NEFMC Ecosystem-based Fisheries Management prototype Management Strategy Evaluation (EBFM pMSE)

Initial Stakeholder Scoping Workshop
October 13, 2022
Portland, ME

New England Fishery Management Council

School for Marine Science & Technology
UMass Dartmouth

Gulf of Maine Research Institute

Scoping Workshop Goals

A participatory, facilitated process to:

- Frame the problem
- Review goals for the pMSE
- Determine research question scope
- Determine extent of operating model scenarios
- Identify questions the pMSE analyses will be applied to

Main outcome:

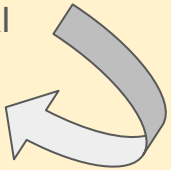
- Co-develop EBFM strategies through Management Strategy Evaluation

Introductions

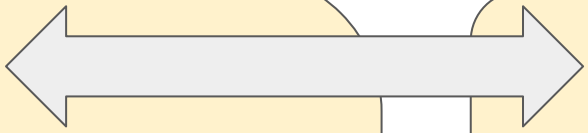
- Who you are, how do you prefer to be addressed?
- One thing you would like to see done at the workshops?
- Any other pertinent information you would like to share about yourself!

EBFM pMSE Project Team & Interaction Structure

- **Analytical Team**
  - Dr. Gavin Fay, SMAST
  - Max Grezlik, SMAST
  - Madeleine Guyant, SMAST
  - Jerelle Jesse, GMRI
  - Dr. Lisa Kerr, GMRI



- **Stakeholders (EBFM Committee & AP Chairs)**
  - Andrew Applegate
  - Peter Aarrestad
  - Mark Alexander
  - Katie Almeida
  - Frank Blount
  - Greg DiDomenico



Technical Advisors (EBFM PDT & SSC)

- Michelle Duval
- James Gutowski
- Jay Hermsen
- Patrick Keliher
- Meghan Lapp
- Ben Martens
- Christopher McGuire
- Adam Nowalsky
- John Pappalardo
- Mike Pierdinock
- Geoff Smith
- Alan Tracy
- John Whiteside

Roles & Responsibilities

- Project Lead- Dr. Gavin Fay
  - Modeling frameworks, architecture for implementation of the EBFM management procedures.
  - Ask about: Project scope, modeling, technical components
- Project Lead- Dr. Lisa Kerr
  - Integration of the multispecies operating model into the existing Groundfish-MSE framework
  - Ask about: Project scope, modeling, technical components
- Quantitative Research Assistant- Jerelle Jesse
  - Modeling, analytical components
- Facilitator- Madeleine Guyant
  - Workshop discussions, engagement with pMSE participants, workshop reports
  - Ask about: Discussions, engagement sequence and scheduling
- Rapporteur- Max Grezlik
  - Workshop documentation

Roles & Responsibilities

- MSE is at the interface between science and decision making
- Scientists:
  - Translate research questions into hypotheses to represent in the models
  - Represent the objectives of the stakeholders quantitatively.
  - Identify factors that could be used in management strategies
  - Perform analyses that evaluate the management alternatives & communicate these.
- Stakeholders (including decision makers):
  - Help to define the problem statement and research questions
  - Identify the management objectives
  - Identify candidate management strategies
  - Evaluate results and help make decisions on management strategies

Roles & Responsibilities

- Designated stakeholders and technical advisors:
  - Members of the EBFM committee, AP members, and additional advisors.
  - Technical advisors PDT, SSC
- Active discussion and co-creation of MSE components.
- Provide input on key elements and decisions that form the basis of any ecosystem-based management procedure.
- Iterate and develop the needed structure for the technical analyses.

Roles & Responsibilities

- Breakout discussion expectations:
  - Be recognized before speaking.
  - Constructively engage with the topic under discussion.
  - To mirror a full MSE process, discussions will emphasize designated stakeholders.
  - Participants outside of stakeholder groups will have opportunities to provide input during breakout and plenary discussions if time permits.

NEFMC Ecosystem-Based Fishery Management work

Draft Example Fishery Ecosystem Plan (eFEP)

for Georges Bank

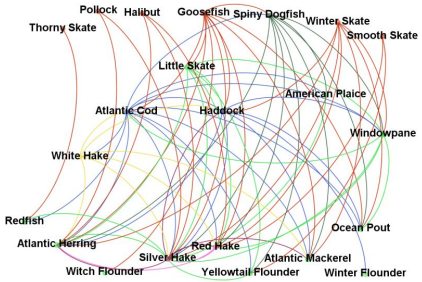
prepared by the

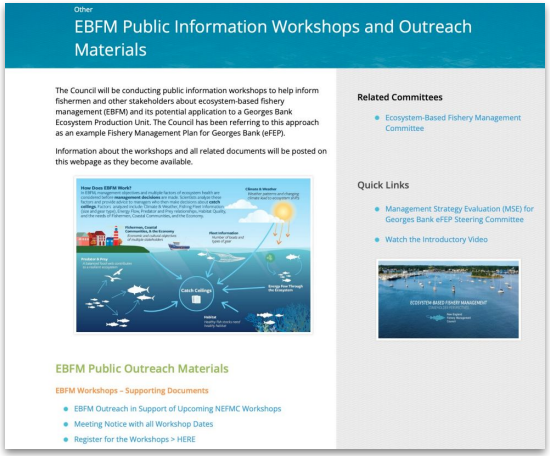
New England Fishery Management Council

and the

Ecosystem Based Fishery Management

Plan Development Team





Other

EBFM Public Information Workshops and Outreach Materials

The Council will be conducting public information workshops to help inform fishermen and other stakeholders about ecosystem-based fishery management (EBFM) and its potential application to a Georges Bank Ecosystem Production Unit. The Council has been referring to this approach as an example Fishery Management Plan for Georges Bank (eFEP).

Information about the workshops and all related documents will be posted on this webpage as they become available.

Related Committees

- Ecosystem-Based Fishery Management Committee

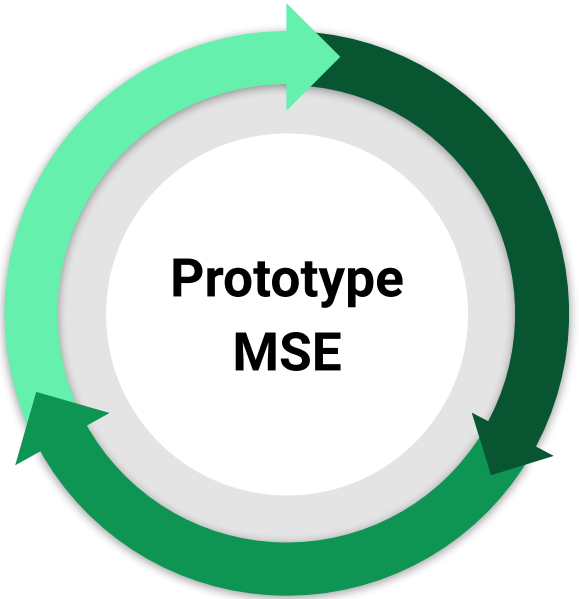
Quick Links

- Management Strategy Evaluation (MSE) for Georges Bank eFEP Steering Committee
- Watch the Introductory Video

EBFM Public Outreach Materials

EBFM Workshops – Supporting Documents

- EBFM Outreach in Support of Upcoming NEFMC Workshops
- Meeting Notice with all Workshop Dates
- Register for the Workshops > HERE

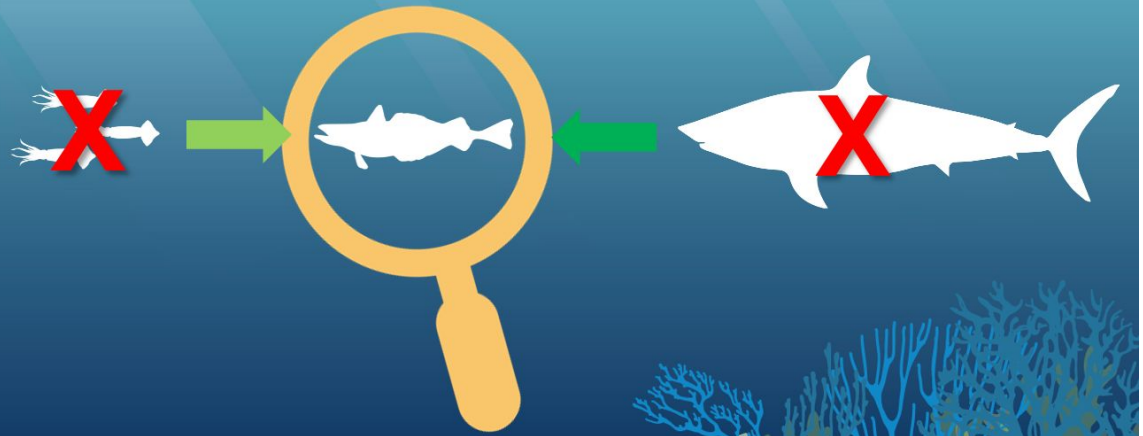


pMSE overall goals

- To showcase a simplified MSE framework and demonstrate how MSE will be used to evaluate EBFM management strategies for a Georges Bank Ecosystem Production Unit.
  - Act as an educational dry run from both a development and an operational perspective.
  - Provide an opportunity for the Council to gain experience with the MSE process
  - Identify and work through the types of decisions to be made during an MSE
- To identify data sources and develop the models and analyses that will support a full EBFM MSE with broad stakeholder participation in the next phase of the Council's EBFM development strategy.
- The prototype MSE results are not intended to be actionable in a fishery ecosystem plan, but results should be able to be used as the basis for a full MSE, which would be the next step

How Are Catch Limits Currently Determined?

1. Fishery management focuses on a **single** species, with little consideration for how a species functions as a **predator** or **prey**.



New England Fishery Management Council

What is EBFM?

“Managing fisheries to coordinate, account for, and include all factors in a holistic, synthetic, integrated fashion. Fisheries are emphasized, but the inclusion of marine mammals, protected species, non-target species, etc., are explicitly included.”

“Ultimately what EAF/EBFM means is that we are trying to manage fisheries in a broader ecosystem context, ….”

