Harvest Strategies:
Objectives, Harvest Control Rules, Reference Points

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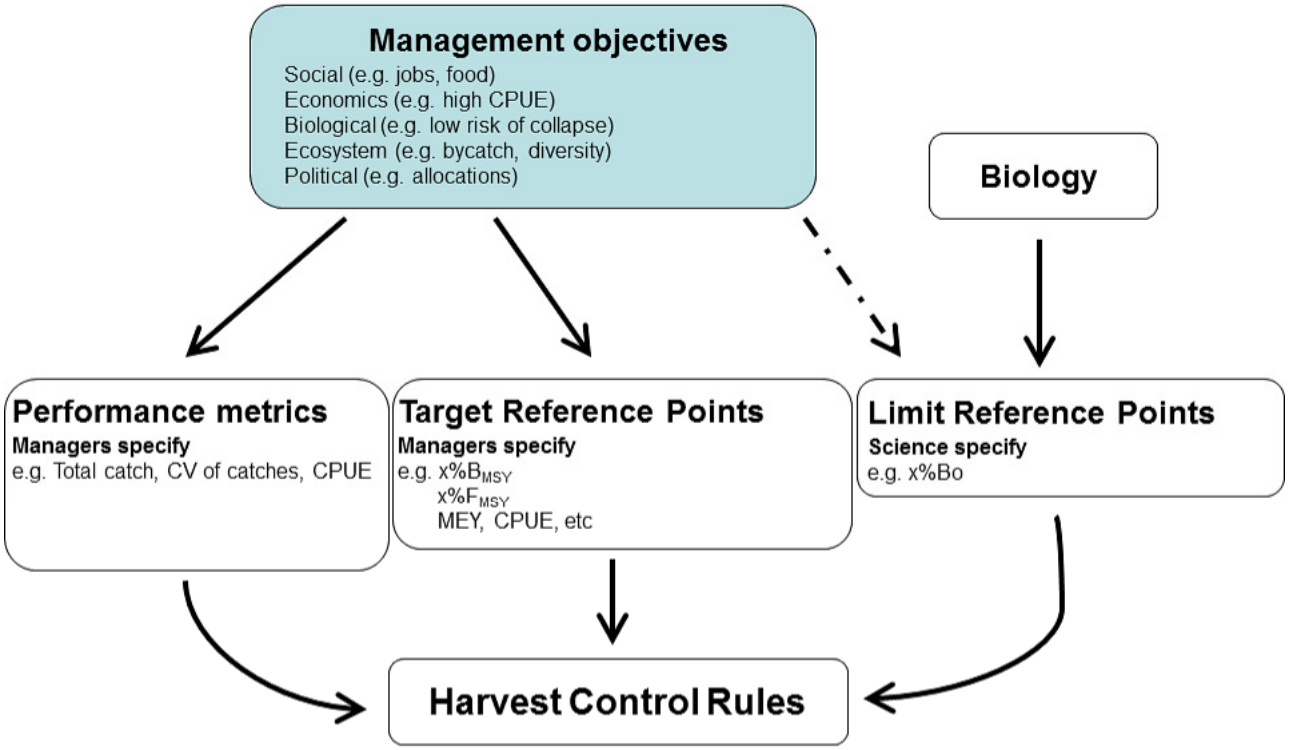
What is a Harvest Strategy?

- **HARVEST STRATEGY:** Combination of monitoring, stock status evaluation, harvest control rule (with or without RPs) and management actions designed to achieve fisheries objectives.
- Development and success of Harvest Strategies benefit from the **involvement of all stakeholders** in the management planning stage.

Harvest strategies



Modified from Berger et al. 2012

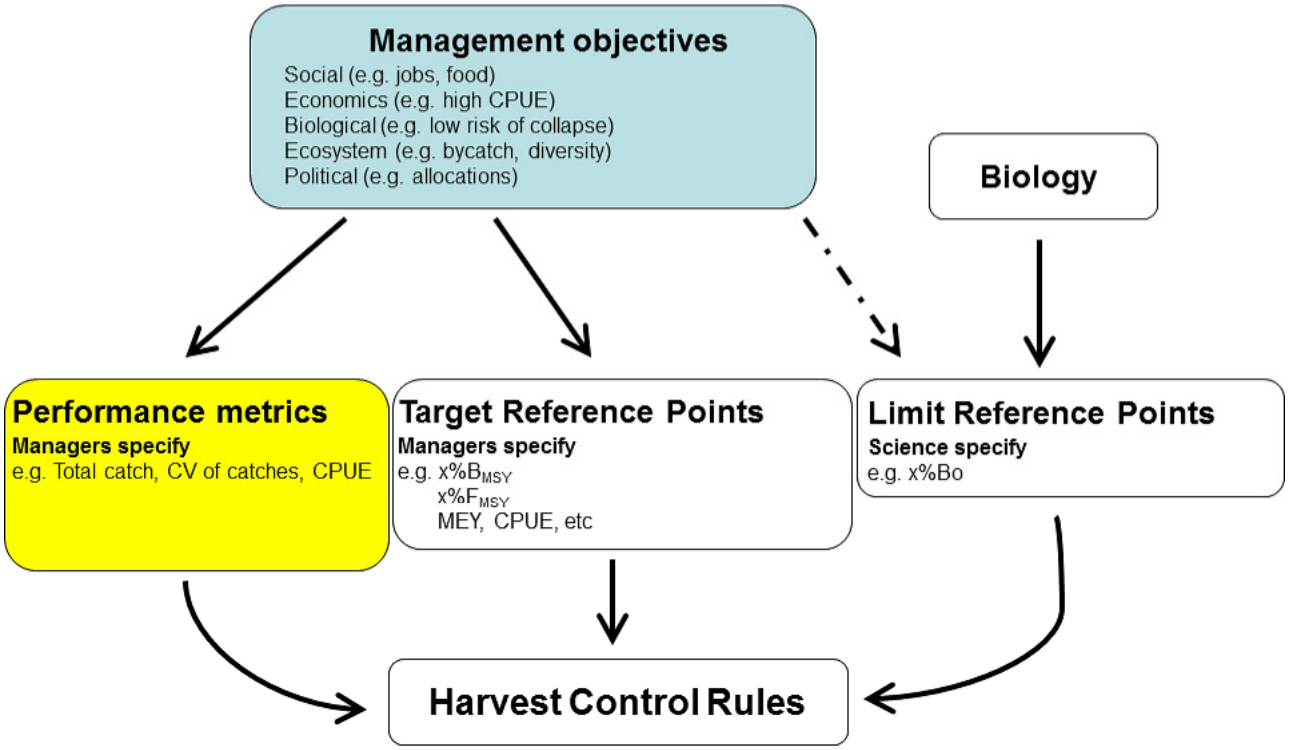
Management objectives

- Stated explicitly, specifically and unequivocally
  - Social (e.g. jobs, food access)
  - Economical (e.g. profitability)
  - Biological (e.g. low risk of collapse)
  - Ecosystem (e.g. bycatch, diversity)
  - Political (e.g. allocation)

Management objectives

- Clear objectives fundamental to establish reference points and evaluate performance of harvest strategies
- Avoid being too generic (examples)
- Should specify:
  - Quantities
  - Probabilities
  - Timelines

Harvest strategies



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Modified from Berger et al. 2012

Performance metrics

"I want it all, and I want it now…"

Freddie Mercury

- Long-term total catch
- Long-term average catch
- Long-term variability in catch
- Short-term variability in catch

- Long-term average CPUE
- Long-term average effort (fishing days)

- Probability of falling below reference points
- Probability of stock recovery
- Many more!

Tradeoffs

"You can't always get what you want…"

Mick Jagger

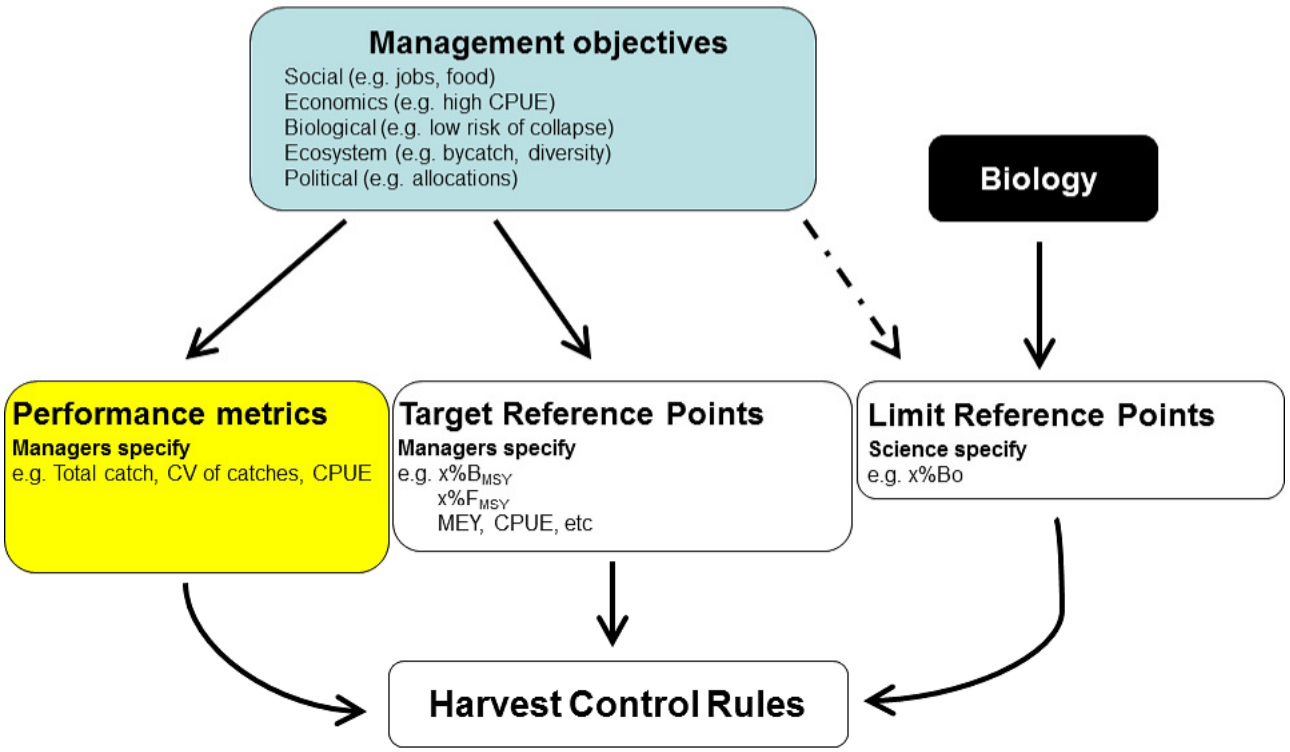
- Long-term catch & Long-term CPUE
- Long-term catch & *Probability* below reference points
- Long-term catch & Short-term catch
- Long-term CPUE & Annual catch variability
- Long-term effort & *Probability of* stock recovery

