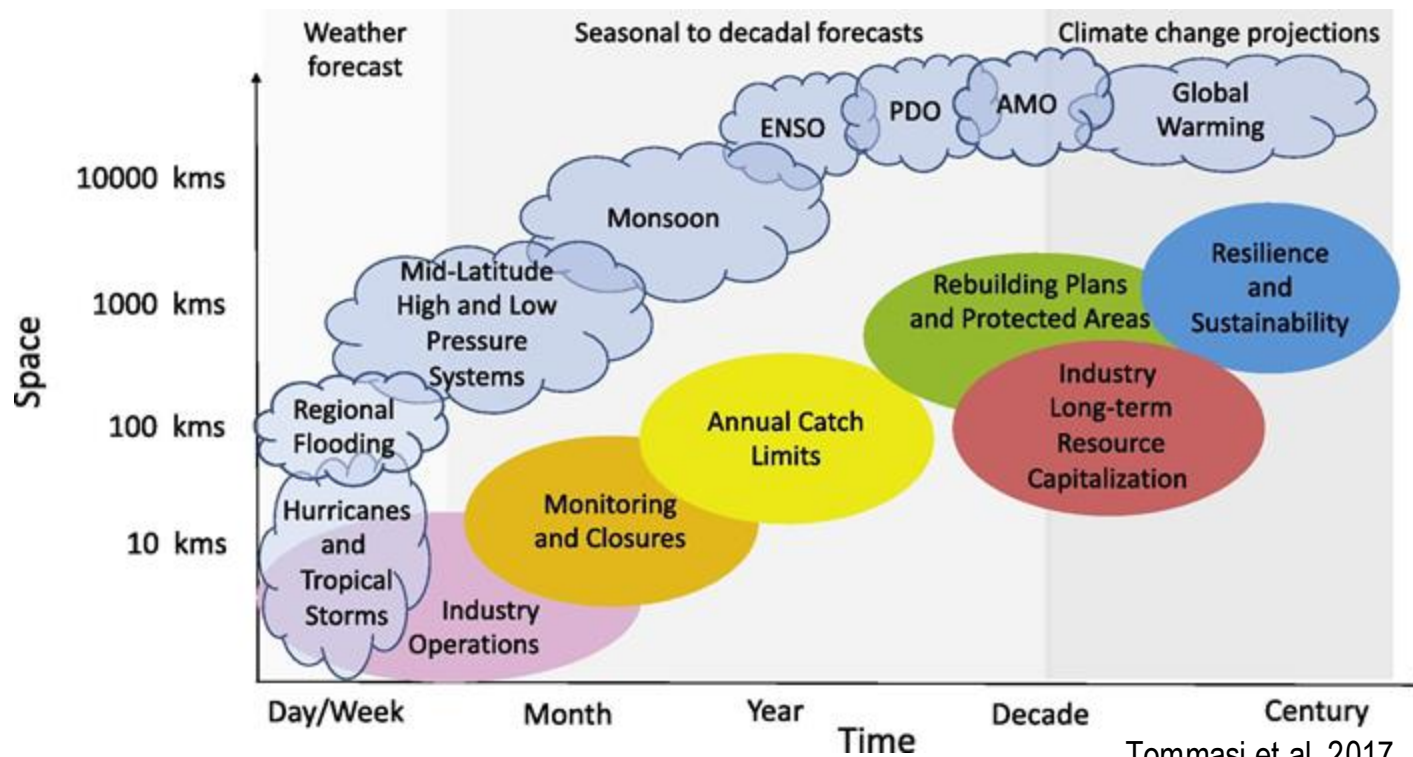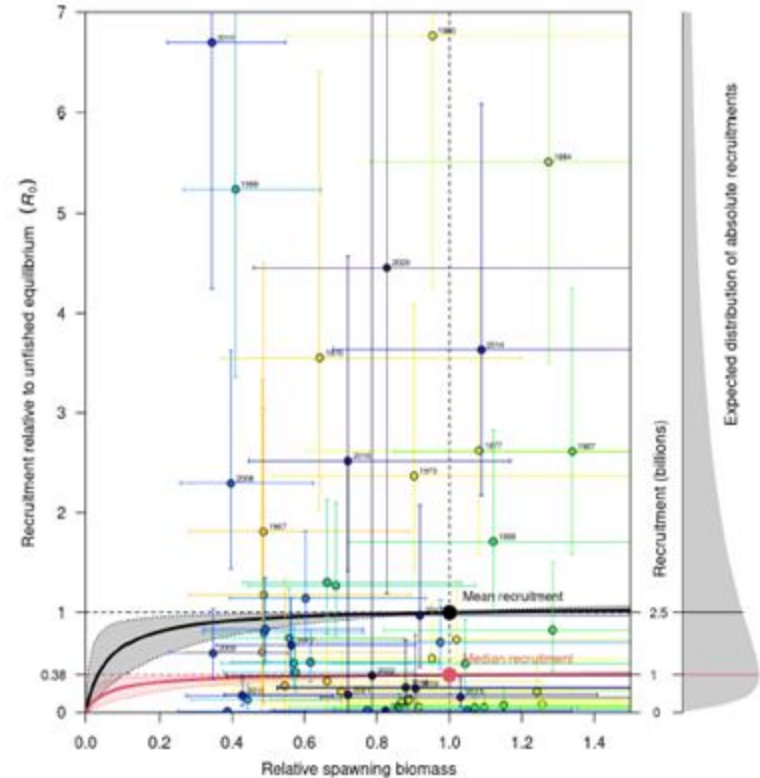

Tommasi et al. 2017

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How to