(Link 2010)

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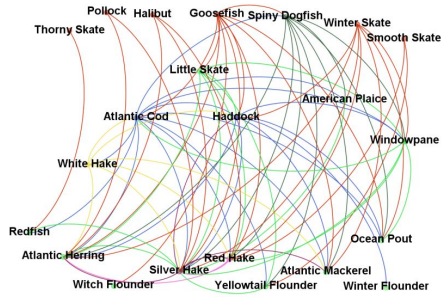
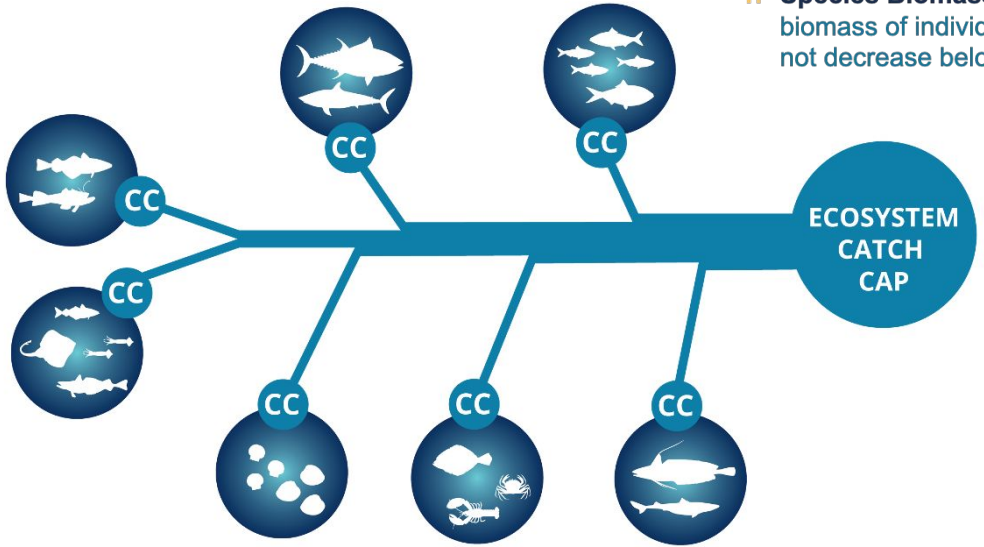


eFEP outlines an approach for EBFM in New England via a draft worked example for Georges Bank.

Based on stock complex management and place-based productivity.

1. **Ecosystem Catch Cap**: Total catch from the ecosystem can not exceed a Cap related to annual productivity.
1. **Stock Complex Ceilings:** Assessments of the balance between **predators and prey** in the ecosystem will help determine Species Complex Ceilings (CC).
1. **Species Biomass Floors:** Total biomass of individual species can not decrease below threshold levels.



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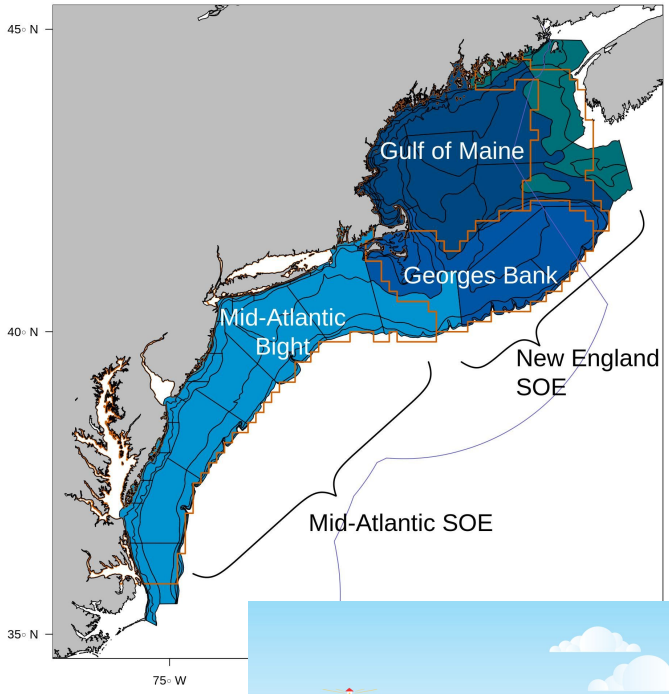

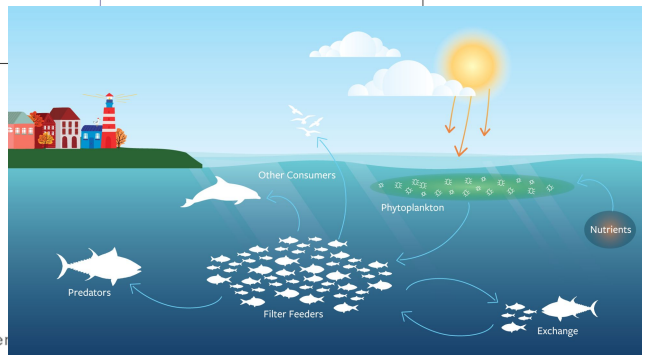

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Seeks to align fishery advice with how the fishery operates (species groups related ecologically and technologically through how they are caught)

		Demersal Trawl	Fixed Gear	Pelagic Trawl
Fish-eaters	*Dogfish*	●	●	●
	Winter Skate	●	●	
	Goosefish	●	●	
	Silver Hake	●		●
	Cod	●	●	
Bottom-feeders	*Haddock*	●	●	●
	Yellowtail Flounder	●		
	Winter Flounder	●		
Plankton-feeders	*Herring*	●		●
	Mackerel	●		●

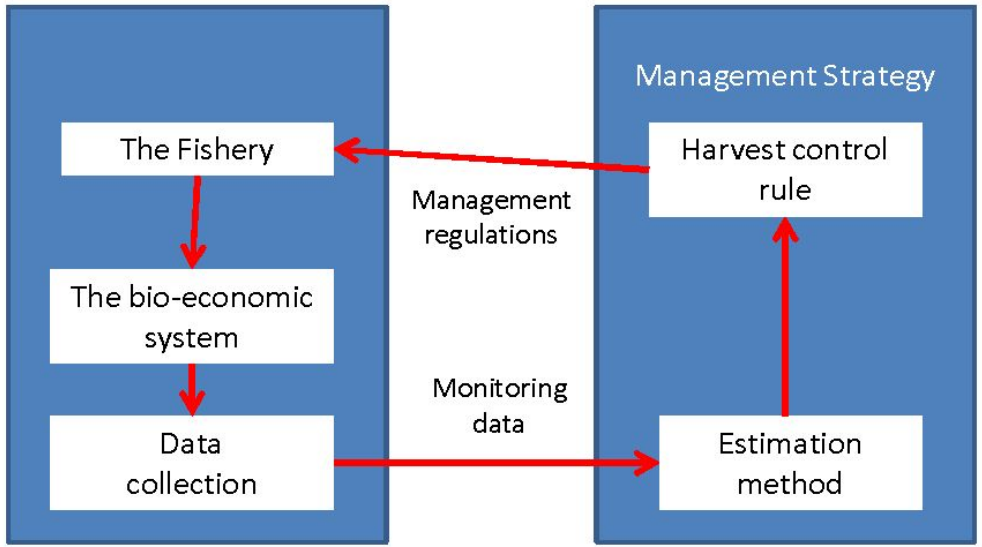
What is Management Strategy Evaluation? (MSE)

A process for:

- Comparing the performance of management strategies under multiple (& often conflicting) management objectives
- Examining impacts, tradeoffs, & robustness of management strategies.

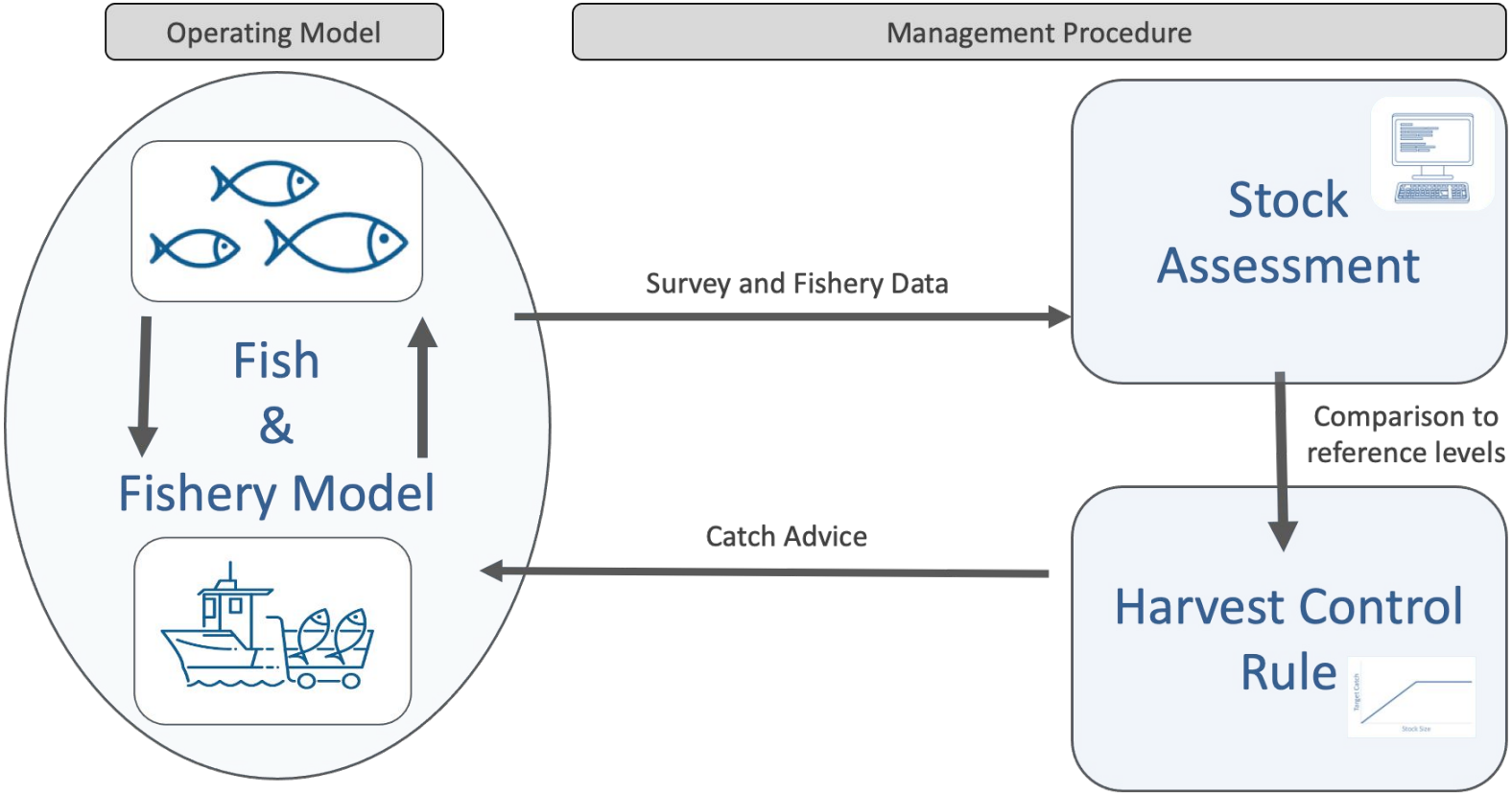
MSEs include analytical simulation frameworks but can be more than this, and develop and evaluate tools and outcomes through iterative stakeholder engagement and knowledge coproduction.

