Are data-poor fisheries certifiable?

Generic Management Procedures and precautionary management

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Fisheries management: data-poor

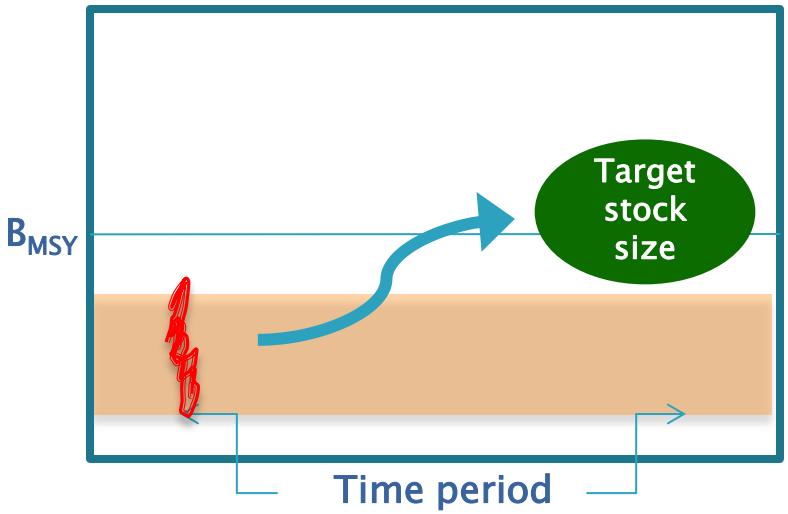
Key questions:

Where are we now?

No reliable estimate

Where do we go?

Somewhere close to B_{MSY}



How do we get there?

Simple generic HCR that relies on few data to give directional advice (at minimum).

Keep it simple stupid!

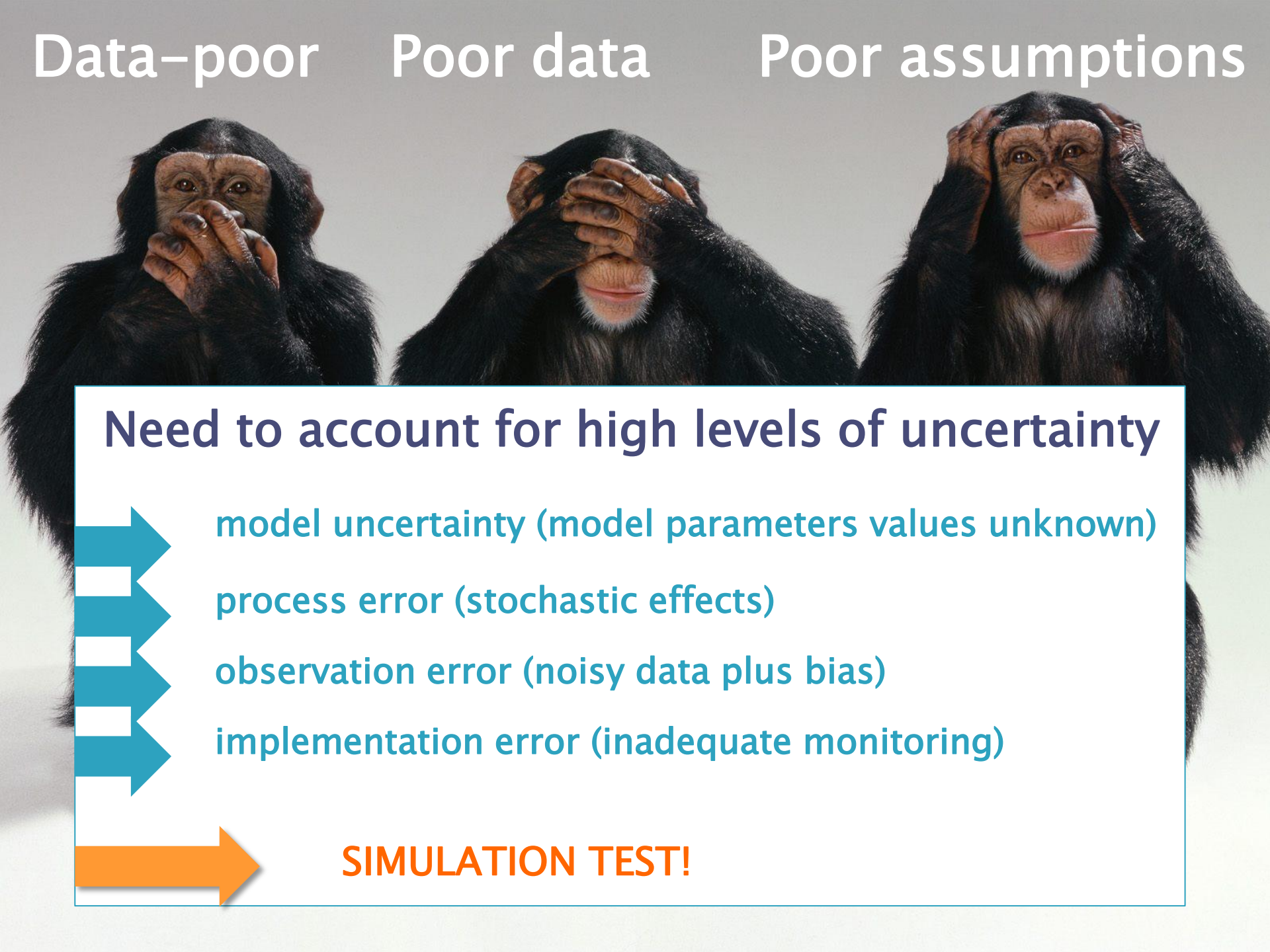
The challenge

What we know we don't know: stock status unknown

- Little knowledge of current depletion
- (where are we now?)
- Little knowledge of B_{MSY} (where do we go?)

