# Simulation Methods for the Assessment and MSE for Short-Lived Species

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bluematter

openMSE
www.openmse.com

https://blue-matter.github.io/slMSE

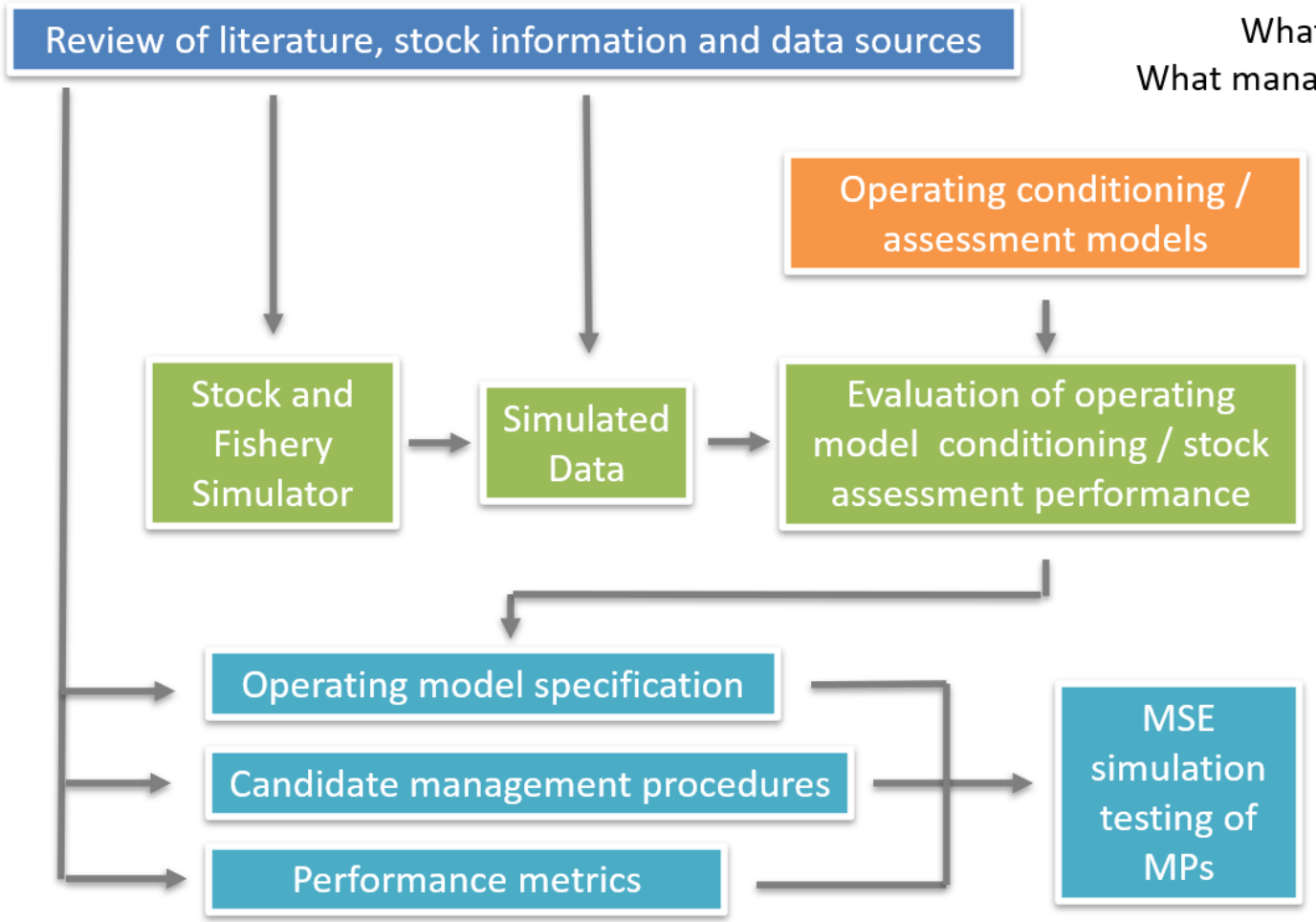
# Challenges in the Assessment and Management of Short-Lived Species

- High natural variability in stock level due to few cohorts (perhaps only one) limiting forecasting certainty and lessening impact of alternative management options;
- Fewer cohorts retain limited information about exploitation rate and hence the scale of the stock;
- Data lags that span a high degree of uncertainty in stock status (available data may be ‘out of date’ and uninformative about an appropriate current management policy);
- Management that does not occur frequently enough to adequately respond to changes in stock and fishery dynamics;
- Environmental drivers of stock level may be more influential than management decisions;
- Conventional fisheries management reference points may not be suitable.

slMSE is a R package for conducting simulations to answer two key questions:

1. What is an appropriate assessment model for a short-lived species?
2. Can we design a management procedures that can meet management objectives robustly given uncertainties in system dynamics?

# slMSE workflow



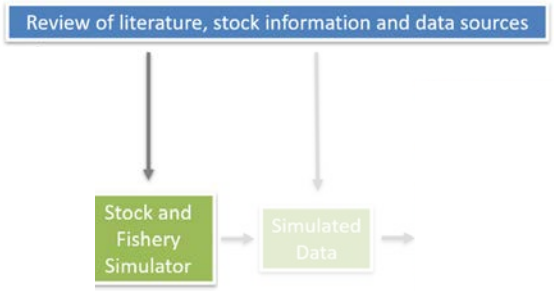

What are plausible system dynamics?
What data types are available?
What management levers could be applied?

