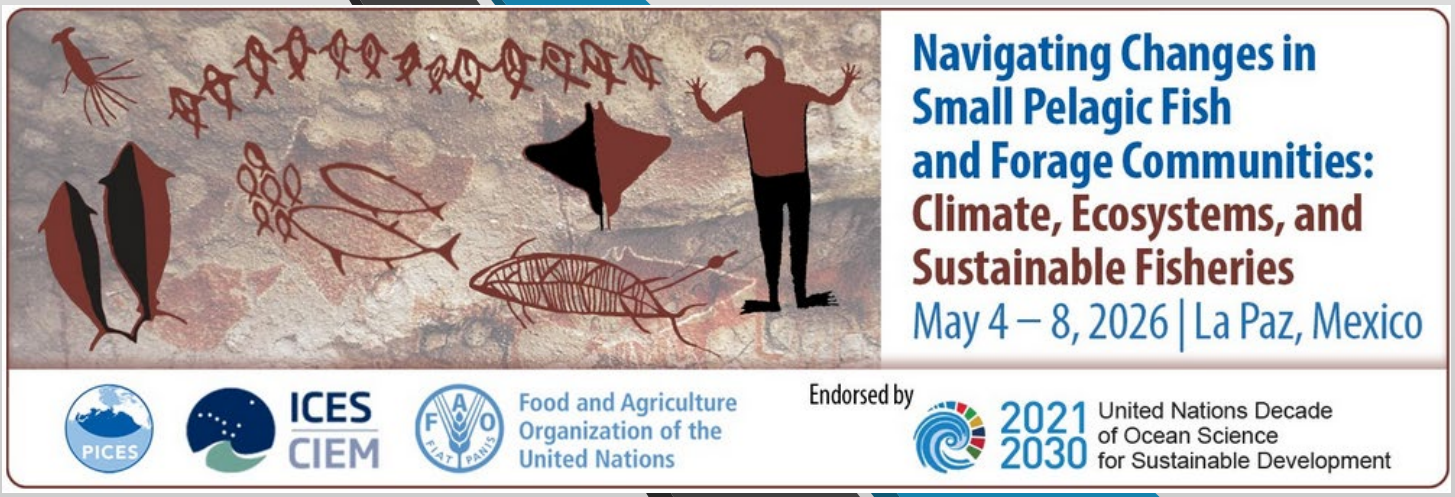
Explicitly Incorporating Ecosystem-Based Fisheries Management (EBFM) into Management Strategy Evaluation (MSE)

Carryn de Moor

Workshop 7: Operationalizing Ecosystem-Based Management of Forage Species using MSE
ICES/PICES SPF International Symposium
4th May 2026



MARAM

Quantitatively Advancing EBFM

- EBFM aims to encapsulate all aspects of the ecosystem in providing responsible fisheries management advice (social, economic, human)
- Need to transition from single-species management to EBFM/EAF is widely recognised
- But progress has been slow and often qualitative

EBFM – Ecosystem Based Fisheries Management
EAF – Ecosystem Approach to Fisheries
MSE – Management Strategy Evaluation
MP – Management Procedure

Management Strategy Evaluation

- Key component of EBFM:

Identifying and exploring trade-offs among different objectives and parts of the ecosystem

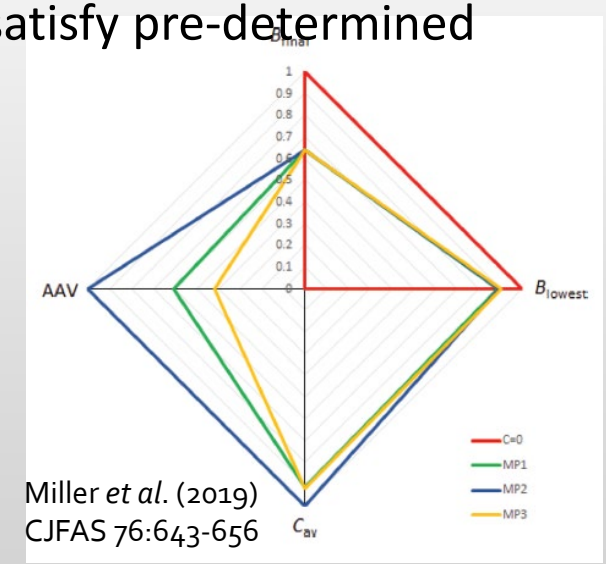
- Key advantage of MSE:

Allows managers to select an MP which has been simulation tested to satisfy pre-determined objectives