What we think we know: limited data

- Some knowledge of life-history parameters
- A catch time-series (likely incomplete and biased/noisy)
- Length data (possibly a mean length index)
- Short index of abundance (if "data-moderate")



Need to account for high levels of uncertainty

- model uncertainty (model parameters values unknown)
- process error (stochastic effects)
- observation error (noisy data plus bias)
- implementation error (inadequate monitoring)

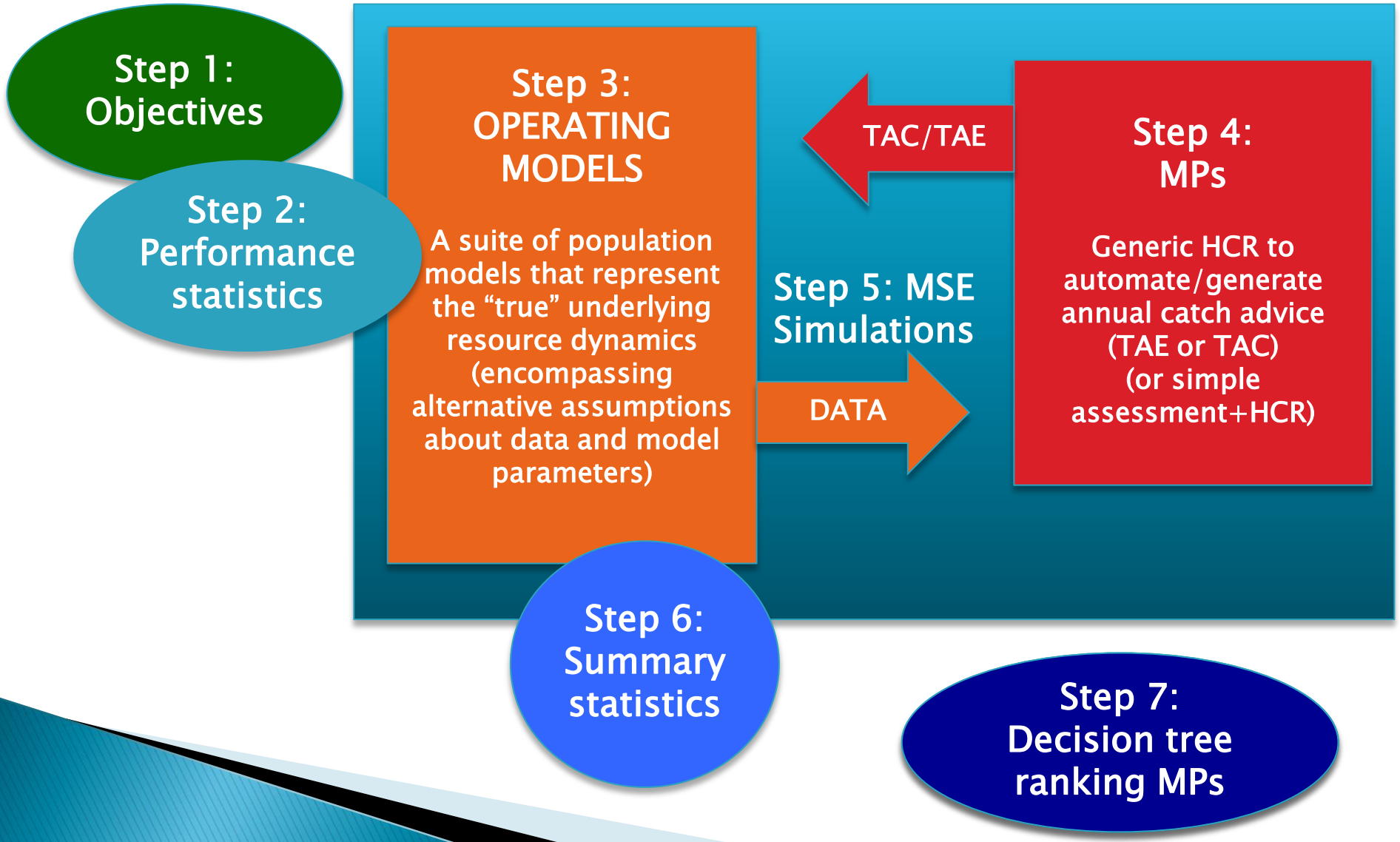
SIMULATION TEST!

Precautionary management approach

- Need simple and cheap management solutions that work in practice
- They must be robust to high levels of uncertainty
- Have feedback to respond to changes in abundance
- Achieve biomass targets within realistic time periods
- Avoid unnecessary fluctuations in catch advice
- Identify appropriate reference points and precautionary buffers to offset increasing uncertainty levels associated with few data
- Incorporate incentives to collect key data to move from data-poor to data-moderate

Management Procedure Approach

MSE: Evaluate performance



Operating Models

Group stocks with similar characteristics in depletion/productivity/fleet baskets. Simple example:

Productivity/ Depletion	Low (M<0.2)	Medium (0.2<M<0.4)	High (M>0.4)
B/K<0.2 (below< PRI)	M:U[0.05,0.2] B/K:U[0.05,0.2]	M:U[0.2,0.4] B/K:U[0.05,0.2]	M:U[0.4,1] B/K:U[0.05,0.2]
0.2<B?K<0.4 Below BMSY	M:U[0.05,0.2] B/K:U[0.2,0.4]	M:U[0.2,0.4] B/K:U[0.2,0.4]	M:U[0.4,1] B/K:U[0.2,0.4)
B/K>0.4Near (above BMSY)	M:U[0.05,0.2] B/K:U[0.4,0.7]	M:U[0.2,0.4] B/K:U[0.4,0.7]	M:U[0.4,1] B/K:U[0.4,0.7]

Parameterise a set of age-structured operating models for each group/basket

Bayes-like approach: sample from prior distributions for key model parameters

Classification of stocks

Productivity (M or M/k):

- Low, medium or high productivity?
- Species with similar life-history data

Depletion:

- Very depleted ($<0.5B_{MSY}$), depleted ($<B_{MSY}$), or at target?
- Difficult: data-poor => no assessment
- Use qualitative and semi-quantitative methods
- Use gray literature
- Use FAO evaluations of the status of world fisheries

Parameterisation of OMs

(Example: depleted stock of medium productivity)

DLMtool "Stock" object

Depletion:	B/K: U[0.2,0.4]
Natural mortality rate:	M: U[0.1,0.3]
Steepness of S-R:	h: U[0.25,0.70]
Growth parameters:	k:U[]0.18:0.28]
	L_{inf}: U[38 42]
	t_0: U[-2.2,-1.8]