Management Conceptually

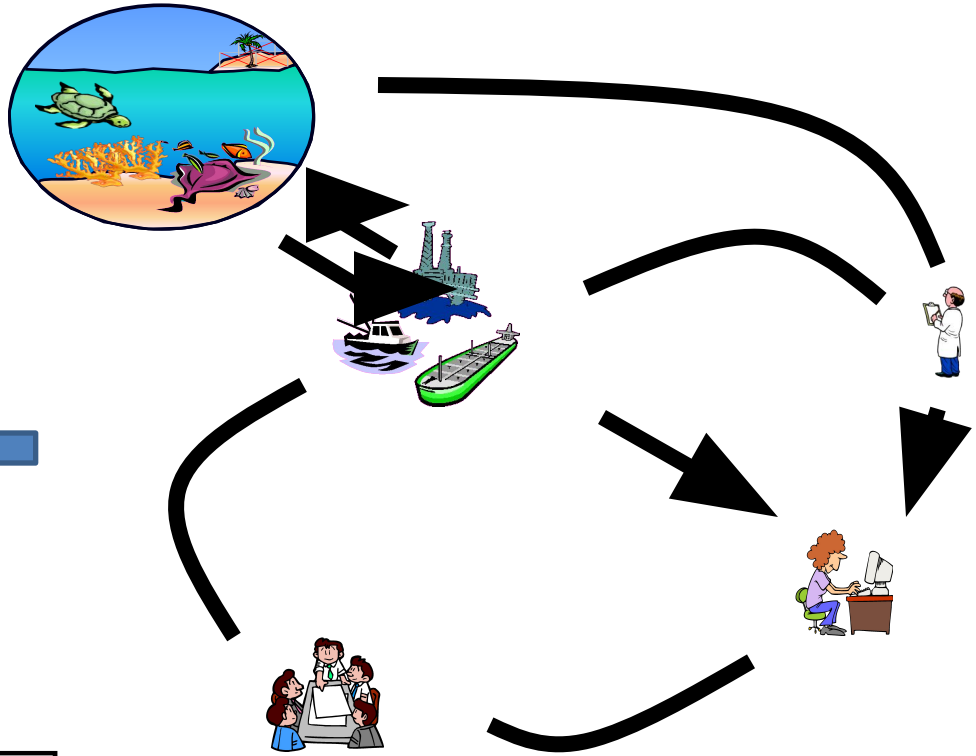


Punt et al. 2016. Fish & Fisheries

Management Strategy Evaluation
Closed Loop Simulation framework



Management Strategy Evaluation



Performance measures

By simulating the system, we can evaluate the performance of our management strategies against the known ‘truth’.

We can’t do this in the real world because we don’t actually know what the truth is.

Options that don’t work in the ordered confines of a computer will probably not do well in the real world.

Why do MSEs?

- Evaluate full management cycle
- Compare relative effectiveness of management strategies for **achieving multiple management objectives**, and to quantify tradeoffs.
- Identify sensitivity of management performance to system drivers and key uncertainty
- Pathway for formal decision analysis
- Simulation cheap, Experimentation expensive
- Play out ‘what if’ scenarios when
  - Truth is known
  - No real negative consequences of poor options

What is a ‘prototype MSE’? What is it for?

- Crystallizing the goals of the process will help us
  - Know what constitutes ‘done’
    - i.e. difference between this & other processes
  - Bound scope
  - Common understanding of tool capabilities
  - Define who the participants should be

- Structured Decision Making community term: “Rapid Prototyping”
  - (e.g. Runge & Bean 2020)
  - Value of defining decision statement, the problem / policy alternatives with a small group of stakeholders
  - Demystify process
  - Identify ‘bad’ decision space
  - Opportunity to ‘fail fast‘

pMSE Objectives

- Develop scientific support for EBFM MSE
  - e.g. “rapid-prototyping” process with the Committee, Advisory Panel Chairs, PDT, and SSC.
- Increase understanding of the eFEP, use the Prototype MSE process and results to demonstrate how MSE can be applied to evaluate EBFM strategies
- Identify management decision points, trade-offs, and potential sequences of decisions within the eFEP to compare the performance of EBFM and existing management strategies;
- Identify data and analytical gaps through the prototype MSE which could be addressed later in a full MSE process.
- Identify and develop summary products for effective communication and discussion of MSE results.

Proposed Overall Approach

- Sequence of collaborative & iterative engagement through the 6-month project period
- Use and link two existing regional modeling frameworks:
  - MSE framework developed for Northeast US groundfish (Kerr et al. 2020, Mazur et al. 2021)
  - multispecies catch at length model Hydra (Gaichas et al. 2017, NEFMC 2019)
- Allow for multispecies biological model dynamics, but use existing MSE structure, data generation, management, and implementation modules.
- Allow for more attention and time for defining the sets and steps associated with management alternatives.
- Some limited additional extension of these platforms will be needed to meet the objectives of the pMSE.
  - Narrow these to allow for focus on evaluating management alternatives and exploration of the implications of decision points via data visualization and communication tools

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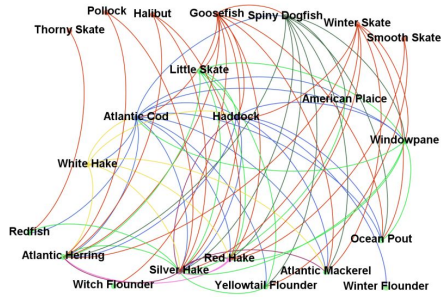

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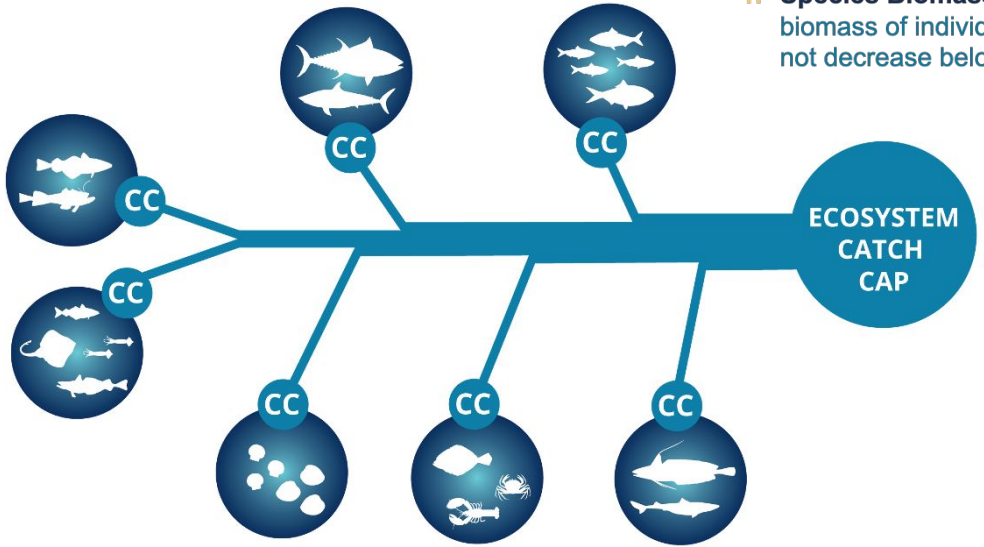

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Timeline and overview of workplan

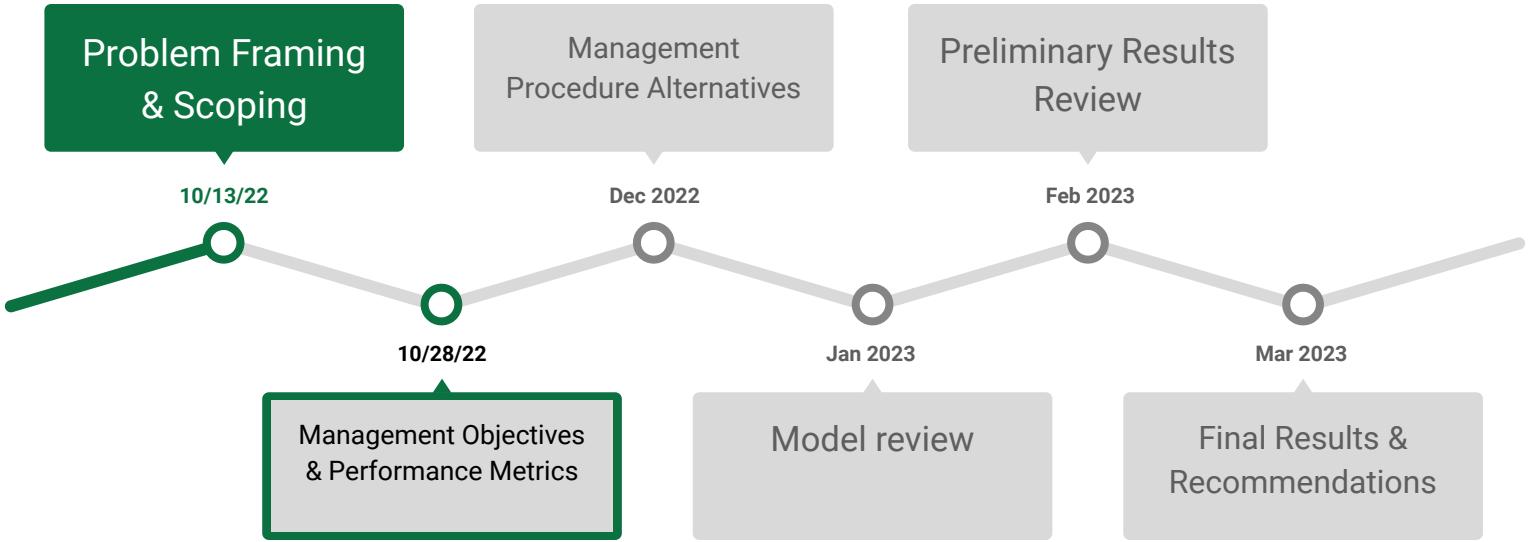
Six month project period (09/26/2022 - 03/31/2023)

Continued engagement with our core stakeholder group and technical advisors (PDT) and the SSC. Analytical work (model development and scenario running) in parallel with this process.

