# USE OF PARAMETRIC BOOTSTRAPPING TO GAUGE THE SIGNIFICANCE OF RETROSPECTIVE PATTERNS IN STOCK ASSESSMENTS

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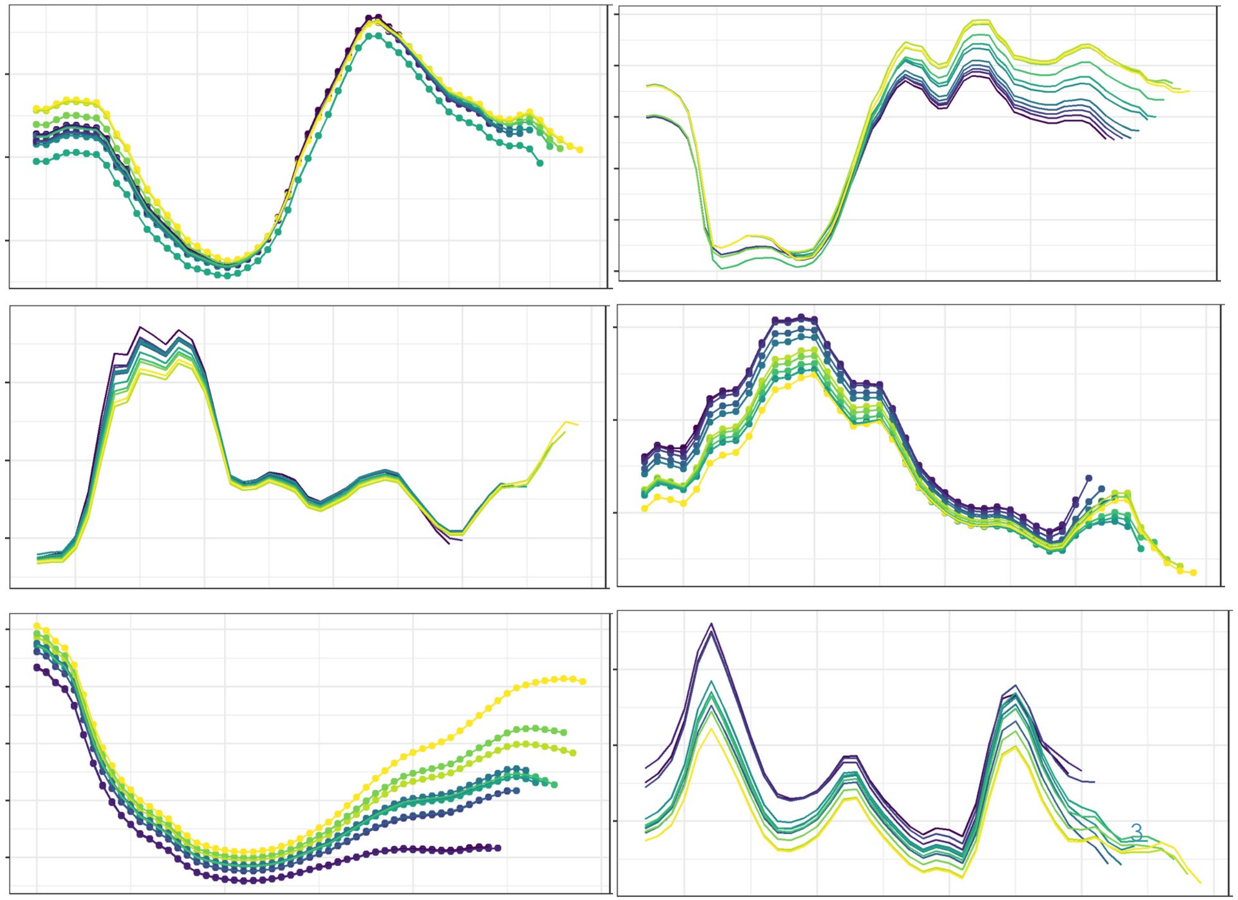
# OUTLINE

- Why use retrospective patterns as a assessment model diagnostic?
- Current method used to determine retrospective pattern significance?
- Propose a new approach
  - Describe the procedure
  - Present results from two case-studies
- Provide guidance about when to use the proposed approach

# RETROSPECTIVE PATTERN AS A DIAGNOSTIC

- Measure internal consistency of an assessment model as new data are added
- Lack of consistency indicates some model misspecification
  - Used, in addition to other evidence, to justify changes in our model structure
    - E.g., time-varying growth, natural mortality, selectivity, catchability