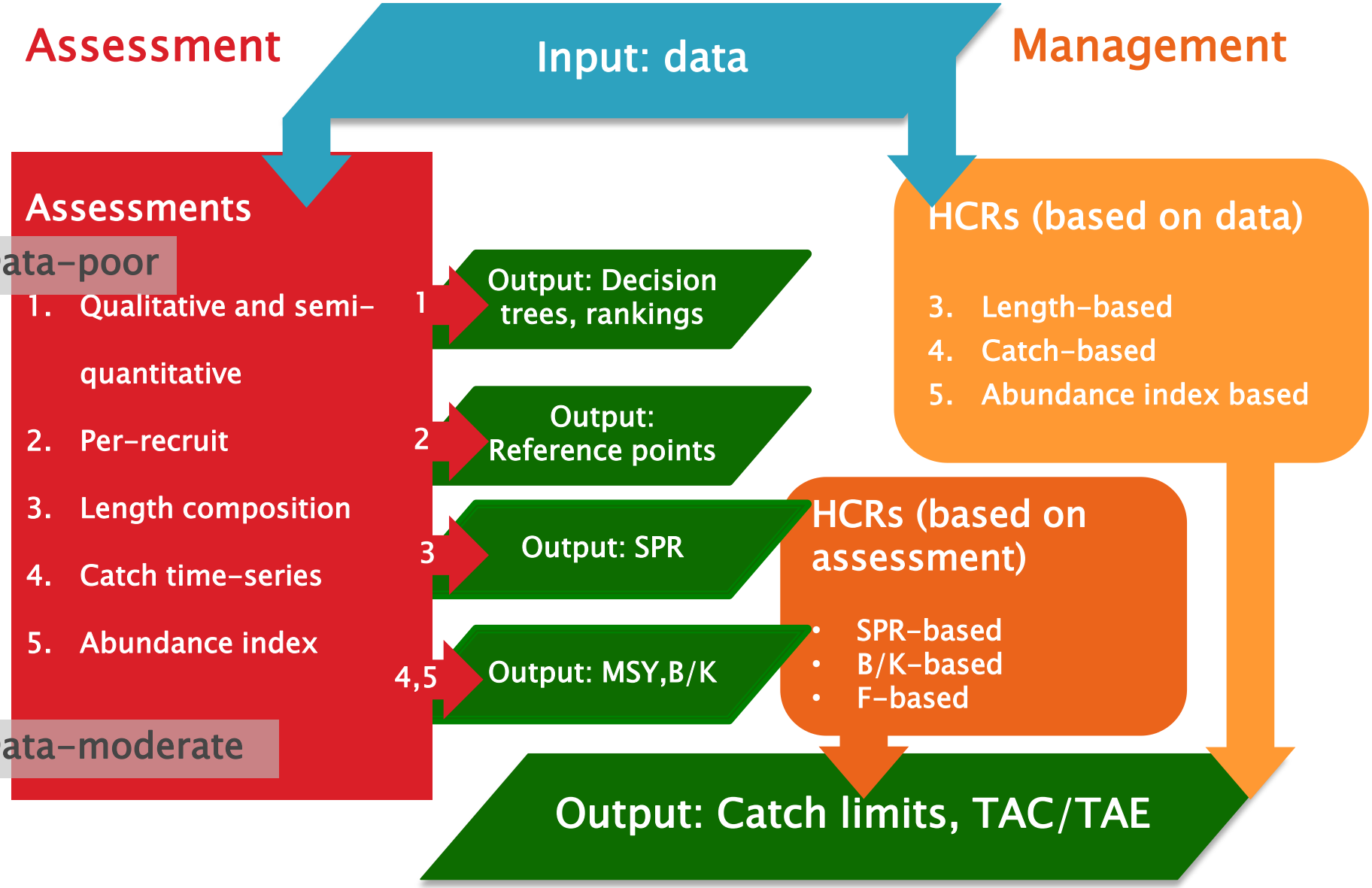
DLMtool "Observation" object:

L-H pars:	Log-normal CV=0.1
Catch-at-length:	CV: U[0.05,0.15]
Index of abundance:	CV: U[0.1,0.4]
Catch time series:	CV: U[0.1,0.3]

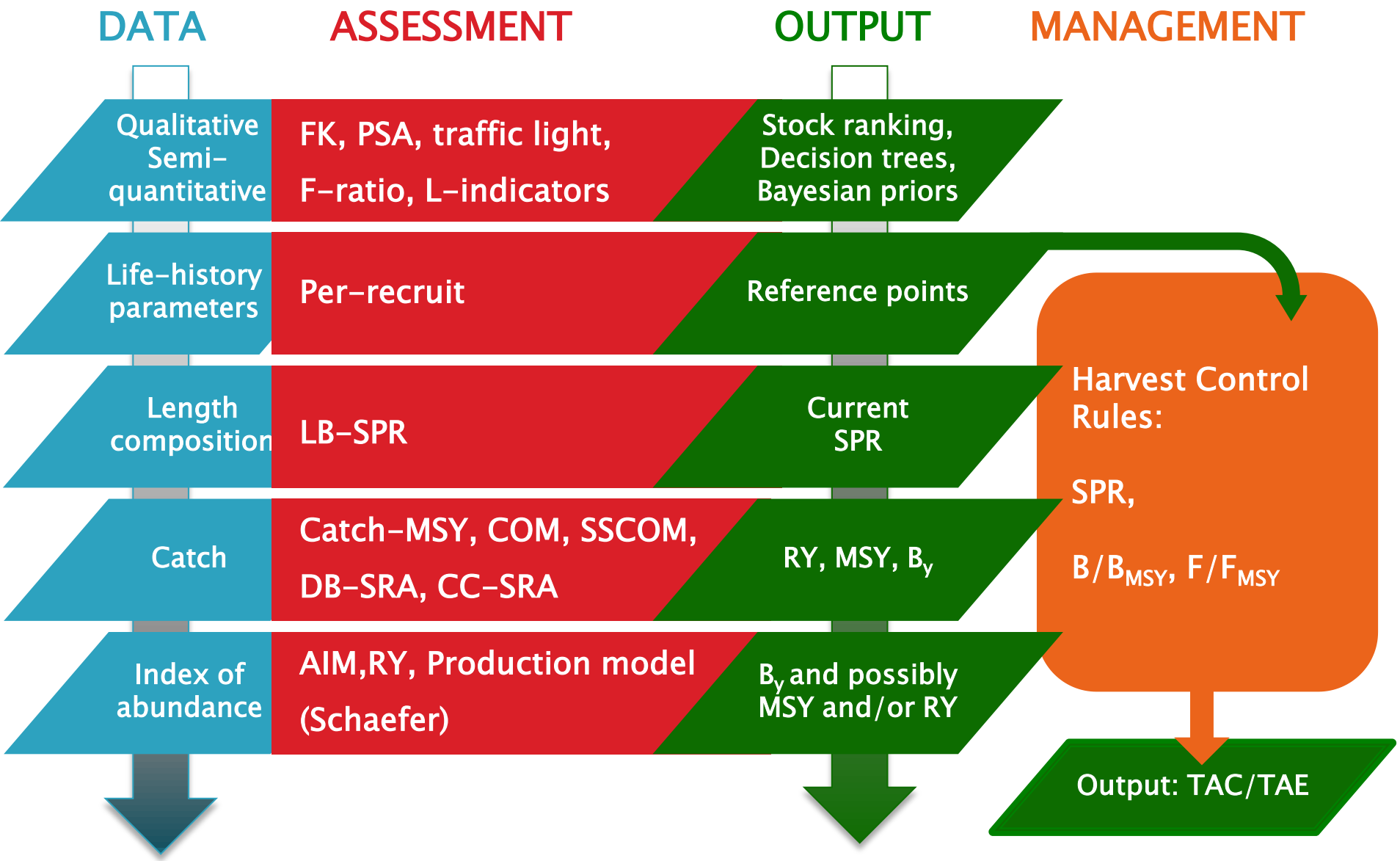
DLMtool "Fleet" object:

Fishing selectivity (vulnerability of oldest age): U[0.4,0.8]

Management Procedure



Data-poor assessment methods



Data-poor assessments (available on DLM Toolkit)

a) Yield-per-recruit: F_{MSY} proxy

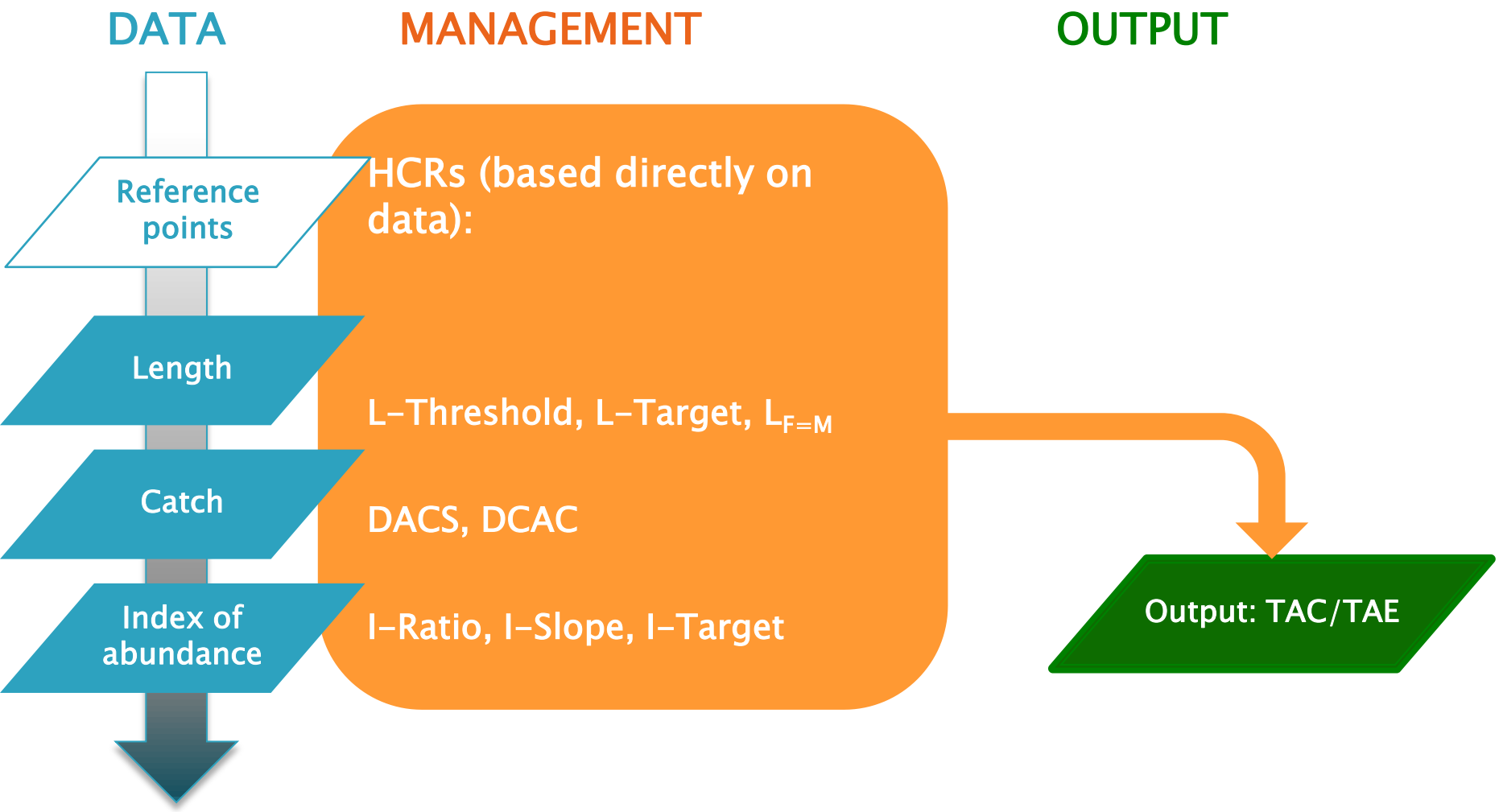
b) Spawning Potential Ratio (LB-SPR): Proxy for stock status

Coupled with a target HCR

c) Depletion-Based Stock Reduction Analysis (DB-SRA): estimate MSY

Coupled with a MSY HCR

Data-poor MPs



Data-poor HCRs (available on DLM Toolkit)

a) MSY rule:

$$TAC_{y+1} = DCAC = \frac{\sum C_y}{n + \mathrm{D} / (MSYL \times c \times M)}$$

< MSY

b) Threshold rule:

$$TAC_{y+1} = TAC_y \pm \text{step if } I_y^{recent} \begin{matrix} > I^{\text{upper threshold}} \\ < I^{\text{lower threshold}} \end{matrix}$$

Status quo with reference points

c) Slope rule

$$TAC_{y+1} = TAC_y(1 + \mathit{l}\ \text{slope}(I_y))$$

Directional (no target or limit)

d) Target rule

$$TAC_{y+1} = TAC^{\text{target}} \left[w + (1 - w) \left(\frac{I_y^{\text{recent}} - I^0}{I^{\text{target}} - I^0} \right) \right]$$

