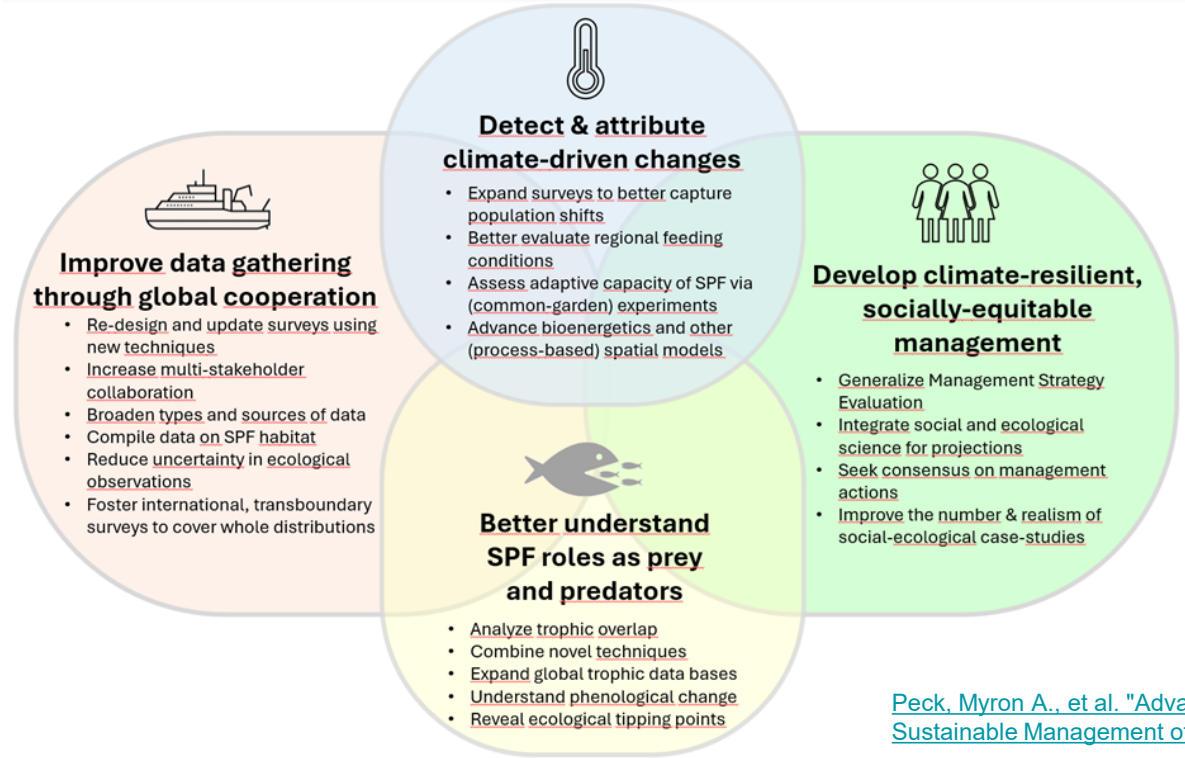
Testing the performance of small pelagic fish stock assessments, using an end-to-end model incorporating environmental and trophic interactions

Isaac Kaplan, Holly Perryman, Sarah Gaichas, Mercedes Pozo Buil, Stephanie Hopkins, Caitlin Allen Akselrud, Robert P. Wildermuth, Desiree Tommasi

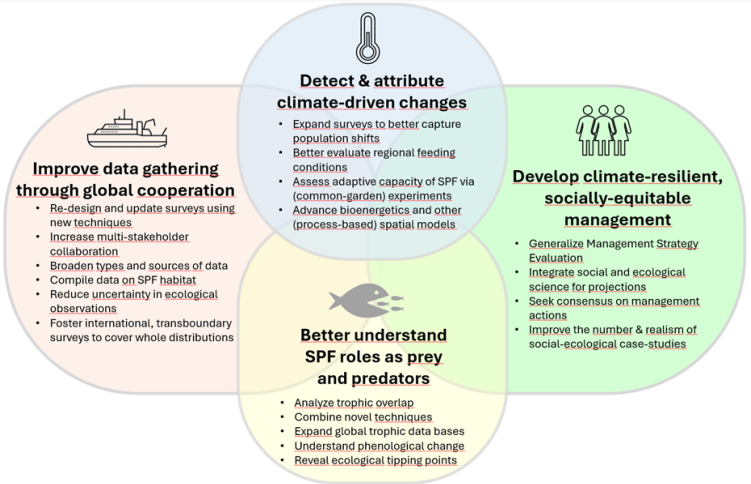
PICES ICES Small Pelagic Fish Symposium, May 7, 2026

CAFA
Climate and Fisheries Adaptation

Recommendations for future activities advancing science-based advice on small pelagic fish within complex social-ecological systems



Peck, Myron A., et al. "Advancing Ecological Understanding and Sustainable Management of Small Pelagic Fish." *Fish and Fisheries* (2025).