**Model specification and fitting tools**
Model configuration and fitting

**Simulation Tools**
Given the plausible system dynamics and available data, is it possible to reliably estimate stock status, trajectory and establish reference points?

**MP and MSE Tools**
What combination of data and management procedure (empirical or assessment + HCR) can meet management objectives robustly?

# Simulated dynamics




**A quarterly, 3-stock, 3-area, 2 fleet demo:**

**(a-c)** Three phenotypes

**(d-e)** Varying survival

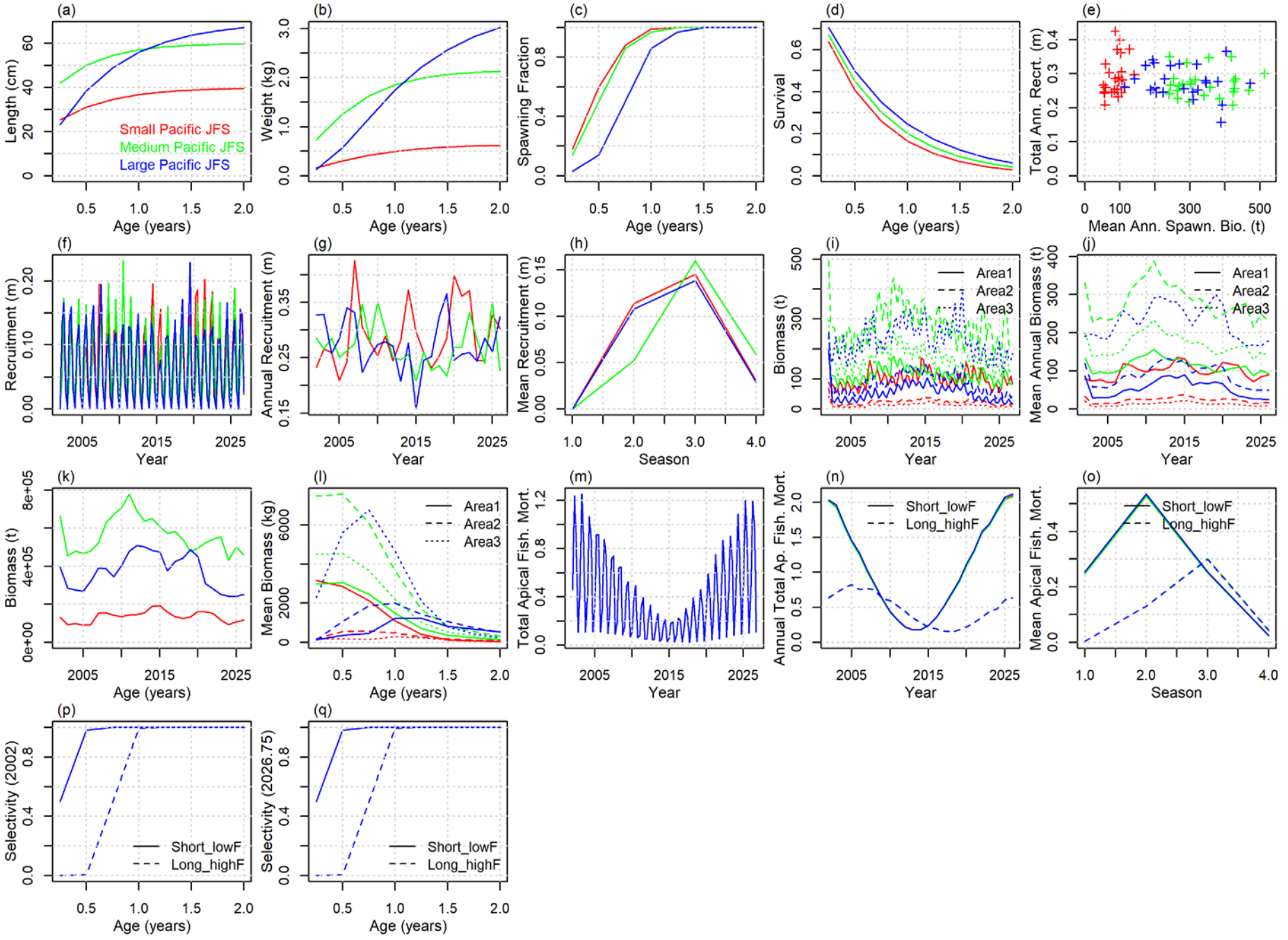