operationalize research on drivers of recruitment for use in fisheries management?
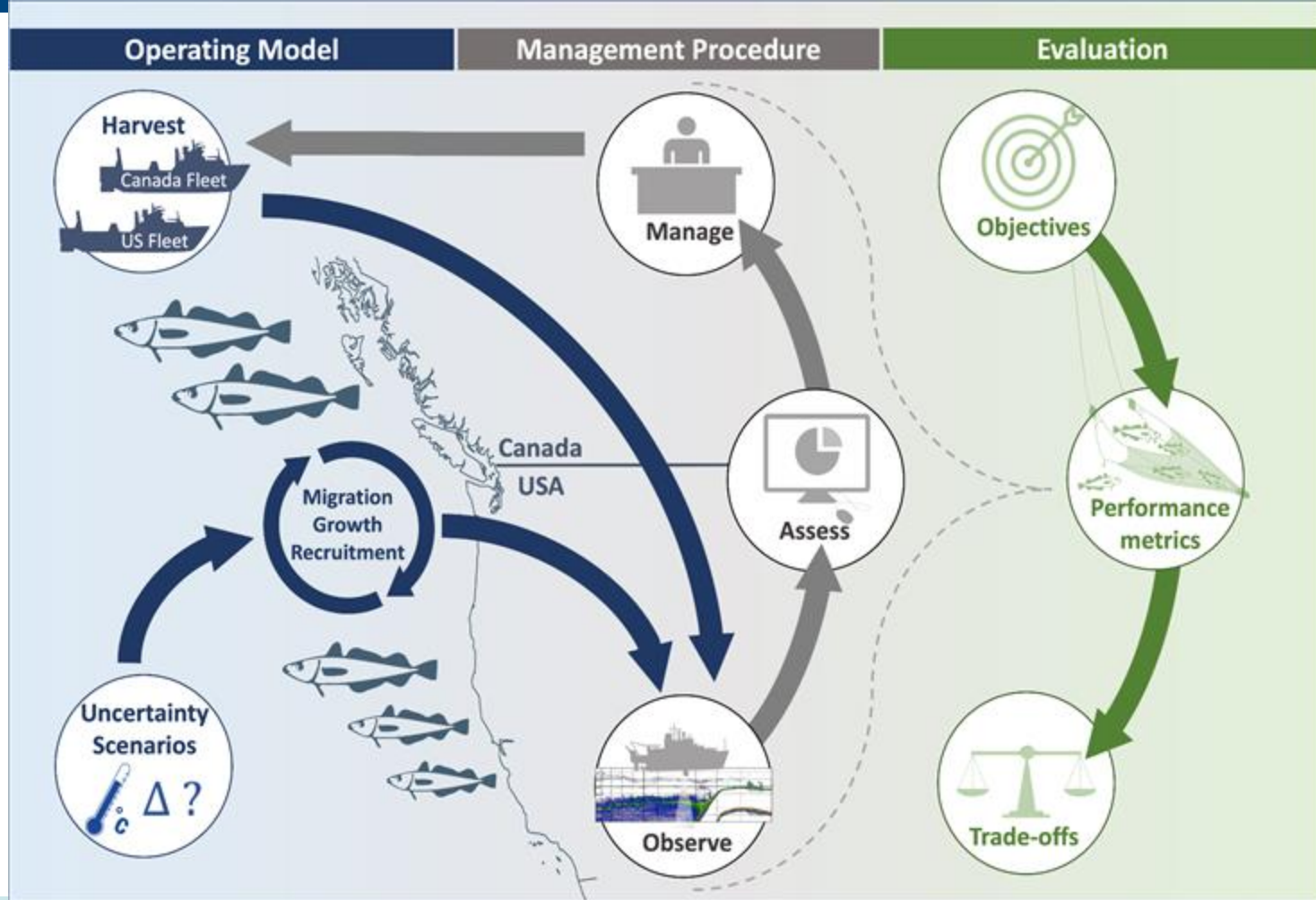
Pacific Hake: dynamic and transboundary