Stakeholders

Competing Objectives

Trade-Offs



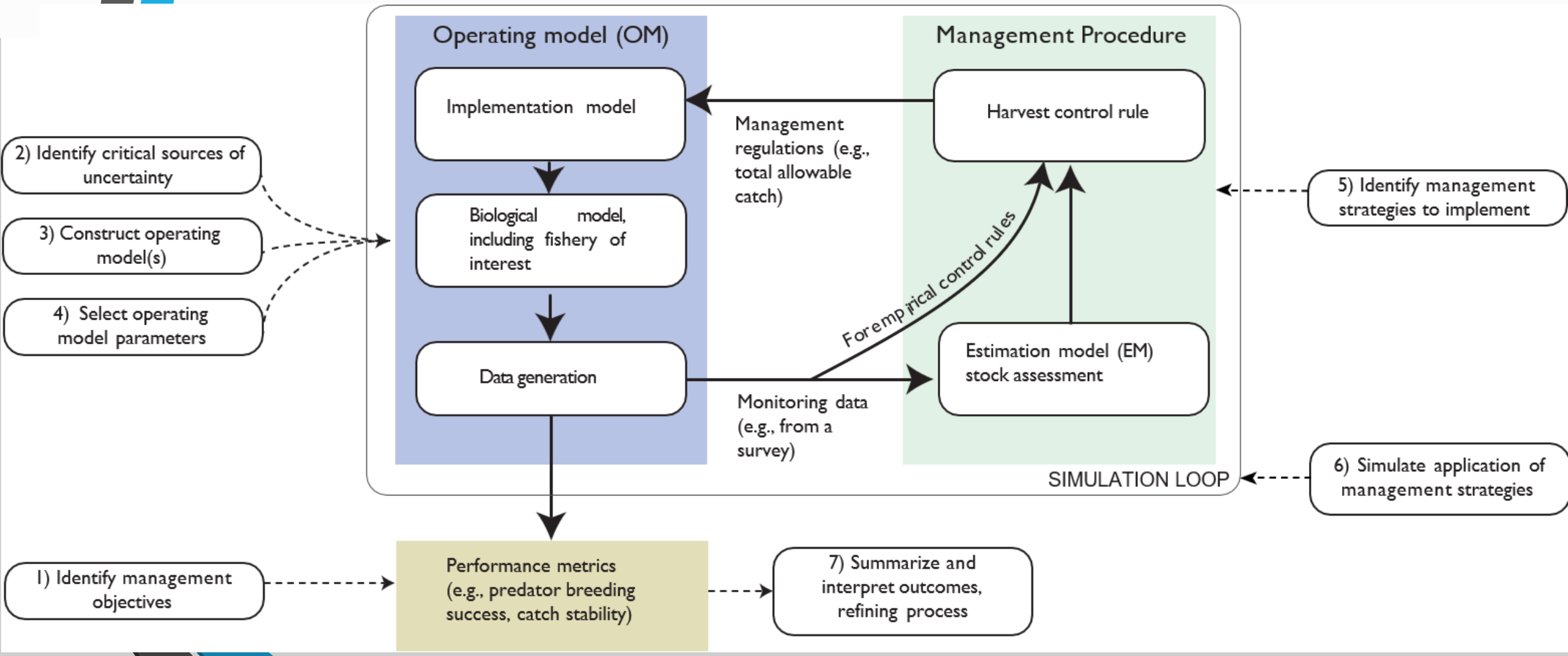
Miller *et al.* (2019)
CJFAS 76:643-656

MSE Performance Statistics

MSE is an ideal tool
to further the implementation of EBFM

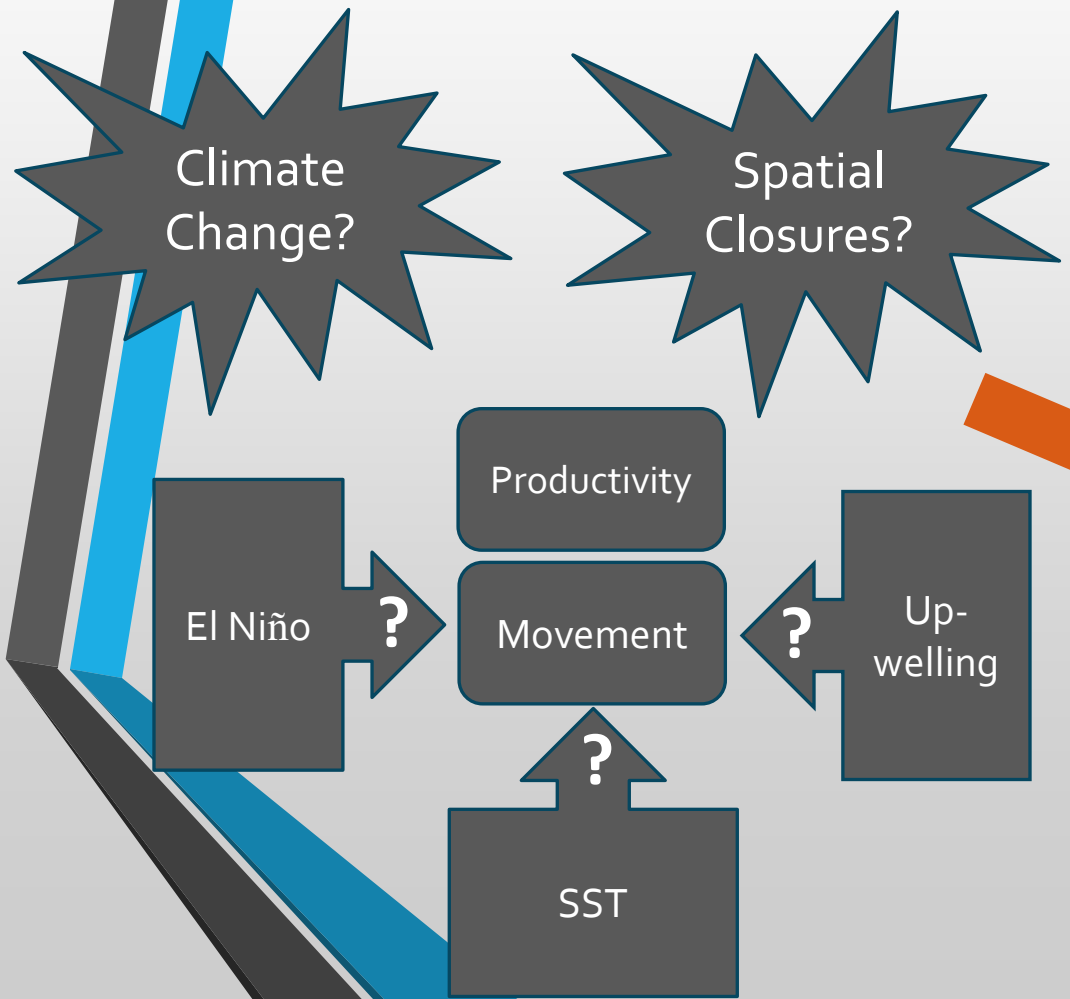
Management Strategy Evaluation

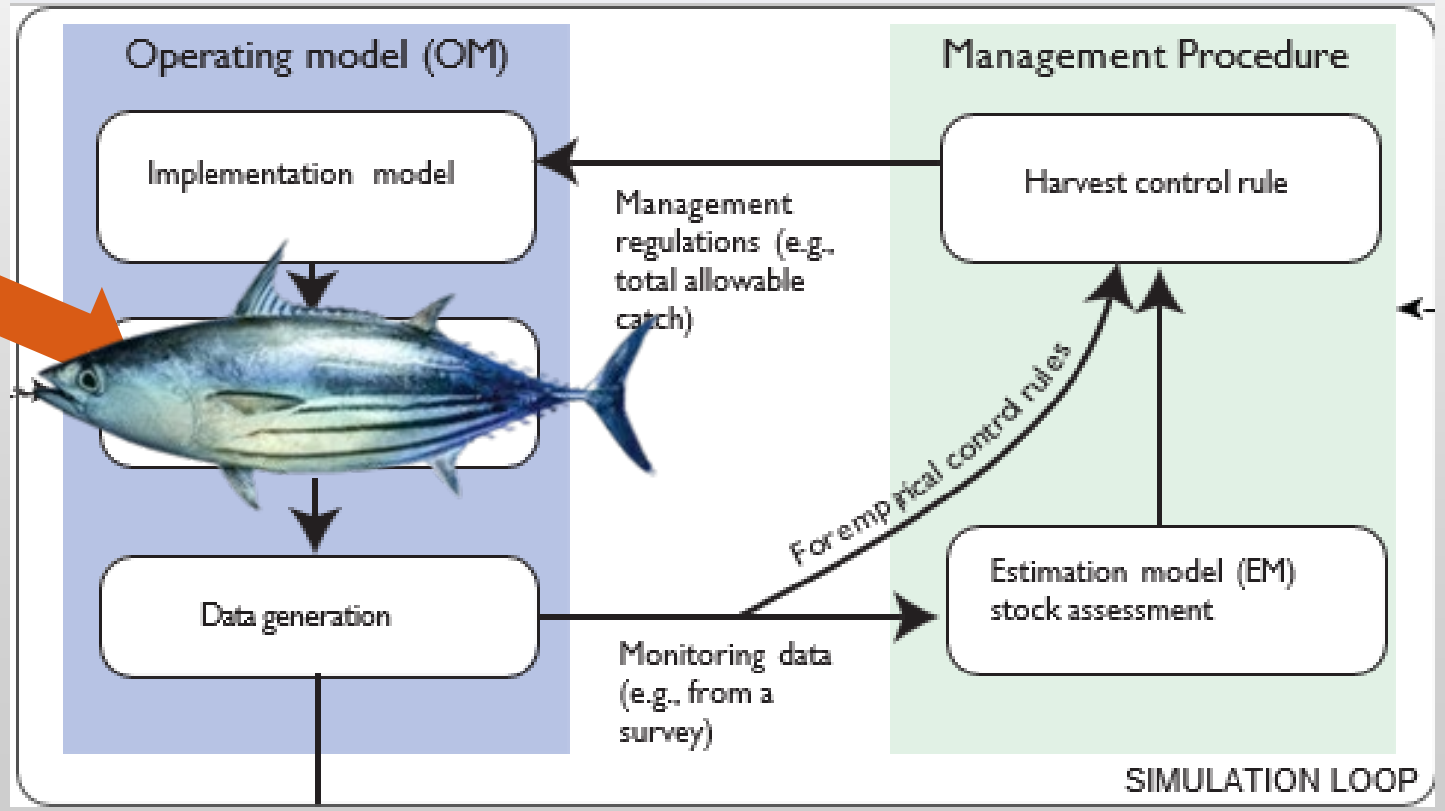
- Today's goal: outline a few ways in which EBFM can be transparently and explicitly considered with MSE