Generalize Management Strategy Evaluation

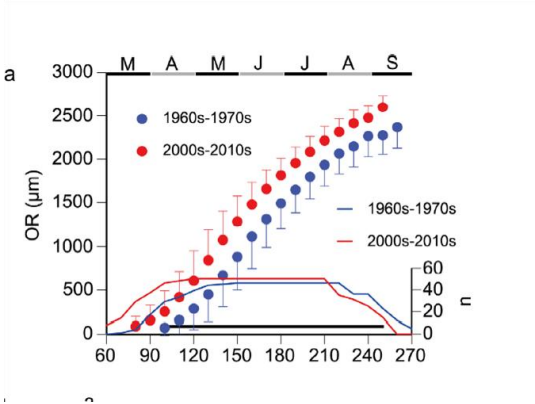
Integrate social and **ecological science for projections**

Peck, Myron A., et al. "Advancing Ecological Understanding and Sustainable Management of Small Pelagic Fish." *Fish and Fisheries* (2025).

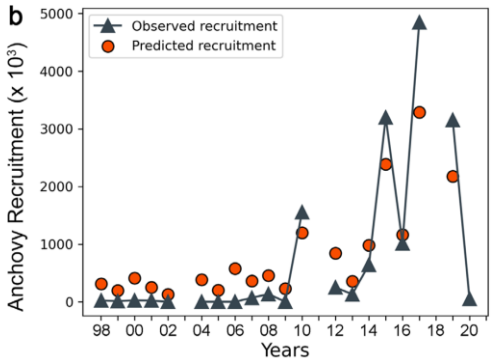
Small pelagic fish exhibit patterns of growth, recruitment, and mortality that vary in time and space, potentially challenging stock assessment

Generalize Management Strategy Evaluation

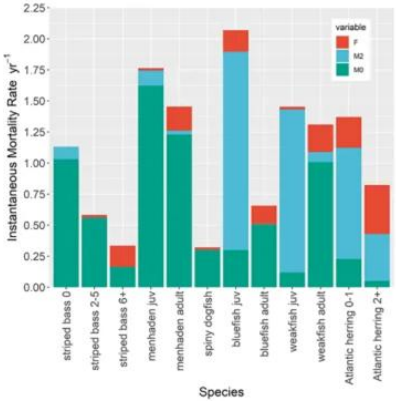
Integrate social and **ecological science for projections**



Growth (otolith radius)
Takahashi et al. *Marine Ecology Progress Series* (2024).



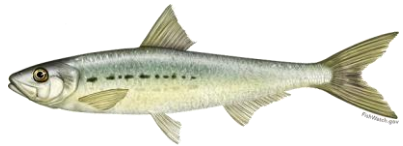
Recruitment
Ferreira et al. *Marine Ecology Progress Series* 741 (2024): 315-330.



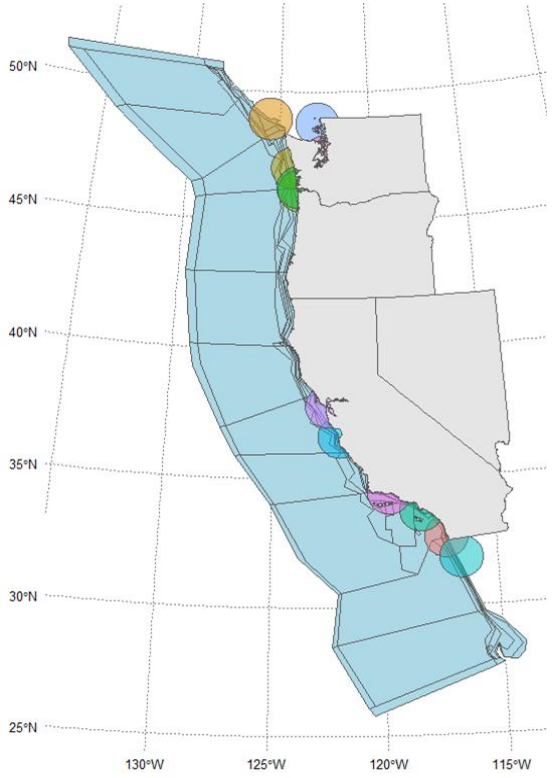
Mortality
Chagaris et al. *Frontiers in Marine Science* 7 (2020): 606417.

Testing the performance of small pelagic fish stock assessments in the California Current

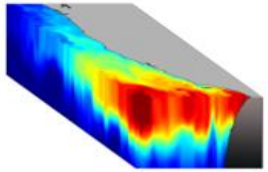
- **Test stock assessment performance under a changing climate**
  - **Operating model: Atlantis**
  - **Translation: AtlantisOM package**
  - **Stock assessment: Stock Synthesis**



Pacific sardine,
Sardinops sagax



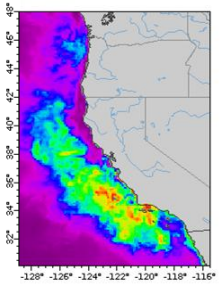
Operating Model: Atlantis



Updated oceanography and projections to 2100 (CMIP5, 3 ESMs)

