

MSE Primer

GMFMC SSC July 2024

Management Procedure (Harvest Strategy) Approach



Management Procedure (Harvest Strategy) Approach

Management Procedure (MP) – fisheries management recipe that details how management advice will be **adaptively** adjusted based on perceived stock behavior

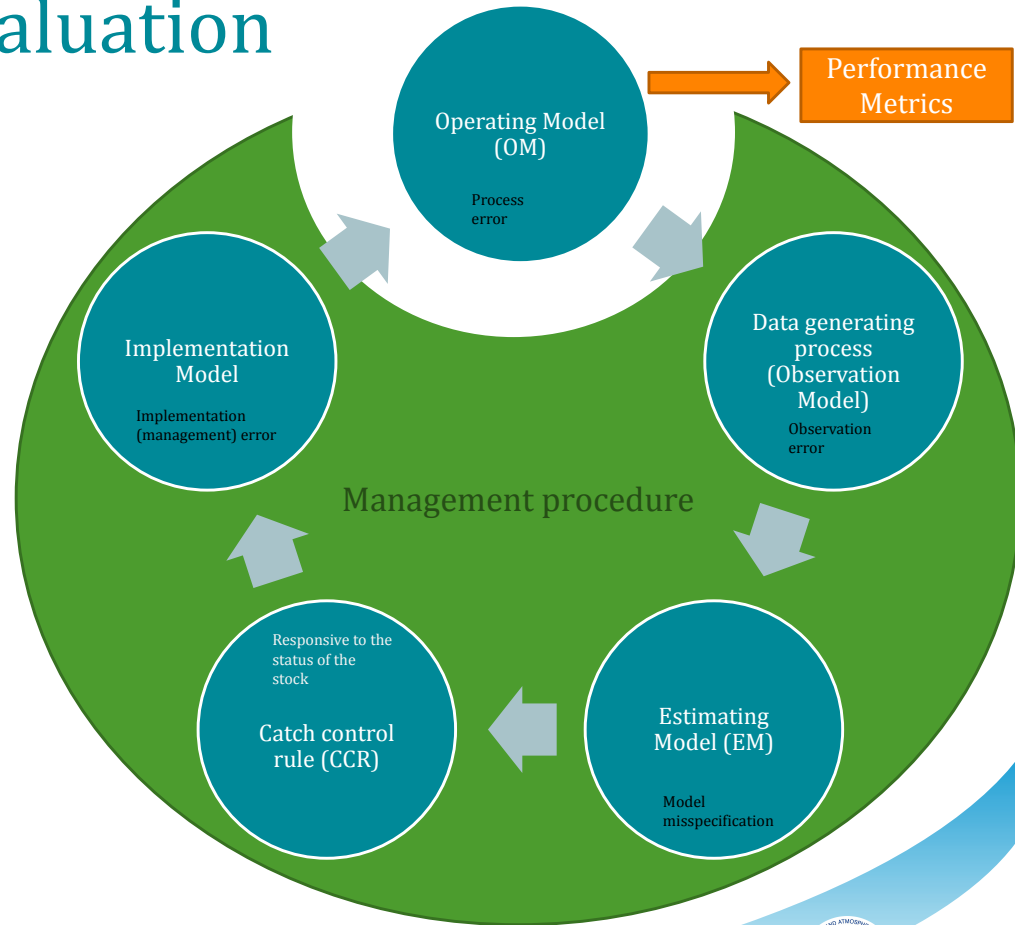
- **Model-based MP** - an MP for which a population dynamics model (i.e., stock assessment) is used to define stock status
- **Empirical MP** (indicator-based) - an MP for which an indicator of stock abundance is used to determine stock status or behavior



Management Strategy Evaluation

Management Strategy Evaluation – a framework to develop and stress-test candidate management procedures using closed-loop simulation

- evaluate MP performance relative to ability to achieve management objectives
- evaluate the trade-offs in MP performance
- ensure candidate MPs are robust to uncertainty



Management Strategy Evaluation:

What defines a good management procedure?

- Depends on the management objectives of the fishery
- Balance trade-offs or biological constraints in maximizing competing management objectives



Management objectives depend on what you want to get out of the fishery now and in the future. Includes:

- “must meet” objectives as defined by MSA with risk tolerance specified by SSC
- “would like” objectives defined by stakeholders
- *Conceptual* versus *operational* management objectives

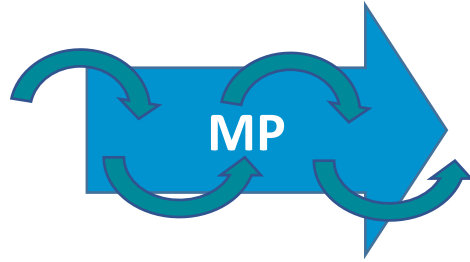
Performance Metrics = quantitative and measurable statistics that reflect the management objectives of the fishery and allowable risk tolerances defined by managers / SSC.

Management Strategy Evaluation:

How do we ensure an MP will be robust?

Stock &
Fishery

Operating
Model



Management Strategy Evaluation:

How do we ensure an MP will be robust?