Adapted from Siple et al. (2021) Considerations for MSE for Small Pelagic Fishes

0) More complex single species OM





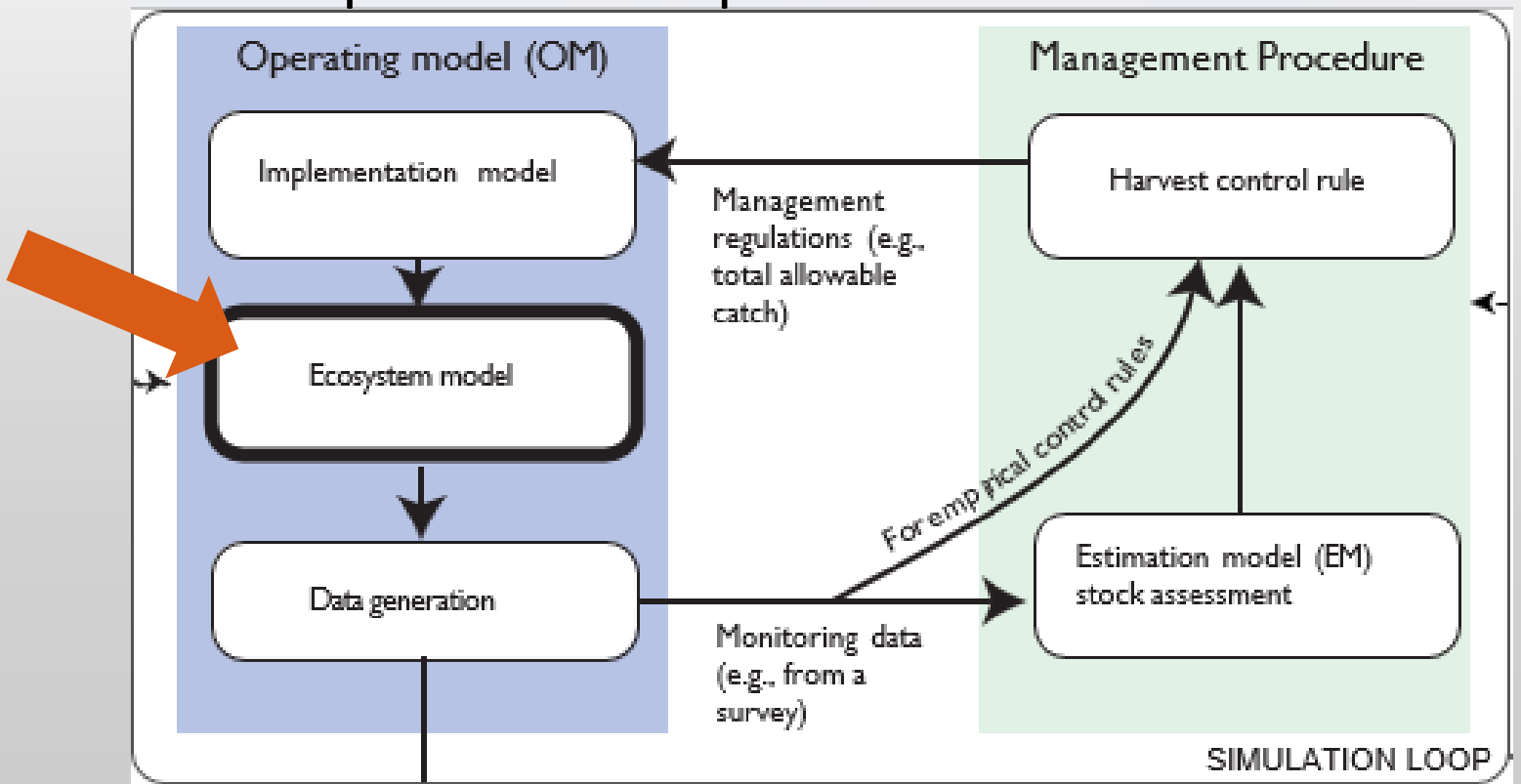
Adapted from Siple et al. (2021)

1) Ecosystem model as (one of) the OMs

- Broadens the set of uncertainties compared to single-species OMs

  - e.g. nonlinear trophic dynamics, climate change/variability

- Parameter value uncertainty often not well established in ecosystem OMs
- Most demanding w.r.t. data and computational requirements



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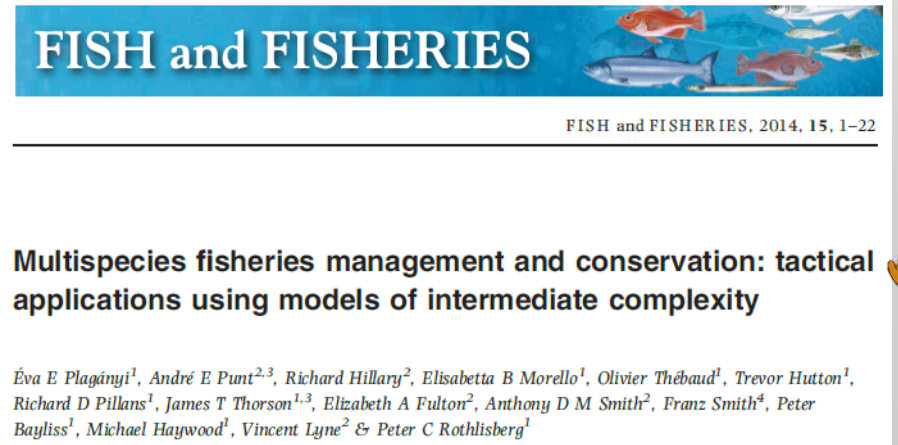
- Broadens the set of uncertainties compared to single-species OMs