Recruitment of CPS

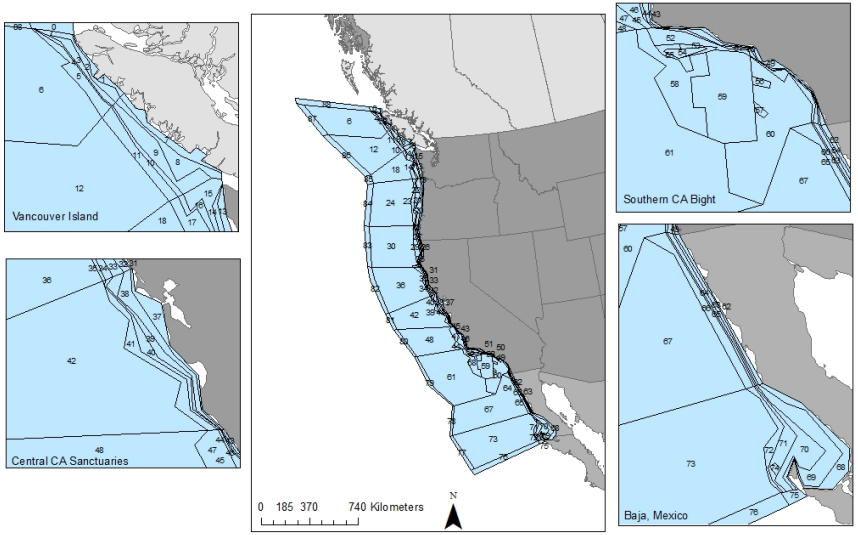
Updated recruitment projections from MICE (Koenigstein et al. 2022)



Dynamic species distributions, responding to climate

New fishing footprints

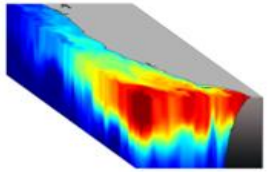
Liu et al. 2025 + slightly newer parameterization



89 spatial boxes

Liu et al. 2025 *Global Change Biology*

Operating Model: Atlantis



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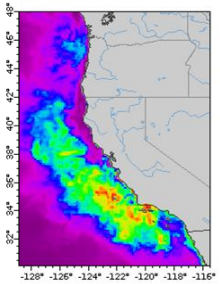


Dynamic species distributions, responding to climate

New fishing footprints

Liu et al. 2025 + slightly newer parameterization

Full food web: Time-varying spatial distributions, growth, natural mortality, recruitment

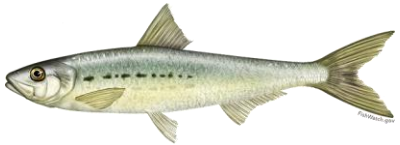
Catch (per fleet, port), size of catch

Projections of sardine + ecosystem, vary by (survey) area

89 spatial boxes

Liu et al. 2025 *Global Change Biology*

Translation: atlantisOM



Operating Model: Atlantis

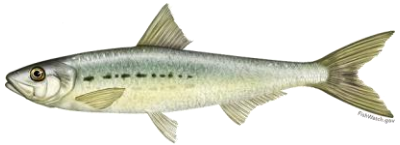
atlantisOM package translates sardine simulated 'data':

- **Time-varying spatial distributions, growth, natural mortality, recruitment**
- **Catch, length composition of catch**
- **Survey Abundance, size and age of survey catch**

Stock assessment Model: Stock Synthesis

https://sgaichas.github.io/poseidon-dev/atlantisom_landingpage.html

Translation: atlantisOM



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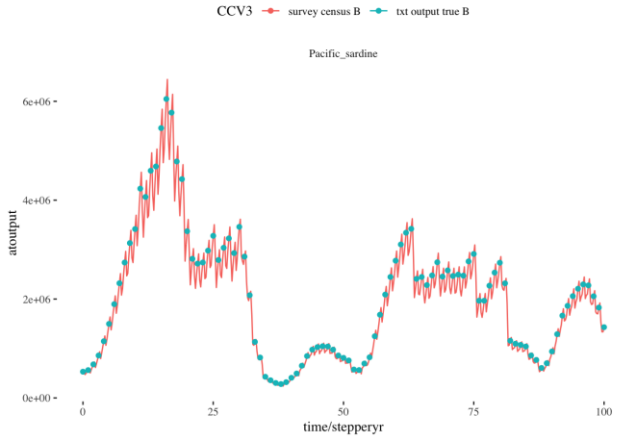

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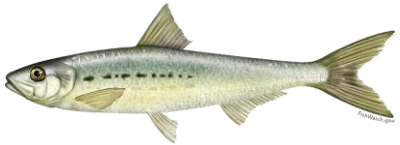


***Simulated sardine 'data'*:**

- survey biomass index
- survey length composition
- survey age composition (conditional catch at age)
- fishery catch (tons)
- fishery length composition
- fishery age composition

Parameters:

"Base model" estimates:

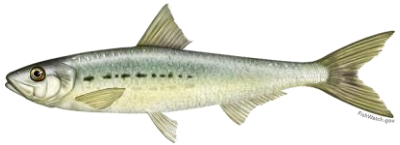
- unfished recruitment (R0)
- growth (max length)
- recruitment deviations

Given:

- maturity at age, weight-length relationship, selectivities, stock-recruit steepness

Methot and Wetzel (2013). Stock Synthesis. *Fisheries Research*

Stock assessment model: Stock Synthesis



Can alternate assessment options help cope with climate-driven patterns in growth, recruitment, and mortality?