**(f-h)** All with seasonal recruitment

**(i-j)** Varying spatial distribution

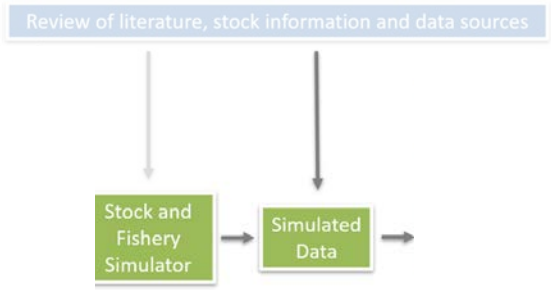
**(k-l)** Varying ontogeny

**(m-n)** Seasonal exploitation with strong historical contrast

**(p-q)** Time-invariant selectivity differs among fleets



# Simulated Data



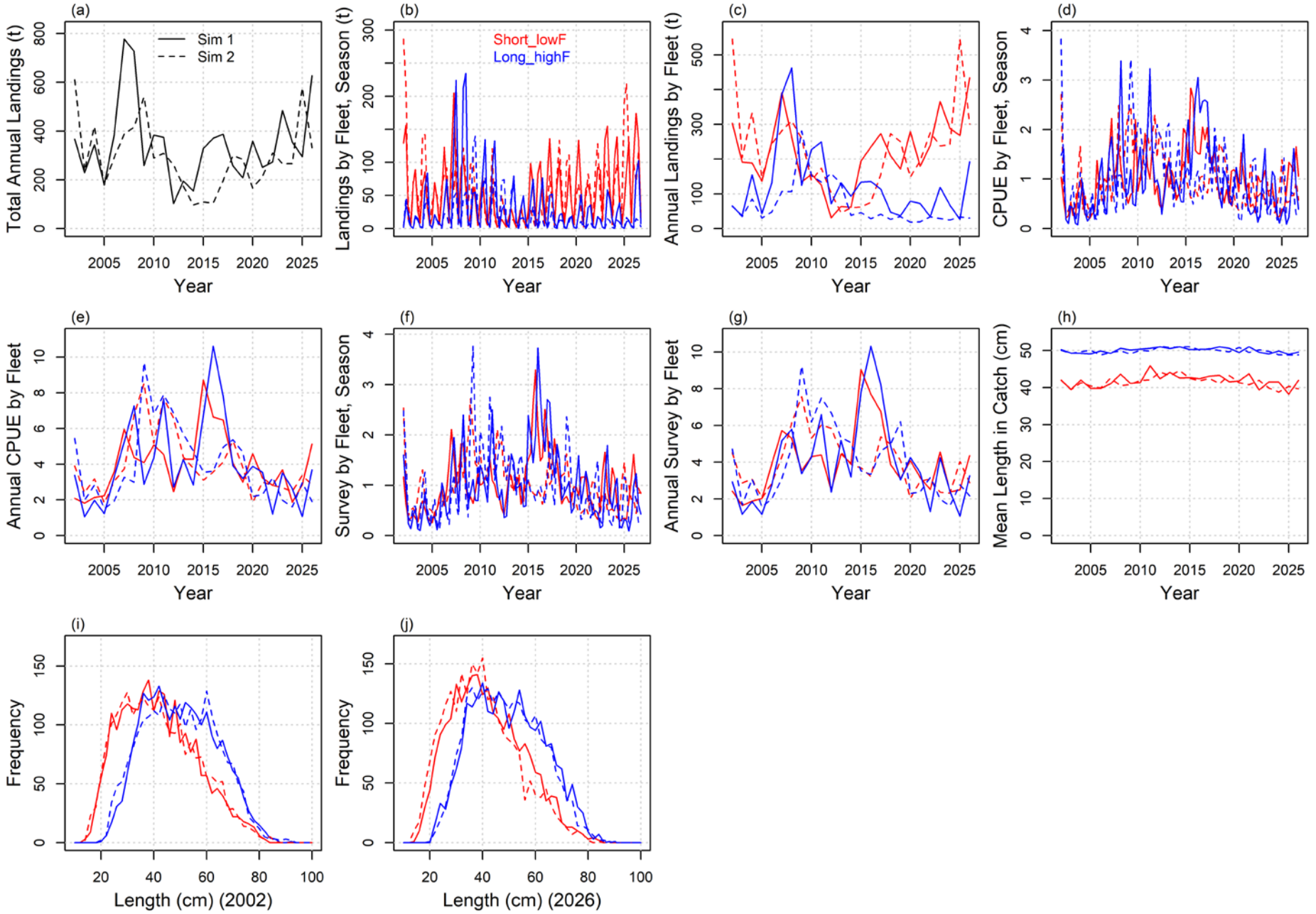

**Quarterly and annual data for two fleets.**

**(a-c)** Landings

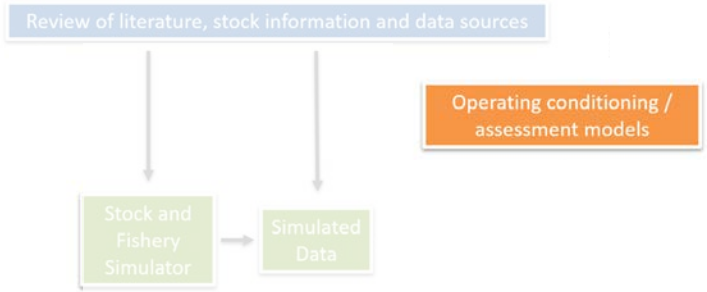
**(d-e)** Fishery-dependent vulnerable biomass index

**(f-g)** Fishery-independent biomass index

**(h-j)** Length composition data



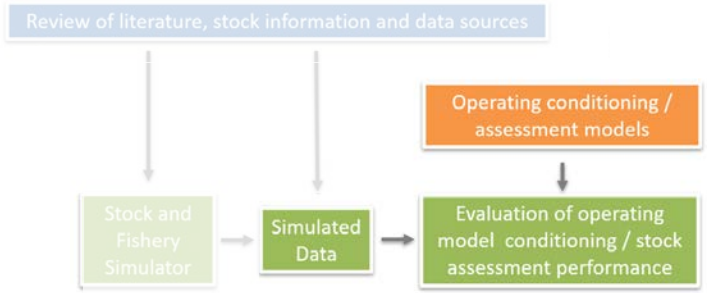
# Assessment Models (OM conditioning models)



