
INTERNATIONAL PACIFIC HALIBUT COMMISSION

# Dynamic Reference Points and their importance for the next generation stock assessment model

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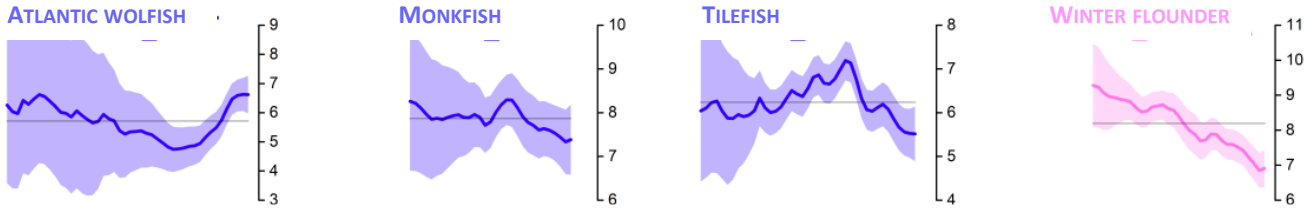
# Outlines

- Changes in Productivity
- Reference Points:
  - Static Reference Points
  - Dynamic Reference points
- Pacific Halibut as a case study
- Conclusions

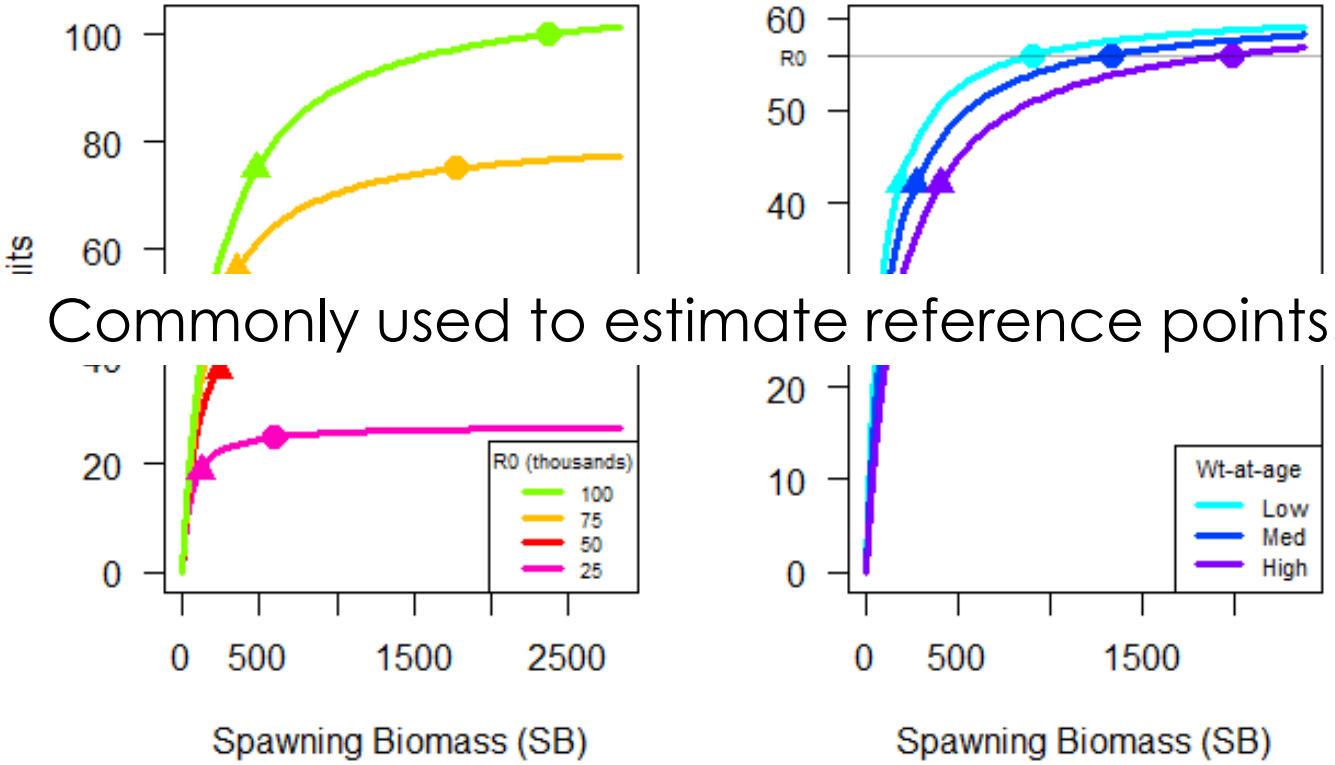
# Productivity changes (or alternative states)