  - e.g. nonlinear trophic dynamics, climate change/variability

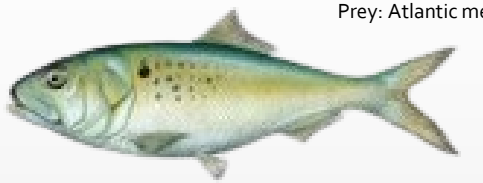
- Parameter value uncertainty often not well established in ecosystem OMs
- Most demanding w.r.t. data and computational requirements
- Models of Intermediate Complexity for Ecosystem assessments (MICE)
  - Include limited, key components of the ecosystem
  - Conditioned to available data for all of the components
  - In principle, useful for **tactical** management advice
  - Realistic computing time (compared to other ecosystem models)



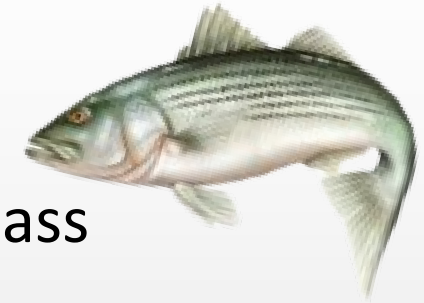
1) Ecosystem model as (one of) the OMs

- MICE OM example:
  - Uncertainty in the importance of prey in the diet of striped bass

Prey: Atlantic menhaden



Predator: Striped bass



- One way to incorporate some of the concerns that arise from multispecies fisheries

Canadian Journal of Fisheries and Aquatic Sciences | dx.doi.org/10.1139/cjfas-2023-0089

Article

Evaluation of alternative harvest policies for striped bass and their prey, Atlantic menhaden

Samantha Schiano[a], Geneviève M. Nesslage[a], Katie Drew[b], Amy M. Schueller[c], Ryan J. Woodland[a], and Michael J. Wilberg[a]

Chapter 11

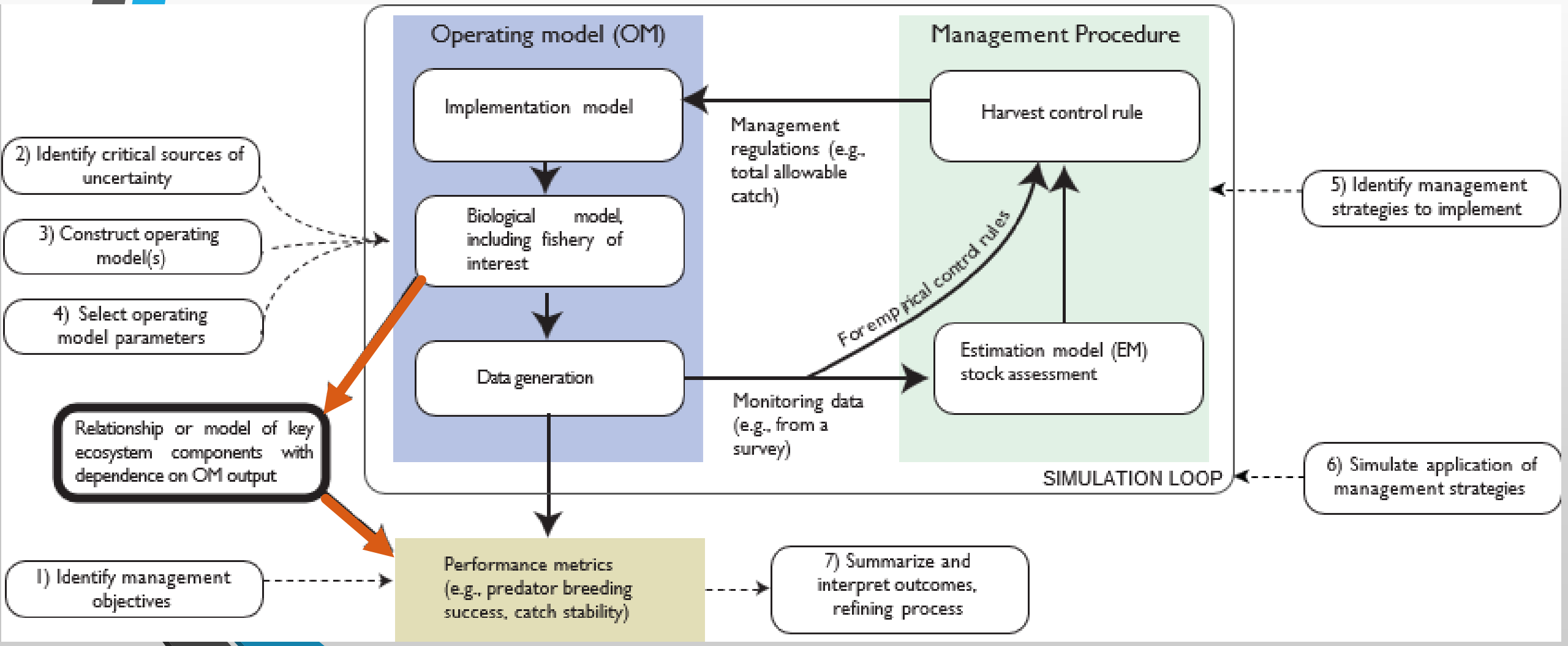
Incorporating technological interactions in a joint management procedure for South African sardine and anchovy

Carryn L. de Moor and Douglas S. Butterworth

- Bycatch concerns and/or constraints
  - MICE (multispecies) OM
  - Frequency of fishery closure and ‘lost’ TAC

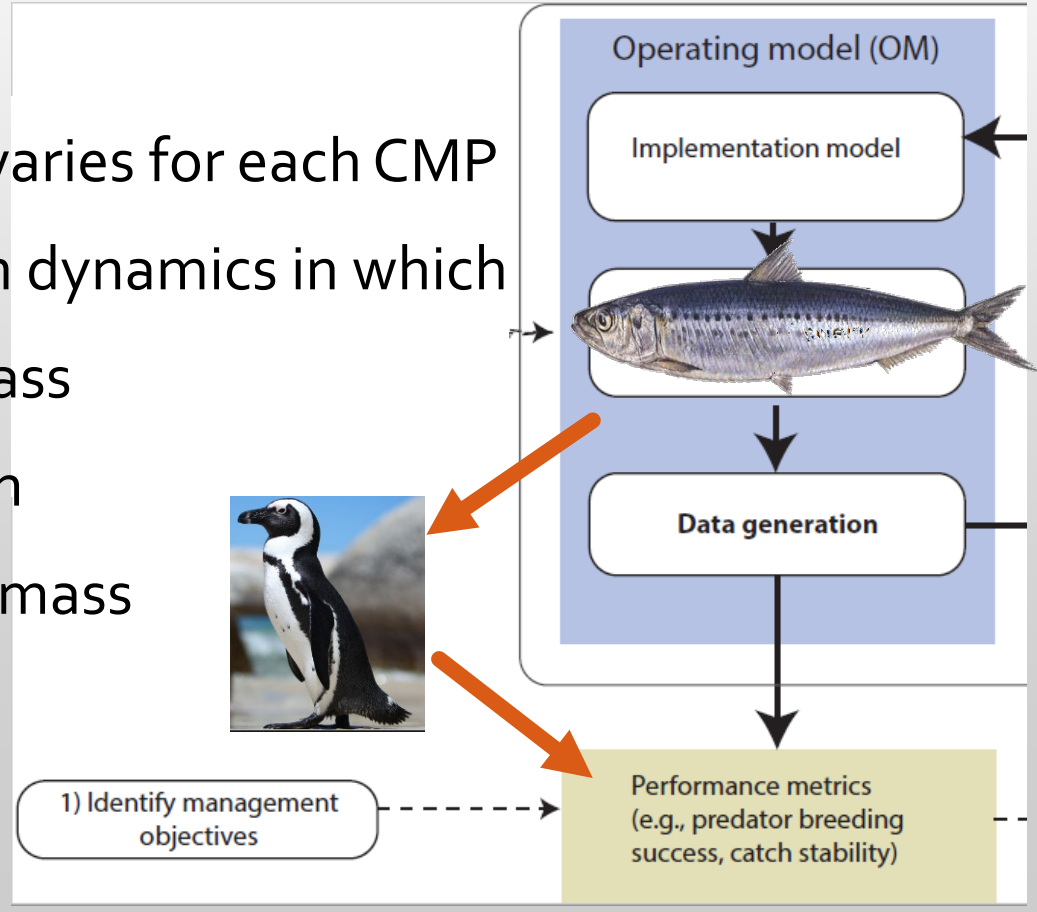
In: Management Science in Fisheries: An Introduction to simulation-based methods
ISBN: 978-1-138-80680