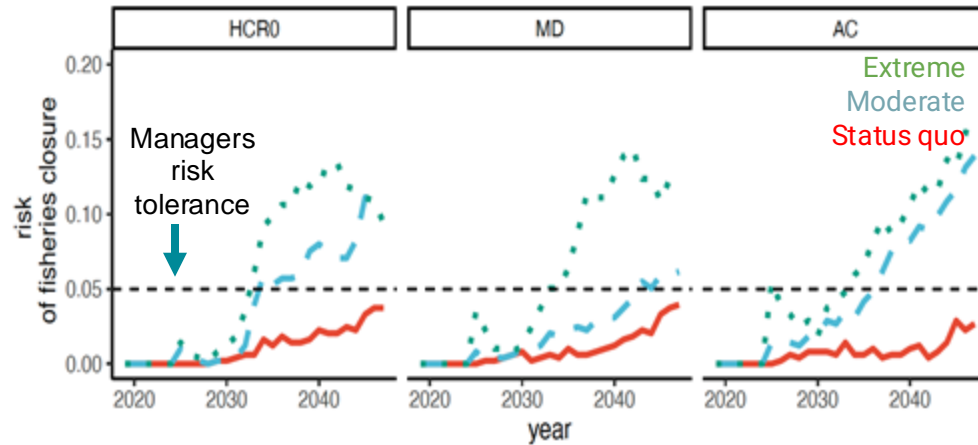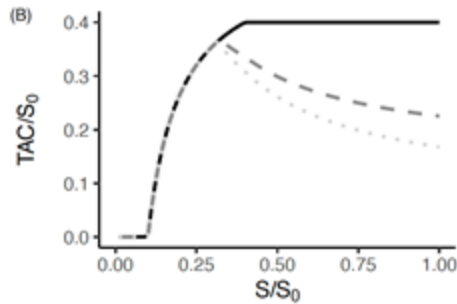Managed under international treaty between US and Canada