- Low-frequency.
- Environmental and biological changes:
  - Habitat
  - Food availability
  - Predator-prey dynamics
  - Body size
- Effect on carrying capacity, growth, maturity, weight at age/length, mortality, egg-production (recruitment).




Extract from Tableau *et al*, 2018

# Stock-recruitment curve




Commonly used to estimate reference points.

# Reference points commonly used

- Maximum Sustainable Yield (MSY)
- Spawning Potential Ratio (SPR)
- Depletion based (e.g. Relative Spawning Biomass - RSB):
  - biomass based reference points that define a reference level of depletion;
  - Calculated as the ratio of the current ($B_{current}$) to a reference biomass level;
  - $SB_0$

# Reference Points (1)

Static Reference Points *vs* Dynamic Reference Points

- Static Reference Points:
  - Fixed throughout the whole time series;
  - Based on stationary stock-recruitment relationship.

# Reference Points (2)

Dynamic Reference points

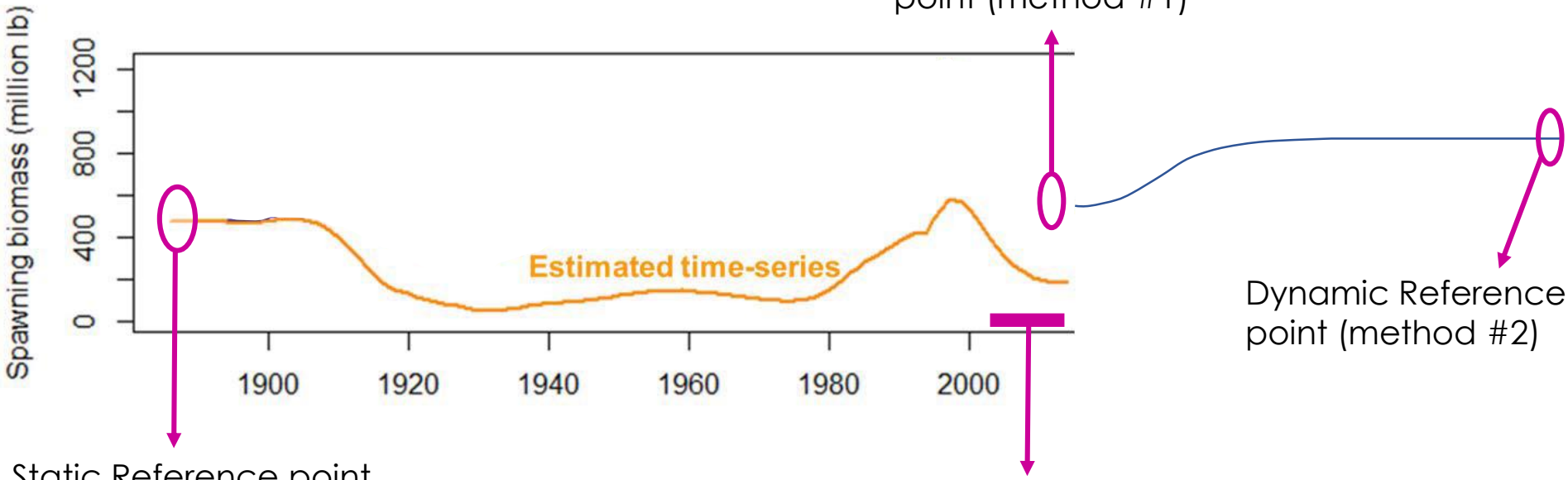
- Method #1:
  - Set fishing = 0 and re-calculated population trajectory;
  - Stock-recruitment relationship, recruitment deviation and all other parameters equal to original estimates;
  - Yearly productivity;
  - Change through time based on productivity;
  - Take into account cohort strength.