Also regular communication with Council staff.

Today’s initial scoping stakeholder workshop provides an opportunity to revise the proposed work plan and sequence of activities as needed, depending on feedback gained and needed development of existing software and alternative procedures.

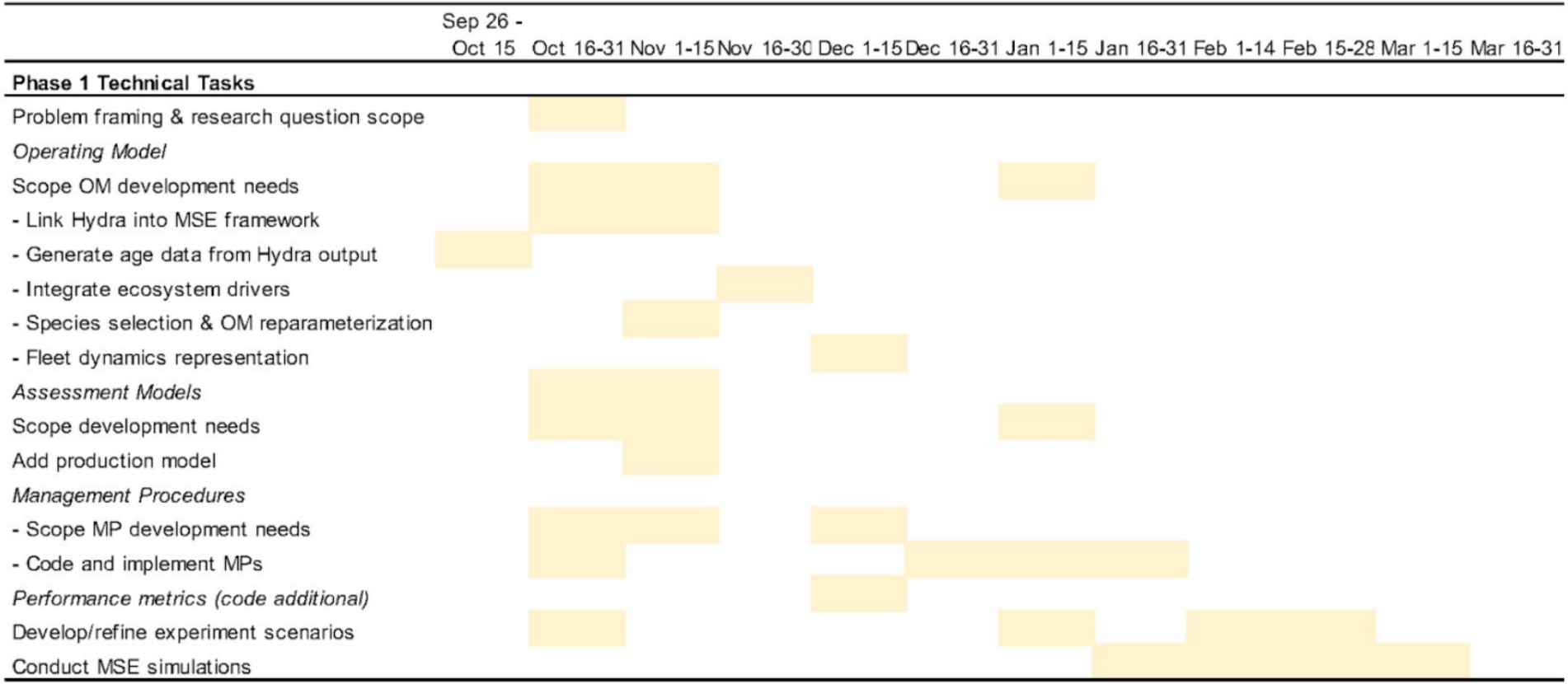
pMSE Stakeholder Workshop Sequence



Parallel sequence of engagement with the PDT (our ‘technical advisory group’)

Each workshop will contain review of previous decisions & progress

Work plan of technical activities



	Sep 26 - Oct 15	Oct 16-31	Nov 1-15	Nov 16-30	Dec 1-15	Dec 16-31	Jan 1-15	Jan 16-31	Feb 1-14	Feb 15-28	Mar 1-15	Mar 16-31
Phase 3: Presentation & Summary												
Identify communication tools & visuals												
Develop graphics/tables												
Develop shiny app for results												
Deliverables												
1. Develop workplan and calendar												
2. Participate in and lead discussions												
3. Meetings, PDT/Committee & stakeholders												
4. Weekly meetings with Council staff												
5. Make software available (github)												
6. Workshop summay reports												
7. Final report												

Engaging beyond the workshops

Documentation of meeting minutes and workshop outcomes will be curated through a Google Drive or similar file sharing, ensuring that all participants in the pMSE have full access to materials and can review documents asynchronously in addition to during workshops and meetings.

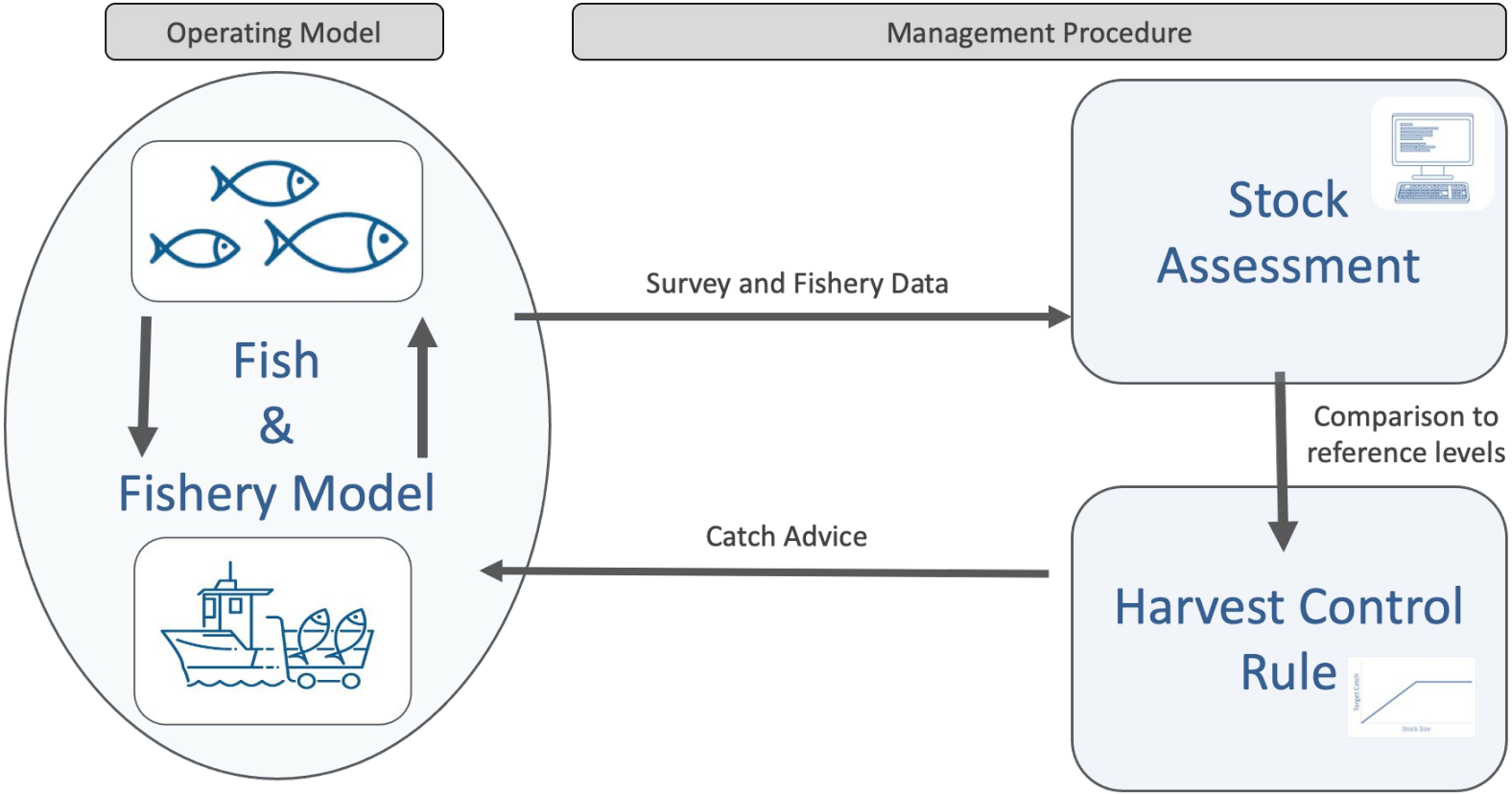
Web surveys (e.g. via Google Forms) if it is necessary to generate additional discussion and response from the stakeholder group during the pMSE. Our

Evaluation survey to assess the effectiveness of the pMSE in meeting the educational goals of providing the Council in gaining experience with the MSE process.