Estimate:

- *Autocorrelation in recruitment*
- *Natural mortality*
- *time-varying growth*

Parameters:

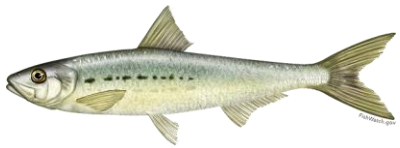
Estimate:

- unfished recruitment (R0)
- growth (max length)
- recruitment deviations

Given:

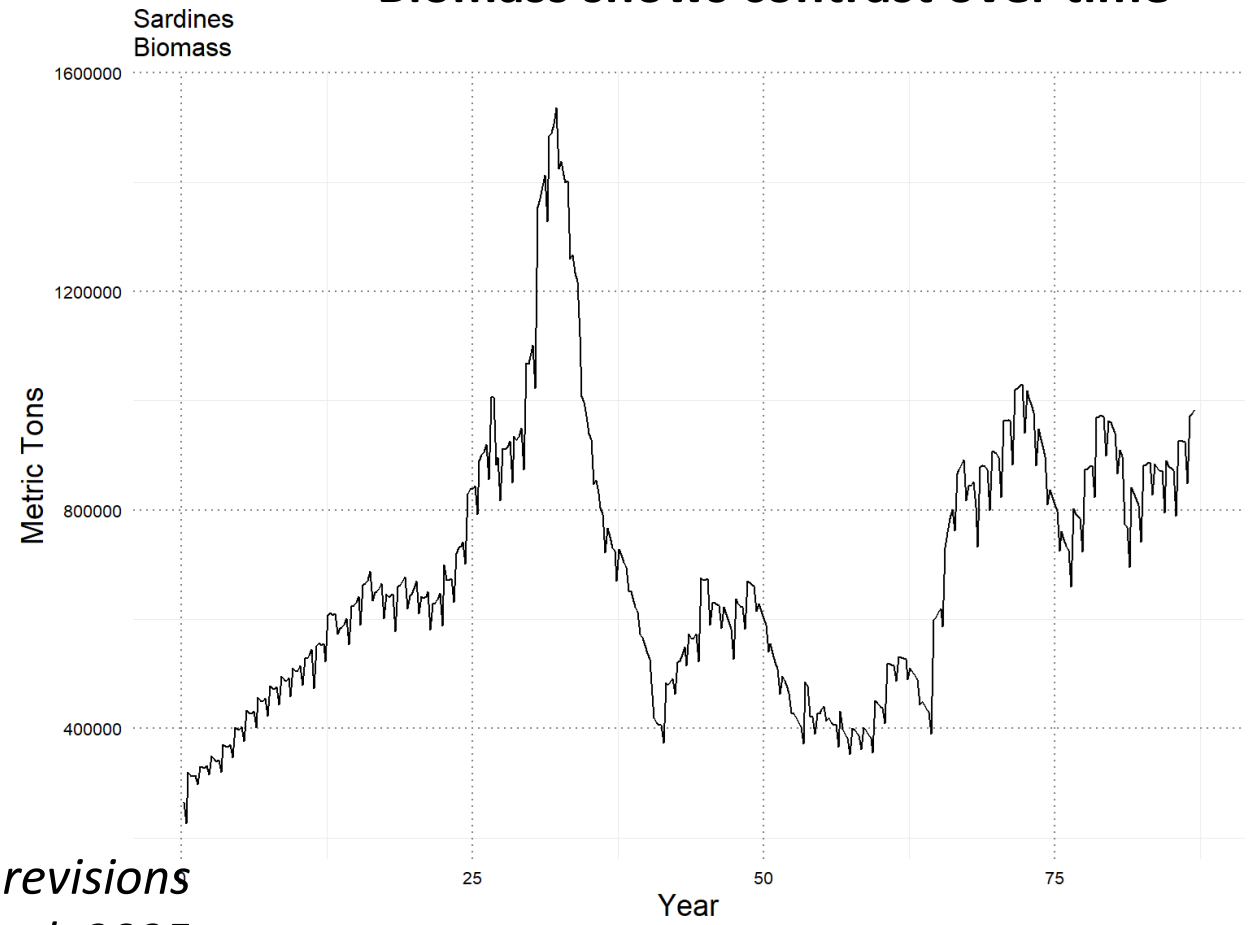
- maturity at age, weight-length relationship, selectivities, stock-recruit steepness

Results: Atlantis operating model exhibits **climate-driven** patterns in **biomass,** mortality, recruitment and growth

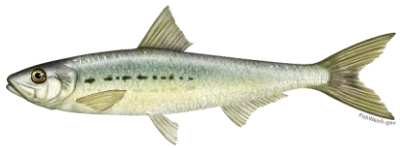


PY Hernvann/ Kaplan slight revisions to parameterization in Liu et al. 2025

Biomass shows contrast over time



Results: Atlantis operating model exhibits **climate-driven** patterns in biomass, mortality, **recruitment** and growth