Method #2:

- Change through time based on defined regime/state;
- Equilibrium calculation;

- Can use single year conditions; **or**
- Can use average conditions (recruitment, weight at age, maturity…) from *n* years.

# Dynamic reference points




Dynamic Reference point (method #1)

Dynamic Reference point (method #2)

Static Reference point

Dynamic Reference point (method #2)

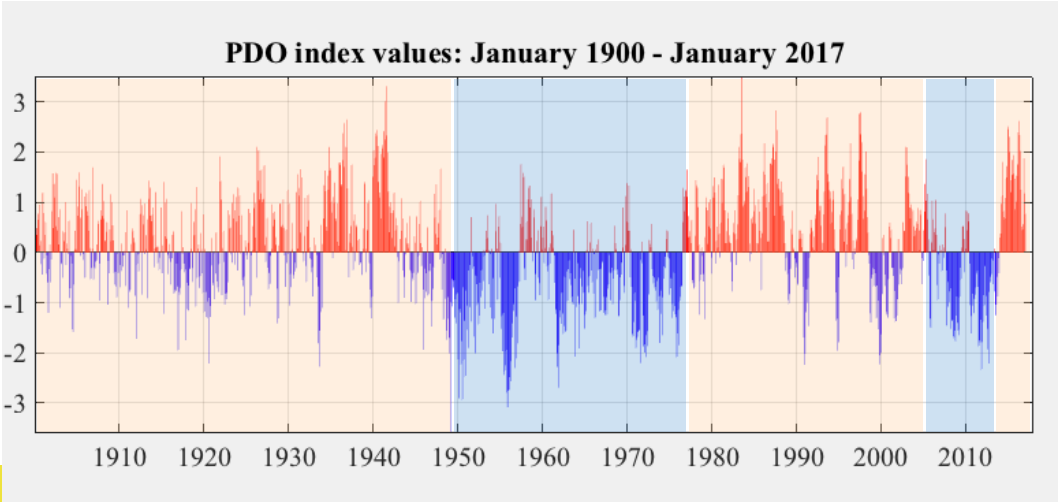
Stewart and Martell, 2013

# Dynamic reference points: caveats

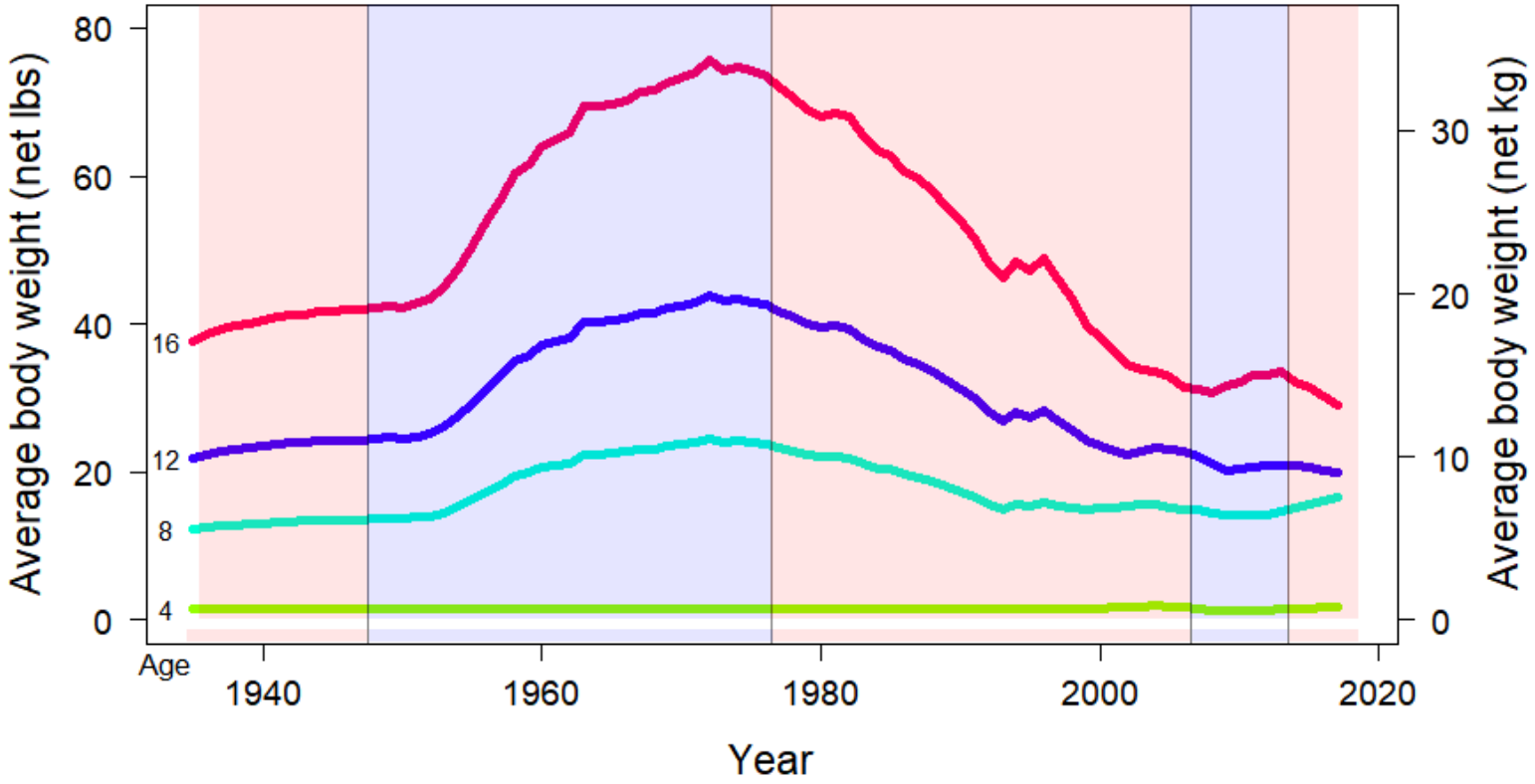
- Several papers have discussed dynamic reference points.
- General caveats:
  - Needs long time series;
  - Stock-Recruitment relationships are often poorly defined;
  - Detection in regime shifts not so straightforward (effect of management? Effect of fishing?);
  - Predictions are difficult;
  - What if relationship breaks or change?
  - Poor performances if productivity changes are wrong.

# Pacific Halibut as a case study

- Non-stationary stock.
- Average recruitment fluctuates between periods of high- and low- regimes.
- Relationship with Pacific Decadal Oscillation (PDO).



# Productivity of Pacific Halibut



# Dynamic Reference Points for Pacific Halibut

- Purpose:
  - provide a basis for defining a target reference point
  - to investigate variability in reference points given
    - changes in productivity and selectivity
    - different types of uncertainty
- Reference points considered: $SB_0$, MSY, $RSB_{MSY}$, $SPR_{MSY}$

# Dynamic Reference Points for Pacific Halibut

- Methodology:
  - Equilibrium model
  - 2018 assessment model
  - Coastwide MSE operating model

- Main sources of variability considered:
  - Environmental regimes (high or low unfished average recruitment)
  - Weight at age
  - Selectivity
  - Steepness
  - Natural mortality

# Dynamic Reference Points for Pacific Halibut

## Equilibrium model

- Grid of scenarios across selectivity, weight at age, steepness, environmental regimes and M.