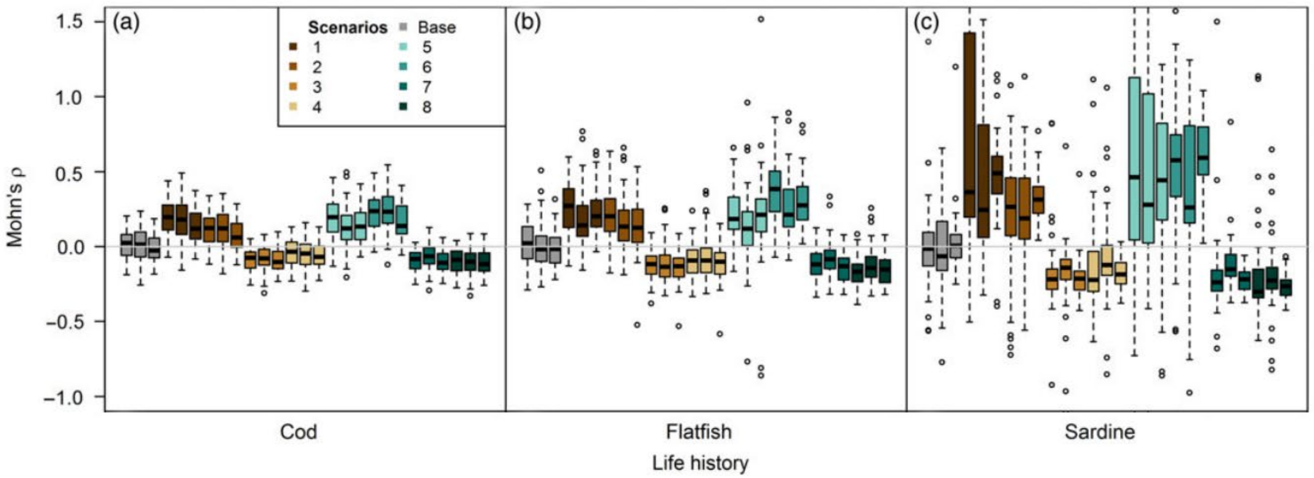


# RISK TABLE

| | Considerations | | | |
|---|---|---|---|---|
| | **Assessment-related** | **Population dynamics** | **Environmental & ecosystem** | Fishery performance |
| Level 3 Major Concern | Major problems with the stock assessment, very poor fits to data, high level of uncertainty, strong retrospective bias. | Stock trends are highly unusual; very rapid changes in stock abundance, or highly atypical recruitment patterns. | Multiple indicators showing consistent adverse signals a) across the same trophic level, and/or b) up or down trophic levels (i.e., predators and prey of stock) | Multiple indicators showing consistent adverse signals a) across different sectors, and/or b) different gear types |

# DEFINING STRONG RETROSPECTIVE PATTERN: CURRENT APPROACH

- Calculate the Mohn’s rho statistic to measure the direction and magnitude of the retrospective pattern
- Hurtado-Ferro et al. (2015) rule of thumb used to determine the significance of the pattern
  - For most AFSC species:
    $-0.15 < \rho < 0.2$
  - Straightforward and simple rule