Tradeoffs

- Risk metrics
  - Probability of overfishing/overfished
  - Probability of collapse (economical o biological)
  - Probability of closures (spatially or temporally)

- Behavior towards risk
  - Risk Averse (avoidance)
  - Risk Prone (seeking)
  - Risk Neutral (indifferent)

Harvest strategies



Modified from Berger et al. 2012

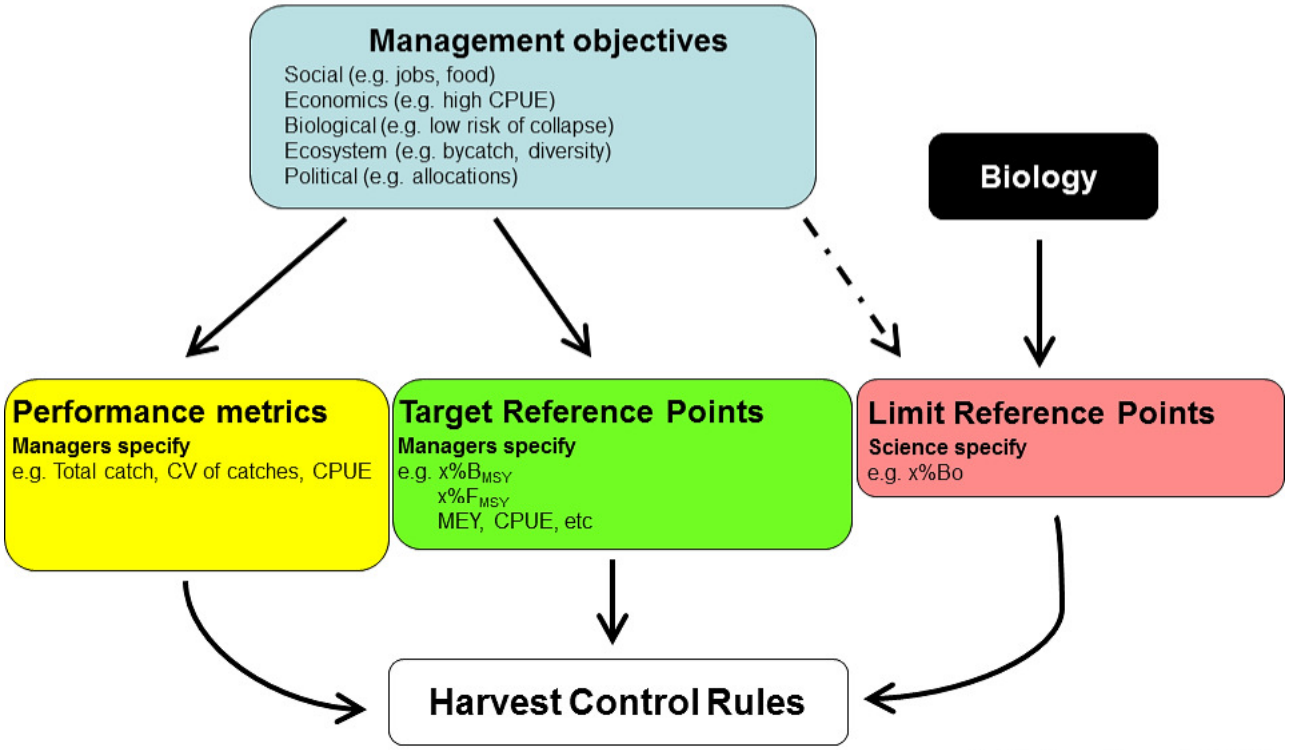
What do we know about Biology?

"Counting fish is like counting trees…

…except they are invisible and they move."

John Shepherd

Harvest strategies



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Reference Points

- Management benchmarks against which to measure stock abundance, fishing mortality or social/economic indicators to determine status.

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Reference Points

Limit Reference Point

Threshold Reference Point

Target Reference Point

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Target Reference Point

Should be met, on average, given a set of management objectives. Corresponds to a desirable fishery or stock status.

Threshold Reference Point

Indicates the biomass fell below the **Target**, or the fishing mortality is over the **Target**, additional management actions are required to prevent the stock reaching the **Limit.**

Limit Reference Point

Not to be exceeded with any substantial probability, given a set of management objectives. When reached, the status of the stock is not desirable and management actions are required. When stock abundance is very low, may result in fishery closures.

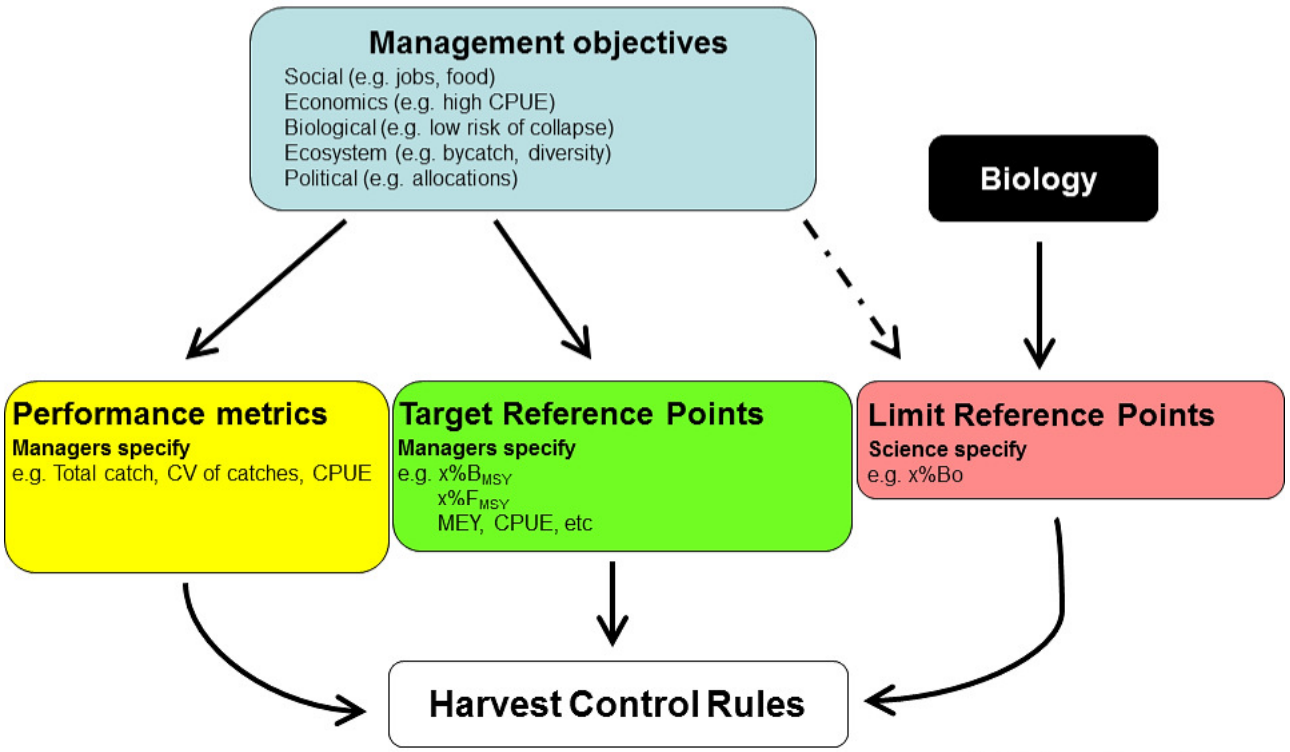
Rebuilding Targets

Implemented for depleted stocks. Important to consider rebuilding level, probability and timeline of recovery, subsequent actions after recovery such as defining a target reference point and rebuilding to it.