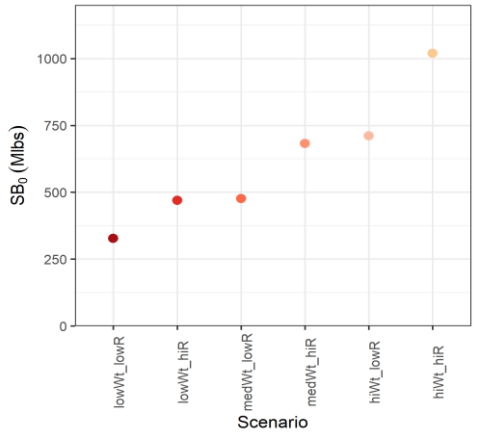
## 2018 Ensemble assessment

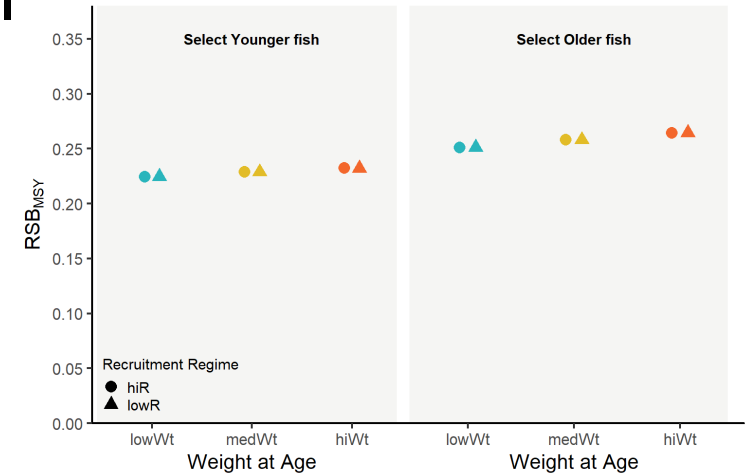
- Used retrospectively;
- Weight-at-age and selectivity for the associated year;
- R0 from the current regime;
- No estimated uncertainty for each year.

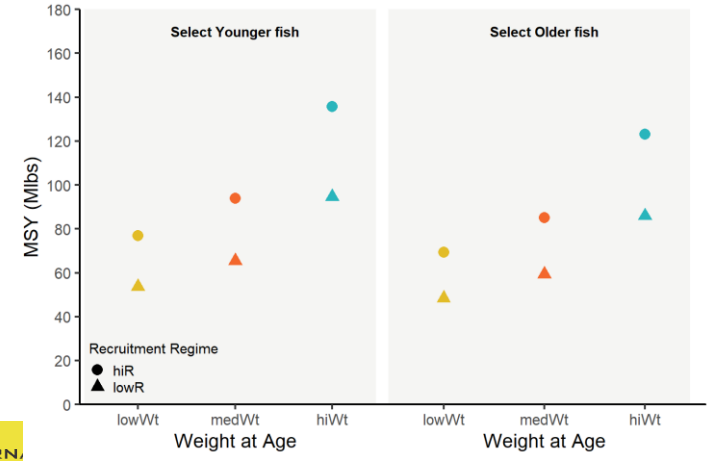
## MSE Operating Model

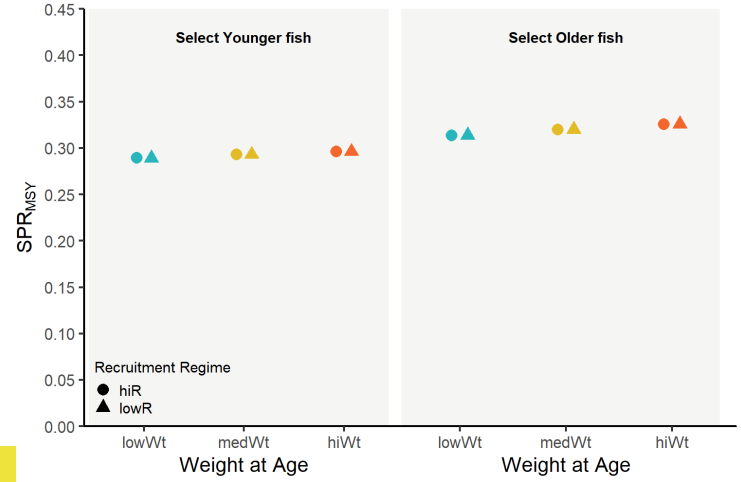
- Short and long coastwide model from 2018 ensemble;
- 100 years projection;
- 500 simulations;
- Low and high regime;
- Weight at age modelled as a random walk, and changes in selectivity as a function of weight at age.