Variable migration and recruitment with links to ocean conditions

Hake MSE goal: evaluate the performance of alternative hake MPs under current and future environmental conditions
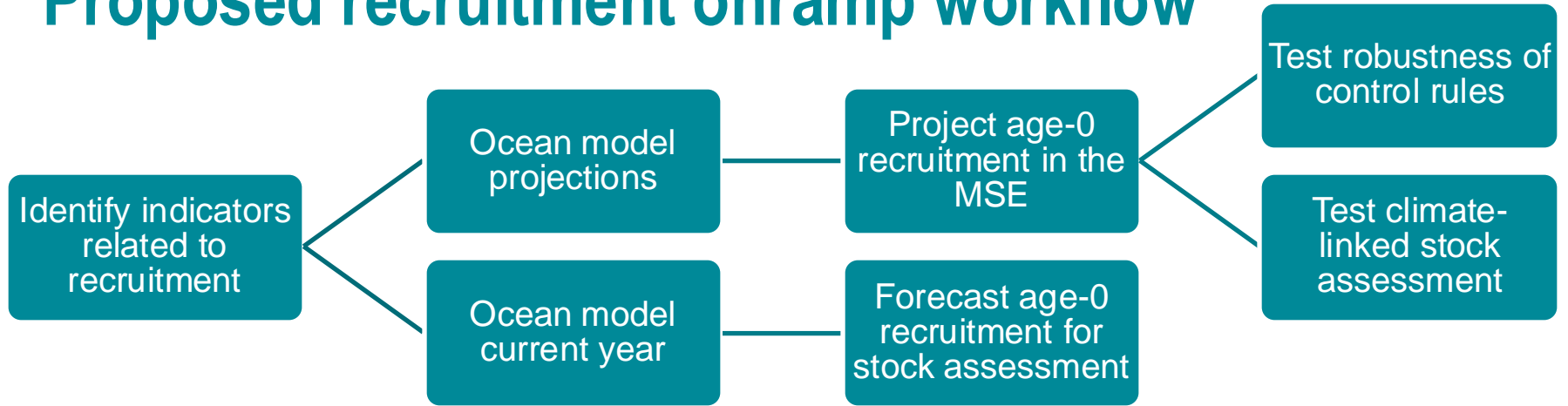
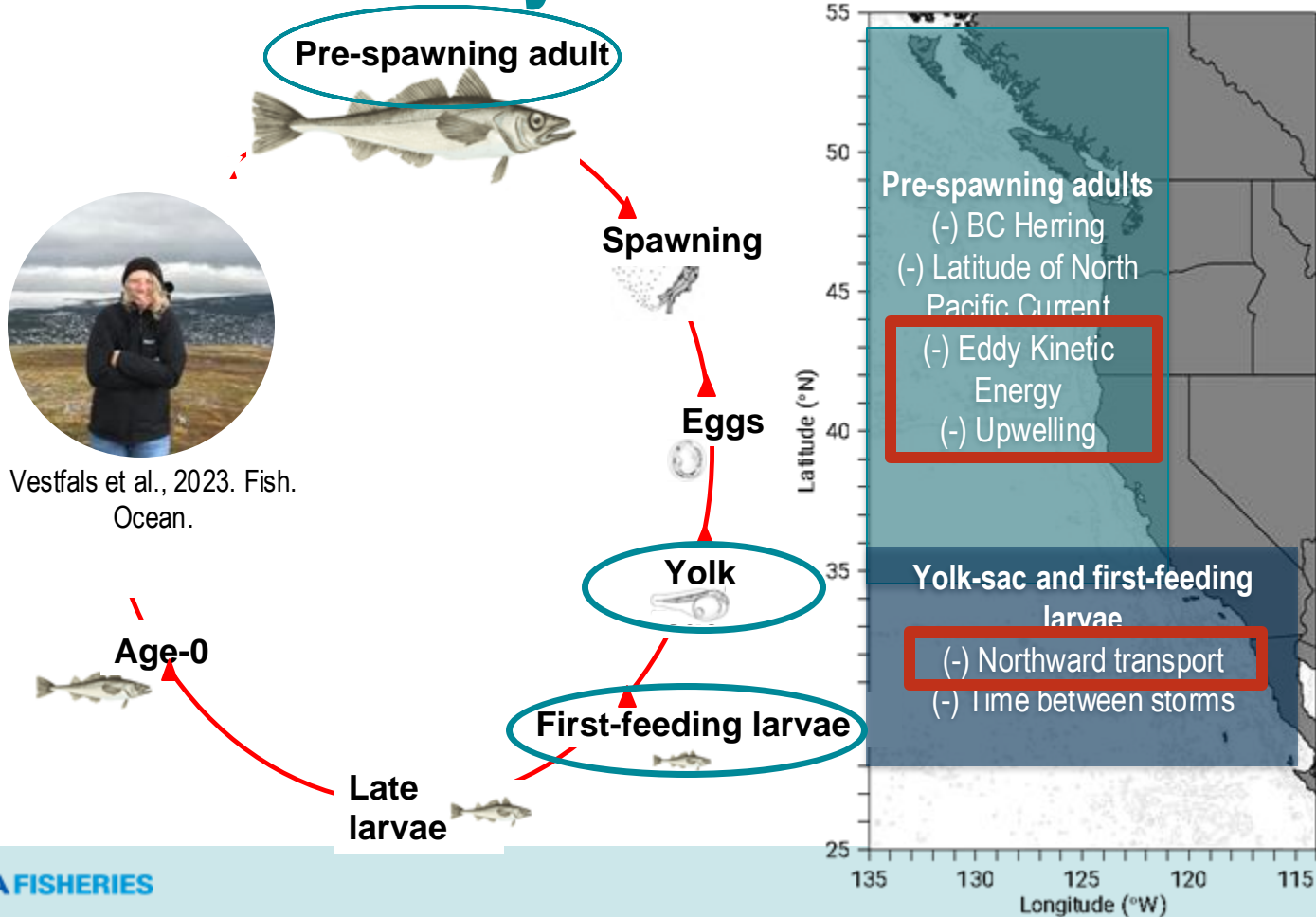# Climate change-induced movement scenarios