Reference Points

- Based on models
  - Biomass (B_{MSY}, B_{MEY}) or fishing mortality (F_{MSY})
  - F_{max}, $F_{0.1}$, $F_{35\%}$, $F_{40\%}$, per-recruit calculations
- Based on data alone (empirical)
  - CPUE
  - Fish size

Harvest strategies



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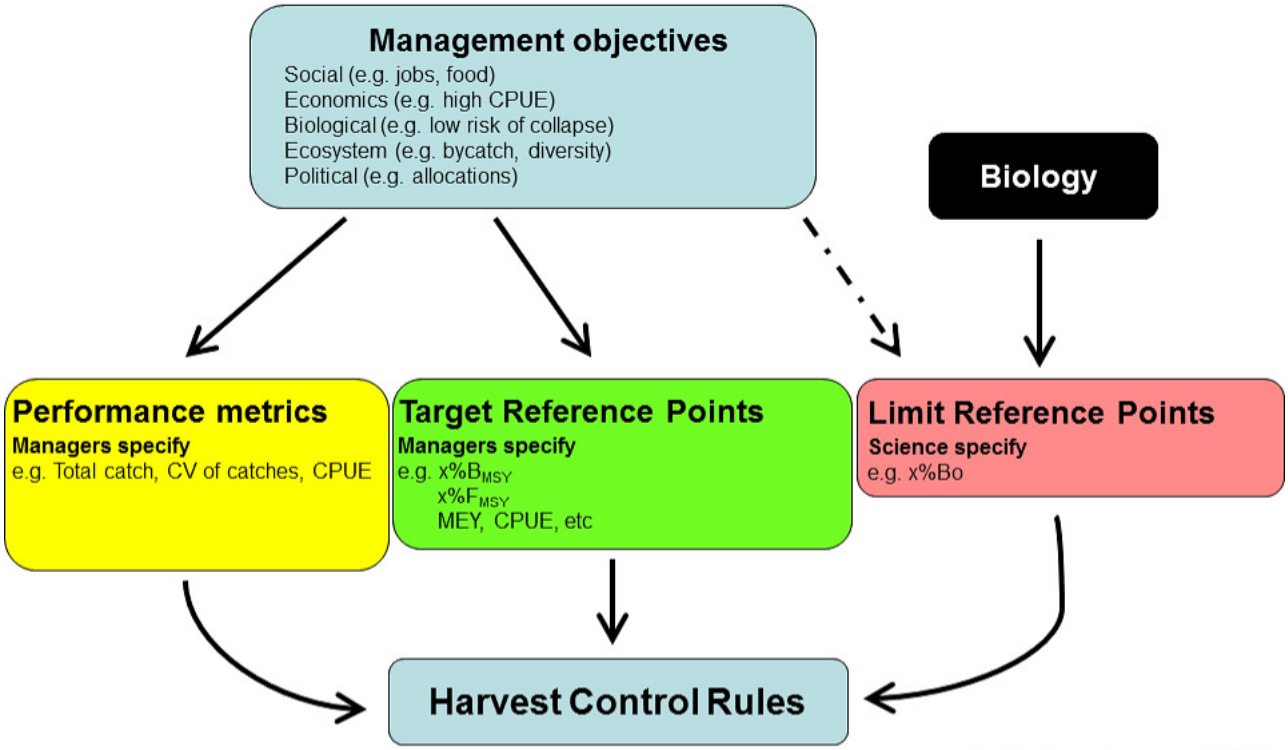
Harvest strategies



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Harvest Control Rules (HCR)

- **Pre-agreed** management actions to changes in the stock and/or environmental, economic factors relative to **reference points**, **or trends** in stock indicators.
- Operationalize **management objectives**
- Increase management decisions **transparency**
- Framework to implement harvest strategies using decision making based on science.

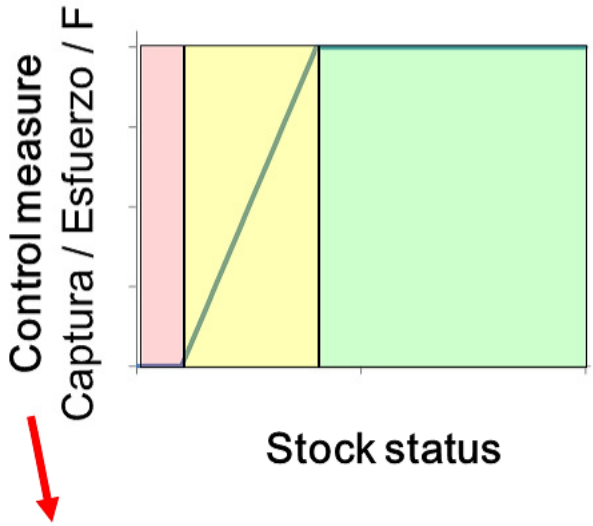
Indicator, or Stock assessment

"Stock"

Reference Points

Control Rule

Additional Harvest Control Rule elements



- Control measure, tactics:
  - Regulations available to apply the strategy

Control measures / Tactics

Input Controls – regulate fishing effort

- number and size of fishing vessels
- length of fishing season
- spatial closures

Output Controls – regulate catch

- total allowed catch (TAC)
- transferable quotas (ITQ)
- Quota allocation by gear/fleet

Control measures / Tactics

Why **Output Controls**?

- Better adherence to allowed catch
- Reduce (not always) the “race for fish”

Challenges of **Output Controls**

- Incentivize catch misreporting
- Less robust to assessment errors
- More difficult and costly to monitor

Control measures / Tactics

Why **Input Controls**?

- Simple and inexpensive to implement
- Easy to monitor
- Mixed fisheries where it is difficult to monitor all species.

Challenges with **Input Controls**

- Incentivize a “race for fish”
- More robust to assessment errors
- Difficult to limit all sources of fishing effort
- Fishing effort can re-distribute or change
- Tend to exceed the allowable catch

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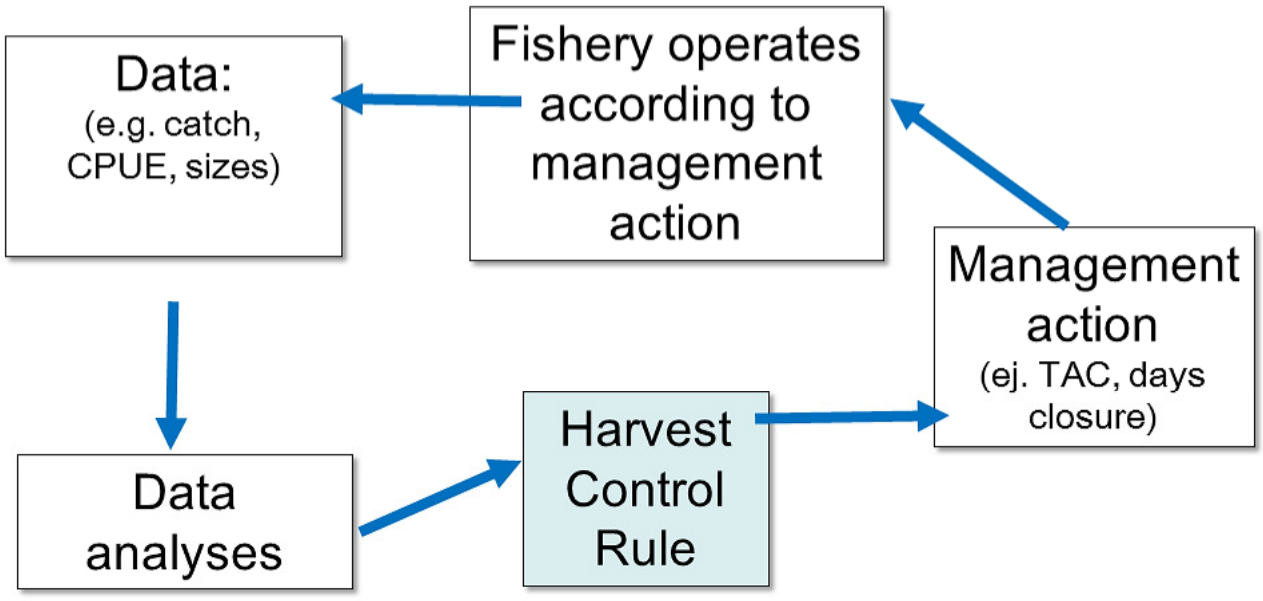
Harvest Control Rule cycle



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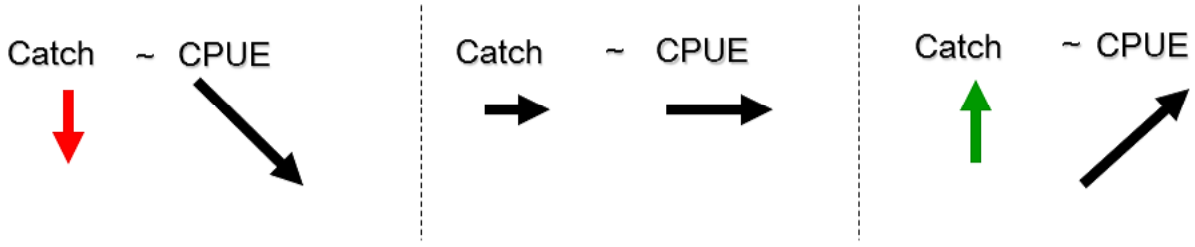
Harvest Control Rule types

- **Constant**
- **Empirical Rule**
  - Minimum treatment of data
  - Easy to compute, explain and understand
  - Care required to minimize responses to noisy data
- **Model-based Rule**
  - Based on models of varied complexity (e.g. assessments)

Empirical rule example

- Based on monitoring and feedback
- Simple rule, even when evaluation of its performance uses complex computer simulations (such as MSE)