2) One-way coupling of the OM with another model/ relationship to provide EBFM performance statistics



2) One-way coupling of the OM with another model/ relationship to provide EBFM performance statistics

- Output from OM is input to additional quantitative model/relationship
- For example
  - OM based on target species (sardine)
  - Output is projected future sardine biomass; this varies for each CMP
  - Input future sardine biomass to model of penguin dynamics in which penguin survival is dependent on sardine biomass
  - Calculate rate of increase (or decrease) in penguin numbers based on projected future sardine biomass



2) One-way coupling of the OM with another model/ relationship to provide EBFM performance statistics

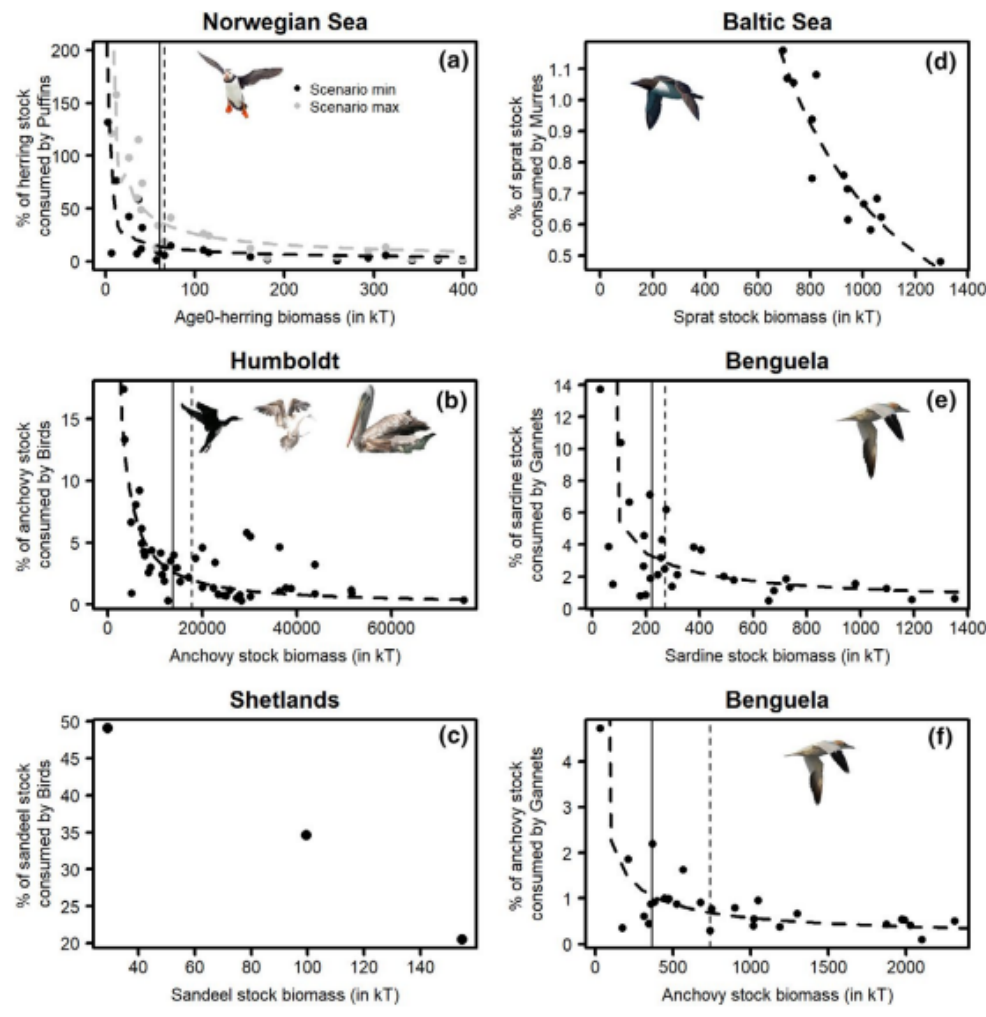
- Computationally more efficient than using an ecosystem model as OM
- Only key components of ecosystem need to be considered
- OM and other model/relationship can be developed independently
- One-way only (e.g. prey impact on predator not vice versa)

3) Adjust M to explicitly consider predation mortality

- M typically includes all forms of non-fishery-related deaths
- Different approaches that one could consider by altering M

A) Use density-dependent M as a proxy for non-negligible changes in predation pressure

- mimic the relatively greater predation when forage fish biomass is low



Saraux *et al.* (2021)
F&F 22:262-279

3) Adjust M to explicitly consider predation mortality

- M typically includes all forms of non-fishery-related deaths

B) Separate out M_2 from baseline M

- Eg test the robustness of CMPs to future sudden temporary or permanent changes in baseline M values

Sprattus sprattus

Canadian Journal of Fisheries and Aquatic Sciences | dx.doi.org/10.1139/cjfas-2023-0090

OPEN ACCESS | Research Article

Developing management plans for sprat (*Sprattus sprattus*) in the Celtic Sea to advance the ecosystem approach to fisheries