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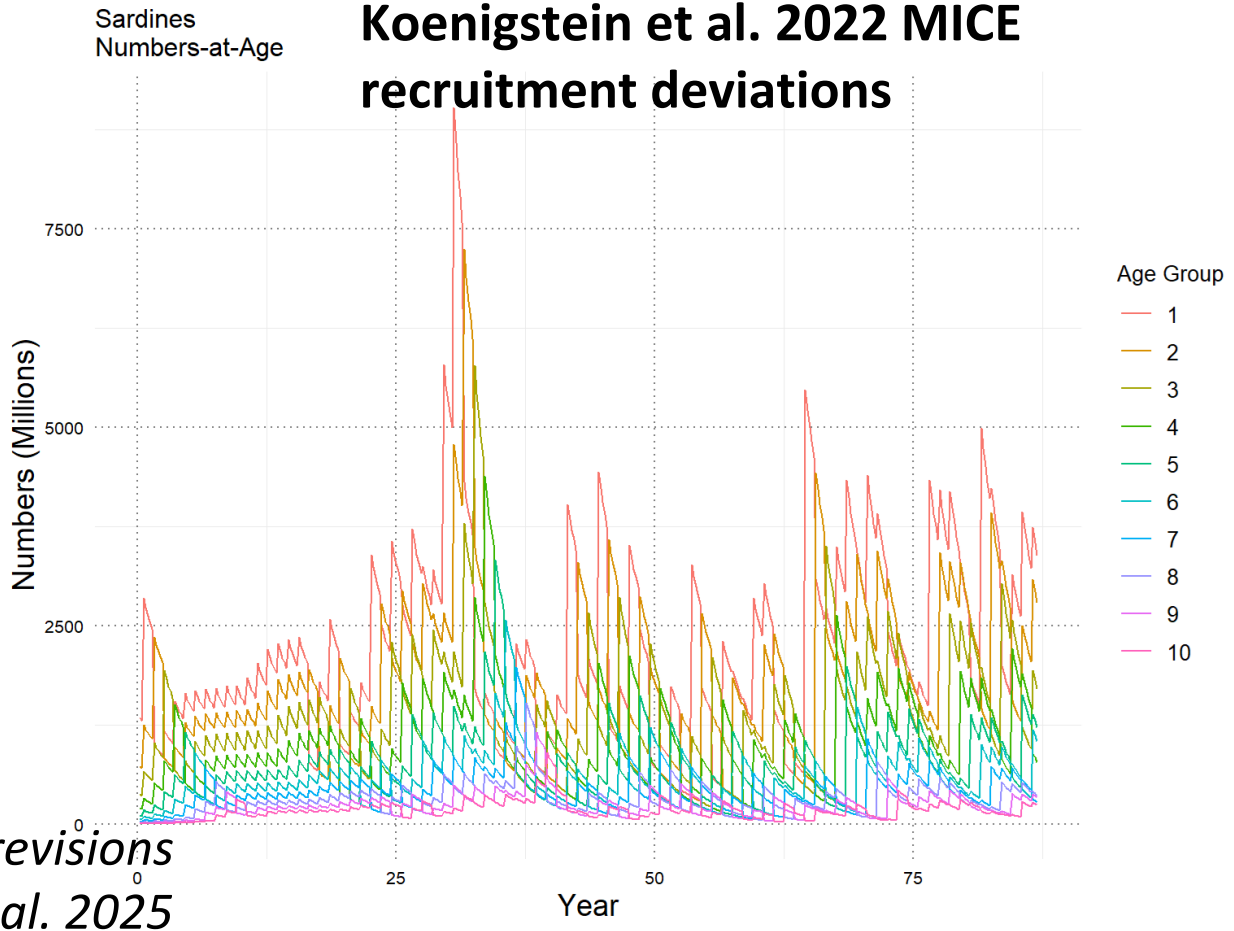
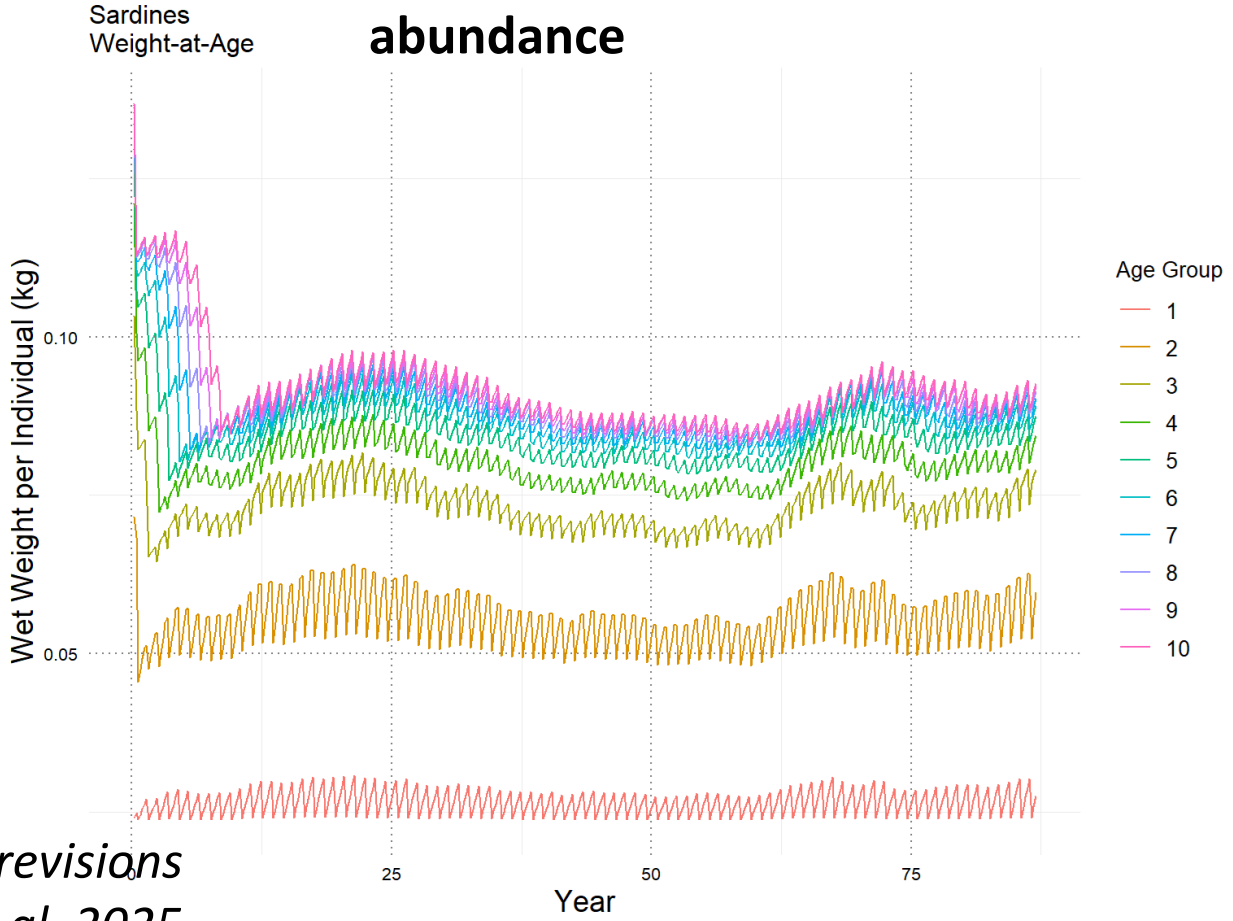
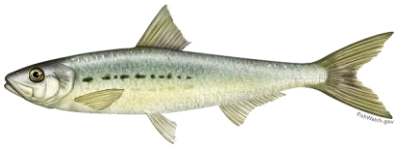
Recruitment variability – driven by Koenigstein et al. 2022 MICE recruitment deviations