Stock & Fishery

OM

MP

MP

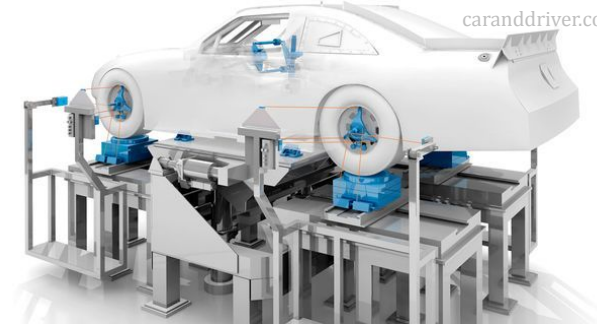
MP

MP



Management Strategy Evaluation:

How do we ensure an MP will be robust?



Operating Model (OM) = each “alternate reality”; represents a hypothesis of the stock, fishery, and ecosystem dynamics of the system.

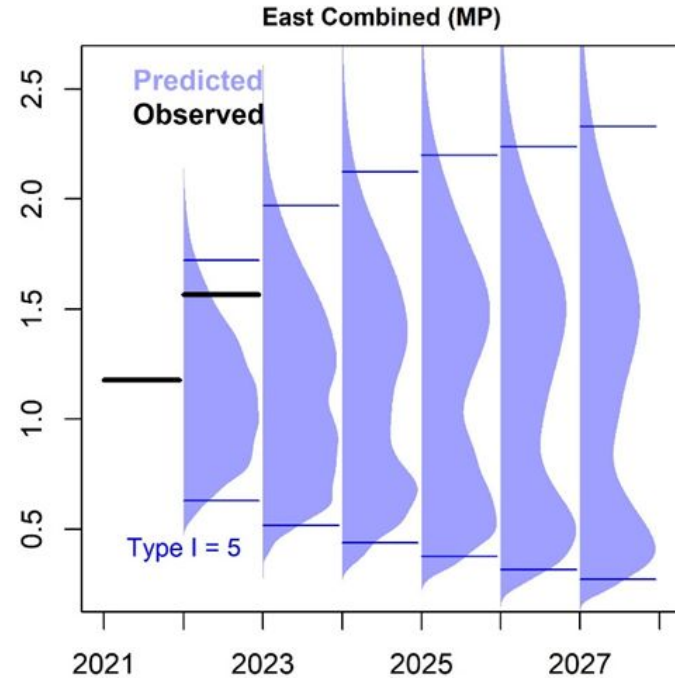
Operating Model (OM) grid = all of the “alternate realities”; the suite of OMs that we will use to test the MPs. Should encompass what we don’t know about the stock and ecosystem.

- Can be separated into “reference OM grid” for main uncertainties and “robustness OM grid” for ancillary uncertainties.

Management Strategy Evaluation:

What happens after an MP is implemented?

1. Exceptional Circumstance Provisions – specify situations when MP can be overridden
 - Defined based on scenarios tested within the MSE.
 - e.g. index outside range tested, inability to update an index for multiple years, natural disasters, etc.
 - test for exceptional circumstances every year
2. Stock assessments will still occur as “health or status” checks, potentially with less frequency
3. Schedule for MP / MSE review and revision determined



Observed index values (black bars) compared to the distribution of simulation-tested future indices (blue distribution) for the MSE. Blue bars represent the 95% intervals.

What's my role?



	Stakeholders	Modeling team	SSC	Council
Operating models	Advise on OM structure and key uncertainties	Construct	Review	Advise
Management objectives	Advise	Quantify	Advise on biological 'must-pays' e.g. not overfishing and rebuilding	Adopt
Management Procedures	Advise	Test and refine	Advise	Adopt and implement management procedure based on performance

MSE Complexity

Full stakeholder MSE

- Full iterative stakeholder involvement
- MSE intended to result in management action
- Where management objectives are not fully developed
- Expensive and time consuming

Intermediate MSE

- Spectrum between full stakeholder MSE and desk MSE
- To moderate resource requirements

Desk MSE

- No stakeholder input
- General research questions
- To develop MPs where management objectives are known

Not MSE

- Simulation exercises where the full feedback-loop characterizing the MSE is not necessary
- Consider other less resource-intensive approaches

