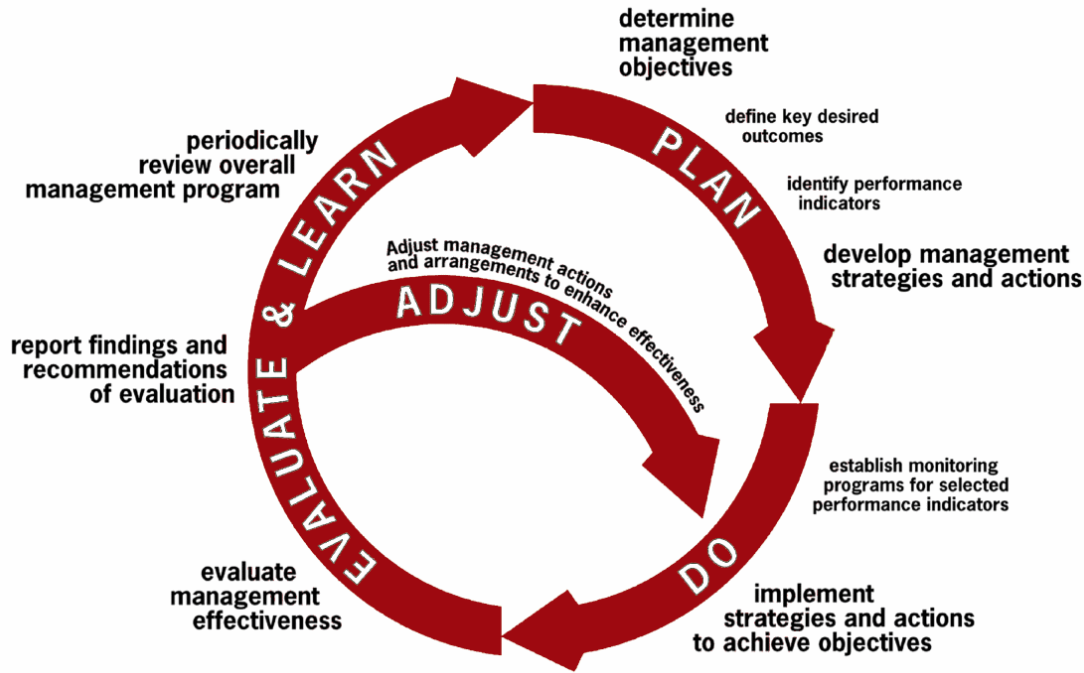


# Introduction to MSE

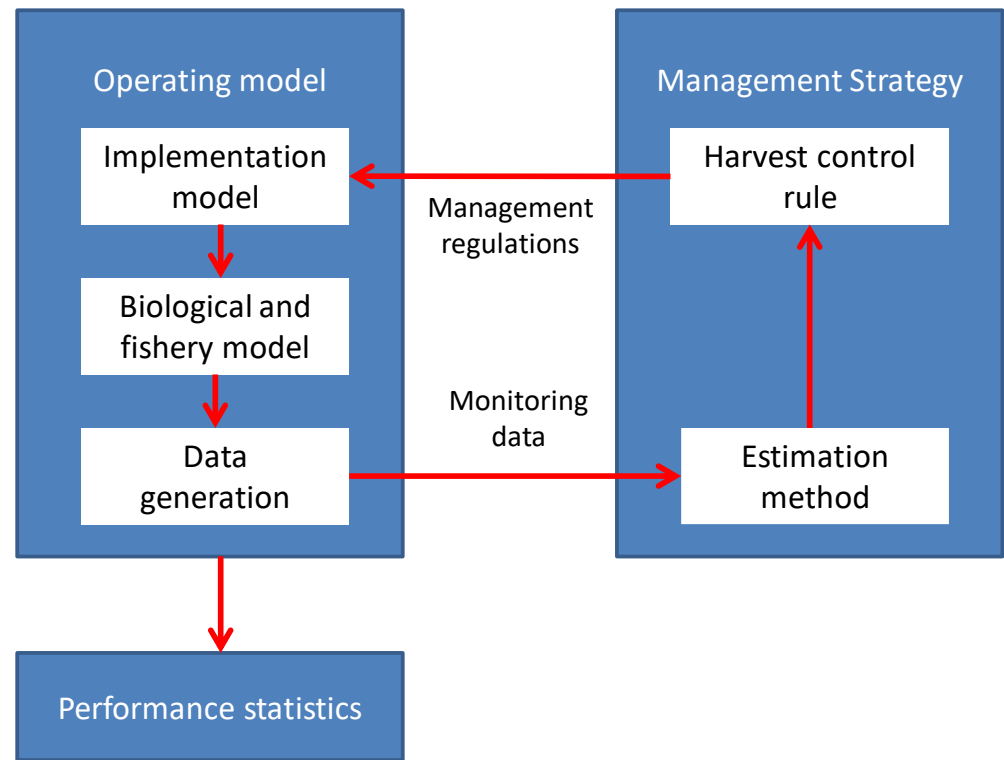
Andre Punt



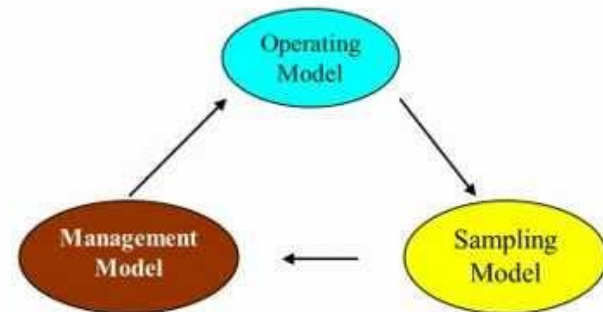
# What is Management Strategy Evaluation (MSE)? A brief primer

# A formal definition

Management strategy evaluation (MSE) involves using **simulation** to compare the relative effectiveness for **achieving management objectives** of different combinations of **data collection schemes**, **methods of analysis** and **subsequent processes** leading to management actions.