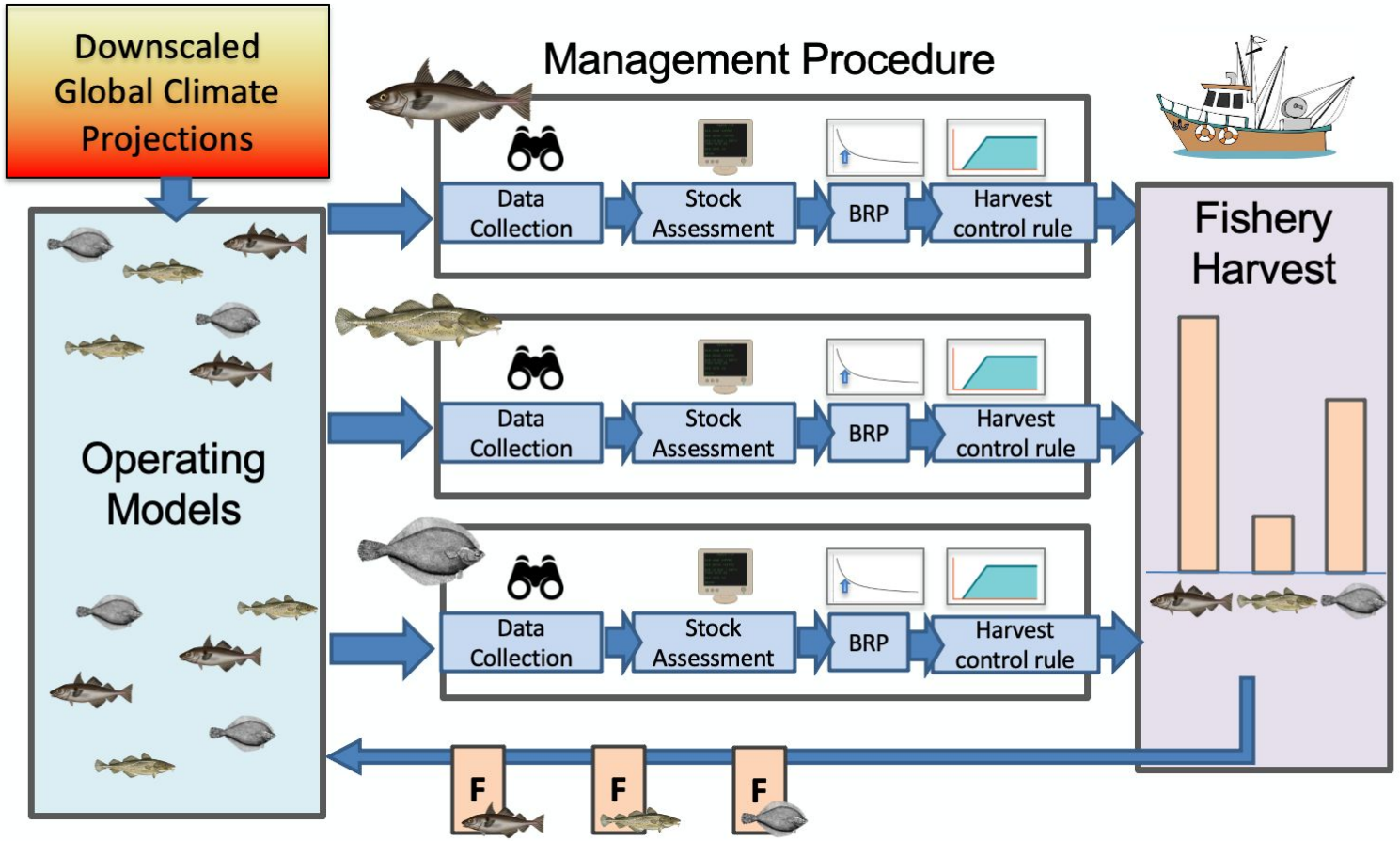
pMSE Technical Objectives

- Apply a multispecies operating model that includes trophic and technical interactions and the potential effects of climate change along with estimation, management, and implementation models in closed loop simulations to address the identified set of critical decision points and data gaps
- Identify and develop a reasonable set of operating models that account for trophic relationships among stocks and reflect a plausible range of ‘states of nature
- Investigate how human behavior (e.g. targeting vulnerable stocks within a stock complex) can impact the ability of EBFM strategies to meet management objectives;
- Identify associated ecosystem management objectives (biological, economic, and social) and associated performance metrics
- Identify a limited set of management alternatives to be evaluated.
- Compare performance of the management alternatives for achieving the management objectives for each scenario.
- Show whether and how the proposed eFEP strategies would have biological outcomes consistent with Magnuson Stevens Act National Standard 1 criteria.

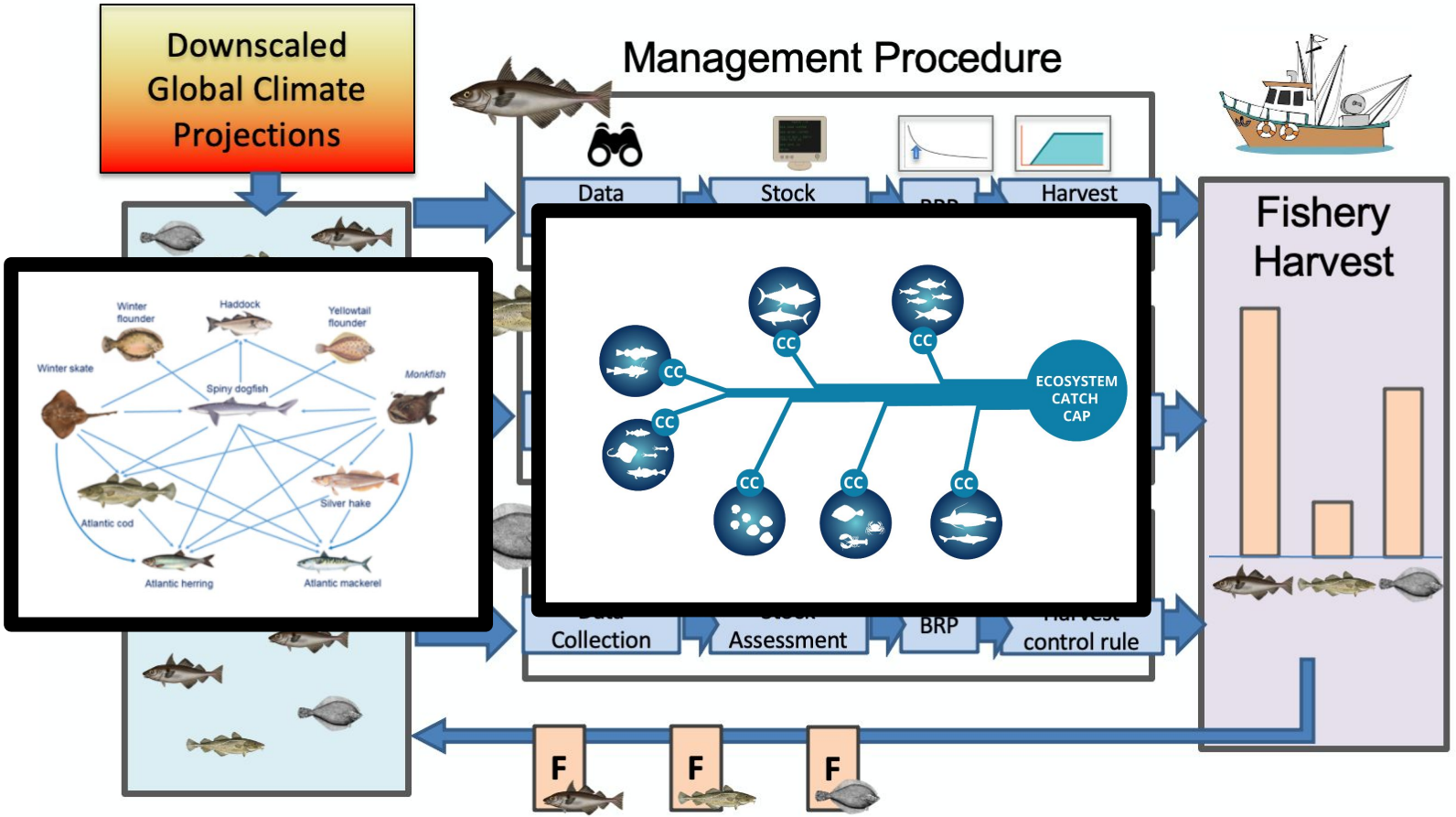
Management Strategy Evaluation
Closed Loop Simulation framework

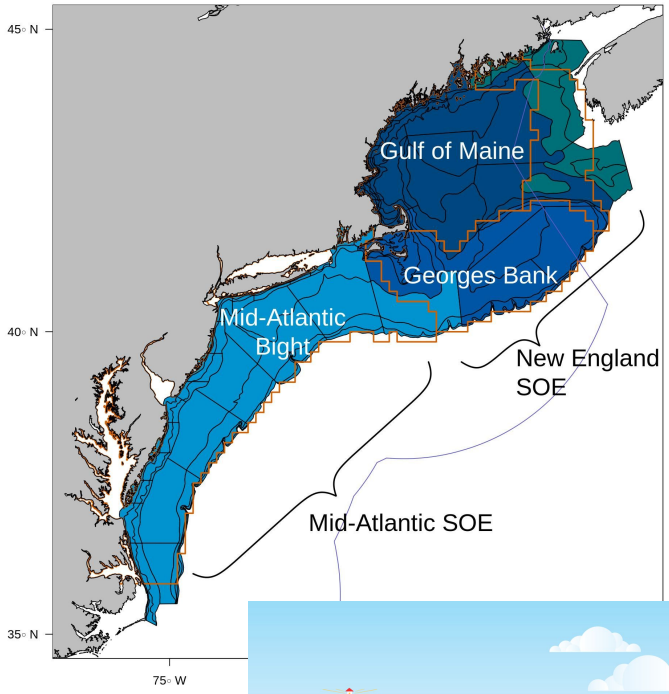


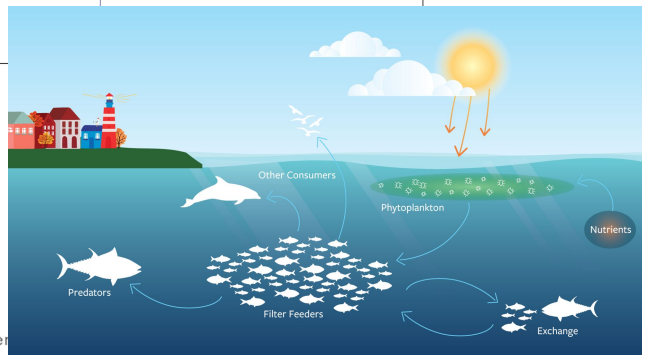
New England Groundfish MSE framework (Kerr et al.)



Multispecies operating model & eFEP management procedures







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	Cod	●	●	
Bottom-feeders	*Haddock*	●	●	●
	Yellowtail Flounder	●		
	Winter Flounder	●		
Plankton-feeders	*Herring*	●		●
	Mackerel	●		●

Management Procedures

Full set of these will be derived through our conversations in workshop #3.

Decision points associated with a management procedure include:

- the type(s) of assessment methods,
- the aggregation (or not) of species in to species complexes,
- evaluation of individual and aggregate stocks to single-species and stock complex level reference points,
- the determination of those reference points,
- the functional forms for how catch advice is adjusted based on assessment results relative to reference points,
- rules for how advice and fishing mortality is realized given allocation to fishing fleets, stock complexes, and constraints imposed by technical interactions.

Range of management procedures

Can include:

- Single-species assessment and management with no adjustment of reference points for underlying operating model dynamics (status quo)
- Single-species assessments and catch advice with dynamic reference points (building from the groundfish MSE work)
- Stock complex-based assessments with ceilings and floors based on abundance index thresholds
- Status quo assessment approaches with ceilings and floors
- Stock complex assessments with dynamic ceilings and floors, which will include rules for allocating catches to species/fishing fleets

Problem framing scoping exercise

Determine research question scope, including the choices for modeling components to understand software development needs in the project (e.g. alternatives/extensions to the proposed framework).

