A brief overview of modeling to operationalize ecosystem-based management of marine socioecological systems

JASON S. LINK MARINE SOCIO-ECOLOGICAL SYSTEMS SYMPOSIUM YOKOHAMA JUNE 4, 2024

# TAKE AWAYS

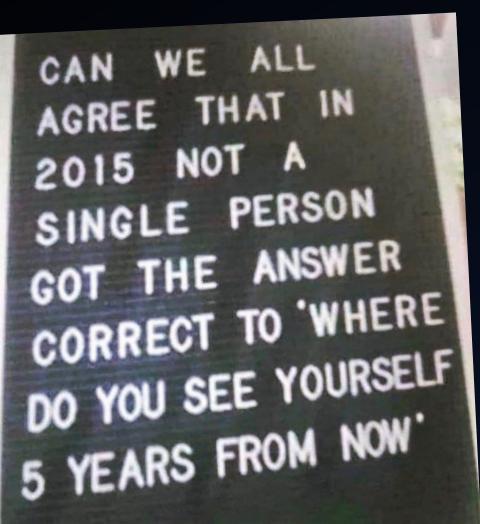
- To truly manage MEs and all MOUs we need to <u>adopt EBM</u> & cover the full range of <u>SES'</u>
- A key facet of implementing EBM operationally is to use models, and <u>best practices</u> to overcome barriers to their <u>operational use</u> are available and can help avoid modeling "black holes"
- Only when we present the <u>economics</u> and related human dimensions do people <u>truly care</u> about and pay attention to our work

# OUTLINE

- Address Assumptions
- Models for Marine Ecosystems
- Model Taxonomy & Dimensions
- Examples of Coupled SES Models for MEs
- Operationalization, Black Holes & Conditions for Success



# CAN WE ALL AGREE??? CAN WE PLEASE JUST MOVE ON???



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- Assumption #1: Everyone here is past the need to justify, define, rationalize, and explain Ecosystem-Based Management.
- Assumption #2: ditto for Socio-Ecological Systems\*.

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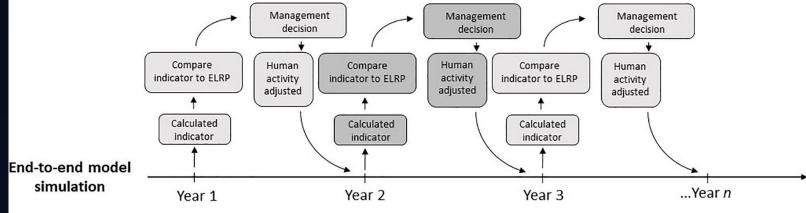
\*Refulio-Coronado et al. 2021

# What is EBM, practically?

How to catch fish, preserve habitat, conserve other critters, derive energy, facilitate shipping, limit environmental risks, extract resources, avoid too much bad stuff, have lots of tourists, utilize the ocean, respect local tribes & communities, minimize pollutants, ensure food security, consider national security, and keep people happy all at once

# CAN WE ALL APPRECIATE THE VALUE OF GOOD MODELING TOOLS?

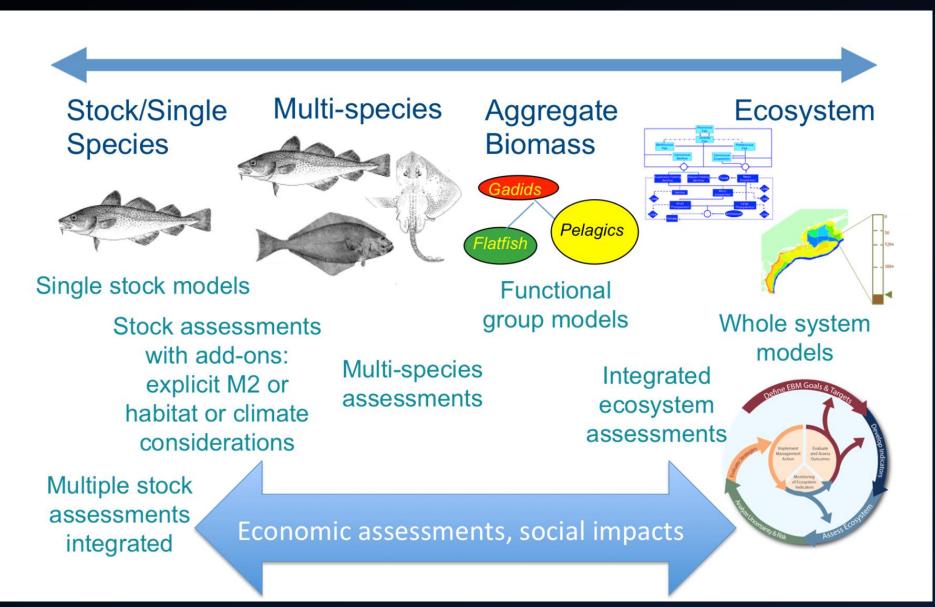
- Assumption #3: Everyone here understands the value, rationale, benefits and reasoning of using models for EBM applications, esp. SES'.
- Assumption #4: Everyone here recognizes that there are many, good, extant modeling tools that are available to use to make EBM operational.