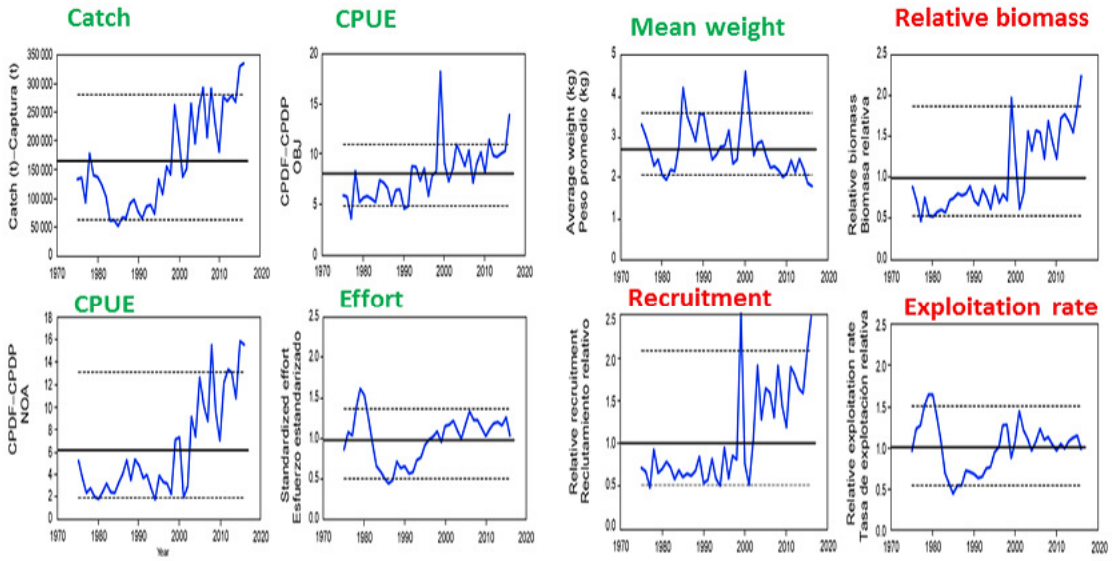
Example: adjust catch using CPUE trends



Indicators, EPO Skipjack tuna

Based on data or simple model population estimates

- **Data** (catch, effort, CPUE, mean weight)
- **Simple model estimates** (biomass, recruitment and exploitation rate)



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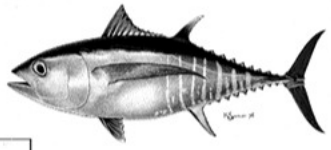
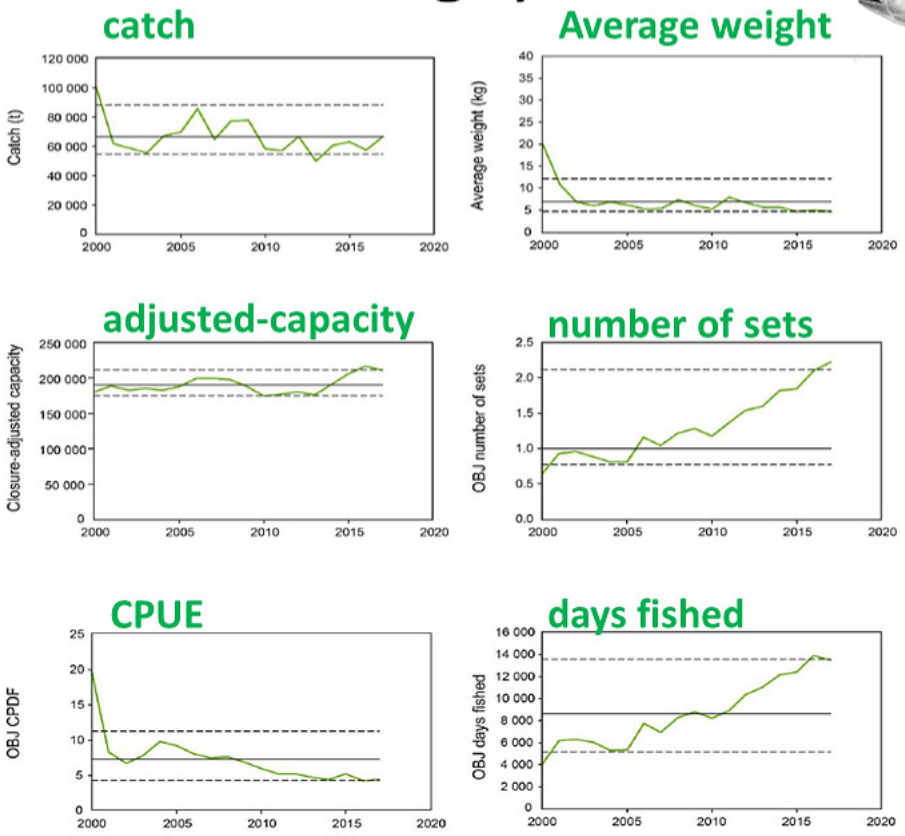
Indicators for bigeye





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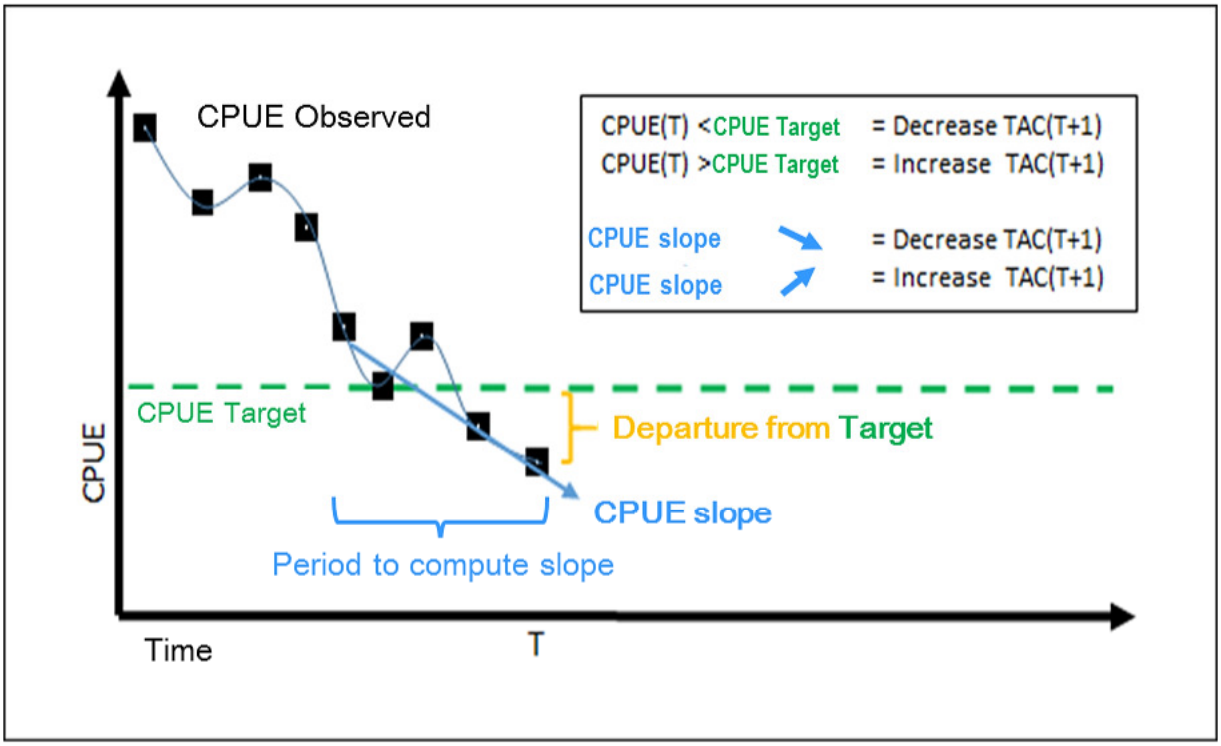
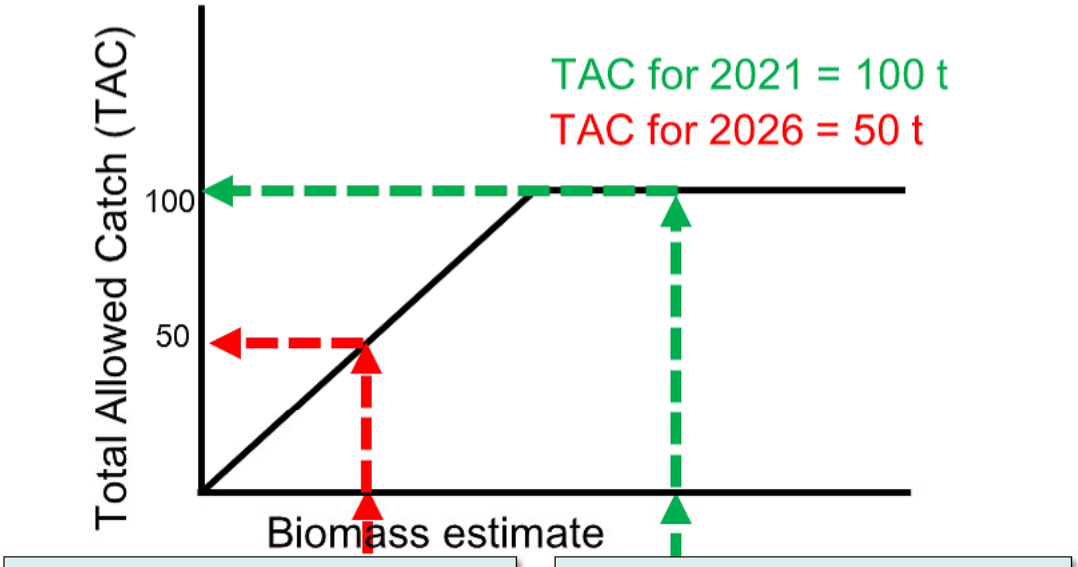
Empirical Rule example