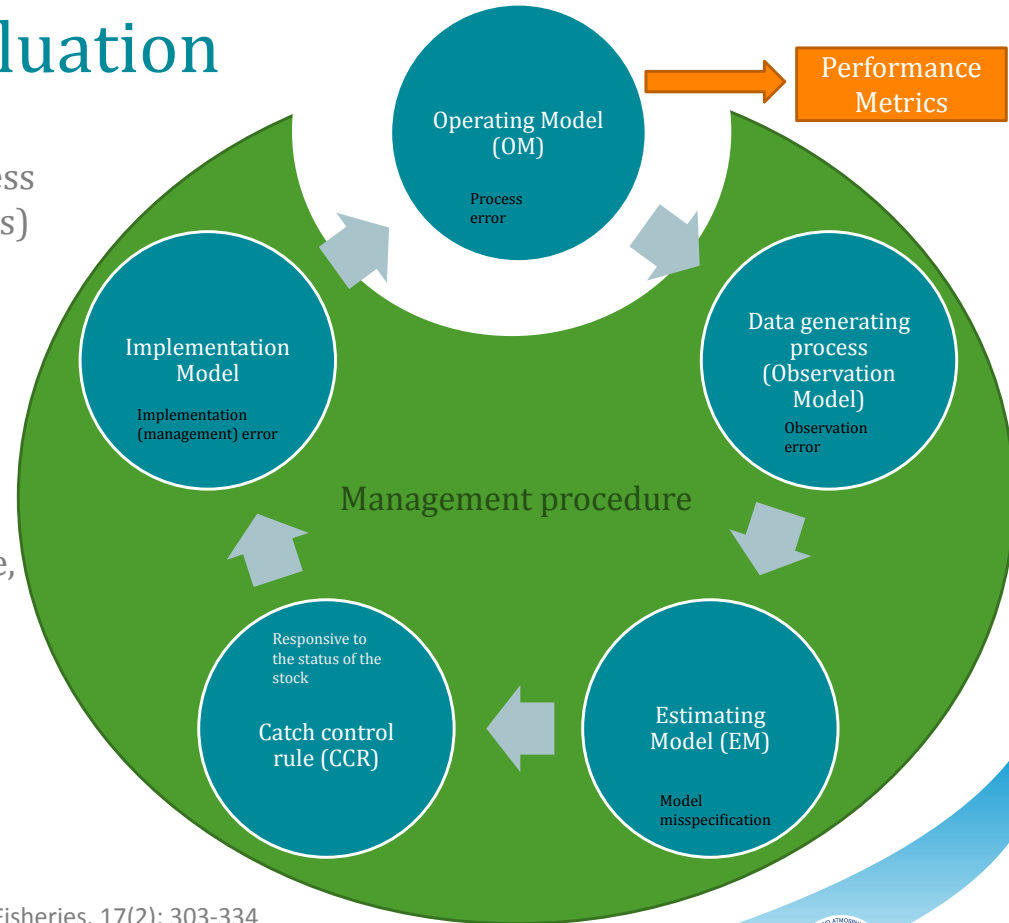
Walter, Peterson, Marshall, Deroba, Gaichas, Williams, Stohs, Tommasi, Ahrens (2023) When to conduct, and when not to conduct, management strategy evaluations. ICES Journal of Marine Science. 80(4): 719–727.



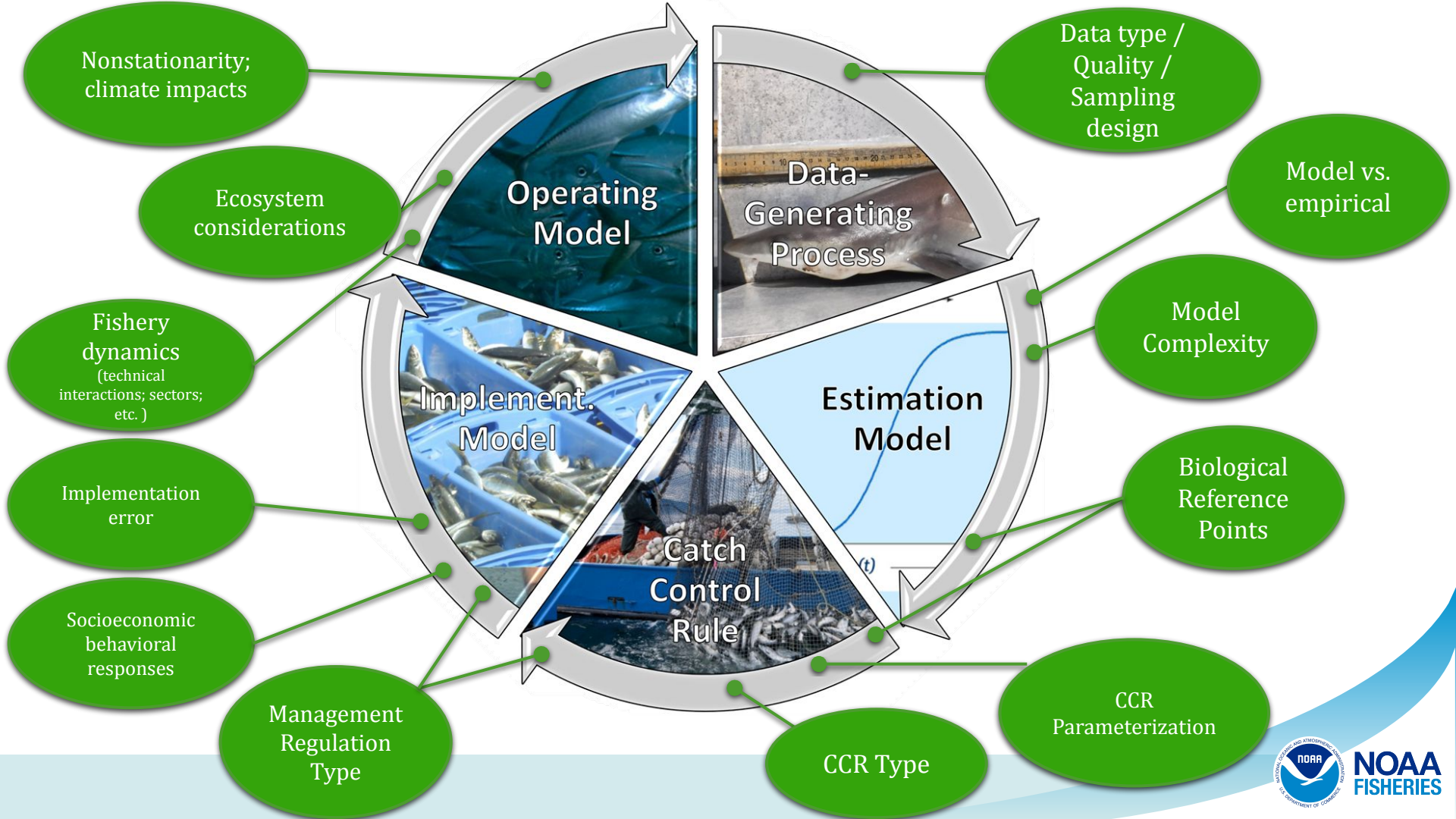
Management Strategy Evaluation

Management Strategy Evaluation (MSE) – process designed to develop management procedures (MPs) that are robust to uncertainty