Tam et al. 2019, FMS

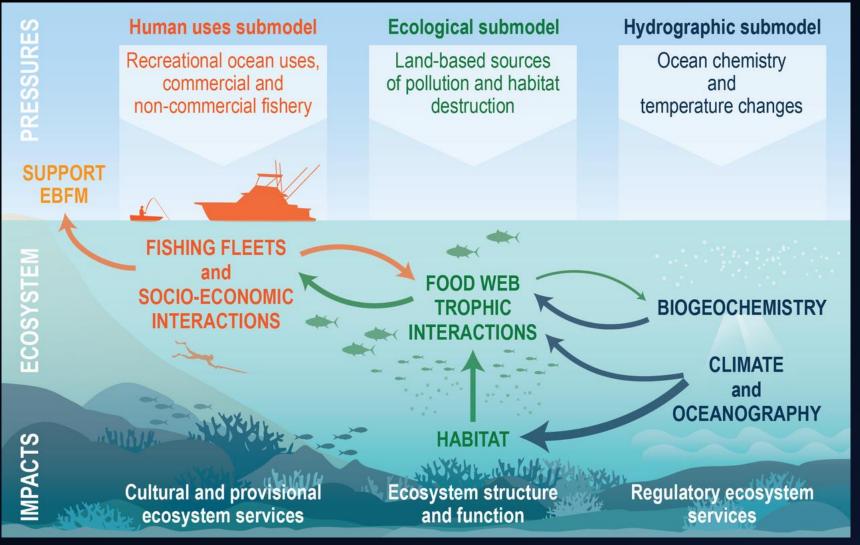
Time

## There are lots of models for MEs



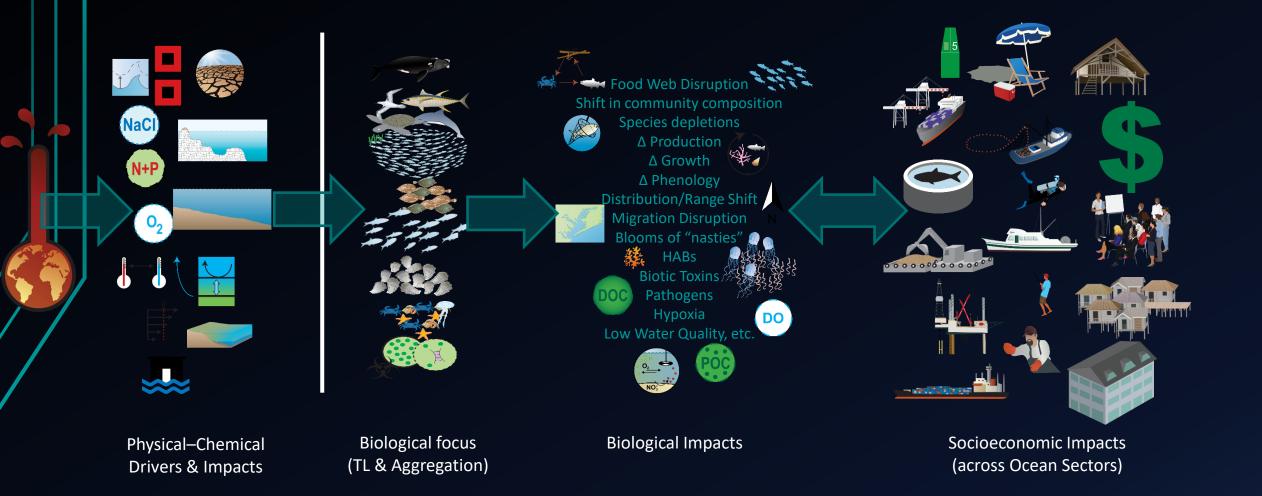
Townsend pers. comm., Link 2002

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