*Hurtado-Ferro et al. Figure 8. upper panel*

# UNCERTAINTY IN RETROSPECTIVE PATTERN

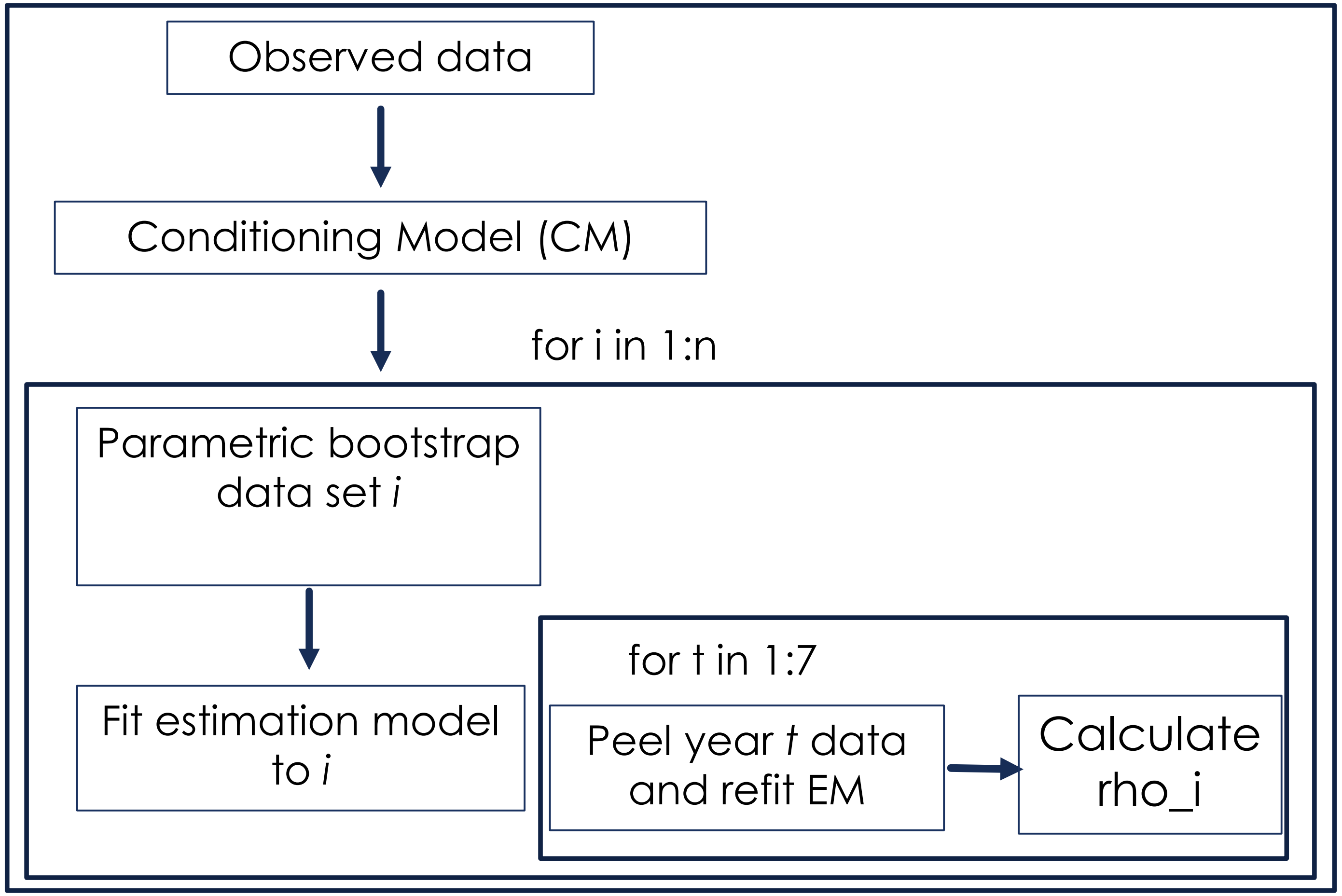
- Quantify uncertainty in rho for individual assessments and use this as the metric to determine significance
- Parametric bootstrap procedure (this is built-in for Stock Synthesis 3 models)
  - Data generated from:
    - Assumed probability distribution of the observed data
    - Using expected values of model fit and weights given by input data
- Miller and Legault (2017) used a bootstrap approach to quantify uncertainty in rho
  - Data generated from:
    - Assumed distributions for each data source
    - Using mean of the observations and weights from observed data

# RESEARCH OBJECTIVES

- Compare parametric bootstrap approaches used to quantify uncertainty in Mohn's rho
- Demonstrate how uncertainty can be used to determine significance of retrospective pattern
- Contrast the results to the current rule of thumb

# PROCEDURE

- Generate *n* data sets using bootstrap procedure and assessment model
- For each bootstrap data set:
  - Fit estimation model (EM)
  - Run retrospective analysis
    - Seven peels
  - Calculate Mohn's rho