1. Identify fishery-specific, stakeholder-defined management objectives
2. Identify relevant uncertainties over which MP should be robust
3. Develop operating models, 'true' states of nature, and condition operating models
4. Identify management procedures that are responsive to stock dynamics (feedback loop)
5. Simulation exercise; summarize and present resulting performance statistics



Punt et al. (2016) Management strategy evaluation: best practices. Fish and Fisheries. 17(2): 303-334



Nonstationarity;
climate impacts

Ecosystem
considerations

Operating
Model

Data type /
Quality /
Sampling
design

Model vs.
empirical

Data-
Generating
Process

Model
Complexity

Fishery
dynamics
(technical
interactions; sectors;
etc.)

Estimation
Model

Biological
Reference
Points

Implementation
error

Implement.
Model

Catch
Control
Rule

CCR
Parameterization

Socioeconomic
behavioral
responses

Management
Regulation
Type

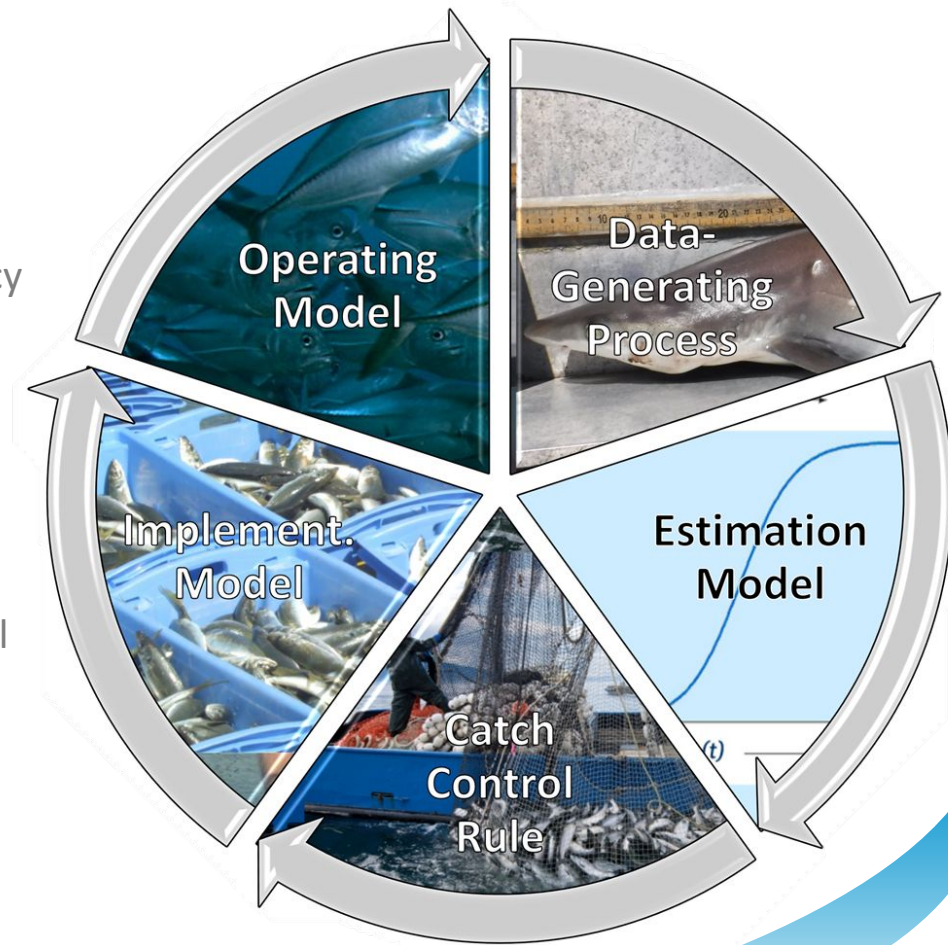
CCR Type



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MSE Ancillary Benefits

- Identify management objectives of system
- Foster increased communication and transparency between stakeholders, managers, and scientists
- Understand stock-specific trade-offs inherent in management of system
- Highlight future research priorities and improve understanding of system uncertainties
- Clearly identify management approaches that will not work
- Take a short-, mid-, and long-term view of the resource
- Improve overall understanding of the management system

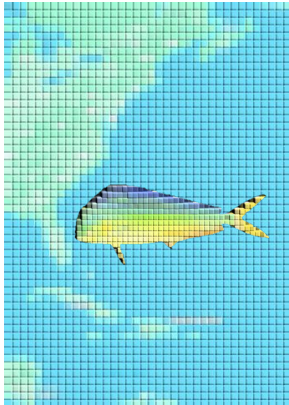


Key MSE Take-Home Messages

In an MSE, we are not predicting the most likely future state of the stock.

Rather, we are designing and testing a management procedure that is robust to uncertainties and that will maximize management objectives.