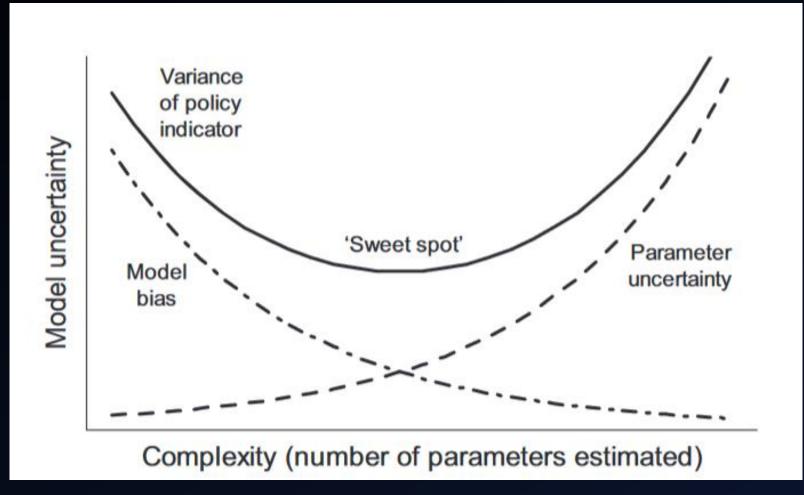


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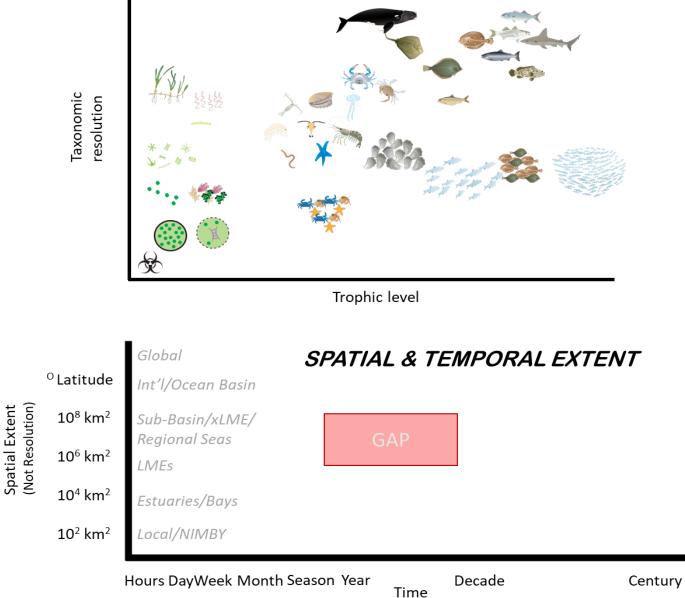


Link et al. 2023 ICES JMS



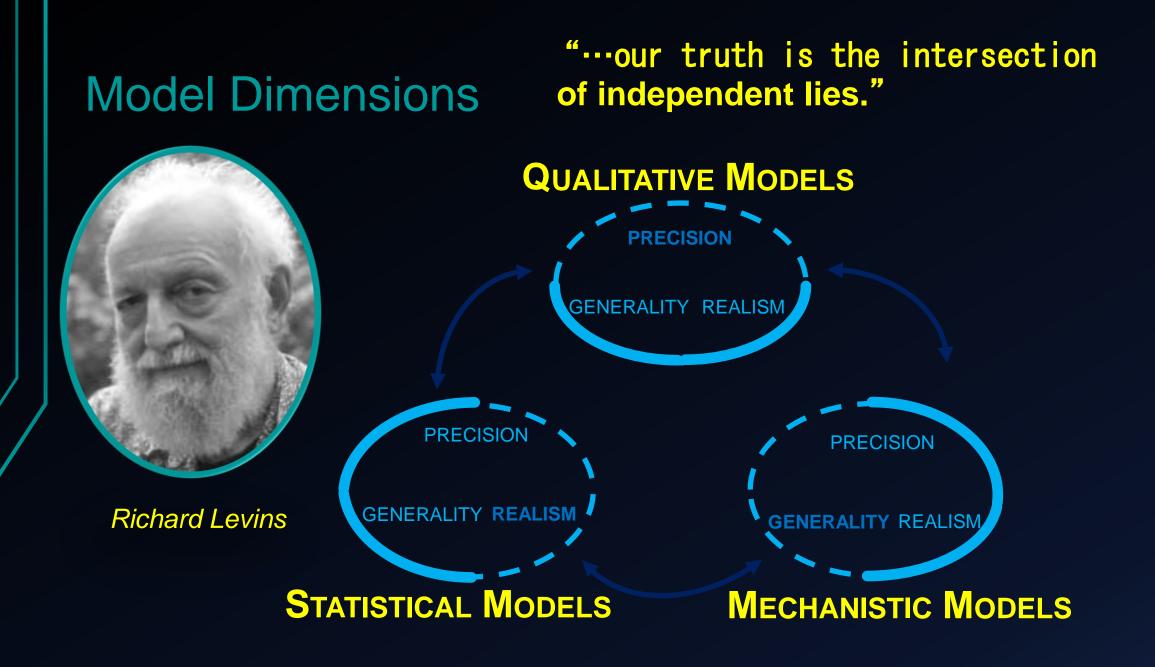
Collie et al. 2016 Fish & Fish.