Facilitated small group discussion.

Problem framing scoping exercise

Discussion prompts:

1. **Are the goals identified for the pMSE accurate and complete?**
   a. Describe desirable outcomes
2. **What key questions does the pMSE need to answer?**
   a. Based on the presentation, what questions do you believe the pMSE will address?
   b. What answers would be most useful to you?
3. **Is there a key area of concern not covered by the proposed approach?**
   a. Modeling components
   b. Software needs
   c. Integration
4. **Does the pMSE process align with expectation?**
   a. Sequencing
   b. Format of engagement

Scoping review

Plenary review of group discussions.

Lunch

Prototype Management Strategy Evaluation for Georges Bank Ecosystem-Based Fishery Management

Modeling overview

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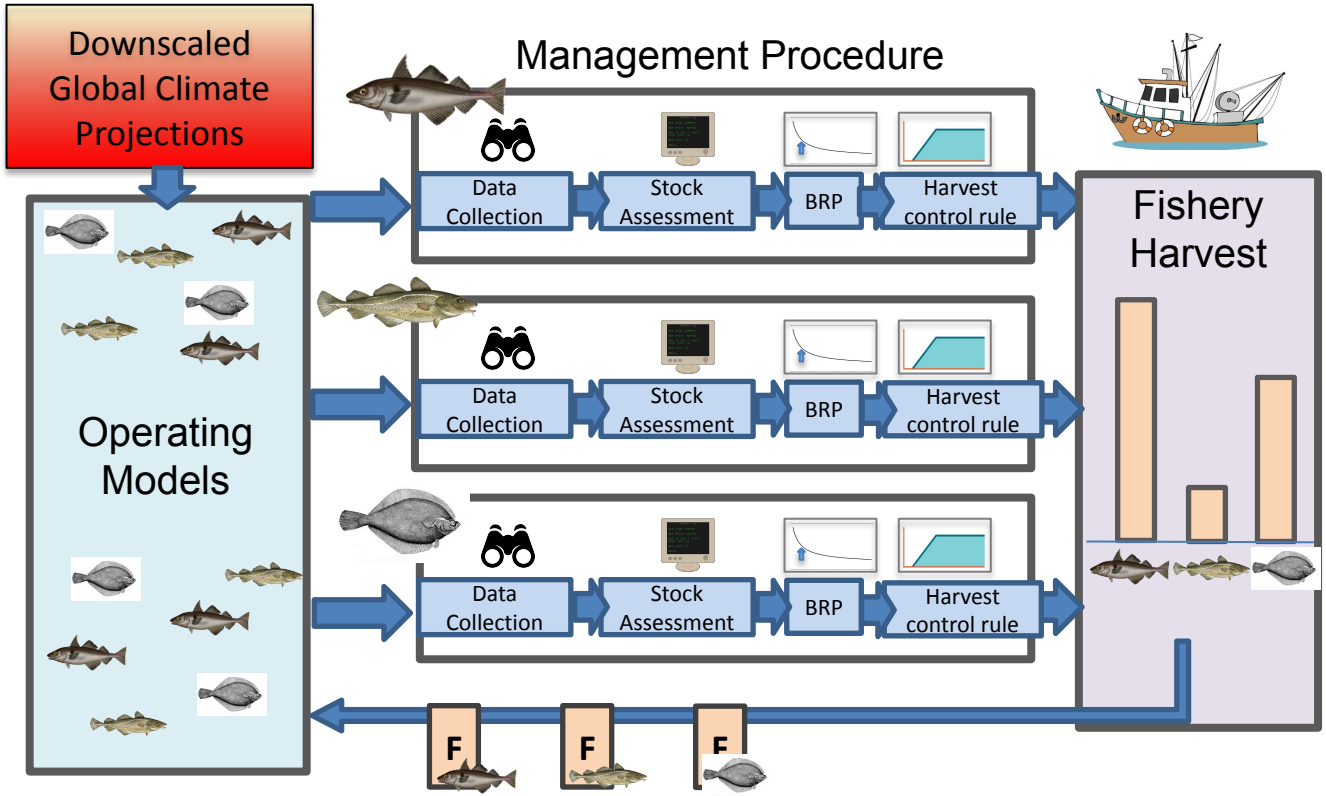
Research Institute
Science. Education. Community.

Acknowledgements

- **Development of MSE architecture by NOAA COCA Project Team**: Lisa Kerr, Samuel Truesdell, Mackenzie Mazur, Jerelle Jesse, Andrew Pershing, Ashley Weston, Steve Cadrin, Gavin Fay, Jonathan Cummings, Sarah Gaichas, Min-Yang Lee, and Anna Birkenbach
- **Funding:** Support for this research is provided by the NOAA COCA program, NOAA SK Program, and New England Fishery Management Council
- **Publicly available GitHub repository:** https://github.com/lkerr/groundfish-MSE

New England Groundfish MSE

Gulf of Maine Research Institute



MSE Framework

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- Framework has general extensibility for future applications.
- Simulations set up to run on high-performance computing cluster.
- Communication, visuals, and tutorial education materials describing the framework, its use, and outputs are available.
- Code and development and diagnostics are publicly available on GitHub.

MSE Framework: Operating Models

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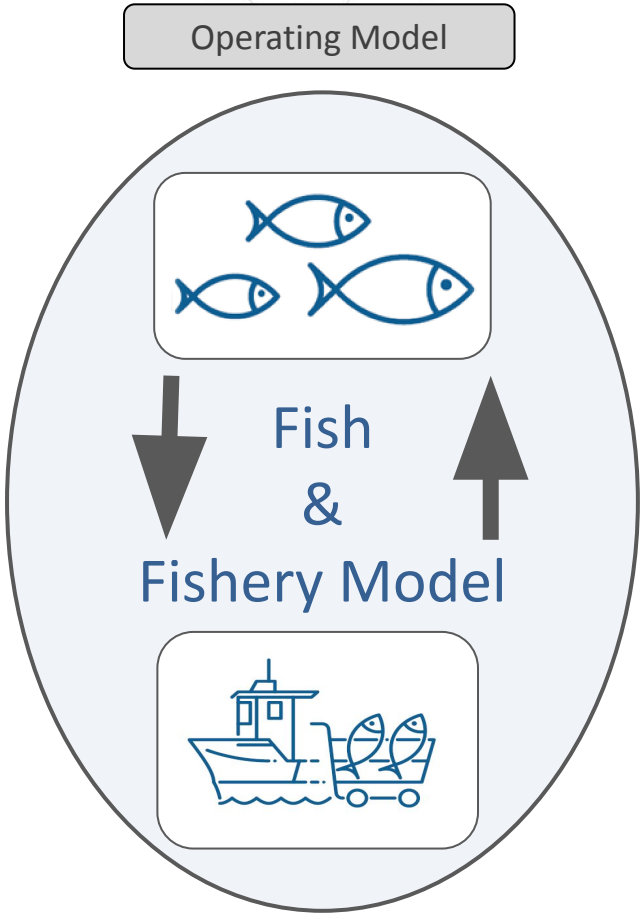
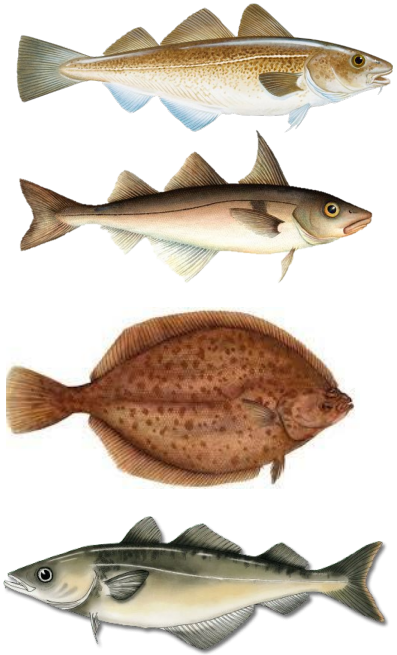


Operating models simulate the “TRUE” fish and fishery dynamics.



MSE Framework: Observation Models

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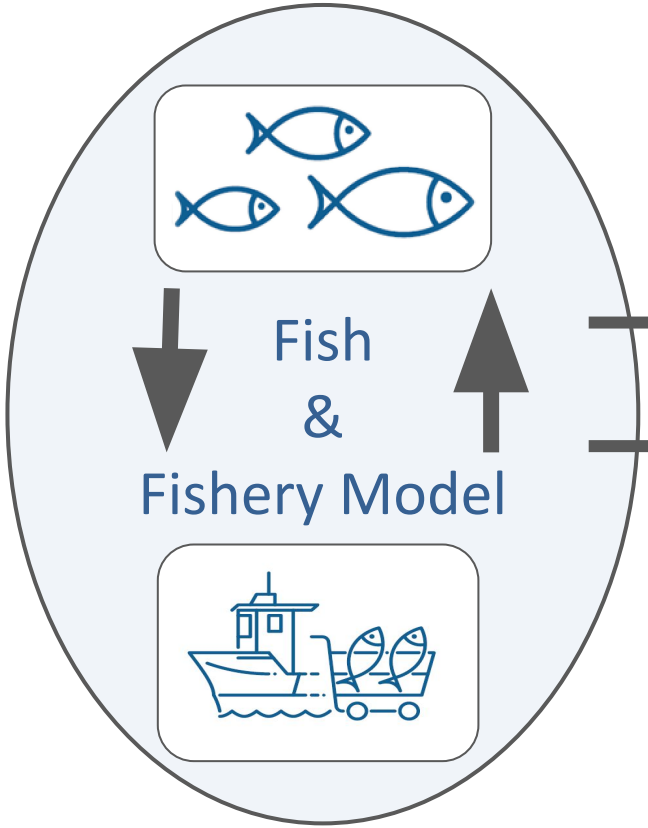
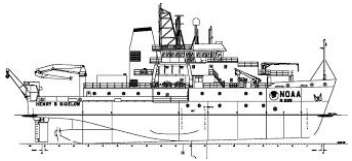
Operating Model

Management Procedure



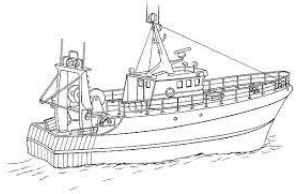
Observation error and bias can be added

Catchability can be modeled as constant or time-varying



Survey: index of fish abundance

Fishery data: catch information



Operating Model(s) are used to generate data with the characteristics of our survey and fishery data collection.