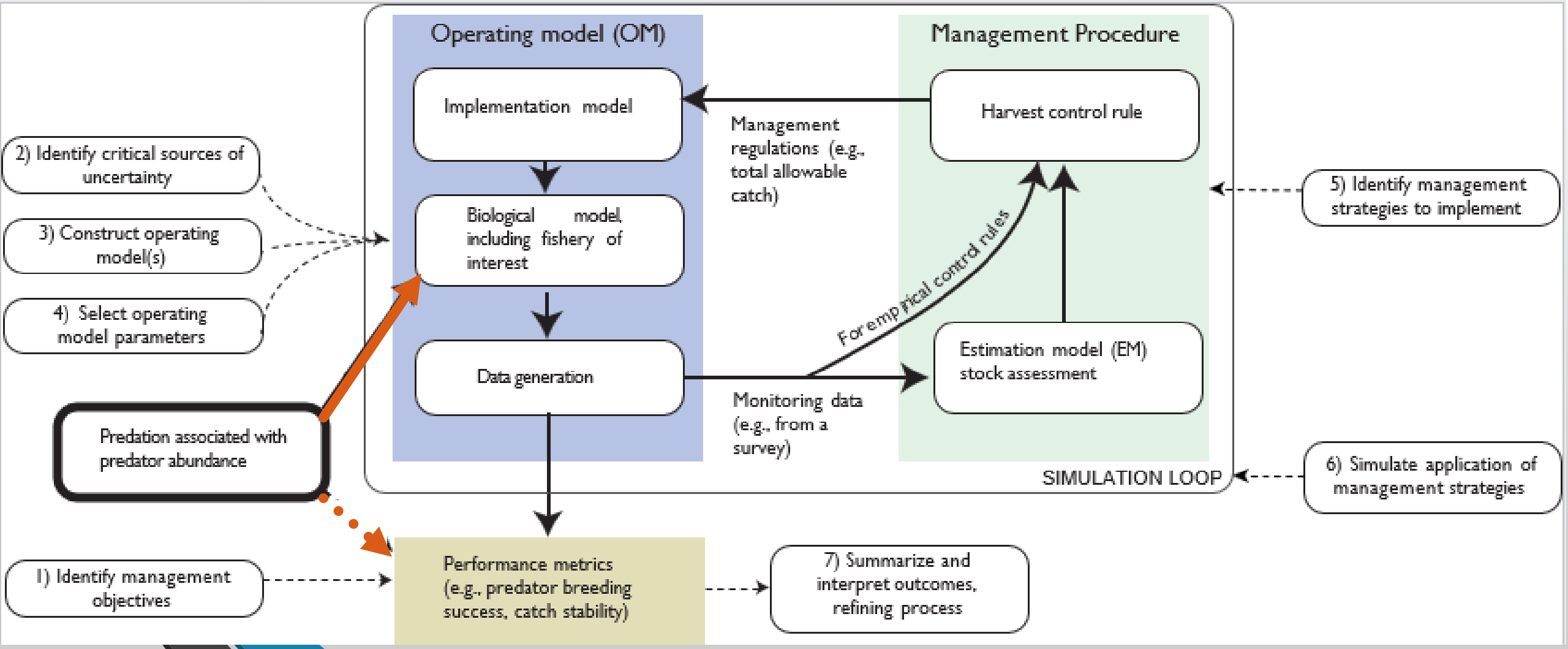
Laurence T. Kell[a], Jacob W. Bentley[b], David A. Feary[c], Afra Egan[d], and Cormac Nolan[d]

C) Treat key predators as fishing fleets (Mosqueira Pers. Comm)

- Eg model bird predation, or “catch”

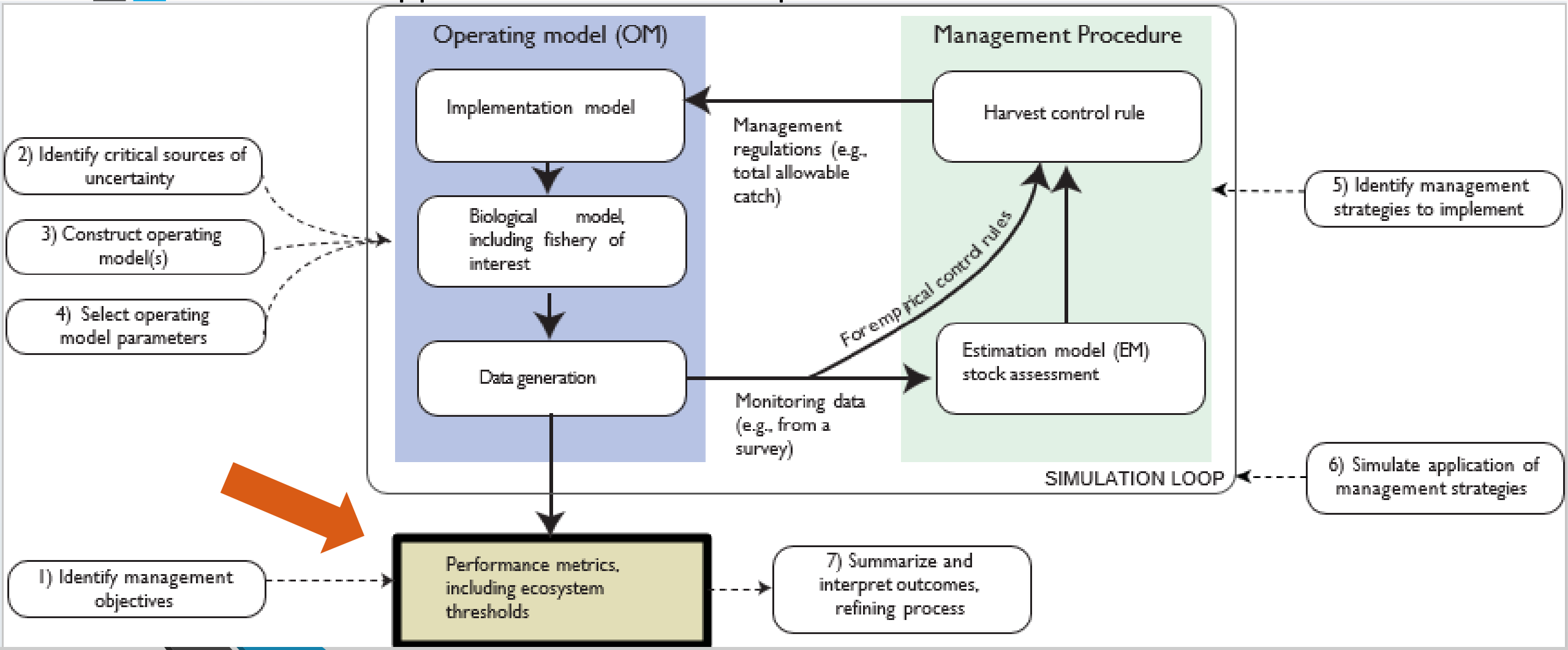
3) Adjust M to explicitly consider predation mortality

- Also does not allow for dual interactions of predators and prey



4) Ecosystem thresholds in performance statistics

- Previous approaches focused on methods linking to the OM
- Next two approaches focus on the performance statistics



4) Ecosystem thresholds in performance statistics

- For example:
  - Proportion of years for / extent to which prey biomass (or combined prey biomass) is predicted to fall below a threshold level for a given CMP
- Threshold should be selected from external data / quantitative relationships
- OMP-14 and OMP-18
  - $p(B_w^{obs}<336\ 000t)$
  - Avg # consec years $B_w^{obs}<336\ 000t$