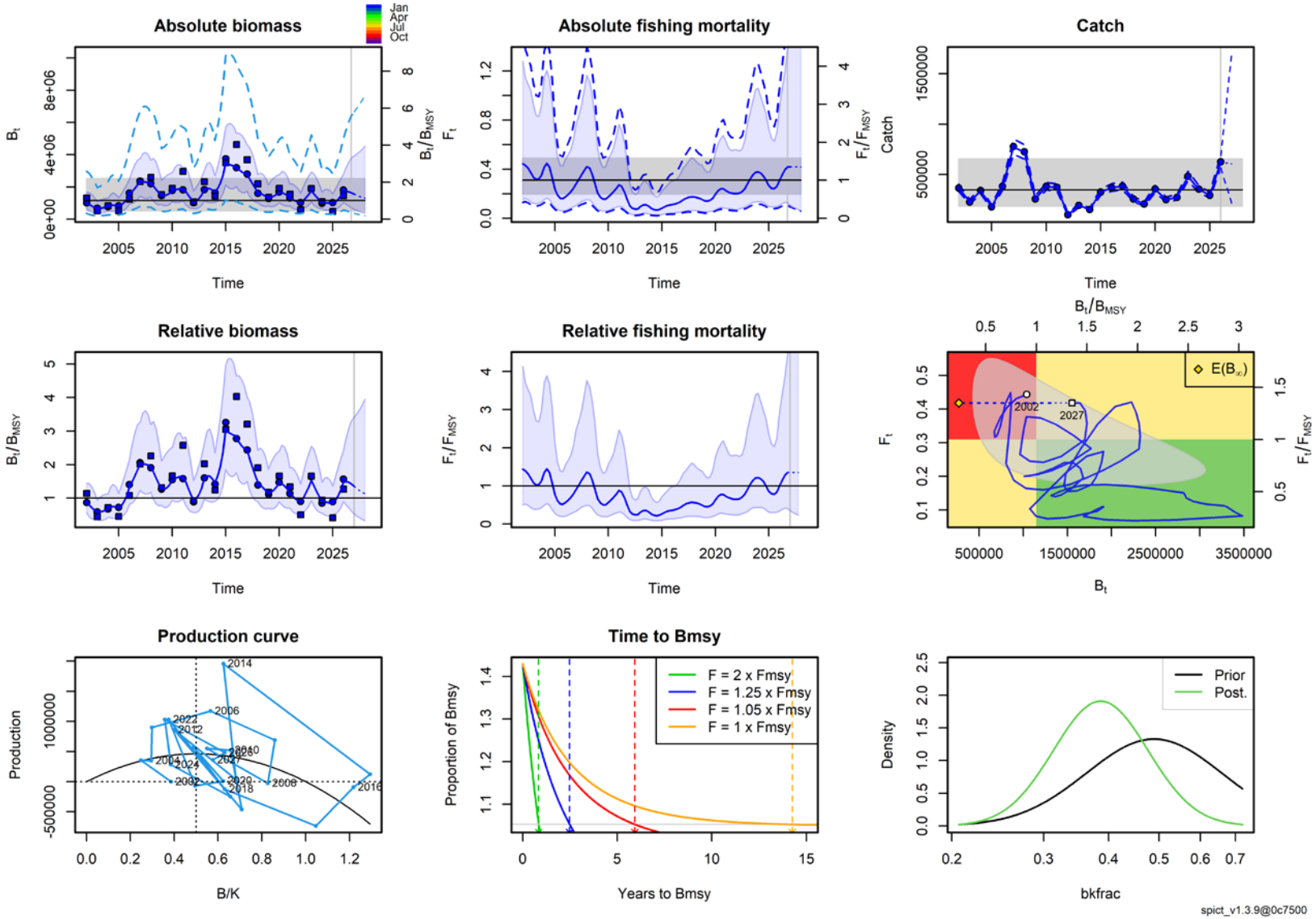

Four assessment methods were coded into slMSE that allow for control over their specification:

- State-Space Surplus Production (SPiCT) with annual time step;
- State-Space Surplus Production (SPiCT) with quarterly time step (estimating seasonality in production);
- Age-Structured Production Model (RCM) with quarterly time step, maturity, growth and selectivity specified;
- Statistical Catch-at-Length (RCM) with quarterly time step, maturity and growth specified, selectivity estimated.