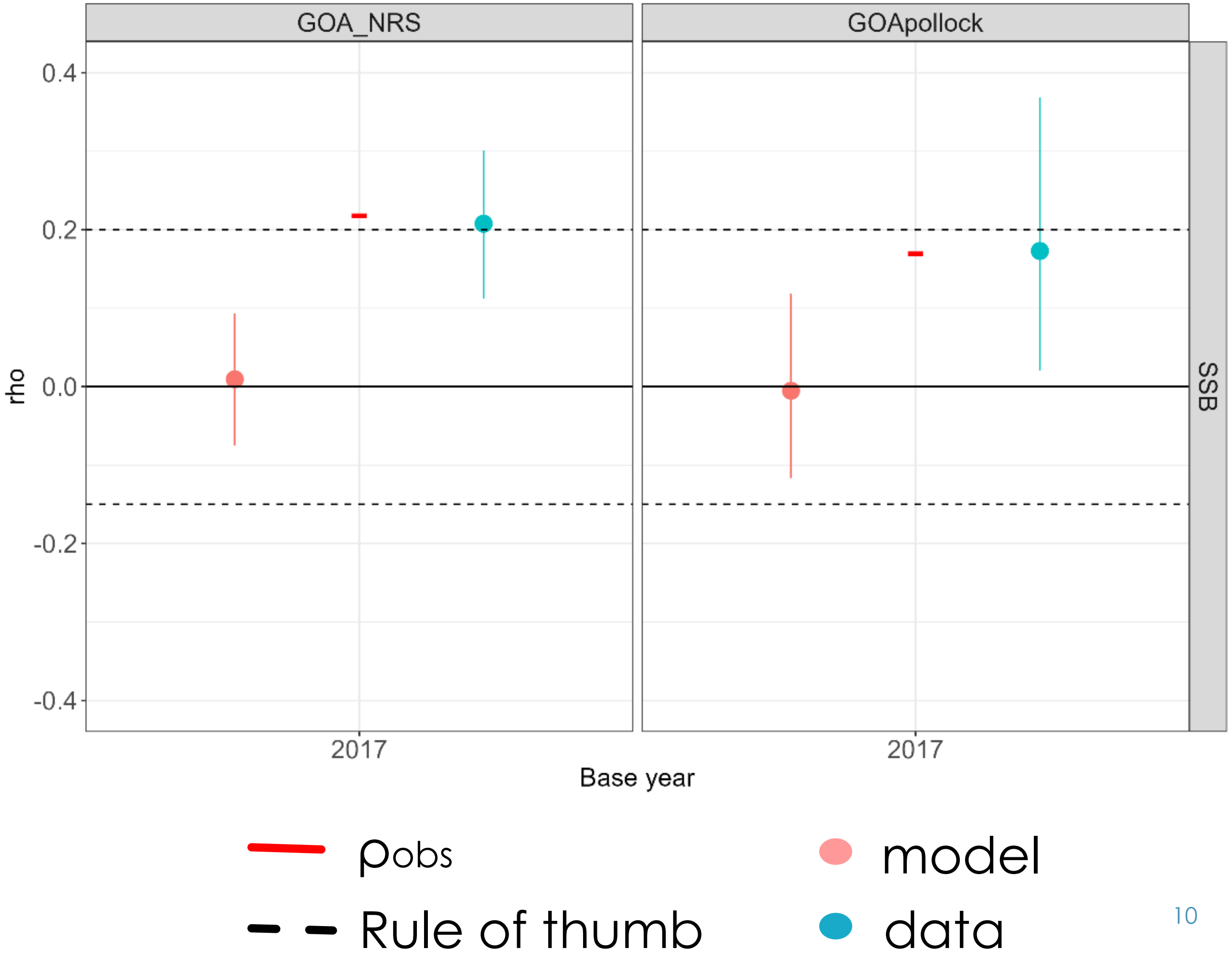
# INTERPRETATION DIFFERENCES

- Bryan and Monnahan
  - "Model" approach
  - Simulated data matches the fitted model structure
  - Null distribution should be centered at 0
  - Rho values outside null distribution suggest significance

- Miller and Legault (2017)
  - "Data" approach
  - Simulated data matches the original data structure (including misspecification or data conflict)
  - Null distribution of rho centered at original rho
  - Rho distribution not containing 0 suggests significance