336 000t

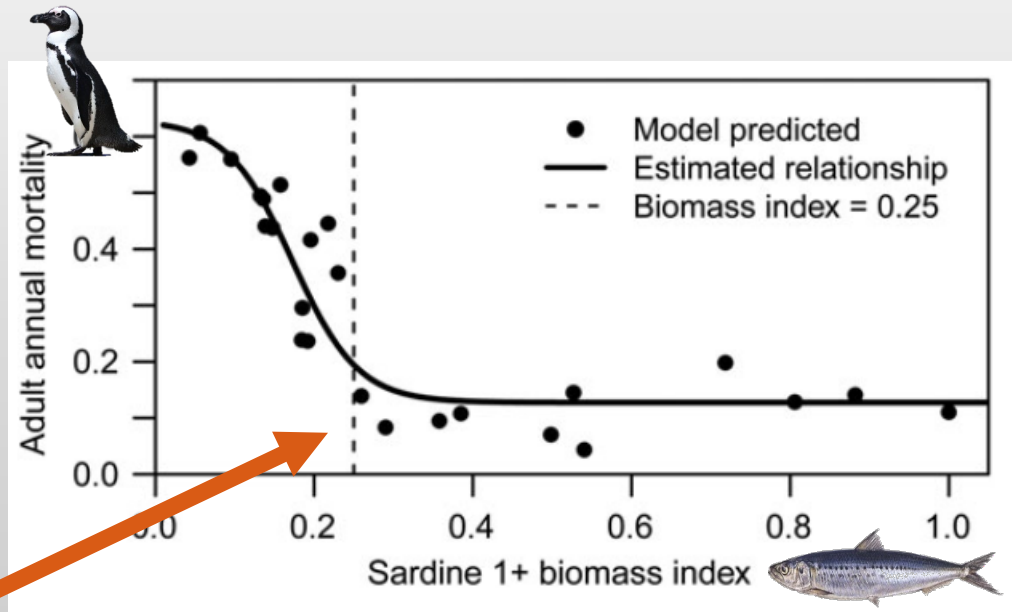
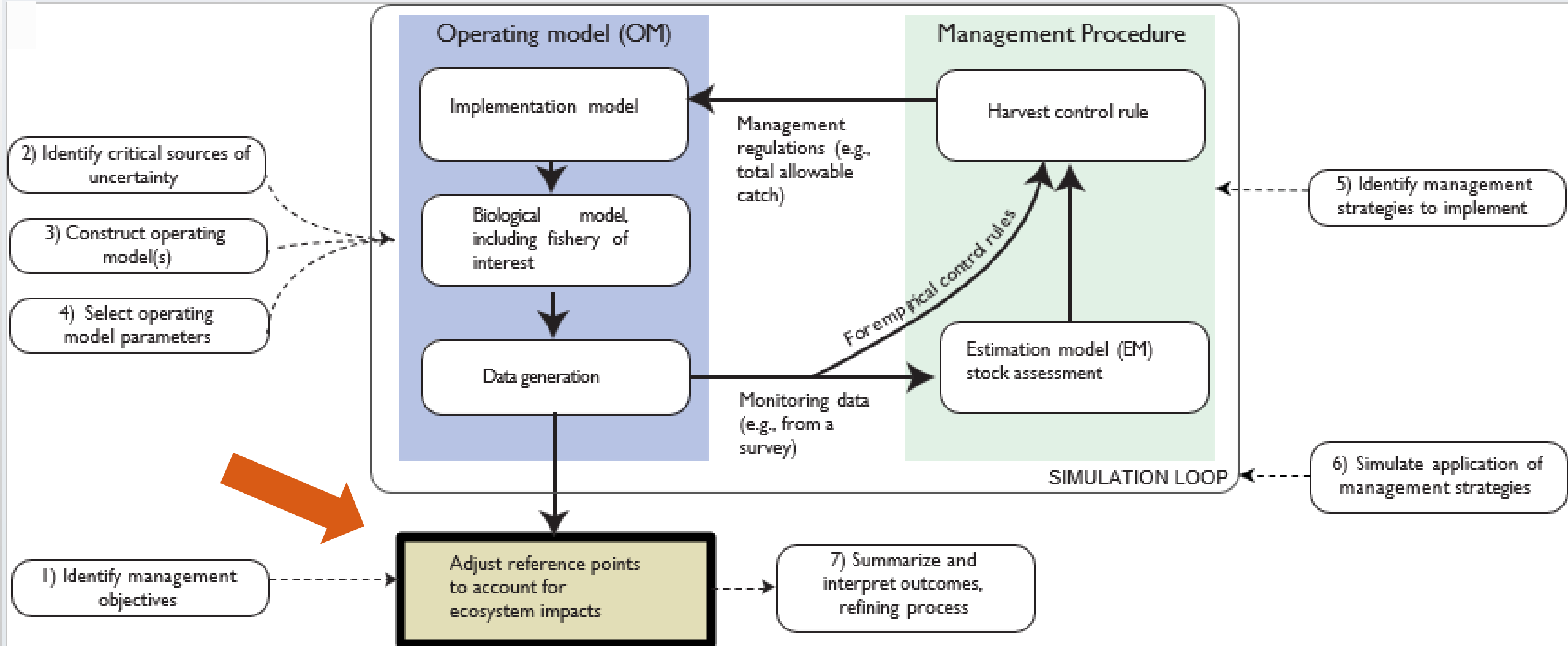


Figure 4. The estimated relationship (posterior mode) between the sardine 1+ biomass index (scaled to the maximum November survey estimate of 1 343 000 t in 2003) and penguin adult mortality. The vertical dashed line is at 25% of the maximum observed biomass.

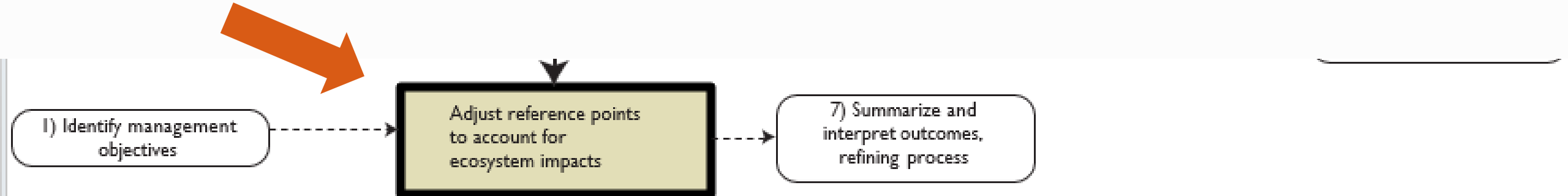
Robinson *et al.* (2015) IJMS 72:1822-1833

5) Adjust reference points (RPs)