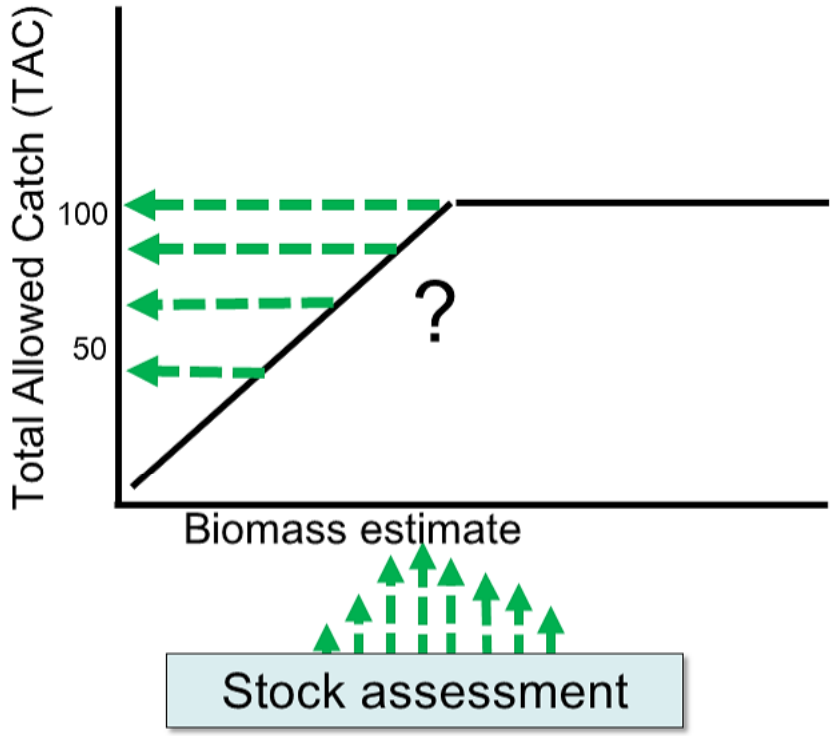


Model-based Rule example

1) Fit a pre-specified stock assessment
2) Use the HCR to determine next year's TAC



Stock assessment uncertainty



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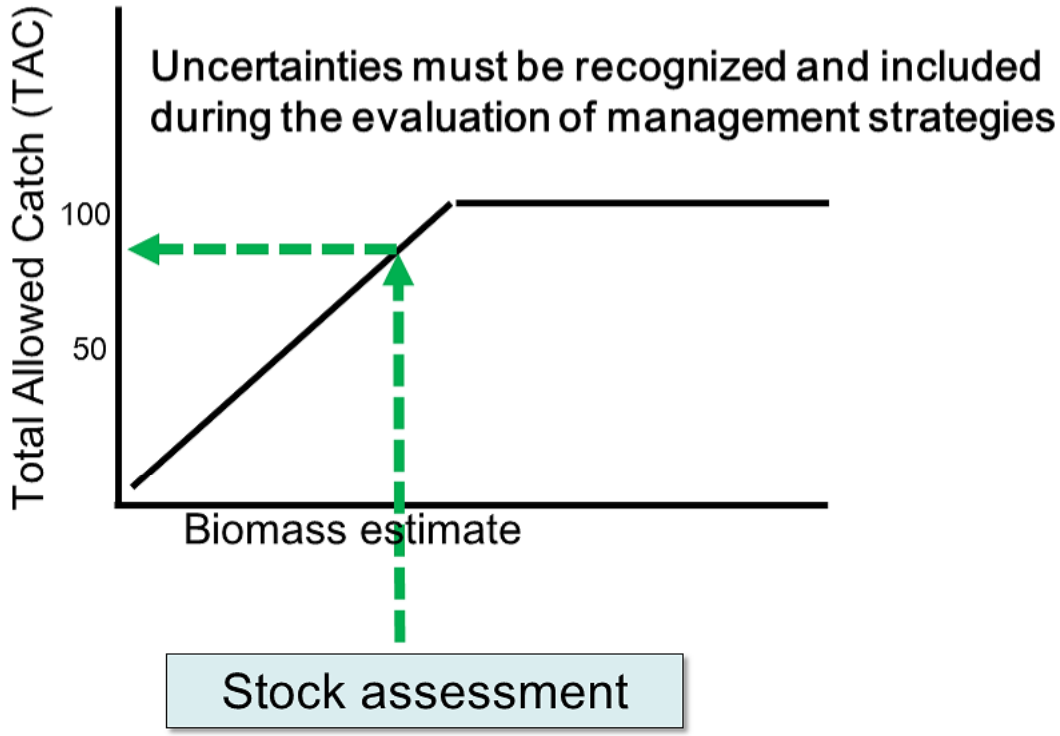
HCR must provide a unique action



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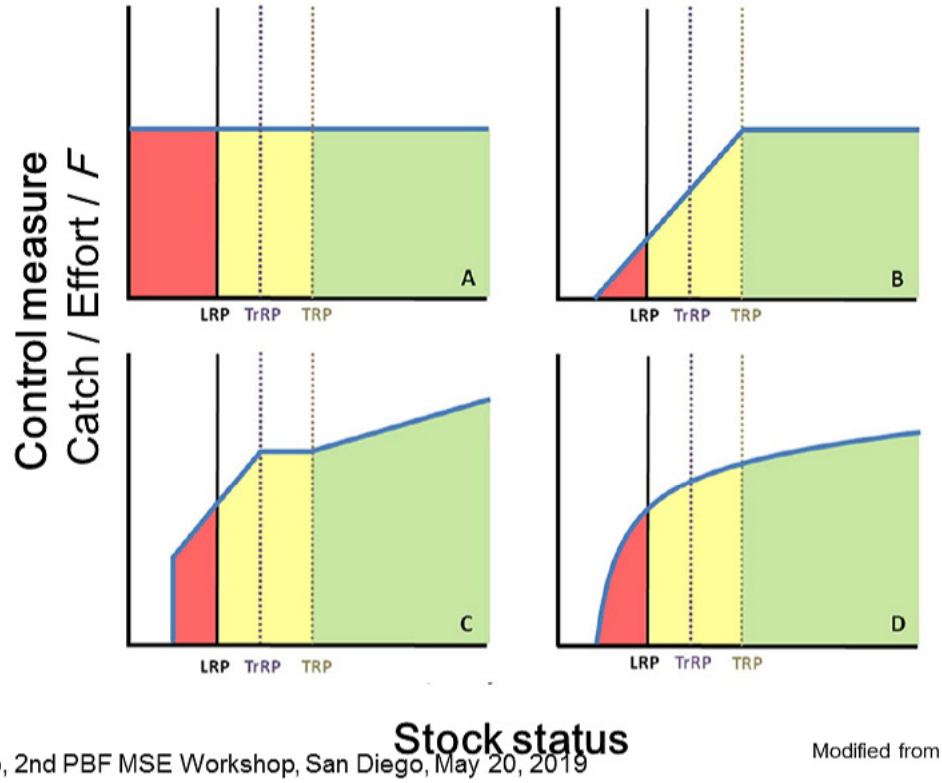
HCR and Reference Points

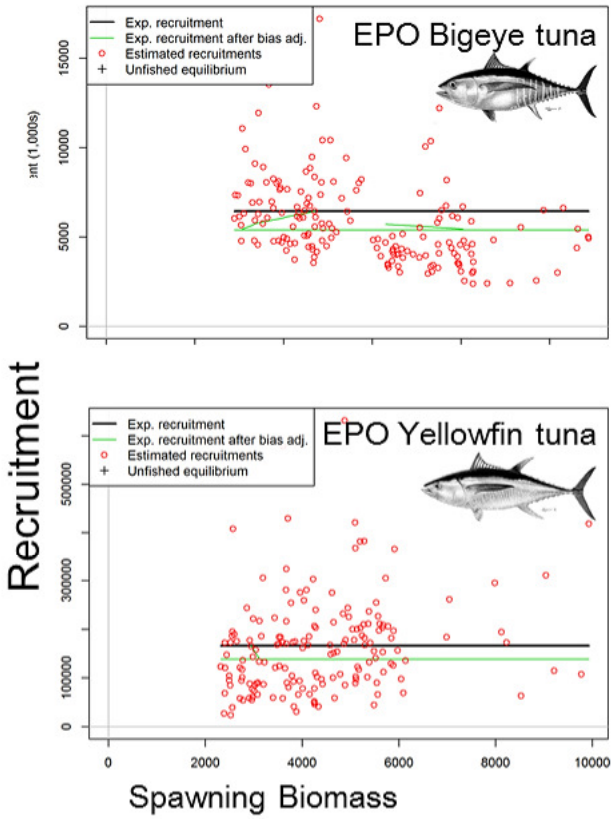


Modified from Berger et al. 2012

HCR development

- Harvest control rules (including their component biological reference points) should be developed in the management planning stage with the **involvement of all stakeholders**
- The success of HCRs is generally enhanced by involvement of stakeholders in the definition of the problem, including assumptions, and as it **facilitates trust and policy "buy in"**