MSE Framework: Stock Assessment

Gulf of Maine Research Institute

Operating Model

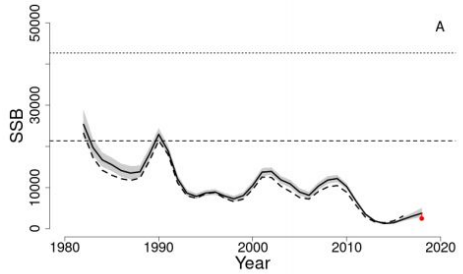
Management Procedure

Fish & Fishery Model

Survey and Fishery Data

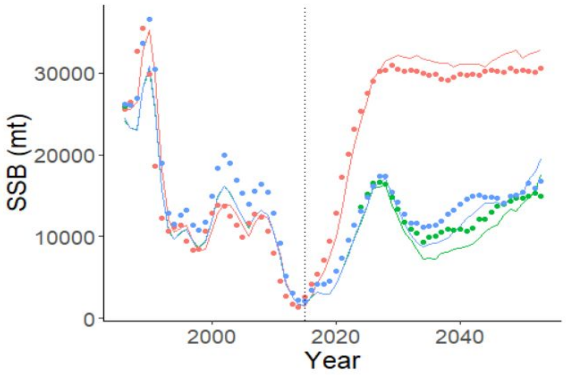
Stock Assessment

Survey and fishery data are used to inform a stock assessment that estimates stock biomass and fishing mortality.



Stock Assessment

- Stock assessments are fit to simulated survey and catch data within the closed-loop simulation.
- Approaches:
    1. Generic SCAA
    2. ASAP
    3. Plan-B smooth
    4. WHAM (in progress)



- Assumptions of stock assessment can be consistent with operating model ("self-test") or emulate misspecification of a stock assessment.
- Options to change assessment frequency and to enable projections.

MSE Framework: Biological Reference Points

Gulf of Maine Research Institute

Operating Model

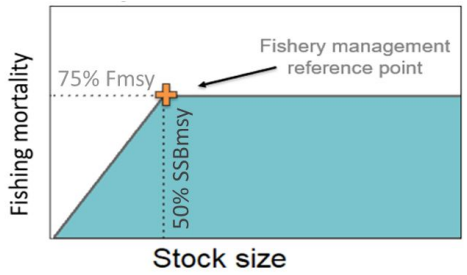
Management Procedure

Fish & Fishery Model

Survey and Fishery Data

Stock Assessment

Comparison to reference levels

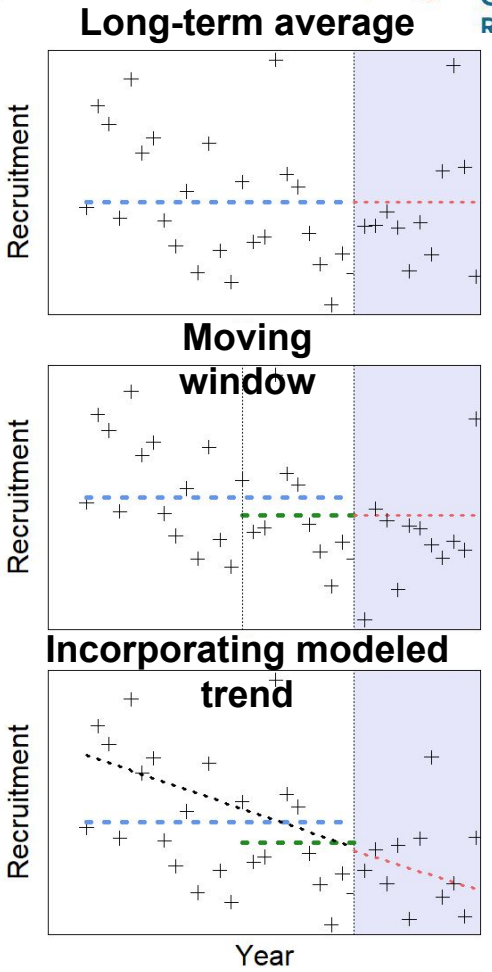


Harvest Control Rule

Biological reference points

- Methods for calculation
  - Yield per recruit
  - Spawning stock biomass per recruit
  - Spawner per recruit
  - Simulation-based methods for estimating Fmsy and Bmsy

Alternative reference time scales (past, recent, future projections) for expectations of stock productivity.

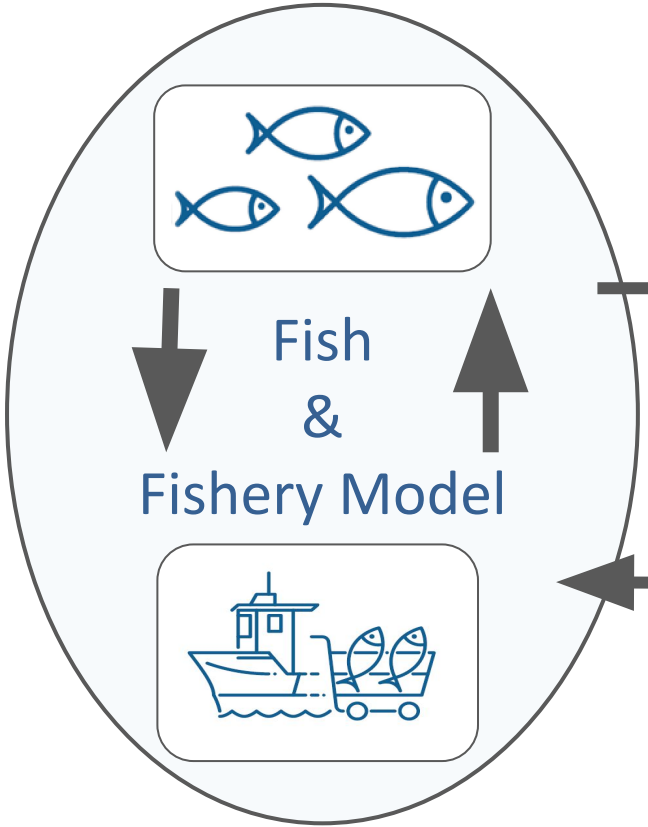


MSE Framework: Harvest Control Rules

Gulf of Maine Research Institute

Operating Model

Management Procedure



Survey and Fishery Data

Stock Assessment

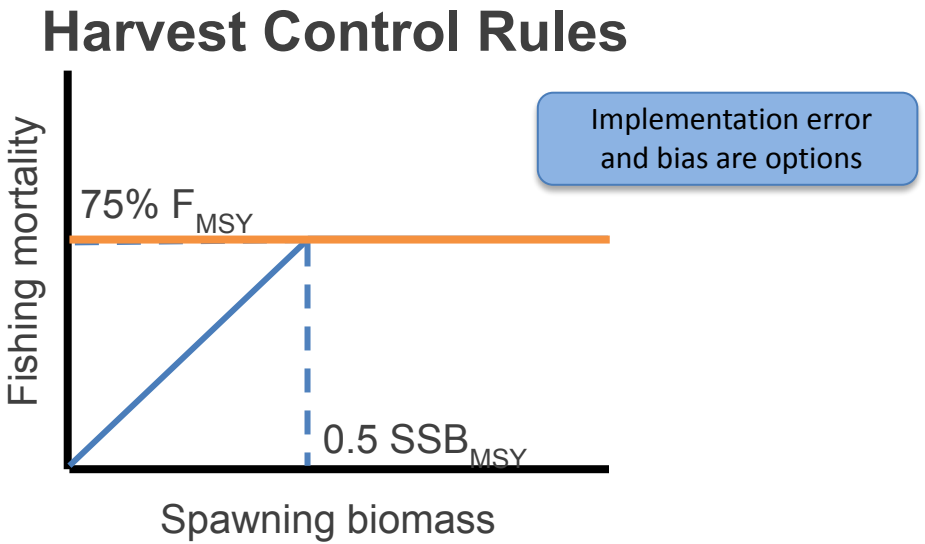
Comparison to reference levels

Catch Advice

Harvest Control Rule

Determination of Catch Advice

- F-based advice
  - Constant fishing mortality
  - Ramped harvest control rule
  - Threshold HCR
  - P* approach
- Catch constraints
  - Constraint on catch variation from year to year
  - Minimum catch constraint



Climate-informed harvest control rules can be directly linked to temperature

Measuring Impacts

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Stock Impacts:

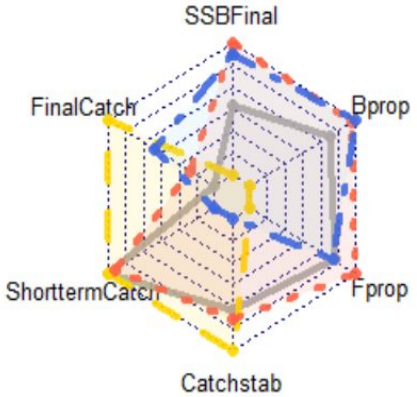
- "True" stock performance (operating model): stock SSB, recruitment, fishing mortality, and catch.

Assessment performance:

- Estimated stock performance: SSB, recruitment, fishing mortality, and catch.
- Relative error of assessment compared to operating model.
- Mohns rho for SSB, recruitment, and fishing mortality

Management performance:

- True and estimated biological reference points



Proposed Upgrades to MSE Framework

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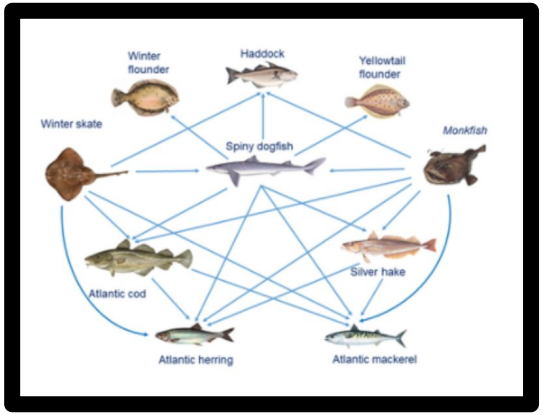
- Include the Hydra multispecies population model (used in the eFEP worked example) as the ecological component of the operating model.
- Represent ecosystem drivers in a version of Hydra that reflects the system our group wants to test using the pMSE.
- Add production model assessment to allow for stock complex aggregate assessments
- Program decision rules for eFEP ceilings/floors approach
- Characterize alternative fishing fleet dynamics via a set of scenarios

Multispecies length-structured model (Hydra)

- Model is based on the simulation model Hydra (Gaichas et al., 2017), implemented in ADMB (Fournier et al., 2012).
- Hydra's structure is derived from the length-based multispecies simulation model, LeMANS (Hall et al., 2006; Rochet et al., 2011)
- Additional options for growth, and recruitment functional forms and more detailed fishing fleets.
- Hydra simulations have previously been used to support EBFM analyses for the New England Fishery Management Council, and were reviewed in 2018 as part of an Ecosystem Based Management Strategy Review for Georges Bank.