Target and limit reference points

Where I = mean length index, or LB-SPR index, or CPUE/survey index

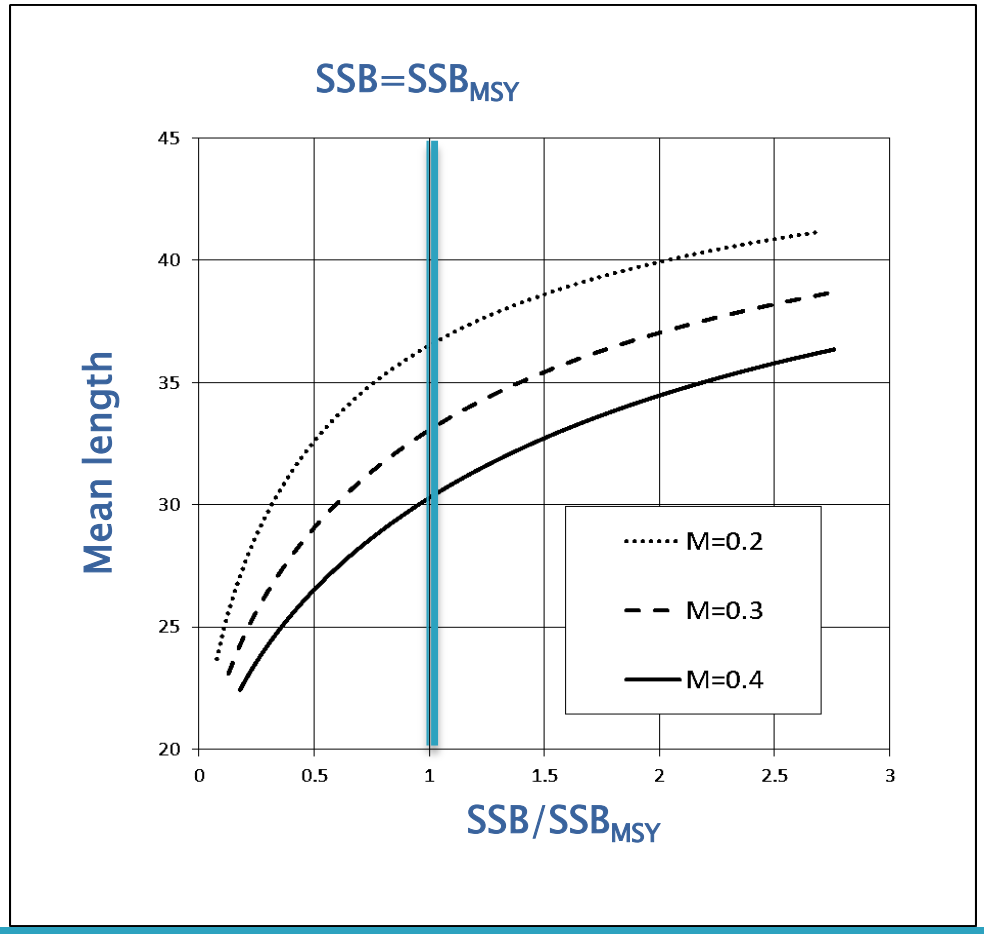
and

TAC^{target} = proxy for MSY ($DCAC$ or DACS)

Data: Mean length of catch

Advantage: Easy and cheap to collect.

Disadvantage: Mean length is an indirect index – not directly proportional to abundance! Delay in feed-back at higher biomass levels (worse for longer-lived stocks (lower M). Same problem for catch-at-length data.

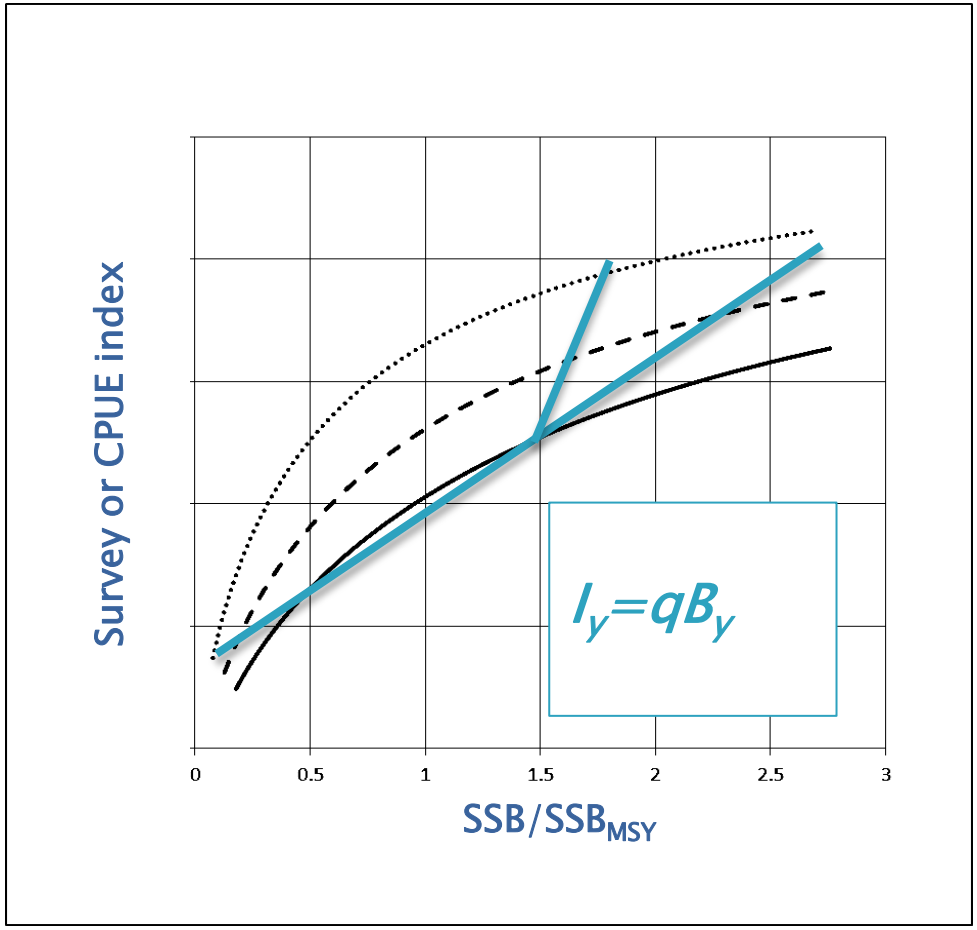


Equilibrium mean length in catch as a function of spawning biomass for age-independent natural mortality rates, *M*, of 0.2, 0.3 and 0.4 yr^{-1}.

Data: survey of CPUE

Advantage: Direct index of abundance.