## MSE Approach



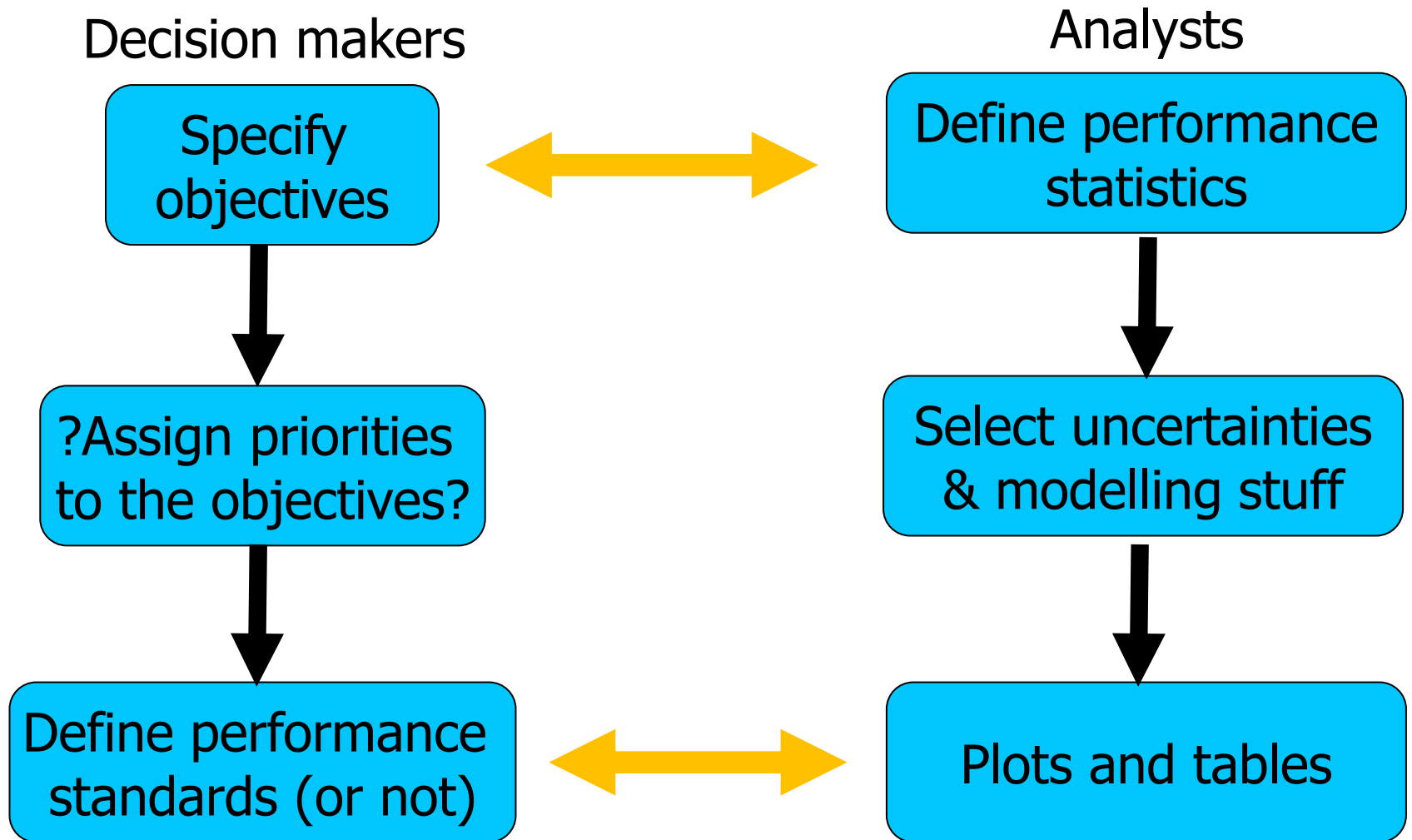
# Uses of MSE

## MSE has four primary uses:

- development of the management strategy for a particular fishery;
  - Examples: Pacific sardine off the US west coast; Strike Limit Algorithms for bowhead and gray whales.
- evaluation of generic management strategies;
  - Example: Potential Biological Removals
- identification of management strategies that will not work and should therefore be eliminated from further consideration;
- evaluation of the benefits of additional data collection