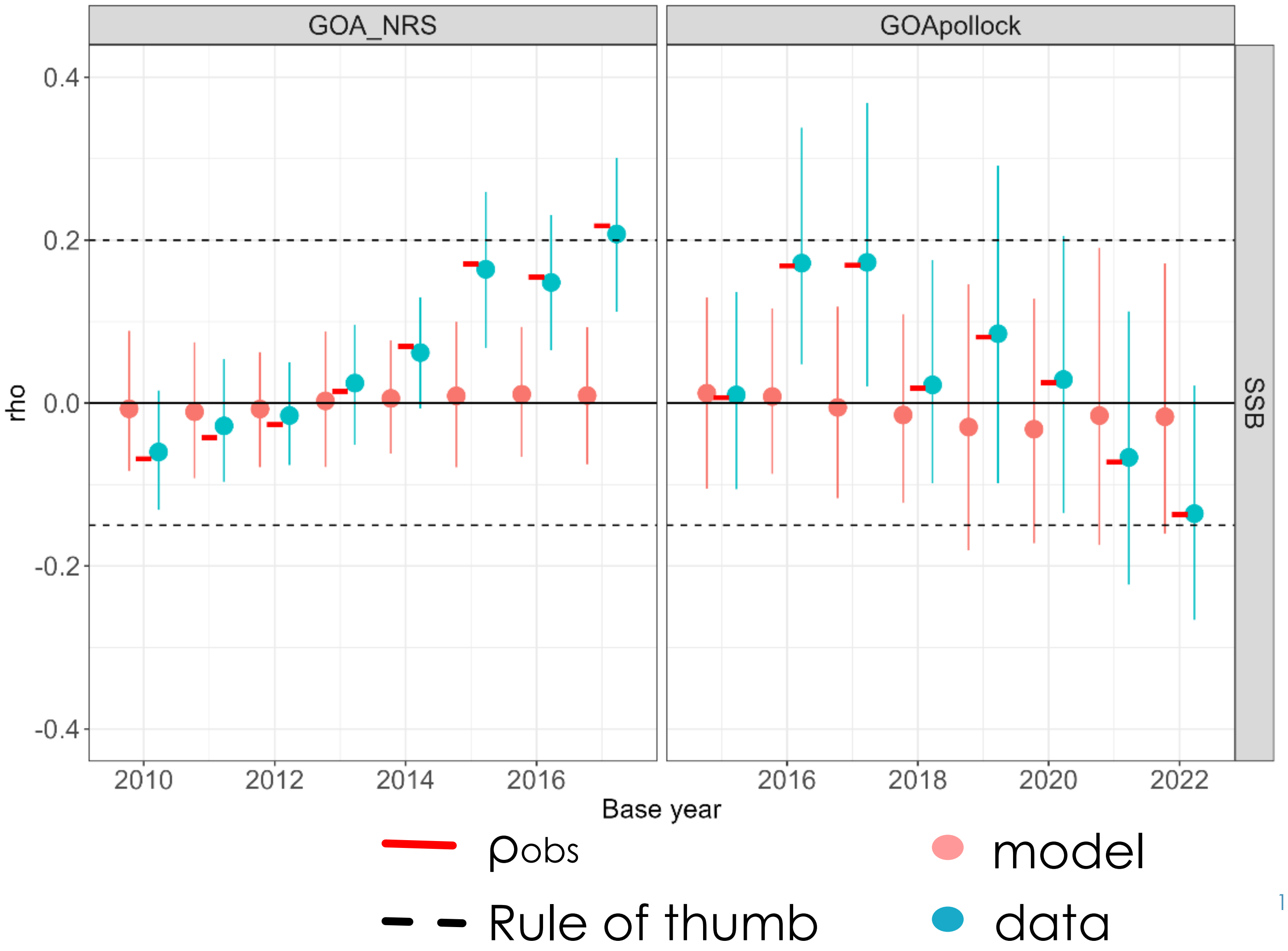
# CASE STUDIES

- Case studies
  - Gulf of Alaska walleye pollock (n=1000)
  - Gulf of Alaska northern rock sole (n=500)
- Results are shown for spawning stock biomass (SSB)