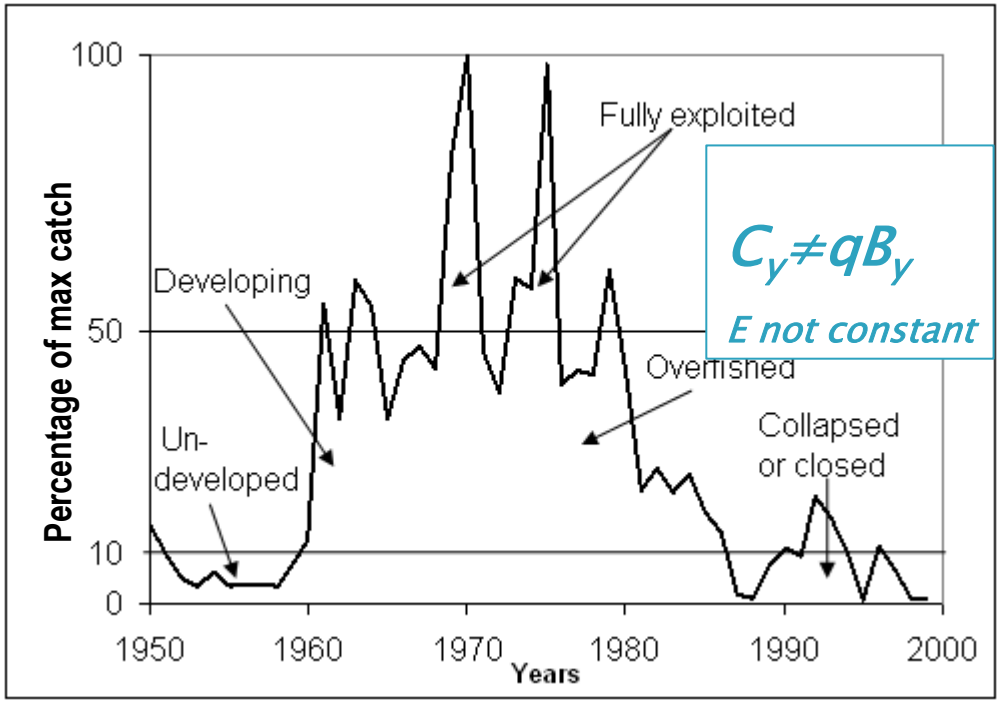
Disadvantage: Scientific surveys can be costly. CPUE data much easier/cheaper to collect, but bias (changes in q) could be problematic.



Data: Total annual catch

Advantage: Time-series data are usually available for most fisheries

Disadvantage: Catch data alone are not informative about stock size. Total removals are not well known for data-poor fisheries due to insufficient monitoring



Catch time-series shown as a percentage of the maximum catch to illustrate the transition phases of a typical fishery (Froese and Kesner-Reyes, 2002).

MSC stock status scores

SG60: stock likely above point where recruitment becomes impaired (PRI)

stock above PRI ($0.2B_0$ or $0.5\ B_{MSY}$)

no decline in one biomass proxy

SG80: stock highly likely above PRI and fluctuating about MSY level

stock above PRI

no decline in two biomass proxies

one proxy to indicate high productivity level

SG100: certain that stock above PRI and fluctuating about or above MSY level

stock above PRI

no decline in three biomass proxies

two proxies to indicate high productivity level

where "likely"=70%-ile, "highly likely"=80%-ile; "certain"=95%-ile

(Default reference points: $B_{MSY}=0.4B_0$, $PRI=0.2B_0$)

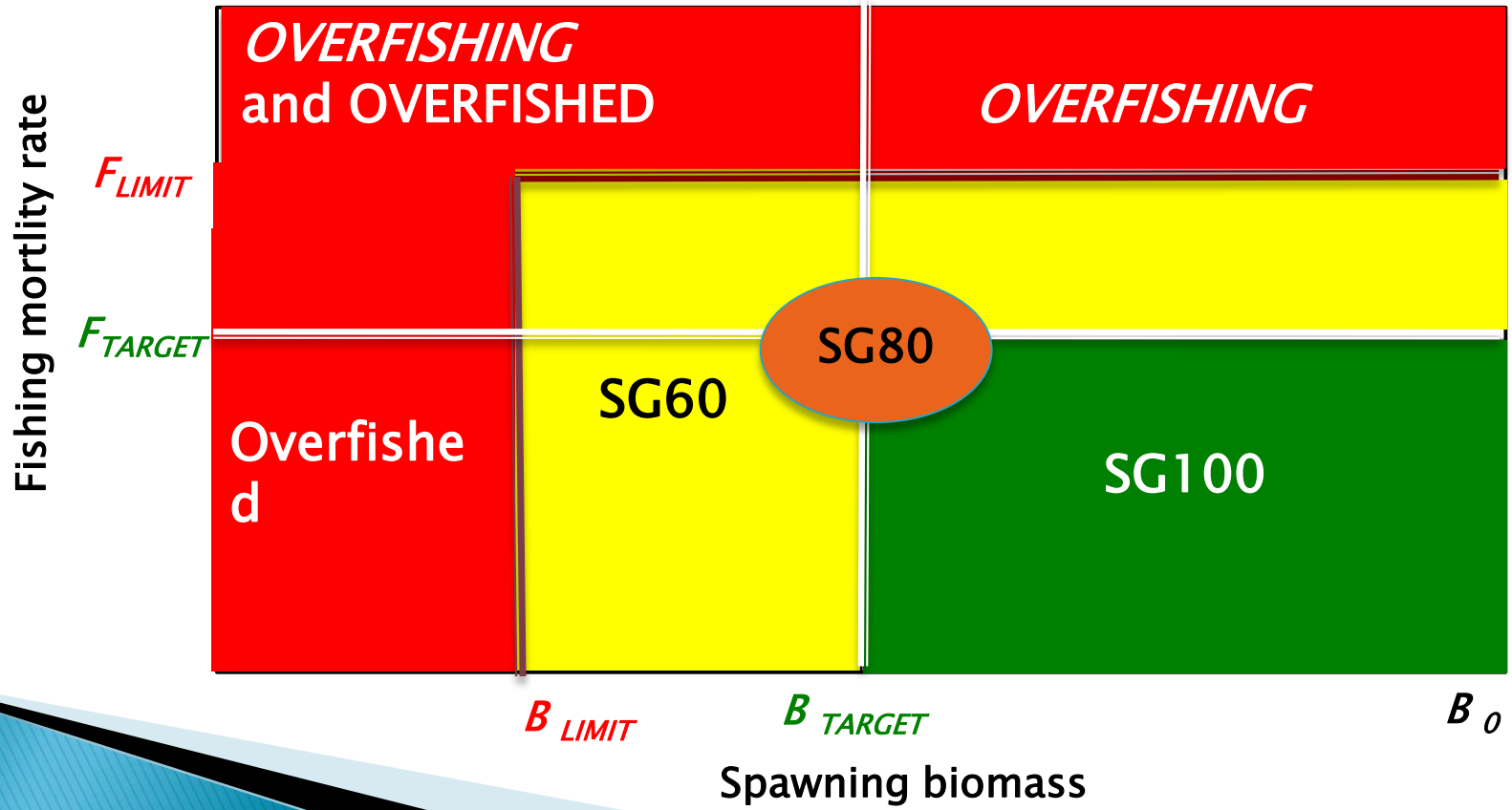
Current stock status not known, but score ito probability to achieve target

Reference points:

SG60: stock likely in yellow zone

SG80: stock highly likely in orange zone

SG100: Stock in green zone with some certainty



Precautionary buffers

Less data and increased levels of uncertainty require more precautionary management and larger buffers

Buffers serve as an incentive to collect data and move stocks from

i) data-poor to data-moderate and

ii) very depleted to moderately depleted.