**Key Note:** The aim is to find management strategies that are **robust to uncertainty** rather than strategies that are optimal if a particular scenario is true

# MSE is stakeholder-focused



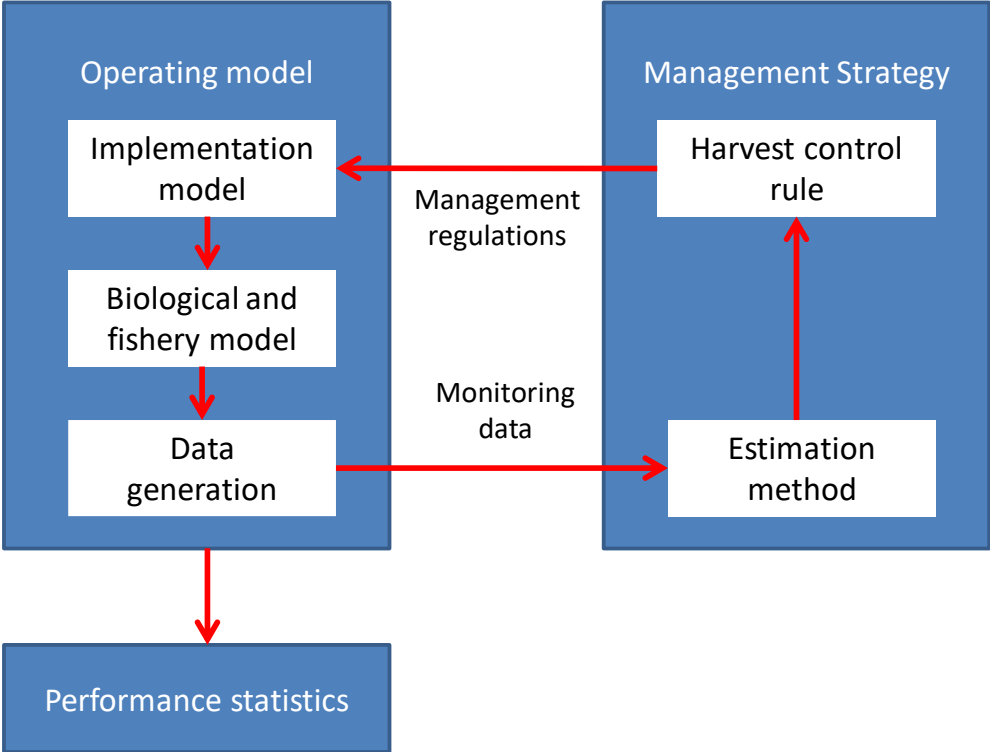
# Some Terminology Arising

- **Objectives:** General goals for managing a resource as set by decision-makers (**we have these for MM populations in the US**)
- **Performance statistics:** Statistics that summarize different aspects of the results of a simulation trial used to evaluate how well a specific strategy achieves some or all of the general objectives (**probability of achieving the conservation target after 100 years**). These may have threshold (**e.g. probability at least 0.95**).