# Assessment (OM conditioning models) Simulation Testing




Standard SPiCT output for fit to a single simulation ➡



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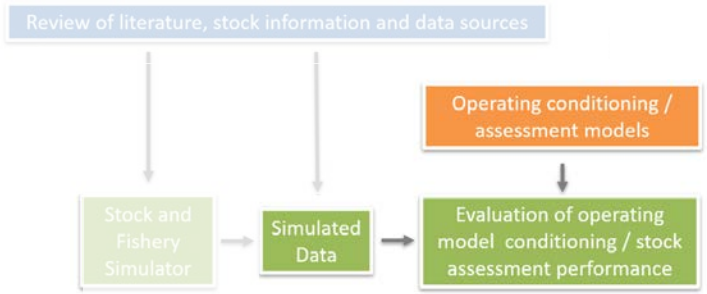
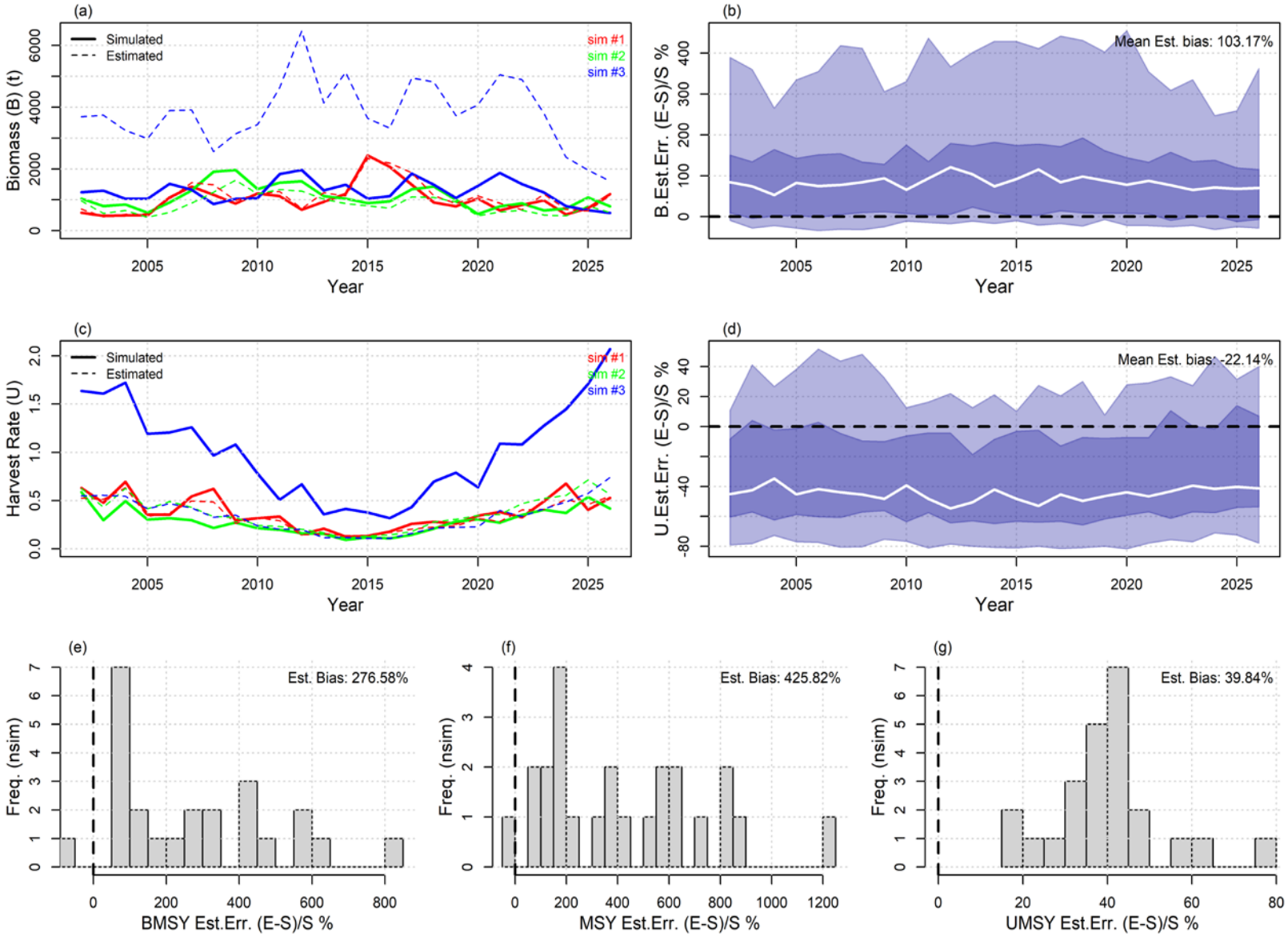



**Annual SPiCT surplus production (default spec) properties:**

**(a-d)** On average, a 100% overestimation of biomass and 20% underestimation of harvest rate.

**(e-f)** More exaggerated overestimation of BMSY and MSY

**(f-h)** Much more accurate characterization of UMSY (FMSY proxy) – inputs to UMSY calculations are just age-vectors that are inputs and not dependent on estimation.