#### TAXONOMIC EXTENT & AGGREGATION



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Link et al. 2023 ICES JMS

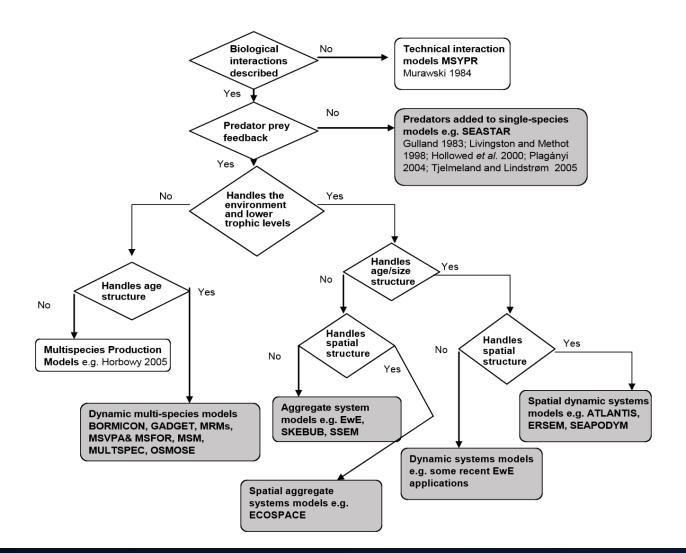


**Levins 1966** 

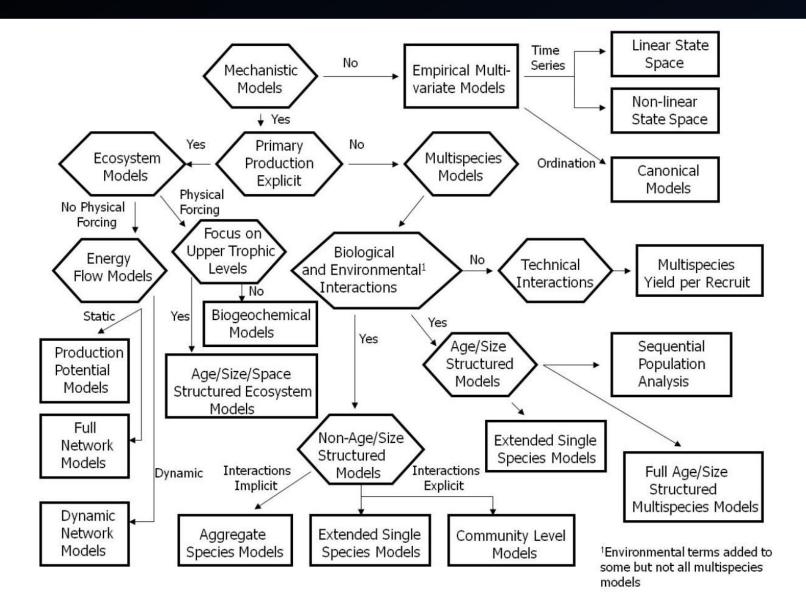
Fulton pers. comm.

FIGURE 1

A flowchart summarizing the classification of the various models listed in Table 1. The flowchart has been modified and updated from that presented in Hollowed *et al.* (2000). Boxes with models covered in this report are highlighted