Conceptual scenarios suggests northward distribution shift could increase risk of fishery closures, but effects of **high recruitment variability** dominate effects of distribution shifts

Jacobsen et al. 2022. ICES JMS.

Proposed recruitment onramp workflow

What drives variability in hake recruitment?

Vestfals et al., 2023. Fish. Ocean.

Pre-spawning adult

Spawning

Eggs

Yolk

First-feeding larvae

Late larvae

Age-0

Pre-spawning adults
(-) BC Herring
(-) Latitude of North Pacific Current
(-) Eddy Kinetic Energy
(-) Upwelling

Yolk-sac and first-feeding larvae
(-) Northward transport
(-) Time between storms

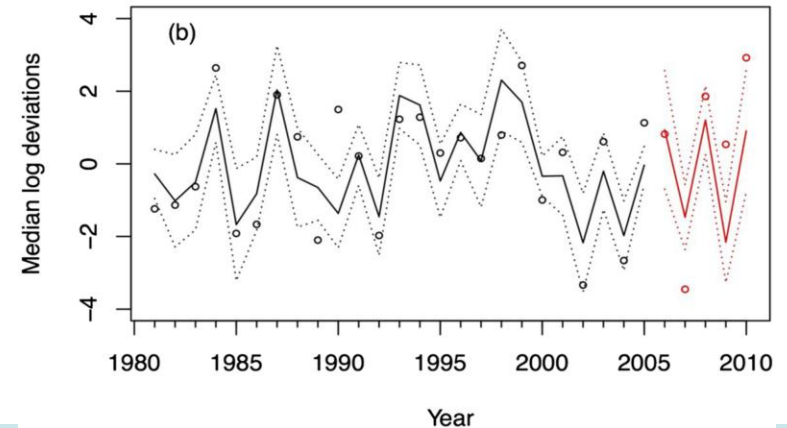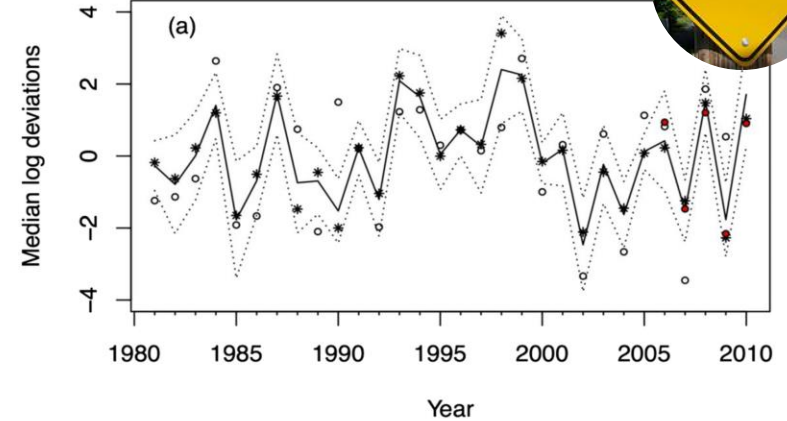NOAA FISHERIES

Challenges to operationalizing

- 59% variability explained with 5 indicators

- Linear relationships only

- Some estimated in opposite direction of hypothesis

- Model fit and validated in 1980-2010

Vestfals et al., 2023. Fish. Ocean.