# More Terminology

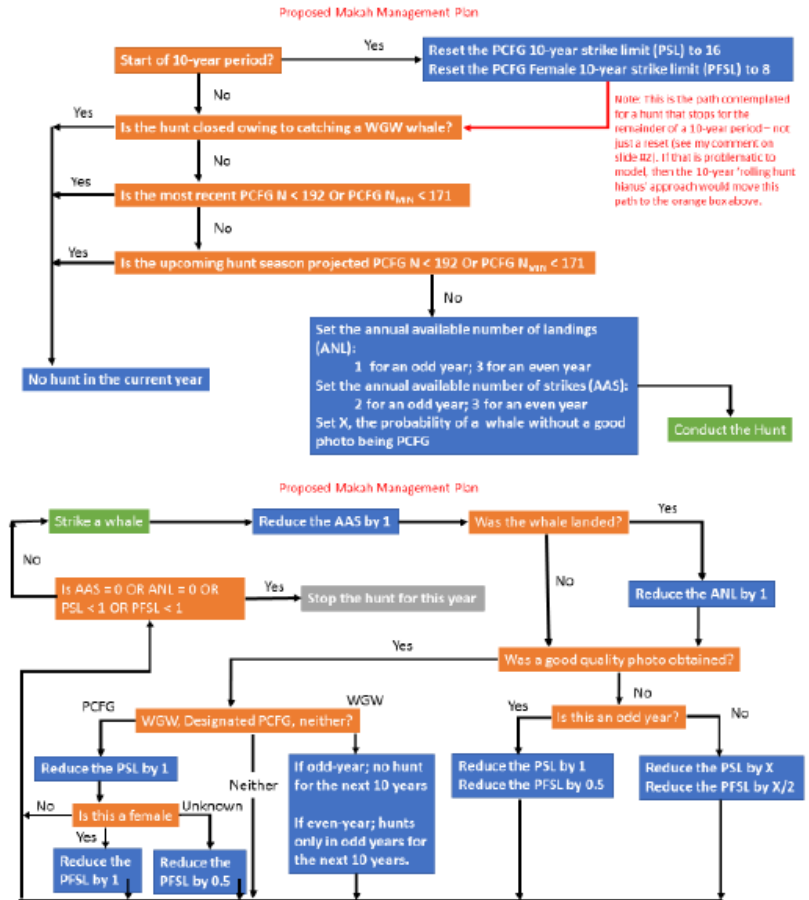
- **Management Strategy:** the combination of pre-defined data, together with an algorithm to which such data are input to provide implementable management measures **(this is the PBR approach with its associated regulations and procedures)**
- **Operating model (OM):** a model used to describe the actual resource dynamics in simulation trials and to generate resource monitoring data when projecting forward. Many OMs are considered to capture **uncertainty.**

# Take Home Message





# A Spectrum of Marine Mammal MSEs





Fisheries.noaa.gov

$$\begin{bmatrix} n_0 \\ n_1 \\ \vdots \\ n_{\omega-1} \end{bmatrix}_{t+1} = \begin{bmatrix} f_0 & f_1 & f_2 & \dots & f_{\omega-2} & f_{\omega-1} \\ s_0 & 0 & 0 & \dots & 0 & 0 \\ 0 & s_1 & 0 & \dots & 0 & 0 \\ 0 & 0 & s_2 & \dots & 0 & 0 \\ \vdots & \vdots & \vdots & \ddots & \vdots & \vdots \\ 0 & 0 & 0 & \dots & s_{\omega-2} & 0 \end{bmatrix} \begin{bmatrix} n_0 \\ n_1 \\ \vdots \\ n_{\omega-1} \end{bmatrix}_t$$



SMRU Consulting

# Core Example: The PBR Approach

# Objectives and Performance Statistics

## Objective (key)

*Maintain populations at their Optimum Sustainable Population Level*

- defined to be above MNPL (and below K)
- Populations thought to be below MNPL can be designated “depleted”

## Objective (Implicit)

*Base decision making on available data*

- Estimate(s) of abundance
- Estimate(s) of human-caused mortality
- Trend data or life history data for maximum growth rate ( $R_{\max}$ )

## Performance statistic (key)

- A population depleted to 30% of carrying capacity should rebuild to NMPL with 95% probability over 100 years