Example:

- Data-poor and MSC score SG60: $B/B_{MSY}>0.5$ => Buff=25%
- Data-moderate and MSC score SG80: $B/B_{MSY}\pm1$=>Buff=10%
- Data-rich and MSC score SG100: $B/B_{MSY}\pm1$=> Buff=0%?

Need to simulation test alternative buffer sizes

MSC rebuilding time frames

SG60: Rebuilding time twice the generation time,
but not longer than 20 years.
Monitor to check that rebuilding strategies are effective

SG80: Some evidence (high likelihood) of recovery within time period

SG100: Short rebuilding time period of between 5 years and one generation time for stock
Strong evidence (high likelihood) of recovery within time

Generation time: $t_{gen} = t_{opt} = t_0 - 1/k \ln(1 - L_{opt}/L_{inf})$

Shortcut method: $t_{gen} = a_{mat} + 1/M$?

Tune HCRs to achieve target in pre-selected time-period
?% of the time

MSC harvest strategy scores

SG60: MP is expected to achieve objectives
The MP is likely to work
Monitoring is in place to provide feedback

SG80: MP is responsive to stock status (feedback)
Elements of MP work together to achieve objectives
MP may not be fully tested, but evidence shows that objectives are met

SG100: MP is responsive to stock status and is designed to achieve objectives
The MP has undergone comprehensive robustness testing
Evidence shows that objectives are met
MP can maintain stock at target levels
MP is reviewed and improved periodically

Aim to produce a guide to appropriate MPs according to stock and fishery types , depletion levels and associated buffer to achieve MSC scores.

Summing up…

- Need consolidated approach to management, which includes data-collection
- Automate management advice: implement a simple HCR that can be updated every 4/5 years (inline with MSC certification schedule).
- Adopt an MP approach which includes fishery stakeholders to inform on management objectives and trade-offs ito MSC scoring module
- Match control rules to stock characteristics and available data
- Index-based HRCs perform best: collect data to construct a reliable direct index of abundance (survey or CPUE)
- Need HCRs with feedback control to self-correct
- HCRs must be shown to be adequately risk-averse

Timeline

1. **Categorisation of stock groups and specification of OMs:**
   Identification of generic baskets of stock types. Setting up of generic OMs using DLM Toolkit and example input data files. Specification of robustness tests, reference points, performance statistics and appropriate projection periods (generation times).
2. **Specifications of candidate methods:**
   Identify candidate MPs corresponding to each OM basket. Specification of reference points (targets and limits) and precautionary buffers for each MP.
3. **MSE:** Simulation testing and tuning of MPs for each OM basket. Evaluation of appropriate control parameters and precautionary buffers for each MP.
4. **Decision tree** :
   Inspection of final summary statistics. Comparison performance for each basket to rank methods and construction of a decision tree to aid with method selection.
5. **MSC scoring module:**
   Coding of DLM Toolkit module to translate performance statistics to MSC scoring.

Deliverables

Technical specifications of stock categorisation and OMs:

Identification of generic baskets of stock types. Specification of robustness tests. Performance statistics and appropriate projection periods.

Technical specifications of candidate HCRs:

HCRs corresponding to each basket. Specification of control parameters, reference points (targets and limits) and precautionary buffers for each HCR.

Technical document summarising MSE results:

Summary of comparative performance of HCRs across alternative baskets. Identification of key uncertainties and trade-offs.

Decision tree :

Drafting of a decision tree to prioritise methods and data according to generic basket (stock/fishery type and depletion range), with assumptions/advantages/disadvantages of each method. Identification of key data and uncertainties to prioritise future research.

MSC scoring module:

A DLM Toolkit module to translate performance statistics to MSC scoring. Operational module for fishery stakeholders to tune candidate MPs.

Collaboration: global data-poor initiatives

UBC (DLM Toolkit):
R package to perform MSE which includes many data-poor HCRs. LB-SPR will soon be incorporated. Contact: Tom Carruthers, Adrian Hordyk

CSIRO (SESSF Harvest Strategy Policy):
Tier system to group stocks according to data and methods (Tier 4 for data-poor stocks). HCRs fully tested using MSE. Contact: Tony Smith

NOAA (Fishery Management Plan):
NPFMC uses a Tier system to groups stocks according to reliability of estimates of B and MSY reference points. PFMC groups stocks into 3 categories: data-rich, data-moderate and data-poor according to type of assessment methods used. Contact person: Andre Punt

ICES (WKLIFE):
European data-poor methods Working Group based on life-history traits. Stocks categorised according to data and methods. Contact: Jose De Oliveira

SNAP:
Data-poor initiative. In-house MSE code unknown. Similarities in approach. Contact: Jono Wilson, Natalie Dowling

JRC (a4a):
European stock assessment initiative. FLR code fully tested and documented. Moving towards testing of data-poor methods. Contact: Ernesto Jardim

FAO: On-going data poor MSE projects; FAO data-base. Contact: Yimin Ye, Marcello

DLM Toolkit: MSE framework

Carruthers *et al.* (In review). Performance review of simple management procedures. ICES Journal of Marine Science

MSE to compare a range of MPs for setting catch-limits in fisheries.

Performance evaluated with respect to

- life-history type,
- level of stock depletion,
- data quality and
- auto-correlation in recruitment strength.