Validating recruitment prediction with new approaches

'Big data' non-mechanistic approach
(methods in Ward et al. 2023)

Compare multiple model types

Univariate and multivariate

Performance based on in-sample and
out-of-sample prediction skill

FISH and FISHERIES | WILEY

ORIGINAL ARTICLE

## Leveraging ecological indicators to improve short term forecasts of fish recruitment

Eric J. Ward[1] | Mary E. Hunsicker[2] | Kristin N. Marshall[3] | Kiva L. Oken[3] | Brice X. Semmens[4] | John C. Field[5] | Melissa A. Haltuch[3,6] | Kelli F. Johnson[3] | Ian G. Taylor[3] | Andrew R. Thompson[7] | Nick Tolimieri[1]

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Potential operational indicators for hake recruitment

- Hake life-history informed ROMS variables (Vestfals et al. 2023)

- Ecosystem-state ROMS variables (Hunsicker et al. 2022)

- Survey time series of early life history stages

  - Larval fish (CalCOFI, 1985-2020)

  - Juvenile fish (RREAS, 1988-2018)

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Within-sample prediction skill
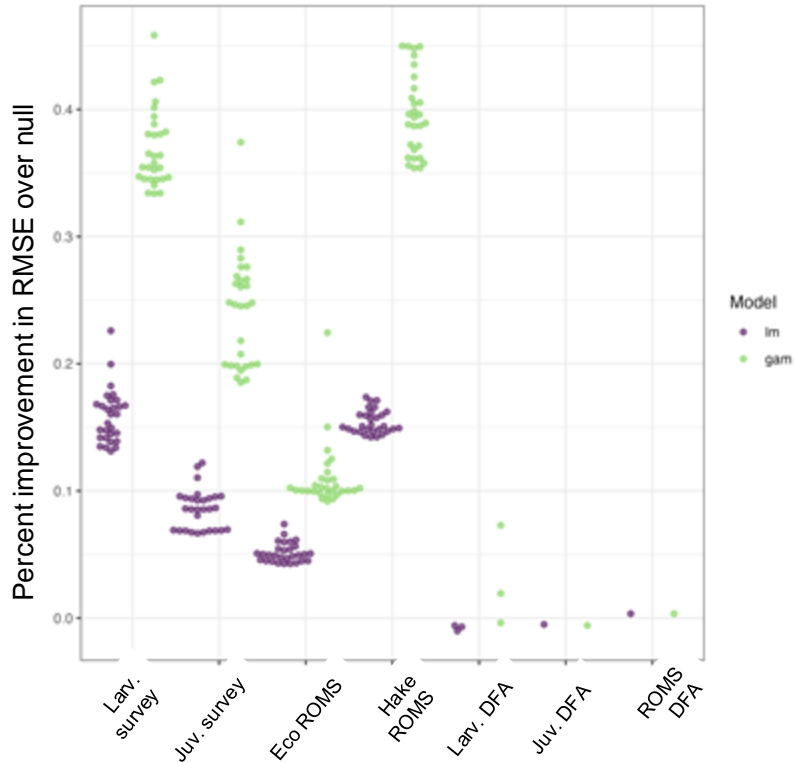
Hake-specific ROMS and larval survey perform well

Better performance with ROMS indicators supported by mechanistic hypotheses than naïve ROMS

GAMs reduced number of indicators needed for higher performance

Validate with out-of-sample prediction skill

- Age-0 recruitment deviation prediction

- Moving window one year out of sample prediction

- Hake-specific ROMS or GLORYS variables

- Performance measured as reduction in RMSE compared to a null model, over 5 or 10 forecasts