# 1994 amendments to MMPA

- Requires assessment of all stocks
- Assessments must estimate human-caused mortality level and a mortality threshold (PBR)
- Stocks with mortality  $>$  PBR are “strategic”
- Take Reduction Teams may be formed to reduce bycatch of strategic stocks that interact with Category I or II fisheries

# Potential Biological Removal (PBR)

*Definition:* the maximum number of animals, not including natural mortalities, that may be removed from a marine mammal stock while allowing that stock to reach or maintain its optimum sustainable population

$$\text{PBR} = N_{\min} * 1/2 R_{\max} * \text{RF}$$

$N_{\min}$  = the minimum population estimate of the stock

$R_{\max}$  = the maximum net productivity rate

RF = a recovery factor between 0.1 and 1.0

# Operating Model and Simulations

## Basic simulations

Theta-logistic model

- Base-case theta = 1.0 (logistic model)

Log-normal abundance estimate every four years to calculate PBR

- CV = 0.2 or 0.8
- $R_{\max} = 0.04$  (cetaceans) or 0.12 (pinnipeds)

Normally distributed bycatch estimate every year, with mean equal to a calculated PBR and CV=0.3

## Some of the sensitivity scenarios

1. Mortality estimate biased low
2. Abundance estimate biased high
3.  $R_{\max}$  biased high
4. Abundance CV biased low
5. Mortality CV biased low

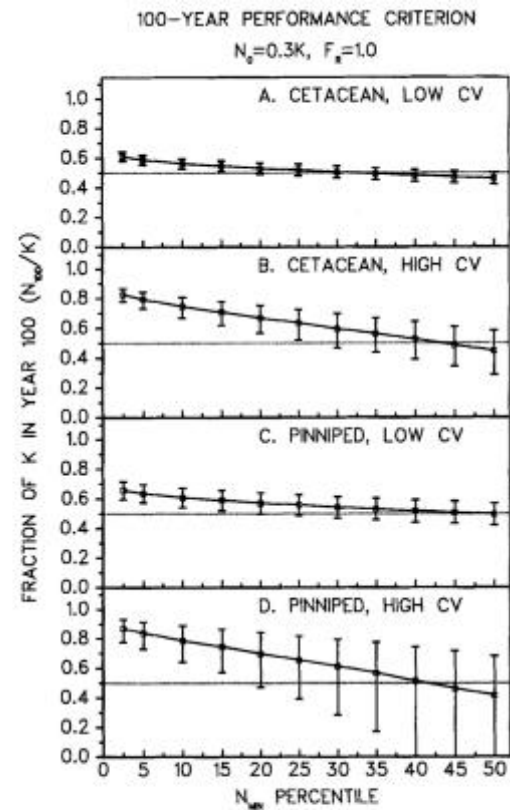
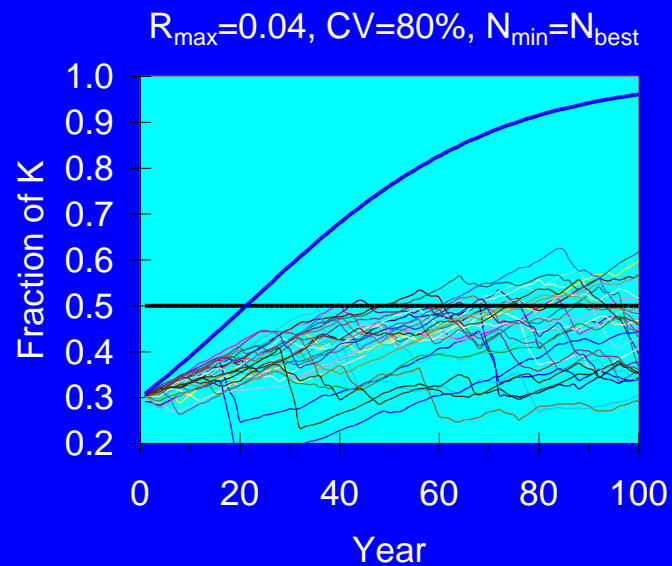
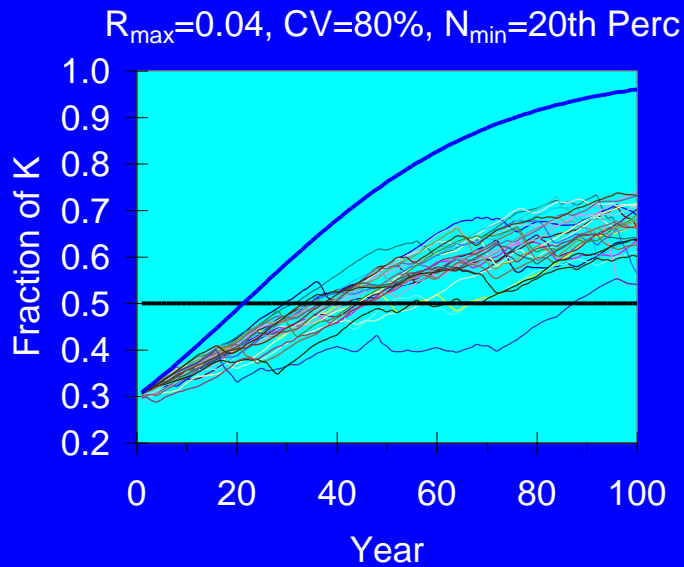