RP and HCR for EPO tunas

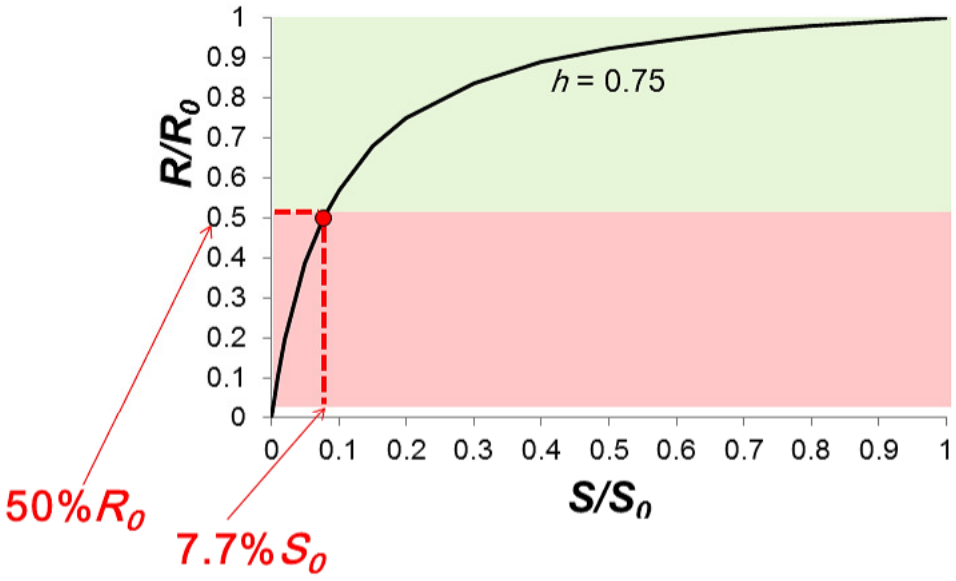


- No identifiable Spawner-recruit relationship
- EPO YFT and BET IATTC stock assessments assume steepness $h = 1$

IATTC Reference Points

- IATTC adopted interim target (TRP) and limit (LRP) reference points in 2014.
- Target:
  - Biomass (B) and Fishing mortality rate (F) corresponding to maximum sustainable yield (B_{MSY} and F_{MSY})
- Limit:
  - Those associated with a 50% reduction in unfished recruitment (50%R_0) using a conservative assumption of stock-recruitment relationship (steepness, or h = 0.75).

IATTC Limit Reference Point



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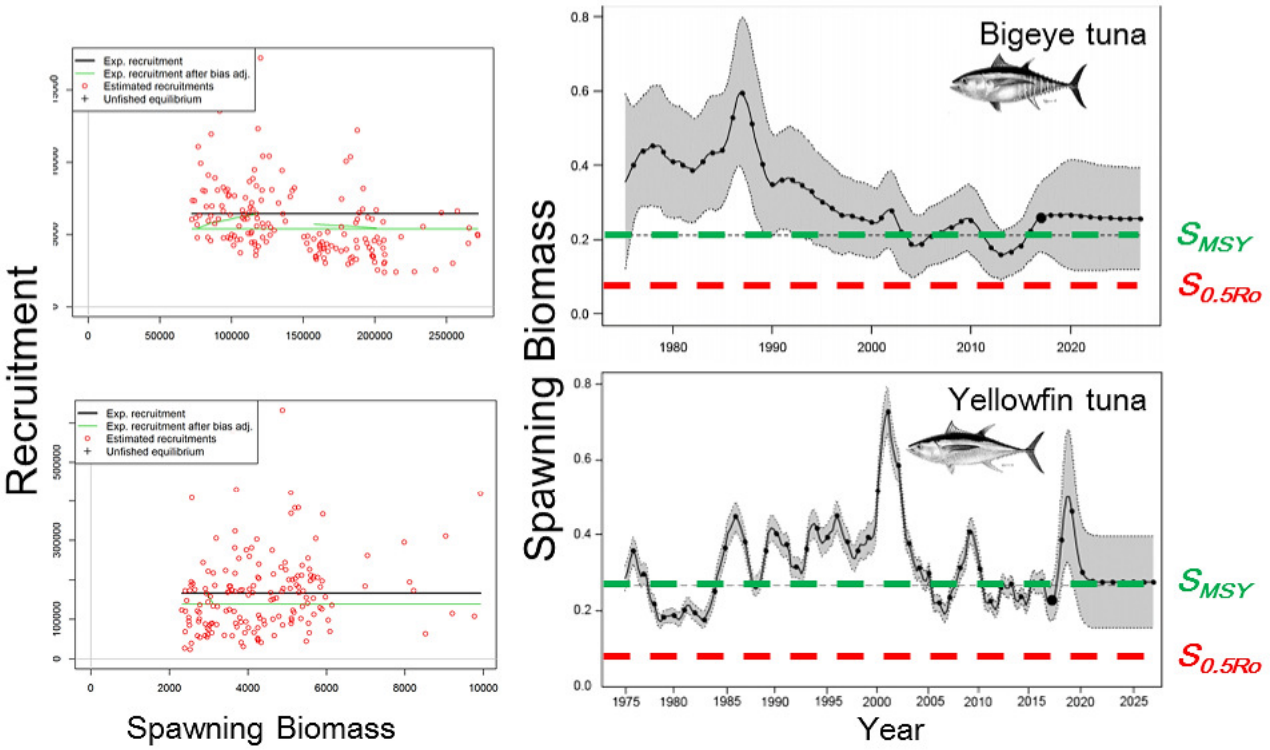

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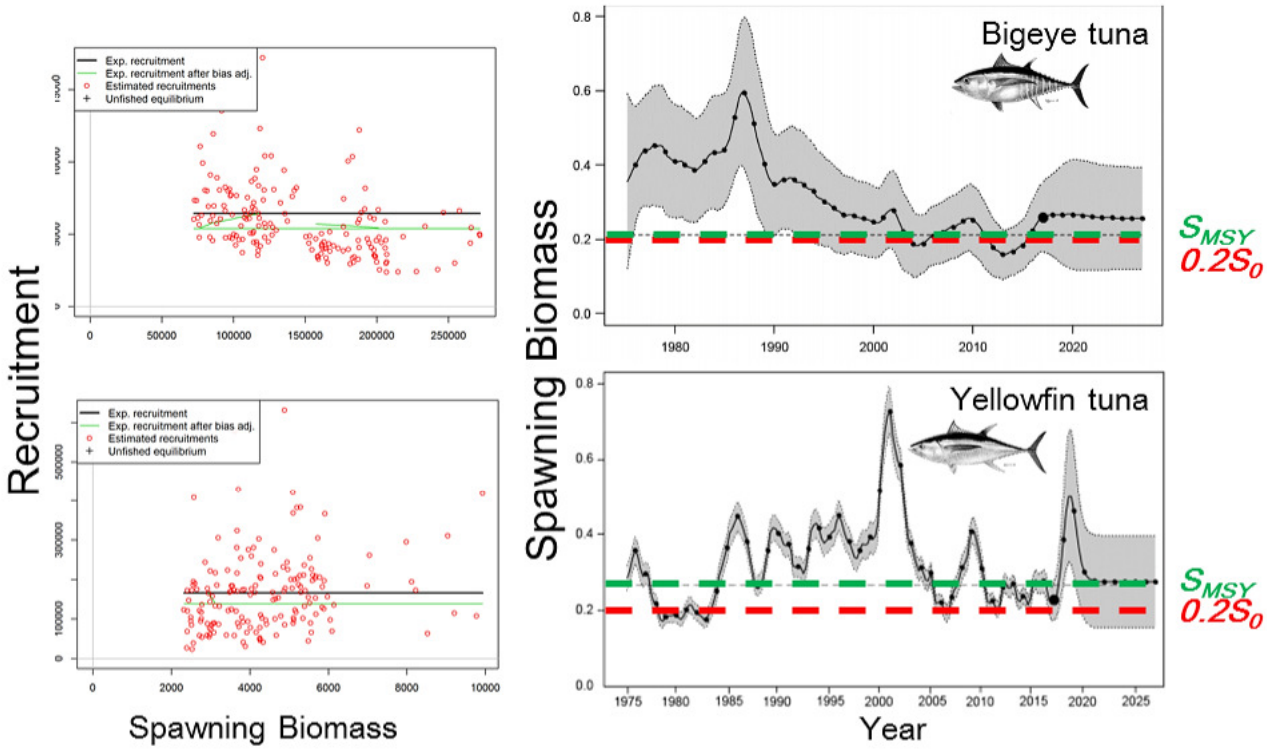

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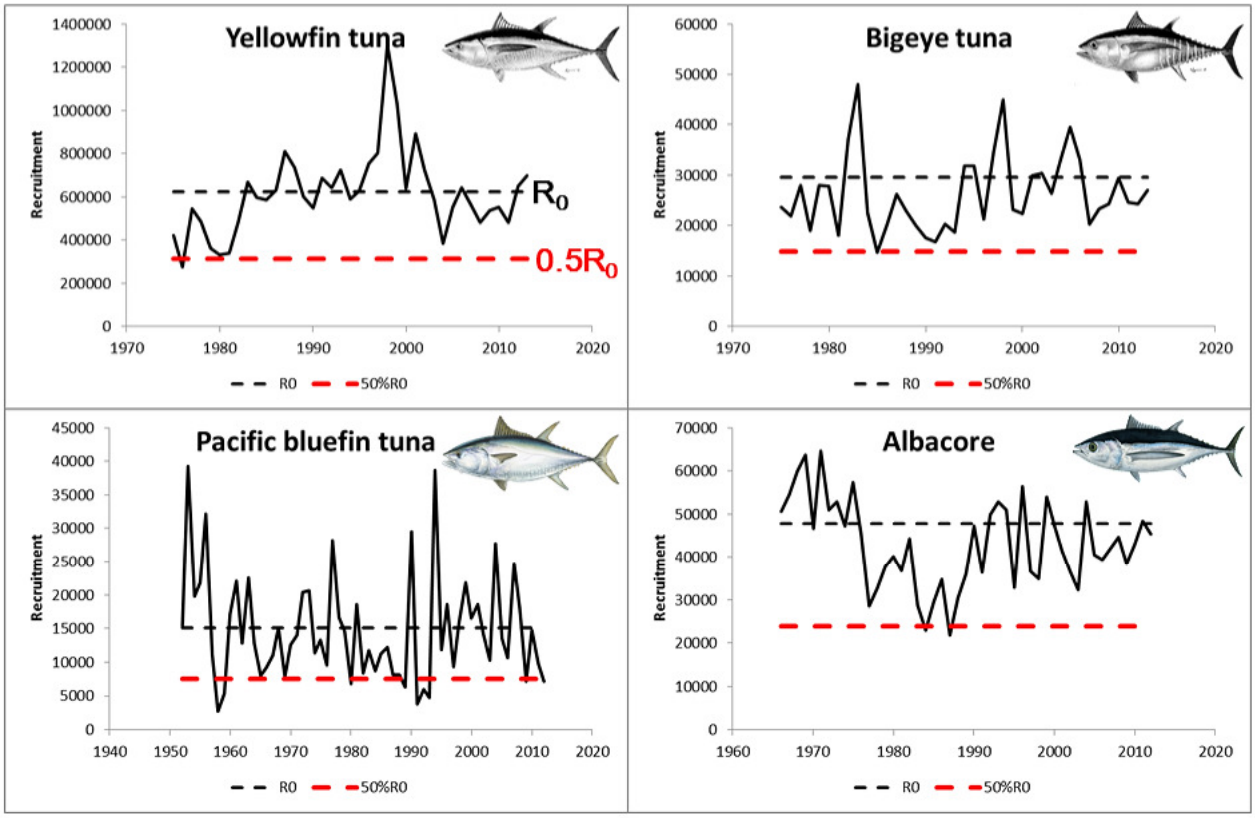