# Results: Equilibrium model

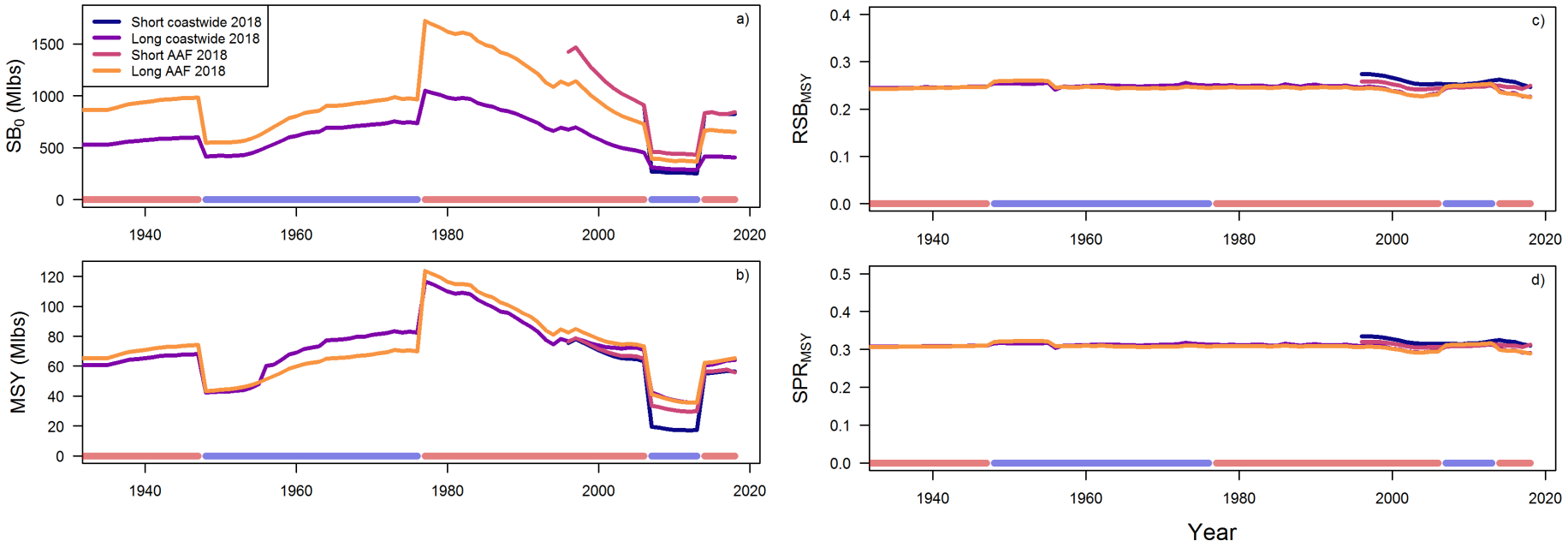


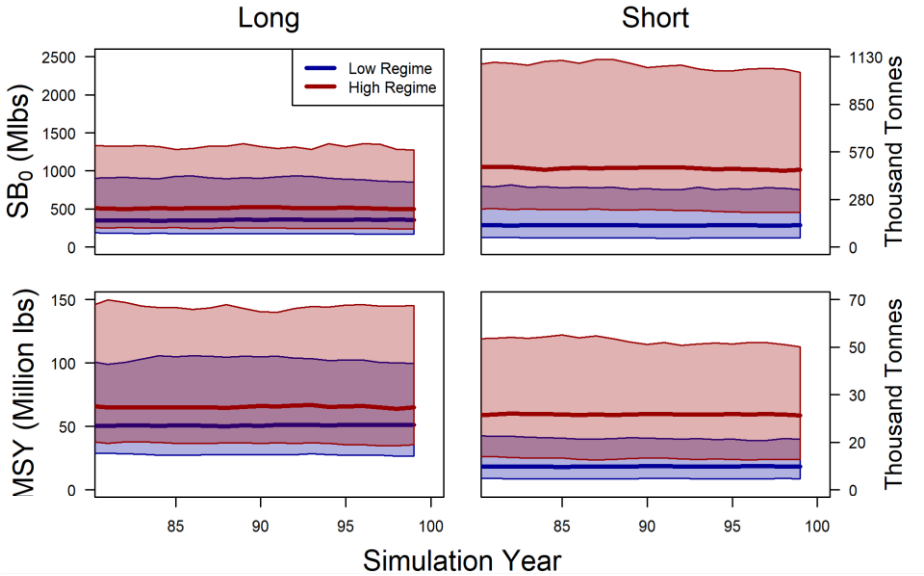



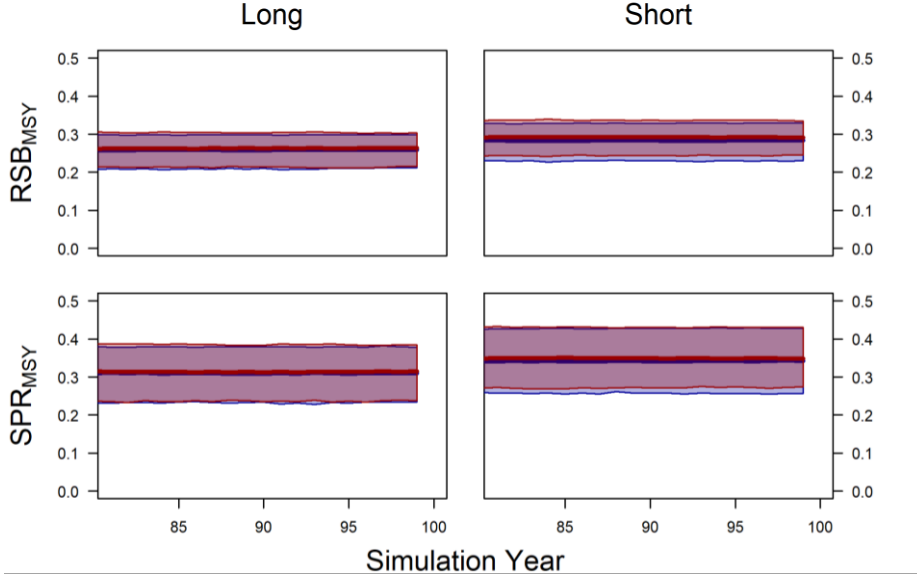



# Results: stock assessment models (SS)



# Results: MSE operating model



# Conclusions

- $SB_0$ and MSY are highly variable depending on the regime;
- $RSB_{MSY}$ and $SPR_{MSY}$ are more stable;
- Overall uncertainty captured by all models is similar.

# General discussion

- Beneficial for non-stationary stocks.
- Caveat: dynamics must be identified correctly.

- Applicability depends on management specific conditions.
- Next generation assessment model would help understand if useful for a stock: beneficial to have both static and dynamics.
- Next generation assessment model would need capability to compare and transition among reference points calculations.
- Variance (and coviarance) estimates essential.

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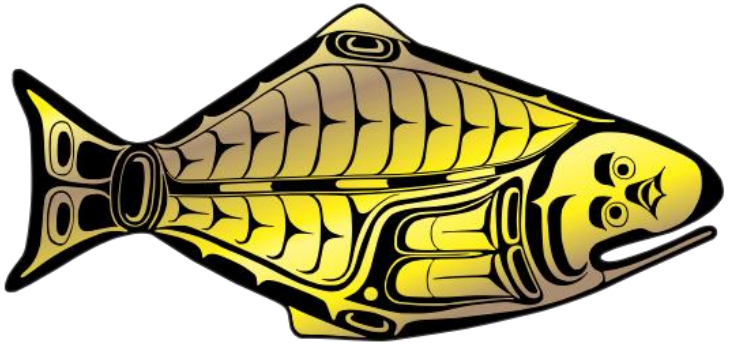

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