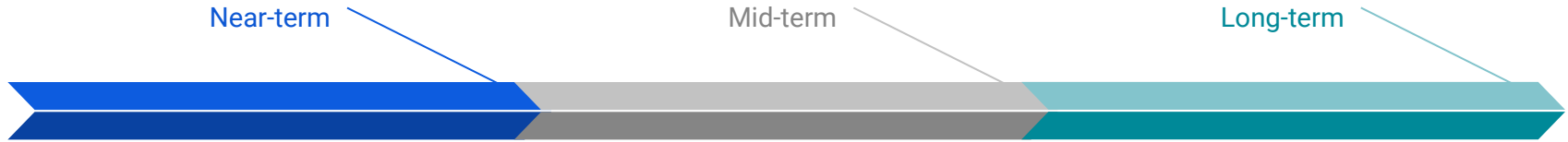
MSE is a research tool. When conducted with managers in the driver's seat, MSE can be a management tool.



An MP is a management recipe and is designed to be accepted by managers as a recipe – not as a sequence of TACs or other management recommendations.

When an MP is implemented, so are safeguards to ensure that we are not “jumping off a cliff.”

MSEs in the Gulf of Mexico



1. Capacity building
2. MSE to address FES pilot study results
3. Future directions
 - a. Validate and tune interim assessment approaches and simple MPs
 - b. Measure effects of stock assessment frequency and complexity on risk tolerance
 - c. Characterize uncertainty buffers and CCRs
 - d. Ensure MPs are climate-ready (i.e., robust to future climate-induced nonstationarity)

Species	SEDAR
Yellowedge Grouper	SEDAR 85
Spanish Mackerel	SEDAR 81
Gray Snapper	SEDAR 75
Red Snapper (3-area)	SEDAR 74
Red Snapper (2-area)	SEDAR 52
Gag Grouper	SEDAR 72
Greater Amberjack	SEDAR 70
Scamp	SEDAR 68
Vermilion Snapper	SEDAR 67
Red Grouper	SEDAR 61
Gray Triggerfish	SEDAR 43
King Mackerel	SEDAR 38 Update
Cobia	SEDAR 28 Update
Tilefish	SEDAR 22

Capacity building



github.com/nmfs-fish-tools/SSMSE

SSMSE development to accommodate Gulf stock structure

1. Treatment of discards
2. Resampling of specific data types (e.g., CAAL)
3. Treatment of bycatch and/or red tide fleets
4. Inclusion of multiple areas
5. Treatment of time-varying parameters
6. Beta testing and bug fixes

MSEs in the Gulf of Mexico

FES MSE



Near-term
(Months)



GMFMC request:

“Given [the MRIP pilot study results and timeline], and to better understand how variability in recreational landings and discards for Spanish mackerel might ultimately affect the health of the stock, **the Council requests that the Southeast Fisheries Science Center (SEFSC) conduct a desk management strategy evaluation (MSE) to examine the impacts of recreational landings data on management.** This evaluation should consider, but not be limited to differences in historical calibrations of landings in the eastern Gulf, and uncertainties in these calibrations for state and federal landings that may contribute to additional management uncertainty. The evaluation could also consider the performance of decreasing the recreational bag limit. The Council requests that this desk MSE be presented in full to its Scientific and Statistical Committee (SSC) upon completion for evaluation and recommendations.”

Skyler Sagarese, Nathan Vaughan, LaTreese Denson, Matt Smith, Katie Siegfried, John Walter, Shannon Calay, Cassidy Peterson & others



FES MSE



Near-term
(Months)



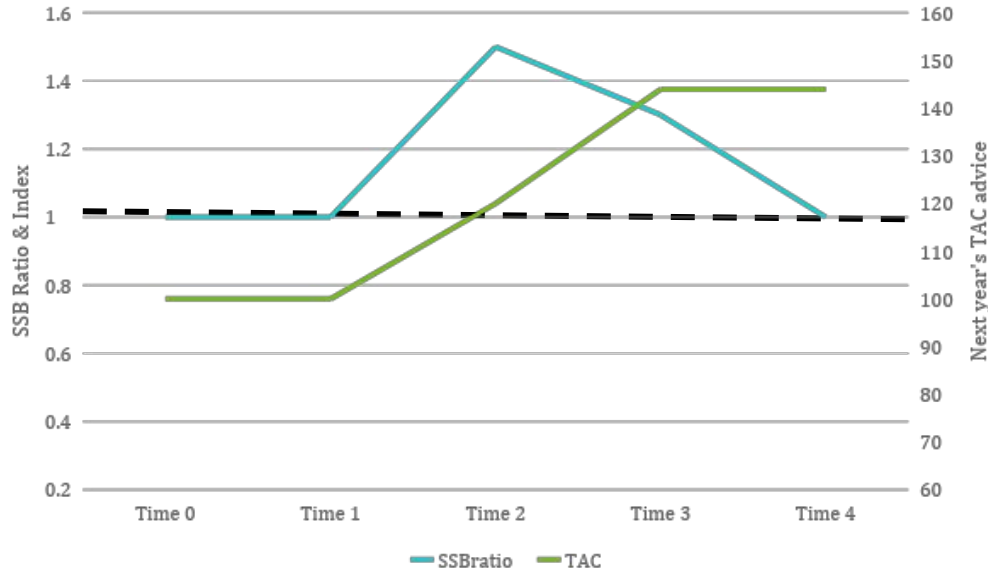
Spanish mackerel

- No allocation issues
- Small pelagic fish – high variability in population dynamics and data

Purpose: Understand management implication when true vs. measured recreational landings and discards are on different scales.