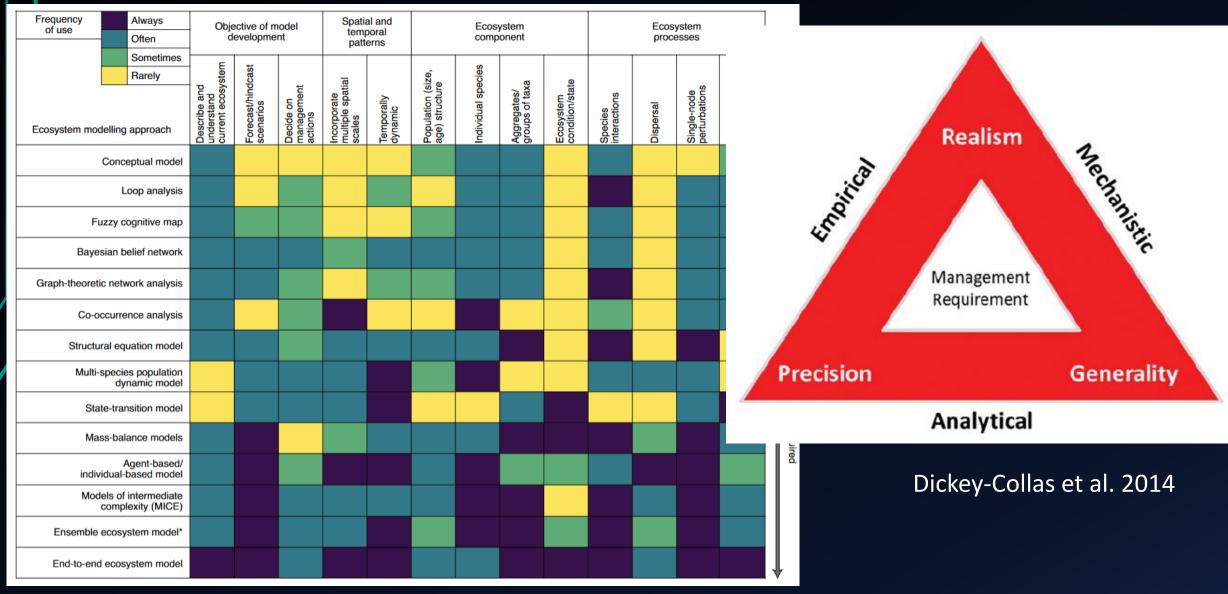


Plaganyi 2007



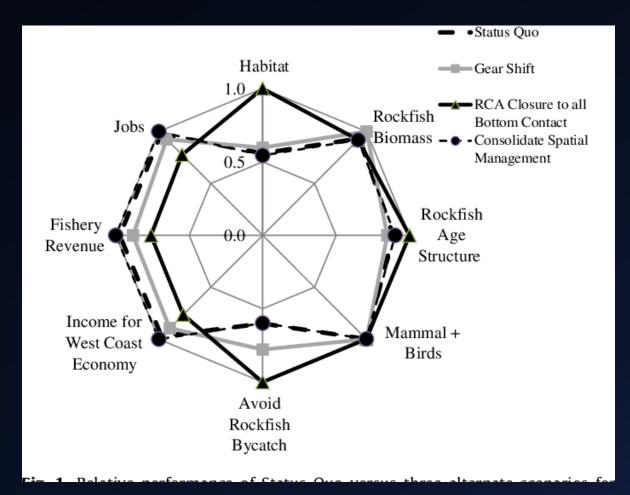
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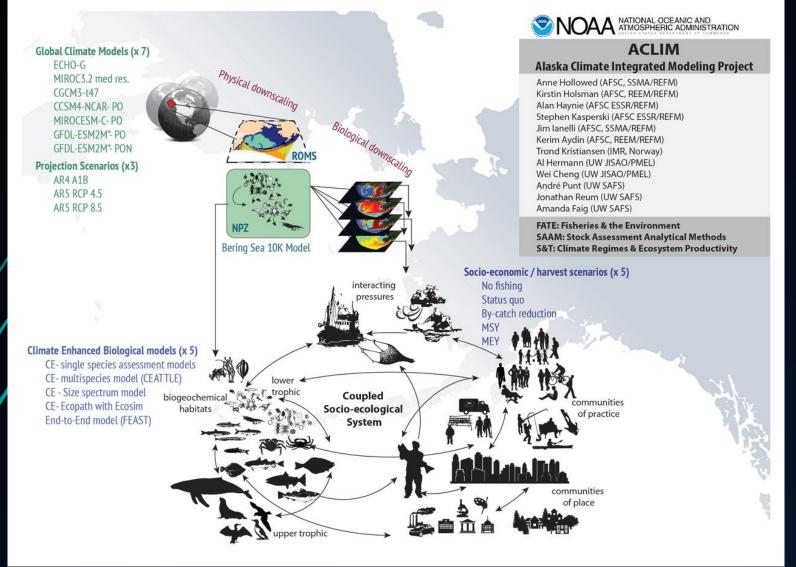


Geary et al. 2020 Nat. Ecol. Evo.; also c.f. Schlüter et al. 2019 Ecology and Society

- Statically coupled outputs from an Atlantis model
- For multiple scenarios
- With an I/O model to gauge and report on Economic impacts of the scenarios
- Powerful demonstration & tool to compare ecological and economic impacts simultaneously
- Identified some of the better options
- Been discussed in various management bodies