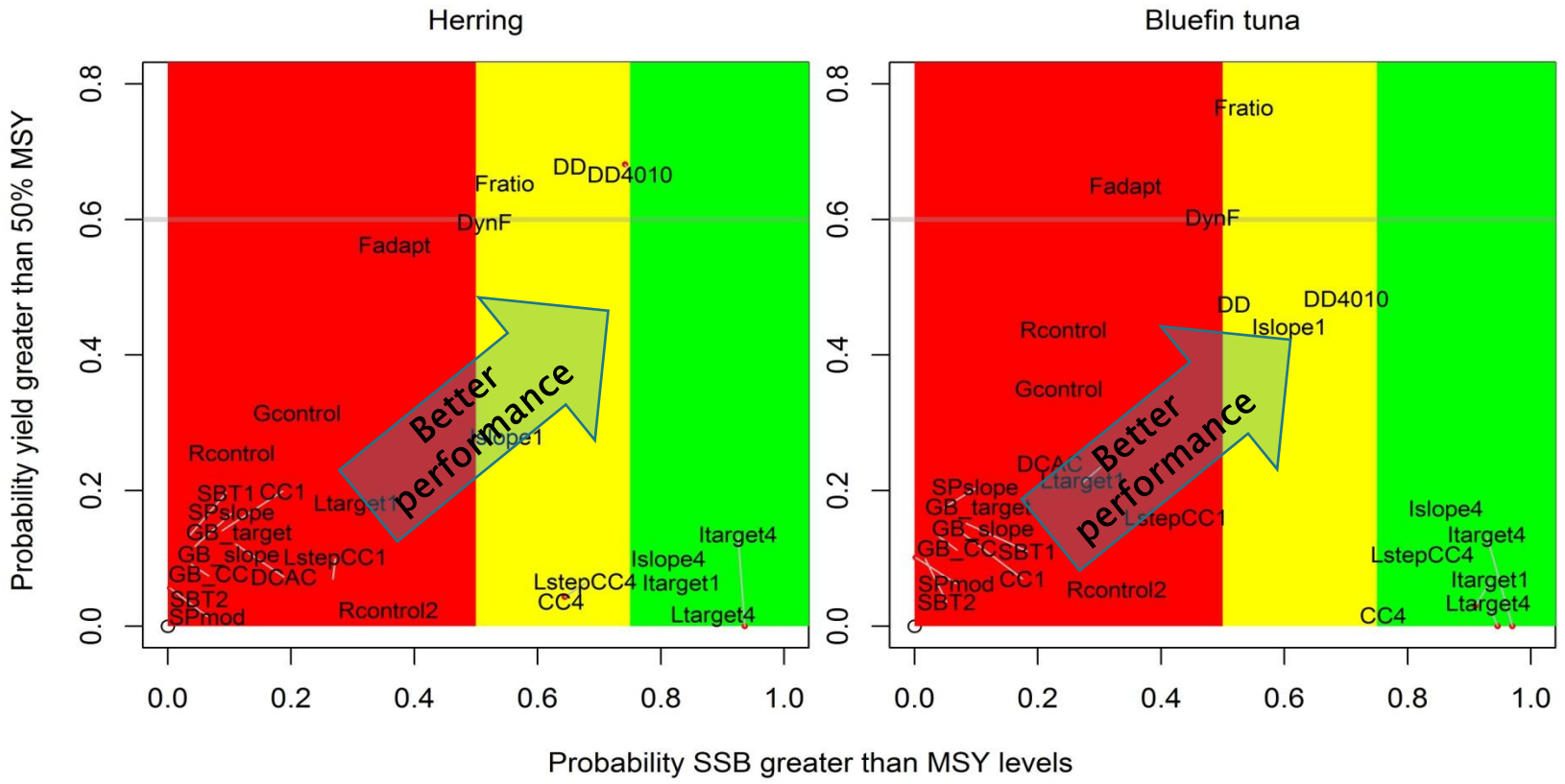
Evaluate robustness of MPs to biases in data.

=> Performance sensitive to biases in catch data.

⇒ Best performance: MPs based on absolute biomass or stock depletion estimates

Need a scientific survey

Comparative performance: DLM Toolbox MPs



Yield-risk trade-offs for herring and bluefin tuna using DLM Toolkit (from Carruthers *et al.* submitted)

CSIRO (Australia)

Harvest Strategy Policy (HSP):

Four tiers to classify stocks from data-rich to data-poor:

Tiers 1 and 2: Stocks with robust quantitative assessments

Tier 3. Stocks with no quantitative assessment but with estimates M and fishing mortality -> F-type HCR (5% discount factor)

Tier 4. Stocks with no quantitative assessment but with reliable CPUE data -> target-type HCR (15% discount factor)

Data-poor

NOAA (USA)

The North Pacific Fishery Management Council (NPFMC) adopts six tiers to classify stocks from data-rich to data-poor:

Tier 1, 2 and 3: Stocks with quantitative assessements and reliable estimates of B and MSY reference points (RFs), or proxies.

Tier 4. Stocks with reliable estimates of B but lacking MSY RFs.

Tier 5. Stocks with reliable estimates of B and M (no RFs).

-> HCR: F=M (25% discount factor)

Tier 6. Catch-only stocks: Stocks with no quantitative assessment

-> HCR: C_{ave} (25% discount factor)

Data-poor

NOAA (USA)

The Pacific Fishery Management Council (PFMC) adopts three categories to classify stocks from data-rich to data-poor:

Category 1: Data-rich -> age/length disaggregated assessment

Category 2: Data-moderate -> age-aggregated assessment (uncertainty buffer of 0.25)

Category 3: Data-poor -> C_{ave}, DCAC, DB-SRA (uncertainty buffer of 0.5)

Data-poor

ICES (Europe)

Six categories to classify stocks from data-rich to data-poor:

1. Data-rich stocks with accepted quantitative assessments.
2. Stocks with quantitative assessments (used qualitatively).
3. Stocks with reliable index: -> index-based HCR
4. Stocks with reliable catch data ->DCAC
5. Data-poor stocks with landings data only -> PSA
6. Stocks negligible landings -> PSA

Data-poor

Science for Nature And People (SNAP)

1. Develop a assessment and management framework for data-poor fisheries:

   Compile a data-base of data-poor assessment methods. Review performance indicators. Categorise fishery types in terms of life-history parameters. Compare data-poor assessment methods using MSE. Develop a framework to assess and manage data-poor fisheries. Provide guidance regarding the most suitable method according to fishery type and data availability.

2. Evaluate the costs/benefits of additional data:

   Quantify the costs of data collection and analysis. Evaluate benefits of extra data to reduce uncertainty/risk.Design adaptive management guidelines for fishers. Assist fishers to maximise economic benefits from monitoring, data collection and improved management.

3. Implement assessment and management framework for depleted data-poor fisheries:

   Identify data-poor fishery case studies. Train fishers to use assessment and management framework. Organise the data. Design adaptive management and monitoring protocols. Organise stakeholder workshops to engage local fishers in data collection, analysis, application and enforcement of management framework.

Thank you