1. Examine the impact that unknown magnitude of recreational landings data may have on management performance for Gulf of Mexico stocks.
2. Identify alternate management approaches that may better perform when absolute values of recreational landings are biased.

Percent change MP



FES MSE



Purpose: Understand management implication when true vs. measured recreational landings and discards are on different scales.

Ongoing Progress to Date

- SSMSE development
- Convert Gulf assessments into SSMSE OMs
- Developmental proof of concept

Next Steps

- Continued SSMSE development
- Apply simple 2x2 OM-MP grid to Gulf stocks
- Expand OM and/or MP scenarios

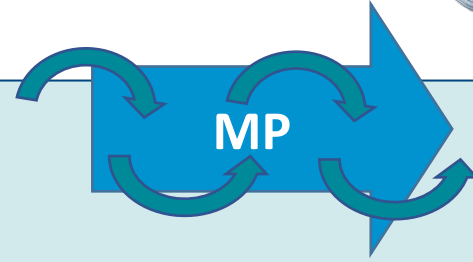
Ancillary Benefits

- Beta test of SSMSE
- Build foundation for future Gulf MSEs

FES MSE



1. **Base** - true and measured recreational removals match
2. **Hi Rec** - measured recreational removals are biased high



1. **Conventional MP** - TAC advice generated using assessment forecasts
2. **Percent change MP** - adjust last year's TAC by this year's SSB ratio (SSB / SSB_{MSY})



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FES MSE



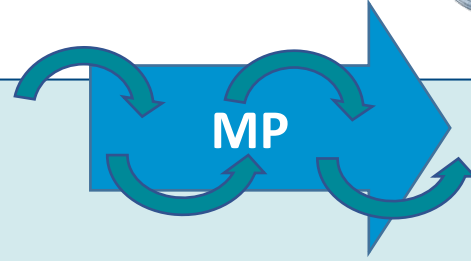
Operating Models

1. **Base** - true and measured recreational removals match
2. **Hi Rec** - measured recreational removals are biased high

What project deliverables would you like to see?

What results are most informative to you?

What does the SSC want to add to this request?



1. **Conventional MP** - TAC advice generated using assessment forecasts
2. **Percent change MP** - adjust last year's TAC by this year's SSB ratio (SSB / SSB_{MSY})



What other OMs should be tested?

What other management approaches should be considered?



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MSEs in the Gulf of Mexico

Interim and simple MPs

Assessment frequency and complexity

Long-term



Validate and tune interim assessment approaches and simple MPs

- RESTORE crossover – MP approaches and parameterizations to be informed by RESTORE project
- Develop and build SSMSE capacity for interim assessments and empirical MPs
- Identify target stocks and ensure assessment compatibility with SSMSE
- Run MSE to test and tune candidate interim and empirical MPs

Measure effects of stock assessment frequency and complexity on risk tolerance

- RESTORE crossover – EM parameterization and treatment of uncertainty
- Identify target stocks and ensure assessment compatibility with SSMSE
- Develop and build SS3 models of different levels of complexity
- Run MSE to measure management impact of altered stock assessment frequency and complexity in collaboration with fishery managers

PI Nathan Vaughan RESTORE



Project will

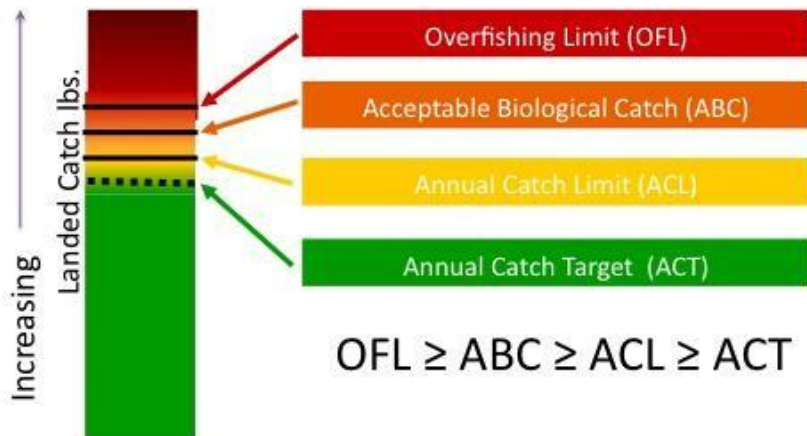
- Identify practical solutions and approaches to address assessment and management complexity
- Characterize sources of modeling uncertainty to better approximate reality

Take solutions and ideas from RESTORE to

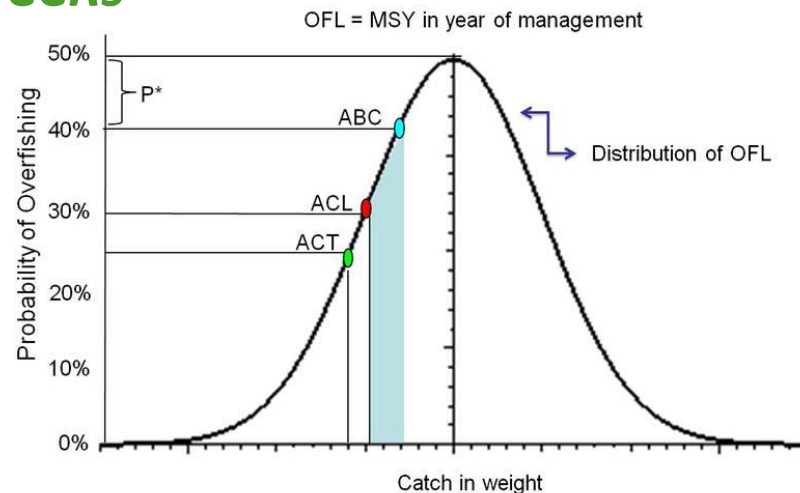
- better characterize Gulf MSEs
- test and tune example solutions

