Ecosystem Modeling: Living Marine Resource Management

Data-limited Calculations
- Biomass dynamics models
- Age/Size Structured Models
- Age/size Models w/ external factors
- Multi-species Models
- Biophysical Models
- Aggregate Food Models
- Biogeochemical Models

Stock Assessment/Single Species Models
- Ecosystem Assessment/Multi-species model
Onion of Model Simplifications

AGE-STRUCTURED (recruitment, nat. mort., selectivity)

BIOMASS DYNAMICS

\[ B_{t+1} = f(B_t) - C_t + e_t \]

DATA-LIMITED

HABITAT

SPATIAL

CLIMATE

FOOD WEB

OCEAN

Source: R. Methot, NMFS 2015
Ecosystem Modeling: Living Marine Resource Management

The primary reason to use Ecosystem Modeling (EM) is to establish a transparent connection between single species and ecosystem-based advice in a stock assessment or Integrated Ecosystem Assessment context.

- Application as operating models for Management Strategy Evaluation and skill assessment.
- Application of a range of models for multiple model inference to deal with uncertainty.
- Application for risk assessment and trade-off evaluation in a bioeconomic context.
EM Coordination Efforts To Date

Primarily effort has been through National Ecosystem Modeling Workshops (NEMoWs) in 2007, 2010, and 2014.

NEMoW was designed as a NMFS-wide, national workshop to examine NMFS ecosystem, bio-physical and multispecies modeling approaches to explore the establishment of ecosystem modeling standards of use and review for living marine resource management applications.
Initiate development of a standardized approach for EM across NMFS and examine:

- Software packages
- Recommendations for use and data requirements
- Parameterization protocols
- Validation protocols and verification of model results

Stock Assessment/Single Species Models  Ecosystem Assessment/Multi-species model
Key for EMs to be used in providing ecosystem-based LMR management advice is to ensure that all stakeholders, reviewers, managers and scientists using them have full confidence in what the models are doing in general and that the models have been applied appropriately in specific instances.
Evaluating methods, rationales, and communication methods for using MMI in an LMR context in an effort to reduce uncertainty

Drew on expertise from other disciplines
Major Recommendations from NEMoWs

- **Formally support/expand** dedicated EM efforts at Centers
- **Adopt** a National Standards of EM use
- **Establish** regular NEMoWs
- **Identify** and note sources of EM uncertainty as a must for EM use and review
- **Adopt** Multiple Model Inference (MMI) best practices
- **Perform** simulation studies to evaluate the skill of models to be used for MMI
Major Outcomes from NEMoWs

Networking and swapping of best practices

Vehicle to advance ecosystem modeling and ecosystem-oriented efforts

During NEMoW
1, 2 out of 7 Centers (and Habitat Conservation Office) had dedicated EM efforts/groups, there are now 4.5 (+) out of 7 such groups

At least 3 centers have had formal review of ecosystem models so that Councils can use the EMs
ToR 1: Goals for Ecosystem Modeling

**Conduct science** to understand ecosystems

- Modeling the processes, drivers, threats, status, and trends of our ecosystems

**Explore and address trade-offs** within an ecosystem

- Establish sufficient EBFM modeling capacity to analyze trade-offs
- Develop Management Strategy Evaluation capabilities to better conduct ecosystem-level analyses to provide ecosystem-wide management advice

**Incorporate ecosystem considerations** into management advice

- Develop and monitor Ecosystem-Level Reference Points
- Incorporate ecosystem considerations into appropriate LMR assessments, control rules, and management decisions
- Provide systematic advice for other management considerations, particularly applied across multiple species within an ecosystem
ToR 2 & 3: Integration and Addressing Needs

**MAJOR GOALS OF ECOSYSTEM MODELING COORDINATION**

1. **Ensuring Centers have adequate capacity** for developing and applying models.

2. **Ensuring uptake** by regional management bodies.
ToR 4: Addressing Priorities

Cataloging
EM activities at Centers

Consulting
with Centers on EM priorities

Developing Toolbox
so models can be more readily applied and reviewed

Gadids
Flatfish
PelagicS

MSVPA-X
ToR 5: Communication

Primarily through Tech Memos and scientific publications

As other aspects ramp-up (e.g. Toolbox) will develop appropriate comms
Strengths

- Strong ecosystem modeling programs at some Centers
- NEMoW: History of collaborative and collegial interactions across Centers
- Clear direction and goals in the EBFM Road Map
# Challenges and Possible Solutions

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<thead>
<tr>
<th>Challenges</th>
<th>Possible Solutions</th>
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<tbody>
<tr>
<td>Not all Centers have dedicated EM staff or Models in place to meet LMR management needs</td>
<td>Staff; S&amp;T EM coordinator collaborations; coordination with existing programs</td>
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<td>Few Councils have used EM for decision-making</td>
<td><strong>Focused effort</strong> on developing ecosystem-level reference points; Development of FEPs; NEMoW to swap ideas on application &amp; operational EMs to address LMR issues</td>
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<td>Lack of standard peer-review process for EM</td>
<td><strong>Development</strong> of EM Toolbox and review guidelines for tool</td>
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