Figure 4. MNPL goal (100-yr performance criterion): population size after 100 yr versus percentile of abundance estimate used to calculate  $N_{MIN}$ , with  $F_R = 1.0$  and initial population size equal to  $0.3K$ . Boxes represent median value of simulations. Confidence limits capture 90% of simulations. Dotted line represents MNPL ( $0.5K$ ). If lower confidence limit is above MNPL, simulation meets 100-yr performance criterion of 95% of trajectories ending above MNPL. (A) Cetacean ( $R_{MAX} = 0.04$ ) with low CV (0.2). (B) Cetacean ( $R_{MAX} = 0.04$ ) with high CV (0.8). (C) Pinniped ( $R_{MAX} = 0.12$ ) with low CV (0.2). (D) Pinniped ( $R_{MAX} = 0.04$ ) with high CV (0.8).

Wade 1998. Calculating limits to the allowable human-caused mortality of cetaceans and pinnipeds. *Marine Mammal Science*

ICES Journal of Marine Science (2018), 75(5), 1813–1831. doi:10.1093/icesjms/fsy049

## Original Article

### Conserving and recovering vulnerable marine species: a comprehensive evaluation of the US approach for marine mammals

André E. Punt<sup>1\*</sup>, Paula Moreno<sup>2</sup>, John R. Brandon<sup>3</sup>, and Michael A. Mathews<sup>4</sup>

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Punt, A. E., Moreno, P., Brandon, J. R., and Mathews, M. A. Conserving and recovering vulnerable marine species: a comprehensive evaluation of the US approach for marine mammals. – ICES Journal of Marine Science, 75: 1813–1831.

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# Extending the PBR approach