MSEs in the Gulf of Mexico

Characterize uncertainty buffers and CCRs



Magnuson-Stevens Fishery Conservation and Management Act; National Standard 1



Characterize uncertainty buffers and CCRs

- RESTORE crossover – EM parameterization and treatment of uncertainty
- Configure OMs to ensure different levels of stock assessment variability
- Identify target stocks and ensure assessment compatibility with SSMSE

- **Catch (Harvest) Control Rules (CCRs)** – a pre-defined decision rule that specifies management actions that will take place in response to perceived states of nature; converts information about stock status (e.g., OFL) to ABC to account for scientific and management uncertainty

MSEs in the Gulf of Mexico

Long-term

Climate-ready MPs

Ensure MPs are climate-ready (i.e., robust to future climate-induced nonstationarity)

- CEFI crossover
- Identify linkages between climate / environmental indicator and stock population dynamics
 - Mechanistic (descriptive vs. mechanistic) or empirical
- Develop and build climate-informed OMs / MPs
- Tune MPs and Run MSE



Climate, Ecosystems, and Fisheries Initiative

MSE can provide **actionable** and **transformative** science by developing *climate-ready management approaches* that can be implemented to our real-world fisheries.

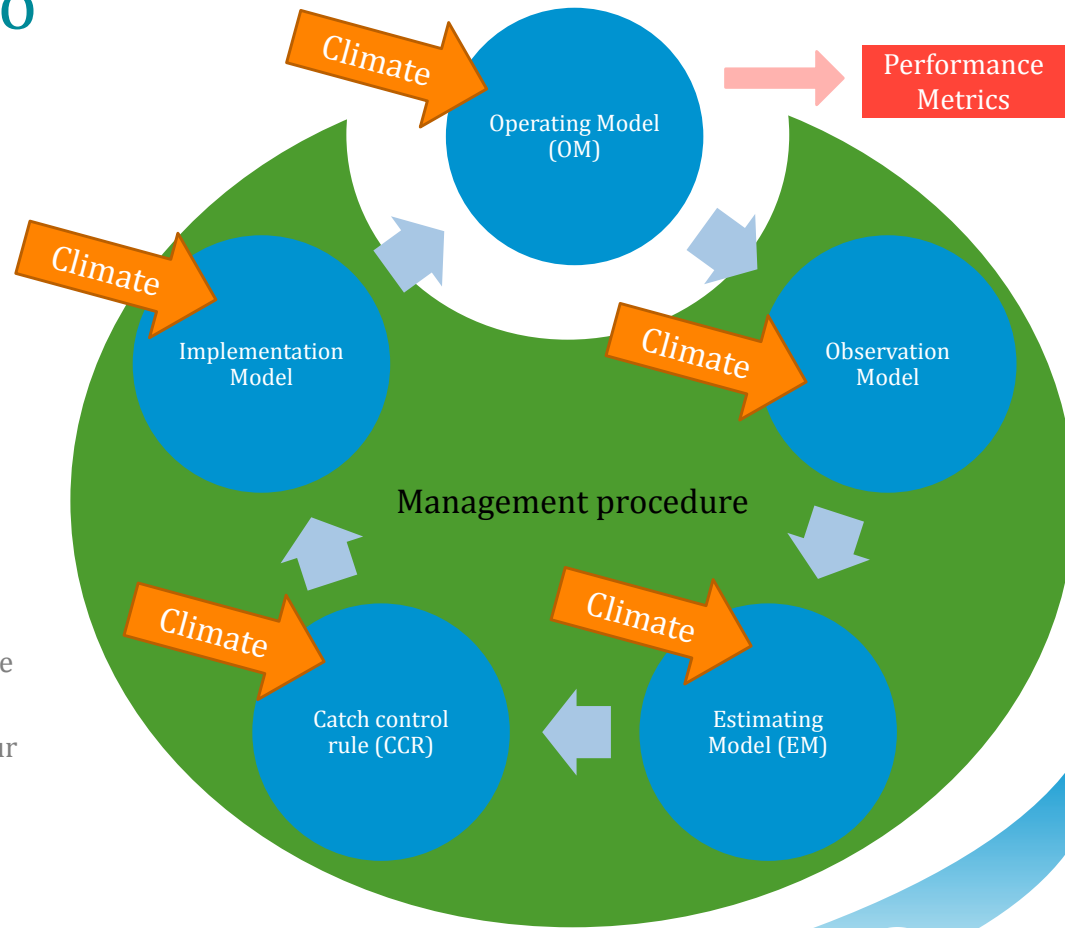


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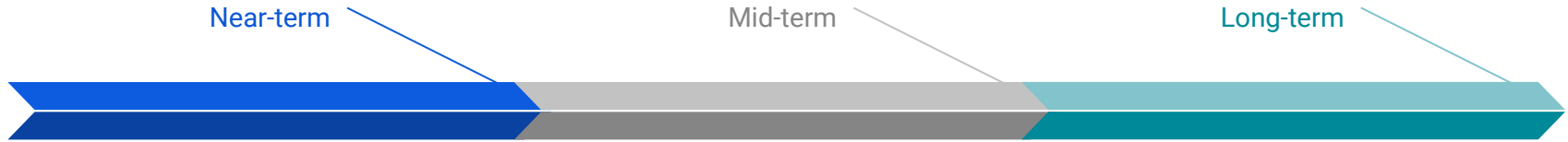
MSEs in the Gulf of Mexico