Features of Hydra model that make it useful here

Multispecies length-structured model, includes trophic interactions among modeled species and size-based mortality (e.g. predation of smaller fish by larger fish)

Already parameterized for a subset of stocks on Georges Bank

Flexible fishing fleet implementation

Ability for externally forced drivers of population productivity and growth

Existing supporting diagnostics and data processing for input files

Reviewed as part of the 2018 Center for Independent Experts review of the NEFSC Ecosystem-Based Fishery Management Strategy

Familiarity of the model with the NEFMC EBFM committee through its use in the eFEP worked example simulation analyses

Code and development and diagnostics publicly available on GitHub.

Key Operating model development tasks & decision points

- Embed Hydra as an operating model into the MSE loop within the MSE framework
- Write code to generate age composition data based on Hydra length composition output
- Include an environmental driver to link deviations in annual recruitments among species to reflect systemic changes in productivity
- Species selection
- Fishing fleet dynamics representation
- Initialization and Operating Model Scenarios

Operating model scenarios discussion points

- alternative expectations for future stock productivity (which could include alternative initial stock status based on historical stock sizes),
- climate change effects on future growth and recruitment,
- alternatives for fishing fleet dynamics that vary the flexibility (or otherwise) of technical interactions among species, to understand how changes in the ability to target individual stocks/species may intersect with the various management alternatives.
- At least one operating model scenario (if not the base case) will model one or more species in a depleted state to help achieve pMSE goals of understanding FEP performance for responding to & recovering overfished stocks.

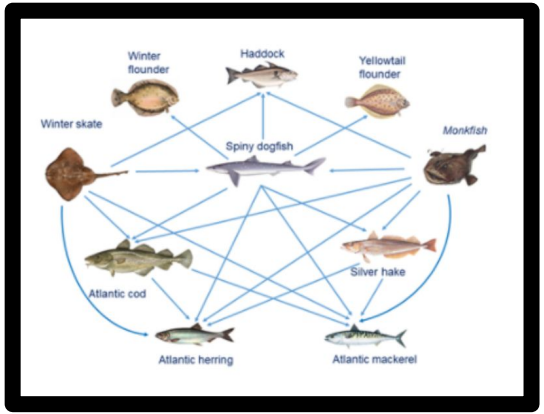
Operating model Species selection, Stock complexes, & Fishery designation

10-species in the worked example.

Would including other species help address the research questions?

How should fishing fleets be represented?

How should species be aggregated into complexes?



Environmental drivers of ecosystem productivity

The goals for the pMSE include understanding implications of changing ecosystem productivity on the performance of the eFEP approaches.

Proposed approach: include environmental driver to link deviations in annual recruitments among species to reflect systemic changes in productivity, emulating the effects of time-varying ecosystem productivity that leads to dynamic reference points (in addition to those resulting from trophic interactions).

Hydra does not include phytoplankton forcing and so this functionality will emulate this desired property in the modeled ecosystem dynamics.

Plausible alternatives for the parameterization of this driver will be based on existing work to correlate climate drivers and ecosystem indicators with recruitment of relevant stocks.

Fishing fleet dynamics representation

Fishing can be modeled as size-based mortality process, with linkages among species due to size-based selectivity and relative catchababilities among stocks.

Provides the capability to include the effects of technical interactions that result in linked fishing mortality among stocks.

Proposal: use a simple fleet-based approach to modeling technical interactions but discuss the feasibility of other simple approaches within the current software during initial problem framing and model scoping discussions.

Extending the fishing fleet model to include dynamic representation of targeting behavior is beyond the scope of this project but the MSE framework does have capability for extensibility to include this in additional future applications.

Assessment models

Choices in the management alternatives about species aggregation (or not) will help guide the selection of assessment methods for those management alternatives. (e.g. need for aggregate stock complex level biomass estimates or need for single species assesment and catch advice)

Proposal: add an additional assessment model, a surplus production model, to the MSE framework, to create functionality to fit aggregate stock complex models (e.g. Gaichas et al. 2012, Nesslage and Wilberg 2019, NEFMC 2019) to catch and abundance index information generated from the operating model. Will use existing state-space surplus production modeling software such as available functions in the MSEtool R package (Hordyk et al. 2022).

For the pMSE, we are NOT proposing using a multispecies stock assessment model.

Model scope discussion exercise

Determine extent of operating model scenarios, species to include, and specific questions the pMSE analyses will be applied to.

Facilitated small group discussion.

Model scope discussion exercise

Discussion prompts:

1. **What species should be included?**
2. **What diagnostics would be useful to compare approaches?**
3. **What constraints to fisheries management are critical to include?**
    a. Environmental drivers, legal constraints
4. **What fishing fleets should be included and how should their dynamics be represented?**

Scenario discussion

Plenary review of group discussions.

Next Steps

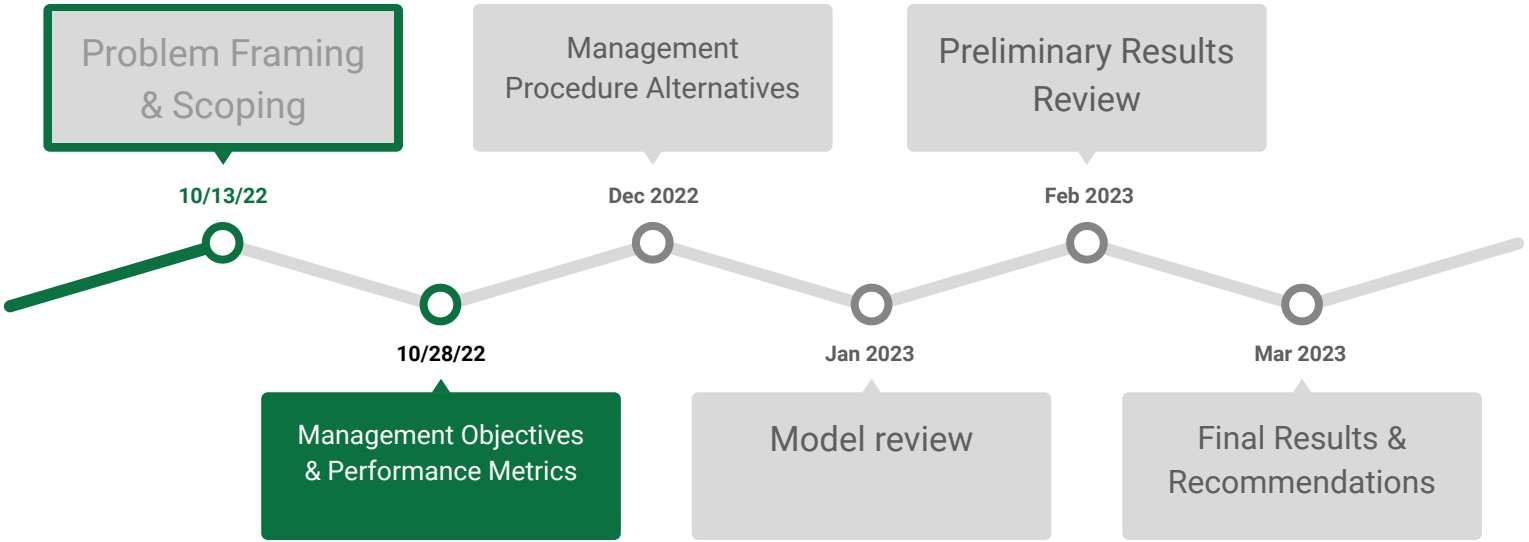
10/19: Project team meeting with the EBFM PDT.

10/28: Management Objectives & Performance metrics workshop

Meeting summary will be distributed.

Survey from Madeleine about management objectives

Questions?
Madeleine
mguyant@umassd.edu
Gavin
gfay@umassd.edu
Lisa
lkerr@gmri.org



Extra slides

Supplementary Material
Multispecies Size Structured Model "Hydra": Model Description

Hydra is a length-based multispecies, multifleet, spatial model designed to provide simulated data for performance testing of simpler (non-size structured) multispecies assessment models and management procedures for the Northeast U.S. Continental Shelf.

We focus on body size rather than age because:

- Predation is a length-based process
- Harvesting is a length-based process
- Routine age determinations are not available for all ecologically and economically important species

In this initial model we are working with a set of 10 interacting species on Georges Bank. The model is being developed in ADMB (Fournier *et al.*, 2012) with a modular design to accommodate expansion of model components, multiple functional forms for growth and recruitment, and incorporation of environmental effects on growth, recruitment, and other processes.

Workshops - what can you expect?

Scoping workshop (now): problem framing, review goals for the pMSE and determine research question scope, including the choices for modeling components to understand software development needs in the project (e.g. alternatives/extensions to the proposed framework), extent of operating model scenarios, species to include, and specific questions the pMSE analyses will be applied to.

Objectives and Performance metrics workshop (10/28): identify the fundamental and means management objectives for the pMSE analyses, and develop a suite of quantitative performance metrics that can be calculated and used to assess how the chosen management procedures are able to meet the management objectives. Identification of visualization tools and summary graphics that can support interpretation of performance metrics.

Management Procedure workshop: develop the set of management procedures (combinations of monitoring, species complex aggregations, assessment methods, and types of control rules) to be tested within the pMSE; outline and work through the needed steps and decision points associated with each management procedure, and identify gaps associated with implementation that can and can not be addressed within the pMSE analyses.

Modeling workshop: overview, review, and discussion on the modeling software and model scenarios, including technical details of operating models, MSE closed-loop simulation structure, and management procedure implementations.

Preliminary results workshop: walk-through of preliminary results for initial pMSE scenarios, with review of graphic and other presentations of results, including comparison among a subset of management procedures. Opportunity for stakeholder group to see a small version of the final results format, and for project team to learn and revise presentation/communication tools as well as identify needed changes for final analyses.

Final results workshop: presentation of pMSE results including comparison of performance among management procedures and tradeoff analysis, supported by interactive Shiny application for results viewer. Identification of key pMSE outcomes, and recommendations for further model development, data synthesis, and exploration of alternative candidate management procedures that could be included in the next stage of the Council's EBFM MSE process (e.g. a broader public stakeholder-based MSE).