Results: Atlantis operating model exhibits **climate-driven** patterns in biomass, mortality, recruitment and **growth**

Weight-at-age varies based on prey abundance





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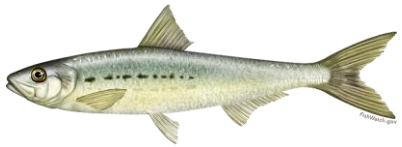
Results: Stock assessment model



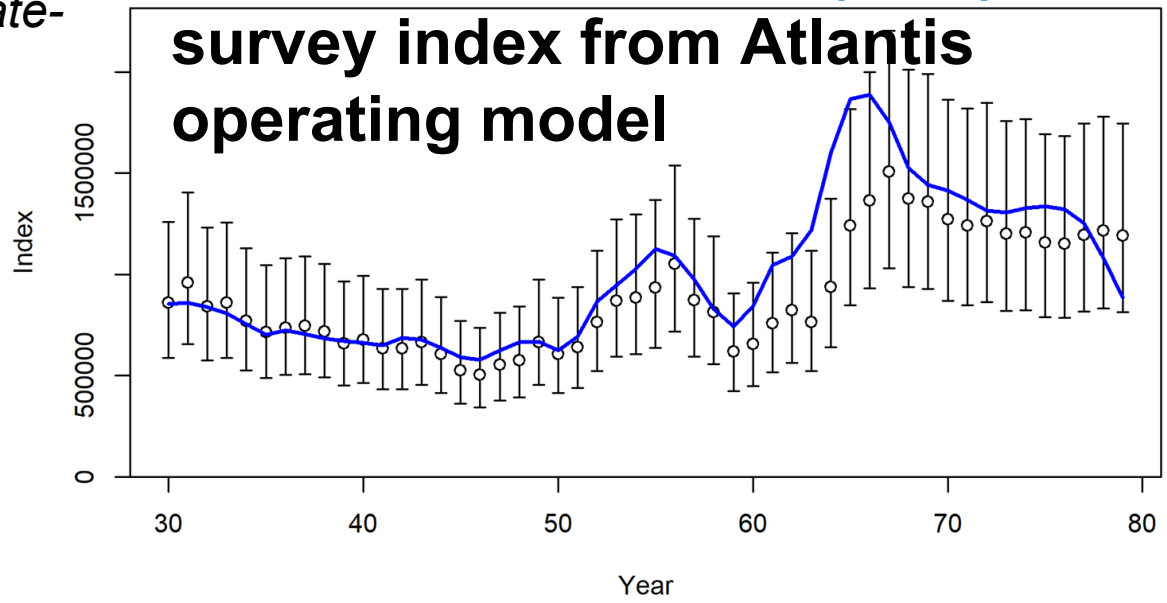
Can alternate assessment options help cope with climate-driven patterns in growth, recruitment, and mortality?

- ***Base Model***

Alternate models:

- *Autocorrelation in recruitment*
- *Natural mortality*
- *Time-varying growth*

Stock assessment fit (blue) to survey index from Atlantis operating model



Results: Stock assessment model

Stock assessment fit (green) to lengths from Atlantis operating model

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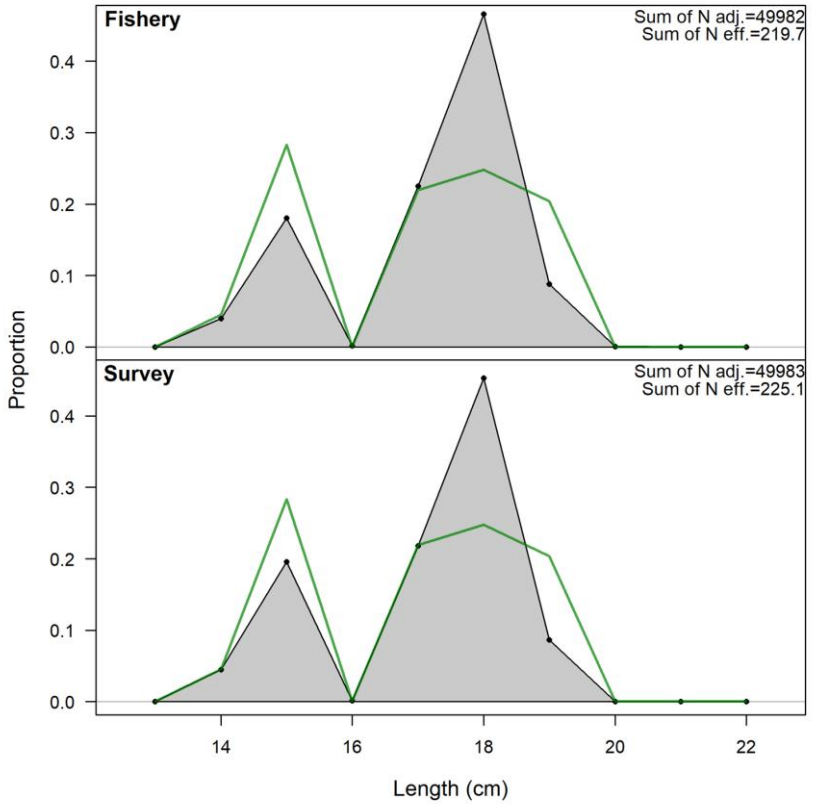

Results: Stock assessment model

Stock assessment fit (green) to ages from Atlantis operating model

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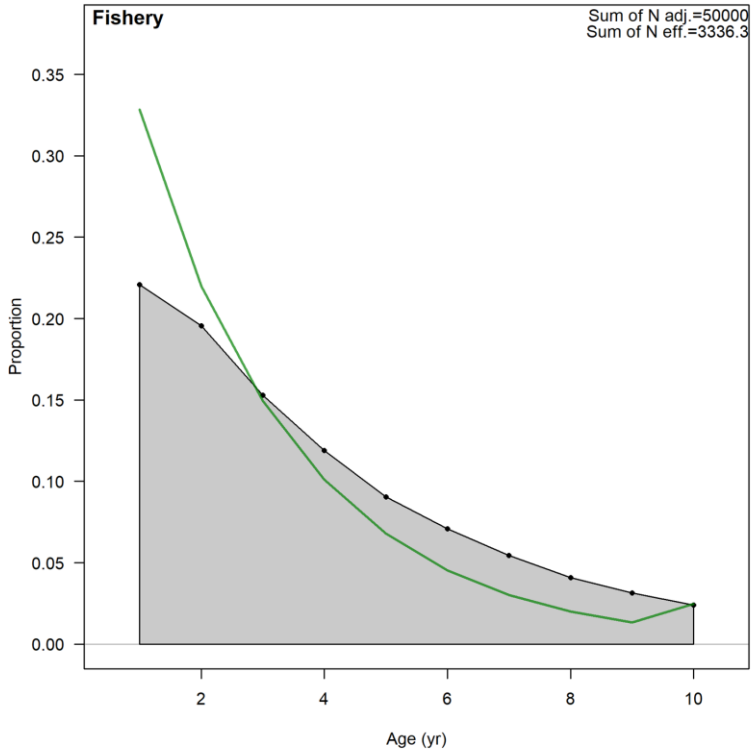


Results: Stock assessment model

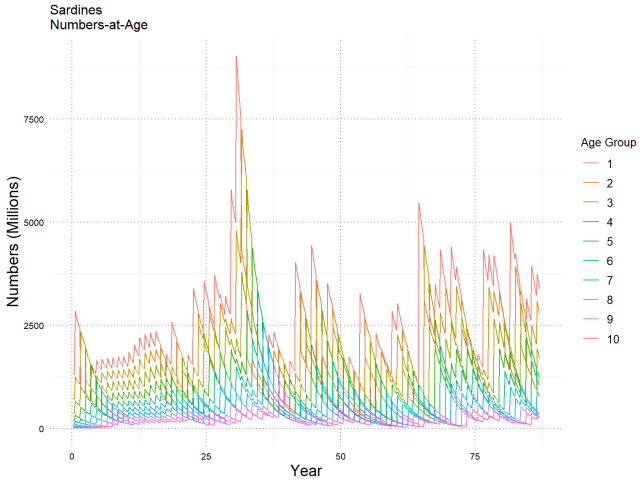
Can alternate assessment options help cope with climate-driven patterns in growth, recruitment, and mortality?