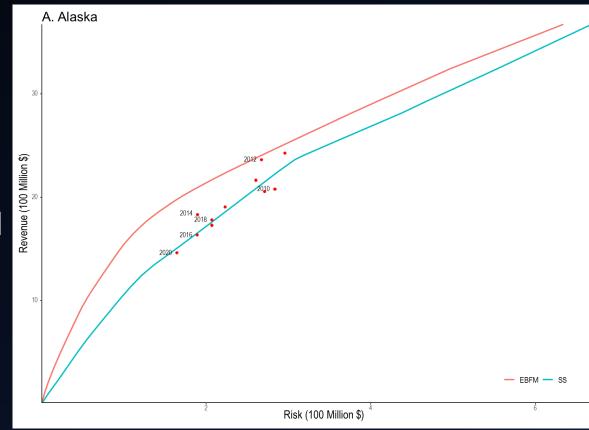
Kaplan & Leonard 2012



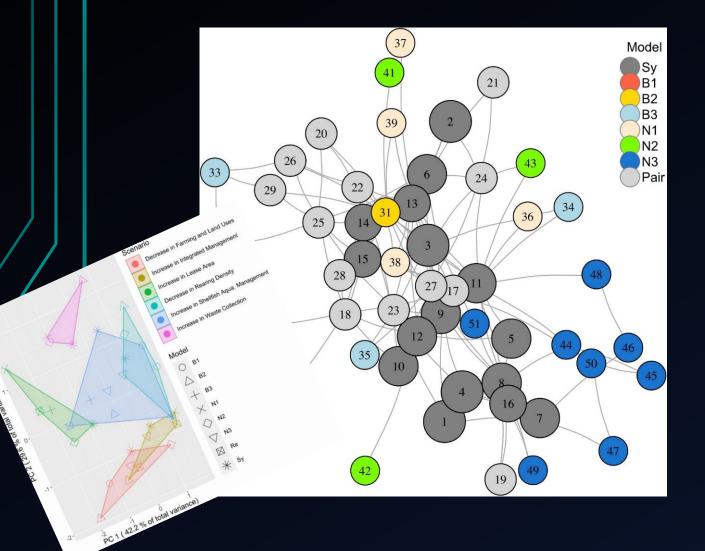
- Model ensembles and coupled models
- Clear Socio-economic outputs
- Been used in various management bodies, both tactically and strategically
- Clearly shows tradeoffs among (mainly) climate scenarios
- Expanding to include social networks, risk analyses

AFSC 2019, Hollowed et al. 2020

- Portfolio approach
- Compared landed value- risk & revenueto portfolio frontier
- EBFM/MS approach resulted in better outcomes
- Uses commonly available data, examined from an economic perspective
- Potential metric of socio-econ performance
- Discussed at various management councils

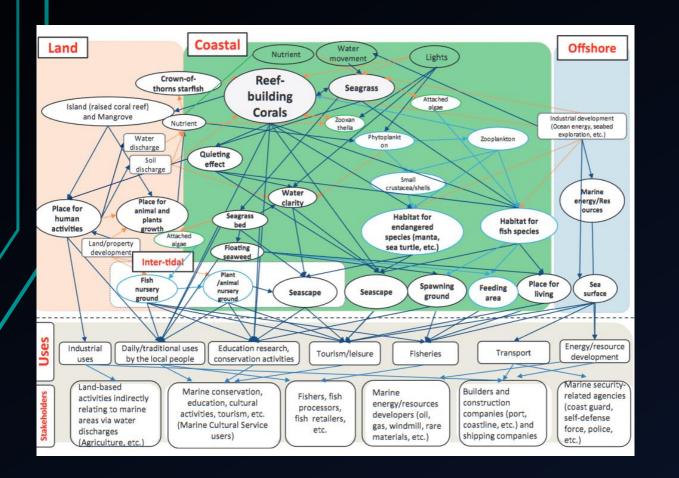


Townsend et al., in review | Brewster et al. in review



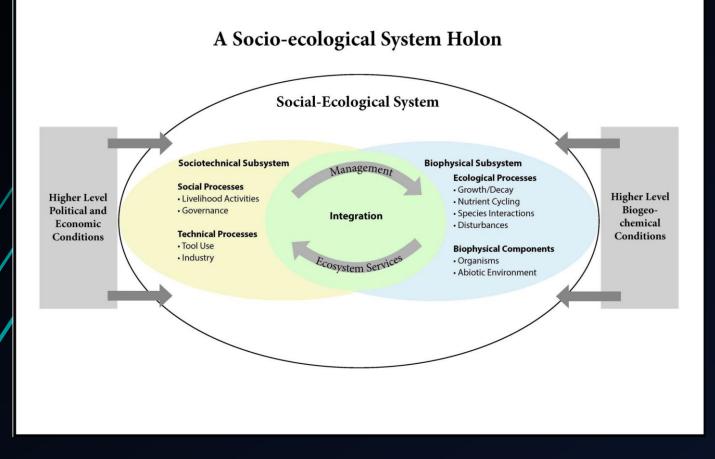
- Qualitative modeling
- Loop analysis used to engage multiple stakeholders
- Explored sustainability and attitudes towards shellfish aquaculture
- Results converged across 6 regions
- Led to suggestions of best options for sustainability (namely lower rearing density)

Gourguet et al. 2021



- "Mapped" major features of a Coastal Lagoon in Japan via a qualitative network
- Explored policy interventions and overlap
- Demonstrated high degree of overlap across sectoral uses and policies
- Confirmed integration/ coordination across sectors would be beneficial

Makino et al. 2021, in Saito et al. eds.