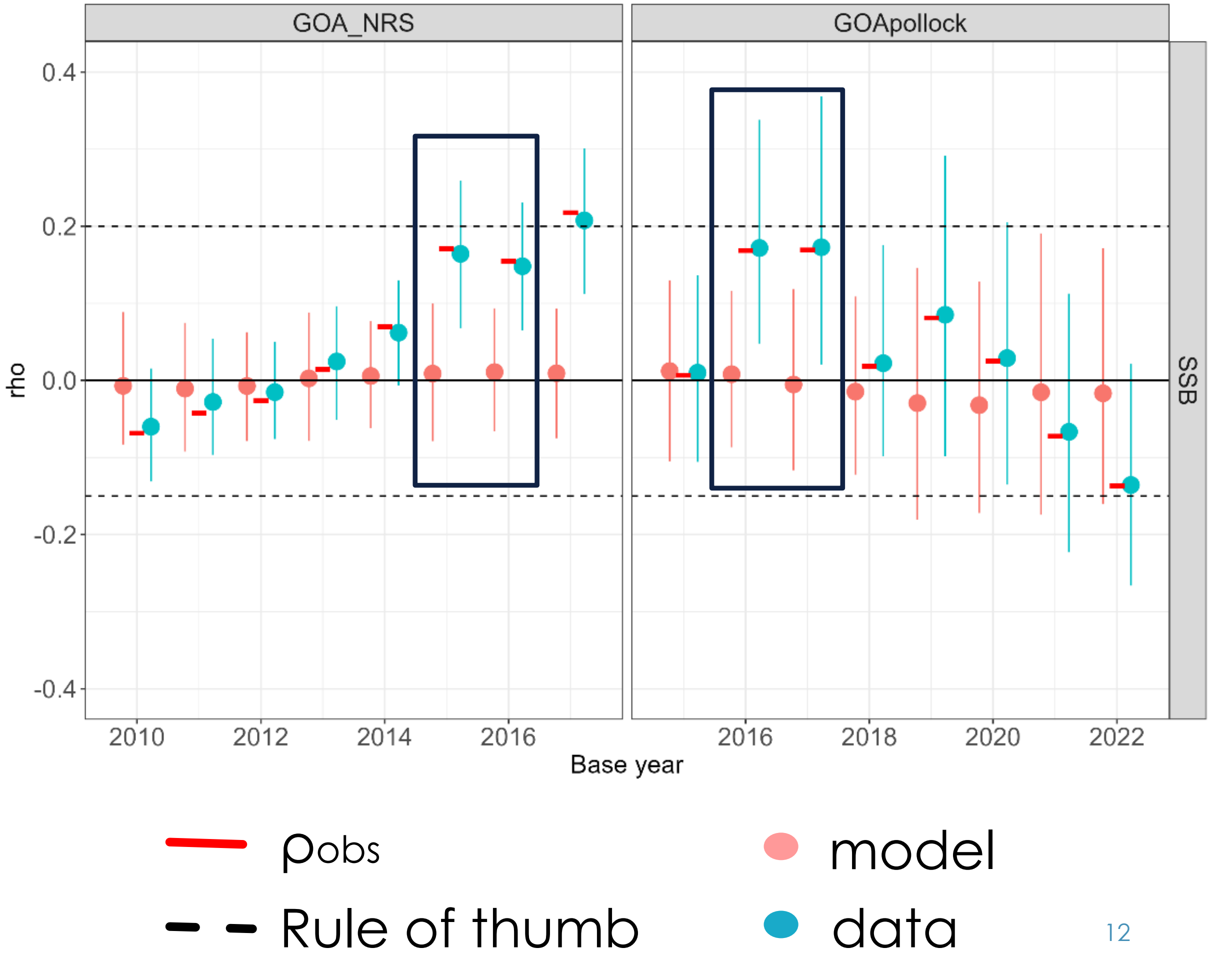
# RESULTS

- Evaluated the rho distribution for several terminal years
- In all cases, the model and data approaches agree



# RESULTS

- Uncertainty approaches and rule of thumb generally agree, but not always
  - Boxes show disagreement with the rule of thumb



# WHEN AND HOW TO ACT

- Statistical significance from model or data approaches
- Scientific significance
  - Rho adjustment (Miller and Legault 2017):
    - $SSB_{adjust} = \frac{SSB_{terminal}}{1+\rho}$
    - Adjustment > 10% (AFSC threshold for major model change)
- Szuwalski et al. (2018) - modeling the wrong time-varying process can lead to true bias in reference points and catch advice

| | **Scientific significance** | |
|---|---|---|
| **Statistical significance** | not significant and small (No action) | Not significant and large (Modify model with care, Szuwalski et al.) |
| | Significant and small (Risk table) | Significant and large (Modify model) |

# CONCLUSIONS AND RECOMMENDATIONS FOR IMPLEMENTATION

- Model and data uncertainty approaches provide a new statistical basis to determine significance of retrospective patterns
- Model approach assumes the fitted model is correct
  - This approach evaluates the inherent retrospective pattern in the model and represents a case-specific rule of thumb
  - Improvement on current rule of thumb
    - Breivik, O.N. et al. (2023) – similar to our model approach for a state space assessment model

# CONCLUSIONS AND RECOMMENDATIONS FOR IMPLEMENTATION

- When should we implement this approach?
  - Introducing a new model
  - Stocks where observed rho changed dramatically between full assessments
  - Stocks that are changing rapidly or near overfished status
  - Stocks that have had historically large rho values

# ACKNOWLEDGMENTS

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