Skill in 5- and 10-year forecast windows

- Shorter forecast period shows higher skill but less variability explained in training period
- Sensitivity of indicators to assignment of testing/training years
- Tradeoffs between forecast skill and within sample R^2
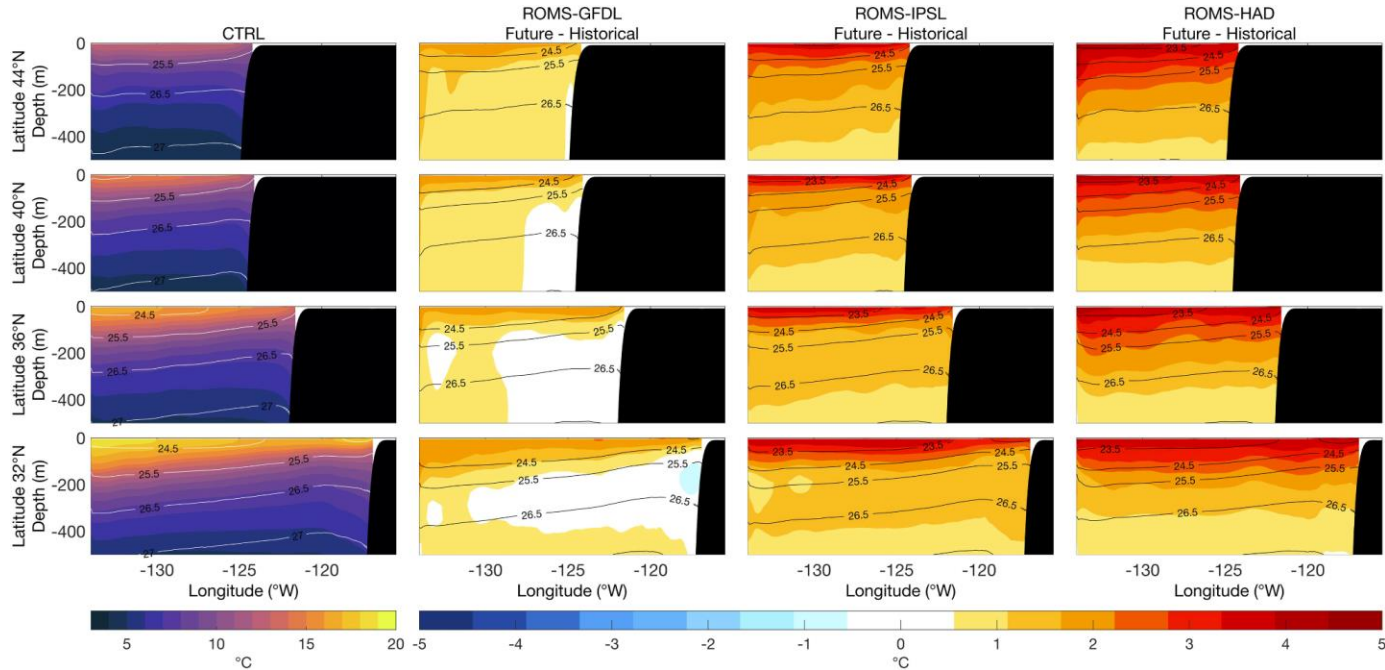- Similar results with ROMS or GLORYS
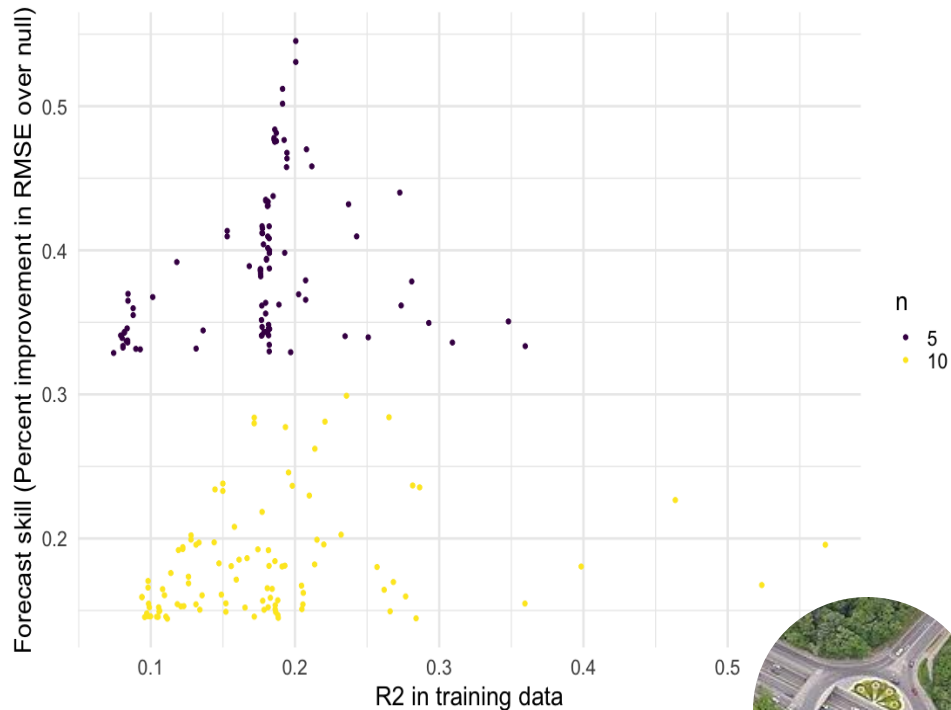
Most highly skilled forecasts
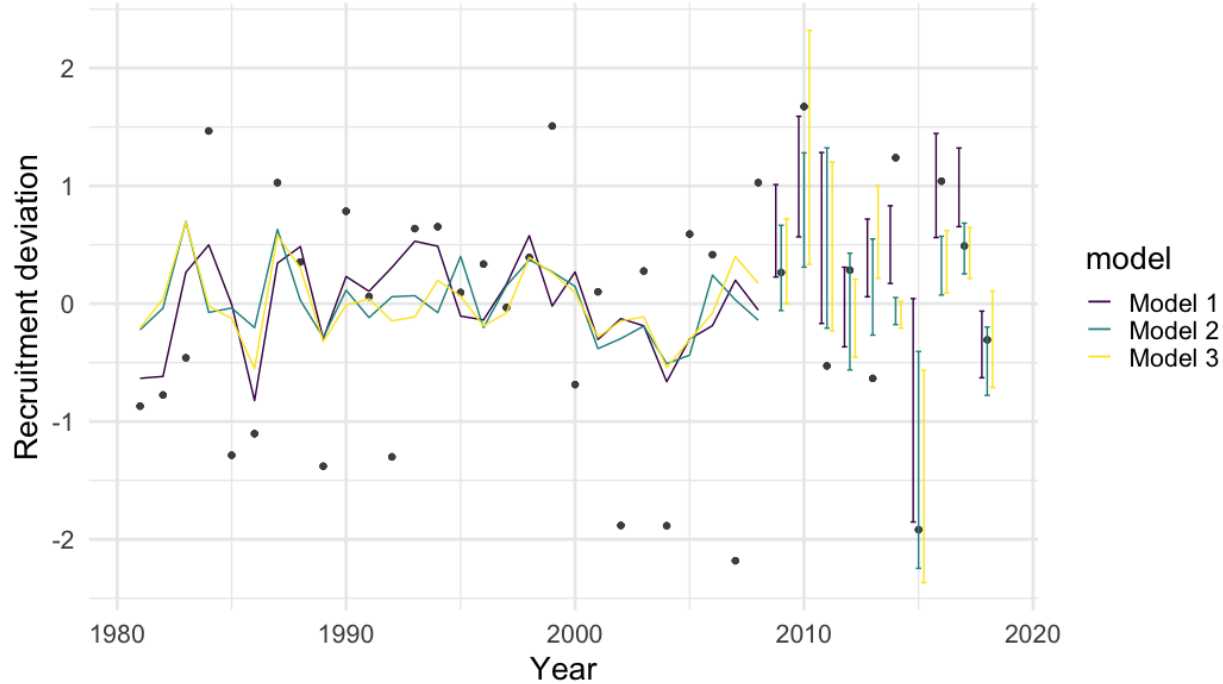
Indicators include:

Temperature/degree days

Upwelling (BEUTI)

Alongshore transport

Cross-shelf transport

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Next steps

- MSE: Develop recruitment projections from ROMS (Pozo Buil et al. 2021)

- Assessment: Use indicators that perform well to test in assessment and/or risk table

Conclusions

- Species- and life-history based ROMS/GLORYS indicator selection method validated

- Ecosystem indicators (larval stages) may be useful for hake age-0 recruitment prediction

- Recommend skill metrics and out-of-sample forecast windows that match intended operational use

- Need to adapt our expectations for stable/stationary statistical relationships between ocean indicators and recruitment variability

Thanks!

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