Turner 2021

- There are other examples from around the globe, but the rate of these developing is not increasing as would be expected
- Few are fully coupled and fewer still are dynamically coupled
- Many are using qualitative or scenario-based modeling approaches
- Use in mgt and decision-making contexts is either growing or at least planned for
- In summation- the degree of presenting and evaluating tradeoffs among/across scenarios remains the chief rationale & benefit

- Yay, I finished building a model
- It actually used data (tuned/calibrated/validated/etc.)
- It produces reasonable results



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- It is informing decisions indirectly
- It is informing decisions kinda directly







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- It is informing decisions kinda directly
- Decisions are now based (at least in part) on my model
- Decisions are improved/better from having used my model
- Status of the resource modeled is ultimately improved







# Time Out: What does "operational" mean?



In the context of EBM of marine resources and Ecosystem Goods and Services...

- <u>Routinely and regularly provided (i.e., not research)</u>
- Using an already <u>vetted and verified</u> method/approach/model (i.e., not research)
- Incorporating latest <u>data updates</u> (which along w/synthesis outputs are reviewed)
- Used to inform, support or assist <u>decisions</u> (i.e., applied, not theoretical)
- Typically <u>tactical</u> (short term, specific actions) and focused on <u>actionable</u> choices/outcomes/ impacts
- Can also be strategic, heuristic or contextual, namely to bound tradeoff solution space

## What does it mean to use a model operationally?

#### OPERATIONAL- MODELS AND RESULTANT PREDICTIONS THAT ARE "USED TO SUPPORT AND INFORM RESOURCE MANAGEMENT," AS CHARACTERIZED BY:

(1) use of established methodological approaches and best practices during model development,

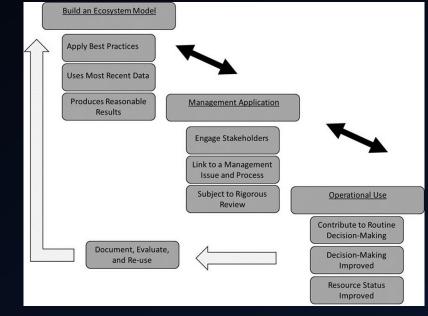
(2) regular use of the model to provide information in support of a resource management process,

(3) use of the most recently available data that has been quality-controlled, archived, and is easily accessible,

(4) model outputs that can inform actionable choices from a defined set of alternatives, and

(5) ideally, evaluation of trade-offs among ecological, socio-economic, and policy objectives.

Craig and Link 2023 Fish & Fish.

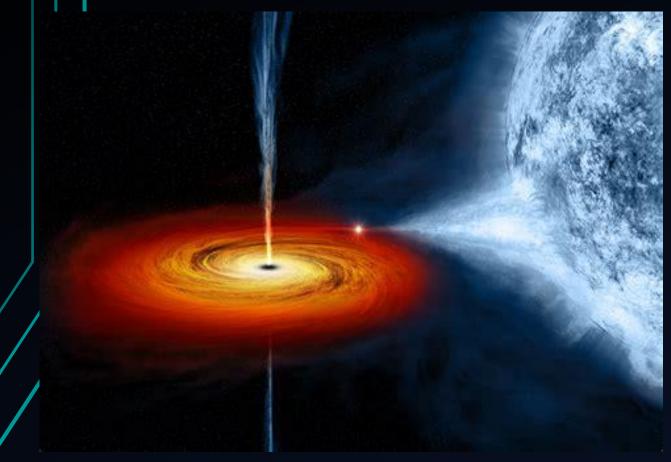


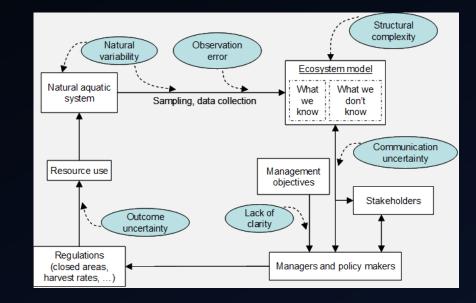
Operational models are also regularly updated using established procedures and their outputs are familiar to decision-makers".