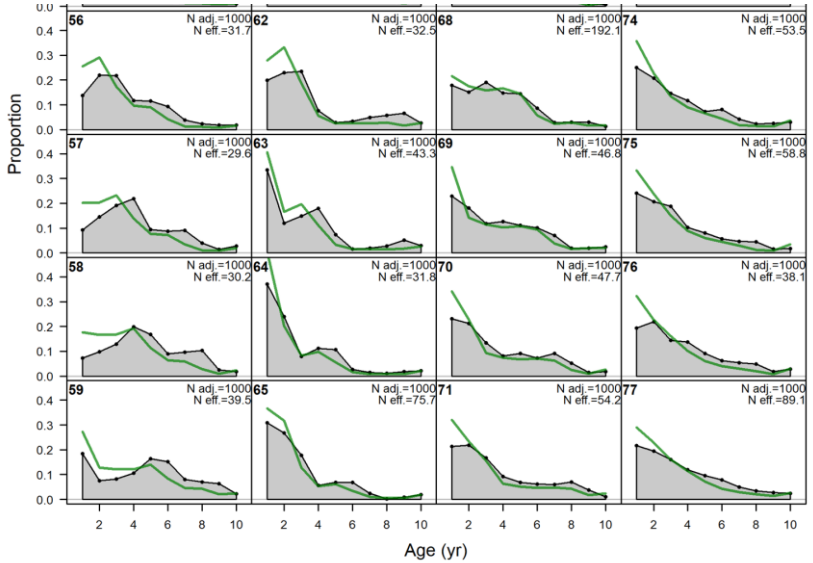
- *Base Model*

Alternate models:

- ***Autocorrelation in recruitment***
- *Natural mortality*
- *Time-varying growth*

Model converges. Some improvement in compositions, and survey fits.





Results: Stock assessment model

Can alternate assessment options help cope with climate-driven patterns in growth, recruitment, and mortality?

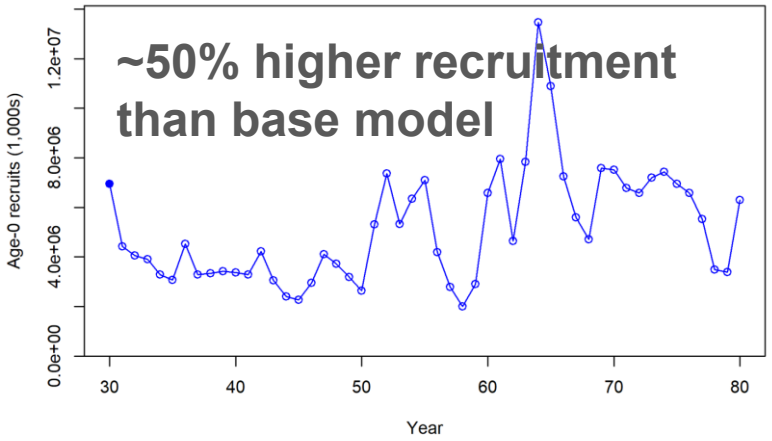
- *Base Model*

Alternate models:

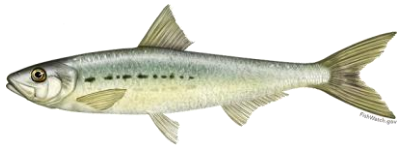
- *Autocorrelation in recruitment*
- ***Natural mortality***
- *Time-varying growth*

Poor convergence and excessive gradients for parameters

Model allows M to drift lower than 'truth', estimating higher recruitment to compensate



Results: Stock assessment model



Can alternate assessment options help cope with climate-driven patterns in growth, recruitment, and mortality?

- *Base Model*

Alternate models:

- *Autocorrelation in recruitment*
- *Natural mortality*
- ***Time-varying growth****

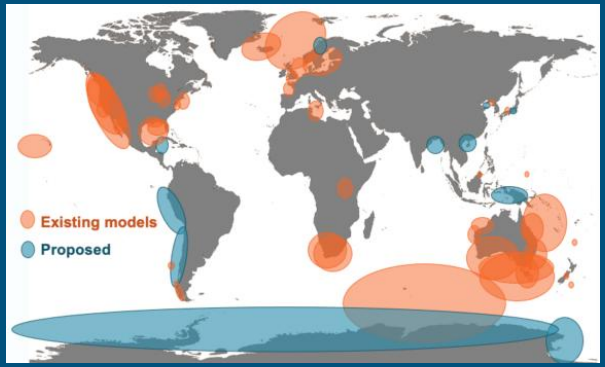
Results Summary: Objective function of stock assessment

	TOTAL Log Likelihood	Survey	Length comps	Age comps	Recruitment	Overall
Base model	98777.2	644.897	48650.6	49463.9	17.3124	Converges, despite variability
Estimate autocorr in recruitment	98025.8	430.787	47592.7	49971.1	31.0576	Converges. Some improvement in length and survey
Estimate M	98763.7	644.972	48643.2	49471.1	3.29194	**Poor convergence. Model allows M to drift low**

Next steps: *Testing the performance of small pelagic fish stock assessments, using an end-to-end model*

- Additional assessment performance metrics
  - Relative Error (Mazur et al. 2023, Li et al. 2021))
  - Mohn's rho for retrospective bias
- New alternate assessment models (time-varying growth, empirical weight-at-age)
- New Atlantis projections (3 ESMs, w/climate, w/o climate, and CMIP5 vs CMIP6)
- Combine alternate assessment models X new Atlantis projections

Summary: *Testing the performance of small pelagic fish stock assessments, using an end-to-end model*



- We can link Atlantis operating model via atlantisOM to Stock Synthesis
- Preliminary stock assessment fits suggest promise for methods related to sardine recruitment variability, but challenges with growth and M.
- Complex end-to-end ecosystem models such as Atlantis can serve as simulation test beds in the assessment context
    - Additional opportunities globally

FUTURE SEAS III

Ensuring resilience and adaptive capacity of California Current System fisheries under climate-driven ecosystem shifts

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Climate and Fisheries Adaptation