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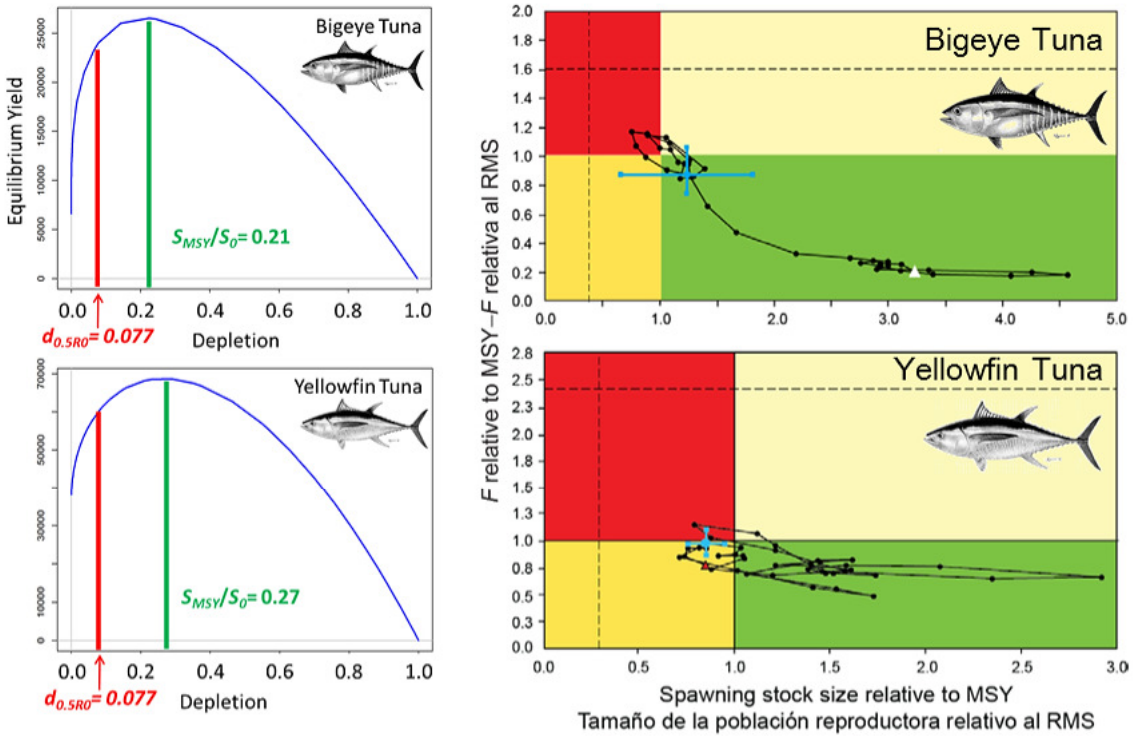

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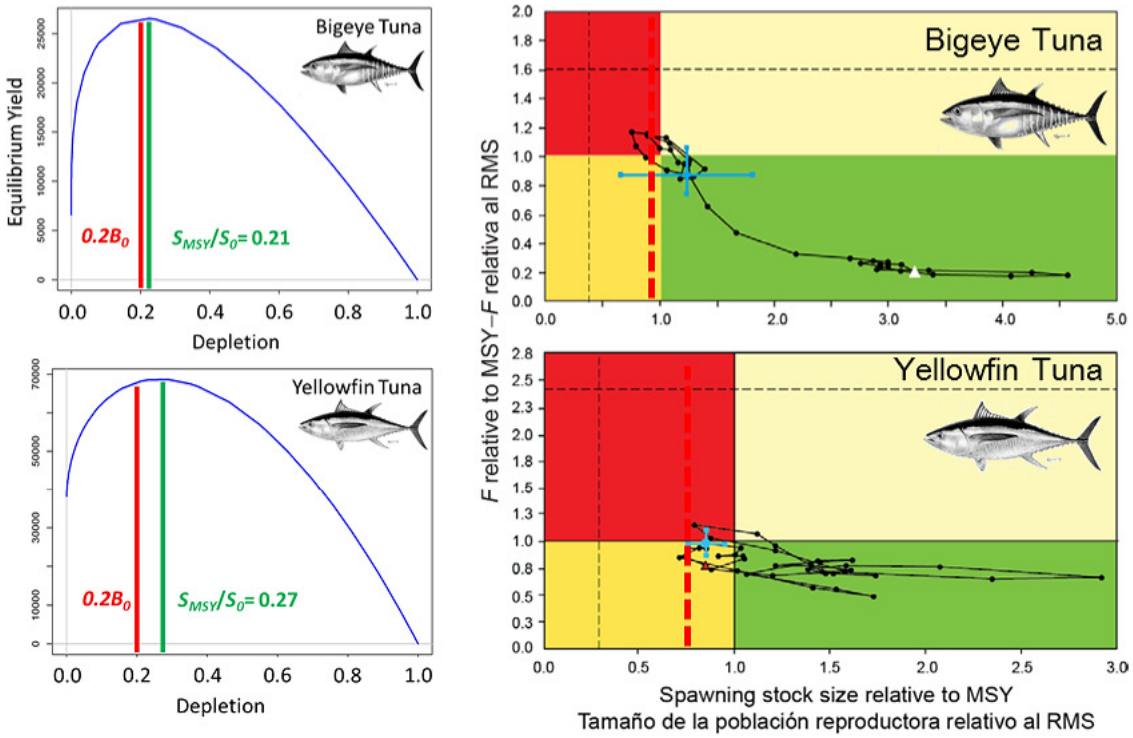
RP and HCR for EPO tuna



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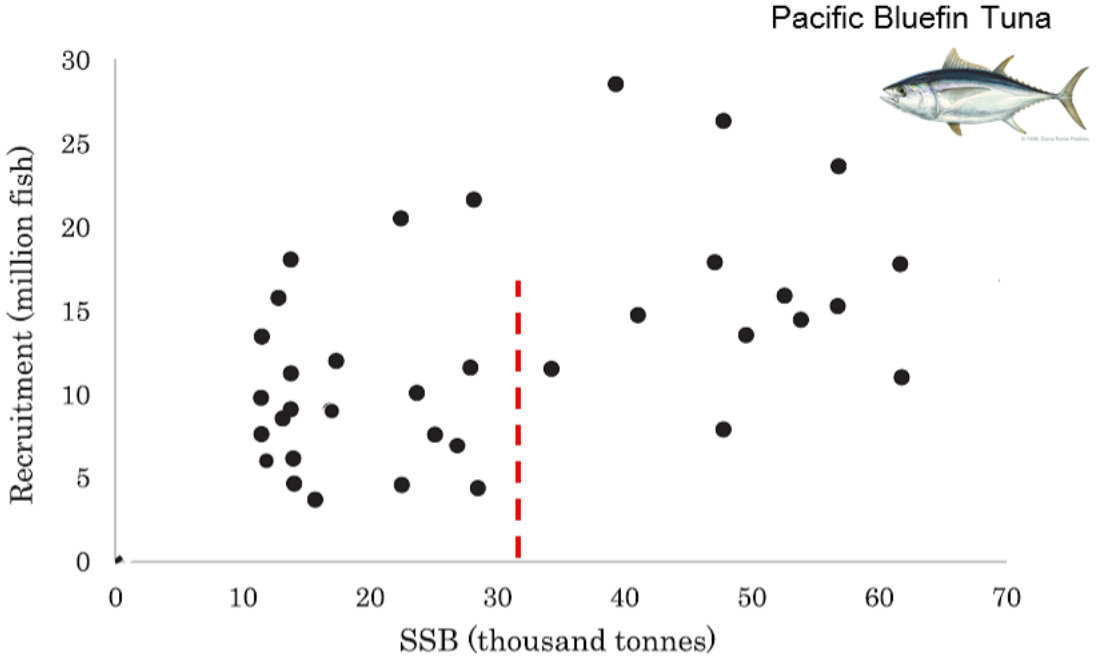
Recently proposed LRP for Pacific bluefin tuna (Nakatsuka et al. 2017)