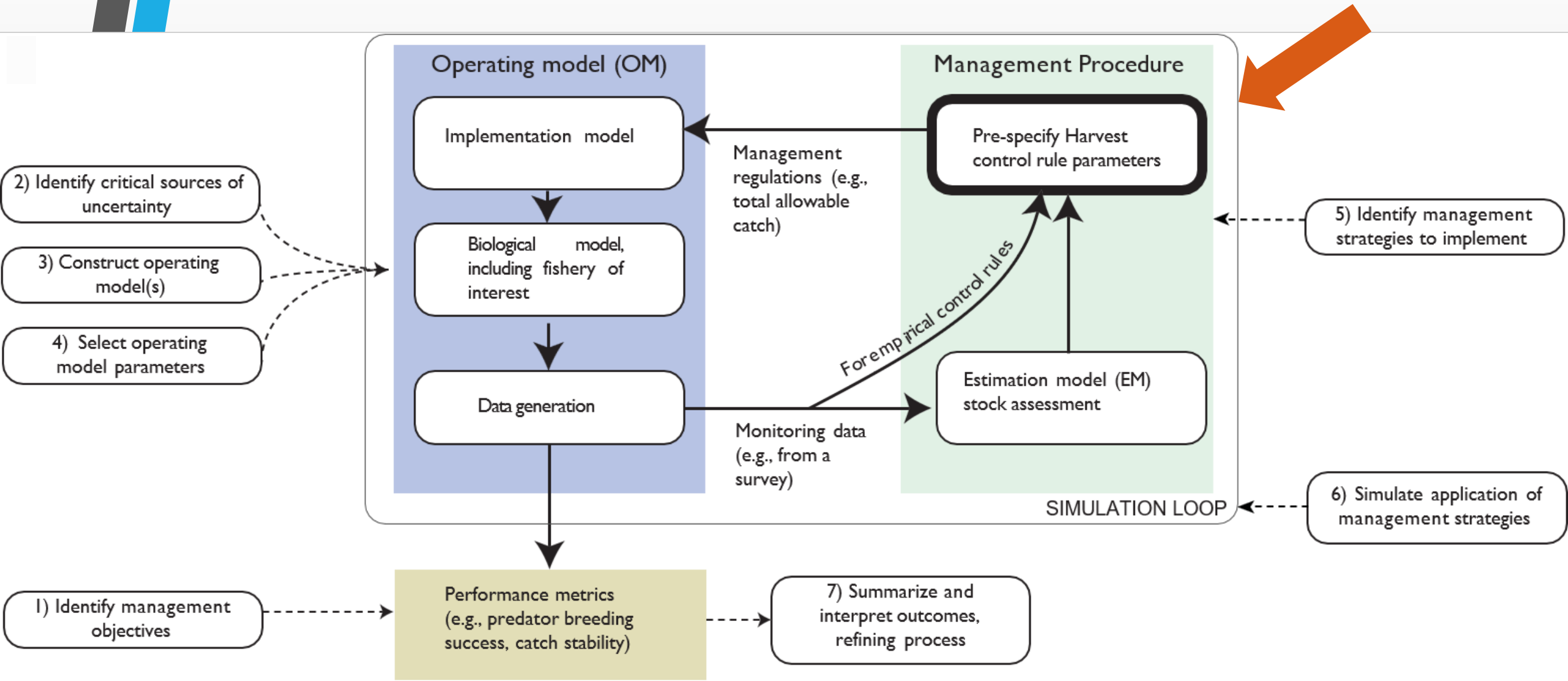


5) Adjust reference points (RPs)

- Performance stats for target resource often based on Target and/or limit RPs
- For example: $p(SSB<SSB_{lim})$ or $p(B>B_{MSY})$
- Marine Stewardship Council : Target RP of $75\%B_0$ for forage fish

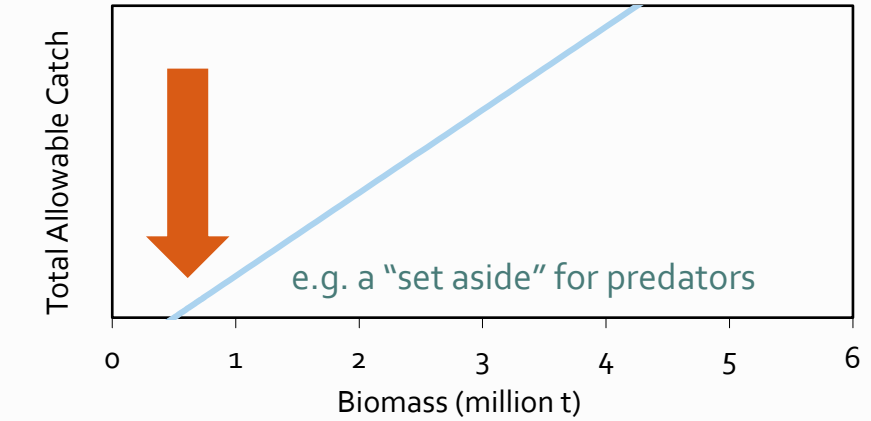


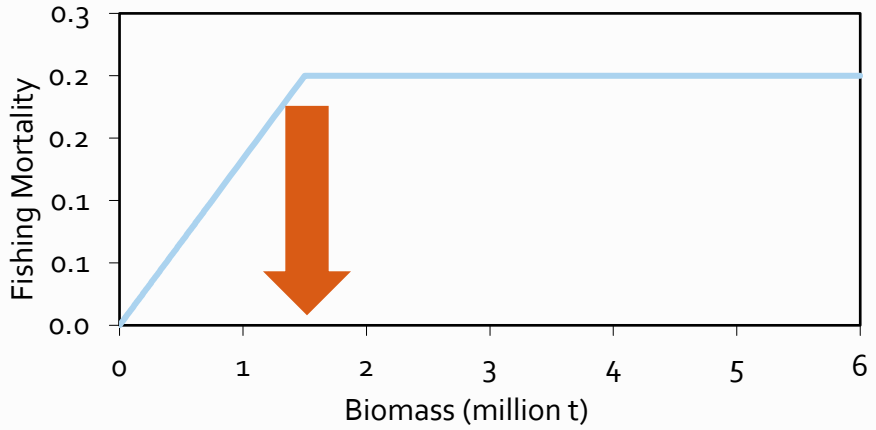
6) Pre-specify HCR control parameters



6) Pre-specify HCR control parameters

- For example: Using external data/relationships to pre-select HCR threshold
- Such thresholds typically result from a particular analysis, dependent on model assumptions
- Control parameters ideally selected by "tuning" the MP to ensure performance statistics meet objectives and/or trade-off between objectives
- An MPs performance in relation to e.g. an EBFM threshold can depend on the OMs used and their relative weighting
- Not preferred; rather use 4th approach





Summary

- Transition from single-species focus to EBFM is widely acknowledged
- But progress has been slow and often qualitative
- Some progress undertaken in parallel with development of tactical fisheries management advice based on single-species methods
- Some steps towards EBFM can be taken in any MSE.
- Small advances should be preferred over waiting for the ‘perfect ecosystem OM’
- The level of data and knowledge available about the ecosystem interactions guides choice between approaches
- Approaches can be combined as data/knowledge allows
- Range of approaches enables us to take advantage of what is already available
- Prioritise research
- Time and computation constraints also guide selection between approaches

EBFM can be implemented quantitatively with Management Procedures, even without complex ecosystem Operating Models!

Thank you for your attention

For further details, please see:

or email: carryn.demoor@uct.ac.za