Andre Punt, Paula Moreno, John Brandon & M. Mathews

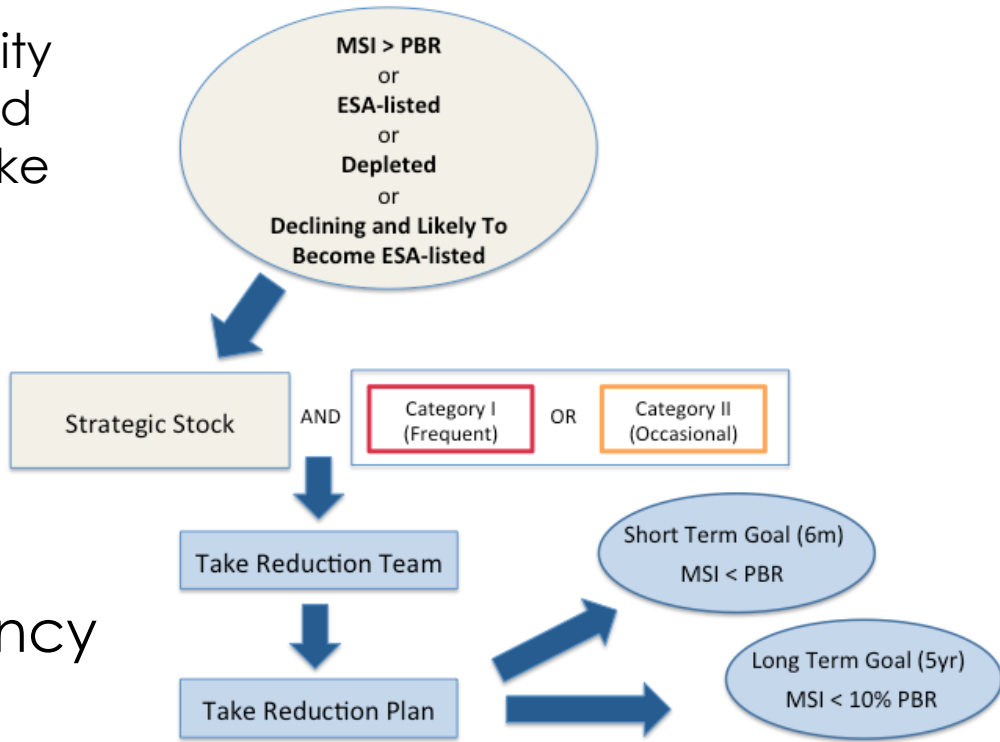


# Paper Objectives

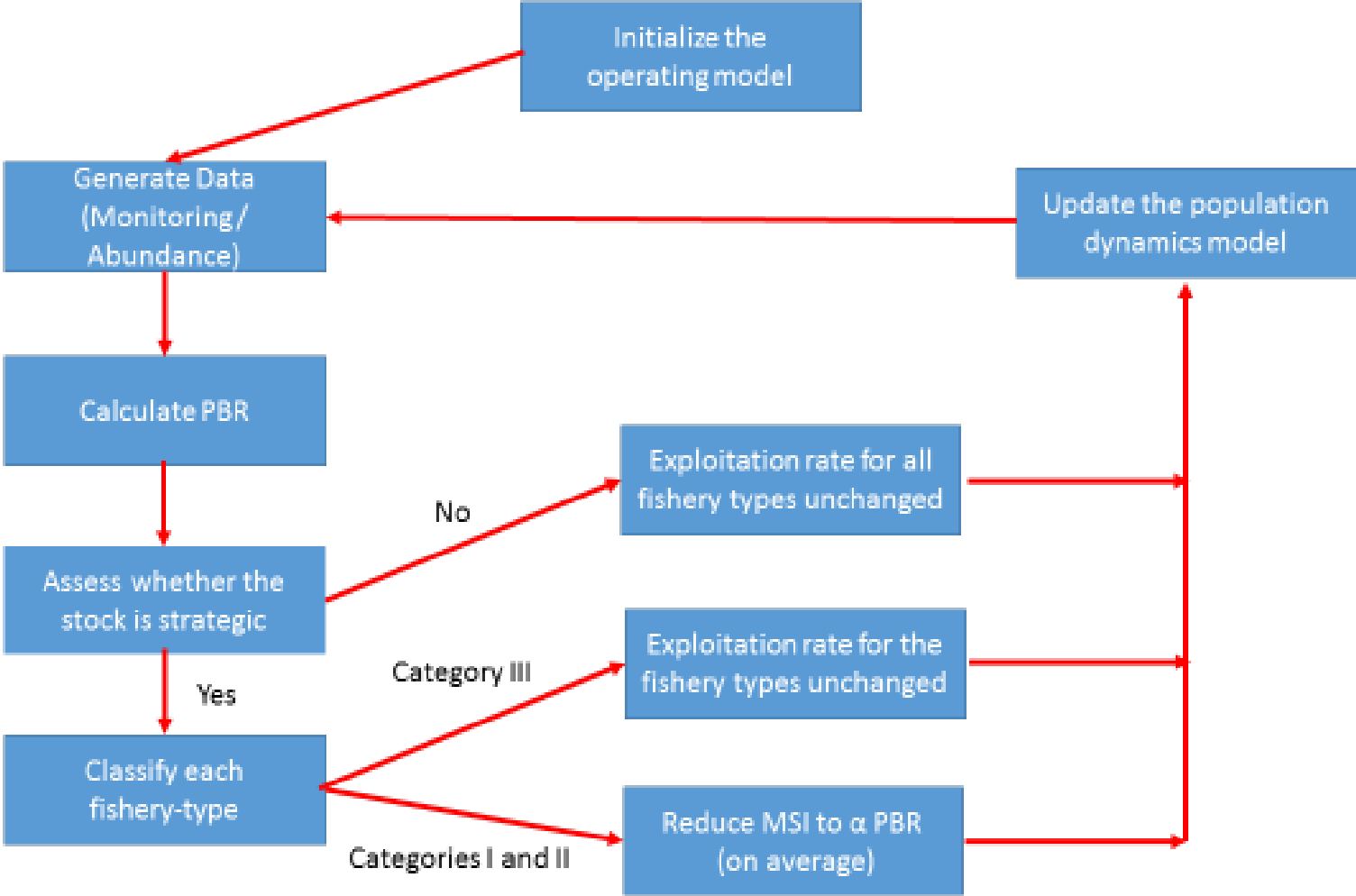
Extend the existing management strategy evaluation framework to:

- include multiple fisheries (instead of only one)
- model demographic stochasticity
- simulate fishery classification and measures recommended by Take Reduction Teams

Evaluate the implications of different levels of observer coverage and survey frequency and precision.