The point is that there are many research models and even published predictions, ...

but for a model to formally provide operational prediction products, as used in a forecasting context, the prediction products need to be routinely and regularly incorporated in a decision-making venue.

# Modeling black hole traps

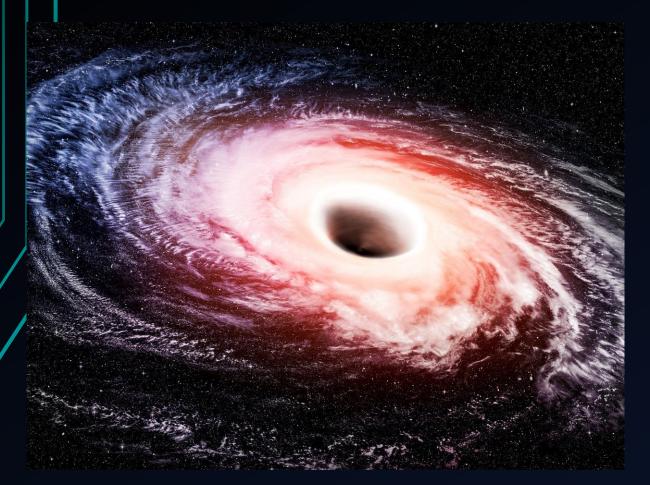




- Mischaracterizing or excessive emphasis on 1-2 types of uncertainty →
- Excessive & Infeasible Statistical Rigor  $\rightarrow$
- Wrong class/type of model use  $\rightarrow$
- Wringing of hands wrt "too little data, too little precision, too much uncertainty" →
- Not using models for SES

c.f. Link et al. 2012, PiO; Rousnsevell et al. 2021 One Earth

# Avoiding Modeling black hole traps



- Balancing model dimensions
- Using Best practices
- Knowing right type of model for the issue/question
- Using right type of model for the issue/question
- Recognizing multiple pathways and insertion points in an operational context
- Focusing on accuracy, outcomes and participation seems wise for SES contexts

# When SES modelling (& model coupling & model operational use) has been done, why has it worked?

#### TECHNICAL

- Interdisciplinary teams
- Using best practices for each discipline (beyond just modeling)
- Rigorous peer review
- Provide multiple forms of output before finalizing

#### MODELING

- Following Int'l Stds or best practices for the component models
- Explicitly addressing the multiple types of uncertainty

#### PROCEDURAL

- Engaging with stakeholders and mgt institutions early and often
- Insertion into the mgt or decisionmaking process
- Develop/apply model to objectives at-hand
- Report on tradeoffs



- Multiple model ensembles
- Iterate on model coupling
- Use *APPROPRIATE* level of model, resolution, dimensions, data, etc.

# What have been some of the main impediments for SES modeling & model coupling operationally?

#### **NON-TECHNICAL**

- A lack of familiarity of modeling options
- A lack of stakeholder engagement
- Unclear management objectives
- "We've never done it that way before" other institutional inertia factors
- Stating tradeoffs explicitly gives away political positioning
- Social/institutional/governance constraints (e.g. discomfort with/inability to handle tradeoffs, what are the value metrics for decision criteria?, etc.).
- Different stds across disciplines

#### TECHNICAL

- Data gaps and resource limitations,
- Modelling issues (complexity, parameterization, validation, technical review)
- Interdisciplinary jargon challenges

C.f. Townsend et al. 2019, FMS | Fulton 2021, Fish & Fish. Craig and Link 2023 Fish & Fish. | Karp et al. 2023, ICES JMS Haugen et al. 2024, Nature Ocean Sust. | Patrick & Link 2015

# Some Global Best Practices

Clear	Important	Best	Active	Connected to a	Multi-	Formal
Objectives	Tradeoff	Practices	Stakeholder	Management	Model	Review
			Engagement	Process	Approach	

#### Plus, Especially for SES Modeling:

- Maintain model taxonomy?
- Understand and work towards operational use
- Coupling across disciplines
- Best metrics for demonstrating tradeoffs
- Wide participation is increasingly key



# TAKE AWAYS

- To truly manage MEs and all MOUs we need to <u>adopt EBM</u> & cover the full range of <u>SES'</u>
- A key facet of implementing EBM operationally is to use models, and <u>best practices</u> to overcome barriers to their <u>operational use</u> are available and can help avoid modeling "black holes"
- Only when we present the <u>economics</u> and related human dimensions do people <u>truly care</u> about and pay attention to our work

QUESTIONS: Email me at: Geret.DePiper@noaa.gov