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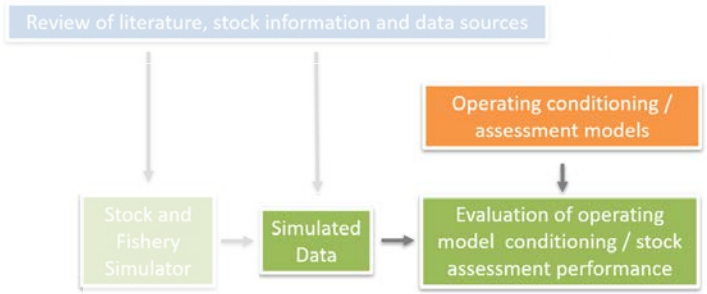
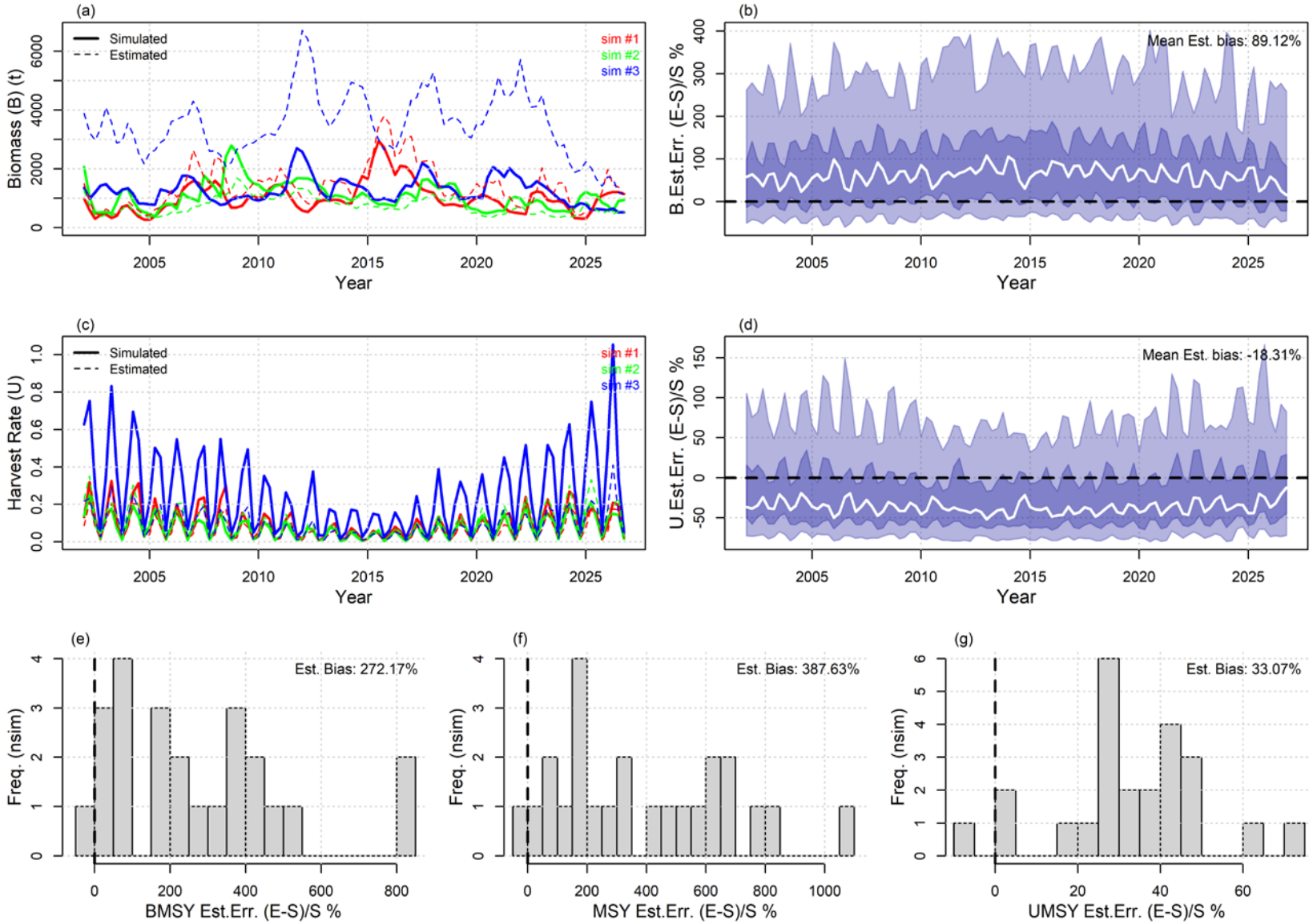



**<u>Quarterly</u> SPiCT surplus production (default spec) properties:**

- Slightly improved accuracy, but still unacceptable.
- These are results with the default arguments for SPiCT. These can be adjusted and explored to find those that provide better estimation performance.