# Basic framework



# Key questions we can ask with this framework

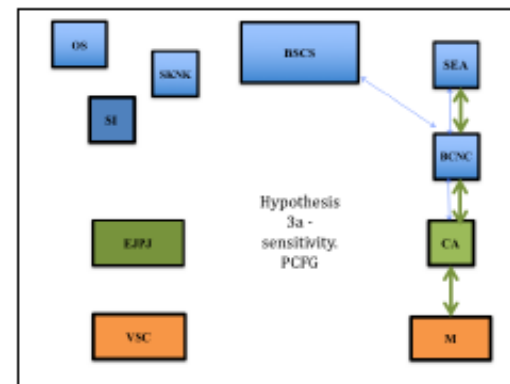
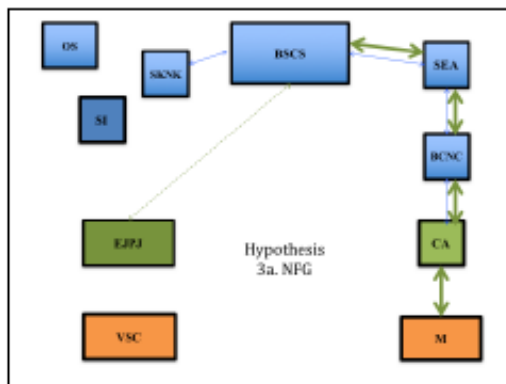
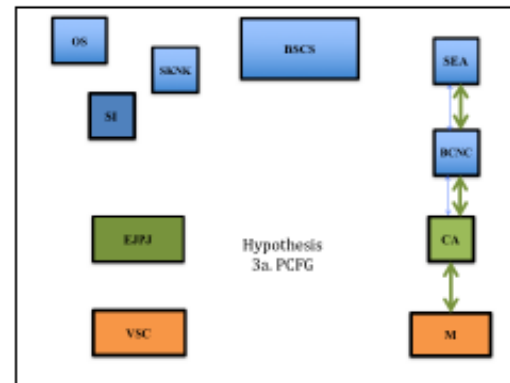
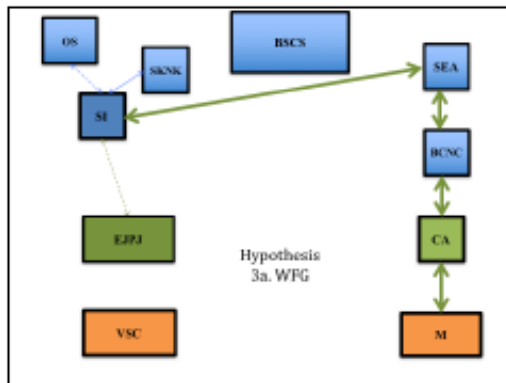
- What are the consequences of basing simulations on a **generic animal with no demographic stochasticity**?
- Would the conclusions of Wade (1998) change (markedly) had the analyses considered: (a) **assessing whether a stock is strategic**, and (b) **classifying fisheries**?
- How well can we determine if a stock is strategic / classify fisheries and achieve conservation goals given the **precision** of the monitoring process for abundance and bycatch?
- How well can we determine if a stock is strategic / classify fisheries and achieve conservation goals given the **frequency** of abundance surveys?

# Stock Structure and transboundary cases?

Eastern North Pacific gray whales

- Bycatch
- Aboriginal whaling in the US and Russia

Hypothesis 3a:



# Take Home Messages

- **MSE**
  - compares strategies (including data collection strategies) in terms of the identified goals;
  - can include multiple groups in the assessment / management approach, each with their own roles;
  - is focused on uncertainty (which model of the world is correct, stock structure, production, etc.);
  - can be tailored to a specific case (or cases) or be generic.
- **MSE is not:**
  - an assessment method;
  - prescriptive about how to address uncertainty; and
  - only something for fisheries.