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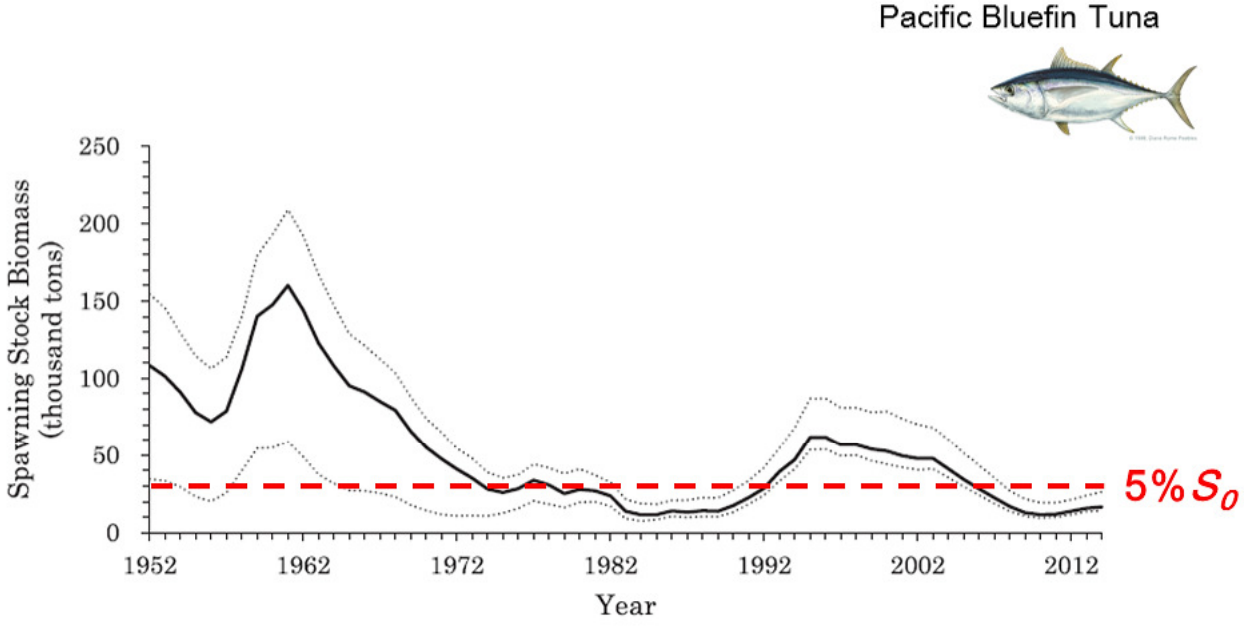

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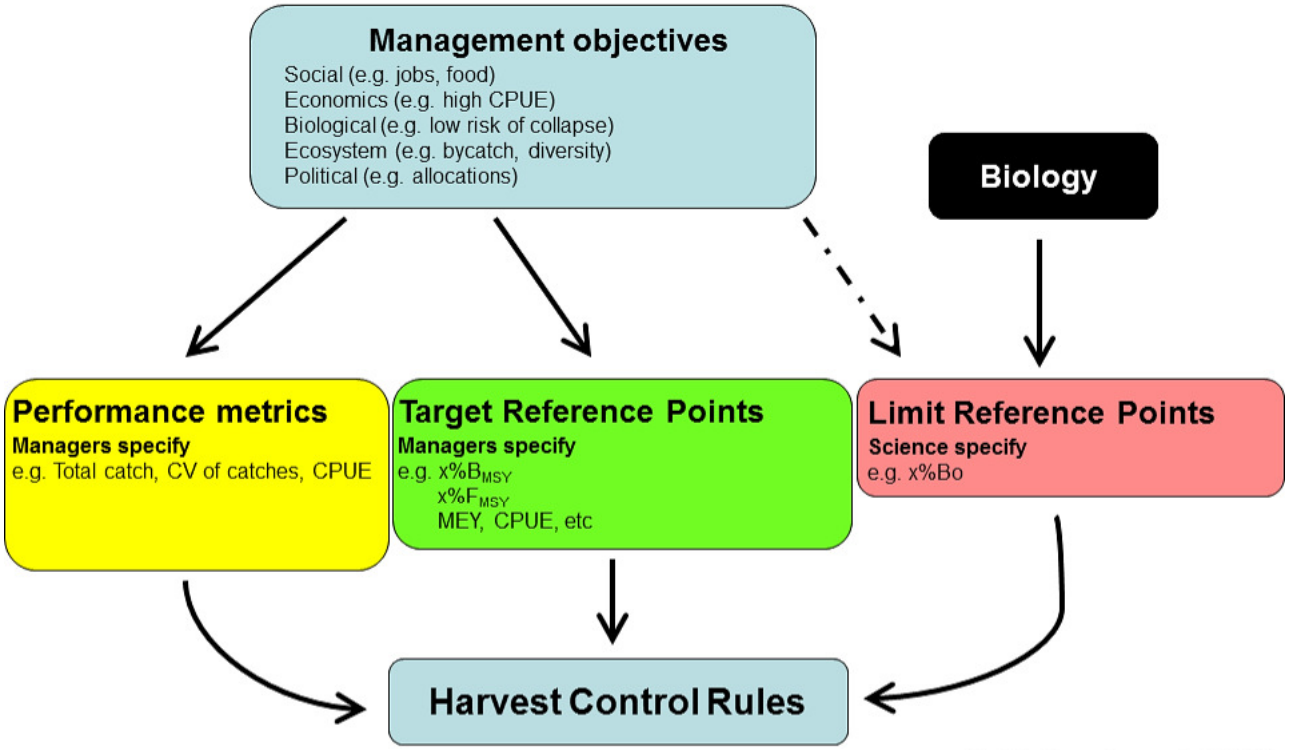
Harvest strategies

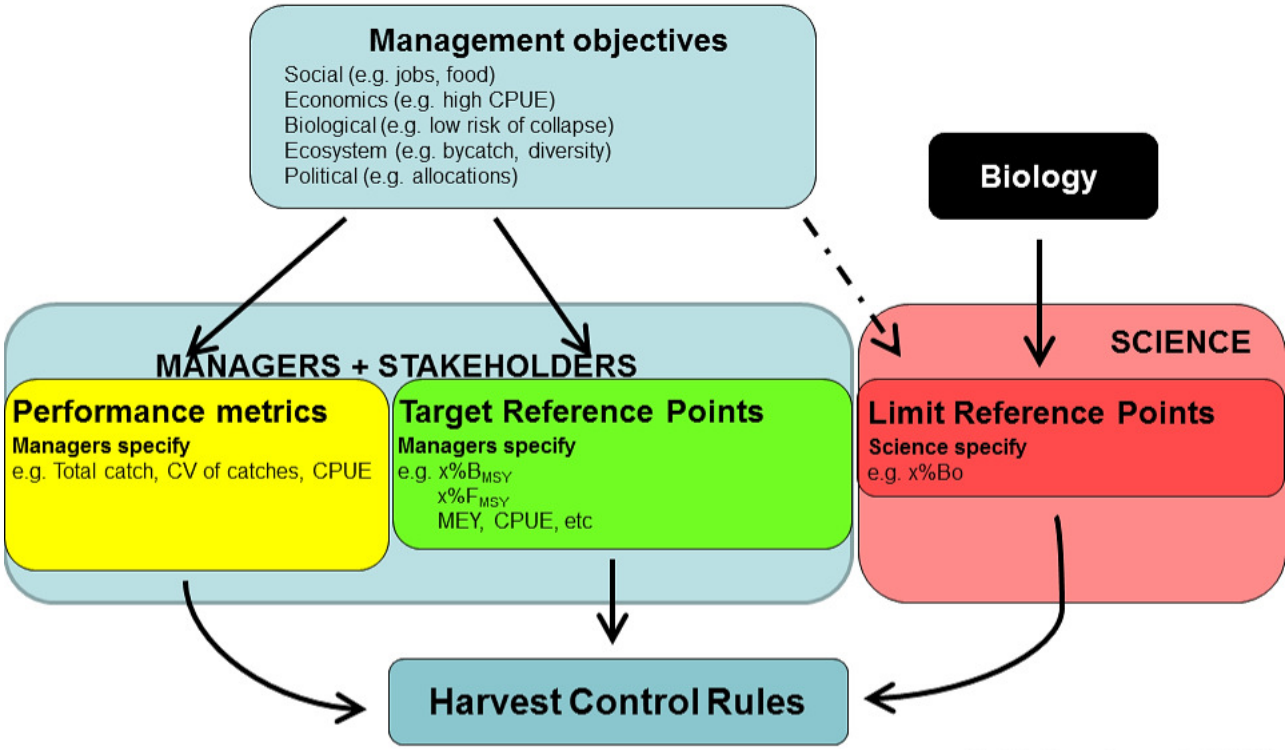


Modified from Berger et al. 2012

Typical roles of participants

- Managers and stakeholders identify:
  - Management objectives,
  - Candidate target reference points,
  - Candidate harvest control rules, criteria against which their performance should be evaluated.
- Scientists identify appropriate biological limits to exploitation and evaluate the performance of identified candidate harvest control rules.

Harvest strategies: Roles



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Harvest Strategies Summary

- **HARVEST STRATEGY:** Combination of monitoring, stock status evaluation, harvest control rule (with or without RPs) and management actions designed to achieve **fisheries objectives**.
- The emphasis of harvest strategy elements varies by fishery, their historical context (e.g. developing, stable, rebuilding) and the level of monitoring, available analyses and management systems.
- RPs and HCRs cannot be properly evaluated without specific management objectives, data collection, analyses, treatment of uncertainty and other components of a harvest strategy.
- Development and success of HCRs and RPs benefit from the **involvement of all stakeholders** in the management planning stage.

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Thank you!
Questions?

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