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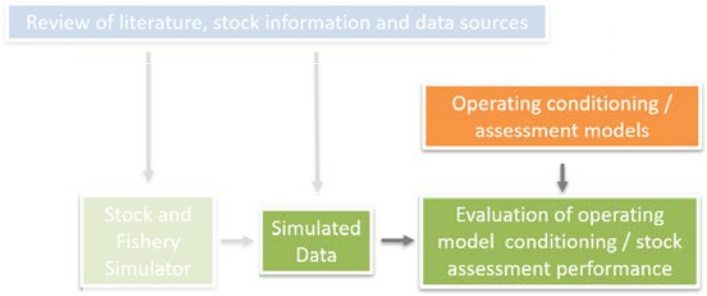
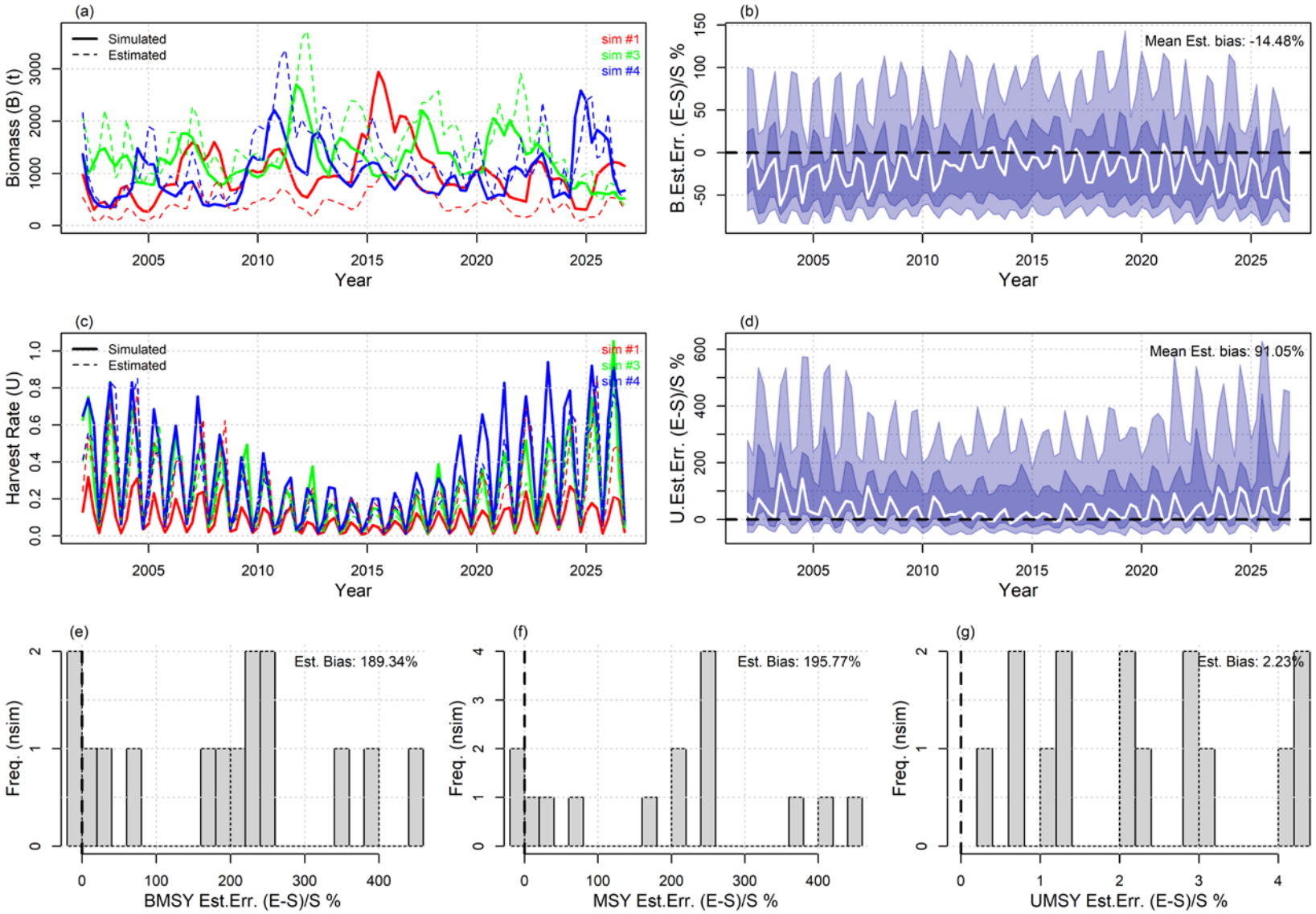
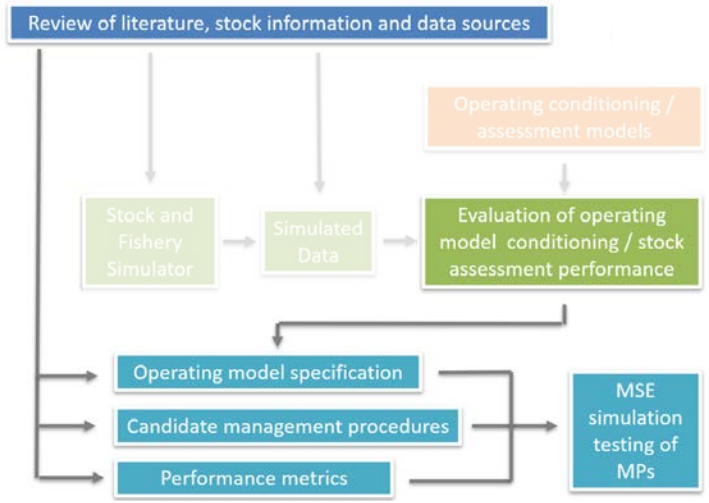