Climate-ready MPs

- MSE can measure the *management implications* of climate & ecosystem drivers impacting each step of the MSE
 - E.g., Are management procedures robust to climate-induced changes to stock productivity or growth?
 - E.g., How will candidate management approaches impact ecosystem?
 - E.g., How will climate-driven changes to data collection protocols impact management performance?
 - E.g., Do climate-informed stock assessments improve our ability to achieve management objectives?
 - E.g., Are climate-informed control rules viable for our fishery?
 - E.g., If climate drivers influence management implementation (e.g., fisher behavior), how will this impact management performance?



MSEs in the Gulf of Mexico



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What feedback do you have on these priorities?

What additional priorities that can be investigated with MSE should be added?





cassidy.peterson@noaa.gov; Acknowledge SEFSC staff & collaborators



SEFSC MSE Strategic Plan

Management Strategy Evaluation Priorities

1. Capacity Development
2. Explore Data-Limited Management Procedures
3. Explore Interim Approaches and Assessment Frequency
4. Explicitly Include Management Procedure Performance Across Climate Change and Non-stationarity
5. Consider Ecosystem Impacts of Fisheries Management
6. Focus on Recreationally Dominated Fisheries
7. “Right-Weight” Assessment Complexity
8. Prioritize Data Availability / Quality / Efficiency
9. Desk MSEs to Improve Understanding of Population Dynamics, Stock Assessment, and Management Processes



Proposed MP: Ratio MP (percent change)

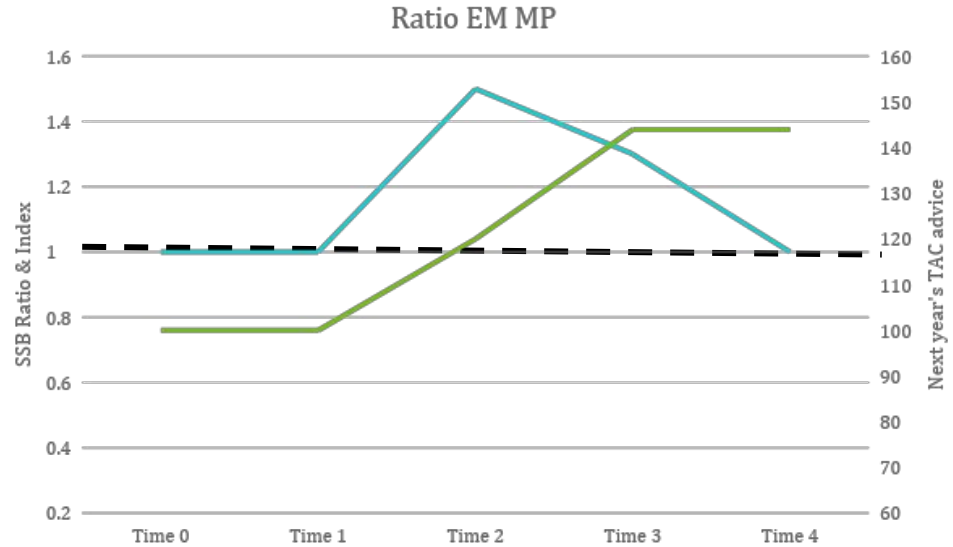
Adjust last year's TAC by this year's SSB ratio (SSB / SSB_{MSY})

- Borrow intuition behind empirical MPs and adding to the value of a model-based MP
 - Stock assessment to update MSY-based reference points (e.g., SSB_{MSY} ; no need for reference period as in empirical MP)
- Uses relative reference points instead of absolute reference points
- Ground management advice in the scale that we use to measure TAC



Ratio MP: Proposal

	SSBratio	TAC
Time 0	1	100
Time 1	1	100
Time 2	1.5	120
Time 3	1.3	144
Time 4	1	144



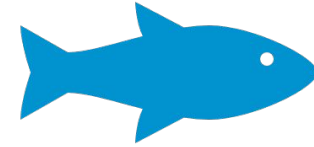
2 options:

$$TAC_{y+1} = \left(\left((SSBratio^* \times TAC_y) - TAC_y \right) \times c \right) + TAC_y$$

$$TAC_y = \exp(\log(SSBratio^* \times TAC_y) \times c) + TAC_y$$

- Where TAC change is limited to 20% up or down.
- Option to dampen TAC change. Example: multiply by constant $c < 1$. $c=1$ would result in a 1:1 change in SSB ratio and percent change in TAC.

Methods: Proof-of-Concept MSE design



OM1: Base
No mismatch in landings

MP1: current forecast-based approach; model-based

MP2: Ratio / percent change MP approach; model-based

OM2: Mismatch
Simple mismatch in landings

MP1: current forecast-based approach; model-based

MP2: Ratio / percent change MP approach; model-based

Assumptions:

1. Constant allocation
2. No data-management lag
3. No implementation error
4. Spatiotemporally constant bias in rec landings
5. Stationary projections

* some of these may optionally be addressed in future work