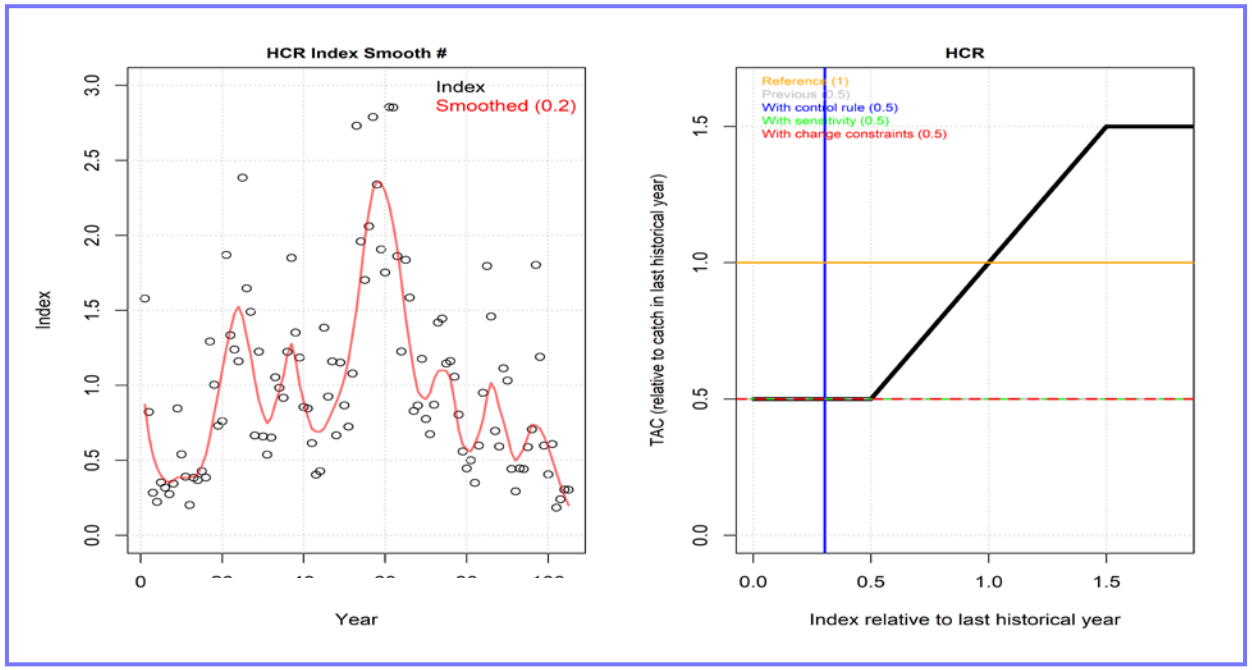

**<u>Quarterly RCM age-structured production model</u> (default spec) properties:**

- Slight underestimation of biomass, overestimation of harvest rate (U).
- Reference point estimation still strongly biased and imprecise.
- UMSY not estimated so both precise and has low bias.



# Operating Model Specification and MPs




**MSE steps:**

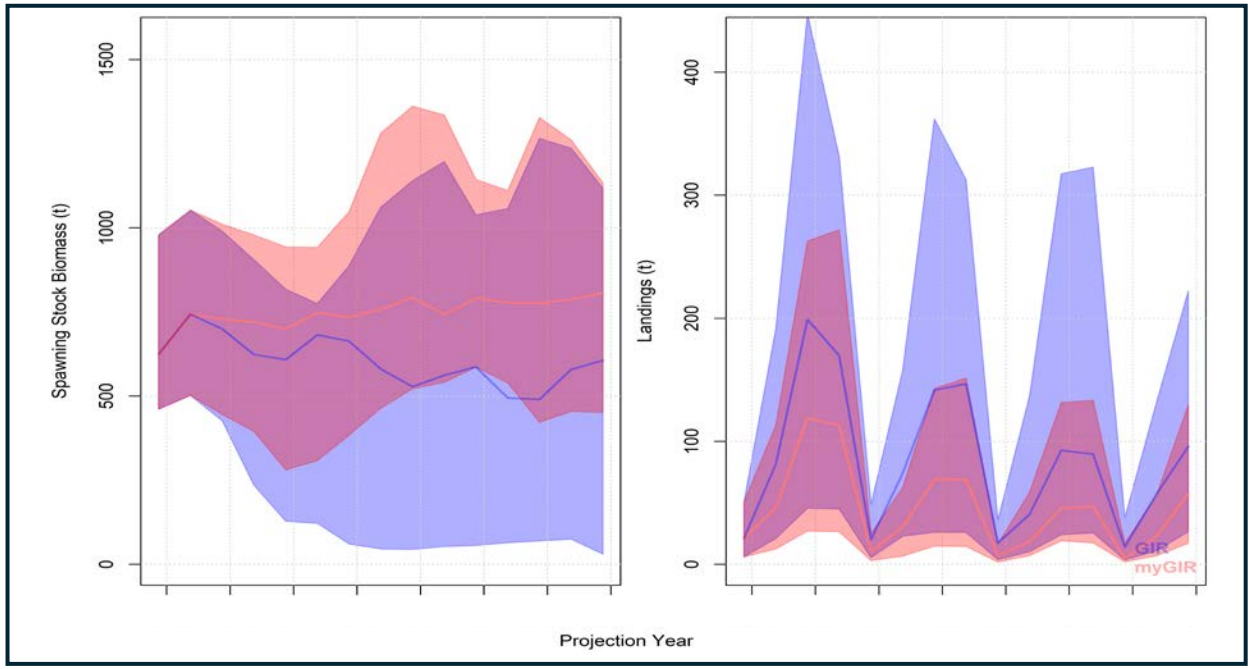
Use simulation-refined assessment model to estimate stock dynamics using real data.

slMSE 'Generic Index Ratio' MP

Make derivatives:

- GIR (upper control rule)
- modified 'myGIR' that has max catch control point at 80% current levels

Use OpenMSE to conduct closed-loop sim testing



# slMSE Summary

- Rapidly create complex multi-stock (or phenotype) and multi-fleet OMs with spatial dynamics such as ontogeny and seasonality.
- Test estimation models typically applied in the assessment of short-lived stocks and refine input parameters to improve estimation performance.
- Condition operating models using refined estimation models  and real data.
- Test and refine responsive management procedures.
- NEXT STEPS: work with RFMO scientists to develop worked case studies for short-lived species of interest.

For more information including code examples please visit the project page:
https://blue-matter.github.io/slMSE

# Acknowledgements

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OpenMSE continues to be developed with support by The Ocean Foundation (OpenMSE version 2.0 coming soon!)